SIEMENS

automotive system group

Engine Management System

# HMC_V6

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**SIEMENS** Automotive



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## Version list

| Version | Date | Author | Comment, Description |
|---|---|---|---|
| | | | |

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# 1 Acquisition of Inputs

## 1.1 Analog Inputs

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| AD_BUFFER | - | | | | Volt |
| Table of raw acquisition values (16) for direct analog inputs. | | | | | |
| MAF_BAS | - | 0...03FFH | 0...4,9951 | 5 / 1024 | Volt |
| Mass air flow sensor raw acquisition. | | | | | |
| V_IGK_BAS | - | 0...03FFH | 0...4,9951 | 5 / 1024 | Volt |
| Battery voltage after Ignition key raw acquisition. | | | | | |
| VB_BAS | - | 0...03FFH | 0...4,9951 | 5 / 1024 | Volt |
| Battery voltage after main relay raw acquisition. | | | | | |
| VLS_UP_1_BAS | - | 0...03FFH | 0...4,9951 | 5 / 1024 | Volt |
| Upstream oxygen sensor voltage raw acquisition - Bank n° 1. | | | | | |
| VLS_UP_2_BAS | - | 0...03FFH | 0...4,9951 | 5 / 1024 | Volt |
| Upstream oxygen sensor voltage raw acquisition - Bank n° 2. | | | | | |
| VLS_DOWN_1_BAS | - | 0...03FFH | 0...4,9951 | 5 / 1024 | Volt |
| Downstream oxygen sensor voltage raw acquisition - Bank n° 1. | | | | | |
| VLS_DOWN_2_BAS | - | 0...03FFH | 0...4,9951 | 5 / 1024 | Volt |
| Downstream oxygen sensor voltage raw acquisition - Bank n° 2. | | | | | |
| LSH_DOWN_1_BAS | - | 0...03FFH | 0...4,9951 | 5 / 1024 | Volt |
| Current equivalent measurement for downstream oxygen sensor heater - Bank n° 1. | | | | | |
| LSH_DOWN_2_BAS | - | 0...03FFH | 0...4,9951 | 5 / 1024 | Volt |
| Current equivalent measurement for downstream oxygen sensor heater - Bank n° 2. | | | | | |
| DTP_BAS | - | 0...03FFH | 0...4,9951 | 5 / 1024 | Volt |
| Differential tank pressure sensor raw acquisition. | | | | | |
| TEGR_BAS | - | 0...03FFH | 0...4,9951 | 5 / 1024 | Volt |
| EGR temperature sensor raw acquisition. | | | | | |
| TPS_BAS | - | 0...03FFH | 0...4,9951 | 5 / 1024 | Volt |
| Throttle position sensor raw acquisition. | | | | | |
| TCO_BAS | - | 0...03FFH | 0...4,9951 | 5 / 1024 | Volt |
| Coolant temperature sensor raw acquisition. | | | | | |
| TI_CO_IS_BAS | - | 0...03FFH | 0...4,9951 | 5 / 1024 | Volt |
| Injection time correction for idle CO-adjustment | | | | | |
| TIA_BAS | - | 0...03FFH | 0...4,9951 | 5 / 1024 | Volt |
| Intake air temperature sensor raw acquisition. | | | | | |

## FUNCTION DESCRIPTION:

### Direct analog inputs

| Name | Acquisition rate (msec.) | Port - Channel | Remark | Application recurrence (msec.) |
|---|---|---|---|---|
| MAF | 1 | 5 - 0 | 120 x N (rpm) / NC_CYL_NO | Segment |
| V_IGK | 1 | 5 - 1 | | 10 |
| VLS_UP_1 | 5 | 5 - 2 | | 10 |
| VLS_UP_2 | 5 | 5 - 3 | | 10 |
| VLS_DOWN_1 | 5 | 5 - 4 | | 20 |
| VLS_DOWN_2 | 5 | 5 - 5 | | 20 |
| LSH_DOWN_1 | 1 | 5 - 6 | Current O2 downstream sensor 1 | To be defined |
| LSH_DOWN_2 | 1 | 5 - 7 | Current O2 downstream sensor 2 | To be defined |
| DTP | 10 | 5 - 8 | | 50<br>during monitoring<br>1 sec out of monitoring |
| TEGR | 10 | 5 - 9 | | 100 |
| TPS | 5 | 5 - 10 | | 10 |
| TCO | 100 | 5 - 11 | | 500 |
| TI_CO_IS | 100 | 5 - 12 | | 100 |
| VB | 1 | 5 - 13 | | 10 |
| TIA | 100 | 5 - 14 | | 500 |
| KNKS | 0,3 | 5 - 15 | During knock window . | |

### 1.1.1 Acquisition of mass air - flow

#### 1.1.1.1 Basic software

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| MAF_ACC | - | 0...FFFFFFFFH | 0...6.7109E7 | 0.015625 | kg/h |
| Accumulated mass air - flow measurements for segment number (2n), n = 1,2,3,... | | | | | |
| MAF_ACC1 | - | 0...FFFFFFFFH | 0... 6.7109E7 | 0.015625 | kg/h |
| Accumulated mass air - flow measurements for segment number (2n-1), n = 1,2,3,... | | | | | |
| MAF_ACC_SUM | - | 0...FFFFH | 0...65535 | 1 | - |
| Counter for accumulated mass air - flow measurements for segment number (2n), n = 1,2,3,... | | | | | |
| MAF_ACC1_SUM | - | 0...FFFFH | 0...65535 | 1 | - |
| Counter for accumulated mass air - flow measurements for segment number (2n-1), n = 1,2,3,... | | | | | |
| L_MAF_ACC_CHOICE | - | 0...01H | 0...1 | 1 | - |
| Indicates if segment number is even or odd in order to choose MAF_ACC / MAF_ACC_SUM or MAF_ACC1 / MAF_ACC1_SUM. | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| AD_BUFFER | MAF_BAS | | |

**FUNCTION DESCRIPTION:**

General information:

The raw value for mass air flow ( MAF_BAS ) is measured by continuous conversion (10 bits) every **1 msec.**

The raw values are converted by a table ID_MAF_TAB__V_MAF_1__V_MAF_2 into values with the unit **[kg/h]** and sum up in one of the two buffers, MAF_ACC and MAF_ACC1.

For this conversion, only ( MAF_BAS / 4 ) is taken into account for set points (8 bits)**:**

V_MAF_1 ← ( MAF_BAS / 4 ) / 16

V_MAF_2 ← ( MAF_BAS / 4 ) module 16

The number of values is counted in MAF_ACC_SUM and MAF_ACC1_SUM.

A two-buffer-system is used to avoid incorrect mass air flow calculation. The buffers alternate with each change of segment, i.e. L_MAF_ACC_CHOICE is toggled each segment.

After having read out one buffer - MAF_ACC or MAF_ACC1 - the applicative software has to clear this buffer as well as the corresponding counter - MAF_ACC_SUM or MAF_ACC1_SUM -.

**Initialisation :**

After hardware reset, the buffers MAF_ACC and MAF_ACC1 and the corresponding counters MAF_ACC_SUM and MAF_ACC1_SUM have to be cleared and a pointer has to be initialised with the address of the linearization table
ID_MAF_TAB__V_MAF_1__V_MAF_2.

**Formula section:**

Accumulated mass air flow calculation :

$$MAF\_ACC = \sum_{i=1}^{i=MAF\_ACC\_SUM} MAF[i]$$

$$MAF\_ACC1 = \sum_{i=1}^{i=MAF\_ACC1\_SUM} MAF[i]$$

with MAF[i] ← ID_MAF_TAB__V_MAF_1__V_MAF_2 (MAF_BAS / 4) : acquisition converted by the linearization table.

**Remark:** During updating of calibration files the linearization table ID_MAF_TAB__V_MAF_1__V_MAF_2 will not be updated.

**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| ID_MAF_TAB__V_MAF_1__V_MAF_2 | 16 x 16 | 0...FFFFH | 0...65535 / 64 | 0.015625 | kg/h |
| | | | | | |
| Conversion table for linearization of MAF value acquisition. | | | | | |

### 1.1.1.2 Applicative software

#### 1.1.1.2.1 Mass air - flow variables

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| MAF_KGH_MES | V | 0...FFFFH | 0...16383.75 | 0.25 | kg/h |
| Mass air flow value calculated in kg/h. | | | | | |
| MAF_KGH | V | 0...FFFFH | 0...16383.75 | 0.25 | kg/h |
| Mass air flow value in kg/h | | | | | |
| MAF_MES | V | 0...FFFFH | 0...1389 | 0.0212 | mg/TDC |
| Mass air flow value measured in mg/TDC. | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| MAF_ACC | MAF_ACC1 | MAF_ACC_SUM | MAF_ACC1_SUM |
| N | NC_FAC_MAF_CYL | NC_CYL_NO | MAF_SUB_DIAG |
| LV_MAF_ERR | | | |

**FUNCTION DESCRIPTION:**

General information:

The buffers alternate with each change of segment. Also mass air flow per segment is calculated out of these average values.

**Formula section:**

*- Calculation of MAF_KGH_MES in kg/h :*

**MAF_KGH_MES** = 1/16 * MAF_ACC / MAF_ACC_SUM

**or** **MAF_KGH_MES** = 1/16 * MAF_ACC1 / MAF_ACC1_SUM

*- Calculation of MAF_KGH in kg/h :*

**If** LV_MAF_ERR = 0
**then** **MAF_KGH** = MAF_KGH_MES
**else** **MAF_KGH** = MAF_SUB_DIAG * N / NC_FAC_MAF_CYL

**Remark :** For further Information on MAF_SUB_DIAG refer to Chapter Diagnosis Management (Mass Air Flow Sensor Diagnosis)

*- Calculation of MAF_MES in mg/TDC :*

**MAF_MES** = NC_FAC_MAF_CYL * MAF_KGH / N

**Remark :** MAF_MES is used by various functions as the load signal.

## Calibration data:

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| NC_FAC_MAF_CYL | 1 | 0...FFFFH | 0...1.996 | 0.0000304 | - |
| Weighting factor for MAF_MES calculation function of the number of cylinder - Non adjustable calibration. | | | | | |

**Applicative Value :** NC_FAC_MAF_CYL = **8000**H = 1 dec.

### 1.1.2 Acquisition of knock sensor input signal

#### 1.1.2.1 Basic software

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| KNKS_[CYL] | V | 0...FFH | 0...4,9805 | 5 / 256 | V. |
| Knock - noise for each cylinder. | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| KNKWB_[CYL] | KNKWE_[CYL] | | |

**FUNCTION DESCRIPTION:**

General information:

The knock sensor signal is measured with the SIEMENS - " Knock I.C. ".

It is possible to use one or two knock sensors.

**Initialization :**

By the synchronisation on the crankshaft signal the next knock - window has to be performed. Therefore two configuration bytes show the next segment :

NC_CYL_NO_TDC_REF_TOOTH_1 : actual segment number of the first TDC after the tooth n° **1**.

NC_CYL_NO_TDC_REF_TOOTH_61 : actual segment number of the first TDC after the tooth n° **61**.

**System Description :**

**1 - Knock control window :**

As the vibrations typical for knocking occur only at certain crankshaft angle positions, the values are measured precisely in these ranges.

Therefore each cylinder has its own input data for the *beginning* of the knock - window

( **KNKWB_[CYL** ) and the *end* of the knock window ( **KNKWE_[CYL]** ). Within this range the knock noise is sampled every NC_KNOCK_SAMPLE_RELOAD µsec.

The control window is calculated in any engine operating condition and at any operating point.

At the end of the knock - window, the next knock - window (beginning and end) is performed.

## 2 - Selection of the knock sensor :

At the end of each knock - window the knock sensor for the next knock - window is selected.

The configuration byte NC_KNOCK_SENSOR shows the right knock sensor. For each segment, it is represented by a bit :

0 -> Knock sensor bank 1

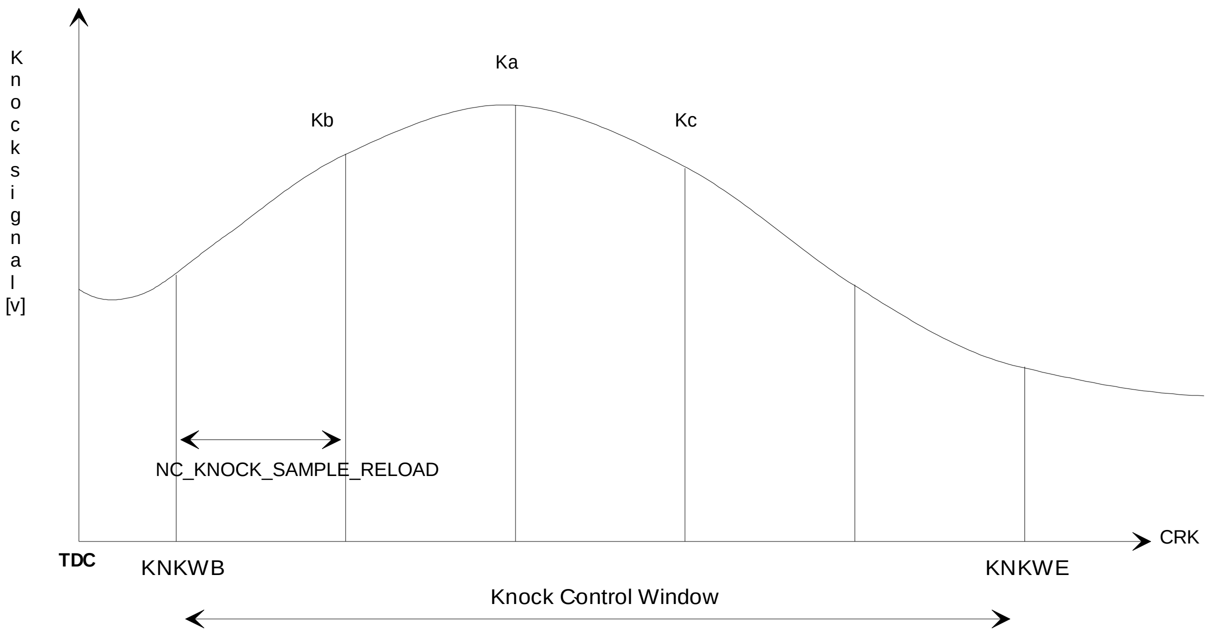
1 -> Knock sensor bank 2

## 3 - Calculation of the knock - noise :

While the control - window is ON, the signal is subject to cyclic sampling by the knock sensor (every NC_KNOCK_SAMPLE_RELOAD µs).

The three highest values derived from these measurements (Ka, Kb, Kc) are used for the knock - noise calculation.

For this purpose, the highest one of the 3 measured values (Ka) receives the highest weighting. At segment intervals, the knock value KNKS[CYL is determined individually for each cylinder.




The knock value KNKS[CYL] is determined on the basis of the three highest values (Ka,Kb,Kc) according to the following algorithm :

- if the knock - control window is too " small " for sampling at least three values, then :

  1 sample : KNKS_[CYL] = Ka

  2 samples : KNKS_[CYL] = (Ka + Kb)/2

- if the knock - control window is sufficient for sampling at least three values, then :

$$KNKS\_[CYL] = [ Ka + (Kb + Kc) / 2 ] / 2$$

**4 - Amplification of knock signal :**

The knock sensor signal is controlled by a PWM signal.

(Refer to the specification of " PWM Outputs")

**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| NC_KNOCK_SAMPLE_RELOAD | 1 | 0001...FFFFH | 0,004...262 | 4 | msec |
| Sample period for knock sensor signal calculation - Non adjustable calibration. | | | | | |
| NC_KNOCK_SENSOR | 1 | 00...FFH | 0...255 | 1 | - |
| Bit information for knock sensor number for each cylinder - Non adjustable calibration. | | | | | |
| NC_CYL_NO_TDC_REF_TOOTH_1 | 1 | 00...FFH | 0...255 | 1 | - |
| Segment number of the first TDC, after tooth n° 1. (NC_CYL_NO) - Non adjustable calibration. | | | | | |
| NC_CYL_NO_TDC_REF_TOOTH_61 | 1 | 00...FFH | 0...255 | 1 | - |
| Segment number of the first TDC, after tooth n° 61. (NC_CYL_NO) - Non adjustable calibration. | | | | | |
| NC_CYL_NO | 1 | 00...FFH | 0...255 | 1 | - |
| Number of Cylinders - Non adjustable calibration. | | | | | |

**Applicative Values :**

NC_KNOCK_SAMPLE_RELOAD = **46**H = 75 dec. x 4 µsec = 300 µsec.

NC_KNOCK_SENSOR = **2A**H = 00101010 bin.

NC_CYL_NO_TDC_REF_TOOTH_1 = **01**H = 1 dec.

NC_CYL_NO_TDC_REF_TOOTH_61 = **04**H = 4 dec.

NC_CYL_NO = **06**H = 6 cylinders

**Remark :**

The applicative software is using the variables **KNKS_[CYL]** as the knock noise, and their values are corresponding to the **KNKS[CYL]** signal given by the basic software.

### 1.1.2.2 Applicative software

#### 1.1.2.2.1 Knock signal amplification

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| KNKPWM | V | 00...FFH | 0...99,609 | 0,3891 | % |
| Knock - noise amplified PWM send to basic software for generation of PWM output. | | | | | |
| NL_FAC_MMV | V | 00...FFFFH | 0...1,999 | 2 / 65536 | - |
| Correction factor to calculate KNKPWM (the gain of the voltage - controlled amplifier for knock signal). | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| NL_[CYL] | C_NL_CRLC | NC_CYL_NO | LV_ES |
| LV_ST | LV_KNK_ACT | | |

**FUNCTION DESCRIPTION:**

General information:

A voltage - controlled amplifier is integrated into the input signal processing. The gain is controlled via a pulse - width modulated output signal of the processor.

The total gain consists of an open - loop control value IP_V_KNK__N_32 and a correction factor NL_FAC_MMV

It is calculated at intervals of 720 °CRK **:** IP_V_KNK__N_32 * NL_FAC_MMV

The result of the calculation above - mentioned is sent to the basic software (**KNKPWM**) for generation of the PWM Output.

**Formula section:**

*- Initialization :*

During engine operating states engine stopped LV_ES and start LV_ST, the correction factor NL_FAC_MMV is set to 1.

*- Calculation :*

For the purpose of the correction factor, the noise value derived from the mean value of each cylinders is compared to the target value IP_NL_SP__N and then :

**If** **LV_KNK_ACT = Active** since at least 1 segment
**then** NL_FAC_MMV (n) = NL_FAC_MMV (n-1)
+ [ 1 - ( Σ NL_[x] / NC_CYL_NO ) / IP_NL_SP__N_32 ] * C_NL_FAC_CRLC

**If** **LV_KNK_ACT = Passive**
**then** NL_FAC_MMV (n) = 1 using gradient limitation C_NL_FAC_LGRD * 720 °CRK

The calibration data C_NL_FAC_CRLC is a filtering factor which serves to determine the control rate of the I - controller.

***This filtering factor must be less than the filtering factor C_NL_CRLC used for generation of the noise value.***

*- Limitation :*

C_NL_FAC_MMV_MIN ≤ NL_FAC_MMV ≤ C_NL_FAC_MMV_MAX

The final valid value for NL_FAC_MMV is not changed if the total gain reaches the maximum value (**FF**H).

*- Limp Home :*

If a diagnostic error is detected on one of the knock sensors, the correction factor NL_FAC_MMV is set to 1.

**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| C_NL_FAC_CRLC | 1 | 0...FFH | 0...0,1245 | 0,0005 | - |
| Filtering factor for calculation of the correction factor used to calculate the voltage controller amplifier gain. | | | | | |
| C_NL_FAC_MMV_MIN | 1 | 00...FFH | 0...1,992 | 2 / 256 | - |
| Minimum value for the correction factor of voltage controller amplifier gain. | | | | | |
| C_NL_FAC_MMV_MAX | 1 | 00...FFH | 0...1,992 | 2 / 256 | - |
| Maximum value for the correction factor of the voltage controller amplifier gain. | | | | | |
| C_NL_FAC_LGRD | 1 | 0...7FFFH | 0...0,9999 | 1 / 32768 | - |
| Gradient limitation for NL_FAC_MMV calculation when knock control is inactive. | | | | | |
| IP_NL_SP__N_32 | 8 | 0...FFH | 0...4,9805 | 5 / 256 | V. |
| | | | | | |
| Noise level threshold for knock signal amplification. | | | | | |
| IP_V_KNK__N_32 | 8 | 0...FFH | 0...0,996 | 1 / 256 | - |
| | | | | | |
| Gain of the voltage controlled amplifier versus engine speed for amplification of knock signal. | | | | | |

### 1.1.2.2.2 Knock control window



**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| KNKWB_[CYL] | - | 01...FFH | 0,375...95,625 | 0,375 | °CRK |
| Beginning of the control window for each cylinder (after TDC) send to the basic software. | | | | | |
| KNKWE_[CYL] | - | 0...FFH | 12...107,625 | 0,375 | °CRK |
| End of the control window for each cylinder send to the basic software. | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| MAF_KNK | N_KNK | | |

**FUNCTION DESCRIPTION:**

General information:

The control window is calculated in any engine operating condition and at any operating point. For the purpose of the adjustment, the control window must definitely be >= 1 msec.

Moreover, an interval of at least 1 msec. must be provided between the end of the current control window and the beginning of the following one, for the following cylinder.



**Formula section:**

- The start of the knock control window required for measurement of the knock signals is taken cylinder individually from one of the following tables:

ID_KNKWB_[CYL]__N_KNK__MAF_KNK

- The end of the control window is taken cylinder individually from one of the following tables:

ID_KNKWE_[CYL]__N_KNK__MAF_KNK

**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| ID_KNKWB_[CYL]__N_KNK__MAF_KNK | 16 x 4 | 01...FFH | 0,375...95,625 | 0,375 | °CRK |
| The tables for beginning of control window to the cylinders and knock sensors. | | | | | |
| ID_KNKWE_[CYL]__N_KNK__MAF_KNK | 16 x 4 | 0...FFH | 12...107,625 | 0,375 | °CRK |
| The tables for end of the control window to cylinders and knock sensors. | | | | | |

### 1.1.2.2.3 Hysteresis function

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| N_KNK | V | 0...FFH | 0...8160 | 32 | rpm |
| Specific engine speed for knock control active. | | | | | |
| MAF_KNK | V | 0...FFH | 0...1389 | 5,45 | mg/TDC |
| Specific mass air flow for knock control active. | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| MAF | N | LV_KNK_ACT | |

**FUNCTION DESCRIPTION:**

General information:

A hysteresis function is applied on engine speed and mass air flow for all tables and maps within the knock control active (LV_KNK_ACT = Active). It is used in order to avoid some jumps in the case of small engine speed and mass air flow changes.

**Application conditions:**

LV_KNK_ACT = Active

**Formula section:**

**If** $|N\_KNK - N_{actual}| > C\_IGA\_N\_HYS\_KNK$

**then** $N\_KNK = N_{actual}$

**else** N_KNK remains unchanged.

**If** $|MAF\_KNK - MAF_{actual}| > C\_IGA\_MAF\_HYS\_KNK$

**then** $MAF\_KNK = MAF_{actual}$

**else** MAF_KNK remains unchanged.

**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| C_IGA_N_HYS_KNK | 1 | 0...FFH | 0...8160 | 32 | rpm |
| Engine speed hysteresis for knock control active. | | | | | |
| C_IGA_MAF_HYS_KNK | 1 | 0...FFH | 0...1389 | 5,45 | mg/TDC |
| Mass air flow hysteresis for knock control active. | | | | | |

#### 1.1.2.2.4 Load range for knock control



**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| LV_KNK_ACT | V | 0...01H | 0...1 | 1 | - |
| Boolean for knock control active. | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| MAF | N | TCO | LV_ST |
| LV_TCO_ERR | LV_MAF_ERR | LV_ES | |

**FUNCTION DESCRIPTION:**



General information:

The load range in which the knock control is active is defined by an engine speed and coolant temperature dependent characteristic.

If the actual mass air flow is below a threshold, only the noise value will be generated and the ignition angle correction IGA_KNK_[CYL] is reset using change limitation C_IGA_LGRD_3 (refer to chapter „Diagnosis“) and will be controlled back.

**Application conditions:**

*Initialization :*

**LV_KNK_ACT= Passive**

*Activation:*

**If** MAF >= IP_MAF_MIN_KNK__N__TCO
**and** LV_ES= 0 (no engine operating state “ Engine Stopped “)
**and** LV_ST= 0 (no engine operating state “Start “)
**then** **LV_KNK_ACT = Active**

*Deactivation:*

**If** MAF < IP_MAF_MIN_KNK__N__TCO
**or** LV_ES = 1 (engine operating state “ Engine Stopped “)
**or** LV_ST = 1 (engine operating state “Start “)
**or** Key OFF
**then** **LV_KNK_ACT = Passive**

*Limp Home :*

In case of diagnostic error on coolant temperature (LV_TCO_ERR) or mass air flow meter (LV_MAF_ERRthe corresponding limp home values will be used.
(Refer to chapter : “ Diagnosis Management “)

## Calibration data:

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| C_IGA_LGRD_3 | 1 | 01...7FFFH | 0,0015...47,9985 | 0,0015 | °CRK |
| Ignition angle limitation gradient for area 3 (x 120 °CRK) | | | | | |
| IP_MAF_MIN_KNK__N__TCO | 8 x 4 | 0...FFH | 0...1389 | 5,45 | mg/TDC |
| Mass air flow threshold for activation of knock control. | | | | | |

### 1.1.2.2.5 Engine speed and load dynamics relative to knock control

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| LV_N_GRD_MAX_KNK | V | 0...01H | 0...1 | 1 | - |
| Boolean for engine speed dynamics relative to knock control. | | | | | |
| LV_TPS_GRD_TRA_KNK | V | 0...01H | 0...1 | 1 | - |
| Boolean for load dynamics relative to knock control. | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| TPS_GRD | N | N_KNK | N_GRD |
| C_FAC_TRA_KNK | | | |

**FUNCTION DESCRIPTION:**

General information:

To allow a fast follow-up of the knock - noise values in case of a fast changing engine speed or engine load, some conditions for dynamics detection are defined.

**Application conditions:**

Available for all engine operating states.

- *Initialization :*

**LV_N_GRD_MAX_KNK = 0**

**LV_TPS_GRD_TRA_KNK = 0**

- *Activation:*

a - Engine speed dynamics :

**If** |N_GRD| >= ID_N_GRD_MAX_KNK__N_KNK
**then** **LV_N_GRD_MAX_KNK = 1**

*Moreover, when LV_N_GRD_MAX_KNK = 1, the values of the knock adaptation are only read.*

b - Load dynamics :

**If** TPS_GRD>= ID_TPS_GRD_TRA_KNK__N

**then** **LV_TPS_GRD_TRA_KNK = 1** during ID_FAC_TRA_CYCNR_KNK__N cycles.

*Moreover, when LV_TPS_GRD_TRA_KNK = 1, the knock detection sensitivity is reduced with the weighting factor C_FAC_TRA_KNK and the values of the knock adaptation are only read.*

*Deactivation:*

a - Engine speed dynamics :

**If** |N_GRD| < ID_N_GRD_MAX_KNK__N_KNK

**then** **LV_N_GRD_MAX_KNK = 0**

b - Load dynamics :

**If** TPS_GRD< ID_TPS_GRD_TRA_KNK__N

**or** the active period ID_FAC_TRA_CYCNR_KNK__Nhas run out

**then** **LV_TPS_GRD_TRA_KNK= 0**

**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| ID_N_GRD_MAX_KNK__N_KNK | 16 | 0...7FH | 0...4064 | 32 | rpm/sec |
| N_GRD threshold to detect engine speed dynamic relative to knock control. | | | | | |
| ID_TPS_GRD_TRA_KNK__N | 4 | 0...FFH | 0...2988 | 11,72 | °TPS/sec |
| TPS_GRD threshold to detect engine load dynamic relative to knock control. | | | | | |
| ID_FAC_TRA_CYCNR_KNK__N | 4 | 0...FFH | 0...255 | 1 | - |
| Duration of the engine load dynamic detected (x 120 °CRK) | | | | | |

### 1.1.2.2.6 Noise value

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| NL_[CYL] | V | 0...FFFFH | 0...4,9999 | 5 / 65536 | V. |
| Noise value of cylinder i. | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| KNKS_[CYL] | N | LV_TPS_GRD_TRA_KNK | |

**FUNCTION DESCRIPTION:**

General information:

The noise value NL_[CYL] is calculated individually for each cylinder. It is a floating mean - value of the knock value KNKS[CYL]. Two different filter constants are used depending on steady state or transients.

**Application conditions:**

NL_[CYL] calculation is made in all engine operating states.

*Initialization :*

NL_[CYL] = IP_NL_SP__N

**Formula section:**

*Calculation :*

**If** LV_TPS_GRD_TRA_KNK = 0 (engine load dynamic not active)

**then** NL_[CYL] = NL_[CYL] + ( KNKS_[CYL - NL_[CYL] ) * C_NL_CRLC

**If** LV_TPS_GRD_TRA_KNK = 1 (engine load dynamic active)

**then** NL_[CYL] = NL_[CYL] + ( KNKS_[CYL] - NL_[CYL] ) * C_NL_CRLC_TRA

*Limitation :*

- Maximum limit :

The noise value NL_[CYL] is limited to C_NL_MAX.

- Minimum limit :

If all the noise values relative to a knock sensor are below a threshold C_NL_MIN_DIAG then a diagnostic error is detected. For the emergency operation, refer to chapter “Diagnosis Management“.

## Calibration data:

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| C_NL_CRLC | 1 | 01...FFH | 0,004...0,9961 | 1 / 256 | - |
| Knock - noise filtering factor in steady state. | | | | | |
| C_NL_CRLC_TRA | 1 | 01...FFH | 0,004...0,9961 | 1 / 256 | - |
| Knock - noise filtering factor with engine speed and / or engine load dynamics active. | | | | | |
| IP_NL_SP__N | 8 | 0...FFH | 0...4,9805 | 5 / 256 | V. |
| Knock - noise level threshold for knock signal amplification. | | | | | |
| C_NL_MIN_DIAG | 1 | 0...FFH | 0...4,9805 | 5 / 256 | V. |
| Knock - noise level threshold for knock acquisition diagnostic error detection. | | | | | |
| C_NL_MAX | 1 | 0...FFH | 0...4,9805 | 5 / 256 | V. |
| Maximum knock - noise level limitation. | | | | | |

### 1.1.2.2.7 Knock detection threshold

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| LV_KNK | V | 0...01H | 0...1 | 1 | - |
| Boolean for knock detected above the knock - noise threshold. (- / KNK) | | | | | |
| NL_THD_KNK | V | 0...FFH | 0...4,9805 | 5 / 256 | V |
| Noise level threshold for knock detection updated each segment. | | | | | |
| NL_THD_KNK_[CYL] | V | 0...FFH | 0...4,9805 | 5 / 256 | V |
| Noise level threshold for knock detection updated each crankshaft revolution. | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| NL_[CYL] | N_KNK | MAF_KNK | LV_TPS_GRD_TRA_KNK |

**FUNCTION DESCRIPTION:**

General information:

The knock thresholds NL_THD_KNK_[CYL] are the limits for the knock values and are used for the knock control decision. They are calculated individually for each cylinder depending on the noise value and conditions for dynamics.

In case of engine load dynamics, a weighting factor C_FAC_TRA_KNK is used to calculate the absolute knock threshold.

**Formula section:**

*Calculation :*

1 - **If** NL_[CYL] < C_NL_MIN_DIAG (absolute threshold) **then**

**a -** Engine load dynamics not active :

(LV_TPS_GRD_TRA_KNK = 0)

The noise level threshold NL_THD_KNK_[CYL is calculated as following :

(C_NL_MIN_DIAG+ ID_ADD_KNK__N_KNK) * ID_FAC_KNK_[CYL]__N_KNK__MAF_KNK

**b -** Engine load dynamics active :

(LV_TPS_GRD_TRA_KNK = 1)

The noise level threshold NL_THD_KNK_[CYL] is calculated as following :

(C_NL_MIN_DIAG + ID_ADD_KNK__N_KNK) * ID_FAC_KNK_[CYL]__N_KNK__MAF_KNK * C_FAC_TRA_KNK

2 - **If** NL_[CYL] >= C_NL_MIN_DIAG (relative threshold) **then**

**a -** *Engine load dynamics not active :*

(LV_TPS_GRD_TRA_KNK = 0)

The noise level threshold NL_THD_KNK_[CYL] is calculated as following :

(NL_[CYL] + ID_ADD_KNK__N_KNK) * ID_FAC_KNK_[CYL]__N_KNK__MAF_KNK

**b -** *Engine load dynamics active :*

(LV_TPS_GRD_TRA_KNK = 1)

The noise level threshold NL_THD_KNK_[CYL] is calculated as following :

(NL_[CYL] + ID_ADD_KNK__N_KNK) * ID_FAC_KNK_[CYL]__N_KNK__MAF_KNK * C_FAC_TRA_KNK

*Remark :*

The additive correction ID_ADD_KNK__N_KNK is used to shift the knock threshold in the positive or negative direction, depending on the engine speed.

**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| C_FAC_TRA_KNK | 1 | 20...FFH | 1...7,968 | 0,0313 | - |
| Correction factor for knock detection threshold calculation with engine speed and / or engine load dynamics active. | | | | | |
| ID_FAC_KNK_[CYL]__N_KNK__MAF_KNK | 16 x 4 | 0...FFH | 0...7,968 | 0,0313 | - |
| Multiplicative factor for knock detection threshold calculation for each cylinder. | | | | | |
| ID_ADD_KNK__N_KNK | 16 | 80...7FH | -2,5...2,48 | 5 / 256 | V. |
| Additive factor for knock detection threshold calculation. | | | | | |
| C_NL_MIN_DIAG | 1 | 0...FFH | 0...4,9805 | 5 / 256 | V. |
| Knock - noise level threshold for knock acquisition diagnostic error detection. | | | | | |

#### 1.1.2.2.8 Knock detection

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| KNK_INT_CYL_[CYL] | V | 0...02H | 0...2 | 1 | - |
| Knock intensity detected for the corresponding cylinder (No, Intensity 1, Intensity 2). | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| KNKS_[CYL] | LV_KNK_ACT | NL_THD_KNK_[CYL] | |

**FUNCTION DESCRIPTION:**

General information:

If the knock value KNKS_[CYL] is greater or equal to the knock detection threshold NL_THD_KNK_[CYL] and engine load above a threshold (LV_KNK_ACT = Active), then knock is detected on the corresponding cylinder.

According to KNKS_[CYL] value, two knock intensities are distinguished.

**Formula section:**

**If** KNKS_[CYL] < NL_THD_KNK_[CYL]

**then** KNK_INT_CYL_[CYL] = 0 (**No**)

**If** NL_THD_KNK_[CYL] ≤ KNKS_[CYL] < 2 * NL_THD_KNK_[CYL]

**then** KNK_INT_CYL_[CYL] = 1 (**Intensity 1**)

**If** KNKS_[CYL] ≥ 2 * NL_THD_KNK_[CYL]

**then** KNK_INT_CYL_[CYL] = 2 (**Intensity 2**)

### 1.1.3 Acquisition of after main relay battery voltage



**Output data:**

| Name | Type | V/S | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|---|
| VB_MES | 2U | - | 0...03FFH | 0...25,9746 | 26 / 1024 | Volt |
| Battery voltage value measured (10 bits). | | | | | | |
| L_KEY_OFF | Bool | - | 0...01H | 0...1 | 1 | - |
| Boolean for ignition key status (ON / OFF). | | | | | | |

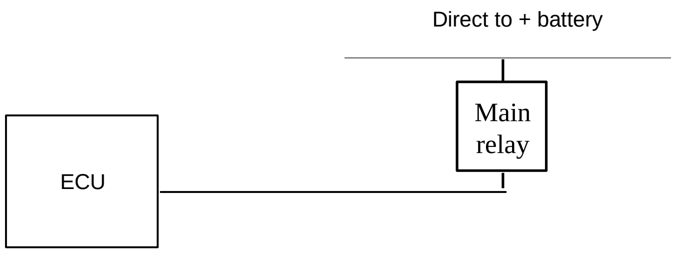
**Input data:**

| | | | |
|---|---|---|---|
| VB_BAS | | | |

**FUNCTION DESCRIPTION:**



General information:




The analog input signal for ignition key ON / OFF detection is used for battery voltage acquisition and the battery voltage acquisition is used to elaborate corrections, to drive actuators and enable to secure diagnosis.
The raw value for battery voltage (VB_BAS) is measured by continuous conversion (10 bits) every 1 msec.

**Formula section:**

The application recurrence is **10 msec**.

$$VB\_MES = 1 / 8 \quad * \quad \sum_{n=1}^{n=8} VB\_BAS_n$$

### 1.1.4 Acquisition of after ignition key battery voltage

**Output data:**

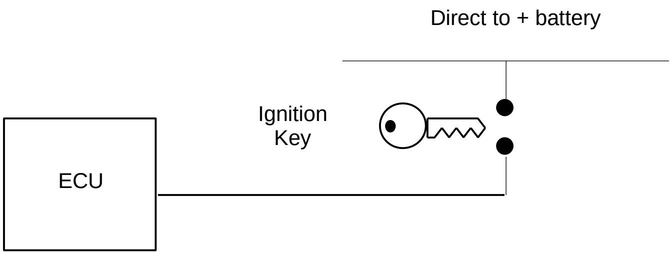
| Name | Type | V/S | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|---|
| V_IGK_MES | 2U | - | 0...03FFH | 0...25,9746 | 26 / 1024 | Volt |
| Battery voltage value measured (10 bits). | | | | | | |
| L_KEY_OFF | Bool | - | 0...01H | 0...1 | 1 | - |
| Boolean for ignition key status (ON / OFF). | | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| V_IGK_BAS | | | |

**FUNCTION DESCRIPTION:**

General information:




The battery voltage acquisition is used to elaborate corrections, to drive actuators and enable to secure diagnosis.
The raw value for battery voltage (V_IGK_BAS) is measured by continuous conversion (10 bits) every 1 msec.

**Formula section:**

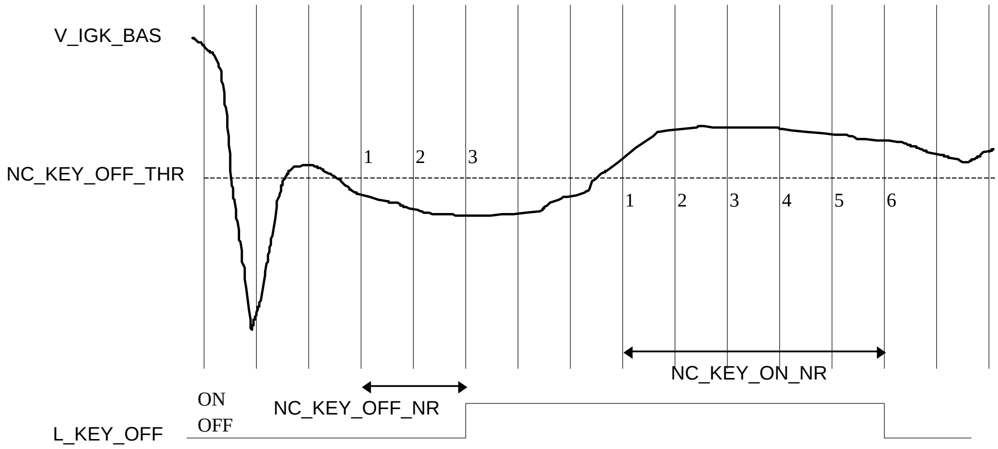
The application recurrence is **10 msec**.

$$V\_IGK\_MES = 1/8 * \sum_{n=1}^{n=8} V\_IGK\_BAS_n$$

### 1.1.4.1 Ignition key ON / OFF recognition

**FUNCTION DESCRIPTION:**

General information:






According to the battery voltage raw value (V_IGK_BAS) after ignition key, the ignition key ON / OFF recognition is performed.

**Formula section:**

*Ignition key ON recognised :*

**If** V_IGK_BAS **>** NC_KEY_OFF_THR
for more than NC_KEY_ON_NR number of successive samples ( * 1 msec. )
**then** L_KEY_OFF **= 0** (ON)

*Ignition key OFF recognised :*

**If** V_IGK_BAS **<** NC_KEY_OFF_THR
for more than NC_KEY_OFF_NR number of successive samples ( * 1 msec. )
**then** L_KEY_OFF **= 1** (OFF)

**Calibration data:**

| Name | Type | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|---|
| NC_KEY_OFF_THR | 2U | 1 | 0...03FFH | 0...25,9746 | 26 / 1024 | Volt |
| Battery voltage threshold for ignition key ON / OFF recognition. | | | | | | |
| NC_KEY_OFF_NR | 1U | 1 | 0...FFH | 0...255 | 1 | - |
| Number of samples (battery voltage raw acquisition) for ignition key OFF validation. | | | | | | |
| NC_KEY_ON_NR | 1U | 1 | 0...FFH | 0...255 | 1 | - |
| Number of samples (battery voltage raw acquisition) for ignition key ON validation. | | | | | | |

**Applicative Values :** NC_KEY_OFF_THR = **00C4H** = 196 dec. = 5 Volt.
NC_KEY_OFF_NR = **03H** = 3 dec. = 3 msec.
NC_KEY_ON_NR = **06H** = 6 dec. = 6 msec.

### 1.1.4.2 Applicative software

**Output data:**

| Name | Type | V/S | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|---|
| VB | 1U | V | 0...FFH | 0...25,8984 | 26 / 256 | Volt |
| Battery voltage. | | | | | | |
| LV_IGK | Bool | V | 0...01H | 0...1 | 1 | - |
| Boolean for ignition key status - ( Passive / Active ). | | | | | | |
| LV_VB_JUMP | Bool | V | 0...01H | 0...1 | 1 | - |
| Boolean for over voltage - ( Passive / Active ). | | | | | | |
| LV_CDN_VB_OBD1 | Bool | V | 0...01H | 0...1 | 1 | - |
| Boolean for battery voltage condition fulfilled at OBD-I Variants. | | | | | | |
| LV_CDN_VB_OBD2 | Bool | V | 0...01H | 0...1 | 1 | - |
| Boolean for battery voltage condition fulfilled at OBD-II Variants. | | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| VB_MES | L_KEY_OFF | V_IGK_MES | |

**FUNCTION DESCRIPTION:**

General information:

The application recurrence is **10 msec**.

### 1.1.4.3 Battery voltage

VB ← VB_MES / 4 (8 bits)
V_IGK ← V_IGK_MES / 4 (8 bits)

### 1.1.4.4 Ignition key detection

**If** L_KEY_OFF **= 0** (ON)

**then** LV_IGK **= 1** (Active)

**else** LV_IGK **= 0** (Passive)

### 1.1.4.5 Battery over voltage detection

**If** VB ≤ C_VB_MIN_JUMP

**and** V_IGK ≤ C_VB_MIN_JUMP

**then** LV_VB_JUMP **= 0** (Passive)

**else** LV_VB_JUMP **= 1** (Active)

### 1.1.4.6 Low Battery voltage detection for OBD-I/-II Diagnosis

**If** VB < C_VB_MIN_OBD_1/2

**or** V_IGK < C_VB_MIN_OBD_1/2

**or** LV_IGK = 0

**then** LV_CDN_VB_OBD1/2 = 0

**else** LV_CDN_VB_OBD1/2 = 1

**Calibration data:**

| Name | Type | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|---|
| C_VB_MIN_JUMP | 1U | 1 | 0...FFH | 0...25,8984 | 26 / 256 | Volt |
| Battery voltage threshold for over voltage detection. | | | | | | |
| C_VB_MIN_OBD1 | 1U | 1 | 0...FFH | 0...25,8984 | 26 / 256 | Volt |
| Battery voltage threshold for low voltage detection for OBD-I Variants. | | | | | | |
| C_VB_MIN_OBD2 | 1U | 1 | 0...FFH | 0...25,8984 | 26 / 256 | Volt |
| Battery voltage threshold for low voltage detection for OBD-II Variants. | | | | | | |

### 1.1.5 Acquisition of oxygen sensor voltage

#### 1.1.5.1 Basic software

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| VLS_1_MES | - | 0...FFH | 0...4.9805 | 5 / 256 | Volt |
| Upstream oxygen sensor voltage value measured (8 bits) - Bank n° 1. | | | | | |
| VLS_2_MES | - | 0...FFH | 0...4.9805 | 5 / 256 | Volt |
| Upstream oxygen sensor voltage value measured (8 bits) - Bank n° 2. | | | | | |
| VLS_CAT_1_MES | - | 0...FFH | 0...4.9805 | 5 / 256 | Volt |
| Downstream oxygen sensor voltage value measured (8 bits) - Bank n° 1. | | | | | |
| VLS_CAT_2_MES | - | 0...FFH | 0...4.9805 | 5 / 256 | Volt |
| Downstream oxygen sensor voltage value measured (8 bits) - Bank n° 2. | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| VLS_UP_1_BAS | VLS_UP_2_BAS | VLS_DOWN_1_BAS | VLS_DOWN_2_BAS |



**FUNCTION DESCRIPTION:**

General information:

The raw value for oxygen sensor voltage (VLS_UP_i_BAS or VLS_DOWN_i_BAS) is measured by continuous conversion (10 bits) every 1 msec.

**Formula section:**

VLS_1_MES ← VLS_UP_1_BAS / 4 (8 bits)

VLS_2_MES ← VLS_UP_2_BAS / 4 (8 bits)

VLS_CAT_1_MES ← VLS_DOWN_1_BAS / 4 (8 bits)

VLS_CAT_2_MES ← VLS_DOWN_2_BAS / 4 (8 bits)

### 1.1.5.2 Applicative software



**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| VLS_1 | V | 0...FFH | 0...4.9805 | 5 / 256 | Volt |
| Upstream oxygen sensor voltage - Bank n° 1. | | | | | |
| VLS_2 | V | 0...FFH | 0...4.9805 | 5 / 256 | Volt |
| Upstream oxygen sensor voltage - Bank n° 2. | | | | | |
| VLS_CAT_1 | V | 0...FFH | 0...4.9805 | 5 / 256 | Volt |
| Downstream oxygen sensor voltage - Bank n° 1. | | | | | |
| VLS_CAT_2 | V | 0...FFH | 0...4.9805 | 5 / 256 | Volt |
| Downstream oxygen sensor voltage - Bank n° 2. | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| VLS_1_MES | VLS_2_MES | VLS_CAT_1_MES | VLS_CAT_2_MES |

**FUNCTION DESCRIPTION:**



General information:

The application recurrence for VLS_1 and VLS_2 is **10 msec.**
The oxygen sensor voltages VLS_i are used mainly for A/F regulation.
They are also used for auxiliary functions like evaporative emissions control and catalyst overheating protection.

The OBDII diagnosis functions require also this data.

The oxygen sensor voltages VLS_CAT_i are used for OBDII diagnosis, mainly catalyst efficiency monitoring.

**Formula section:**

VLS_1 ← VLS_1_MES (8 bits)

VLS_2 ← VLS_2_MES (8 bits)

VLS_CAT_1 ← VLS_CAT_1_MES (8 bits)

VLS_CAT_2 ← VLS_CAT_2_MES (8 bits)

### 1.1.6 Acquisition of coolant temperature

#### 1.1.6.1 Basic software

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| TCO_MES | - | 0...FEH | -48...142,5 | 0,75 | °C |
| Coolant temperature value measured. | | | | | |
| V_TCO | V | 0...FFFFH | 0...4,9951 | 5 / 1024 | Volt |
| Coolant temperature voltage raw value (10 bits). | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| TCO_BAS | | | |

**FUNCTION DESCRIPTION:**

General information:

This function is applicable with a NTC type of sensor.

The raw value for coolant temperature (TCO_BAS) is measured by continuous conversion (10 bits) every 1 msec.

The value of the numeric conversion is adapted to take into account of the electronic component drift. The result of this adaptation must be linearized according to temperature sensor response.

The corresponding value of the first measurement after hardware reset is used for initialisation.

**Formula section:**

The coolant temperature TCO_MES is obtained by linearization of the formatted acquisition with a specific table IP_TCO_TAB__V_TCO with :

V_TCO $\leftarrow$ TCO_BAS * 64 (10 bits)

**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| IP_TCO_TAB__V_TCO | 16 | 0...FEH | -48...142,5 | 0,75 | °C |
| | | | | | |
| Conversion table for linearization of TCO value acquisition. | | | | | |

### 1.1.7 Acquisition of air intake temperature

#### 1.1.7.1 Basic software

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| TIA_MES | - | 0...FEH | -48...142,5 | 0,75 | °C |
| Air intake temperature value measured. | | | | | |
| V_TIA | V | 0...FFH | 0...4,9805 | 5 / 256 | Volt |
| Air intake temperature voltage raw value (8 bits). | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| TIA_BAS | | | |

**FUNCTION DESCRIPTION:**

General information:

This function is applicable with a NTC type of sensor.

The raw value for air intake temperature (TIA_BAS) is measured by continuous conversion (10 bits) every 1 msec.

The value of the numeric conversion is adapted to take into account of the electronic component drift. The result of this adaptation must be linearized according to the temperature sensor response.

The corresponding value of the first measurement after hardware reset is used for initialization.

**Formula section:**

The air intake temperature TIA_MES is obtained by linearization of the formatted acquisition with a specific table IP_TIA_TAB__V_TIA with :

V_TIA ← TIA_BAS / 4 (8 bits)

**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| IP_TIA_TAB__V_TIA | 16 | 0...FEH | -48...142,5 | 0,75 | °C |
| | | | | | |
| Conversion table for linearization of TIA value acquisition. | | | | | |

### 1.1.8 Acquisition of exhaust gas temperature

#### 1.1.8.1 Basic software

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| TEG_MES | - | 0...FEH | -48...142.5 | 0.75 | °C |
| Exhaust gas temperature value measured. | | | | | |
| V_TEG | - | 0...03FFH | 0...4.9951 | 5 / 1024 | Volt |
| Exhaust gas temperature voltage raw value (10 bits). | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| TEG_BAS | | | |

**FUNCTION DESCRIPTION:**

General information:

This function is applicable with a NTC type of sensor.

The raw value for coolant temperature (TEG_BAS) is measured by continuous conversion (10 bits) every 1 msec.

The value of the numeric conversion is adapted to take into account of the electronic component drift. The result of this adaptation must be linearized according to temperature sensor response.

The corresponding value of the first measurement after hardware reset is used for initialisation.

**Formula section:**

The coolant temperature TEG_MES is obtained by linearization of the formatted acquisition with a specific table IP_TEG_TAB__V_TEG with :

V_TEG ← TEG_BAS * 64 (10 bits)

**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| IP_TEG_TAB__V_TEG | 16 | 0...FEH | -48...142.5 | 0.75 | °C |
| Conversion table for linearization of TEG value acquisition. | | | | | |

## 1.2 Logic Inputs

### 1.2.1 Basic software

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| LV_IM_ACIN | - | 0...01H | 0...1 | 1 | - |
| Air Condition selected. | | | | | |
| L_IM_ACCIN | - | 0...01H | 0...1 | 1 | - |
| Air Condition request. | | | | | |
| LV_IM_PRS_ACC | - | 0...01H | 0...1 | 1 | - |
| Pressure switch of Air Condition circuit. | | | | | |
| LV_IM_PVD | - | 0...01H | 0...1 | 1 | - |
| Primary Voltage Diagnosis. | | | | | |
| LV_IM_MIL_FLL_REQ | - | 0...01H | 0...1 | 1 | - |
| Malfunction Indicator Light for Engine Control Unit - Request line for blink code. | | | | | |
| LV_IM_VB_OFF | - | 0...01H | 0...1 | 1 | - |
| Battery disconnected. | | | | | |
| LV_IM_EL_LOAD | - | 0...01H | 0...1 | 1 | - |
| Electrical load input. | | | | | |

**FUNCTION DESCRIPTION:**

**List of logic Inputs**

| Name | Port - Channel | Logic state |
|---|---|---|
| L_PIN_PRS_ACC | 3 - 1 | Positive Logic |
| L_PIN_ACIN | 3 - 4 | Positive Logic |
| L_PIN_ACCIN | 3 - 5 | Positive Logic |
| L_PIN_PVD | 3 - 7 | * - Positive Logic |
| L_PIN_MIL_FLL_REQ | 3 - 14 | Positive Logic |
| L_PIN_EL_LOAD | 3 - 6 | Positive Logic |
| L_PIN_VB_OFF | 8 - 6 | Positive Logic |

* : ECU Internal Signal

### 1.2.2 Applicative software



**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| LV_DRI | V | 0...01H | 0...1 | 1 | - |
| Boolean for DRIVE or REVERSE engaged ( - / DRI ). | | | | | |
| LV_GS | V | 0...01H | 0...1 | 1 | - |
| Boolean for GEAR SHIFT signal ( - / GS ). | | | | | |
| LV_ACIN | V | 0...01H | 0...1 | 1 | - |
| Air condition selected (- / ACIN ). | | | | | |
| LV_ACCIN | V | 0...01H | 0...1 | 1 | - |
| Air condition requested ( - / ACCIN ). | | | | | |
| LV_PRS_ACC | V | 0...01H | 0...1 | 1 | - |
| Air condition switch requested ( - / PRS_ACC ). | | | | | |
| LV_VB_OFF | V | 0...01H | 0...1 | 1 | - |
| Battery disconnected. | | | | | |
| LV_VB_OFF_ACT | V | 0...01H | 0...1 | 1 | - |
| Filtered battery disconnected information bit. | | | | | |
| LV_EL_LOAD | V | 0...01H | 0...1 | 1 | - |
| Electric load. | | | | | |
| LV_SET | V | 0...01H | 0...1 | 1 | - |
| information of One-Bit Memory reset | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| LV_IM_DRI | LV_IM_GS | LV_IM_ACIN | L_IM_ACCIN |
| LV_IM_VB_OFF | LV_IM_EL_LOAD | LV_IM_PRS_ACC | TAR_GC |
| SWI_GS | CONF_TCU | CONF_NVMY_RST | |

**FUNCTION DESCRIPTION:**

**Formula section:**

1 - Air-condition system :

LV_ACIN = LV_IM_ACIN
LV_ACCIN = L_IM_ACCIN
LV_PRS_ACC = LV_IM_PRS_ACC

2 - Automatic transmission system :

| | | | |
|---|---|---|---|
| **If** | | CONF_TCU = 1 | |
| | **and** | TAR_GC > 0 | *(Drive engaged)* |
| **then** | | LV_DRI = 1 | |
| | **and** | LV_GS = SWI_GS | *(from CAN from TCU)* |
| **else** | | LV_DRI = LV_GS = 0 | |

**Remark:** For more detailed information please refer to the CAN-Specification.

3 - Battery off detection:

General information:

A hardware with One-Bit Memory characteristic is provided to detect at system start up if the ECU or the battery was disconnected since the last power latch phase.

If a disconnection is detected and the system is not coded to OBD-II, the following values (mainly the failure memory and adaptation values) will be reset:



- Altitude Correction (MAF_FAC_ALTI_MMV)
- Knock Adaptation (ID_IGA_AD_[CYL]__N_KNK__MAF_KNK)
- TPS Adaptation (TPS_AD_MMV_IS)
- Lambda Adaptation (TI_AD_ADD_MMV_i, TI_AD_FAC_MMV_i)
- ISA Adaptation (ISAPWM_AD_MMV_IS, ISAPWM_DRI_AD_MMV_IS, ISAPWM_ACCIN_AD_MMV_IS)
- Idle Charge Actuator Adaptation (AD_INI_COR_ISA)
- Segment Time Adaptation (SEG_AD_[CYL])
- Fuel Trim Adaptation (T_DLY_AD_i)
- ASR Statistic Counter
- Restart Detection
- Idle Speed CO-Trim
- Fuel System Diagnosis debounce counter
- Secondary Air Values
- OBD Trip Counter
- Failure Memory
- Camshaft edge adaptation

Application recurrence: once after system reset.

| | | |
|---|---|---|
| **If** | CONF_NVMY_RST = 1 | *(Erasement of non volatile data configured)* |
| **then** | LV_VB_OFF_ACT = LV_VB_OFF | *(One-Bit Memory is set)* |
| **and** | therefore the above listed values are reset | |
| **else** | LV_VB_OFF_ACT = 0 | *(reset One-Bit Memory)* |

After the power latch phase the One-Bit Memory is reset (LV_SET = 1) for at least 50 ms.

### 1.2.3 Acquisition of crankshaft signal

#### 1.2.3.1 Basic software

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| T_TOOTH | - | 0...FFFFH | 0...65535 | 4 µsec | sec |
| Tooth time. | | | | | |
| TOOTH_GRD | - | 0...FFH | 0...255 | 1 | - |
| Tooth gradient (0080H = 0.5, 0100H = 1, 0200H = 2 ...) | | | | | |
| CAM_LEVEL_SHR | - | 0...FFH | 0...255 | 1 | - |
| Camshaft level shift register for validation of camshaft level. | | | | | |
| LV_RUN_ENG | - | 0...01H | 0...1 | 1 | - |
| Boolean information for engine running detection. | | | | | |
| LV_SYN_ENG | - | 0...01H | 0...1 | 1 | - |
| Boolean information for complete engine synchronisation. | | | | | |
| LV_LOW_N | - | 0...01H | 0...1 | 1 | - |
| Boolean information for too low engine speed detection. | | | | | |
| CRK_VALID_TEETH_CNT | - | 0...FFH | 0...255 | 1 | - |
| Crankshaft valid teeth counter for synchronisation. | | | | | |
| T_SEG | - | 0...FFFFFFFFH | 0...4294967295 | 4 µsec | sec |
| Segment period. | | | | | |
| TOOTH_COUNTER | - | 0...FFH | 0...255 | 1 | - |
| Tooth numbering. | | | | | |

**FUNCTION DESCRIPTION:**

General information:

This function synchronizes the software with the engine, detects engine stopped (or running) and provides the tooth number and segment period.

The complete algorithm is included in the basic software without any specific pre-treatment.

The input signal is provided by a **60 - 2** crankshaft target wheel. The first active edge after the gap (two missing teeth) should be not later than **78 °CRK** before TDC. It is required to avoid ignition event inside the crankshaft gap (maximum spark advance before TDC : **72 °CRK**).

The resolution of the crankshaft position depends on the CPU frequency NC_F_CPU.

- The timer used for misfire detection use a clock NC_F_CPU / 16
  (→ 16 Mhz / 16 = 1 Mhz → resolution of **1 µsec**)
- The timer used for engine speed calculation use a clock NC_F_CPU / 64
  (→ 16 Mhz / 64 = 0,25 Mhz → resolution of **4 µsec**)

This resolution is used in the complete engine speed range (for cranking and normal engine speed).

### 1.2.3.1.1 Hardware configurable parameters

#### 1.2.3.1.1.1 Active crankshaft edge definition

The active edge is defined by a non applicative calibration **NC_ACTIVE_CRK_EDGE**.

| | | | |
|---|---|---|---|
| If | NC_ACTIVE_CRK_EDGE = **0** | then | " Crankshaft falling edge is active " |
| If | NC_ACTIVE_CRK_EDGE = **1** | then | " Crankshaft rising edge is active " |

#### 1.2.3.1.1.2 Minimum and maximum engine speed

The minimum engine speed **NC_N_MIN** defines :
- the maximum length of normal tooth :

**NC_T_TOOTH_MAX**= NC_T1_FREQ / NC_N_MIN

- the maximum segment duration for engine stalling detection :

**NC_T_SEG_MAX** = ( NC_T1_FREQ * 120 / NC_CYL_NO ) / NC_N_MIN

The maximum engine speed **NC_N_MAX** defines :

- the minimum length of normal tooth :

**NC_T_TOOTH_MIN** = NC_T1_FREQ / NC_N_MAX

The minimum engine speed **NC_LOW_N** defines :

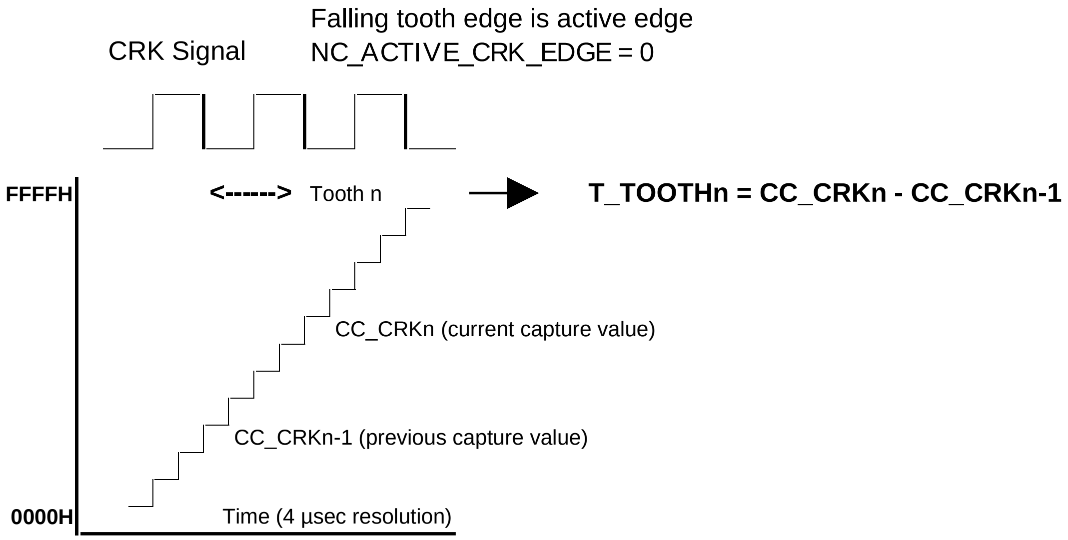
- the maximum segment duration for low engine speed range :

**NC_T_SEG_LOW_N** = ( NC_T1_FREQ * 120 / NC_CYL_NO ) / NC_LOW_N

**Remark :** NC_LOW_N > NC_N_MIN

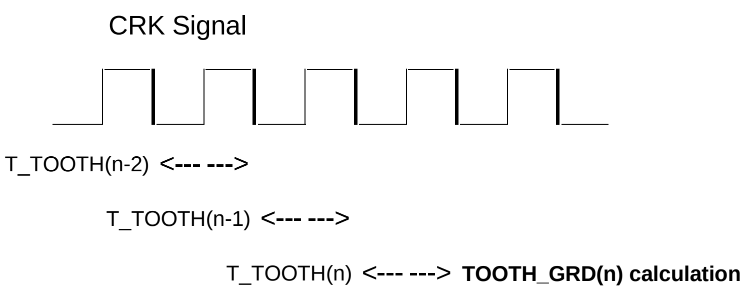
**Formula section:**

### 1.2.3.1.2 Tooth time T_TOOTH calculation




### 1.2.3.1.3 Tooth gradient TOOTH_GRD calculation

The tooth gradient is calculated only when LV_SYN_ENG = 0.
(→ engine running detected and synchronisation ongoing)




**TOOTH_GRD(n) = [ T_TOOTH(n) * T_TOOTH(n-2) ] / [ T_TOOTH(n-1) * T_TOOTH(n-1) ]**

**Remark :** This algorithm is only for detection of discontinuity on the crankshaft signal like crankshaft gap or spikes. When the crankshaft signal is continuous, TOOTH_GRD = 1.

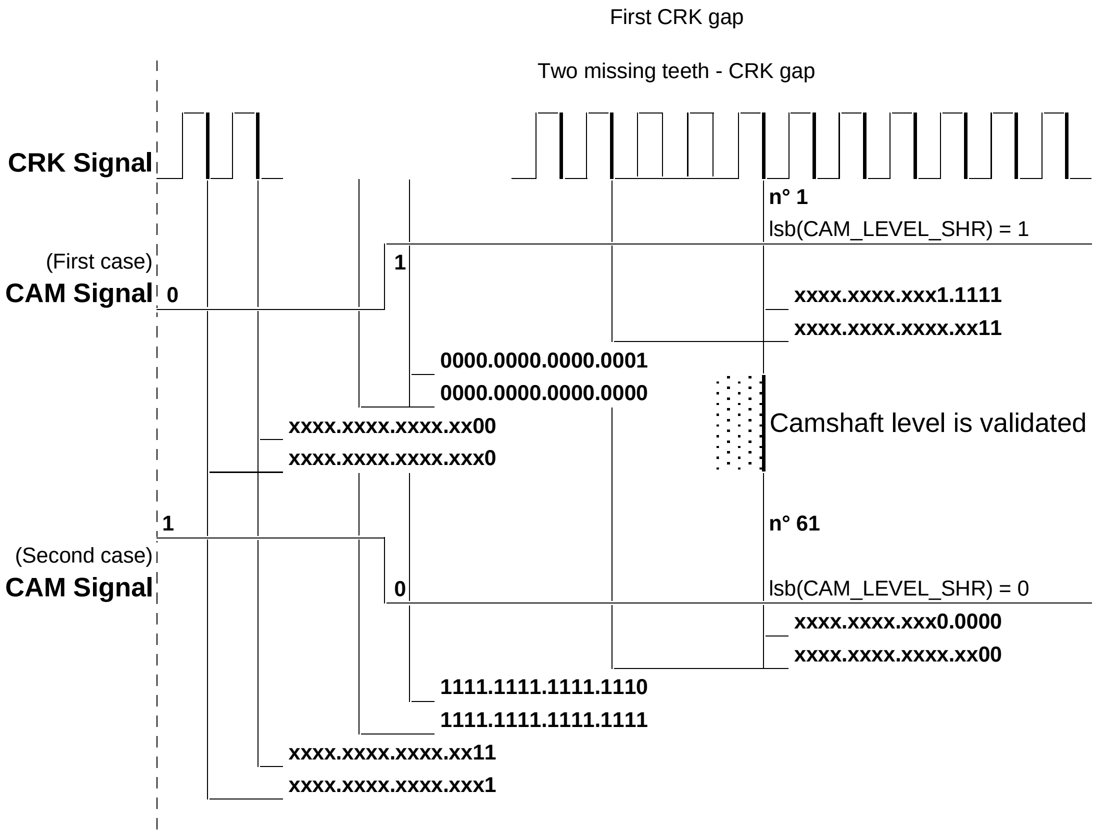
#### 1.2.3.1.4 Camshaft level shift register CAM_LEVEL_SHR

The camshaft level shift register is a word (16 bits) and the least significant bits give the validation of the camshaft level at the crankshaft gap.

During synchronisation phase (beginning from engine stopped) :

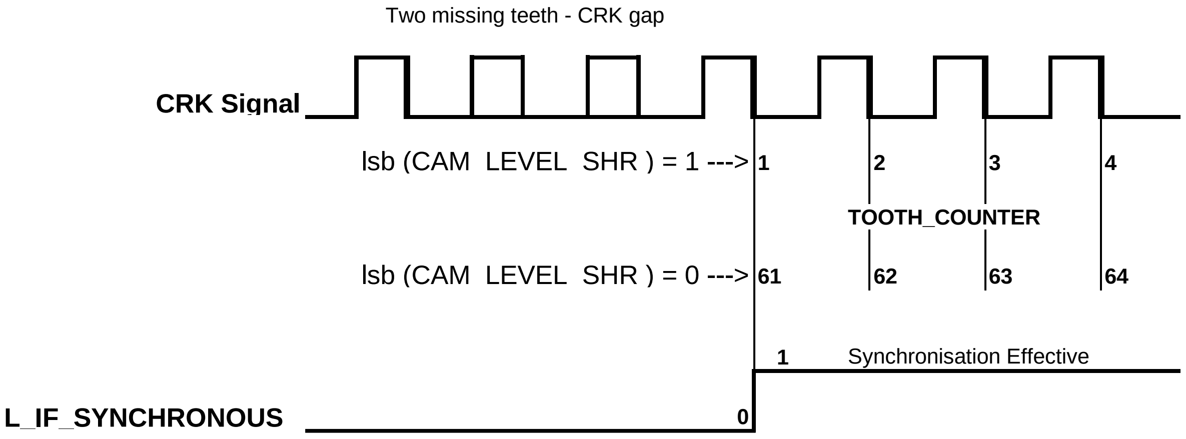
**- if** electrical level on the hardware port is high **then** the corresponding bit from CAM_LEVEL_SHR is set to 1.
**- if** electrical level on the hardware port is low **then** the corresponding bit from CAM_LEVEL_SHR is set to 0.

**If** CAM_LEVEL_SHR(bit 0) to CAM_LEVEL_SHR(bit NC_CAM_LEVEL_SHR_NO - 1) **= 0 or** CAM_LEVEL_SHR (bit 0) to CAM_LEVEL_SHR(bit NC_CAM_LEVEL_SHR_NO - 1) **= 1**
**then** camshaft level is validated as soon as the crankshaft gap has crossed once.



#### 1.2.3.1.5 Tooth number function TOOTH_COUNTER

Teeth are counted on each active edge from **1** to **120**. The tooth counter is valid only if LV_SYN_ENG = 1 (→ synchronisation effective) and out of crankshaft limp home.
TOOTH_COUNTER is set to **1** or **61** as soon as LV_SYN_ENG is set to 1, depending on the camshaft signal level.



### 1.2.3.1.6 Engine running detection LV_RUN_ENG

*Initialisation :*
LV_RUN_ENG = 0
Determination :

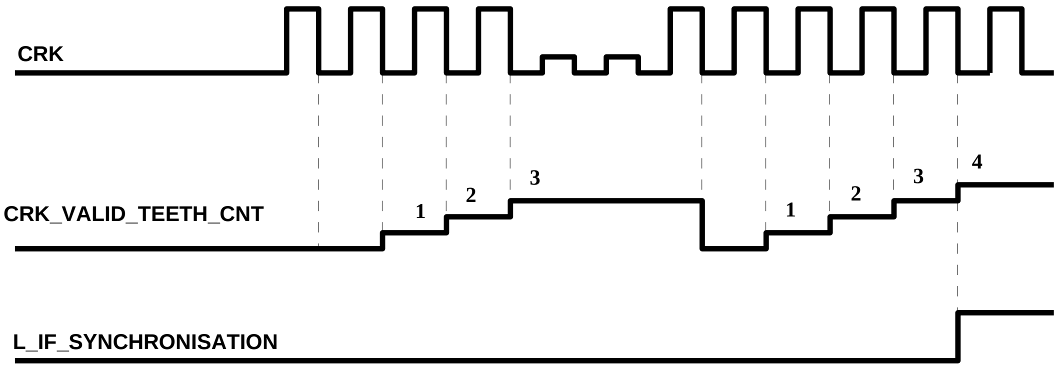
**If** ( NC_T_TOOTH_MIN ≤ T_TOOTH ≤ NC_T_TOOTH_MAX
**and** NC_TOOTH_GRD_MIN ≤ TOOTH_GRD ≤ NC_TOOTH_GRD_MAX)
(determination of valid or invalid tooth)

**then** $CRK\_VALID\_TEETH\_CNT_n$ **=** $CRK\_VALID\_TEETH\_CNT_{n-1}$ + 1
(teeth counter incremented, only if active edge is valid)
  **If** CRK_VALID_TEETH_CNT **=** C_CRK_VLD_TOOTH
  **then** LV_RUN_ENG **=** 1
  (engine running detected)

**else** CRK_VALID_TEETH_CNT **=** 0
  **If** T_TOOTH ≥ NC_T_TOOTH_MAX
  **then** “ Engine Stopped “ is detected
  **else** counting teeth process for valid tooth is performed again.

**Remark :** The crankshaft valid teeth counter is performed to anti-bounce the signal.

e.g. C_CRK_VLD_TOOTH = 4



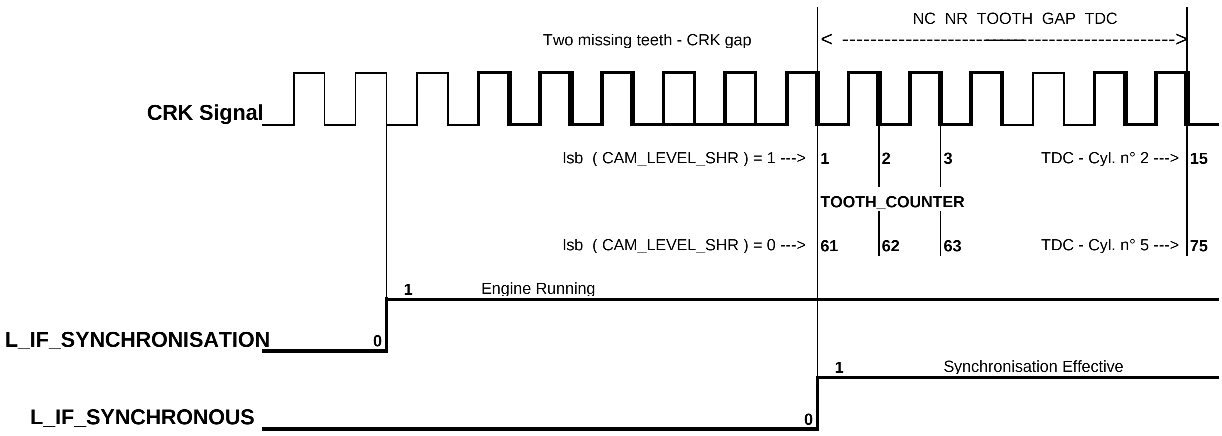
### 1.2.3.1.7 Engine synchronisation detection LV_SYN_ENG

*Initialisation :*
LV_SYN_ENG = 0

Determination :
The algorithm is running as soon as LV_RUN_ENG is set to 1.

**If** T_TOOTH ≥ NC_T_TOOTH_MIN
**and** NC_TOOTH_GRD_MIN_GAP ≤ TOOTH_GRD ≤ NC_TOOTH_GRD_MAX_GAP
  **and** T_TOOTH ≤ 3 * NC_T_TOOTH_MAX
  **and** camshaft level valid (refer to " Camshaft level shift register " chapter)
  (searching for the crankshaft gap)
**then** LV_SYN_ENG **=** 1
  (crankshaft gap detected)
**else**
**If** ( T_TOOTH **>** 3 * NC_T_TOOTH_MAX
**and** NC_TOOTH_GRD_MIN_GAP ≤ TOOTH_GRD ≤ NC_TOOTH_GRD_MAX_GAP )
  **or** T_TOOTH **>** NC_T_TOOTH_MAX
  (tooth time too long)
  **then** " Engine Stopped " is detected
  **else**
**If** ( T_TOOTH ≥ NC_T_TOOTH_MIN
**or** NC_TOOTH_GRD_MIN ≤ TOOTH_GRD ≤ NC_TOOTH_GRD_MAX )
  **then** normal tooth is detected
  **else** invalid tooth is detected and the valid teeth counter CRK_VALID_TEETH_CNT is reset.

TDC position determination :
The TDC (Top Dead Center) position is defined on the NC_NR_TOOTH_GAP_TDC + 1 active edge when LV_SYN_ENG is set to 1.



### 1.2.3.1.8 Engine stalling detection

*Determination :*

**If** LV_SYN_ENG = 1
(synchronisation effective)
**If** T_SEG > NC_T_SEG_MAX
**or** T_TOOTH> NC_T_TOOTH_MAX
(only if LV_LOW_N= 1 and outside the crankshaft gap range)
**or** { no crankshaft signal available since the time out
NC_T_CRK_STL_FAST
(outside crankshaft limp home)
**or** no camshaft signal available since the time out
NC_T_CRK_STL_LIMP_HOME }
(in crankshaft limp home)
**then** engine stalling is detected
**else**
**If** { one crankshaft active edge already detected and no crankshaft
signal available since the time out
NC_T_CRK_STL_SYNCHRONISATION
**or** no camshaft signal available since the time out
NC_T_CRK_STL_LIMP_HOME }
**then** engine stalling is detected.

Calculation (resolution : 65,536 msec.)

NC_T_CRK_STL_FAST**=** (NC_T_CRK_STALL_FREQ / NC_N_MIN) / 65536

NC_T_CRK_STL_LIMP_HOME **=** (NC_T_CRK_STALL_FREQ * 60 / NC_N_MIN) / 65535

NC_T_CRK_STL_SYNCHRONISATION **=** (NC_T_CRK_STALL_FREQ * 3 / NC_N_MIN) / 65535

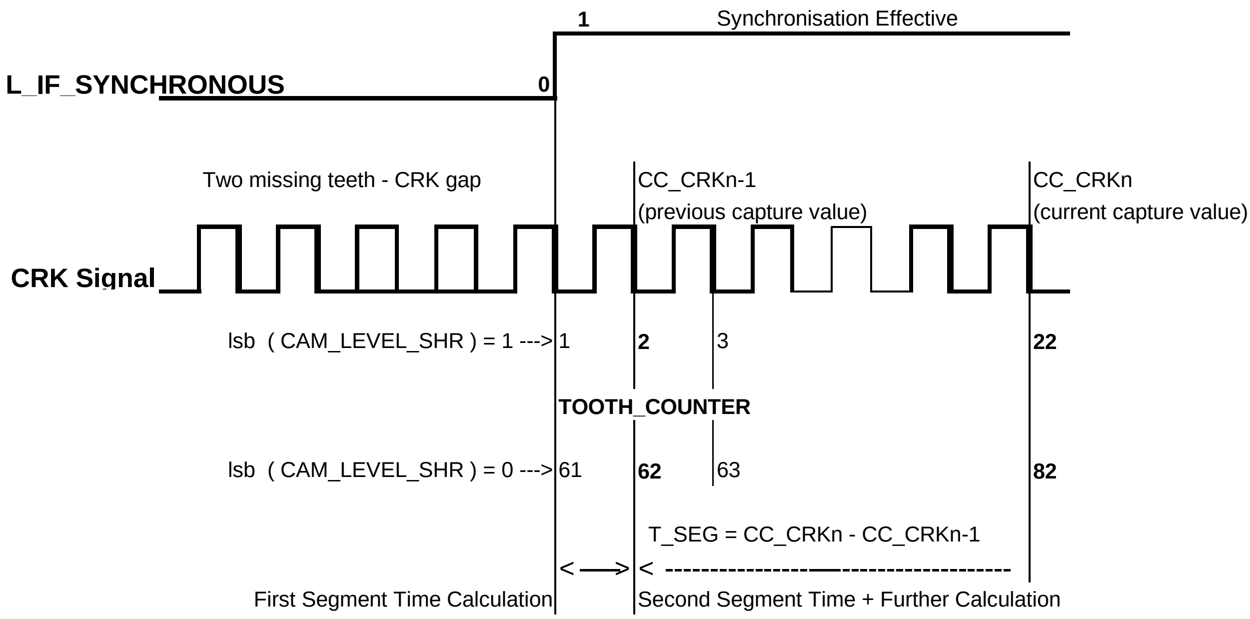
### 1.2.3.1.9 Segment period measurement T_SEG

*Initialization :*

T_SEG **= FFFFFFFF**H

Calculation :
Following synchronisation (LV_SYN_ENG = 1) after the crankshaft gap, the first segment time is calculated using the tooth time, like :
T_SEG **=** T_TOOTH * 120 / NC_CYL_N0

For the others, T_SEG calculation is using the raw crankshaft acquisition for 120 °CRK. (→ between tooth number **02** and **22**, **22** and **42**, **42** and **62**, **62** and **82**, **82** and **102** ...)




### 1.2.3.1.10 Low engine speed range determination LV_LOW_N

This engine speed range is dedicated for first injection application, engine stalling detection and calculation for dwell start.

Determination :

**If** LV_SYN_ENG = 1
(synchronisation effective)

**then**

- **If** T_SEG > NC_T_SEG_LOW_N
- **then** LV_LOW_N **=** 1 (low engine speed detected)
- **else** LV_LOW_N **=** 0

**else**

- **If** T_TOOTH> NC_T_SEG_LOW_N / (120 / NC_CYL_NO)
- **then** LV_LOW_N **=** 1 (low engine speed detected)
- **else** LV_LOW_N **=** 0

## Calibration data:



| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| NC_F_CPU | 1 | | | 1 | Hz |
| Micro-controller frequency - Non adjustable calibration. | | | | | |
| NC_ACTIVE_CRK_EDGE | 1 | 0...01H | 0...1 | 1 | - |
| Active crankshaft edge definition - Non adjustable calibration. | | | | | |
| C_CRK_VLD_TOOTH | 1 | 0...FFH | 4...50 | 1 | - |
| Number of valid teeth necessary for synchronisation when camshaft signal level is validated - Non adjustable calibration. | | | | | |
| NC_N_MIN | 1 | 0...1FE0H | 0...8160 | 1 | rpm |
| Minimum engine speed - Non adjustable calibration. | | | | | |
| NC_LOW_N | 1 | 0...1FE0H | 0...8160 | 1 | rpm |
| Low engine speed range - Non adjustable calibration. | | | | | |
| NC_N_MAX | 1 | 0...FFFFH | 0...65535 | 1 | rpm |
| Maximum engine speed - Non adjustable calibration. | | | | | |
| NC_T1_FREQ | 1 | | | 1 | Hz |
| Timer frequency - Non adjustable calibration. | | | | | |
| NC_CYL_NO | 1 | 0...FFH | 0...255 | 1 | - |
| Number of cylinders - Non adjustable calibration. | | | | | |
| NC_CAM_LEVEL_SHR_NO | 1 | 0...FFH | 0...255 | 1 | - |
| Number of teeth for camshaft level validation - Non adjustable calibration. | | | | | |
| NC_TOOTH_GRD_MIN | 1 | 0...1000H | 0...16 | 0,0039 | - |
| Minimum tooth gradient for valid or invalid tooth detection. | | | | | |
| NC_TOOTH_GRD_MAX | 1 | 0...1000H | 0...16 | 0,0039 | - |
| Maximum tooth gradient for valid or invalid tooth duration. | | | | | |
| NC_TOOTH_GRD_MIN_GAP | 1 | 0...1000H | 0...16 | 0,0039 | - |
| Minimum tooth gradient for valid or invalid crankshaft gap detection. | | | | | |
| NC_TOOTH_GRD_MAX_GAP | 1 | 0...1000H | 0...16 | 0,0039 | - |
| Maximum tooth gradient for valid or invalid crankshaft gap detection. | | | | | |
| NC_NR_TOOTH_GAP_TDC | 1 | 0...FFH | 0...255 | 1 | - |
| Number of teeth after crankshaft gap for TDC reference - Non adjustable calibration. | | | | | |
| NC_T_CRK_STALL_FREQ | 1 | | | 1 | Hz |
| Timer frequency for time out calculation when crankshaft signal is not available for engine stalling detection - Non adjustable calibration. | | | | | |

**Applicative Value :**

NC_F_CPU = 16 MHz
NC_ACTIVE_CRK_EDGE = 00H = 0 dec.
NC_VALID_TEETH_SYNC = 18H = 24 teeth
NC_N_MIN = 001EH = 30 rpm
NC_N_MAX = 2008H = 8200 rpm
NC_LOW_N = 01F4H = 500 rpm
NC_T1_FREQ = 250 kHz
NC_CYL_NO = 06H = 6 cylinders
NC_CAM_LEVEL_SHR_NO = 02H = 2 dec.
NC_TOOTH_GRD_MIN = 0080H = 0,5
NC_TOOTH_GRD_MAX = 0200H = 2
NC_TOOTH_GRD_MIN_GAP = 0280H = 2,5
NC_TOOTH_GRD_MAX_GAP = 0380H = 3,5
NC_NR_TOOTH_GAP_TDC = 0EH = 14 teeth
NC_T_CRK_STALL_FREQ = 1 MHz

### 1.2.4 Acquisition of camshaft signal

#### 1.2.4.1 Basic software

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| LV_CAM_1_LVL | - | 0...01H | 0...1 | 1 | - |
| Boolean information for diagnosis evaluation set on camshaft interrupt (falling and rising edge). | | | | | |
| LV_CAM_1_EDGE | - | 0...01H | 0...1 | 1 | - |
| Boolean information for diagnosis evaluation set on active camshaft edge. | | | | | |
| CAM_1_POS_TOOTH | 1 | 0...78H | 0...120 | 6 | °CRK |
| Crankshaft tooth number when camshaft active edge occurs. | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| LV_SYN_ENG | LV_CRK_ERR_LIH | TOOTH_COUNTER | CAM_LEVEL_SHR |

**FUNCTION DESCRIPTION:**

General information:

The camshaft wheel is designed with 2 asymmetrical segments (170 ° high level, 190 ° low level).

Its signal is performed for synchronisation and limp home function.
Concerning synchronisation, the camshaft signal is strongly linked to the crankshaft signal and the edge of the camshaft should not be in the crankshaft gap (two missing teeth).

**Formula section:**

The measurement of the camshaft position, relative to the crankshaft signal is performed as soon as synchronization is effective (LV_SYN_ENG = 1).

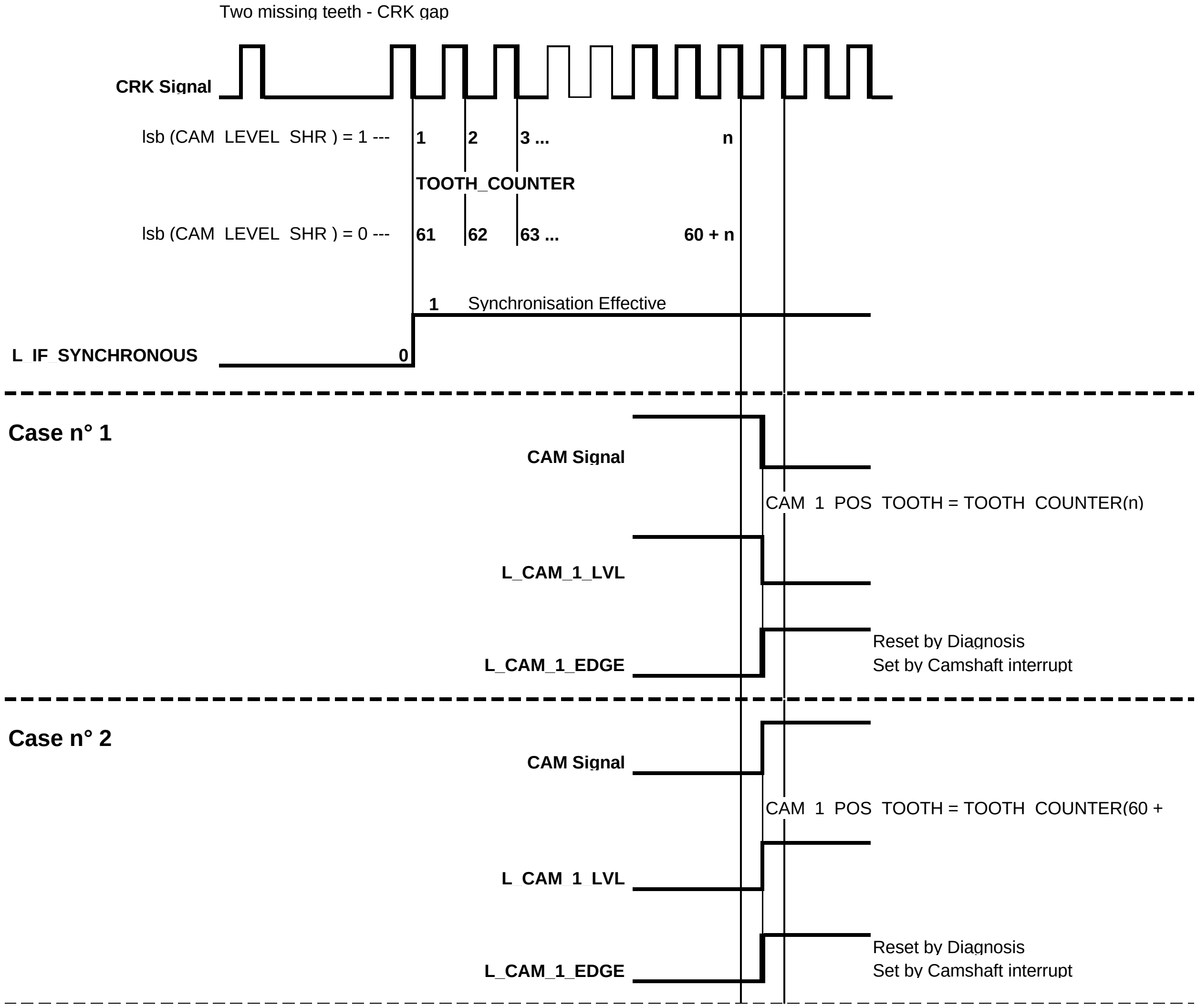
Before synchronisation (engine running detection), only the level of the camshaft signal is evaluated (CAM_LEVEL_SHR).

***** The camshaft position measurement is identified by three output datas :

- **CAM_1_POS_TOOTH** : Current value of the tooth counter TOOTH_COUNTER at camshaft signal interrupt.
- **LV_CAM_1_EDGE** : Boolean information set with camshaft signal interrupt and reset by the diagnosis algorithm for camshaft missing signal.
- **LV_CAM_1_LVL** : Boolean information set with camshaft interrupt (falling or rising edge) updated as soon as synchronisation is effective.

**Remark :** If LV_CRK_ERR_LIH = 1 (no crankshaft signal available), then CAM_1_POS_TOOTH and LV_CAM_1_EDGEare not updated.

## Description:



### 1.2.5 Acquisition of vehicle speed

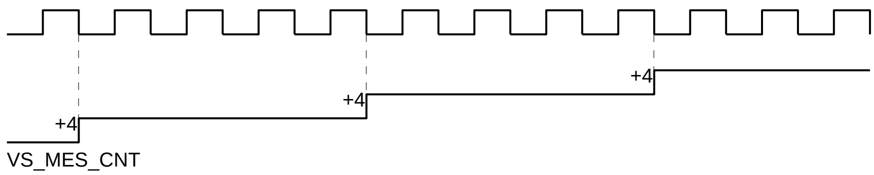
#### 1.2.5.1 Basic software

**Output data:**

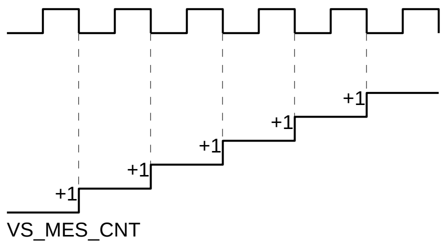
| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| VS_MES | - | 0...FF FFH | 0...65535 | 1 | p/s |
| Pulses per second measured for VS-calculation | | | | | |

**FUNCTION DESCRIPTION:**

Vehicle speed signal from ABS / TCS ECU or from inductive wheel sensor
(CONF_VS = 1 or 2)




Vehicle speed signal from gearbox
(CONF_VS = 0)




**Formula section:**

Application recurrence: 1sec.

VS_MES = VS_MES_CNT - VS_MES_CNT_PREV

VS_MES_CNT_PREV = VS_PULSE_CNT

# 2 Actuation of Outputs

## 2.1 Logic Outputs

**Input data:**

| | | | |
|---|---|---|---|
| L_IM_SAV | LV_IM_RLY_FAN_L | LV_IM_RLY_FAN_H | LV_IM_RLY_SAP |
| LV_IM_SOV | LV_IM_RLY_EFP | LV_IM_RLY_ACCOUT | LV_IM_MIL |
| LV_IM_RLY_MAIN | LV_IM_PWL | L_IM_VIC | |

### 2.1.1 List of direct logic Outputs

| Name | Port - Channel | Logic state | Initialization |
|---|---|---|---|
| L_PIN_SAV | 2 - 12 | Negative Logic | 1 |
| L_PIN_SOV | 4 - 7 | Negative Logic | 1 |
| L_PIN_KNK_WIN_MES | 6 - 5 | * | 1 |
| L_PIN_RLY_MAIN | 6 - 6 | Negative Logic | 0 |
| L_PIN_SET | 8 - 5 | * | 1 |
| L_PIN_VIM | ? | ? | ? |
| L_PIN_PWL | 8 - 7 | * | 1 |

* : ECU Internal Signal

### 2.1.2 List of logic Outputs via Octal Driver

| Name | Channel | Logic state | Initialization |
|---|---|---|---|
| L_SHAD_RLY_FAN_L | 2 | Negative Logic | 1 |
| L_SHAD_RLY_SAP | 3 | Negative Logic | 1 |
| L_SHAD_RLY_ACCOUT | 4 | Negative Logic | 1 |
| L_SHAD_RLY_EFP | 5 | Negative Logic | 1 |
| L_SHAD_RLY_FAN_H | 6 | Negative Logic | 1 |
| L_SHAD_MIL | 7 | Negative Logic | 1 |

**Data definition**

| Name | Definition |
|---|---|
| LV_IM_RLY_FAN_L | Cooling Fan Relay for Low speed. |
| LV_IM_MIL | Malfunction Indicator Light - Flashing code. |
| LV_IM_RLY_ACCOUT | Air Conditioning Compressor Relay. |
| LV_IM_RLY_EFP | Electric Fuel Pump Relay. |
| LV_IM_RLY_FAN_H | Cooling Fan Relay for High speed. |
| LV_IM_RLY_SAP | Secondary Air Pump Relay. |

## 2.2 PWM Outputs



**Input data:**

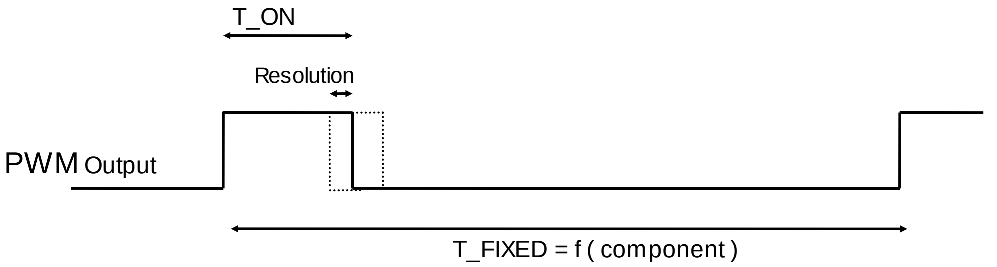
| | | | |
|---|---|---|---|
| ISAPWM | EGRPWM | LSH_UP_1PWM | LSH_UP_2PWM |
| CPPWM | LSH_DOWN_1PWM | LSH_DOWN_2PWM | KNKPWM |
| LV_CT | LV_TPS_ERR | LV_TPS_PLAUS_ERR | |

**FUNCTION DESCRIPTION:**

General information:

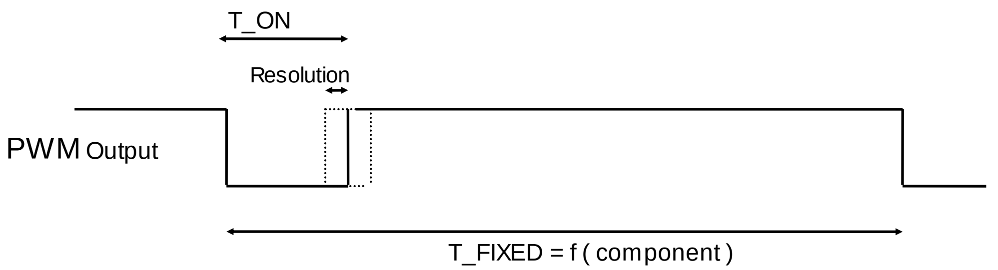
**PWM management principle :**

*“ Positive “ PWM :*




Duty cycle = T_ON / T_FIXED

*“ Negative “ PWM :*




Duty cycle = T_ON / T_FIXED

### List of PWM Outputs

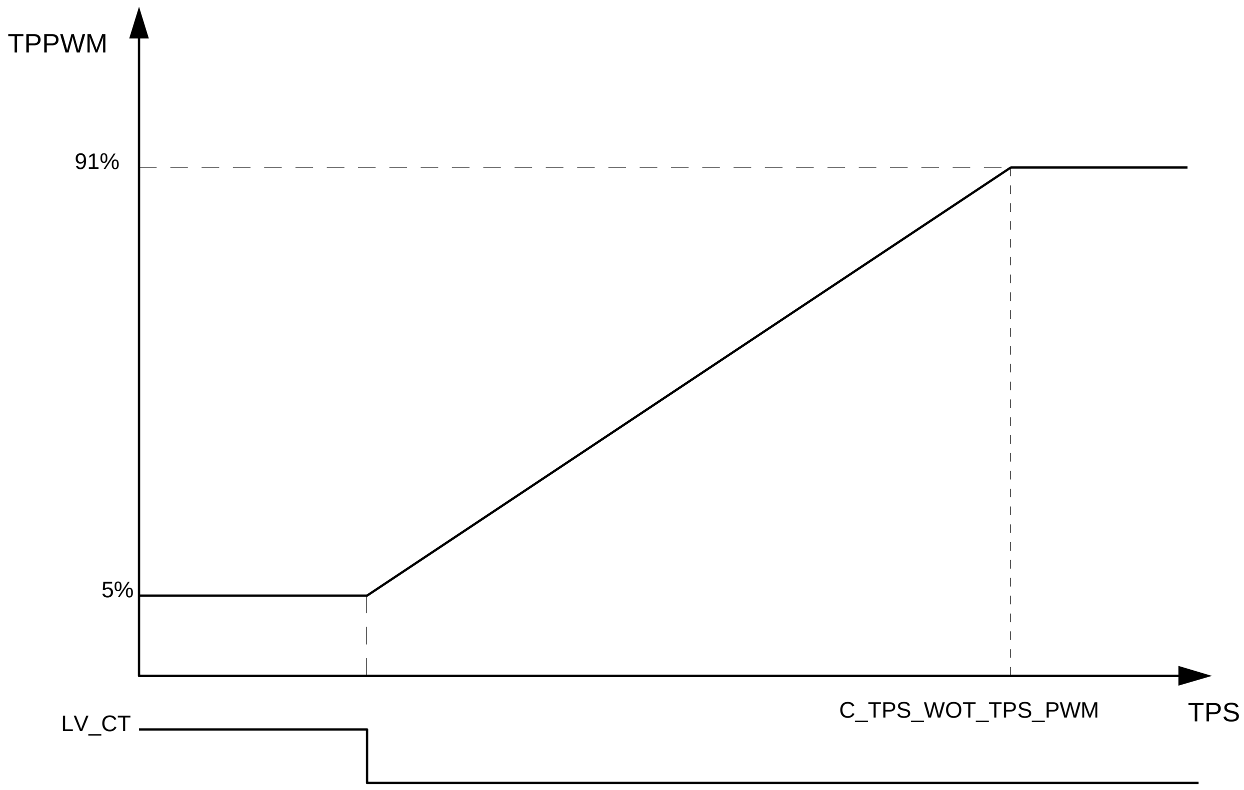
| PWM Output Name<br>T On | Frequency<br>(Hz) | Attached Component | Updating of Duty Cycle (ms) | Range of Duty Cycle (%) | PWM State |
|---|---|---|---|---|---|
| ISAPWM | 100 | BOSCH<br>ZWD3 - 2 | 10 | 3,5 - 96,5 | Negative |
| EGRPWM | 50 | H.E.I. | 100 | 0 - 100 | Negative |
| TPPWM | 100 | T.C.U. | 10 | 5 - 91 | Negative |
| LSH_UP_1PWM | 10 | TiO2<br>NTK | by applicative value | 2,3 - 97,3 | Positive |
| LSH_UP_2PWM | 10 | TiO2<br>NTK | by applicative value | 2,3 - 97,3 | Positive |
| LSH_DOWN_1PWM | 10 | TiO2<br>NTK | by applicative value | 2,3 - 97,3 | Positive |
| LSH_DOWN_2PWM | 10 | TiO2<br>NTK | by applicative value | 2,3 - 97,3 | Positive |
| CPPWM | 20 | BOSCH<br>TEV2 | 100 | 0 - 100 | Negative |
| KNKPWM | 5000 | KONGWHA | 720 °CRK | 0 - 100 | Positive |

### Data definition

| Name | Definition |
|---|---|
| ISAPWM | Double coil idle speed valve PWM output. |
| EGRPWM | Exhaust gas recirculation PWM output. |
| LSH_UP_1PWM | A/F regulation O2 sensor (Bank 1) PWM output. |
| LSH_UP_2PWM | A/F regulation O2 sensor (Bank 2) PWM output. |
| LSH_DOWN_1PWM | Catalyst diagnosis O2 sensor (Bank1) PWM output. |
| LSH_DOWN_2PWM | Catalyst diagnosis O2 sensor (Bank2) PWM output. |
| CPPWM | Canister purge valve PWM output. |
| KNKPWM | Knock amplification PWM output. |

## Calculation of TPPWM:

| | | |
|---|---|---|
| Closed throttle: | 5% TPPWM | |
| C_TPS_WOT_TPS_PWM: | 91% TPPWM | |
| LV_TPS_ERR = 1<br>or<br>LV_TPS_PLAUS_ERR = 1: | 0% TPPWM | (Error on TPS) |




## Calibration data:

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| C_TPS_WOT_TPS_PWM | 1 | 0...FFH | 0...119,5 | 0,47 | °TPS |
| Throttle angle which corresponds with 91% TPPWM | | | | | |

### 2.2.1 Fuel injection output

#### 2.2.1.1 Basic software

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| TI_[CYL] | V | 0...FFFFH | 0...262,14 | 4 µs | msec |
| Individual applied injection time. | | | | | |
| TI_SAM | V | 0...FFFFH | 0...262,14 | 4 µs | msec |
| Applied injection time updated each segment. | | | | | |
| L_PREV_STATE_IV_[CYL] | - | 0...1H | 0...1 | 1 | - |
| Previous injection - Transition to cylinder re-start. | | | | | |
| LV_INH_TIPR | - | 0...1H | 0...1 | 1 | - |
| Re-activation of first injection. | | | | | |
| FCO_SUM | - | 0...FFFFFFFFH | 0...1,72E10 | 4 | µs |
| Accummulated injection time | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| TI_ADD_REAC_SCC_[CYL] | SOI | EOI | INH_SWI_IV |
| CRK_VALID_TEETH_CNT | TI_1 | TI_2 | LV_LOW_N |
| LV_RUN_ENG | TIPR | TI_ADD_DLY | TI_AS_[CYL] |
| LV_SYN_ENG | L_INH_IV_[CYL] | LV_TIPR_SEQ | LV_TIPR_EOI_STOP |
| NC_MAX_EOI | SOI_TIPR | | |



**FUNCTION DESCRIPTION:**

General information:

This specification is applicable for a 6 cylinders engine.

Transient engine operation :

- in case of acceleration, under transient engine operation, it is possible to continue an actual fuel injection (post injection without injector dead time TI_ADD_DLY) or to start a post injection (post injection with injector dead time TI_ADD_DLY).

- in case of deceleration, it is possible to finish an actual fuel injection.

#### 2.2.1.1.1 First injection time programming



**FUNCTION DESCRIPTION:**

General information:

The first injection is taking into account the crankshaft and camshaft acquisitions which performed synchronisation event. It is performed in semi full group for both ignition banks.

If the camshaft level is **high**, the injection bank is nr.1.
If the camshaft level is **low**, the injection bank is nr.2.

The first injection applied to the corresponding cylinders is the value **TIPR** coming from applicative layer with the injector dead time **TI_ADD_DLY** added.

**Remark :** If the value **TIPR** coming from applicative layer is equal to **0**, then the injections coming after the first injection in semi full group (which are of course equal to **0**) are performed immediately (as soon as synchronisation is effective) with the cranking injection time value.

**Formula section:**

**Condition for activation first injection time application (TIPR):**

**If** LV_RUN_ENG **= 0** ⇒ **1**
*(engine running detected)*
**and** LV_LOW_N **= 1**
*(low engine speed range detected)*
**and** LV_INH_TIPR **= 0**
*(authorization of first injection re-activation)*
**then** LV_INH_TIPR **= 1**
**and** First injection TIPR will be applied according to the timing description below
**else** LV_INH_TIPR = 1
**and** fuel injection will start in sequential mode directly when crankschaft synchronisation is performed (LV_SYN_ENG = 1 ⇒ 0)
using TI_[CYL]

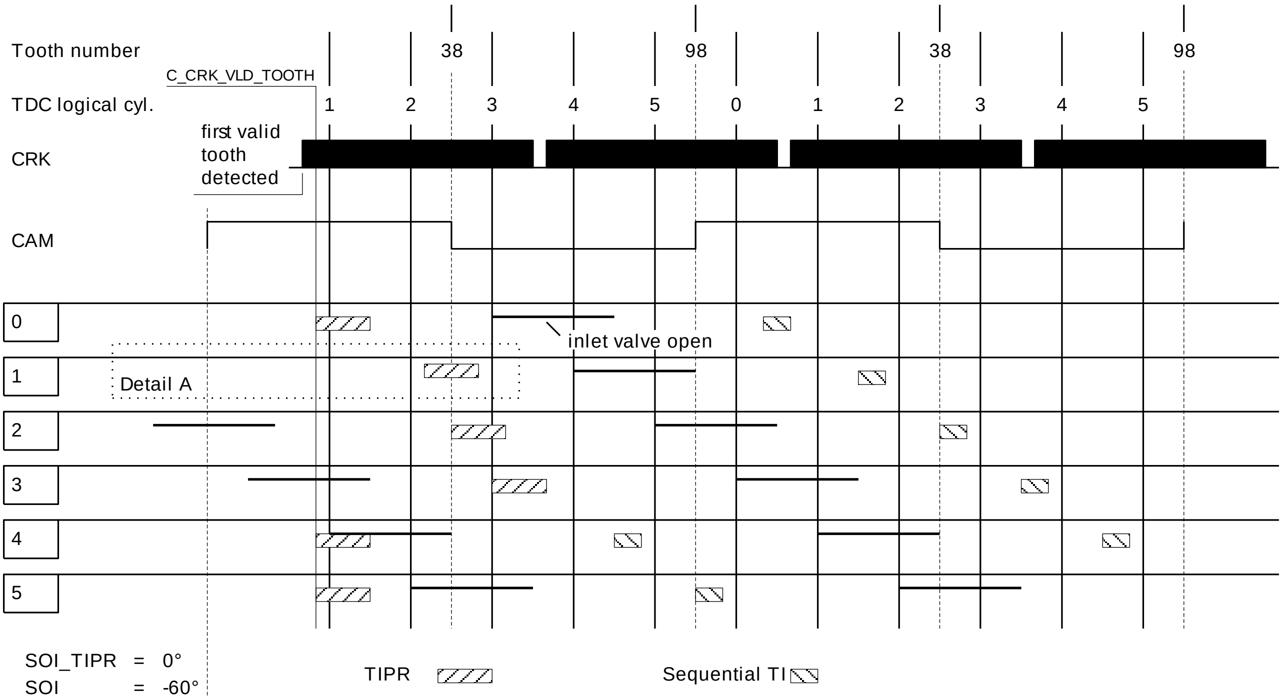
**Condtions to reset LV_INH_TIPR (reactivation of first injection TIPR)**

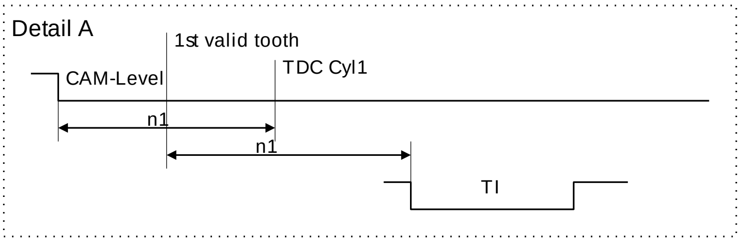
**If** (LV_IGK = 0 and LV_ES = 1)

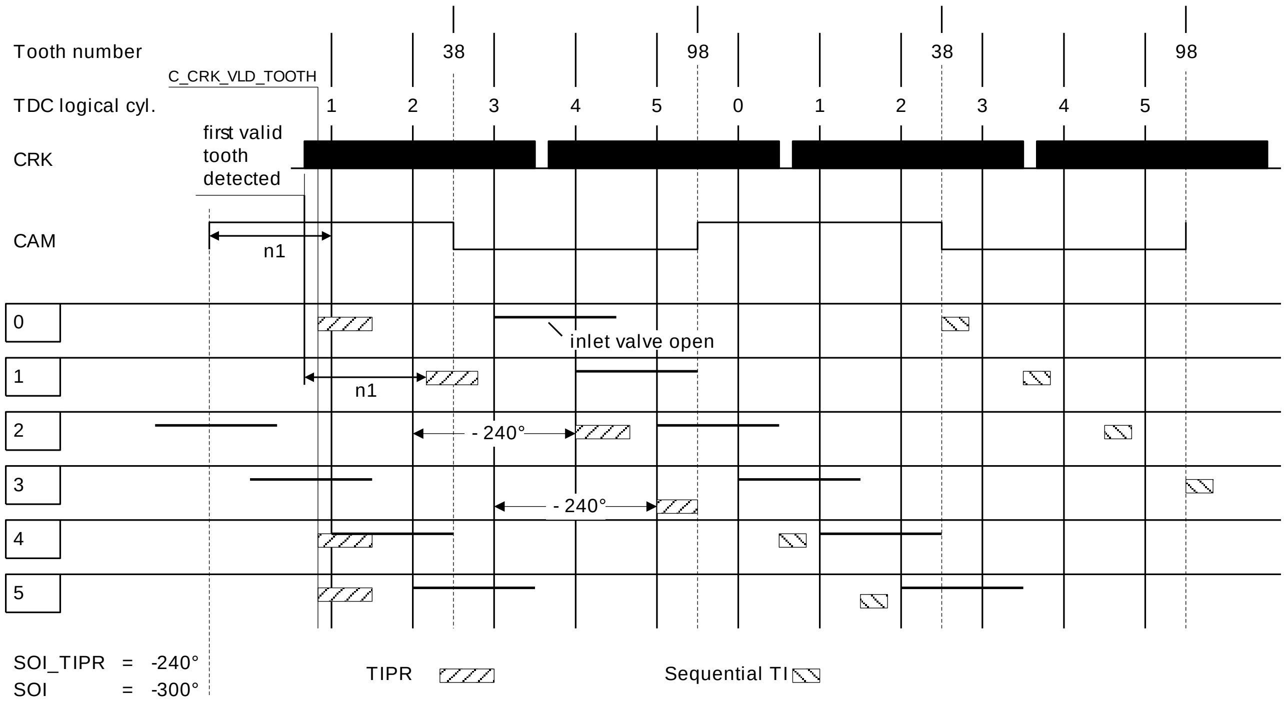
**or** system reset

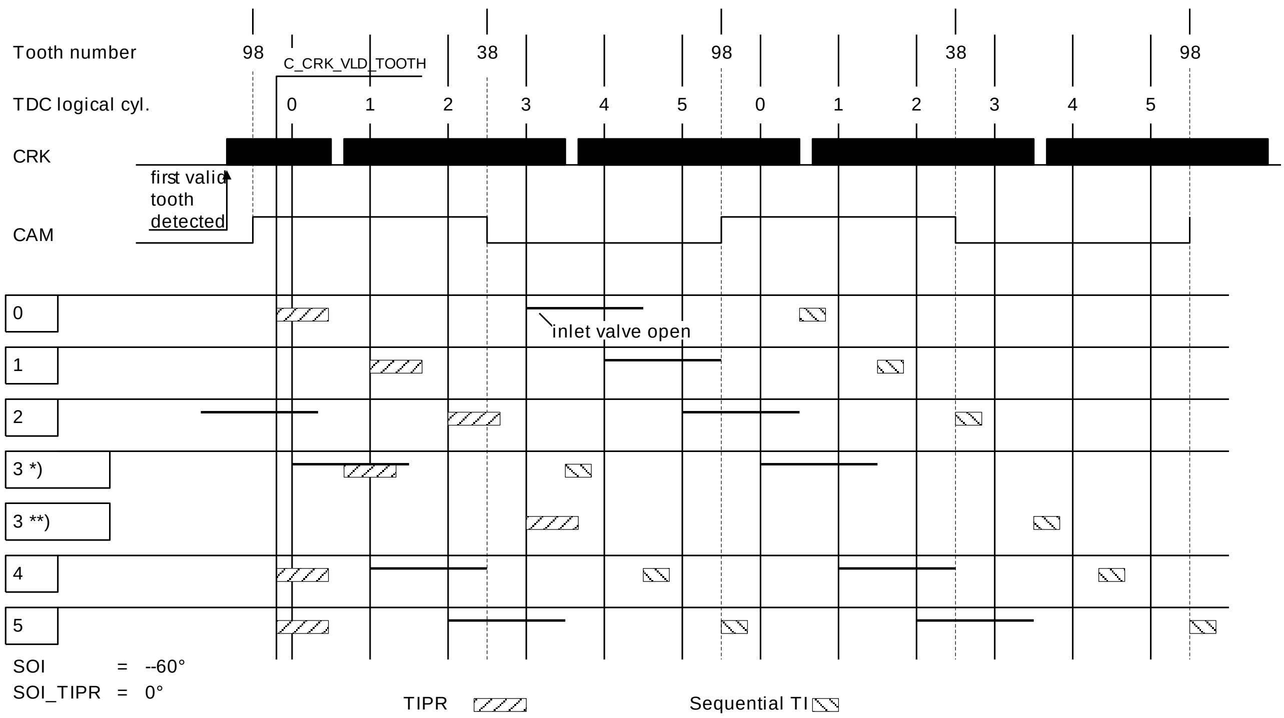
**then** LV_INH_TIPR = 0

## Description:





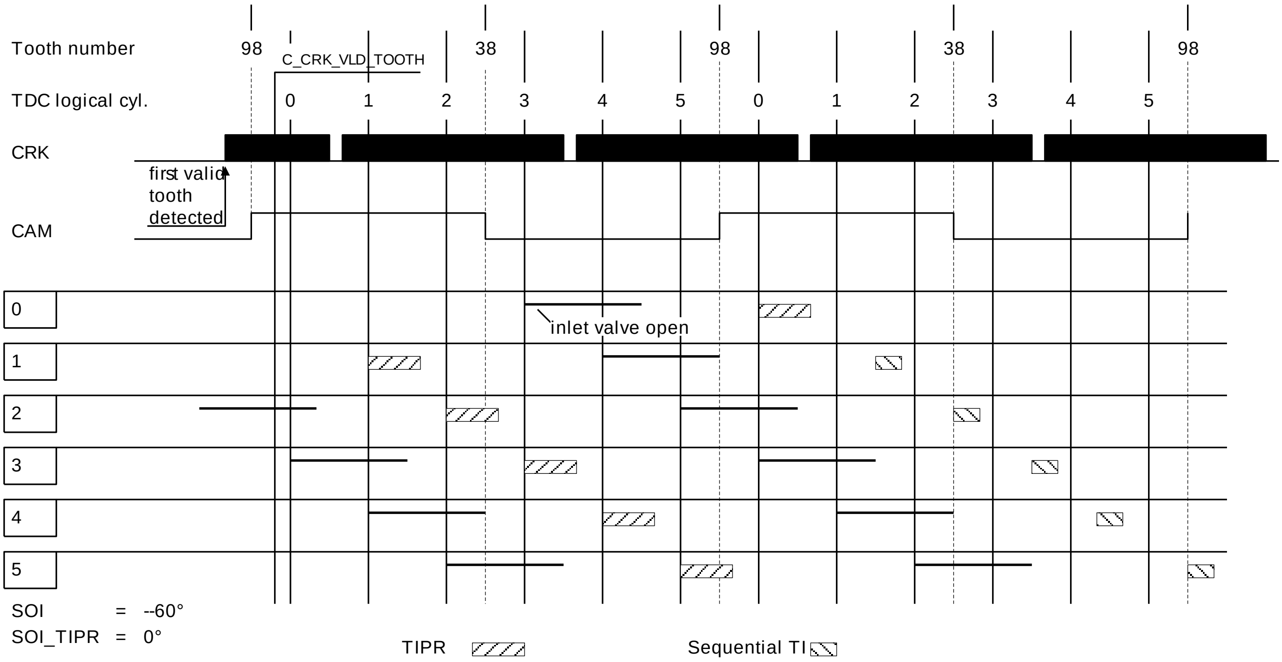

*) TIPR of cyl. 3 can be applied before BDC due to duration of TIPR in relation to current engine speed.

**)TIPR is applied at SOI_TIPR from the second revolution.

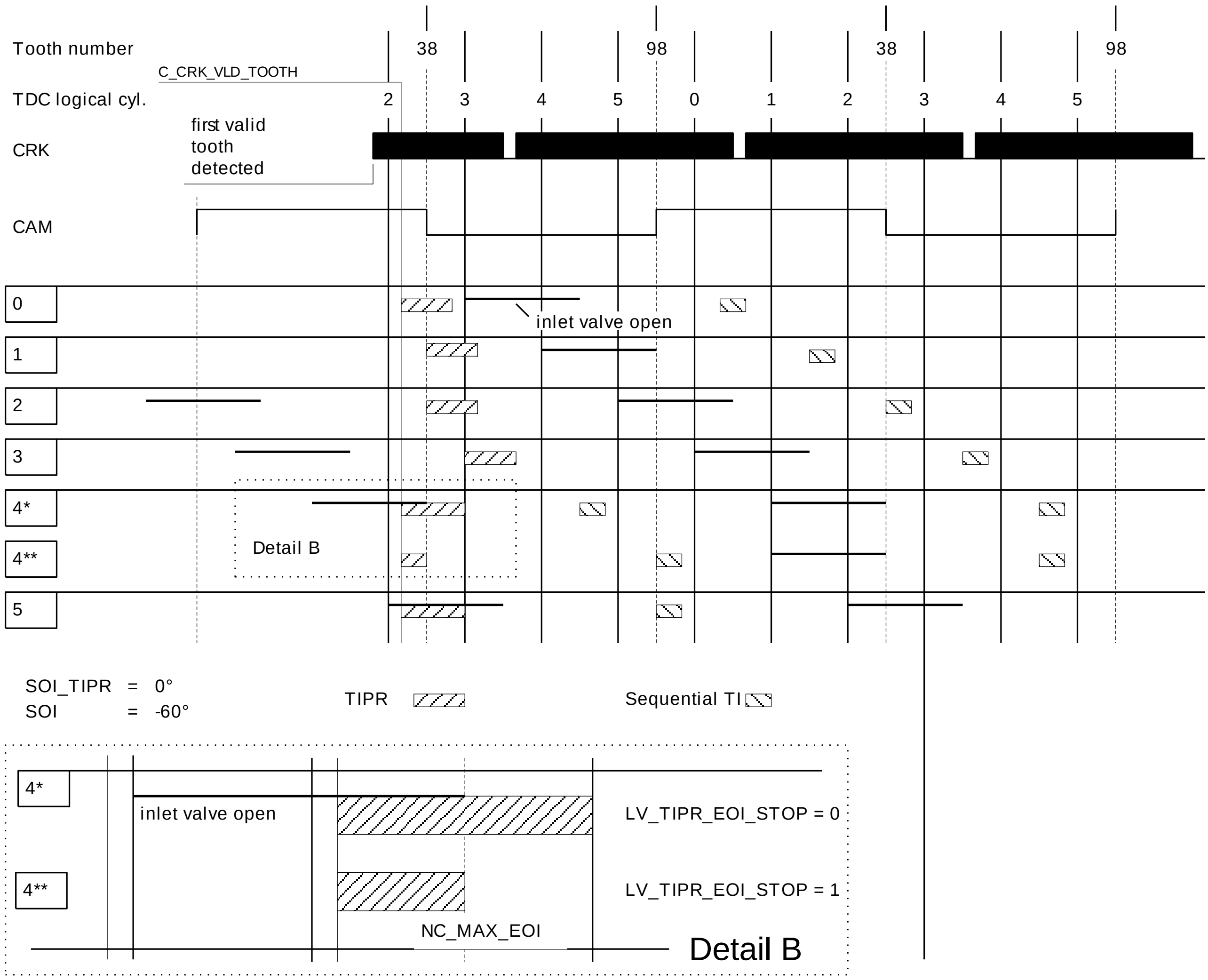
**Remark**: In case of low camshaft edge at start of cranking the cylinder groups are changed but the pre-injection is applied similar.

## Sequential first injection:

**If** LV_TIPR_SEQ = 1
**then** the first injection is carried out as follows:



First injection termination at NC_MAX_EOI




### 2.2.1.1.2 Injection phase programming SOI (Start) and EOI (End)

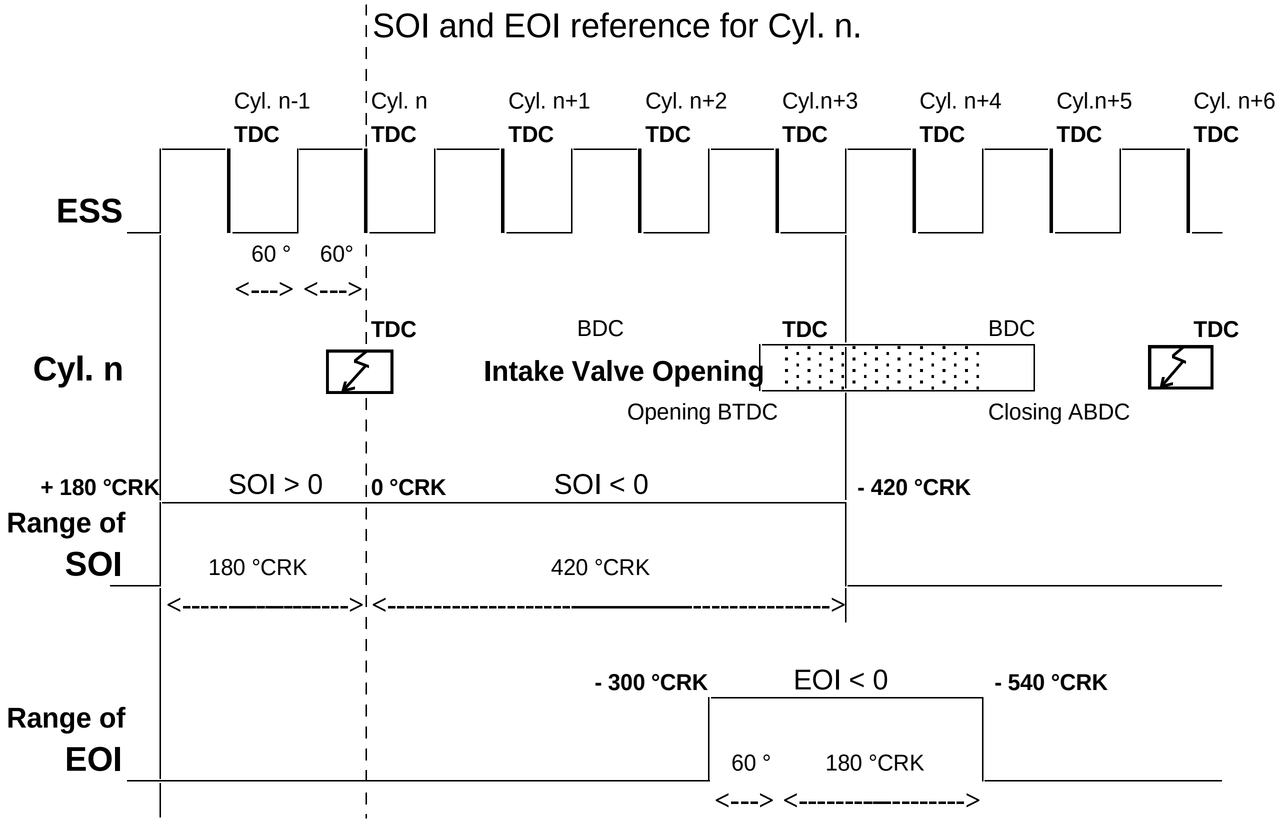
**FUNCTION DESCRIPTION:**

General information:

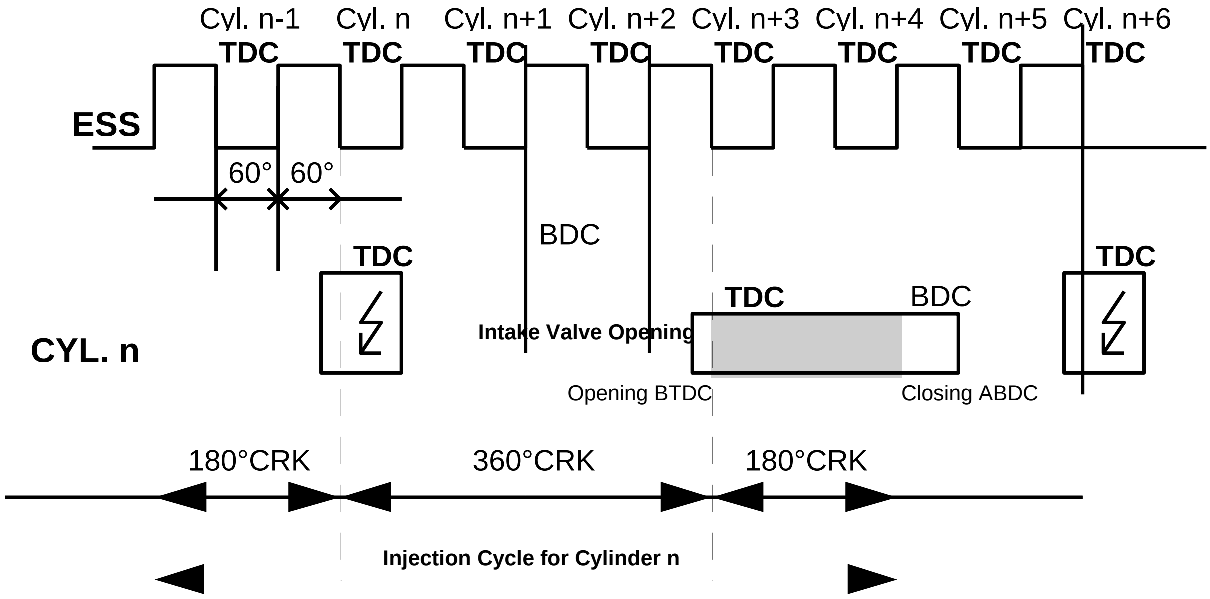
Since the start of injection cycle (180 °CRK before TDC), the opening injection phase has been updated with a segment recurrence until the injector would be opened.

**Formula section:**

- Range description for SOI and EOI :

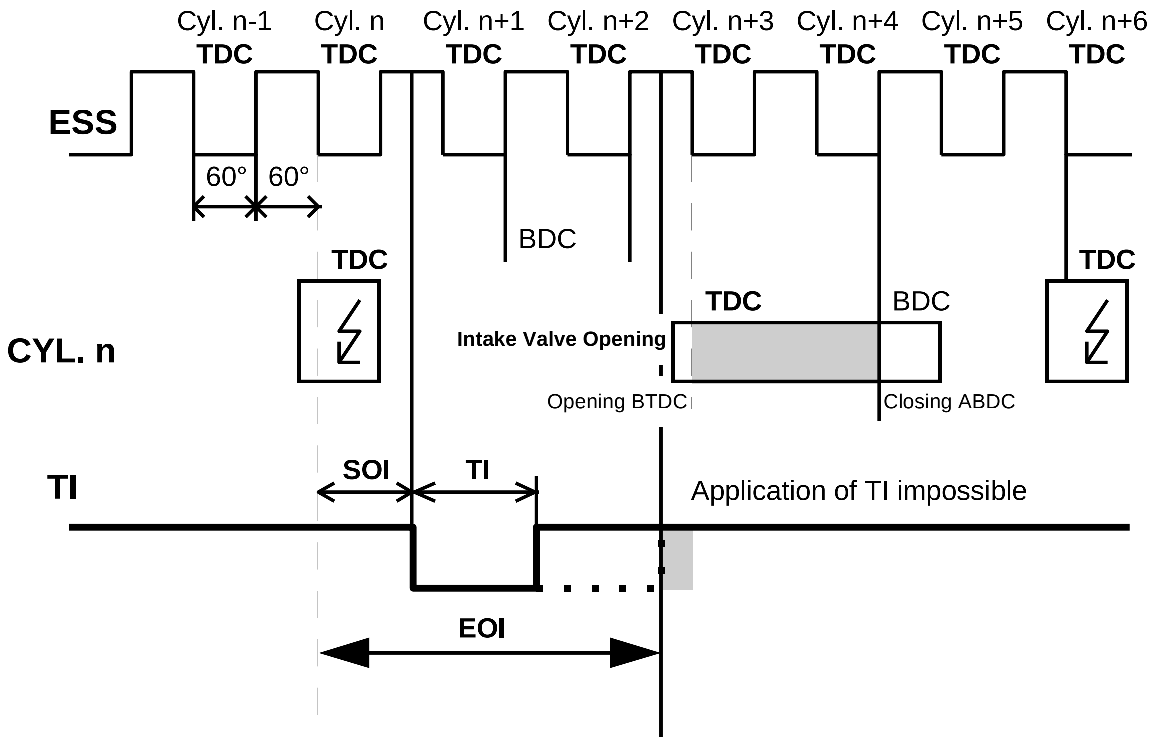


- Injection cycle description :




- Injection time applied :

At the end of injection (EOI), the injector is shut-off and the next opening injection phase (SOI) is programmed.



#### 2.2.1.1.3 Fuel shut-off

##### 2.2.1.1.3.1 Fuel shut-off pattern INH_SWI_IV

**FUNCTION DESCRIPTION:**

General information:

The pattern is scanned from MSB to LSB and the bits are applied to the corresponding injection following the injection order.

For **Bit = 1**, injection is inhibited.

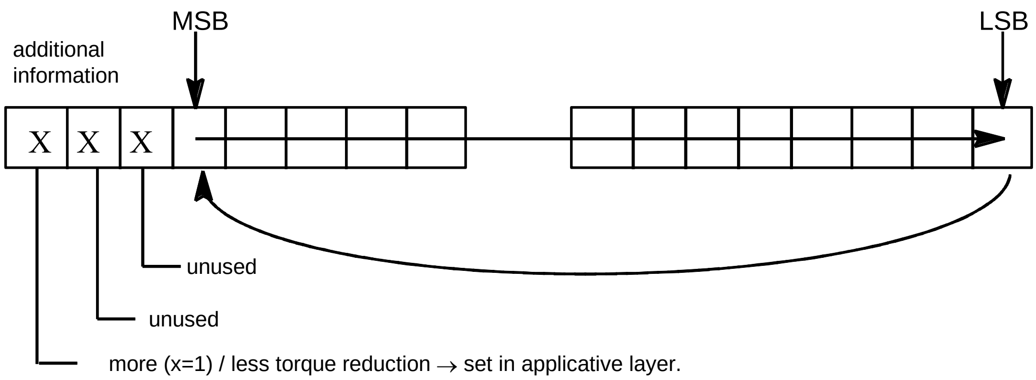
The length of the pattern must be changeable in software from number of cylinders (minimum) to NC_INI_INH_SWI_IV_SHIFT_NR (maximum). Every pattern starts with an inhibition of injection. The pattern are cyclically repeated.

According transient conditions, even in case with start of injection in advance, the following pattern must be scanned.

It is provided when SOI has been reached (beginning of injection). The value of the bit corresponding to the present pointer is checked to know if the present cylinder is allowed to receive injection. If this bit is set to 1, the injection is inhibited immediately and the corresponding injector remains inactive for the current injection cycle.

Description:

**INH_SWI_IV**




With torque reduction requested :

- for each new pattern, the pointer starts at MSB.

Without torque reduction requested :

- for each new pattern, the pointer continues at same position.

### 2.2.1.1.3.2 Fuel shut-off with immediate re-activation versus L_INH_IV_[CYL] state



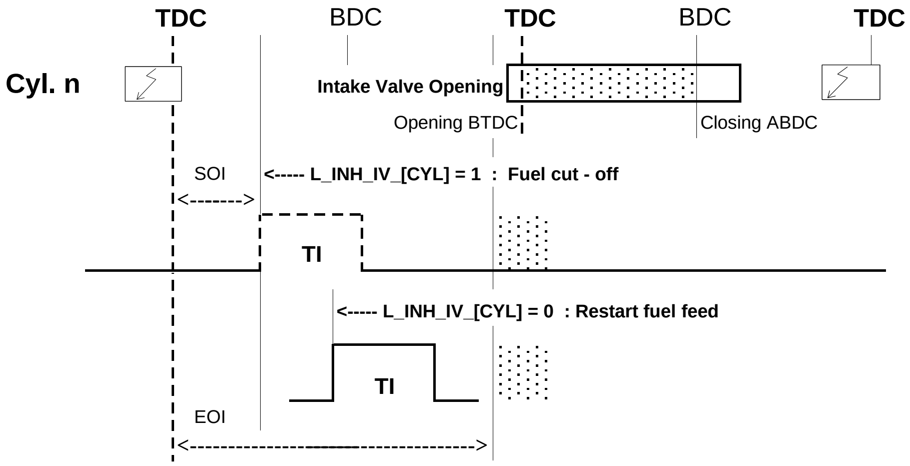
**FUNCTION DESCRIPTION:**

General information:

When the corresponding bit L_INH_IV_[CYL] is set to 1, the corresponding injector is immediately inhibited. The injector remains inhibited while the L_INH_IV_[CYL] is unchanged.

This function is used for trailing throttle fuel cut-off event and for emergency operation in case of misfire rate causing catalyst damage.

Description:



### 2.2.1.1.3.3 Fuel injection information

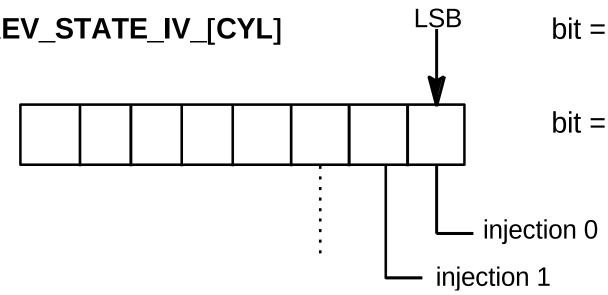
**<u>FUNCTION DESCRIPTION:</u>**

<u>General information:</u>

The basic software update injection information 180 °CRK before TDC. It corresponds to the injection state from the previous injection cycle.
Additionally the fuel quantity applied in the previous injection cycle is accummulated to FCO_SUM. FCO_SUM = FCO_SUM + TI_[CYL]

<u>Description:</u>

**L_PREV_STATE_IV_[CYL]**




bit = 0 correspond to inactive injection during the previous cycle

bit = 1 correspond to active injection during the previous cycle

Each bit position corresponds to an injection.

### 2.2.1.1.4 Injection time programming

**<u>FUNCTION DESCRIPTION:</u>**

**<u>Formula section:</u>**

TI_[CYL] is the real opening duration of the injector.

On injection opening, the programmed injection time is :

| |
|---|
| TI_[CYL] = ( TI_i + TI_ADD_REAC_SCC_[CYL] ) * TI_AS_[CYL] |

The injector control time is TI_[CYL] + TI_ADD_DLY
with :

TI_[CYL] : injector opening time applied to the corresponding injector
TI_i : nominal injection time for bank i coming from applicative layer
TI_ADD_REAC_SCC_[CYL] : injection time correction for individual cylinder restart fuel feed
TI_AS_[CYL] : injection time tuned correction coming from applicative layer
TI_ADD_DLY : injector dead time correction coming from applicative layer.

### 2.2.1.1.5 Fuel injection under transient engine operation



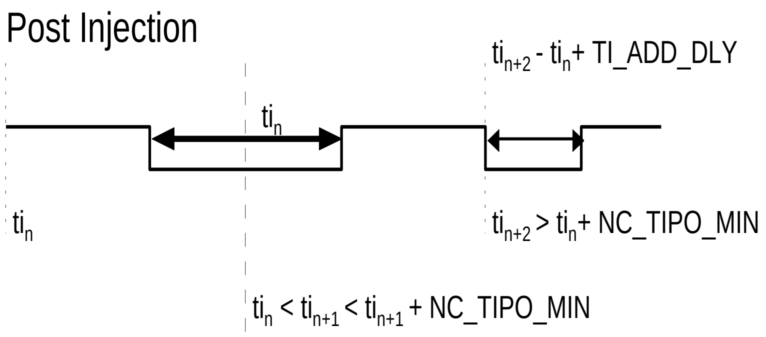
**FUNCTION DESCRIPTION:**

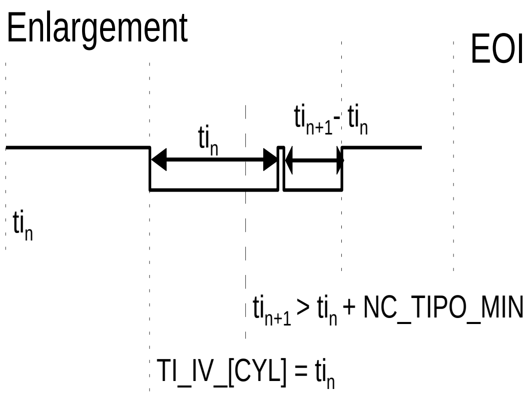
General information:

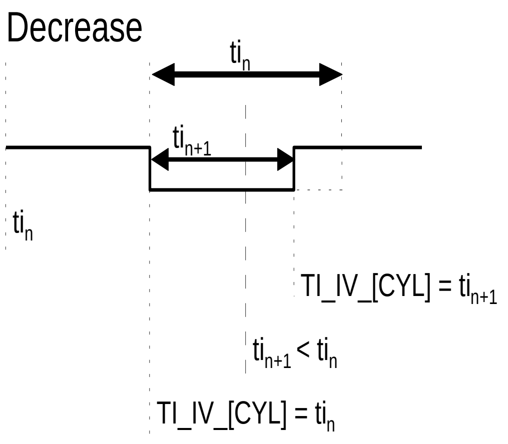
Under transient conditions it might appear that there is a significant change of the calculated injection time compared to the value which was valid when the injector was opened. Three cases are taken into account: refer to drawings below.

- **Injection time decrease:** as long as the injector is opened the injection time could be corrected.
- **Injection time increase while injector is open:** At the end of the regular injection time the additive injection time is applied without TI_ADD_DLY.
- **Injection time increase with injector already closed:** After application of the regular injection time the injector will be reopened including TI_ADD_DLY.

**Remark:** Additive fuel quantity will be applied only if there is an important enlargement (>NC_TIPO_MIN). NC_TIPO_MIN = 200µs


Post Injection
$ti_{n+2}$ - $ti_n$+ TI_ADD_DLY
$ti_n$
$ti_n$
$ti_{n+2}$ > $ti_n$+ NC_TIPO_MIN
$ti_n$ < $ti_{n+1}$ < $ti_{n+1}$ + NC_TIPO_MIN


Enlargement
EOI
$ti_{n+1}$- $ti_n$
$ti_n$
$ti_n$
$ti_{n+1}$ > $ti_n$ + NC_TIPO_MIN
TI_IV_[CYL] = $ti_n$


Decrease
$ti_n$
$ti_{n+1}$
$ti_n$
TI_IV_[CYL] = $ti_{n+1}$
$ti_{n+1}$ < $ti_n$
TI_IV_[CYL] = $ti_n$

### 2.2.2 Spark advance and Dwell output

#### 2.2.2.1 Basic software

**Input data:**

| | | | |
|---|---|---|---|
| T_TOOTH | TD | TD_MPL | TD_MPL_DLY |
| IGA_IGC_[CYL] | LV_LOW_N | LV_MPL_ADV_ACT | |

**FUNCTION DESCRIPTION:**

General information:

This function set the angular position of the Dwell time turn ON in order to have the time to set up the right current in the ignition coil.

The strategy respects dual output ignition coil depending on the current application.

With the beginning of the Dwell time, a time-out (Dwell “watchdog”) has to be initialized to ensure at each time a turn ON of the ignition coil.

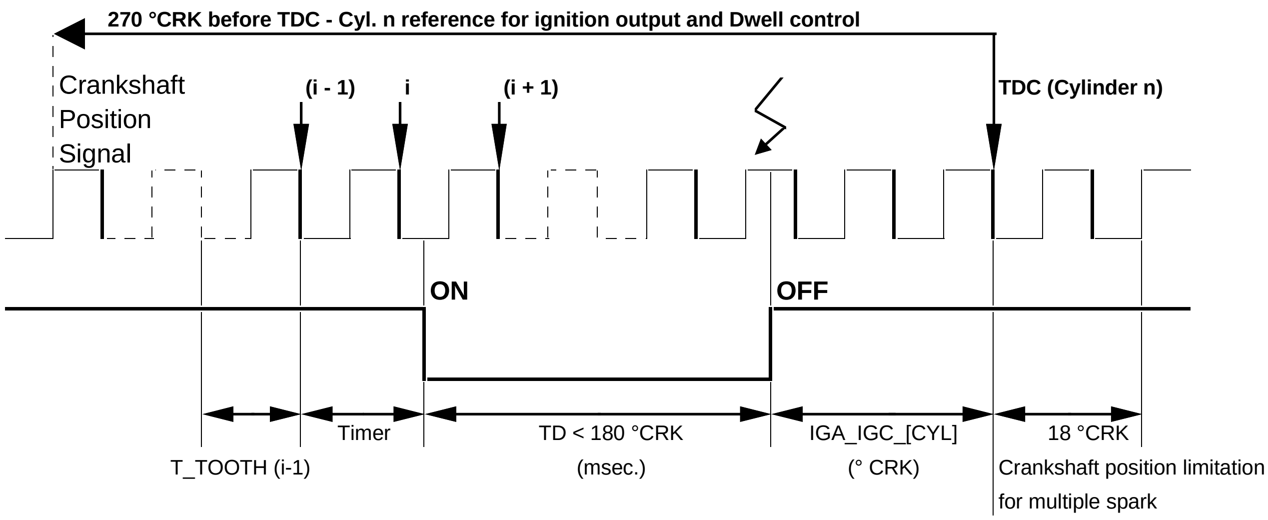
##### 2.2.2.1.1 Normal ignition and Dwell control ( LV_LOW_N = 0 (Passive) )

System meaning :

The calculation for the beginning of the Dwell time is triggered by initialization before any turn ON of each ignition coil.

The coil driver is turned ON at the interruption defined for beginning of Dwell time and turned OFF at IGA_IGC_[CYL] crankshaft position.

Description:




**Remark :**

The timer following $T\_TOOTH_{i-1}$ takes into account this value in order to reach the right crankshaft position to start the beginning of the Dwell time.

#### 2.2.2.1.2 Dwell control in case of low engine speed ( LV_LOW_N = 1 (Active) )

System meaning :

In case of low engine speed ( LV_LOW_N **= 1** (Active) ), beginning at the reference crankshaft position for the corresponding cylinder ( **270 °CRK** before TDC ), it is checked if the Dwell time has to be started within the next two teeth. In this case, the timer before beginning of Dwell time is started as defined previously.

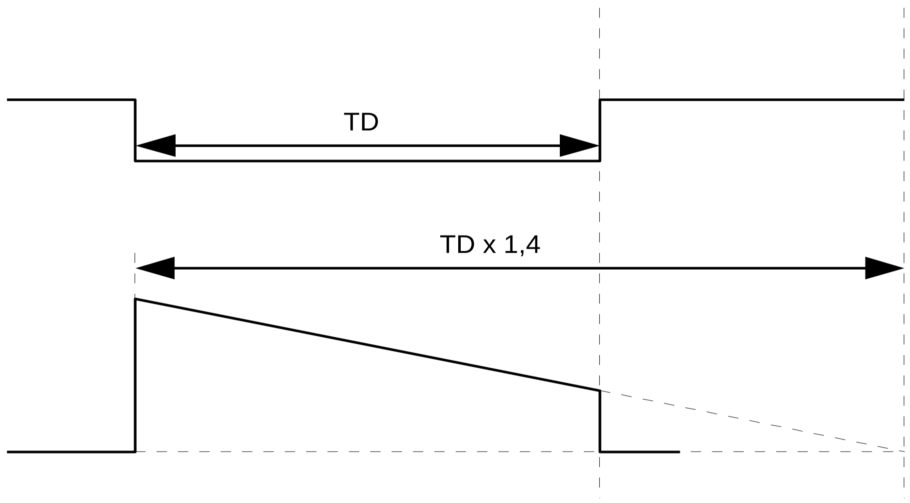
#### 2.2.2.1.3 Dwell time "watchdog"

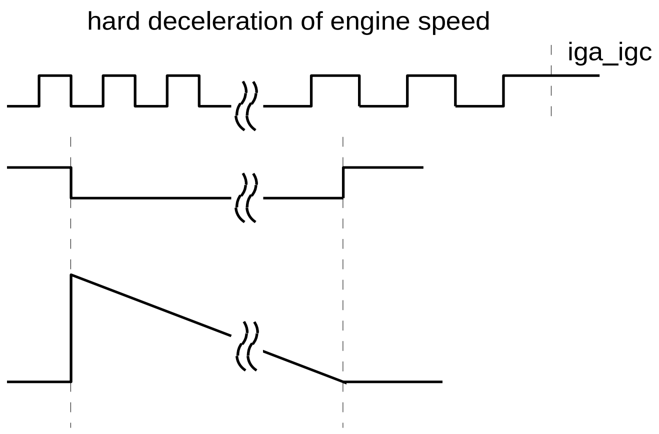
System meaning :

When stalling, the calculated conduction time may be too large because of the reduction of engine speed, between conduction angle calculation and spark. A timer limits the resulting conduction time (ignition power stage protection against high current).

The Dwell "watchdog" time-out duration is defined as :
1,4 * TD

The ignition output is turned OFF immediately before IGA_IGC_[CYL].



### 2.2.2.1.4 Multiple spark

System meaning :

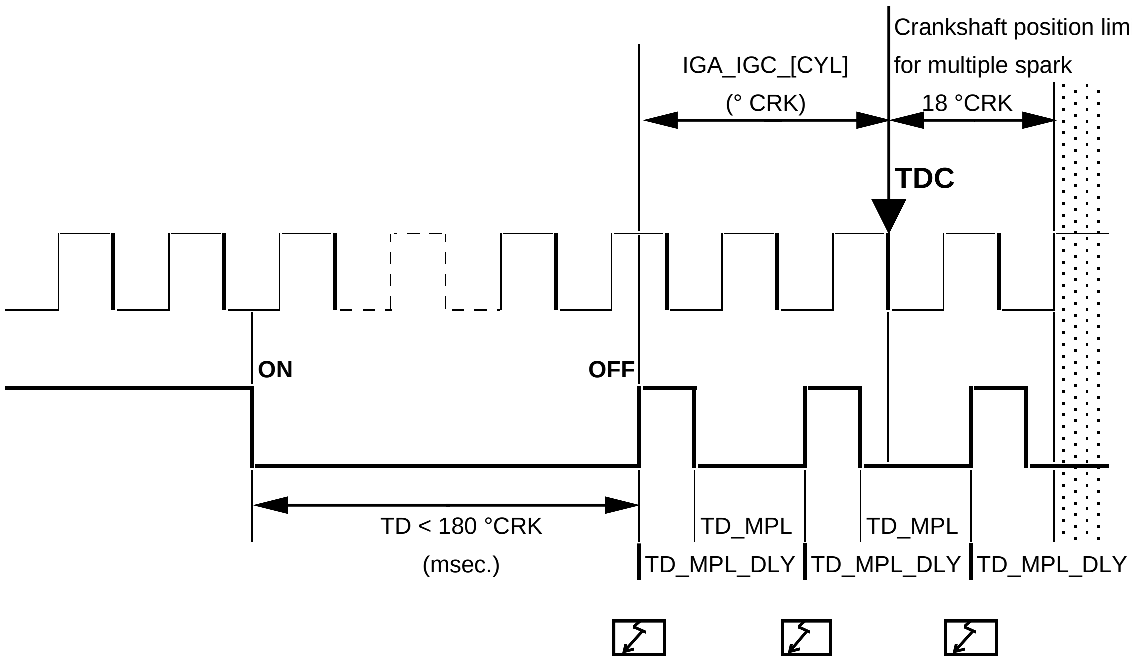
To improve the engine starting phase, the spark advance control can continue until the maximum crankshaft angle is reached (18 °CRK after TDC).

The Boolean LV_MPL_ADV_ACT from applicative layer controls the activation and the deactivation of multiple spark function.

The value TD_MPL determines the conduction time of the ignition coil and the time delay TD_MPL_DLY specifies a time-out when the ignition coil is turn ON for the next spark.

The duration of multiple spark advance is limited to 60 msec.

Description:



### 2.2.2.2 Applicative software

#### 2.2.2.2.1 Dwell time control

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| TD | V | 0...FFFFH | 0...262,14 | 4 µs | msec |
| Dwell time. | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| VB | N_32 | | |

**FUNCTION DESCRIPTION:**

General information:

The Dwell time open-loop control value is calculated versus battery voltage and engine speed.

Application recurrence **: 10 msec**.

**Formula section:**

TD = IP_TD__VB__N_32 + C_TD_AS



**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| IP_TD__VB__N_32 | 8 x 5 | 0...1D4CH | 0...30 | 4 µs | msec |
| | | | | | |
| Dwell time. | | | | | |
| C_TD_AS | 1 | 80...7FH | -8,192...8,128 | 64 µs | msec |
| Dwell time application system. | | | | | |

### 2.2.2.2.2 Multiple spark



**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| TD_MPL | - | 0...FFFFH | 0...262,14 | 4 µs | msec |
| Dwell time for multiple spark. | | | | | |
| TD_MPL_DLY | - | 0...FFH | 0...1,02 | 4 µs | msec |
| Duration between two ignition coil loading phases. | | | | | |
| LV_MPL_ADV_ACT | V | 0...01H | 0...1 | 1 | - |
| Boolean information for multiple spark processing - ( Passive / Active ). | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| VB | N_32 | TCO | LV_VB_JUMP |
| LV_ES | LV_ST | | |

**FUNCTION DESCRIPTION:**

General information:

At start and following application conditions, the ignition is controlled by means of multiple spark.

After the adjustable combustion period C_TD_T_MPL, the ignition coil is loaded with a specific Dwell time IP_TD_MPL__VB related to multiple spark.

The multiple sparks are stopped **18 °CRK** after TDC.

**Formula section:**

**If** engine stopped active (LV_ES)
**or** engine start active (LV_ST)
**and** TCO **<** C_TCO_MAX_MPL
**and** LV_VB_JUMP **= 0** (Passive)
**then** LV_MPL_ADV_ACT **= 1** (Active)
**and** TD_MPL **=** IP_TD_MPL__VB
**and** TD_MPL_DLY **=** C_TD_T_MPL
**else** LV_MPL_ADV_ACT **= 0** (Passive)
**Endif.**

## Calibration data:

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| IP_TD_MPL__VB | 8 | 0...1D4CH | 0...30 | 4 µs | msec |
| | | | | | |
| Dwell time relative to multiple spark. | | | | | |
| C_TD_T_MPL | 1 | 0...FFH | 0...1,02 | 4 µs | msec |
| Duration between two ignition coil loading phases. | | | | | |
| C_TCO_MAX_MPL | 1 | 0...FFH | -48...142,5 | 0,75 | °C |
| Coolant temperature threshold at start for multiple spark application. | | | | | |

### 2.2.3 Fuel consumption signal output FCO

#### 2.2.3.1 Basic software

**Input data:**

| | | | |
|---|---|---|---|
| T_FCO | | | |

**FUNCTION DESCRIPTION:**

General information:

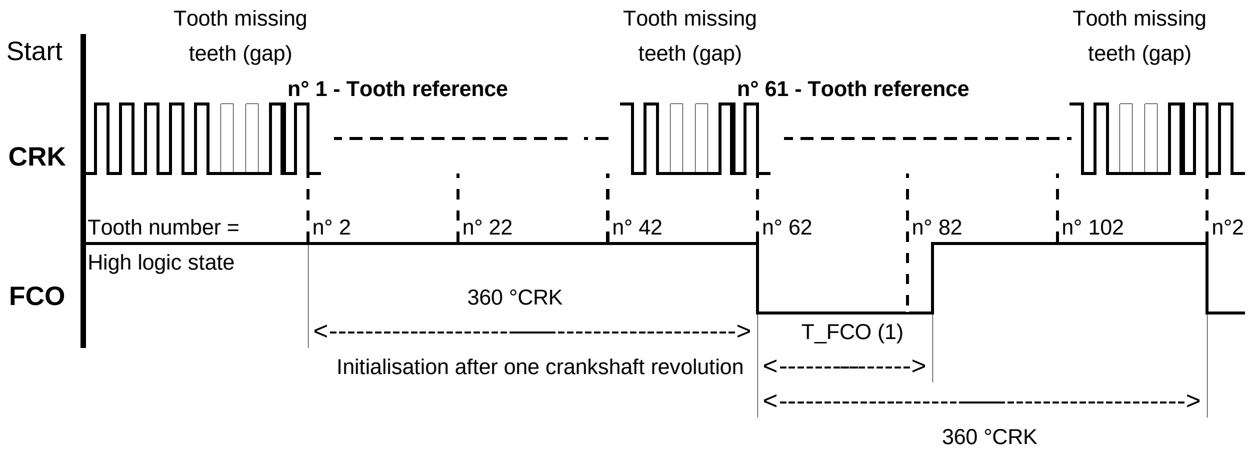
The specification is applicable for a 6 cylinders engine.

The ECU generates a fuel consumption output signal (FCO) to be dispatched to other ECUs (Transmission Control Unit, Dashboard ...).

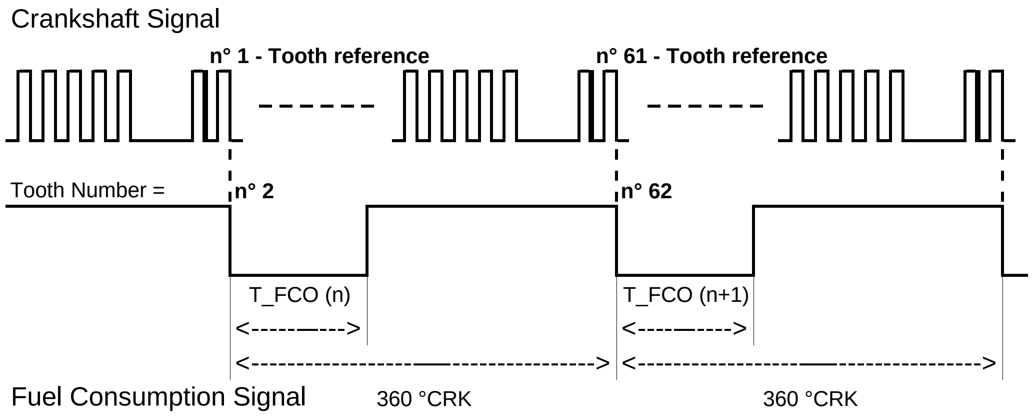
The fuel consumption output signal is activated once per crankshaft revolution and the active time duration T_FCO is derived from the calculated injection time.

**Initialisation :**

The output signal is initialised with a high logic state (1).



## Formula section:




**Remark :**

- If $T\_FCO_i = 0$ then the fuel consumption signal FCO remains with a high logic state.
- In case of overlapping ($T\_FCO_i > T\_REV$ : corresponding segment period), $T\_FCO_i$ is interrupted and $T\_FCO_{i+1}$ is started.

### 2.2.3.2 Applicative software

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| T_FCO | - | 0...FFFFH | 0...262 | 4 µs | msec / rev. |
| Active time duration for fuel consumption signal output. | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| FCO_SUM | | | |

**FUNCTION DESCRIPTION:**

General information:

The active time duration T_FCO is calculated once per crankshaft revolution.

T_FCO is equal to the injected fuel quantity during the last crankshaft revolution.

**Formula section:**

Application recurrence: once per crankshaft revolution.

*- Initialisation :*

At the transition to engine stopped: T_FCO = 0 and FCO_SUM_PREV = FCO_SUM
*- Active time duration T_FCO calculation :*

T_FCO = (FCO_SUM - FCO_SUM_PREV) * C_FCO_FAC
FCO_SUM_PREV = FCO_SUM

**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| C_FCO_FAC | 1 | 0...FFH | 0...1,922 | 7,509E-3 | - |
| Scale factor depending on injector type for calculation of the active time duration T_FCO. | | | | | |

### 2.2.4 Engine speed signal output ESS

#### 2.2.4.1 Basic software

**FUNCTION DESCRIPTION:**

General information:

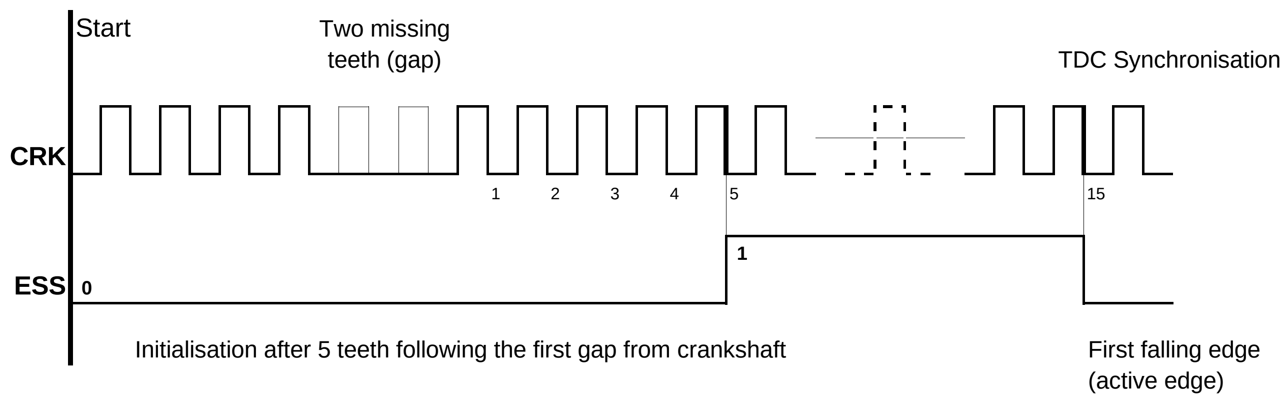
This specification is applicable for a 6 cylinders engine.

The ECU generates an engine speed signal (ESS) to be dispatched to other ECUs (Transmission Control Unit, Dashboard ...)

This output is only activated when the engine is running and the signal is representative of engine speed. It is performed with a fixed logic state ratio and a variable frequency proportional to the engine speed.

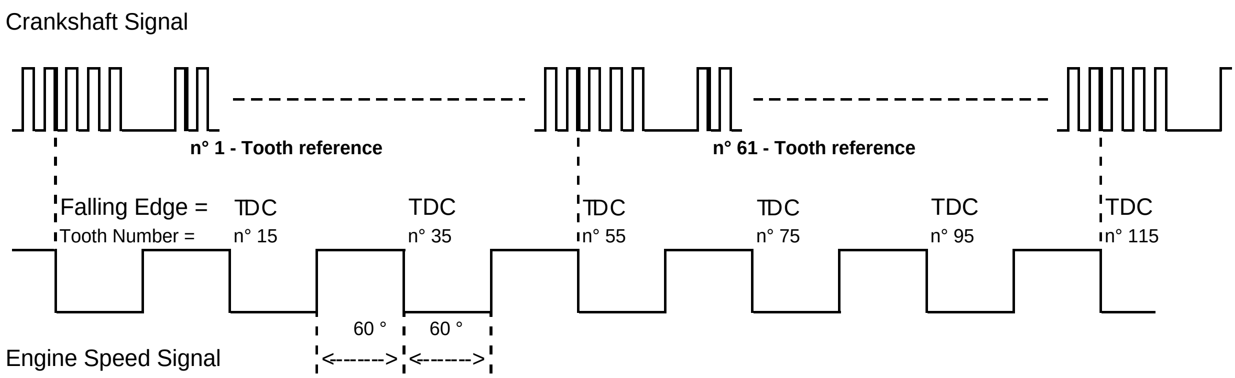
**Initialisation :**

The output signal is initialised with a low logic state (0).




**Formula section:**

The active edge on the engine speed signal is the falling edge, corresponding to the TDC location.



### 2.2.5 Acquisition of primary over voltage duration V_DUR_IGC_[CYL]

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| V_DUR_IGC_[CYL] | V/S | 0...7FFFH | 0...131000 | 4 | µs |
| Ignition coil primary over voltage duration for the corresponding cylinder. | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| C_IGC_DUR_N_MAX_DIAG | | | |

**FUNCTION DESCRIPTION:**

General information:

This function is applicable with a 6 cylinders engine but the type of spark plugs and ignition coils (double or single output) must be taken into account.

The ignition coil primary over voltage duration **V_DUR_IGC_[CYL]** acquisition is provided for ignition diagnosis.

This duration is measured with a gated timer of the micro-processor, see also chapter „Diagnosis Management“. The gated timer is allowed to count after the turn-off of the ignition output until the turn-off of the following ignition output, to ensure in case of spark break-off a correct measurement.

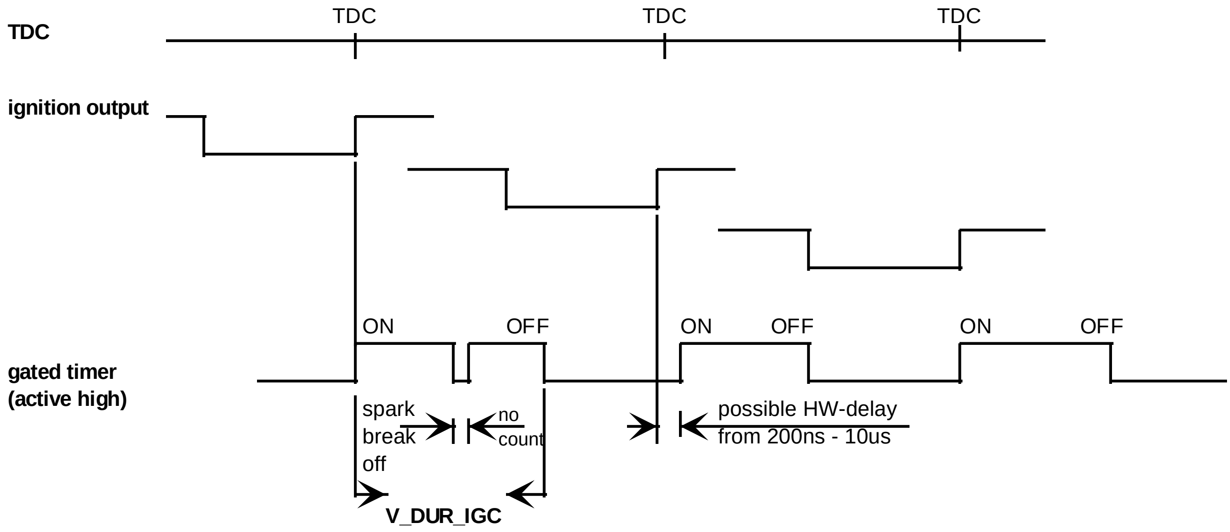
The ignition coil primary over voltage of each ignition output of engines up to 6 cylinders are not overlapping in the normal operating mode at C_IGC_DUR_N_MAX_DIAG rpm engine speed. But the software strategy must detect overlapping. In this case the bit 15 of **V_DUR_IGC_[CYL]** is set to **1**.

**Failure on input gated timer :** V_DUR_IGC_[CYL] = 0

Description:

V_DUR_IGC_[CYL] is calculated with a gated timer and respects spark break-off as well as overlapping.





### 2.2.6 Acquisition of throttle position

#### 2.2.6.1 Basic software



**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| TPS_MES | V | 0...FFH | 0...4,9805 | 5 / 256 | V. |
| Throttle position sensor voltage measured (8 bits). | | | | | |
| TPS_MES_10 | - | 0...03FFH | 0...4,9951 | 5 / 1024 | V. |
| Throttle position sensor voltage measured (10 bits). | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| TPS_BAS | | | |

**FUNCTION DESCRIPTION:**

General information:

The raw value for throttle position (TPS_BAS) is measured by continuous conversion (10 bits) every 1 msec.

The corresponding value of the first measurement after hardware reset is used for initialisation.



**Formula section:**

TPS_MES_10 ← TPS_BAS (10 bits)

TPS_MES ← TPS_BAS / 4 (8 bits)

### 2.2.6.2 Applicative software

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| TPS | V | 0...FFH | 0...119,5 | 0,47 | °TPS |
| Relative throttle angle. | | | | | |
| TPS_CAN | V | 20...F5H | 0...100 | 0,444 | % |
| Relative throttle angle distributed via CAN. | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| TPS_MES_DIAG | TPS_MES_10_DIAG | LV_TPS_ERR | TPS_AD_MMV_IS |



**FUNCTION DESCRIPTION:**

General information:

The application recurrence is **10 msec**.

**Formula section:**

** Hysteresis :*

To filter out signal noise, the signal is filtered using the adjustable value C_TPS_HYS.
The throttle angle is accepted only if TPS_MES_10_DIAG differs from the value last measured by more than C_TPS_HYS and if the conditions for a plausibility diagnosis error are not fulfilled (LV_TPS_ERR = 0).

** Gradient :*

In order for possible malfunctions not to become effective, a permissible throttle gradient is checked for exceeding. The old measured value TPS_MES_DIAG remains the same if the difference between the old and the new value is greater than C_TPS_GRD_MAX.

**If** $\left| TPS\_MES\_10\_DIAG_n - TPS\_MES\_10\_DIAG_{n-1} \right| > C\_TPS\_HYS$

**then**

**If** $\left| TPS\_MES\_DIAG_n - TPS\_MES\_DIAG_{n-1} \right| < C\_TPS\_GRD\_MAX$

**then** $TPS = TPS\_MES\_DIAG_n - TPS\_AD\_MMV\_IS$ with $TPS \geq 0$

**else** $TPS = TPS\_MES\_DIAG_{n-1} - TPS\_AD\_MMV\_IS$ with $TPS \geq 0$

**Remark :** If during the subsequent measurement period (10 msec) it is determined again that C_TPS_GRD_MAX was exceeded, the new measured value is taken as valid.

## Calibration data:

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| C_TPS_HYS | 1 | 0...03FFH | 0...119,88 | 120/1024 | °TPS |
| Noise filtering factor for TPS. | | | | | |
| C_TPS_GRD_MAX | 1 | 0...FFH | 0...119,5 | 0,47 | °TPS |
| Maximum TPS gradient. | | | | | |

Document: **System variables**

Project: **Engine Management System**

**HMC_V6**



Version: a

Date: 17-Dec-97

Number of pages: 47

Revision Code-No.: 153589 from 18.12.97

Construction protocol-No.:

Software version: 650H0000

| | Name | Department | Phone | Date | Sign |
|---|---|---|---|---|---|
| Author | Müller O. | AT PT SI TSA 11 | 3211 | 09.12.97 | |
| 1. Check | Pioch O. | AT PT SI TSA 11 | 3212 | 09.12.97 | |
| 2. Check | Gessner S. | AT PT SI TSA 11 | 5398 | 09.12.97 | |
| Responsible | Brückner D. | AT PT SI TSA 16 | 4279 | 09.12.97 | |

## Version list

| Version | Date | Author | Comment, Description |
|---|---|---|---|
| | | | |

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## C

# 1 System variables

## 1.1 Engine speed variables

### 1.1.1 Engine speed N and N_32

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| N_32 | V | 0...FFH | 0...8160 | 32 | rpm |
| Engine speed - Resolution 32 rpm. | | | | | |
| N | V | 0...1FE0H | 0...8160 | 1 | rpm |
| Engine speed - Resolution 1 rpm | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| T_SEG | | | |

**FUNCTION DESCRIPTION:**

General information:

The engine speed is determined in each segment from the segment period. The time for the passage of this segment T_SEG is measured with a resolution of 1 / NC_T1_FREQ microseconds. This method is used to determine engine speed in the entire engine speed range.

**Formula section:**

- **N = NC_T_SEG_ES_CLC/ T_SEG**

with NC_T_SEG_ES_CLC= NC_T1_FREQx 60 x 2 / NC_CYL_NO

- **N_32 = N / 32**

**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| NC_T1_FREQ | 1 | | | 1 | Hz |
| Timer frequency - Non adjustable calibration. | | | | | |
| NC_CYL_NO | 1 | 0...FFH | 0...255 | 1 | - |
| Number of cylinders - Non adjustable calibration. | | | | | |

**Applicative Values :**

NC_T1_FREQ = **250** kHz

NC_CYL_NO = **06**H = 6 cylinders

### 1.1.2 Nominal idle speed N_SP_IS



**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| N_SP_IS | V | 0...1FE0H | 0...8160 | 1 | rpm |
| Nominal idle speed. | | | | | |
| N_SP_ADD_CH | V | 0...1FE0H | 0...8160 | 1 | rpm |
| Nominal idle speed offset with catalyst heating function and LV_DRI = 0 | | | | | |
| DRI_N_SP_ADD_CH | V | 0...1FE0H | 0...8160 | 1 | rpm |
| Nominal idle speed offset with catalyst heating function and LV_DRI = 1 | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| TCO | LV_ACIN | LV_DRI | LV_N_SP_ADD_CH |
| N_SP_IS_ADJ_ASA | | | |

**FUNCTION DESCRIPTION:**



General information:

The nominal idle speed in the engine operating state Idle (LV_IS) depends on:

- Coolant temperature TCO
- Catalyst heating function LV_N_SP_ADD_CH
- the additional loads: Drive with A/T gearbox, air conditionning.
- Adjustment by service tester/keyword

The offset N_SP_ADD_CH is applied on N_SP_IS if catalyst heating function is active.

The transition from a nominal idle speed to another is performed with an adjustable change limitation C_N_SP_LGRD_IS

**Formula section:**

- N_SP_ADD_CH calculation :

**If** LV_N_SP_ADD_CH **=** 1

**then** N_SP_ADD_CH **=** IP_N_SP_ADD_CH__TCO

**else** N_SP_ADD_CH **=** 0

- DRI_N_SP_ADD_CH calculation :

**If** LV_N_SP_ADD_CH **=** 1

**then** DRI_N_SP_ADD_CH **=** IP_DRI_N_SP_ADD_CH__TCO

**else** **D**RI_N_SP_ADD_CH **=** 0

- N_SP_IS calculation :

*Nominal idle speed without additional load (LV_DRI = 0 and LV_ACIN = 0) :*

**N_SP_IS = IP_N_SP_IS__TCO**
**+ N_SP_ADD_CH**
**+ N_SP_IS_ADJ_ASA * IP_FAC_N_SP_IS__TCO**

*Nominal idle speed with DRIVE (A/T) position engaged (LV_DRI = 1 and LV_ACIN = 0) :*
**N_SP_IS = IP_DRI_N_SP_IS__TCO**
**+ DRI_N_SP_ADD_CH**
**+ N_SP_IS_ADJ_ASA * IP_FAC_N_SP_IS__TCO**

*Nominal idle speed with air conditioner switched on (LV_DRI = 0 and LV_ACIN = 1) :*
**N_SP_IS = IP_ACIN_N_SP_IS__TCO**
**+ N_SP_IS_ADJ_ASA * IP_FAC_N_SP_IS__TCO**

*Nominal idle speed with DRIVE (A/T) position engaged and air conditioner switched on (LV_DRI = 1 and LV_ACIN = 1) :*
**N_SP_IS = IP_DRI_ACIN_N_SP_IS__TCO**
**+ N_SP_IS_ADJ_ASA * IP_FAC_N_SP_IS__TCO**

N_SP_IS is computed below the engine speed NC_ISAPWM_N_MAX.
N_SP_IS is limited to NC_N_SP_IS_MAX.

## Calibration data:

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| IP_N_SP_IS__TCO | 6 | 0...1FE0H | 0...8160 | 1 | rpm |
| | | | | | |
| Nominal idle speed without additional load on the engine. | | | | | |
| IP_DRI_N_SP_IS__TCO | 6 | 0...1FE0H | 0...8160 | 1 | rpm |
| | | | | | |
| Nominal idle speed with DRIVE (A/T) engaged. | | | | | |
| IP_ACIN_N_SP_IS__TCO | 6 | 0...1FE0H | 0...8160 | 1 | rpm |
| | | | | | |
| Nominal idle speed with air conditioner switched on. | | | | | |
| IP_DRI_ACIN_N_SP_IS__TCO | 6 | 0...1FE0H | 0...8160 | 1 | rpm |
| | | | | | |
| Nominal idle speed with DRIVE (A/T) engaged and air conditioner switched on. | | | | | |
| IP_FAC_N_SP_IS__TCO | 9 | 0...FFH | 0...0,9961 | 1/256 | - |
| | | | | | |
| Correction factor for nominal idle speed adjustment. | | | | | |
| C_N_SP_LGRD_IS | 1 | 01...FFH | 0,25...63,75 | 0,25 | rpm |
| Nominal idle speed change limitation. | | | | | |
| IP_N_SP_ADD_CH__TCO | 6 | 0...1FE0H | 0...8160 | 1 | rpm |
| | | | | | |
| Nominal idle speed offset with catalyst heating function active and LV_DRI = 0 | | | | | |
| IP_DRI_N_SP_ADD_CH__TCO | 6 | 0...1FE0H | 0...8160 | 1 | rpm |
| | | | | | |
| Nominal idle speed offset with catalyst heating function active and LV_DRI = 1 | | | | | |
| NC_ISAPWM_N_MAX | 1 | 0...FFH | 0...8160 | 32 | rpm |
| Maximum engine speed threshold for calculation of N_SP_IS - Non adjustable calibration. | | | | | |
| NC_N_SP_IS_MAX | 1 | 0...FFH | 0...8160 | 32 | rpm |
| Maximum engine speed value for N_SP_IS - Non adjustable calibration. | | | | | |

## Applicative Values :

NC_ISAPWM_N_MAX = **4E**H = 2496 rpm.

NC_N_SP_IS_MAX = **FF**H = 8160 rpm

### 1.1.3 Nominal idle speed threshold N_SP_IS_MAX



**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| N_SP_IS_MAX | V | 0...1FE0H | 0...8160 | 1 | rpm |
| Nominal idle speed threshold. | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| N_SP_IS | N_DIF_MMV | | |

**FUNCTION DESCRIPTION:**

General information:

In order to define the basic engine operating states, the nominal engine speed threshold is available.



**Formula section:**

*In idle (LV_IS ) :*

N_SP_IS_MAX= N_SP_IS+ C_N_DIF_MAX_IS - N_DIF_MMV * C_N_DIF_FAC

*Out of idle :*

N_SP_IS_MAX= N_SP_IS + C_N_DIF_MAX_IS

**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| C_N_DIF_FAC | 1 | 00...FFH | 0...0,997 | 3,895E-3 | - |
| Weighting factor for the idle speed variable controller. | | | | | |
| C_N_DIF_MAX_IS | 1 | 0...1FE0H | 0...8160 | 1 | rpm |
| Engine speed hysteresis before engine operating state idle (LV_IS). | | | | | |

### 1.1.4 Engine speed gradient N_GRD

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| N_GRD | V | 80...7FH | -4096 : 4064 | 32 | rpm/s |
| Engine speed gradient | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| T_SEG | N | | |

**FUNCTION DESCRIPTION:**

General information:

The engine speed gradient calculation is triggered every segment.

**Formula section:**

The engine-speed gradients are calculated from the corresponding segment periods :

$$T\_REV\_ACT = (T\_SEG_{n} + T\_SEG_{n-1} + T\_SEG_{n-2})$$

$$T\_REV\_LAST = (T\_SEG_{n-3} + T\_SEG_{n-4} + T\_SEG_{n-5})$$

**N_GRD= 60 * $NC\_T1\_FREQ^2$ * Fehler!**

The timer resolution is 1 / NC_T1_FREQ and the formula above produce the engine-speed dependent resolutions of the engine-speed gradient without taking into account errors introduced by rounding or evaluation. The following deviation is caused by the timer resolution :

**$\Delta$N_GRD** = **Fehler!**

**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| NC_T1_FREQ | 1 | | | | |
| Timer frequency - Non adjustable calibration. | | | | | |

**Applicative Values :**

NC_T1_FREQ = **250** kHz

### 1.1.5 Engine speed deviations N_DIF, N_DIF_MMV, N_DIF_COR

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| N_DIF | V | 8000H... 7FFFH | -32768 : 32767 | 1 | rpm |
| Engine speed deviation. | | | | | |
| N_DIF_MMV | V | 8000H... 7FFFH | -32768 : 32767 | 1 | rpm |
| N_DIF moving mean value. | | | | | |
| N_DIF_COR | V | 8000H... 7FFFH | -32768 : 32767 | 1 | rpm |
| Idle speed control variable. | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| N | N_SP_IS | | |

**FUNCTION DESCRIPTION:**

**Formula section:**

***** *N_DIF calculation :*
The application recurrence is the **segment**. The deviation N_DIF from the nominal idle speed is defined as :

**N_DIF = N_SP_IS- N**

**Remark :** N_DIF is computed if N ≤ NC_ISAPWM_N_MAX.

***** *N_DIF_MMV calculation :*
As soon as the engine operating state idle (LV_IS) is set, N_DIF_MMVis set to N_DIF taking into account the limits defined below. Then the moving mean value is determined :

$$\text{N\_DIF\_MMV}_{(n)} = \text{N\_DIF\_MMV}_{(n-1)} * (1 - \text{C\_N\_DIF\_CRLC}) + \text{N\_DIF} * \text{C\_N\_DIF\_CRLC}$$

The correlation constant C_N_DIF_CRLC may assume 3 discrete values :

a1) Decreasing engine speed above nominal idle speed as soon as idle is set (LV_IS) **and** conditions b) & c) not previously met (**or** N_DIF **<** NC_N_DIF_MIN_CRLC) :
( $\text{N\_DIF}_{(n-3)} < \text{N\_DIF}_{(n)}$ **and** $\text{N\_DIF}_{(n)} < 0$ )

**C_N_DIF_CRLC = C_N_DIF_CRLC** (per adjustment)

a2) Decreasing engine speed above nominal idle speed
**and** N_DIF **>** NC_N_DIF_MIN_CRLC **and** condition b) previously fulfilled :

**C_N_DIF_CRLC = 1**

b) Increasing engine speed above nominal idle speed
( $N\_DIF_{(n-3)} \geq N\_DIF_{(n)}$ **and** $N\_DIF_{(n)} < 0$)

**C_N_DIF_CRLC = 1**

c) Engine speed below nominal idle speed
($N\_DIF_{(n)} \geq 0$)

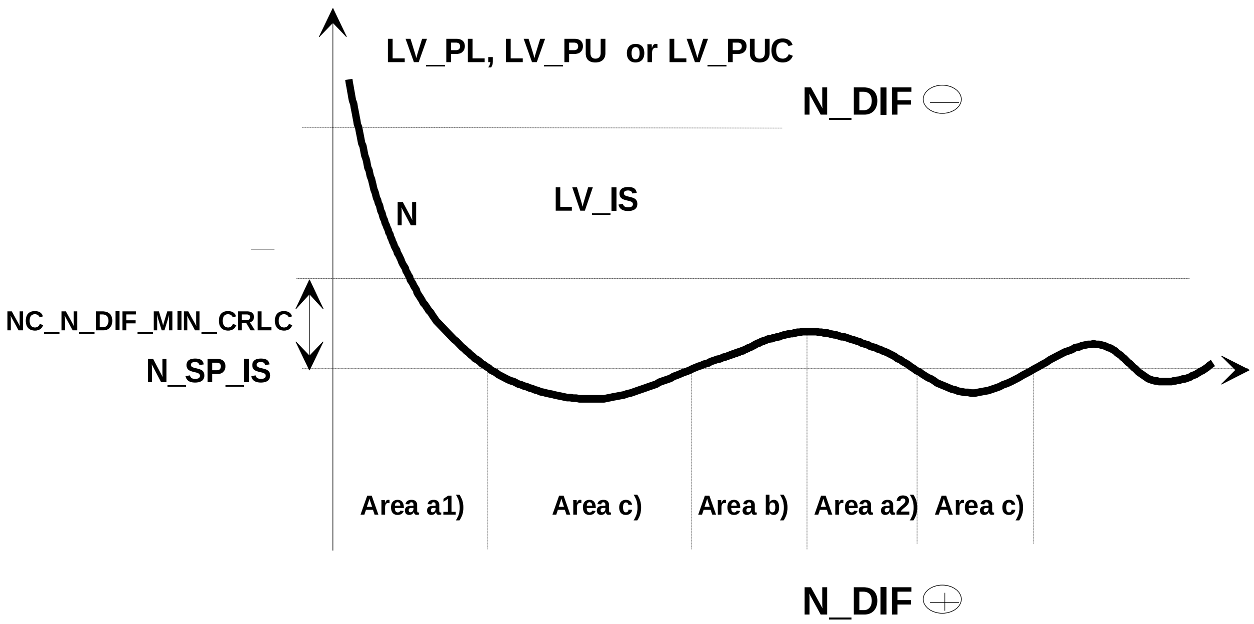
**C_N_DIF_CRLC = 0**

**Remark :** Limits of N_DIF_MMV : C_N_DIF_MIN_MMV ≤ N_DIF_MMV ≤ 0

N_DIF_MMV is set to 0 when exiting idle (LV_IS).

Description:






** N_DIF_COR calculation :*

N_DIF_COR is relevant for the idle controller (idle-charge actuator and ignition timing) :

**If** N ≤ NC_ISAPWM_N_MAX

**then** **N_DIF_COR = N_DIF - N_DIF_MMV * C_N_DIF_FAC**

**If** N > NC_ISAPWM_N_MAX

**then** **N_DIF_COR = 0**

## Calibration data:

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| C_N_DIF_CRLC | 1 | 00...FFH | 0...0,997 | 3,895E-3 | - |
| Correlation factor for N_DIF_MMV calculation. | | | | | |
| C_N_DIF_FAC | 1 | 00...FFH | 0...0,997 | 3,895E-3 | - |
| Multiplicative factor for N_DIF_COR calculation. | | | | | |
| C_N_DIF_MIN_MMV | 1 | F010...0000H | -4080...0 | 1 | rpm |
| Minimum threshold for N_DIF_MMV limitation. | | | | | |
| NC_N_DIF_MIN_CRLC | 1 | 8000...7FFFH | -32768...32767 | 1 | rpm |
| Engine speed deviation threshold - Non adjustable calibration. | | | | | |
| NC_ISAPWM_N_MAX | 1 | 0...FFH | 0...8160 | 32 | rpm |
| Maximum engine speed threshold for calculation of N_SP_IS and N_DIF - Non adjustable calibration. | | | | | |

## Applicative Values :

NC_N_DIF_MIN_CRLC = FEB0H = -150 rpm

NC_ISAPWM_N_MAX = 4EH = 2496 rpm

### 1.1.6 Engine running detected during last system run

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| LV_ENG_RUN_IS_PL | | 0...1H | 0...1 | 1 | - |
| Information bit for engine running detected during last system run | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| LV_ST | LV_IS | LV_PL | |

**General information:**

The bit LV_ENG_RUN_IS_PL is set at the transition from start to idle or partload and is reset at the transition out of powerlatch.

**Formula section:**

**If** transition from LV_ST = 1 to LV_IS = 1
**or** transition from LV_ST = 1 to LV_PL = 1
**then** LV_ENG_RUN_IS_PL = 1

**If** Transition out of power latch
**then** LV_ENG_RUN_IS_PL = 0

## 1.2 Mass air flow variables

### 1.2.1 Calculation of mass air flow correction MAF

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| MAF | V | 0...FFFFH | 0...1389 | 0.0212 | mg/TDC |
| Corrected mass air flow. | | | | | |

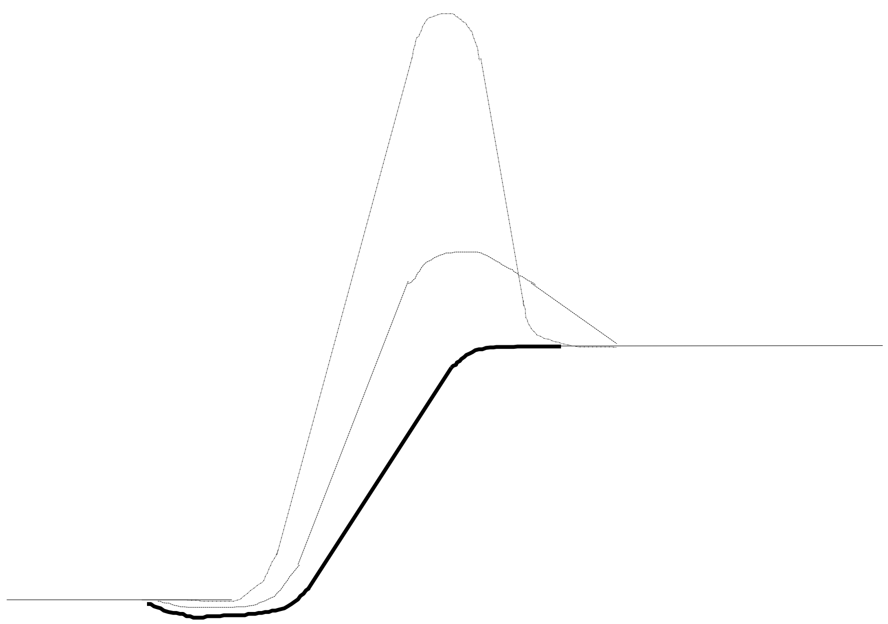
**Input data:**

| | | | |
|---|---|---|---|
| MAF_MES | N_32 | VS | LV_ST |
| LV_PUR | LV_AE | LV_INF | LV_IS |

**FUNCTION DESCRIPTION:**

General information:

In order to minimize the effect of the transient mode, the measured mass air flow MAF_MES is filtered. The corrected mass air flow is calculated for every engine operating state except start (LV_ST).



..-..-.. : air mass inflow measured

------- : induction pipe pressure curve

- - - - : corrected air mass

**Formula section:**

This correction is obtained using an adjustable time filtering factor which depends on the induction tract design and the engine operating state.

$$MAF_{(n)} = MAF_{(n-1)} + MAF\_CRLC * ( MAF\_MES - MAF_{(n-1)} )$$

The correlation factor MAF_CRLC depends on engine operating states.

Its computation is in accordance with the following algorithm :

a) **If** trailing throttle fuel reduction is set without acceleration enrichment
(LV_PUR = 1 and LV_AE = 0)

**then MAF_CRLC = IP_MAF_CRLC_PUR__N_32___MAF_MES**

**else**
b) **If** intercept function is set (LV_INF = 1)

**then MAF_CRLC = C_MAF_CRLC_INF**

**else**
c) **If** idle speed is set with vehicle stopped (LV_IS = 1 **and** VS = 0)

**then MAF_CRLC = C_MAF_CRLC_IS**

**else**
d) **If** trailing throttle is set or trailing throttle fuel cut off or idle speed
(LV_PU = 1 **or** LV - PUC = 1 **or** LV_IS = 1)

**then MAF_CRLC = IP_MAF_CRLC_PU__N_32**

**else**
e) **If** start is set (LS_ST = 1)

**then MAF_CRLC = 1**

**else**

**MAF_CRLC = IP_MAF_CRLC_PL__N_32__MAF_MES**

## Calibration data:

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| IP_MAF_CRLC_PL__N_32__MAF_MES | 6x6 | 0...FFH | 0...0.9961 | 0.0039 | - |
| MAF signal filtering factor triggered in part load. | | | | | |
| IP_MAF_CRLC_PUR__N_32__MAF_MES | 4x4 | 0...FFH | 0...0.9961 | 0.0039 | - |
| MAF signal filtering factor triggered in trailing throttle fuel reduction without acceleration enrichment. | | | | | |
| IP_MAF_CRLC_PU__N_32 | 4 | 0...FFH | 0...0.9961 | 0.0039 | - |
| MAF signal filtering factor triggered in trailing throttle or in trailing throttle fuel cut off or in idle with vehicle running. | | | | | |
| C_MAF_CRLC_IS | 1 | 00...FFH | 0...0.997 | 3.895E-3 | - |
| MAF signal filtering factor triggered in idle with vehicle stopped. | | | | | |
| C_MAF_CRLC_INF | 1 | 00...FFH | 0...0.997 | 3.895E-3 | - |
| MAF signal filtering factor triggered for intercept function. | | | | | |

### 1.2.2 Air mass difference for rapidly falling load MAF_MMV, MAF_MMV_DIF

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| MAF_MMV | V | 0...FFFFH | 0...1389 | 0.0212 | mg/TDC |
| MAF moving mean value. | | | | | |
| MAF_MMV_DIF | - | 0...FFH | 0...1389 | 5.45 | mg/TDC |
| Difference between MAF moving mean value and MAF. | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| MAF | LV_PL | LV_PU | LV_PUC |

**FUNCTION DESCRIPTION:**

General information:

In the case of rapidly falling load, the transition to trailing throttle fuel cut off can be accelerated in order to avoid an engine speed run-up, which is undesirable.

In order to trigger this function (see the following chapters: ignition, ignition angle correction for trailing throttle) some load conditions have to be fulfilled. For this reason, the values MAF_MMV and MAF_MMV_DIF are calculated from the corrected air mass MAF.

**Formula section:**

** MAF_MMV calculation :*

**If** $MAF_{(n)} \geq MAF_{(n-1)}$ (increasing mass air flow) **then :**

$$\mathbf{MAF\_MMV_{(n)} = MAF_{(n)}}$$

**If** $MAF_{(n)} < MAF_{(n-1)}$ (decreasing mass air flow) **then :**

$$\mathbf{MAF\_MMV_{(n)} = MAF\_MMV_{(n-1)} + ( MAF_{(n)} - MAF\_MMV_{(n-1)} ) * C\_MAF\_MMV\_DIF\_CRLC}$$

** MAF_MMV_DIF calculation :*

After transition (LV_PL) -> (LV_PU) :

$$\mathbf{MAF\_MMV\_DIF_{(n)} = MAF\_MMV_{(n)} - MAF_{(n)}}$$

**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| C_MAF_MMV_DIF_CRLC | 1 | 0...FFH | 0...0.996 | 0.0039 | - |
| MAF moving mean value filtering factor. | | | | | |

### 1.2.3 Mass air flow ratio calculation MAF_RATIO_PUR, MAF_RATIO_AE

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| MAF_RATIO_PUR | V | 00...FFH | 0...0.997 | 3.895E-3 | - |
| Mass air flow ratio for trailing throttle fuel reduction (LV_PUR). | | | | | |
| MAF_RATIO_AE | V | 00...FFH | 0...0.997 | 3.895E-3 | - |
| Mass air flow ratio for acceleration enrichment (LV_AE). | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| MAF | MAF_MES | LV_AE | LV_PUR |

**FUNCTION DESCRIPTION:**

**Formula section:**

** MAF_RATIO_PUR calculation for trailing throttle fuel reduction (LV_PUR = 1) :*

MAF_RATIO_PUR is the quotient between the uncorrected mass air flow currently measured and the last corrected mass air flow MAF when trailing throttle fuel reduction was triggered (LV_PUR).

**MAF_RATIO_PUR = MAF_MES / MAF** when LV_PUR was triggered

** MAF_RATIO_AE calculation for acceleration enrichment (LV_AE = 1) :*

MAF_RATIO_AE is the quotient between the last corrected mass air flow (MAF) when acceleration enrichment was triggered (LV_AE) and the uncorrected mass air flow currently measured.

**MAF_RATIO_AE = MAF** when LV_AE was triggered **/ MAF_MES**

### 1.2.4 Altitude correction MAF_FAC_ALTI, MAF_ALTI_COR

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| MAF_FAC_ALTI | V | 0...FFH | 0...1.992 | 7.78 E-3 | - |
| Mass air flow correction factor for altitude. | | | | | |
| MAF_FAC_ALTI_MMV | V/S | 0...FFH | 0...1.992 | 7.78 E-3 | - |
| Moving mean value of mass air flow correction factor for altitude. | | | | | |
| MAF_FAC_ALTI_MMV_CAN | V | 0...FFH | 0...100 | 0.392 | % |
| Moving mean value of mass air flow correction factor for altitude distributed via CAN. | | | | | |
| MAF_FAC_ALTI_MAX_PUC | - | 0...FFH | 0...1.992 | 7.78 E-3 | - |
| Maximum of mass air flow correction factor for altitude in current PUC-phase. | | | | | |
| MAF_ALTI_COR | V | 0...FFH | 0...1389 | 5.4 | mg/TDC |
| Mass air flow corrected versus atmospheric pressure. | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| MAF_KGH | MAF_KGH_SUB_DIAG | MAF | TCO |
| LV_MAF_ERR | LV_MAF_PLAUS_ERR | LV_TPS_ERR | LV_TPS_PLAUS_ERR |
| LV_IV_[CYL]_ERR | LV_ISA_i_ERR | LV_TIA_ERR | LV_WUP |
| LV_PL | LV_AE | LV_PUC | LV_PUR |

**FUNCTION DESCRIPTION:**

**Formula section:**

In order to take in account different atmospheric pressures at different altitudes, an altitude correction factor MAF_FAC_ALTI is calculated from division of MAF_KGH by MAF_SUB_DIAG_KGH. MAF_FAC_ALTI_MMV is the filtered value of MAF_FAC_ALTI.
The correction factor is calculated in different ways in engine operation state trailling throttle fuel cut-off (LV_PUC = 1) and the other engine operation states, as only an increase of the correction factor is allowed in PUC. The calculation is started after the time C_T_MAF_ALTI_MIN_PUC has ellapsed and the MAF_FAC_ALTI-increase is limited during one PUC-phase to C_MAF_FAC_ALTI_DIF_MAX_PUC.

The altitude correction is applied to TIPR_CST, TI_CST and ISAPWM_INI_I_ST during start, to evaporative emission control in MIN- and NORMAL-operation.

MAF_ALTI_COR is the mass air flow corrected to sea level, which is used for ISA-adaptation, ISAPWM-calculation with activated A/C, LAM_TRA-calculation and for the canister-purge conditions (see corresponding chapters).

*Calculation of MAF_FAC_ALTI:*

MAF_FAC_ALTI is calculated in all engine operation states:

**MAF_FAC_ALTI = MAF_KGH / MAF_KGH_SUB_DIAG**

Application recurrence : **1 sec.**

*Calculation of MAF_FAC_ALTI_MMV :*

a.) Out of trailing throttle fuel cut-off (LV_PUC = 0)

**If** MAF > C_MAF_ALTI_MIN

**and** TCO > C_TCO_MAF_ALTI_MIN
**and** TPS > C_TPS_MAF_ALTI_MIN
**and** part load is set without acceleration enrichment, trailing throttle fuel cut-off reduction and out of warm-up (LV_PL = 1 and LV_PUR = 0 and LV_AE = 0 and LV_WUP= 0)
**and** no error currently present for the mass air flow sensor (LV_MAF_ERR = 0 and LV_MAF_PLAUS_ERR = 0)
**and** no error currently present for the throttle position sensor (LV_TPS_ERR = 0 and LV_TPS_PLAUS_ERR = 0)
**and** no error currently present for the injector valves (LV_IV_[CYL]_ERR = 0)
**and** no error currently present for idle charge actuator command (LV_ISA_i_ERR = 0)
**and** no error currently present for air intake temperature sensor (LV_TIA_ERR = 0)

**then**

$$\mathbf{MAF\_FAC\_ALTI\_MMV_{(n)} = MAF\_FAC\_ALTI\_MMV_{(n-1)} * (1 - C\_MAF\_FAC\_ALTI\_CRLC) + (MAF\_FAC\_ALTI * C\_MAF\_FAC\_ALTI\_CRLC)}$$

MAF_FAC_ALTI_MAX_PUC = MAF_FAC_ALTI_MMV + C_MAF_FAC_ALTI_DIF_MAX_PUC
*(maximum increase of MAF_FAC_ALTI_MMV in next PUC-phase)*

**If** MAF_FAC_ALTI_MMV < C_MAF_FAC_ALTI_MMV_MIN
**then** MAF_FAC_ALTI_MMV = C_MAF_FAC_ALTI_MMV_MIN
*(Limitation to lower limit)*

**If** MAF_FAC_ALTI_MMV > C_MAF_FAC_ALTI_MMV_MAX
**then** MAF_FAC_ALTI_MMV = C_MAF_FAC_ALTI_MMV_MAX
*(Limitation to upper limit)*

b.) In trailing throttle fuel cut-off (LV_PUC = 1)

**If** time C_T_MAF_ALTI_MIN_PUC ellapsed since transition from PL to PUC
**and** TCO > C_TCO_MAF_ALTI_MIN
**and** no error currently present for the mass air flow sensor (LV_MAF_ERR = 0 and LV_MAF_PLAUS_ERR = 0)
**and** no error currently present for the throttle position sensor (LV_TPS_ERR = 0 and LV_TPS_PLAUS_ERR = 0)
**and** no error currently present for the injector valves (LV_IV_[CYL]_ERR = 0)
**and** no error currently present for idle charge actuator command (LV_ISA_i_ERR = 0)
**and** no error currently present for air intake temperature sensor (LV_TIA_ERR = 0)

**then**

**If** (MAF_FAC_ALTI - MAF_FAC_ALTI_MMV) > C_MAF_FAC_ALTI_DIF_MIN_PUC
*(Only increasing values are taken in account, i.e. downhill-drive assumed)*

**then**

$$\mathbf{MAF\_FAC\_ALTI\_MMV_{(n)} = MAF\_FAC\_ALTI\_MMV_{(n-1)} * (1 - C\_MAF\_FAC\_ALTI\_CRLC) + (MAF\_FAC\_ALTI * C\_MAF\_FAC\_ALTI\_CRLC)}$$

**If** MAF_FAC_ALTI_MMV > MAF_FAC_ALTI_MAX_PUC
**then** MAF_FAC_ALTI_MMV = MAF_FAC_ALTI_MAX_PUC
*(Limitation for this PUC-phase)*

**If** MAF_FAC_ALTI_MMV > C_MAF_FAC_ALTI_MMV_MAX
**then** MAF_FAC_ALTI_MMV = C_MAF_FAC_ALTI_MMV_MAX
*(Limitation to upper limit)*

**If** MAF_FAC_ALTI_MMV < C_MAF_FAC_ALTI_MMV_MIN
**then** MAF_FAC_ALTI_MMV = C_MAF_FAC_ALTI_MMV_MIN
*(Limitation to lower limit)*

Application recurrence : **1 sec.**

MAF_FAC_ALTI_MMV is stored in non-volatile memory. At each new start MAF_FAC_ALTI_MAX_PUC is calculated from the stored value of MAF_FAC_ALTI_MMV.
For a new car MAF_FAC_ALTI_MMV is initialised to 1.

*Calculation of MAF_ALTI_COR :*

**MAF_ALTI_COR = MAF / MAF_FAC_ALTI_MMV**

MAF_ALTI_COR is calculated every **100 msec**, even if the conditions for renewal of MAF_FAC_ALTI_MMV are not fulfilled. In this case the last calculated value MAF_FAC_ALTI_MMV is used.

**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| C_MAF_ALTI_MIN | 1 | 0...FFFFH | 0...1389 | 0.0212 | mg/TDC |
| MAF-Threshold for calculation of MAF_FAC_ALTI. | | | | | |
| C_TCO_MAF_ALTI_MIN | 1 | 0...FEH | -48...142.5 | 0.75 | °C |
| TCO-threshold for calculation of MAF_FAC_ALTI. | | | | | |
| C_TPS_MAF_ALTI_MIN | 1 | 0...FF | 0...119.5 | 0.47 | °TPS |
| TPS-threshold for calculation of MAF_FAC_ALTI. | | | | | |
| C_T_MAF_ALTI_MIN_PUC | 1 | 0...FFH | 0...255 | 1 | sec |
| Time delay after which calculation of MAF_FAC_ALTI is allowed in PUC. | | | | | |
| C_MAF_FAC_ALTI_CRLC | 1 | 0...FFH | 0...0.997 | 3.895E-3 | - |
| MAF_FAC_ALTI_MMV filtering factor. | | | | | |
| C_MAF_FAC_ALT_DIF_MAX_PUC | 1 | 0...FFH | 0...1.992 | 7.78 E-3 | - |
| Maximum difference to preceding MAF_FAC_ALTI_MMV -value at entrance in PUC. | | | | | |
| C_MAF_FAC_ALT_DIF_MIN_PUC | 1 | 0...FFH | 0...1.992 | 7.78 E-3 | - |
| Minimum difference between MAF_FAC_ALTI and MAF_FAC_ALTI_MMV to calculate MAF_FAC_ALTI_MMV in PUC. | | | | | |
| C_MAF_FAC_ALTI_MMV_MIN | 1 | 0...FFH | 0...1.992 | 7.78 E-3 | - |
| Lower limit of MAF_FAC_ALTI_MMV. | | | | | |
| C_MAF_FAC_ALTI_MMV_MAX | 1 | 0...FFH | 0...1.992 | 7.78 E-3 | - |
| Upper limit of MAF_FAC_ALTI_MMV. | | | | | |

## 1.3 Throttle angle variables

### 1.3.1 Throttle potentiometer adaptation TPS_AD_MMV_IS

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| TPS_AD_MMV_IS | V/S | 0...FFC0H | 0...119,5 | 0,001825 | °TPS |
| Minimum throttle angle adaptation. | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| TPS_MES | LV_TPS_ERR | LV_VS_ERR | VS |
| TPS | | | |

**FUNCTION DESCRIPTION:**

#### 1.3.1.1 Initialization of throttle potentiometer adaptation

- If the car is “new“ or the control unit not previously initialized, the throttle potentiometer adaptation is initialized with the following algorithm :

**If** TPS_MES < C_TPS_MIN_MAF_KGH_DIAG

**then** $TPS\_AD\_MMV\_IS_{(0)}$ = C_TPS_MAX_IS

**else** $TPS\_AD\_MMV\_IS_{(0)}$ = TPS_MES + C_TPS_ADD

- Whenever the control unit is initialized (transition Key OFF->ON and power latch was elapsed):

**If** TPS_MES > TPS_AD_MMV_IS

**then** $TPS\_AD\_MMV\_IS_{(n)} = TPS\_AD\_MMV\_IS_{(n-1)}$ + C_TPS_ADD

**else** $TPS\_AD\_MMV\_IS_{(n)} = TPS\_AD\_MMV\_IS_{(n-1)}$

### 1.3.1.2 Calculation of the throttle potentiometer adaptation TPS_AD_MMV_IS



General information:

The throttle potentiometer adaptation is performed every **1000 ms**.

**Formula section:**

- General formula for TPS_AD_MMV_IS:

**If** TPS < C_TPS_IS (LV_CT = 1)
**and** no error currently present on the throttle position sensor (LV_TPS_ERR = 0)

**then** $TPS\_AD\_MMV\_IS_{(n)} = TPS\_AD\_MMV\_IS_{(n-1)} + C\_TPS\_AD\_CRLC * (TPS\_MES_{(n)} - TPS\_AD\_MMV\_IS_{(n-1)})$

- Limitation for updating TPS_AD_MMV_IS value:

**If** VS = 0
**or** Error currently present on vehicle speed (LV_VS_ERR = 1)

**then** **$TPS\_AD\_MMV\_IS_{(n)}$ can not be increased by more than C_TPS_ADD compared to $TPS\_AD\_MMV\_IS_{(n-1)}$**

**else** **$TPS\_AD\_MMV\_IS_{(n)}$ can not be increased compared to $TPS\_AD\_MMV\_IS_{(n-1)}$**



**Remark :** (n-1) = adaptation value from last adaptation before conditions of calculation or adaptation value stored up to control unit reset.

- General limitation:

TPS_AD_MMV_IS ≤ C_TPS_MAX_IS

- TPS_AD_MMV_IS value in case of TPS failure:

**If** LV_TPS_ERR **=** 1
**then**
$TPS\_AD\_MMV\_IS_{(n)}$ and $TPS\_AD\_MMV\_IS_{(n-1)}$ are set to C_TPS_MAX_IS

## Calibration data:

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| C_TPS_MIN_MAF_KGH_DIAG | 1 | 0...FFH | 0...119,5 | 0,47 | °TPS |
| TPS-threshold for detection of MAF-signal line short to ground or broken. | | | | | |
| C_TPS_MAX_IS | 1 | 0...FFH | 0...119,5 | 0,47 | °TPS |
| Maximum TPS_AD_MMV_IS value | | | | | |
| C_TPS_ADD | 1 | 0...FFH | 0...119,5 | 0,47 | °TPS |
| Additive offset. | | | | | |
| C_TPS_IS | 1 | 0...FFH | 0...119,5 | 0,47 | °TPS |
| Closed throttle detection threshold. | | | | | |
| C_TPS_AD_CRLC | 1 | 00...FFH | 0...0,997 | 3,895E-3 | °TPS |
| TPS_AD_MMV_IS filtering factor. | | | | | |

### 1.3.2 Closed throttle definition LV_CT



**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| LV_CT | V | 0...01H | 0...1 | 1 | - |
| Closed throttle information. | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| TPS | | | |

**FUNCTION DESCRIPTION:**

**Formula section:**

The closed throttle information LV_CT is defined as follows :

**If** TPS < C_TPS_IS

**then** LV_CT = 1

**else** LV_CT = 0

### 1.3.3 Throttle gradient TPS_GRD

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| TPS_GRD | V | FF01...00FFH | - 2988...2988 | 0,0912 | °TPS/sec |
| Throttle position gradient. | | | | | |

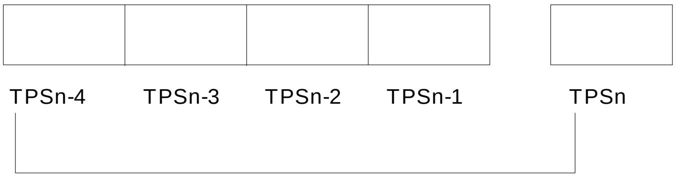
**Input data:**

| | | | |
|---|---|---|---|
| TPS | | | |

**FUNCTION DESCRIPTION:**

**Formula section:**

The application recurrence is **10 msec**.
Therefore, the converted throttle values are written into a ring buffer. This means that the last four throttle values are available in addition to the current throttle value.




The throttle gradient is based on the change in throttle angle over **40 ms**.

$$\mathbf{TPS\_GRD = ( TPS_{(n)} - TPS_{(n-4)} ) * 25}$$

### 1.3.4 Full load throttle threshold LV_TPS_FL

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| LV_TPS_FL | V | 0...01H | 0...1 | 1 | - |
| Full load throttle position information. | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| TPS | | | |

**FUNCTION DESCRIPTION:**

**Formula section:**

*Activation conditions:*

**If** TPS ≥ ID_TPS_FL__N_32

**then** LV_TPS_FL = **1**

*Deactivation conditions:*

**If** LV_TPS_FL = 1 **and** TPS < ID_TPS_FL__N_32 - C_TPS_HYS_FL

**then** LV_TPS_FL= **0**

**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| ID_TPS_FL__N_32 | 16 | 0...FFH | 0...119,5 | 0,47 | °TPS |
| | | | | | |
| Throttle position threshold for full load detection. | | | | | |
| C_TPS_HYS_FL | 1 | 0...FFH | 0...119,5 | 0,47 | °TPS |
| Throttle position hysteresis for full load detection. | | | | | |

## 1.4 Vehicle speed variables

### 1.4.1 Vehicle speed VS

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| VS | V | 0...FFH | 0...255 | 1 | km/h |
| Vehicle speed. | | | | | |
| VS_MIN | - | 0...FFH | 0...255 | 1 | km/h |
| Minimum vehicle speed to detect vehicle stopped | | | | | |
| VS_MAX | - | 0...FFH | 0...255 | 1 | km/h |
| Maximum vehicle speed. | | | | | |
| VS_FAC | - | 03E8...7530H | 1000...30000 | 1 | Pulse /km |
| Factor to calculate vehicle speed in km/h | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| VS_SEG_T_MES | SEG_T_MES_0_RR | CONF_VS | |



**FUNCTION DESCRIPTION:**

General information:

Application recurrence is **10 msec.**

With the configuration byte CONF_VS, different possibilities of vehicle speed acquisition are configurable (gear box, inductive wheel sensor, ABS/TCS electronic unit). The following variables are automatically adjusted according to CONF_VS:

- VS_MIN : minimum vehicle speed to detect vehicle stopped
- VS_MAX : maximum vehicle speed
- VS_FAC : factor to make the conversion from pulse to km/h

**Formula section:**

- VS_MIN, VS_MAX, VS_FAC calculation:

**If** CONF_VS **=** 0

**then** VS_MIN **=** C_VS_MIN_0
VS_MAX **=** C_VS_MAX_0
VS_FAC **=** C_VS_FAC_0

**else** VS_MIN **=** C_VS_MIN_1_2
VS_MAX **=** C_VS_MAX_1_2
VS_FAC **=** C_VS_FAC_1_2

The calculation is performed once after system reset.

- VS_SEG_T_MES and SEG_T_MES_0_RR definition :

VS_SEG_T_MES is used in case of signal coming from the Gearbox (CONF_VS=0). It is the time for 1 teeth averaged over 4 last tooth.

SEG_T_MES_0_RR is used in case of signal coming from the Wheel (CONF_VS=1 or 2). It is the time for 4 tooth.

(Time resolution is 4 µsec)

- VS calculation :

**If** CONF_VS **=** 0

**then** VS **=** ( 3600 * $10^6$ ) / ( VS_FAC * VS_SEG_T_MES )

**else**

VS **=** ( 900 * $10^6$ ) / ( VS_FAC * SEG_T_MES_0_RR )

( VS is set to 0 is VS < VS_MIN)

**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| C_VS_MIN_0 | 1 | 0...FFH | 0...255 | 1 | km/h |
| Minimum Vehicle speed for Vehicle Stop Detection if CONF_VS = 0 | | | | | |
| C_VS_MIN_1_2 | 1 | 0...FFH | 0...255 | 1 | km/h |
| Minimum Vehicle speed for Vehicle Stop Detection if CONF_VS = 1 or 2 | | | | | |
| C_VS_MAX_0 | 1 | 0...FFH | 0...255 | 1 | km/h |
| Maximum Vehicle speed if CONF_VS = 0 | | | | | |
| C_VS_MAX_1_2 | 1 | 0...FFH | 0...255 | 1 | km/h |
| Maximum Vehicle speed if CONF_VS = 1 or 2 | | | | | |
| C_VS_FAC_0 | 1 | 03E8...7530H | 1000...30000 | 1 | Pulse/km |
| Number of Pulses/km which appear on the ECU Input if CONF_VS = 0 | | | | | |
| C_VS_FAC_1_2 | 1 | 03E8...7530H | 1000...30000 | 1 | Pulse/km |
| Number of Pulses/km which appear on the ECU Input if CONF_VS = 1 or 2 | | | | | |

### 1.4.2 Vehicle speed for rough road detection VS_RR

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| VS_RR | 1 | 0...FFH | 0...255 | 1 | km/h |
| Vehicle speed used for rough road detection. | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| CONF_MIS | VS | | |

**FUNCTION DESCRIPTION:**

General information:

Application recurrence is **10 msec**.

**Formula section:**

**If** CONF_MIS **=** 1

**then** VS_RR **=** VS

**else** VS_RR **=** 0

### 1.4.3 Vehicle speed state VS_STATE_CFA

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| VS_STATE_CFA | V | 0...02H | 0...2 | 1 | - |
| Vehicle speed state for cooling fans. | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| VS | LV_ACCIN | LV_VS_ERR | |

**FUNCTION DESCRIPTION:**

General information:

The fans are controlled according to the vehicle speed. For this purpose, a vehicle speed state is determined. The vehicle speed thresholds are different if the air conditioner is selected or not.

**Formula section:**

*Initialization:*

At ECU initialization, VS_STATE_CFA is set to 0.

*Calculation :*

* LV_ACCIN = 0

**If** ( VS_STATE_CFA = 0 **and** VS **>** C_VS_2_CFA )
**then** VS_STATE_CFA **= 1**
**If** ( VS_STATE_CFA = 1 **and** VS **<** C_VS_2_CFA - C_VS_HYS_1_CFA )
**then** VS_STATE_CFA **= 0**

* LV_ACCIN = 1

**If** ( VS_STATE_CFA = 0 **and** VS **>** C_VS_1_CFA )
**then** VS_STATE_CFA **= 1**
**If** ( VS_STATE_CFA = 1 **and** VS **<** C_VS_1_CFA - C_VS_HYS_1_CFA )
**then** VS_STATE_CFA **= 0**

* Independently of LV_ACCIN

**If** ( VS_STATE_CFA = 1 **and** VS **>** C_VS_3_CFA )
**then** VS_STATE_CFA **= 2**
**If** ( VS_STATE_CFA = 2 **and** VS **<** C_VS_3_CFA - C_VS_HYS_2_CFA )
**then** VS_STATE_CFA **= 1**

**Remark :** C_VS_1_CFA **<** C_VS_2_CFA **<** C_VS_3_CFA

*Limp Home :*

**If** LV_VS_ERR **=** 1 *(Error currently present on vehicle speed sensor)*

**then** VS_STATE_CFA **=** 0

**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| C_VS_1_CFA | 1 | 0...FFH | 0...255 | 1 | km/h |
| Vehicle speed threshold for fans management. | | | | | |
| C_VS_2_CFA | 1 | 0...FFH | 0...255 | 1 | km/h |
| Vehicle speed threshold for fans management. | | | | | |
| C_VS_3_CFA | 1 | 0...FFH | 0...255 | 1 | km/h |
| Vehicle speed threshold for fans management. | | | | | |
| C_VS_HYS_1_CFA | 1 | 0...FFH | 0...255 | 1 | km/h |
| Vehicle speed hysteresis for VS_STATE_CFA transition 1 -> 0. | | | | | |
| C_VS_HYS_2_CFA | 1 | 0...FFH | 0...255 | 1 | km/h |
| Vehicle speed hysteresis for VS_STATE_CFA transition 2 -> 1. | | | | | |

## 1.5 Coolant temperature variables

### 1.5.1 Coolant temperature TCO

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| TCO | V | 0...FEH | -48...142,5 | 0,75 | °C |
| Coolant temperature. | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| TCO_MES | | | |

**FUNCTION DESCRIPTION:**

General information:

The temperature TCO_MES is monitored for unplausible gradient.

**TCO = TCO_MES**

Exception :

The difference between the old and the new TCO_MES value exceeds the permissible gradient C_TCO_GRD_MAX_DIAG, then the TCO value remains unchanged.

During the next measurement, if the maximum gradient is exceeded again, the new measured value will be stored in the RAM.

Errors are not stored with the monitoring of gradients. The only purpose is to extract implausible measured values (malfunctions).

**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| C_TCO_GRD_MAX_DIAG | 1 | 0...FEH | 0...190,5 | 0,75 | °C/500msec |
| Maximum coolant temperature gradient for diagnostic. | | | | | |

## 1.5.2 Coolant temperature at start TCO_ST



**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| TCO_ST | V/S | 0...FEH | -48...142,5 | 0,75 | °C |
| Coolant temperature at engine operating state start (LV_ST). | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| TCO | LV_ST | | |

TCO_ST is the coolant temperature at the time of transition from engine stop (LV_ES) to start (LV_ST). It is updated with the current TCO-value as long as the engine operation state start (LV_ST) is not exited to idle or part load.

### 1.5.3 Coolant temperature at re-start TCO_REST



**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| TCO_REST | V/S | 0...FEH | -48...142,5 | 0,75 | °C |
| Coolant temperature stored to detect a re-start event. | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| TCO | N | LV_ES | IP_N_MAX_TOL_ST__TCO |

**FUNCTION DESCRIPTION:**

General information:



A timer is started when N ≥ IP_N_MAX_TOL_ST__TCO.

If the engine operating state engine stopped (LV_ES) is detected after idle or part load before the timer has reached it's maximum value C_T_MAX_REST, the related coolant temperature is stored :

**TCO_REST** ← TCO

Instead if the engine operating state engine stopped (LV_ES) is detected after the timer has reached it's maximum, FFH is stored. If the engine stalls before N is exceeding IP_N_MAX_TOL_ST__TCO FFH is stored also.

TCO_REST is used as input for the restart-detection function.

**Calibration data:**

| Name | Type | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|---|
| C_T_MAX_REST | 2U | 1 | 1...FFFFH | 0,01...655,35 | 0,01 | sec |
| Duration between LV_IS and LV_ES, to detect LV_REST. | | | | | | |

## 1.6 Intake Air Temperature Variable TIA

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| TIA | V | 0...FEH | -48...142,5 | 0,75 | °C |
| Induction air temperature | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| TIA_MES | | | |

**FUNCTION DESCRIPTION:**

General information:

The temperature TIA_MES is monitored for unplausible gradient.

**TIA = TIA_MES**

Except if :

The difference between the old and the new TIA_MES value exceeds the permissible gradient C_TIA_GRD_MAX_DIAG, then the TIA value remains unchanged.

During the next measurement, if the maximum gradient is exceeded again, the new measured value will be stored in the RAM.

Errors are not stored with the monitoring of gradients. The only purpose is to extract implausible measured values (malfunctions).

**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| C_TIA_GRD_MAX_DIAG | 1 | 0...FEH | 0...190,5 | 0,75 | °C/500msec |
| Maximum induction air temperature gradient for diagnostic. | | | | | |

### 1.6.1 Intake Air Temperature at Start TIA_ST

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| TIA_ST | V | 0...FEH | -48...142,5 | 0,75 | °C |
| Intake Air Temperature at engine operating state start (LV_ST). | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| TIA | LV_ST | | |

TIA_ST is the Intake Air Temperature at the time of transition from engine stop (LV_ES) to start (LV_ST).

## 1.7 Gear ratio

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| GR_MT | V | 0...5H | 0...5 | 1 | - |
| Gear Ratio for M/T vehicle | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| CONF_TCU | CRK_VS_RR_N_RATIO_OSC | LV_VS_ERR | LV_CRK_ERR |
| VS | | | |

**FUNCTION DESCRIPTION:**

General information:

In order to improve driveability with M/T vehicle, engaged gear ratio detection is needed for various functions :

- Minimum engine speed for fuel cut-off
- Activation for injection pattern at rewetting

**Formula section:**

**If** CONF_TCU **=** 0
**and** LV_VS_ERR **=** 0
**and** LV_CRK_ERR **=** 0
**and** VS **>** 0
**Then**
GR_MT **=** ID_GR_MT__CRK_VS_RR_N_RATIO_OSC
**Else**
GR_MT **=** 0

**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| ID_GR_MT | 6 | 00...05H | 0...5 | 1 | - |
| | | | | | |
| Gear ratio determination | | | | | |

## 1.8 Idle speed actuator variables

### 1.8.1 Time delay to apply drive correction

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| LV_DRI_ISAPWM | V | 0...01H | 0...1 | 1 | - |
| Boolean for DRIVE or REVERSE engaged ( - / DRI ) with time delay applied. | | | | | |

**Input data:**

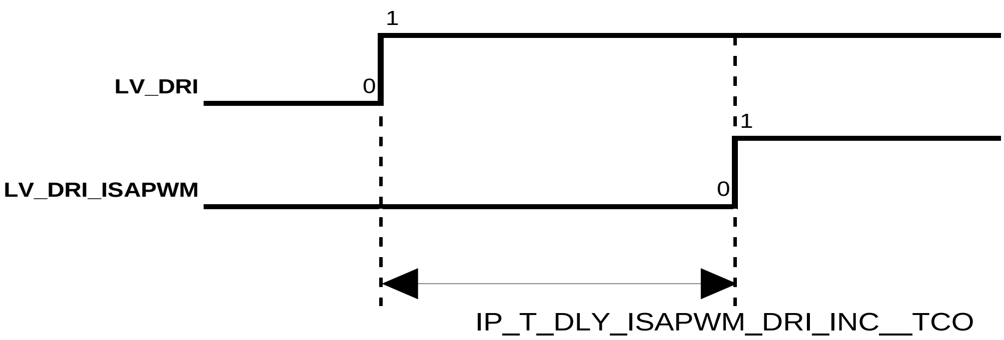
| | | | |
|---|---|---|---|
| LV_DRI | | | |

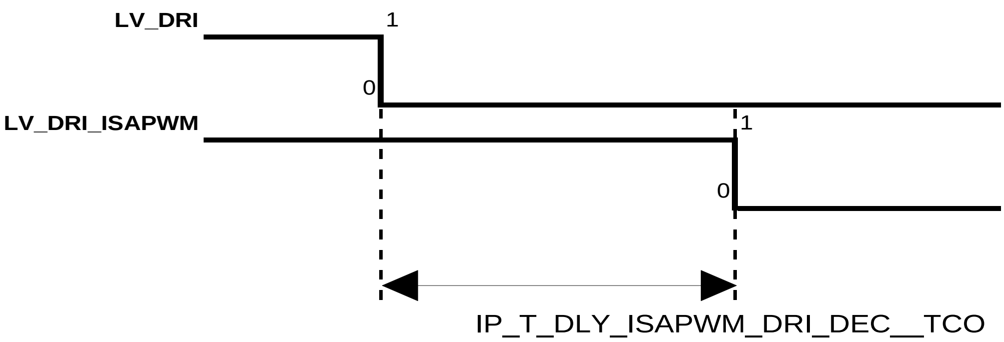
**FUNCTION DESCRIPTION:**

*Engagement of DRIVE:*

At transition from PARK/NEUTRAL to DRIVE (LV_DRI changes from 0 to 1) LV_DRI_ISAPWM is changed in the same way as LV_DRI after the time delay IP_T_DLY_ISAPWM_DRI_INC__TCO has ellapsed. In opposite direction, i.e. at transition from DRIVE to PARK/NEUTRAL (LV_DRI changes from 1 to 0), LV_DRI_ISAPWM is also changed like LV_DRI after IP_T_DLY_ISAPWM_DRI_DEC__TCO has ellapsed.

These time delays are used to counteract the temperature influence of the converter, which locks the clutch when the DRIVE position is engaged.



*Engagement of REVERSE:*

At transition from PARK/NEUTRAL to REVERSE additional to the time delay IP_T_DLY_ISAPWM_DRI_INC__TCO for engaging DRIVE the time delay C_T_DLY_ISAPWM_DRI_INC has to be ellapsed before LV_DRI_ISAPWM is changed in the same way as LV_DRI:

IP_T_DLY_ISAPWM_DRI_INC__TCO + C_T_DLY_ISAPWM_RVS_INC

In opposite direction, i.e. at transition from REVERSE to PARK/NEUTRAL, LV_DRI_ISAPWM is changed like LV_DRI after IP_T_DLY_ISAPWM_DRI_DEC__TCO + C_T_DLY_ISAPWM_DRI_DEC has ellapsed.

IP_T_DLY_ISAPWM_DRI_DEC__TCO + C_T_DLY_ISAPWM_RVS_DEC

**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| C_T_DLY_ISAPWM_RVS_INC | 1 | 0...FFH | -1.27...1.28 | 10 | msec |
| Additional time delay to apply Idle charge - actuator opening increase at engage of REVERSE. | | | | | |
| C_T_DLY_ISAPWM_RVS_DEC | 1 | 0...FFH | -1.27...1.28 | 10 | msec |
| Additional time delay to apply Idle charge - actuator opening decrease at disengage of REVERSE. | | | | | |
| IP_T_DLY_ISAPWM_DRI_INC__TCO | 6 | 0...FFH | 0...2.55 | 10 | msec |
| Time delay to apply Idle charge - actuator opening increase at engage of DRIVE. | | | | | |
| IP_T_DLY_ISAPWM_DRI_DEC__TCO | 6 | 0...FFH | 0...2.55 | 10 | msec |
| Time delay to apply Idle charge - actuator opening decrease at disengage of DRIVE. | | | | | |

| | |
|---|---|
| Document: | **Engine operating states** |
| Project: | **Engine Management System** |
| | **HMC_V6** |
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|---|---|---|---|---|---|
| Author | Müller O. | AT PT SI TSA 11 | 3211 | 09.12.97 | |
| 1. Check | Pioch O. | AT PT SI TSA 11 | 3212 | 09.12.97 | |
| 2. Check | Gessner S. | AT PT SI TSA 11 | 5398 | 09.12.97 | |
| Responsible | Brückner D. | AT PT SI TSA 16 | 4279 | 09.12.97 | |

## Version list

| Version | Date | Author | Comment, Description |
|---|---|---|---|
| | | | |

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## C

## 1.1 General

A distinction is made on principle between the basic operating states and the auxiliary functions.

The basic operating states (e.g. **LV_ES**, **LV_ST**, **LV_IS**, **LV_PL**, **LV_PU** & **LV_PUC**) are independent basic functions which can only occur alternatively. Contrary to this, auxiliary functions can be simultaneously active and they always are superimposed on a basic operating state.

### 1.1.1 Engine operating state detection

General information:

If the detection of an engine operating state influences several output signals, this engine operating state is described in the chapter " Basic Operating States ".

The engine operating state transitions are dependent on **throttle position** and **engine speed.**

The driver must be able to switch - off the engine by the ignition key in any operating state. To implement this, the battery voltage is measured.

For more explanations, refer to " Acquisition of ignition key battery voltage " in the major chapter " Inputs ".

### 1.1.2 Power Latch

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| PWL_DLY_CTR | V | 0...FFH | 0...255 | 1 | - |
| Display lock of power latch resources by several functions | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| LV_IGK | LV_ES | | |

General information:

Ignition key on activates the power supply. The controller then starts initialization. During initialization the main relay is switched on. All actuators are supplied by the main relay with battery voltage, except ignition coils which are supplied from ignition key.

The power latch function is activated after ignition key off recognition and engine stopped. The power latch function holds the main relay active (and therefore the power supply) for a certain time. In this time for example learned values and detected failures can be stored to the flash. After expiration of the delay time main relay and power supply are switched off by the controller.
Furthermore certain functionalities can request continuation of post operating phase by increment of PWL_DLY_CTR. If they need no more power latch ressources, they can stop their request by decrementation of PWL_DLY_CTR.

The detection of power latch is done every 10 ms.

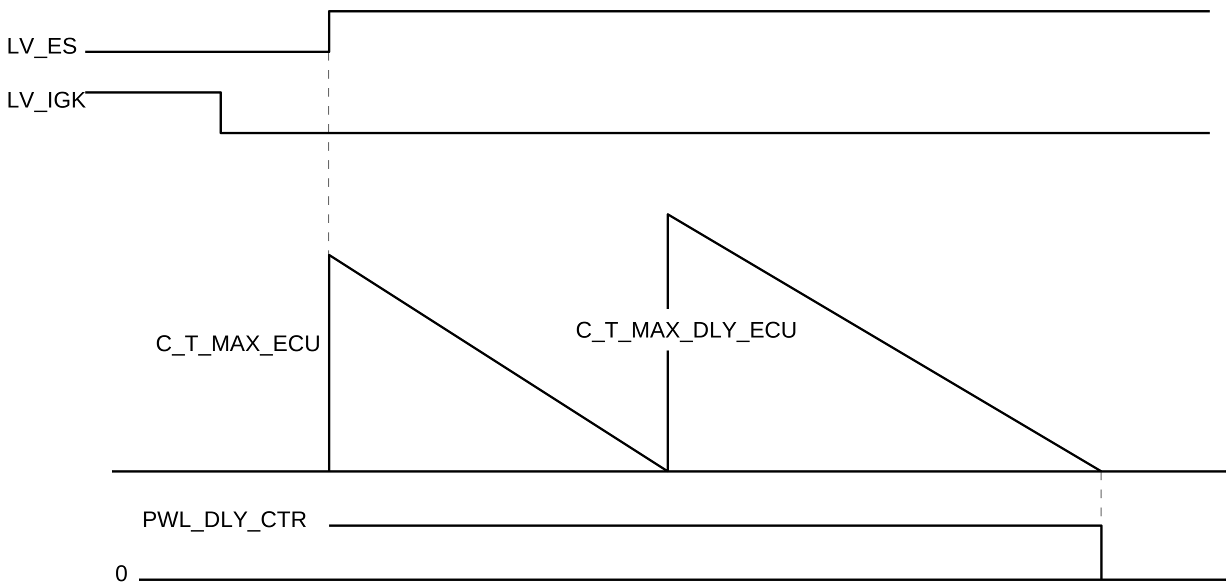
## Application conditions:

*Activation:*

During initialization, main relay is switched to on.

*Deactivation:*

If the conditions (LV_IGK = 0) AND (LV_ES = 1) are fulfilled for an uninterrupted time C_T_MAX_ECU and PWL_DLY_CTR = 0, main relay and power supply are switched to off. After expiration of C_T_MAX_ECU a timer C_T_MAX_DLY_ECU will be initialized if PWL_DLY_CTR ≠ 0 and main relay is switched off latest after expiration of C_T_MAX_DLY_ECU.




## Calibration data:

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| C_T_MAX_ECU | 1 | 0...FFFFH | 0...65535 | 1 | s |
| Duration of the normal power latch | | | | | |
| C_T_MAX_DLY_ECU | 1 | 0...FFFFH | 0...65535 | 1 | s |
| Maximum on-time of ECU after ignition key off. | | | | | |

#### 1.1.2.1 Function initialization

After initialization of the operating system and self - diagnosis of the control unit, the engine functions are assigned to their initial values.

The first measured values are diagnosed and backup values are made available as appropriate.

#### 1.1.2.2 Reset with the system running

**Input data:**

| | | | |
|---|---|---|---|
| N | NC_N_MIN | N_32 | IP_N_MAX_TOL_ST__TCO |
| LV_ST | | | |

**FUNCTION DESCRIPTION:**

General information:

If a reset occurs for N ≥ NC_N_MIN, initialization is performed as for an under-voltage reset.

In the case of an engine speed N_32 ≥ IP_N_MAX_TOL_ST__TCO the engine operating state start (LV_ST) is not executed.

Instead, the system immediately branches to the current engine operating state.

### 1.1.3 Engine operating state “ Engine Stopped ” ( LV_ES )



**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| LV_ES | V | 0...01H | 0...1 | 1 | - |
| Engine operating state ” Engine Stopped ” - Engine Operating State = ES. | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| LV_IGK | LV_ST | N | NC_N_MIN |

**FUNCTION DESCRIPTION:**

General information:

The engine operating state engine stopped (LV_ES) is characterized by ignition key **on** ( LV_IGK **= 1** (Active) ) and N **<** NC_N_MIN.

In this engine operating state, the functions are assigned to initialization values.

The entire scope of diagnosis and actuator control is accessible.

**Application conditions:**

*Deactivation:*

Exit to **LV_ST :** Start

During the synchronisation phase, the tooth duration is taken into account to calculate the engine speed.

**If** N ≥ NC_N_MIN is detected in the operating state engine stopped (LV_ES)

**then** the fuel pump is switched on

*(refer to chapter : “ Relays control “ in major chapter “ Auxiliary Functions “)*

**and** the first injection is performed

*(refer to chapter : “ Fuel injection output “ in major chapter “ Outputs “)*

## 1.2 Basic Operating States : LV_ST, LV_IS, LV_PL, LV_PU, LV_PUC

### 1.2.1 Engine operating state : " Start " ( LV_ST )

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| LV_ST | V | 0...01H | 0...1 | 1 | - |
| Engine operating state " Start " - Engine Operating State = ST. | | | | | |
| CYCNR_ES_ST | - | 0...FFFFH | 0...65535 | 1 | - |
| Cycle-counter started at transition from LV_ES to LV_ST. | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| LV_CT | N_32 | LV_IS | LV_PL |
| TCO | | | |

**FUNCTION DESCRIPTION:**

General information:

The engine operating state " Start " (LV_ST) is detected from all engine operating states via means of engine speed.

At transition from LV_ES to LV_ST the cycle-counter CYCNR_ES_ST is started; it will be incremented each segment and reset at exit to LV_IS or LV_PL (see also chapter „Start break-off detection").

**Application conditions:**

*Deactivation:*

1) **Exit to LV_IS:** Idle Speed

a) N_32 ≥ IP_N_MAX _TOL_ST__TCO

b) and LV_CT = 1

2) **Exit to LV_PL :** Part Load

a) N_32 ≥ IP_N_MAX_TOL_ST__TCO

b) and LV_CT = 0

**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| IP_N_MAX_TOL_ST__TCO | 9 | 0...FFH | 0...8160 | 32 | rpm |
| High engine speed threshold between LV_ST and LV_IS. | | | | | |

### 1.2.2 Engine operating state : " Idle Speed " ( LV_IS )

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| LV_IS | V | 0...01H | 0...1 | 1 | - |
| Engine operating state " Idle Speed " - Engine Operating State = IS. | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| LV_CT | N_SP_IS_MAX | N_32 | N |
| LV_ST | LV_PL | LV_PU | |

**FUNCTION DESCRIPTION:**

**Application conditions:**

*Deactivation:*

1) **Exit to LV_ST :** Start

a) N_32 < C_N_MAX_BOL_ST

2) **Exit to LV_PL :** Part Load

a) N_32 ≥ C_N_MAX_BOL_ST

b) and LV_CT = 0

3) **Exit to LV_PU :** Trailing Throttle

a) N ≥ N_SP_IS_MAX

b) and LV_CT = 1

c) and N_32 ≥ C_N_MAX_BOL_ST

**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| C_N_MAX_BOL_ST | 1 | 0...FFH | 0...8160 | 32 | rpm |
| Engine speed threshold to detect LV_ES from LV_PL or LV_FL or LV_IS. | | | | | |

### 1.2.3 Engine operating state : “ Part Load ” ( LV_PL )

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| LV_PL | V | 0...01H | 0...1 | 1 | - |
| Engine operating state ” Part Load ” - Engine Operating State = PL. | | | | | |
| LV_PU_PUC_TRA_FAST | V | 0...01H | 0...1 | 1 | - |
| Boolean for fast deceleration status - (Passive / Active). | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| N | N_32 | N_SP_IS_MAX | TCO |
| LV_CT | LV_ST | LV_IS | LV_PU |
| C_N_MAX_BOL_ST | TPS_GRD | MAF_MMV_DIF | MAF_MMV |

**FUNCTION DESCRIPTION:**

**Application conditions:**

*Deactivation:*

1) **Exit to LV_ST :** Start

a) N_32 **<** C_N_MAX_BOL_ST

2) **Exit to LV_IS :** Idle Speed

a) N_32 ≥ C_N_MAX_BOL_ST

b) **and** N **<** N_SP_IS_MAX

c) **and** LV_CT **= 1**

3) **Exit to LV_PU :** Trailing Throttle

a) N ≥ N_SP_IS_MAX

b) **and** LV_CT **= 1**

c) **and** N_32 ≥ C_N_MAX_BOL_ST

*Fast Deceleration Detection **: LV_PU_PUC_TRA_FAST***

**If** ( |TPS_GRD| **>** C_TPS_GRD_MIN_PU **and** TPS_GRD **<** 0 )
**and** TCO **>** C_TCO_MIN_PU
**and** MAF_MMV_DIF **>** C_MAF_MMV_DIF_MIN_PU
**and** msb(MAF_MMV) **>** IP_MAF_MMV_MIN_PU__N_32
**then**
**If** ( N_32 ≥ C_N_MIN_LGRD_PU **or** N_GRD **>** C_N_GRD_MIN_PU )
**then** LV_PU_PUC_TRA_FAST **= 1**
**else** LV_PU_PUC_TRA_FAST **= 0**

## Calibration data:

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| IP_MAF_MMV_MIN_PU__N_32 | 6 | 0...FFH | 0...1389 | 5,45 | mg/TDC |
| | | | | | |
| MAF_MMV threshold to detect fast deceleration. | | | | | |
| C_TPS_GRD_MIN_PU | 1 | 0...FFH | 0...2988 | 11,72 | °TPS/sec |
| TPS_GRD threshold to detect fast deceleration. | | | | | |
| C_TCO_MIN_PU | 1 | 0...FEH | -48...142,5 | 0,75 | °C |
| Coolant temperature threshold to detect fast deceleration. | | | | | |
| C_MAF_MMV_DIF_MIN_PU | 1 | 0...FFH | 0...1389 | 5,45 | mg/TDC |
| MAF_MMV_DIF threshold to detect fast deceleration. | | | | | |
| C_N_MIN_LGRD_PU | 1 | 0...FFH | 0...8160 | 32 | rpm |
| Engine speed threshold to detect fast deceleration. | | | | | |
| C_N_GRD_MIN_PU | 1 | 80...7FH | -4096...4064 | 32 | rpm/sec |
| Engine speed gradient threshold to detect fast deceleration. | | | | | |

### 1.2.4 Engine operating state : " Trailing Throttle " ( LV_PU )

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| LV_PU | V | 0...01H | 0...1 | 1 | - |
| Engine operating state " Trailing Throttle " - Engine Operating State = PU | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| LV_CT | LV_PU_PUC_TRA_FAST | LV_PL | LV_IS |
| LV_PUC | LV_RLY_ACCOUT | N | N_32 |
| N_SP_IS_MAX | N_GRD | IGA_PU_PUC | TCO |

**FUNCTION DESCRIPTION:**

**Application conditions:**

*Deactivation:*

1) **Exit to LV_PL :** Part Load

a) LV_CT **= 0**

2) **Exit to LV_IS :** Idle Speed

a) LV_CT **= 1**

b) **and** N **<** N_SP_IS_MAX

3) **Exit to LV_PUC :** Trailing Throttle Fuel Cut Off

a) LV_CT **= 1**

b) **and**

b1) N_32 ≥ IP_N_MIN_PUC__TCO__GR_MT + Hysteresis

b2) **or** N_32 ≥ IP_N_ACCIN_MIN_PUC__TCO__GR_MT + Hyst.

*(LV_RLY_ACCOUT = 1)*

c) **and** ISAPWM_D_IS is inactive

d) **and**

d1) N_32 ≥ C_N_MAX_INF

d2) **or** ( N_32 **<** C_N_MAX_INF **and** N_GRD ≥ C_N_GRD_MIN )

**Remark :**

The conditions to leave immediately or to stay temporarily in trailing throttle (LV_PU) to trailing throttle fuel cut-off (LV_PUC) are depending on the type of deceleration (LV_PU_PUC_TRA_FAST) and engine speed threshold (N_32).

*( refer to the chapter " Trailing throttle ignition angle correction (IGA_PU_PUC) " in the major chapter " Ignition " )*

## Calibration data:

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| IP_N_MIN_PUC__TCO__GR_MT | 6*6 | 0...FFH | 0...8160 | 32 | rpm |
| LV_PUC engine speed threshold. | | | | | |
| IP_N_ACCIN_MIN_PUC__TCO__GR_MT | 6*6 | 0...FFH | 0...8160 | 32 | rpm |
| LV_PUC engine speed threshold with air conditioning compressor active. | | | | | |
| C_N_MAX_INF | 1 | 0...FFH | 0...8160 | 32 | rpm |
| Engine speed threshold for intercept function. | | | | | |
| C_N_GRD_MIN | 1 | 80...FFH | -4096...0 | 32 | rpm/sec |
| Negative engine speed gradient threshold when ISAPWM_D_IS is inactive. | | | | | |

### 1.2.5 Engine operating state : “ Trailing Throttle Fuel Cut Off ” ( LV_PUC )



**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| LV_PUC | V | 0...01H | 0...1 | 1 | - |
| Engine operating state ” Trailing Throttle Fuel Cut - Off ” - Engine Operating State = PUC. | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| LV_CT | C_N_GRD_MIN | N | N_32 |
| N_SP_IS_MAX | N_GRD | TCO | ISAPWM_D_IS |
| LV_PL | LV_IS | LV_PU | LV_RLY_ACCOUT |
| IP_N_MIN_PUC__TCO__GR_MT | IP_N_ACCIN_MIN_PUC__TCO__GR_MT | C_N_MAX_INF | |

**FUNCTION DESCRIPTION:**



General information:

The engine speed threshold for the detection of LV_PUC is derived from a characteristic as a function of coolant temperature IP_N_MIN_PUC__TCO__GR_MT. There is a special characteristic for the air condition compressor active IP_N_ACCIN_MIN_PUC__TCO__GR_MT.

*Limp Home :*

If a present failure is detected on the idle-charge actuator (refer to chapter „Diagnosis management“), the engine speed threshold for the detection of trailing throttle fuel cut-off (LV_PUC) is set to C_N_MIN_PUC_DIAG (limp-home value). This causes trailing throttle fuel cut-off to be shifted towards higher engine speed when the engine is at operating temperature.

*Function ” **LV_PUC Hysteresis** ” :*

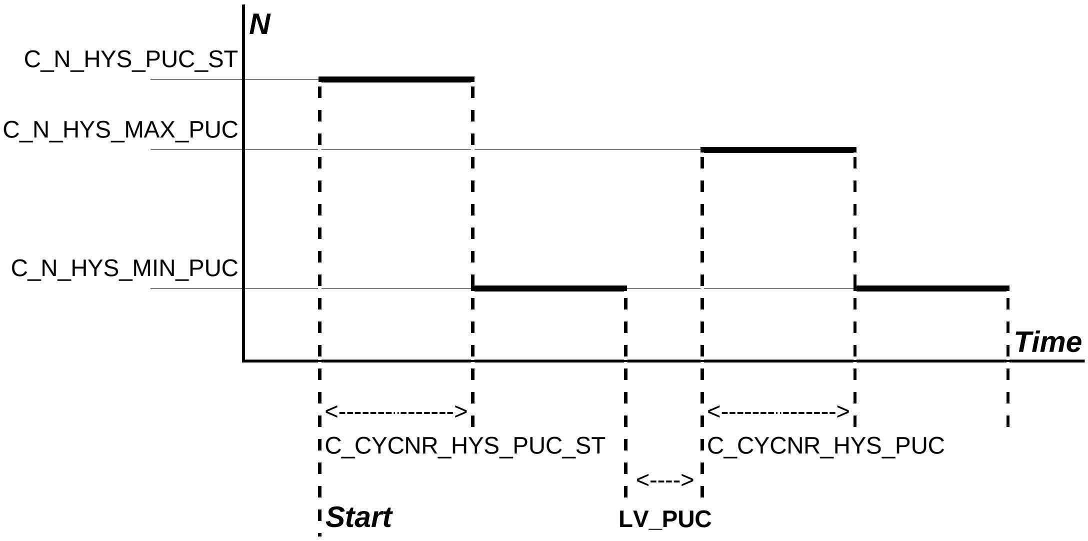
When entering trailing throttle fuel cut-off (LV_PUC), the engine speed hysteresis is set to a larger value, i.e. C_N_HYS_MAX_PUC, and a cycle counter is loaded with an adjustable number, i.e. C_CYCNR_HYS_PUC. The cycle counter is decremented at intervals of a crank angle segment in any engine operating state except trailing throttle fuel cut-off (LV_PUC).

When the counter has been ran down, the engine speed hysteresis is reset to the value C_N_HYS_MIN_PUC. This measure is to prevent the injection system from being switched on and off continuously, which is undesirable.

If the coolant temperature is below the threshold C_TCO_MIN_PUC_ST when the engine is started, then the engine speed hysteresis for the detection of trailing throttle fuel cut off LV_PUC is increased to an adjustable value, i.e. C_N_HYS_PUC_ST, for an adjustable number of cycles C_CYCNR_HYS_PUC_ST. This results in faster catalyst heat-up during trailing throttle operation.

When the trailing throttle fuel cut-off (LV_PUC) is active, the individual cylinder restart fuel feed function can be started.

Description:






**Application conditions:**

*Deactivation:*

1) **Exit to LV_IS :** Idle Speed

a) LV_CT **= 1**

b) **and**

b1)

b12) N_32 **<** IP_N_MIN_PUC__TCO__GR_MT

b13) **or** N_32 **<** IP_N_ACCIN_MIN_PUC__TCO__GR_MT

*( LV_RLY_ACCOUT = 1 )*

b2) **or**

b21) N_32 **<** C_N_MAX_INF

b22) **and** N_GRD **<** C_N_GRD_MIN

b3) **or**

b31) N_32 **<** C_N_MAX_INF

b32) **and** N_GRD **<** C_N_GRD_MIN_D

*( ISAPWM_D_IS is active )*

c) **and** N **<** N_SP_IS_MAX

2) **Exit to LV_PU :** Trailing Throttle

a) LV_CT **= 1**

b) **and**

b1)

b12) N_32 **<** IP_N_MIN_PUC__TCO__GR_MT

b13) **or** N_32 **<** IP_N_ACCIN_MIN_PUC__TCO__GR_MT

*( LV_RLY_ACCOUT = 1 )*

b2) **or**

b21) N_32 **<** C_N_MAX_INF

b22) **and** N_GRD **<** C_N_GRD_MIN

b3) **or**

b31) N_32 **<** C_N_MAX_INF

b32) **and** N_GRD **<** C_N_GRD_MIN_D

*( ISAPWM_D_IS is active )*

c) **and** N ≥ N_SP_IS_MAX

3) **Exit to LV_PL:** Part Load

a) LV_CT **= 0**

**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| C_N_GRD_MIN_D | 1 | 80...00H | - 4096...0 | 32 | rpm/s. |
| Negative engine speed gradient threshold when ISAPWM_D_IS is active. | | | | | |
| C_N_MIN_PUC_DIAG | 1 | 0...FFH | 0...8160 | 32 | rpm |
| Engine speed threshold for trailing throttle fuel cut off limp home. | | | | | |
| C_N_HYS_MAX_PUC | 1 | 0...FFH | 0...8160 | 32 | rpm |
| Engine speed hysteresis set entering LV_PUC. | | | | | |
| C_N_HYS_MIN_PUC | 1 | 0...FFH | 0...8160 | 32 | rpm |
| Engine speed hysteresis reset when C_CYCNR_HYS_PUC_xx achieved. | | | | | |
| C_N_HYS_PUC_ST | 1 | 0...FFH | 0...8160 | 32 | rpm |
| Engine speed hysteresis set entering LV_PUC in cold condition. | | | | | |
| C_CYCNR_HYS_PUC | 1 | 0...FFFFH | 0...65535 | x Segment | ° CRK |
| Cycle counter to reset the LV_PUC engine speed hysteresis | | | | | |
| C_CYCNR_HYS_PUC_ST | 1 | 0...FFFFH | 0...65535 | x Segment | ° CRK |
| Cycle counter to reset the LV_PUC engine speed hysteresis in cold condition. | | | | | |
| C_TCO_MIN_PUC_ST | 1 | 0...FEH | - 48...142,5 | 0,75 | ° C |
| Coolant temperature to select the LV_PUC engine speed hysteresis. | | | | | |

## 1.3 Basic functions : LV_FL, LV_AE, LV_PUR, LV_INF, LV_REAC

### 1.3.1 Full Load ( LV_FL )

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| LV_FL | V | 0...01H | 0...1 | 1 | - |
| Basic function " Full Load " - LV_FL = FL | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| TPS | N_32 | TCO | VS |
| LV_AE | LV_PL | LV_TPS_FL | C_TPS_HYS_FL |
| ID_TPS_FL__N_32 | | | |

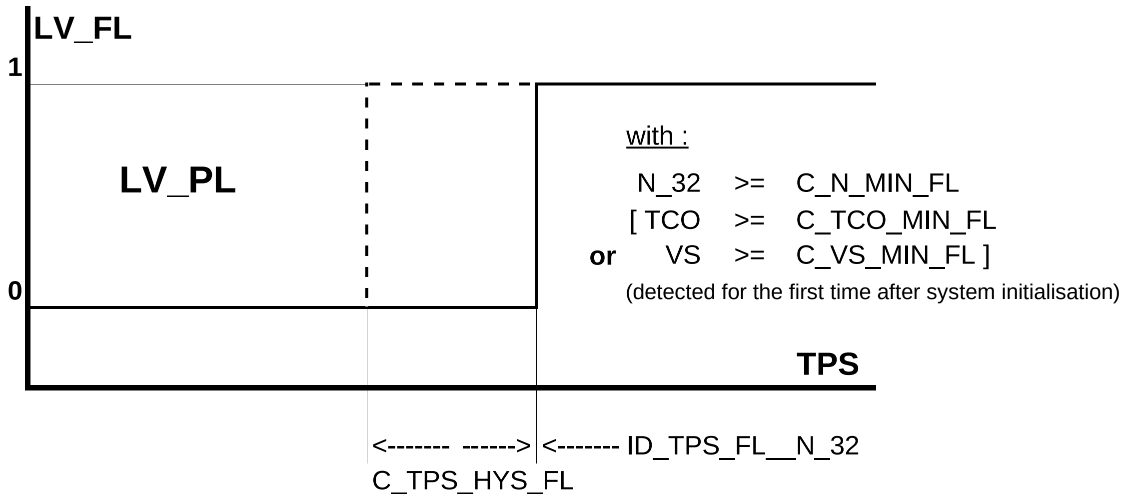
**FUNCTION DESCRIPTION:**

General information:

The throttle position angle threshold required for detection of the full load state (LV_FL) is derived from an engine speed related table.

Another acceleration enrichment (LV_AE) cannot be triggered during full load (LV_FL); an existing acceleration enrichment (LV_AE) intervention continues, taking into account maximum injection time value selection.

Description:



## Application conditions:

*Activation:* **LV_FL = FL**

a) LV_TPS_FL **= 1** (Active)

b) **and** N_32 ≥ C_N_MIN_FL

c) **and**

- c1) TCO ≥ C_TCO_MIN_FL
- c2) **or** VS ≥ C_VS_MIN_FL
  (detected for the first time after system initialisation)

*Deactivation:* **LV_FL = -**

a) LV_TPS_FL **= 0** (Passive)

b) **or** N_32 **<** C_N_MIN_FL

c) **or**

- c1) TCO **<** C_TCO_MIN_FL
- c2) **and** VS **<** C_VS_MIN_FL
  (since system initialisation)

## Calibration data:

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| C_N_MIN_FL | 1 | 0...FFH | 0...8160 | 32 | rpm |
| Engine speed threshold for LV_FL detection. | | | | | |
| C_TCO_MIN_FL | 1 | 0...FEH | -48...142,5 | 0,75 | °C |
| Coolant temperature threshold for LV_FL detection. | | | | | |
| C_VS_MIN_FL | 1 | 0...FFH | 0...255 | 1 | km / h |
| Vehicle speed threshold for LV_FL detection. | | | | | |

### 1.3.2 Acceleration Enrichment ( LV_AE )



**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| LV_AE | V | 0...01H | 0...1 | 1 | - |
| Basic function " Acceleration Enrichment " - LV_AE = AE. | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| LV_CT | LV_PL | LV_PUR | N_32 |
| TCO | TPS | TPS_GRD | LV_DRI_ISAPWM |
| TI_AE | LV_VS_MAX | LV_IS | LV_TPS_ERR |
| LV_TPS_PLAUS_ERR | LV_RLY_ACCOUT_CTRL | TAR_GC | |

**FUNCTION DESCRIPTION:**

General information:

The acceleration enrichment function (LV_AE) is activated if:

- Throttle position gradient (TPS_GRD), determined in part load (LV_PL), exceeds a threshold.
- Gear ratio with A/T (TAR_GC) is increasing or A/C swithed ON in Idle and coolant temperature is below a threshold

**Application conditions:**

*Activation: **LV_AE= AE***

a) LV_CT = 0

a1) **and** TPS_GRD ≥ ID_TPS_GRD_BOL_AE(_AT)__N_32__TPS
+ ID_TPS_GRD_ADD_AE(_AT)__TCO

a2) **and** TPS_GRD ≥ 0

b) **or**

b1) TCO **<** C_TCO_DRI_MIN_AE

b2) **and**
c1) LV_IS **=** 1
c2) **and** Transition A/C Off -> On
(LV_RLY_ACCOUT_CTRL = **0 -> 1**)
**or**
d1) $TAR\_GC_{n}$ **>** $TAR\_GC_{n-1}$

e) **and** No Cylinder shut-off

f) **and** No disabling conditions for fuel enrichment due to an auxiliary function (LV_VS_MAX = 0)

**Remark :** Limp home function

In case of a failure currently detected at the throttle position sensor (LV_TPS_ERR = 1 or LV_TPS_PLAUS_ERR = 1) a substitute value is available. In this case, the release threshold for the instationary function LV_AE / LV_PUR (TPS_GRD condition) is modified to be less sensitive by addition of C_TPS_GRD_ADD_DIAG. These conditions have only to be met to trigger acceleration enrichment (LV_AE).

*Deactivation:* ***LV_AE = -***

After being activated, acceleration enrichment function (LV_AE) continues until it is automatically deactivated (TI_AE = 0), or until it is disabled by one of the following events :

a) LV_CT = 1

a1) **and** Engine operating state idle not active LV_IS = 0

b) **or** Transition Drive (LV_DRI_ISAPWM = **1**) -> Park/Neutral (LV_DRI_ISAPWM = **0**)

b1) **and** Engine operating state idle not active LV_IS = 0

c) **or** Transition A/C requested (LV_ACCIN = **1**) -> A/C off (LV_ACCIN = **0**)

c1) **and** Engine operating state idle not active LV_IS = 0

d) **or** disabling conditions for fuel enrichment due to an auxiliary function ( LV_VS_MAX = 1 (Active) )

e) **or** cylinder shut-off active.

## Calibration data:

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| ID_TPS_GRD_BOL_AE(_AT)__N_32__TPS | 6 x 4 | 0...FFH | 0...2988 | 11,71 | ° TPS / sec |
| | | | | | |
| Throttle position gradient threshold versus N_32 and TPS for LV_AE detection. | | | | | |
| ID_TPS_GRD_ADD_AE(_AT)__TCO | 6 | 80...7FH | - 1500...1488 | 11,71 | ° TPS / sec |
| | | | | | |
| Throttle position gradient threshold versus TCO for LV_AE detection. | | | | | |
| C_TPS_GRD_ADD_DIAG | 1 | 0...FFH | 0...2988 | 11,71 | ° TPS / sec |
| Throttle position gradient threshold for LV_AE limp home detection. | | | | | |
| C_TCO_DRI_MIN_AE | 1 | 0...FEH | -48...142,5 | 0,75 | °C |
| Maximum coolant temperature to activate AE after a transition Neutral -> Drive | | | | | |

### 1.3.3 Trailing Throttle Fuel Reduction ( LV_PUR )



**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| LV_PUR | V | 0...01H | 0...1 | 1 | - |
| Basic function " Trailing Throttle Fuel Reduction " - LV_PUR = PUR. | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| LV_TPS_FL | TPS | TPS_GRD | N_32 |
| LV_AE | LV_PUC | TCO | LV_TPS_ERR |
| C_TPS_GRD_ADD_DIAG | LV_VS_MAX | TI_PUR | L_INH_IV_[CYL] |
| LV_TPS_PLAUS_ERR | | | |

**FUNCTION DESCRIPTION:**



General information:

The trailing throttle fuel reduction function (LV_PUR) is triggered when the negative throttle position gradient TPS_GRD reaches or falls below a threshold.

The states LV_AE and LV_PUR can be simultaneously active.

The dashpot function is reset independently of LV_PUR.

**Application conditions:**

*Activation:* ***LV_PUR = PUR***

a) LV_TPS_FL = 0

b) **and**

b1) $|TPS\_GRD| \geq$ ID_TPS_GRD_BOL_PUR(_AT)__N_32__TPS

\+ ID_TPS_GRD_ADD_PUR(_AT)__TCO

b2) **and** TPS_GRD **<** 0

c) **and** No disabling conditions for fuel enrichment due to an auxiliary function.

( LV_VS_MAX = 0 (Passive) )

**Remark :** Limp home function

In case of a present failure detected on the throttle position sensor (LV_TPS_ERR = 1 or LV_TPS_PLAUS_ERR = 1), a substitute value is available. In this case, the release threshold for the instationary function LV_AE / LV_PUR (TPS_GRD condition) is modified to be less sensitive by addition of C_TPS_GRD_ADD_DIAG.

*Deactivation:* ***LV_PUR = -***

After being activated, the trailing throttle fuel reduction function (LV_PUR) continues until it is automatically deactivated (TI_PUR = 0), or until it is disabled by one of the following events :

a) LV_TPS_FL = 1

b) **or** disabling conditions for fuel enrichment due to an auxiliary function ( LV_VS_MAX = 1 (Active) )

c) **or** the injection of one or more cylinders is inhibited (L_INH_IV_[CYL = 1)

**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| ID_TPS_GRD_BOL_PUR(_AT)__N_32__TPS | 6 x 4 | 0...FFH | 0...2988 | 11,71 | ° TPS / sec |
| Throttle position gradient threshold versus N_32 and TPS for LV_PUR detection. | | | | | |
| ID_TPS_GRD_ADD_PUR(_AT)__TCO | 6 | 80...7FH | - 1500...1488 | 11,71 | ° TPS / sec |
| Throttle position gradient threshold versus TCO for LV_PUR detection. | | | | | |

### 1.3.4 Intercept function ( LV_INF )



**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| LV_INF | V | 0...01H | 0...1 | 1 | - |
| Basic function " Intercept "- LV_INF = INF. | | | | | |
| LV_N_GRD_INF | V | 0...01H | 0...1 | 1 | - |
| " Intercept " conditions for ignition intervention - ( Passive / Active ). | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| LV_PU | LV_PUC | LV_IS | N_GRD |
| C_N_GRD_MIN | C_N_GRD_MIN_D | C_N_MAX_INF | N_DIF |
| N_32 | ISAPWM_D_IS | LV_CT | C_ISAPWM_LGRD_D |

**FUNCTION DESCRIPTION:**

General information:

In the engine operating conditions trailing throttle (LV_PU), trailing throttle fuel cut-off (LV_PUC) or restart fuel feed function (LV_PUR) active in idle speed (LV_IS), the intercept function (LV_INF) can be enabled below an engine speed threshold C_N_MAX_INF.

The engine-speed gradient N_GRD is monitored for this purpose.

The engine operating state trailing throttle fuel cut-off (LV_PUC) is aborted when the intercept function (LV_INF) is triggered, and a transition to trailing throttle (LV_PU) or idle speed (LV_IS) takes place.

**Application conditions:**

*Activation:* **LV_INF = INF**

a) **If** LV_CT = 1

**and** N_32 **<** C_N_MAX_INF

**and** N_GRD **<** C_N_GRD_MIN

**then** LV_N_GRD_INF **= 1** (Active)

**and** an ignition intervention is initiated to counteract the high negative engine speed gradient.

**else** LV_N_GRD_INF **= 0** (Passive)

b) **If** LV_CT = 1

**and** N_DIF ≤ 0

**then**

**If** N_32 **<** C_N_MAX_INF

**and** N_GRD **<** C_N_GRD_MIN_D

**and** ISAPWM_D_IS inactive

**then** a “ D - component “ from idle speed regulation correction becomes effective (and a timer C_T_MIN_D_ISA is activated) in order to facilitate an engine intercept without drop below the nominal engine idle speed.

*Deactivation:* ***LV_INF = -***

a) After being activated, the intercept function (LV_INF) continues until it is automatically deactivated (with ignition intervention).

b) **or** ( LV_CT = 0 **or** N_DIF **>** 0)
The “D - component” of idle speed regulation correction is controlled down to 0 using C_ISAPWM_LGRD_D (limitation gradient) and the timer C_T_MIN_D_ISA is reset.

**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| C_T_MIN_D_ISA | 1 | 01...FFFFH | 0,01...655,35 | 0,01 | sec |
| Time delay to abort D - component idle-control device with LV_INF function. | | | | | |

### 1.3.5 Re-start fuel feed function ( LV_REAC )



**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| LV_REAC | V | 0...01H | 0 :1 | 1 | - |
| Basic function " Re-start fuel feed "- LV_REAC = REAC. | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| LV_PU | LV_PUC | LV_IS | LV_PL |
| LV_AE | | | |

**FUNCTION DESCRIPTION:**

General information:

In order to obtain a soft engine torque built, the ignition angle is controlled from the trailing throttle fuel cut-off (LV_PUC) ignition angle to the new target ignition angle using a gradient limitation.



If *ignition intervention* for re-start fuel feed function is active, then LV_REAC **= 1** ( REAC ).

**Application conditions:**

*Activation: **LV_REAC = 1** ( REAC )*

Re-start fuel feed at idle (LV_IS) or at trailing throttle (LV_PU) or at part load (LV_PL) (with or without acceleration enrichment (LV_AE)) is enabled while the trailing throttle fuel cut-off (LV_PUC) is active, when the corresponding engine operating state is performed.

*Deactivation: **LV_REAC = 0** ( - )*

After being activated, the re-start fuel feed at idle (LV_IS) or at trailing throttle (LV_PU) or at part load (LV_PL) continues until it is automatically de-activated (when ignition intervention is over).

## 1.4 Auxiliary functions

### 1.4.1 Start break-off detection ( LV_ST_ES )

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| LV_ST_ES | V | 0...01H | 0...1 | 1 | - |
| Detection of engine start break-off- ( Passive / Active ). | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| LV_ST | LV_ES | CYCNR_ES_ST | N_32 |
| NC_N_MIN | IP_N_MAX_TOL_ST__TCO | C_T_MAX_ECU | |

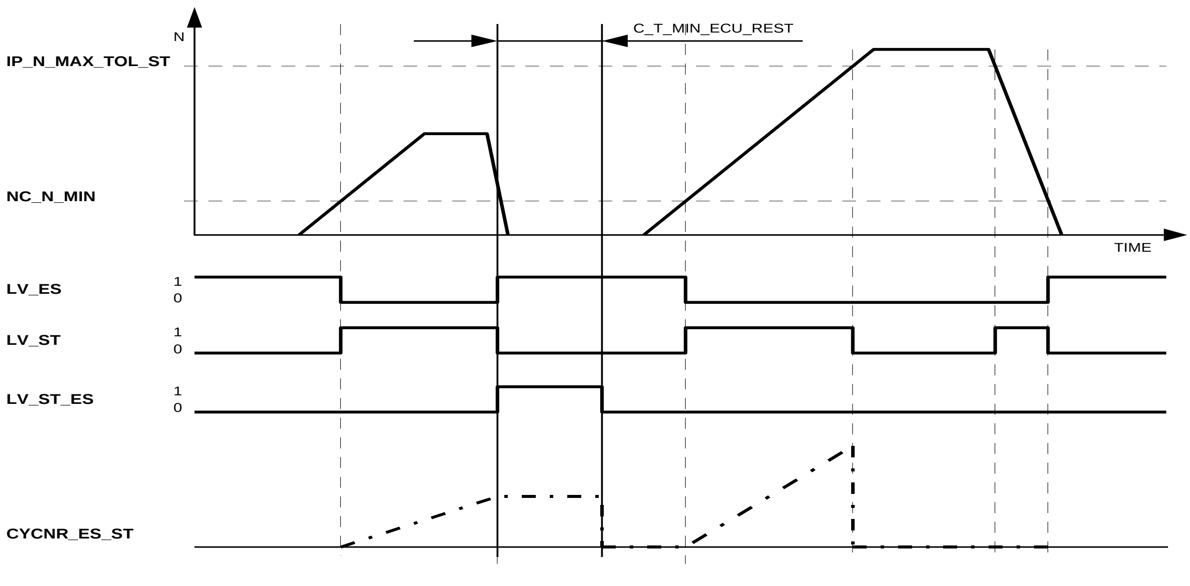
**FUNCTION DESCRIPTION:**

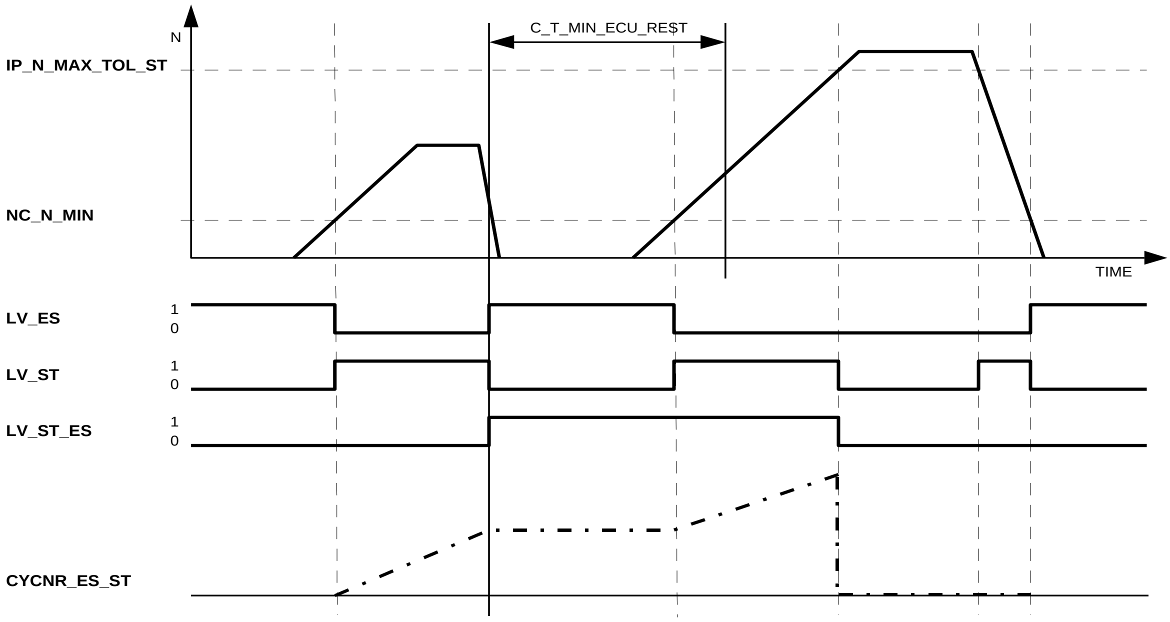
General information:

For engine stall during start phase, i.e. transition from LV_ST to LV_ES before N_32 reaching IP_N_MAX_TOL_ST__TCO, the flag LV_ST_ES is set to 1. At the same time the counter CYCNR_ES_ST will be freezed to its actual value.

Additionally a timer is started at the transition from LV_ST to LV_ES. If the timer ellapses before a new start takes place (T > C_T_MIN_ECU_REST), LV_ST_ES is reset (see picture on this page) and CYCNR_ES_ST is set to zero.
Whereas LV_ST_ES remains set to 1 until the engine operation state start is exited to part load or idle if a new start takes place before the timer has ellapsed (T < C_T_MIN_ECU_REST) In this case the counter CYCNR_ES_ST starts with the frozen value at the new start (see picture on next page).

Description:








**Remark :**

If C_T_MIN_ECU_REST is greater then C_T_MAX_ECU the housekeeping phase is extended to C_T_MIN_ECU_REST.

**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| C_T_MIN_ECU_REST | 1 | 1...FFFFH | 0,01...655,35 | 0,01 | sec |
| Time threshold to detect new start after start-break off. | | | | | |

### 1.4.2 Restart detection function ( LV_REST )

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| LV_REST | V | 0...01H | 0...1 | 1 | - |
| Auxiliary function " Restart " - ( Passive / Active ). | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| TCO | TCO_REST | LV_ST | LV_IS |
| LV_PL | LV_ST_ES | LV_ES | C_T_MIN_ECU_REST |
| C_T_MAX_ECU | CYCNR_ES_ST | | |

**FUNCTION DESCRIPTION:**

General information:

The restart function is requested as an injection time correction during start and after start phase.

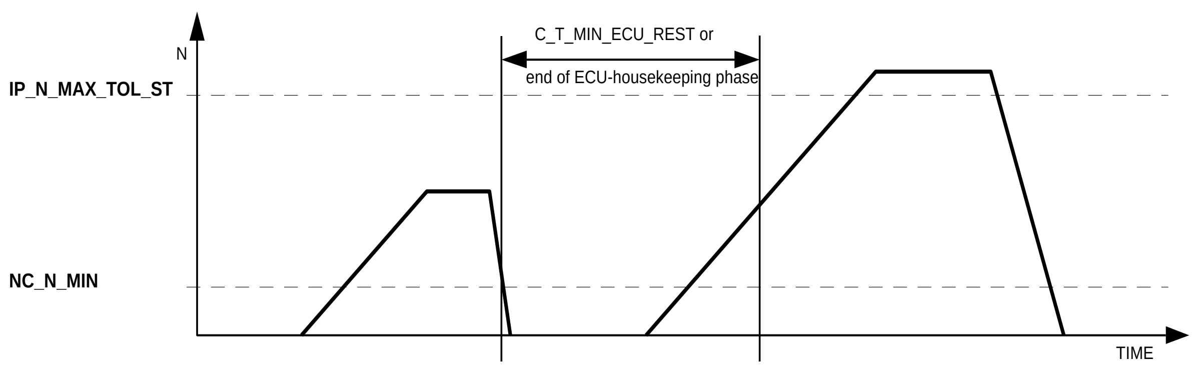
**Application conditions:**

LV_REST is updated each **500 ms** at engine stop (LV_ES = 1).
There are 4 possible combinations regarding start - restart timing sequence:

a.) Case 1:

After start break-off is detected, LV_ST_ES is set to 1 (see chapter 1.4.1). This case is not considered as a restart and therefore the restart-flag LV_REST is set to **0**.

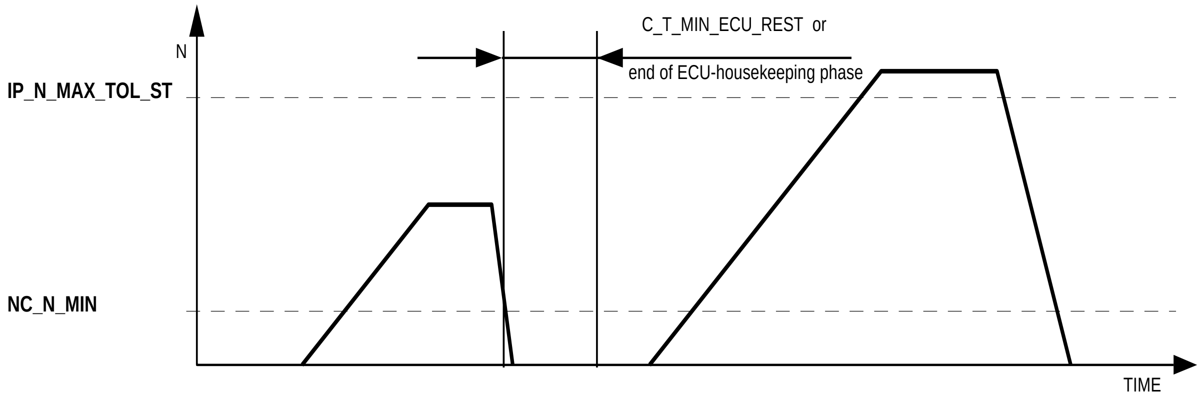
If a new start takes place before the timer has ellapsed or before the end of the housekeeping-phase the factor IP_TIPR_FAC_ST_ES__TCO will be applied on preinjection time (see chapter „Injection") at the next start and the calculation of start injection time deactivation factor will start with the previous freezed CYCNR_ES_ST-value.



b.) Case 2:

After start break-off is detected, LV_ST_ES is set to 1 (see chapter 1.4.1). This case is not considered as a restart and therefore the restart-flag LV_REST is set to **0**.

If a new start takes place after the timer has ellapsed or after the end of the housekeeping-phase no corrections are applied on the injection time.




**Remark :**

The housekeeping phase is extended to C_T_MAX_ECU if C_T_MIN_ECU_REST is greater than C_T_MAX_ECU.

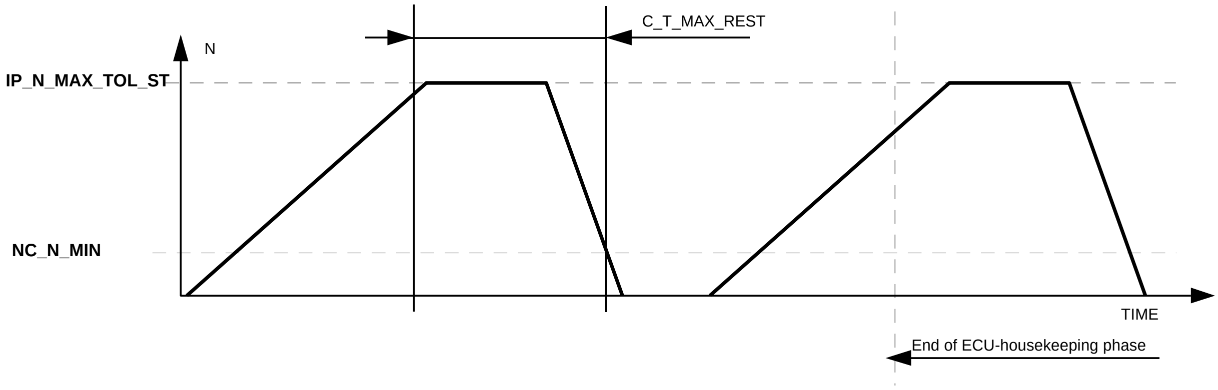
c.) Case 3:

After transition from engine start (LV_ST = 1) to engine stop (LV_ES = 1) LV_REST is checked each 500 ms to the end of the house keeping-phase. As the engine was operated in part load or idle before engine stop, the next start is considered as a restart if following conditions are fullfilled:

**If** TCO_REST < FFH
**and** TCO >= TCO_REST - C_TCO _DIF_MAX_REST

**then** LV_REST = 1
**else** LV_REST = 0

Therefore the restart-flag LV_REST is set to **1** during housekeeping phase as long as the coolant temperature did not drop to much.
The calculation of start injection time deactivation factor will start with CYCNR_ES_ST = 0.



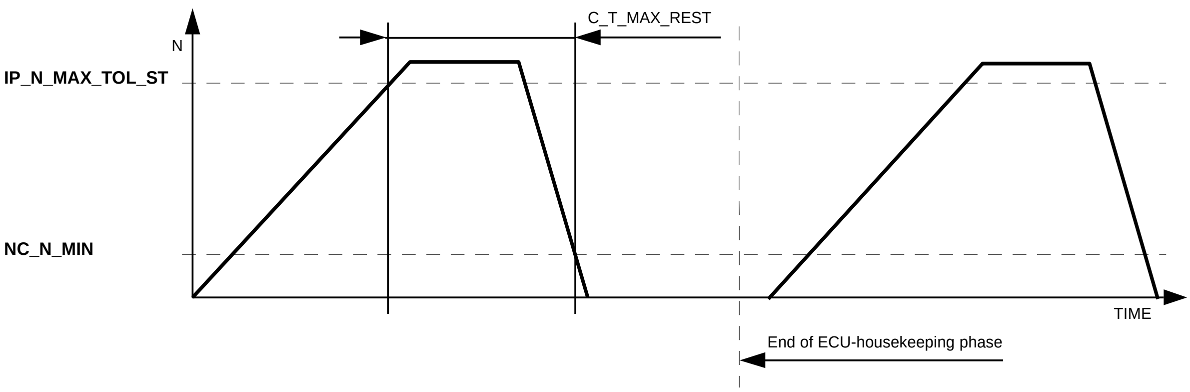

c.) Case 4:

As the next start takes place after the end of the house keeping-phase LV_REST is checked only once at the new start, after receiving the stored TCO_REST from non-volatile memory. As the engine was operated in part load or idle before engine stop, the new start is considered as a restart if following conditions are fullfilled:

**If** TCO_REST < FFH
**and** TCO >= TCO_REST - C_TCO _DIF_MAX_REST

**then** LV_REST = 1
**else** LV_REST = 0

Therefore the restart-flag LV_REST is set to **1** before the new start only if TCO did not drop to much. The calculation of start injection time deactivation factor will start with CYCNR_ES_ST = 0.




**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| C_TCO_DIF_MAX_REST | 1 | 0...50H | 0...60 | 0,75 | °C |
| Coolant temperature threshold to detect LV_REST. | | | | | |

### 1.4.3 Post - Start function ( LV_TI_AST, LV_IGA_AST )

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| LV_TI_AST | V | 0...01H | 0...1 | 1 | - |
| Injection intervention for auxiliary function " Post - Start " - ( Passive / Active ). | | | | | |
| LV_IGA_AST | V | 0...01H | 0...1 | 1 | - |
| Ignition intervention for auxiliary function " Post - Start " - ( Passive / Active ). | | | | | |
| CYCNR_ST_AST | - | 0...FFFFH | 0...65535 | 1 | - |
| Cyclet counter started at transition LV_ST to LV_TI:AST/LV_IGA_AST. | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| LV_ST | LV_IS | LV_PL | TI_CAST |
| IGA_DYN_COR_IS | LV_ISAPWM_IS_ACT | N_DIF | |

**FUNCTION DESCRIPTION:**

General information:

The post - start function serves to supply the extra injection quantity required after start by the cold walls of the combustion chamber.

The engine state post - start is requested whenever the engine exits the operating state start (LV_ST) and is executed simultaneously with other engine operating states, except start (LV_ST).

It takes into account an injection time correction (TI_CAST) and an ignition angle intervention (IGA_DYN_COR_IS). At the same time the cycle counter CYCNR_ST_AST is started; it is incremented each segment.

**Application conditions:**

*- Injection time correction ( TI_CAST ) due to post start function :*

Activation: **LV_TI_AST = 1** (Active) :
It is activated as soon as the engine operating state start (LV_ST) is exited to go to the engine operating states idle speed (LV_IS) or part load (LV_PL).

Deactivation : **LV_TI_AST = 0** (Passive) :
The injection time enrichment corresponding to post - start (TI_CAST) is complete, i.e. the deactivation factor has elapsed.

*- Ignition angle intervention ( IGA_DYN_COR_IS ) due to post start function :*

| | | |
|---|---|---|
| **If** | LV_ST → LV_IS | *(engine operating state in idle for the first time)* |
| **and** | N_DIF **<** 0 | *(engine speed above nominal idle speed)* |
| **and** | LV_ISAPWM_IS_ACT **= 0** (Passive) | *(idle speed regulation passive)* |
| **then** | **LV_IGA_AST = 1** (Active) | |
| **else** | **LV_IGA_AST = 0** (Passive) | |

### 1.4.4 Warm - Up function ( LV_WUP )



**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| LV_WUP | V | 0...01H | 0...1 | 1 | - |
| Auxiliary function " Warm - Up " - ( Passive / Active ). | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| LV_ES | LV_ST | TI_WUP | |

**FUNCTION DESCRIPTION:**

General information:

The injection time is corrected with the warm - up enrichment.



**Application conditions:**

*Activation:* **LV_WUP = 1** (Active)

The state LV_WUP is activated as soon as the engine operating state engine stopped (LV_ES) is disabled (transition LV_ES / LV_ST).

*Deactivation:* **LV_WUP = 0** (Passive)

As soon as the injection time correction TI_WUP (multiplicative term of the basic injection time) has reached **1**, the warm - up flag is disabled.

### 1.4.5 Rich mixture Warm - Up ( LV_RWUP )

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| LV_RWUP | V | 0...01H | 0...1 | 1 | - |
| Auxiliary function " Rich mixture warm-up " - ( Passive / Active ). | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| LV_SAV | LV_RLY_SAP | LV_IS | LV_PL |

**FUNCTION DESCRIPTION:**

General information:

To warm up the catalyst to its service temperature as quickly as possible after the engine has been started, the secondary air function (LV_SAV and LV_RLY_SAP) is used.

The rich mixture warm - up (LV_RWUP) takes effect in connection with the secondary air function.

Refer to major chapter " Auxiliary Functions " for the description of the secondary air function management .

***The boolean LV_RWUP is bound to injection time correction.***
Refer to major chapter " Injection " for the description of the secondary air injection time correction.

**Application conditions:**

*Activation:* **LV_RWUP = 1** (Active)

The injection time correction for air secondary function (bound to LV_RWUP) is enabled with a delay after activation of the secondary air pump (LV_SAP). This delay can be applied separately to idle (LV_IS) and part load (LV_PL) :

LV_IS ------> C_T_ON_RWUP_IS
LV_PL ------> C_T_ON_RWUP

**Remark :**

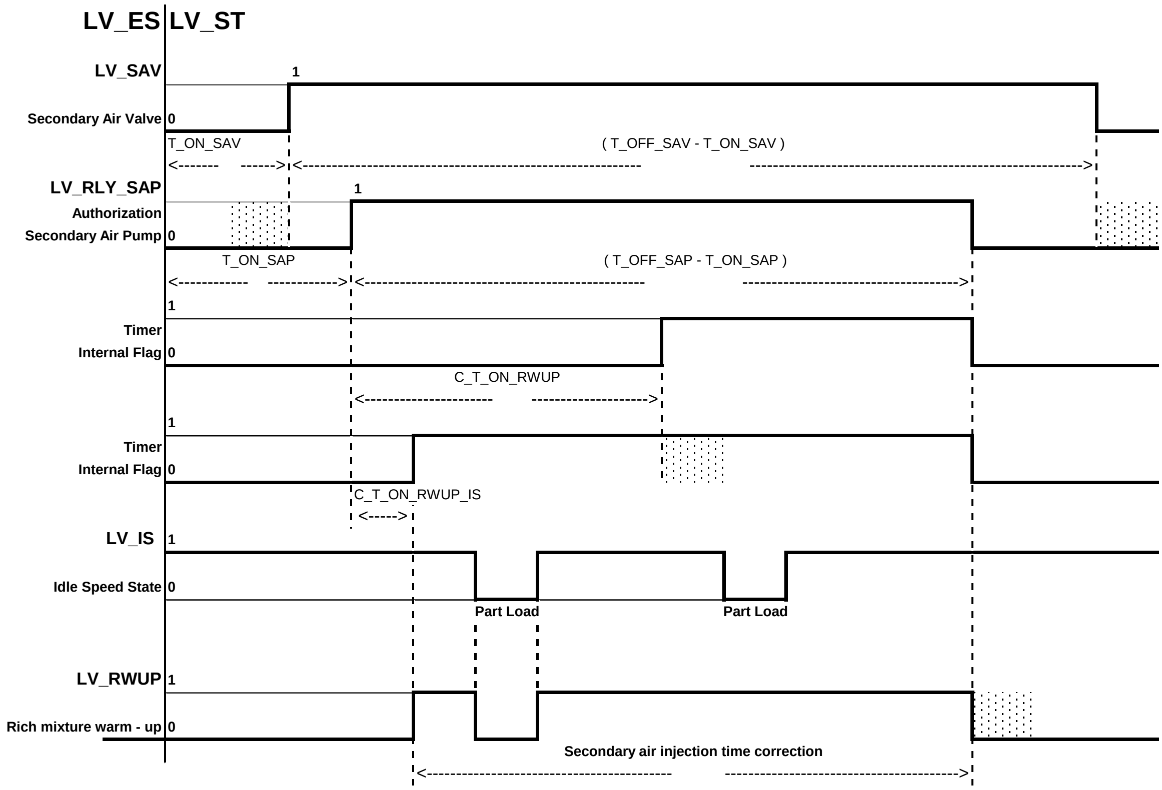
**If** C_T_ON_RWUP_IS ≥ C_T_ON_RWUP
**then** C_T_ON_RWUP will be used in idle (LV_IS)

If this correction is already enabled on transition from idle (LV_IS) to part load (LV_PL) while however C_T_ON_RWUP has not yet elapsed after activation of the secondary air pump (LV_RLY_SAP), the flag LV_RWUP is reset.

*Deactivation:* **LV_RWUP = 0** (Passive)

The injection time correction for air secondary function (bound to LV_RWUP) is disabled as soon as the activation duration for the secondary air pump (LV_RLY_SAP) has elapsed.

Description:




**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| C_T_ON_RWUP_IS | 1 | 01...FFFFH | 0,1...6553,5 | 0,1 | sec. |
| Duration after authorisation of the air secondary pump in idle to apply the injection time correction for LV_RWUP. | | | | | |
| C_T_ON_RWUP | 1 | 01...FFFFH | 0,1...6553,5 | 0,1 | sec. |
| Duration after authorisation of the air secondary pump in part load to apply the injection time correction for LV_RWUP. | | | | | |

### 1.4.6 Catalyst Heating functions ( LV_IGA_CH, LV_TI_CH, LV_N_SP_ADD_CH)



**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| LV_IGA_CH | V | 0...01H | 0...1 | 1 | - |
| Ignition angle correction for catalyst heating active | | | | | |
| LV_TI_CH | V | 0...01H | 0...1 | 1 | - |
| Injection time correction for catalyst heating active | | | | | |
| LV_N_SP_ADD_CH | V | 0...01H | 0...1 | 1 | - |
| Increased nominal idle speed for catalyst heating function active | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| LV_ST | LV_IS | LV_TPS_FL | VS |
| LV_LSCL_1 | LV_LSCL_2 | LV_MAF_ERR | N_SP_IS |
| LV_ACIN | TCO_ST | | |

**FUNCTION DESCRIPTION:**

General information:

After start, to warm up the catalyst to its service temperature as quickly as possible, the following measures are taken for an adjustable time :

1) Increasing the nominal idle speed (N_SP_IS) in idle (LV_IS)
The offset on nominal idle speed is different in Park/Neutral and Drive. An idle speed valve opening correction is linked to the nominal idle speed increase.
*(refer to major chapter : "System Variables" and "Idle speed control").*

2) Calculation of an ignition angle correction (IGA_CH) applied to all engine operating states.
When IGA_CH is applied in Idle, an idle speed valve opening correction is also activated.
*(refer to major chapter : "Ignition" and "Idle speed control").*

3) Adaptation of the injection time (lean correction - TI_CH) depending on the catalyst heating ignition angle intervention (IGA_CH) and the beginning of the lambda control correction.
*(refer to major chapter : "Injection").*

This functions are activated after Start (LV_ST) during a time which depends on coolant temperature at Start (TCO_ST). The IGA correction has the priority on others functions.

## Application conditions:

*Activation:*

* For all the functions: (LV_IGA_CH **=** LV_TI_CH **=** LV_N_SP_ADD_CH**= 1**)

a) Transition from Start (LV_ST)
b) **and** no error currently present on MAF (LV_MAF_ERR **= 0**)

*Deactivation:*

* Ignition angle intervention and idle speed valve correction :

a) the duration ID_IGA_T_CH__TCO_ST has elapsed
b) **or** error currently present on mass air flow sensor (LV_MAF_ERR **= 1**)
c) **or** VS **>** C_IGA_VS_MAX_CH one time
d) **or** LV_TPS_FL **= 1** one time

Thus, **LV_IGA_CH = 0** (Passive)

* Injection time correction :

a) the duration ID_TI_T_CH__TCO_ST has elapsed
b) **or** error currently present on mass air flow sensor (LV_MAF_ERR **= 1**)
c) **or** the lambda control starts ( LV_LSCL_i **= 1** (ON) )
d) **or** LV_IGA_CH **= 0**

Thus, **LV_TI_CH = 0** (Passive)

* Nominal idle speed increase and idle speed valve correction :

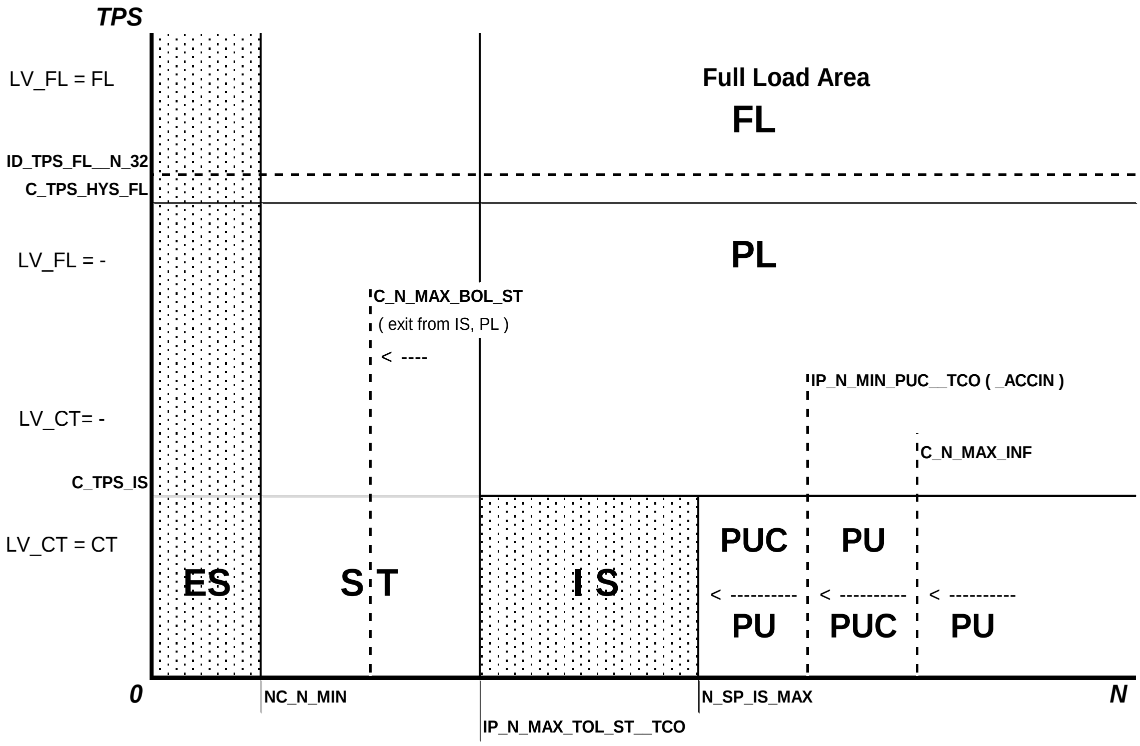
a) the duration ID_N_SP_T_CH__TCO_ST has elapsed
b) **or** error currently present on mass air flow sensor (LV_MAF_ERR **= 1**)
c) **or** LV_ACIN **= 1** one time
d) **or** LV_IGA_CH **= 0**
e) **or** Engine operating state PL active during C_N_SP_T_CH seconds one time

Thus, **LV_N_SP_ADD_CH = 0** (Passive)

## Calibration data:

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| ID_IGA_T_CH__TCO_ST | 8 | 0...FFFFH | 0,1...6553,5 | 0,1 | sec. |
| | | | | | |
| Duration after start to switch on the ignition angle intervention for catalyst heating function. | | | | | |
| ID_TI_T_CH__TCO_ST | 8 | 0...FFFFH | 0,1...6553,5 | 0,1 | sec. |
| | | | | | |
| Duration after start to switch on the injection time correction for catalyst heating function. | | | | | |
| ID_N_SP_T_CH__TCO_ST | 8 | 0...FFFFH | 0,1...6553,5 | 0,1 | sec. |
| | | | | | |
| Duration after start to switch on the nominal idle speed correction for catalyst heating function. | | | | | |
| C_IGA_VS_MAX_CH | - | 0...FFH | 0...255 | 1 | km/h |
| Maximum vehicle speed for active catalyst heating function | | | | | |
| C_N_SP_T_CH | - | 0...FFFFH | 0...655,35 | 10 | msec. |
| Time in PL to stop catalyst heating function related to nominal idle speed | | | | | |

## 1.5 General Drawing




| | | |
|---|---|---|
| **LV_ES** | : | Engine Stopped |
| **LV_ST** | : | Start |
| **LV_IS** | : | Idle Speed |
| **LV_PL** | : | Part Load |
| **LV_PU** | : | Trailing Throttle |
| **LV_PUC** | : | Trailing Throttle Fuel Cut Off |
| **LV_FL** | : | Full Load |

Document: **Ignition**

Project: **Engine Management System**

**HMC_V6**



| | |
|---|---|
| Version: | a |
| Date: | 17-Dec-97 |
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| Software version: | 650H0000 |

| | Name | Department | Phone | Date | Sign |
|---|---|---|---|---|---|
| Author | Müller O. | AT PT SI TSA 11 | 3211 | 09.12.97 | |
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| 2. Check | Gessner S. | AT PT SI TSA 11 | 5398 | 09.12.97 | |
| Responsible | Brückner D. | AT PT SI TSA 16 | 4279 | 09.12.97 | |

## Version list

| Version | Date | Author | Comment, Description |
|---|---|---|---|
| | | | |

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## 1.1 General

### 1.1.1 Total formulas

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| IGA_BAS | V | 0...FFH | -23,625...72 | 0,375 | °CRK |
| Basic ignition angle calculation without gradient limitation. | | | | | |
| IGA_ADD_COR | - | 0...FFH | -23,625...72 | 0,375 | °CRK |
| Global ignition angle correction. | | | | | |
| IGA_CYL_[CYL] | V | 0...FFH | 72...-23,625 | 0,375 | °CRK |
| Individual ignition angle calculation without torque intervention. | | | | | |
| IGA_SAM | V | 0...FFH | 72...-23,625 | 0,375 | °CRK |
| Individual ignition angle calculation without torque intervention updated each segment. | | | | | |
| IGA_IGC_[CYL] | V | 0...FFH | 72...-23,625 | 0,375 | °CRK |
| Individual applied ignition angle with torque intervention. | | | | | |
| IGA_IGC_SAM | V | 0...FFH | 72...-23,625 | 0,375 | °CRK |
| Individual applied ignition angle with torque intervention updated each segment. | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| LV_SYN_ENG | LV_ES | LV_ST | IGA_ST |
| IGA_KNK_[CYL] | IGA_AS_[CYL] | IGAB | IGA_DYN_COR_IS |
| IGA_TIA_TCO | IGA_CAT | IGA_EGR | IGA_TQR |
| IGA_TRA_KNK | IGA_AJ | IGA_PU_PUC | IGA_BAS_LGRD |
| LV_IS | LV_PU | LV_PUC | LV_PL |



#### 1.1.1.1 Ignition angle calculation ( IGA_CYL_[CYL] , IGA_SAM )

##### 1.1.1.1.1 Cranking ignition angle calculation

###### 1.1.1.1.1.1 First ignition angle at engine stopped (LV_ES)

**If** LV_SYN_ENG = 1 *(synchronisation effective)*
**and** engine stopped (LV_ES)
**then** IGA_CYL_[CYL] **=** NC_INI_IGA

###### 1.1.1.1.1.2 Ignition angle at start (LV_ST)

| | | | |
|---|---|---|---|
| IGA_CYL_[CYL] | = | IGA_ST | Cranking ignition angle. |
| | + | IGA_KNK_[CYL | Knock correction. |
| | + | IGA_AS_[CYL] | Application system intervention. |

Application recurrence **: Segment**

##### 1.1.1.1.2 Nominal ignition angle (out of start) calculation

###### 1.1.1.1.2.1 Basic ignition angle without gradient limitation ( IGA_BAS )

| | | | |
|---|---|---|---|
| IGA_BAS | = | IGAB | Basic ignition angle. |
| | + | **min (** IGA_ADD_COR, | Global ignition angle correction. |
| | | IGA_AJ**)** | Anti-jerk correction. |

Application recurrence **: Segment**

###### 1.1.1.1.2.2 Global ignition angle correction ( IGA_ADD_COR )

| | | | |
|---|---|---|---|
| IGA_ADD_COR | = | IGA_DYN_COR_IS | Dynamic correction in idle (LV_IS) |
| | + | IGA_TIA_TCO | Air and coolant temperatures correction. |
| | + | IGA_CH | Catalyst heating correction. |
| | + | IGA_EGR | EGR correction. |
| | + | IGA_TRA_KNK | Instationary correction. |
| | + | IGA_PU_PUC | Trailing throttle correction (LV_PU / LV_PUC) |

Application recurrence **: Segment**

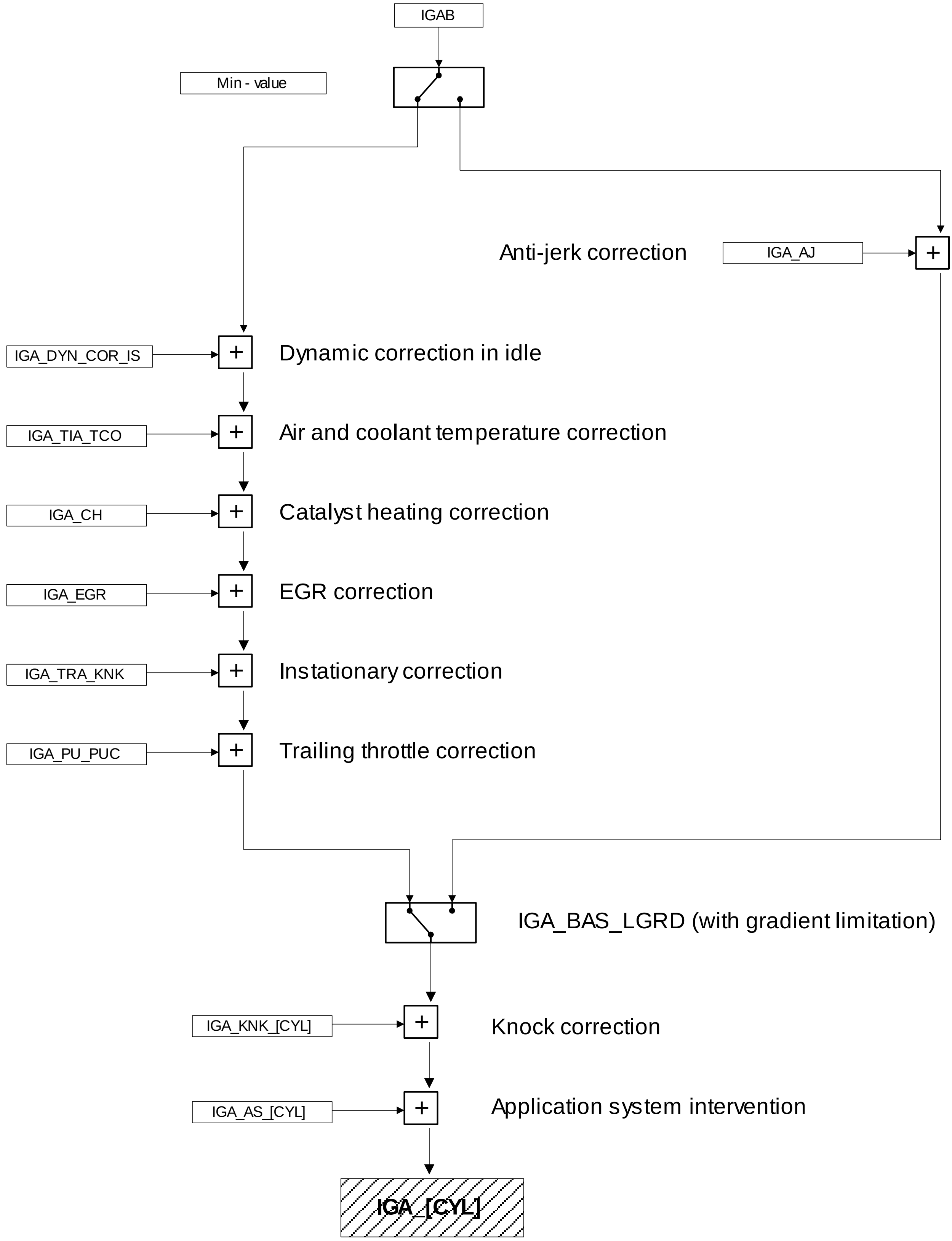
###### 1.1.1.1.2.3 Ignition angle out of start without torque intervention ( IGA_CYL_[CYL] )

| | | | |
|---|---|---|---|
| IGA_CYL_[CYL] | = | IGA_BAS_LGRD | Basic ignition angle with gradient limitation. |
| | + | IGA_KNK_[CYL] | Knock correction. |
| | + | IGA_AS_[CYL] | Application system intervention. |

Application recurrence **: Segment**

See next page for illustration.

**Remark :**
The basic ignition angle with gradient limitation IGA_BAS_LGRD is described in chapter 1.1.2.


IGAB
Min - value
Anti-jerk correction
IGA_AJ
IGA_DYN_COR_IS
Dynamic correction in idle
IGA_TIA_TCO
Air and coolant temperature correction
IGA_CH
Catalyst heating correction
IGA_EGR
EGR correction
IGA_TRA_KNK
Instationary correction
IGA_PU_PUC
Trailing throttle correction
IGA_BAS_LGRD (with gradient limitation)
IGA_KNK_[CYL]
Knock correction
IGA_AS_[CYL]
Application system intervention
IGA_[CYL]

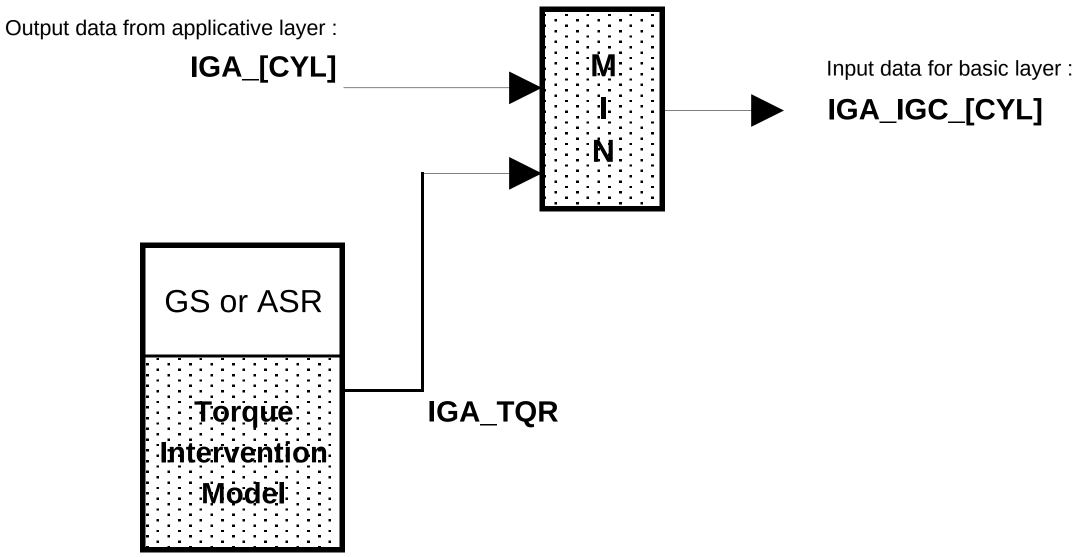
### 1.1.1.2 Ignition angle application ( IGA_IGC_[CYL], IGA_IGC_SAM)

General information:

The algorithm for torque intervention (GS, ASR or MSR) uses ignition angle control.
It provides IGA_IGC_[CYL] with IGA_CYL_[CYL] from applicative layer and IGA_TQR through a torque intervention model as input data.

The minimum ignition angle is limited to ID_IGA_MIN_PL__TCO in part load (LV_PL).

**Description:**




**Formula section:**

**If** LV_PL = 1
**then**

**If** IGA_IGC_[CYL] <= ID_IGA_MIN_PL__TCO
**then** IGA_IGC_[CYL] = ID_IGA_MIN_PL__TCO

**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| ID_IGA_MIN_PL__TCO | 8 | 0...FFH | 72 ...-23,625 | 0,375 | °CRK |
| | | | | | |
| Ignition angle limitation in retard direction in part load. | | | | | |
| NC_INI_IGA | 1 | 0...FFH | 72 ...-23,625 | 0,375 | °CRK |
| First ignition angle following synchronisation in engine stopped (LV_ES) - Non adjustable calibration. | | | | | |

**Applicative Value :**

NC_INI_IGA = **50**H = 6,375 °CRK

## 1.2 Calculation of ignition angle corrections

### 1.2.1 Dynamic ignition angle correction in idle ( IGA_DYN_COR_IS )

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| IGA_DYN_COR_IS | V | 0...FFH | -48...47,625 | 0,375 | °CRK |
| Dynamic ignition angle correction in idle (LV_IS). | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| LV_IS | LV_ST | LV_IGA_AST | LV_ISAPWM_IS_ACT |
| N_DIF_COR | TCO | VS | |

**FUNCTION DESCRIPTION:**

General information:

This ignition angle intervention is depending on the engine speed deviation from the nominal idle speed.

The calculation is made depending on the state of the idle speed regulation. As soon as the regulation is active, the dynamic ignition angle correction is applied with a factor which depends on VS and N_DIF_COR. It also prevents excessive overshooting when a transition from start (LV_ST) to idle (LV_IS) appeared with engine speed above nominal idle speed.

Application recurrence **: Segment**

**Formula section:**

**- If** engine operating state idle (LV_IS) active
**and** LV_ISAPWM_IS_ACT **= 1** (Active) *(idle speed regulation active)*
**then**
**If** **(** VS **= 0** **or** N_DIF_COR **> 0** **)**
**then**
IGA_DYN_COR_IS **=** IP_IGA_N_DIF_IS(_AT)__N_DIF_COR * IP_IGA_FAC_IS(_AT)__TCO
**else**
IGA_DYN_COR_IS **=** IP_IGA_N_DIF_IS__N_DIF_COR * IP_IGA_FAC_IS(_AT)__TCO * C_IGA_N_DIF_FAC_IS
**else**
**If** engine operating state idle (LV_IS) active
**and** LV_IGA_AST **= 1** (Active) *(ignition angle intervention due to post start function)*
**then**
IGA_DYN_COR_IS = IP_IGA_AST__N_DIF_COR
**else**
IGA_DYN_COR_IS **= 0**
**Endif.**

## Calibration data:

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| IP_IGA_AST__N_DIF_COR | 4 | 0...FFH | -48...47,625 | 0,375 | °CRK |
| | | | | | |
| Dynamic ignition angle correction for post start function (LV_IGA_AST). | | | | | |
| IP_IGA_N_DIF_IS(_AT)__N_DIF_COR | 12 | 0...FFH | -48...47,625 | 0,375 | °CRK |
| | | | | | |
| Dynamic ignition angle correction for idle speed stabilisation (LV_ISAPWM_IS_ACT). | | | | | |
| IP_IGA_FAC_IS(_AT)__TCO | 4 | 0...FFH | 0...0,996 | 1 / 256 | - |
| | | | | | |
| Weighting factor versus coolant temperature for dynamic ignition angle correction. | | | | | |
| C_IGA_N_DIF_FAC_IS | 1 | 0...FFH | 0...0,996 | 1/256 | - |
| Dynamic angle correction in case of vehicle running | | | | | |

### 1.2.2 Air and coolant temperatures correction out of idle ( IGA_TIA_TCO )



**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| IGA_TIA_TCO | V | 0...FFH | -48...47,625 | 0,375 | °CRK |
| Ignition angle correction versus temperatures out of idle. | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| TIA | TCO | N_32 | MAF |

**FUNCTION DESCRIPTION:**

General information:

The basic ignition angle out of idle is adjusted versus ambient conditions.

It is increased for low coolant temperature and decreased for high air temperature when engine is warm.

Application recurrence **: 720 °CRK**



**Formula section:**

IGA_TIA_TCO = IP_TIA_TCO_FAC(_AT)__TIA__TCO * IP_IGA_N_MAF__N_32__MAF

**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| IP_TIA_TCO_FAC(_AT)__TIA__TCO | 6 x 6 | 00...FFH | -1...0,992 | 7,8125E-3 | - |
| | | | | | |
| Weighting factor versus temperatures for ignition angle correction IGA_TIA_TCO. | | | | | |
| IP_IGA_N_MAF__N_32__MAF | 8 x 6 | 0...FFH | -48...47,625 | 0,375 | °CRK |
| | | | | | |
| Basic ignition angle correction versus temperatures out of idle. | | | | | |

### 1.2.3 Catalyst heating correction ( IGA_CH )

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| IGA_CH | V | 0...FFH | -48...47,625 | 0,375 | °CRK |
| Catalyst heating ignition angle correction. | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| LV_IGA_CH | LV_IS | N_32 | MAF |
| TCO | T_AST | LV_TPS_FL | ID_IGA_T_CH__TCO_ST |

**FUNCTION DESCRIPTION:**

General information:

The basic ignition angle out of start is adjusted in order to improve catalyst heating during warm-up. Thus, the catalyst reaches its service temperature quicklier and earlier its own efficiency.

Application recurrence **:**
- segment : if LV_IGA_CH = 1 (Active). IGA_CH is performed without gradient limitation.
- **720 °CRK :** if LV_IGA_CH deactivated. IGA_CH is reset with a gradient limitation.

**Formula section:**

**If** LV_IGA_CH **= 1** (Active)
**then**
**If** engine operating state idle speed (LV_IS) active
**then**

IGA_CH **=** IP_IGA_CH_IS__N_32__MAF * IP_IGA_TCO_CH_IS__TCO__T_AST

**else**

IGA_CH **=** IP_IGA_CH__N_32__MAF * IP_IGA_TCO_CH__TCO__T_AST

*(out of idle)*

**Remark :**
- When the duration ID_IGA_T_CH__TCO_ST has elapsed, the catalyst heating ignition angle correction is disabled using a gradient limitation C_IGA_LGRD_CH.
- The ignition angle intervention for catalyst heating function is stopped when full load (LV_TPS_FL) is required.

## Calibration data:

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| IP_IGA_CH_IS__N_32__MAF | 8 × 8 | 0...FFH | -48...47,625 | 0,375 | °CRK |
| | | | | | |
| Catalyst heating ignition angle correction versus engine speed in idle (LV_IS). | | | | | |
| IP_IGA_TCO_CH_IS__TCO__T_AST | 8 x 8 | 0...FFH | 0...0,997 | 3,895E-3 | - |
| | | | | | |
| Catalyst heating ignition angle factor versus coolant temperature in idle (LV_IS). | | | | | |
| IP_IGA_CH__N_32__MAF | 8 x 8 | 0...FFH | -48...47,625 | 0,375 | °CRK |
| | | | | | |
| Catalyst heating ignition angle correction versus engine speed out of idle. | | | | | |
| IP_IGA_TCO_CH__TCO__T_AST | 8 x 8 | 0...FFH | 0...0,997 | 3,895E-3 | - |
| | | | | | |
| Catalyst heating ignition angle factor versus coolant temperature out of idle. | | | | | |
| C_IGA_LGRD_CH | 1 | 01H...7FFFH | 0,00146...48 | 48 / 32767 | °CRK |
| Gradient limitation for catalyst heating ignition angle correction disabling. | | | | | |

### 1.2.4 Instationary correction ( IGA_TRA_KNK )

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| IGA_TRA_KNK | V | 0...80H | -48...0 | 0,375 | °CRK |
| Ignition angle for instationary correction. | | | | | |
| LV_TRA_KNK_ACT | V | 0...01H | 0...1 | 1 | - |
| Boolean information for ignition instationary correction requested - ( Passive / Active ). | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| LV_PL | N_32 | MAF | TIA |
| LV_PUC | TCO | TPS_GRD | C_TPS_GRD_BOL_RPL |
| LV_REAC | ID_IGA_RPL__N_32__TCO | | |

**FUNCTION DESCRIPTION:**

General information:

In order to prevent knock during strong acceleration, an ignition angle correction is applied to the nominal ignition angle out of start.
Application recurrence **: Segment.**

**Application conditions:**

*- Preliminary :*

**If** LV_PUC → LV_PL ( restart fuel feed at part load - LV_REAC **= 0 → 1** )
**and** TPS_GRD **<** C_TPS_GRD_BOL_RPL ( smooth acceleration )
**and** IGA_TRA_KNK**<** ID_IGA_RPL__N_32__TCO
**or**
engine operating state part load (LV_PL) active
**and** TPS_GRD ≥ ID_IGA_TPS_GRD_TRA__N_32 ( strong acceleration )
**then** LV_TRA_KNK_ACT **= 1** (Active)
**else** LV_TRA_KNK_ACT **= 0** (Passive)
**Endif.**

**Formula section:**

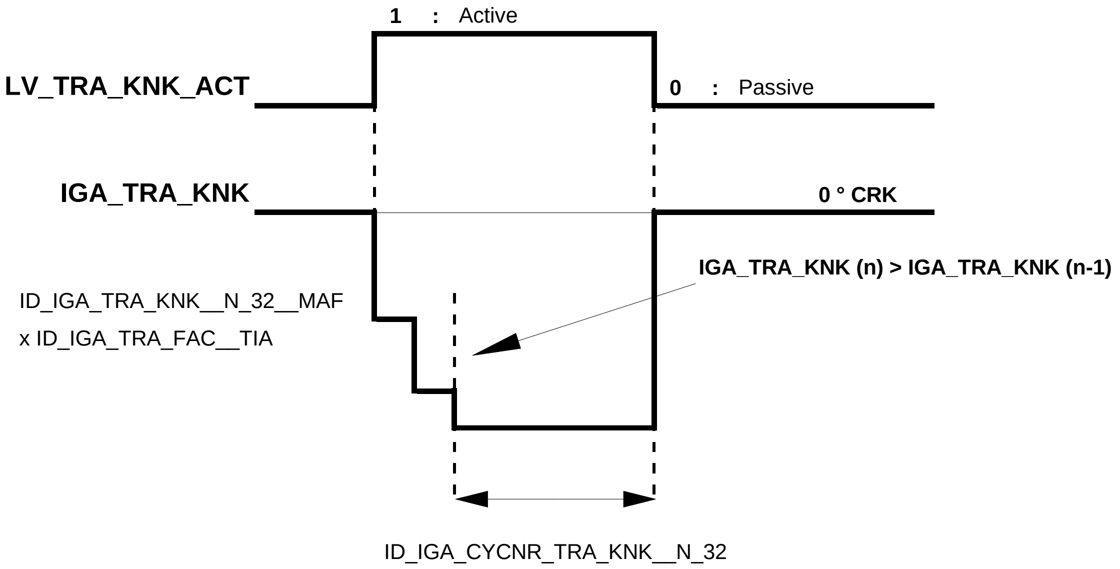
**If** LV_TRA_KNK_ACT **= 1** (Active)
**then**

| |
|---|
| IGA_TRA_KNK **=** ID_IGA_TRA_KNK(_AT)__N_32__MAF * IP_IGA_TRA_FAC(_AT)__TIA |

**and** as soon as $IGA\_TRA\_KNK_n \geq IGA\_TRA\_KNK_{n-1}$,
IGA_TRA_KNK remains unmodified during
ID_IGA_CYCNR_TRA_KNK__N_32__MAF **x** segments.

**else** IGA_TRA_KNK **= 0.**

Description:






**Calibration data:**

| **Name** | **Dim** | **Hex. limits** | **Phys. limits** | **Resol.** | **Unit** |
|---|---|---|---|---|---|
| ID_IGA_TPS_GRD_TRA__N_32 | 4 | 0...FFH | 0...2988 | 2988 / 256 | °TPS/sec |
| | | | | | |
| TPS_GRD threshold for ignition angle with instationary correction detection. | | | | | |
| ID_IGA_TRA_KNK(_AT)__N_32__MAF | 4 x 4 | 0...80H | -48...0 | 0,375 | °CRK |
| | | | | | |
| Ignition angle for instationary correction versus engine operating point. | | | | | |
| IP_IGA_TRA_FAC(_AT)__TIA | 4 | 0...FFH | 0...0,996 | 1 / 256 | - |
| | | | | | |
| Weighting factor versus air temperature for ignition angle during instationary correction. | | | | | |
| ID_IGA_CYCNR_TRA_KNK(_AT)__N_32 | 4 | 0...FFH | 0...255 | 1 | - |
| | | | | | |
| Duration of ignition angle during instationary correction - ( x Segment ). | | | | | |

### 1.2.5 Anti - jerk correction ( IGA_AJ )



**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| IGA_AJ | V | 80H...7FH | -48...47,625 | 0,375 | °CRK |
| Anti - jerk ignition angle correction. | | | | | |
| T_MES_GRD_AJ | V | 8000...7FFFH | -0,125...0,125 | 3,814E-5 | - |
| Segment time ratio for activation conditions of the anti - jerk function. | | | | | |
| SUM_TRIG_AJ | V | 0...0AH | 0...10 | 1 | - |
| Triggering counter for successive ignition angle intervention. | | | | | |
| LV_TRA_TPS_GRD_MIN_AJ | V | 0...01H | 0...1 | 1 | - |
| Boolean corresponding to TPS gradient conditions for activation of the anti - jerk function (passive / active). | | | | | |
| LV_AJ_ACT | V | 0...01H | 0...1 | 1 | - |
| Boolean for ignition angle intervention when anti - jerk function is required (passive / active). | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| N_32 | TPS_GRD | T_SEG | VS |
| N | LV_DRI | LV_PL | LV_IV_[CYL]_ERR |
| MAF | LV_STATE_A_MIS | LV_DUR_IGC_[CYL]_ERR | LV_CRK_ERR |
| TCO | LV_STATE_B_MIS | ID_IGA_LGRD_END_AJ__N_32 | LV_CAM_ERR |



**FUNCTION DESCRIPTION:**

General information:

Due to sudden transition from an engine operating point in low part load to wide open throttle, jerking can occur in the lower engine speed range during acceleration.

These jerks have to be suppressed, which can be achieved by a selective torque reduction. Thus ignition is retarded during the positive half - wave of the engine speed wave.

*1 - Segment time ratio T_MES_GRD_AJ :*

In order to start ignition intervention, “jerk” must be previously detected using the segment time ratio T_MES_GRD_AJ.
It is calculated using the corresponding segment periods :

T_REV_ACT= ( $T\_SEG_n + T\_SEG_{n-1}$)

T_REV_LAST = ( $T\_SEG_{n-2} + T\_SEG_{n-3}$ )

**If** N_32 ≤ C_N_THD_T_MES_AJ
**then** T_MES_GRD_AJ = ( $T\_SEG_n - T\_SEG_{n-1}$ ) / $T\_SEG_n$
**else** T_MES_GRD_AJ = ( T_REV_ACT - T_REV_LAST ) / T_REV_ACT

*2 - TPS gradient condition LV_TRA_TPS_GRD_MIN_AJ :*

In order to start ignition intervention for first triggering, a condition on the gradient of the throttle position sensor must be provided.
It is defined using the following algorithm :

| | | | |
|---|---|---|---|
| **If** | | TPS_GRD **>** C_TPS_GRD_MIN_AJ | ( LV_DRI = - ) |
| | **or** | TPS_GRD **>** C_DRI_TPS_GRD_MIN_AJ | ( LV_DRI = DRI ) |
| **then** | | LV_TRA_TPS_GRD_MIN_AJ = 1 (Active) | |
| | **and** | C_T_TPS_GRD_MIN_AJ is started. | |

| | | |
|---|---|---|
| **If** | | C_T_TPS_GRD_MIN_AJ has elapsed |
| | **or** | anti - jerk deactivation conditions are fulfilled |
| **then** | | LV_TRA_TPS_GRD_MIN_AJ = 0 (Passive) |



**Application conditions:**

1 - Anti - jerk function :

*Activation :*

| | | | |
|---|---|---|---|
| | Engine operating state part load (LV_PL) | | |
| **and** | TCO **>** C_TCO_MIN_AJ | | |
| **and** | C_N_MIN_AJ **<** N_32 **<** C_N_MAX_AJ | | |
| **and** | C_VS_MIN_AJ **<** VS **<** C_VS_MAX_AJ | | |
| **and** | the following diagnosis errors are not permitted : | | |
| | | LV_CRK_ERR = 0 | (crankshaft sensor) |
| | **and** | LV_CAM_ERR = 0 | (camshaft sensor) |
| | **and** | LV_DUR_IGC_[CYL]_ERR = 0 | (ignition coils) |
| | **and** | LV_IV_[CYL]_ERR = 0 | (injector valves) |
| | **and** | LV_STATE_A_MIS = 0 | (misfire status - error CARB A) |
| | **and** | LV_STATE_B_MIS = 0 | (misfire status - error CARB B) |

*Deactivation :*

| | |
|---|---|
| | T_MES_GRD_AJ **>** IP_T_MES_GRD_END_AJ__N_32 |
| **or** | timer C_T_MAX_AJ has elapsed |
| **or** | timer C_T_MAX_GRD_2_ST_AJ has elapsed. |

2 - Ignition intervention - First triggering :

*Activation :*

| | | | |
|---|---|---|---|
| **If** | | LV_TRA_TPS_GRD_MIN_AJ = 1 (active) | |
| | **and** | T_MES_GRD_AJ **<** IP_T_MES_GRD_1_ST_AJ__N_32 | |
| | **and** | T_MES_GRD_AJ ≤ IP_T_MES_GRD_END_AJ__N_32 | |
| **then** | | SUM_TRIG_AJ = 1 | (initialisation) |
| | **and** | LV_AJ_ACT = 1 (active) | (ignition angle intervention takes place) |
| | **and** | C_T_MAX_GRD_2_ST_AJ | (timer initialisation) |
| | **and** | C_T_MAX_AJ | (timer initialisation) |

**Remark :** C_T_MAX_AJ **<** C_T_MAX_GRD_2_ST_AJ

3 - Ignition intervention - Second triggering and further :

*Activation :*

| | | |
|---|---|---|
| **If** | | 1 **<** SUM_TRIG_AJ ≤ C_SUM_TRIG_AJ |
| | **and** | T_MES_GRD_AJ **<** IP_T_MES_GRD_2_ST_AJ__N_32 |
| | **and** | T_MES_GRD_AJ ≤ IP_T_MES_GRD_END_AJ__N_32 |
| **then** | | LV_AJ_ACT = 1 (Active)(ignition angle intervention take place) |
| | **and** | $SUM\_TRIG\_AJ_i = SUM\_TRIG\_AJ_{i-1} + 1$ |
| | **and** | C_T_MAX_AJ initialisation. |

**Formula section:**

*First triggering :*

| | | |
|---|---|---|
| **If** | | LV_AJ_ACT = 1 (Active) |
| | **and** | SUM_TRIG_AJ = 1 |
| **then** | | IGA_AJ = IP_IGA_AJ__N_32__MAF |

Second triggering :

| | | |
|---|---|---|
| **If** | | LV_AJ_ACT = 1 (Active) |
| | **and** | SUM_TRIG_AJ = 2 |
| **then** | | IGA_AJ = IP_IGA_AJ__N_32__MAF * C_IGA_FAC_2_AJ |

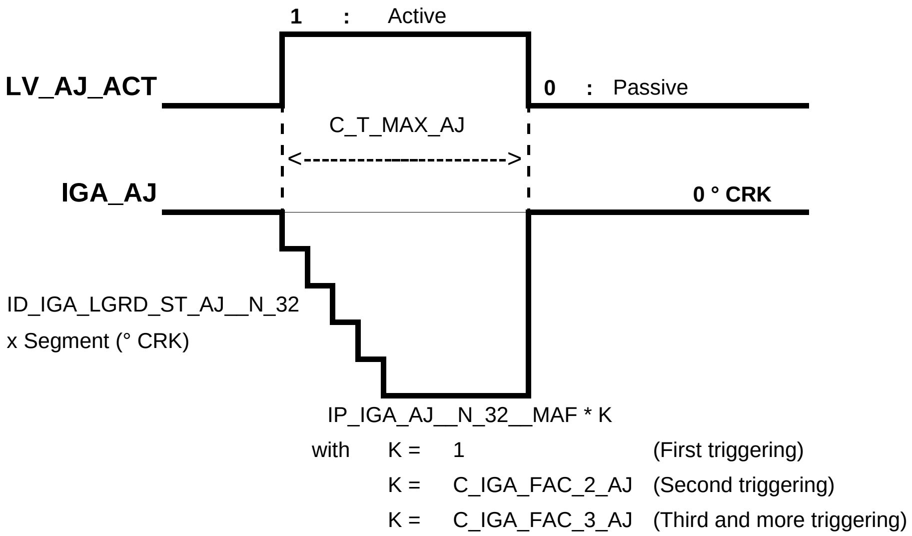
Third and further triggering :

| | | |
|---|---|---|
| **If** | | LV_AJ_ACT = 1 (Active) |
| | **and** | 2 **<** SUM_TRIG_AJ ≤ C_SUM_TRIG_AJ |
| **then** | | IGA_AJ = IP_IGA_AJ__N_32__MAF * C_IGA_FAC_3_AJ |

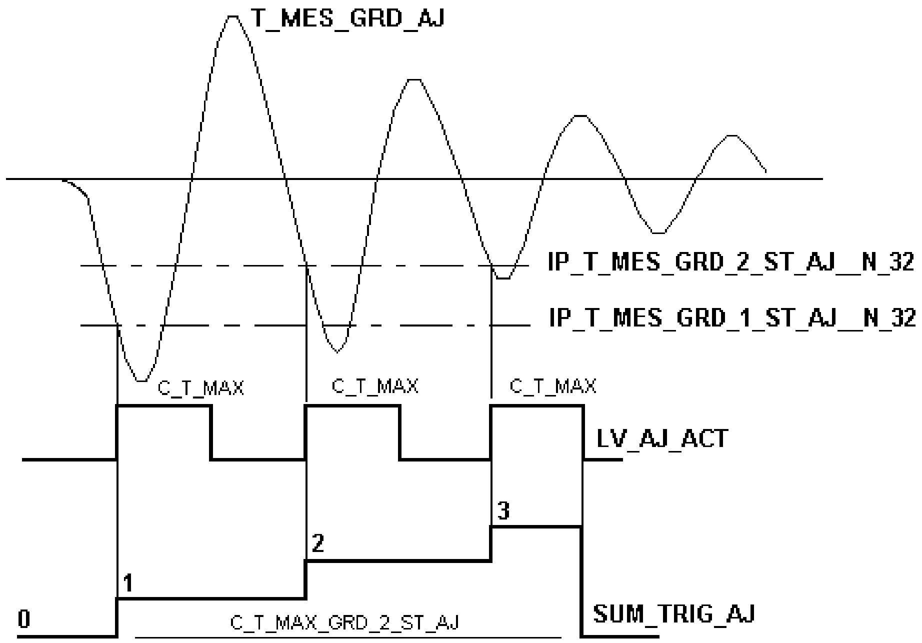
**Remark :**
The ignition angle retard adjustment is applied with a gradient limitation ID_IGA_LGRD_ST_AJ__N_32. The return to the nominal ignition angle at the end of the correction is performed with a gradient limitation ID_IGA_LGRD_END_AJ__N_32 (refer to the chapter “ Ignition angle gradient limitation “)

Description:

1 - Ignition intervention description :




2 - Timer description :



## Calibration data:

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| IP_IGA_AJ__N_32__MAF | 8 x 6 | 0...80H | -48...0 | 0,375 | °CRK |
| | | | | | |
| Basic anti-jerk ignition angle correction. | | | | | |
| ID_IGA_LGRD_ST_AJ__N_32 | 8 | 01...FFH | 0,375...95,625 | 0,375 | °CRK |
| | | | | | |
| Gradient limitation to reach the anti-jerk ignition angle correction (x Segment). | | | | | |
| IP_T_MES_GRD_1_ST_AJ__N_32 | 10 | 0...8000H | -0,125...0 | 3,8E-6 | msec/mse |
| | | | | | |
| T_MES_GRD_AJ threshold for first ignition intervention triggering. | | | | | |
| IP_T_MES_GRD_2_ST_AJ__N_32 | 10 | 0...8000H | -0,125...0 | 3,8E-6 | msec/mse |
| | | | | | |
| T_MES_GRD_AJ threshold for second and further ignition intervention triggering. | | | | | |
| IP_T_MES_GRD_END_AJ__N_32 | 10 | 0...8000H | -0,125...0 | 3,8E-6 | msec/mse |
| | | | | | |
| T_MES_GRD_AJ threshold to cancel anti-jerk ignition angle correction. | | | | | |
| C_N_THD_T_MES_AJ | 1 | 0...FFH | 0...8160 | 32 | rpm |
| Engine speed threshold for calculation of T_MES_GRD_AJ. | | | | | |
| C_TCO_MIN_AJ | 1 | 0...FEH | -48...142,5 | 0,75 | °C |
| Minimum coolant temperature threshold for application condition of anti-jerk function. | | | | | |
| C_N_MIN_AJ | 1 | 0...FFH | 0...8160 | 32 | rpm |
| Minimum engine speed threshold for application condition of anti-jerk function. | | | | | |
| C_N_MAX_AJ | 1 | 0...FFH | 0...8160 | 32 | rpm |
| Maximum engine speed threshold for application condition of anti-jerk function. | | | | | |
| C_VS_MIN_AJ | 1 | 0...FFH | 0...255 | 1 | km/h |
| Minimum vehicle speed threshold for application condition of anti-jerk function. | | | | | |
| C_VS_MAX_AJ | 1 | 0...FFH | 0...255 | 1 | km/h |
| Maximum vehicle speed threshold for application condition of anti-jerk function. | | | | | |
| C_TPS_GRD_MIN_AJ | 1 | 0...FFH | 0...2988 | 11,72 | °TPS/sec |
| Minimum TPS_GRD threshold for application condition of anti-jerk function. (DRIVE not engaged). | | | | | |
| C_DRI_TPS_GRD_MIN_AJ | 1 | 0...FFH | 0...2988 | 11,72 | °TPS/sec |
| Minimum TPS_GRD threshold for application condition of anti-jerk function. (DRIVE engaged). | | | | | |
| C_IGA_FAC_2_AJ | 1 | 00...FFH | 0...1,000 | 3,906E-3 | - |
| Weighting factor for second ignition intervention triggering. | | | | | |
| C_IGA_FAC_3_AJ | 1 | 00...FFH | 0...1,000 | 3,906E-3 | - |
| Weighting factor for third and further ignition intervention triggering. | | | | | |
| C_T_MAX_AJ | 1 | 01...FFH | 0,01...25,5 | 0,01 | sec |
| Maximum duration of the ignition intervention. | | | | | |
| C_T_MAX_GRD_2_ST_AJ | 1 | 01...FFFFH | 0,01...655,35 | 0,01 | sec |
| Maximum duration of the anti-jerk function. | | | | | |
| C_T_TPS_GRD_MIN_AJ | 1 | 01...FFH | 0,1...25,5 | 0,1 | sec |
| Time exceeding the TPS_GRD threshold for activation and deactivation of the anti-jerk function. | | | | | |
| C_SUM_TRIG_AJ | 1 | 01...0AH | 1...10 | 1 | - |
| Number of anti-jerk ignition angle intervention triggering. | | | | | |

### 1.2.6 Trailing throttle correction ( IGA_PU_PUC )



**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| IGA_PU_PUC | V | 0...80H | -48...0 | 0,375 | °CRK |
| Trailing throttle ignition angle correction. | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| LV_PL | LV_PU | LV_PU_PUC_TRA_FAST | LV_PUC |
| LV_CT | C_IGA_LGRD_x | LV_RLY_ACCOUT | TCO |
| MAF_MMV | N_GRD | ISAPWM_D_IS | ISAPWM_DHP |
| N_32 | N | IP_N_MIN_PUC(_AT)__TCO | C_N_MAX_INF |
| IP_N_ACCIN_MIN_PUC(_AT)__TCO | C_N_GRD_MIN | | |

**FUNCTION DESCRIPTION:**



General information:

A preliminary check is made on the type of deceleration ( LV_PU_PUC_TRA_FAST ) at the transition from engine operating state in part load ( LV_PL ) to trailing throttle ( LV_PU ) in order to define the right ignition angle correction.

- In case of fast deceleration ( LV_PU_PUC_TRA_FAST **= 1** (Active) ), the fuel injection is switched off immediately and the nominal ignition angle out of start is adjusted with IGA_PU_PUCin order to get the lowest possible engine torque to avoid a torque jump.

- In case of slow deceleration ( LV_PU_PUC_TRA_FAST **= 0** (Passive) ), trailing throttle fuel cut-off is delayed and the nominal ignition angle correction out of start is adjusted with IGA_PU_PUCin order to prevent engine acceleration when shifting below high load.

Application recurrence **: Segment.**

**Formula section:**

**-** *IGA_PU_PUC formula:*

**If** LV_PU **=** 0
    **and** LV_PUC **=** 0
**then**
    IGA_PU_PUC **=** 0
**else**
    **if** LV_PUC **=** 1
    **then**
        **if** LV_PU_PUC_TRA_FAST **=** 1
        **then**
            IGA_PU_PUC **=** IP_IGA_MAX_PUC__N
        **else**
            IGA_PU_PUC **=** IP_IGA_PUC(_AT)__N **or**
        IP_IGA_ACCIN_PUC(_AT)__N
    **else**
        **if** LV_PU **=** 1
        **then**
            IGA_PU_PUC **=** IP_IGA_PU__N__TCO
    using gradient limitation <u>in the decreasing direction</u>
    IP_IGA_LGRD_PU(_AT)__N_32__MAF_MMV + ID_IGA_TCO_LGRD_PU__TCO
    **and**
    Exit conditions from LV_PU to LV_PUC are tested

***- Exit conditions from LV_PU to LV_PUC :***

**If** LV_CT = 1
**and** N_32 ≥ IP_N_MIN_PUC(_AT)__TCO + Hysteresis ← (LV_RLY_ACCOUT = 0)
**or** N_32≥ IP_N_ACCIN_MIN_PUC(_AT)__TCO + Hyst.
← (LV_RLY_ACCOUT = 1)
**and** ISAPWM_D_IS= 0 ← (derivative term from idle speed controller inactive)
**and** N_32≥ C_N_MAX_INF
**or** ( N_32 < C_N_MAX_INF **and** N_GRD ≥ C_N_GRD_MIN )
**then**
**If** LV_PU_PUC_TRA_FAST = 1 (Active) ← (fast deceleration)
**then**

| |
|---|
| LV_PUC **=** 1 ← (trailing throttle fuel cut-off immediately)<br>**and** IGA_PU_PUC **=** IP_IGA_MAX_PUC__N ← (without gradient limitation) |

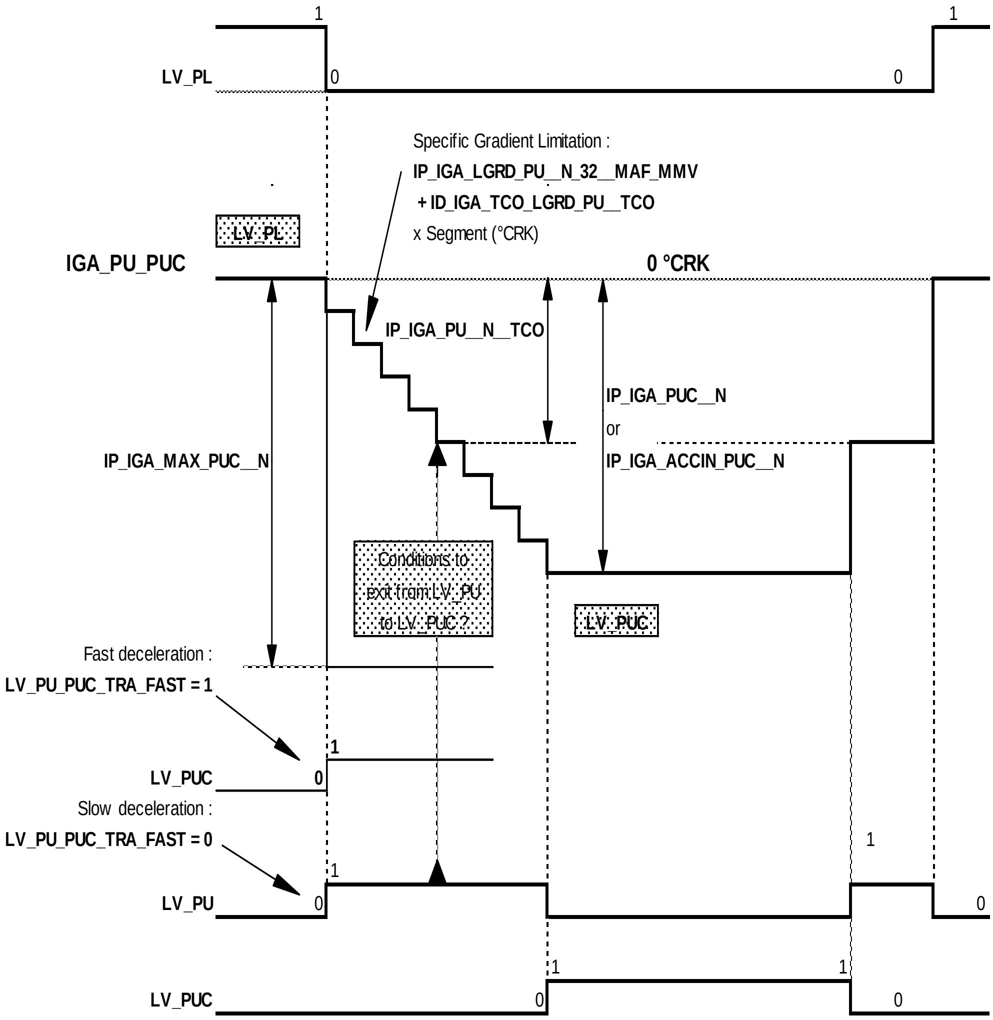
**else** ← (slow deceleration)
**If** N_32 < C_N_MIN_DHP
**or** N_32 ≥ C_N_MIN_DHP
**and** ISAPWM_DHP = 0 ← (dashpot function inactive)
**and** IGA_PU_PUC = IP_IGA_PUC(_AT)__N
**or** IGA_PU_PUC=IP_IGA_ACCIN_PUC(_AT)__N
(LV_RLY_ACCOUT=1)
**then**
LV_PUC **=** 1
**else**

| |
|---|
| LV_PU **=** 1<br>**until** IGA_PU_PUC = IP_IGA_PUC(_AT)__N<br>**or** IGA_PU_PUC = IP_IGA_ACCIN_PUC(_AT)__N ← (LV_RLY_ACCOUT = 1)<br><br>using IP_IGA_LGRD_PU(_AT)__N_32__MAF_MMV + ID_IGA_TCO_LGRD_PU__TCO<br>gradient limitation |

**else**

| |
|---|
| LV_PU **=** 1<br>**and** IGA_PU_PUC = IP_IGA_PU__N__TCO<br><br>using IP_IGA_LGRD_PU(_AT)__N_32__MAF_MMV + ID_IGA_TCO_LGRD_PU__TCO<br>gradient limitation <u>in the decreasing direction</u> |

Description:




**Remark :**

*- Tuning information :*

The gradient limitation used for ignition angle correction (IGA_PU_PUC) in trailing throttle (LV_PU) or trailing throttle fuel cut-off (LV_PUC) must be lower than the general gradient limitation used for the nominal ignition angle out of start (IGA_BAS) **:**

(IP_IGA_LGRD_PU(_AT)__N_32__MAF_MMV + ID_IGA_TCO_LGRD_PU__TCO)
≤ C_IGA_LGRD_x

## Calibration data:

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| IP_IGA_PU(_AT)__N__TCO | 4 x 4 | 0...80H | -48...0 | 0,375 | °CRK |
| | | | | | |
| Target ignition angle in case of slow deceleration in trailing throttle (LV_PU). | | | | | |
| ID_IGA_TCO_LGRD_PU(_AT)__TCO | 4 | 01...7FFFH | 0,0146...48 | 48 / 32767 | °CRK |
| | | | | | |
| Gradient limitation offset versus coolant temperature for ignition angle in trailing throttle. | | | | | |
| IP_IGA_LGRD_PU(_AT)__N_32__MAF_MMV | 4 x 4 | 01...7FFFH | 0,0146...48 | 48 / 32767 | °CRK |
| | | | | | |
| Basic gradient limitation versus engine operating point for ignition angle in trailing throttle. | | | | | |
| IP_IGA_MAX_PUC__N | 4 | 0...80H | -48...0 | 0,375 | °CRK |
| | | | | | |
| Target ignition angle in case of fast deceleration in trailing throttle (LV_PU). | | | | | |
| IP_IGA_PUC(_AT)__N | 4 | 0...80H | -48...0 | 0,375 | °CRK |
| | | | | | |
| Target ignition angle in case of trailing throttle fuel cut-off (LV_PUC). | | | | | |
| IP_IGA_ACCIN_PUC(_AT)__N | 4 | 0...80H | -48...0 | 0,375 | °CRK |
| | | | | | |
| Target ignition angle in case of trailing throttle fuel cut-off (LV_PUC) with air condition compressor active.. | | | | | |
| C_N_MIN_DHP | 1 | 0...FFH | 0...8160 | 32 | rpm |
| Minimum engine speed to wait for the end of the dashpot function from idle speed control to go to fuel cut-off (LV_PUC). | | | | | |

## 1.2.7 Tuning correction ( IGA_AS_[CYL] )



**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| IGA_AS_[CYL] | - | 80...7FH | -48...47,625 | 0,375 | °CRK |
| Tuning correction for individual ignition angle. | | | | | |

**FUNCTION DESCRIPTION:**

General information:

The application tool can perform a cylinder individual ignition angle correction using IGA_AS_[CYL] for development (e.g. knock control...).

Application recurrence **: 1 sec.**

**Formula section:**

**If** IGA_AS_[CYL] not modified by serial communication line
**then** IGA_AS_[CYL] **=** C_IGA_AS_[CYL]
**else** IGA_AS_[CYL] controlled by serial interface until system reset.



**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| C_IGA_AS_[CYL] | 1 | 80...7FH | -48...47,625 | 0,375 | °CRK |
| Application system intervention for ignition angle. | | | | | |

## 1.3 Calculation of basic ignition angle

### 1.3.1 Basic ignition angle at start ( IGA_ST )



**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| IGA_ST | - | 0...FFH | -23,625...72 | 0,375 | °CRK |
| Basic ignition angle at start (LV_ST). | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| LV_ES | LV_ST | N | TCO_ST |

**FUNCTION DESCRIPTION:**

General information:

The basic ignition angle at start (LV_ST) is depending on engine speed N, N_32 and coolant temperature TCO_ST.

It is applied following first ignition angle at engine stopped (LV_ES).

Application recurrence **: Segment**

**Formula section:**

IGA_ST **=** IP_IGA_ST__N__TCO_ST

**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| IP_IGA_ST__N__TCO_ST | 5 x 8 | 0...FFH | -23,625...72 | 0,375 | °CRK |
| | | | | | |
| Basic ignition angle at start (LV_ST). | | | | | |

## 1.3.2 Basic ignition angle out of start ( IGAB )



**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| IGAB | - | 0...FFH | -23,625...72 | 0,375 | °CRK |
| Basic ignition angle out of start. | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| LV_IS | N | N_32 | MAF |
| TCO | | | |

**FUNCTION DESCRIPTION:**

General information:

The basic ignition angle is depending on engine operating point (N, MAF) and on engine operating states (idle (LV_IS) or out of idle).

Application recurrence **: Segment**



**Formula section:**

**If** engine operating state idle (LV_IS) active
**then** IGAB = IP_IGAB_IS__N__MAF + IP_IGA_TCO_IS__TCO
**else** IGAB = IP_IGAB__N__MAF
**Endif.**

**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| IP_IGAB__N__MAF | 16 x 12 | 0...FFH | -23,625...72 | 0,375 | °CRK |
| | | | | | |
| Basic ignition angle out of start and out of idle. | | | | | |
| IP_IGAB_IS__N__MAF | 4 x 4 | 0...FFH | -23,625...72 | 0,375 | °CRK |
| | | | | | |
| Basic ignition angle out of start in idle (LV_IS). | | | | | |
| IP_IGA_TCO_IS__TCO | 6 | 0...FFH | -48...47,625 | 0,375 | °CRK |
| | | | | | |
| Coolant temperature correction of basic ignition angle out of start in idle (LV_IS). | | | | | |

### 1.3.3 Basic ignition angle with gradient limitation ( IGA_BAS_LGRD )



**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| IGA_BAS_LGRD | V | 0...FFH | -23,625...72 | 0,375 | °CRK |
| Basic ignition angle with gradient limitation. | | | | | |

General information:

A gradient limitation is applied to the basic ignition angle calculation IGA_BAS in order to limit ignition angle variations, following the priorities described here below.

Application recurrence **: Segment**

#### 1.3.3.1 Engine operating states without gradient limitation for ignition angle.



**Input data:**

| | | | |
|---|---|---|---|
| LV_ISAPWM_IS_ACT | LV_ST | LV_IGA_AST | LV_PUC |
| IGA_BAS | | | |

**FUNCTION DESCRIPTION:**

**Formula section:**

**If** LV_ISAPWM_IS_ACT **= 1** (Active) *(idle speed regulation ISAPWM_IS active)*
**or** engine operating state start ( LV_ST ) active
**or** LV_IGA_AST **= 1** (Active) (ignition intervention due to post start function)
**or** trailing throttle fuel cut-off ( LV_PUC ) active
**then**

$$IGA\_BAS\_LGRD_n = IGA\_BAS_n$$

**Endif.**

### 1.3.3.2 Gradient limitation for ignition angle at intercept function ( LV_INF )

**Input data:**

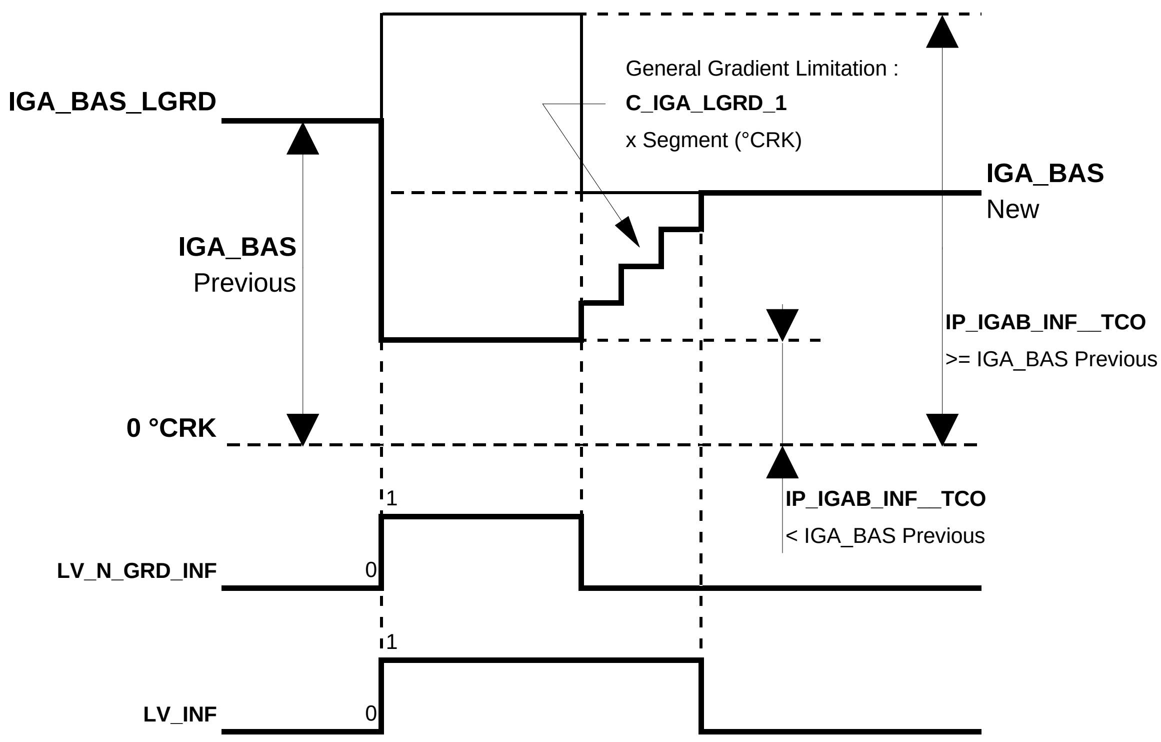
| | | | |
|---|---|---|---|
| LV_INF | LV_N_GRD_INF | IGA_BAS | TCO |
| C_IGA_LGRD_1 | | | |

**FUNCTION DESCRIPTION:**

General information:

In case of an important engine speed gradient below a specific engine speed threshold and in closed throttle position, the general gradient limitation C_IGA_LGRD_1 is applied on specific ignition angle IP_IGAB_INF__TCO at intercept function.

Description:




**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| IP_IGAB_INF__TCO | 4 | 0...FFH | -23,625...72 | 0,375 | °CRK |
| | | | | | |
| Basic ignition angle with intercept function (LV_INF) active. | | | | | |

### 1.3.3.3 Re-start fuel feed ( LV_REAC ) at part load ( LV_PUC → LV_PL )

**Input data:**

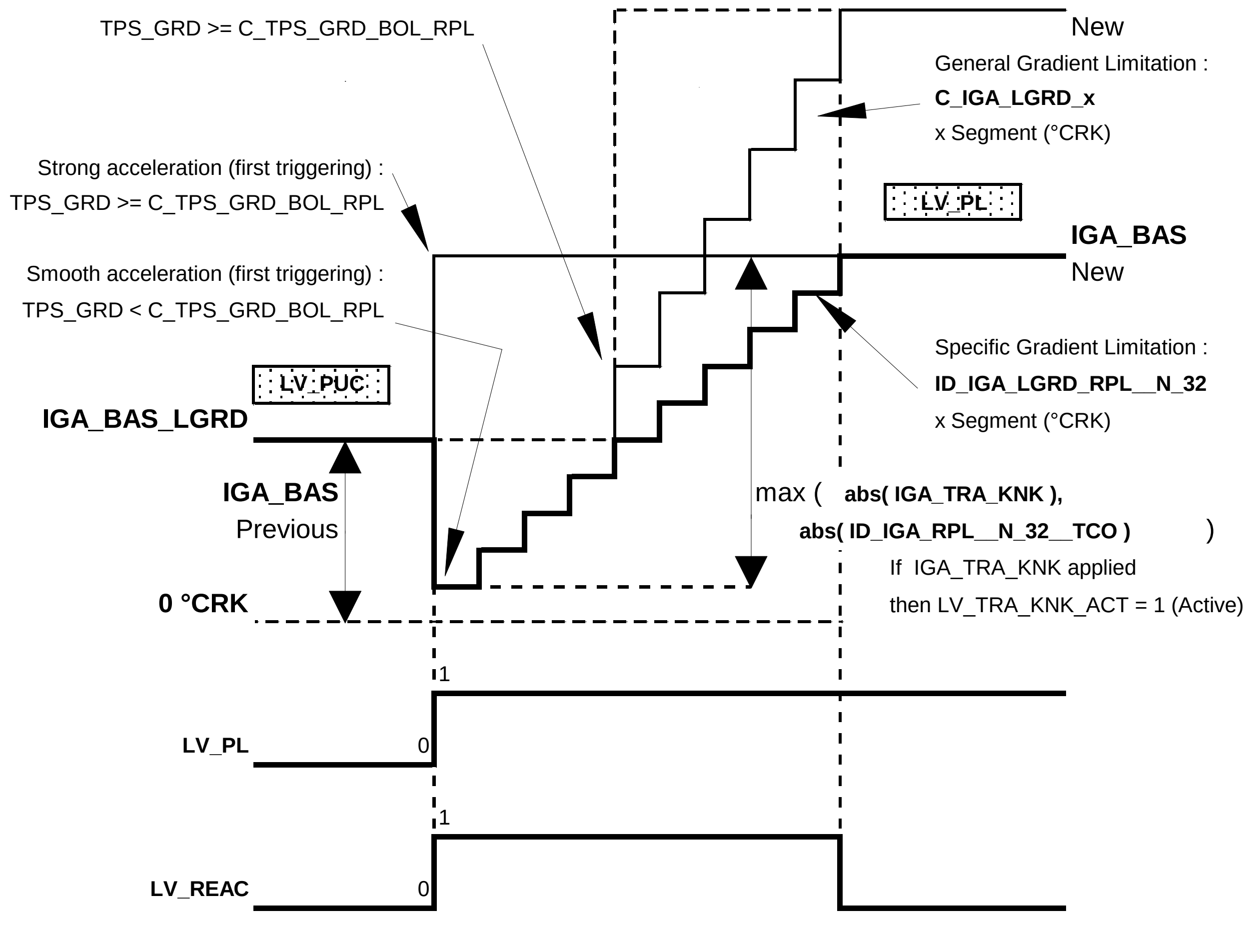
| | | | |
|---|---|---|---|
| LV_PUC | LV_PL | LV_REAC | IGA_BAS |
| N_32 | TCO | TPS_GRD | IGA_TRA_KNK |
| C_IGA_LGRD_1 | C_IGA_LGRD_2 | C_IGA_LGRD_3 | LV_TRA_KNK_ACT |

**FUNCTION DESCRIPTION:**

General information:

In order to obtain a soft engine torque built - up, the ignition angle at part load (LV_PL) is retarded and reached with a gradient limitation, depending on the type of acceleration.
The first triggering ignition angle correction for restart fuel feed at part load takes into account the instationary correction (IGA_TRA_KNK).

Description:



## Calibration data:

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| ID_IGA_RPL__N_32__TCO | 4 x 6 | 0...80H | -48...0 | 0,375 | °CRK |
| | | | | | |
| Ignition angle correction in case of restart fuel feed at part load - First triggering. | | | | | |
| ID_IGA_LGRD_RPL__N_32 | 4 | 01...7FFFH | 0,00146...48 | 48 / 32767 | °CRK |
| | | | | | |
| Ignition angle gradient limitation for restart fuel feed at part load ( x Segment ). | | | | | |
| C_TPS_GRD_BOL_RPL | 1 | 0...FFH | 0...2988 | 2988 / 256 | °TPS/sec |
| TPS_GRD threshold for strong or smooth acceleration detection in case of restart fuel feed at part load. | | | | | |

### 1.3.3.4 Re-start fuel feed ( LV_REAC ) at idle ( LV_PUC → ( LV_PU )→ LV_IS )



**Input data:**

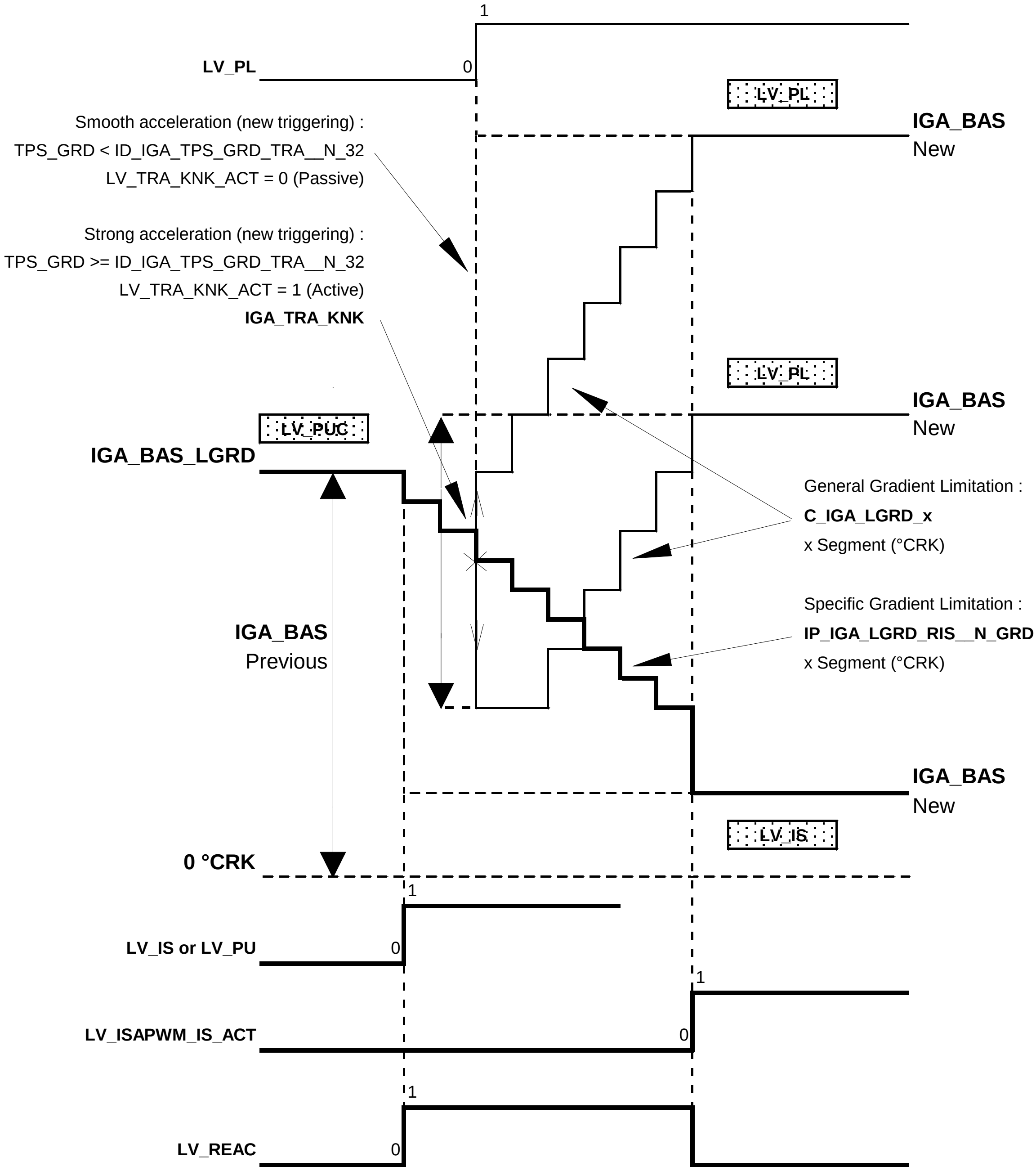
| | | | |
|---|---|---|---|
| LV_PUC | LV_PU | LV_IS | LV_REAC |
| IGA_BAS | N_32 | N_GRD | LV_PL |
| C_IGA_LGRD_1 | C_IGA_LGRD_2 | C_IGA_LGRD_3 | LV_TRA_KNK_ACT |
| IGA_TRA_KNK | TPS_GRD | ID_IGA_TPS_GRD_TRA__N_32 | |

**FUNCTION DESCRIPTION:**

General information:

In order to obtain a soft engine torque built - down, the ignition angle at idle (LV_IS) is retried and reached with a gradient limitation, depending on the type of deceleration.

Description:




## Calibration data:

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| IP_IGA_LGRD_RIS__N_GRD | 4 | 01...7FFFH | 0,00146...48 | 48 / 32767 | °CRK |
| | | | | | |
| Ignition angle gradient limitation for restart fuel feed at idle (LV_IS) or trailing throttle (LV_PU) ( x Segment ). | | | | | |

### 1.3.3.5 Gradient limitation for ignition angle with anti-jerk correction ( LV_AJ_ACT )

**Input data:**

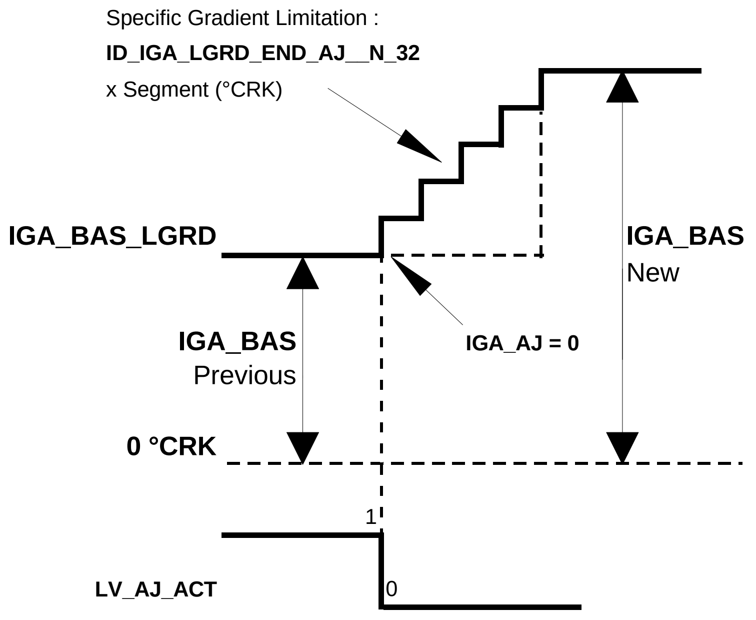
| | | | |
|---|---|---|---|
| LV_AJ_ACT | IGA_BAS | N_32 | IGA_AJ |

**FUNCTION DESCRIPTION:**

General information:

In order to obtain a soft engine torque built - up following anti-jerk intervention ( IGA_AJ ), the nominal ignition angle is reached with a gradient limitation versus engine speed.

Description:




**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| ID_IGA_LGRD_END_AJ__N_32 | 8 | 01...FFH | 0,375...95,625 | 0,375 | °CRK |
| | | | | | |
| Gradient limitation to cancel the anti-jerk ignition angle correction (x Segment). | | | | | |

### 1.3.3.6 Gradient limitation for ignition angle with instationary correction (LV_TRA_KNK_ACT)



**Input data:**

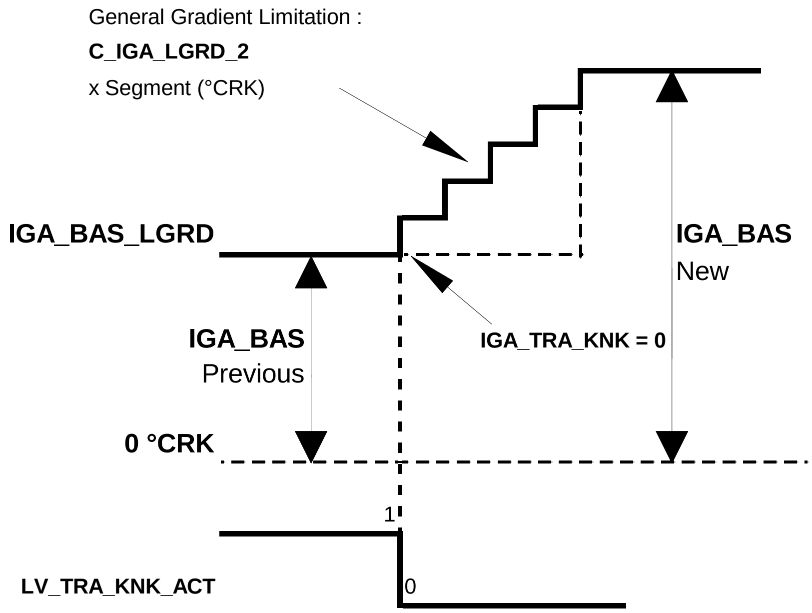
| | | | |
|---|---|---|---|
| LV_TRA_KNK_ACT | IGA_BAS | IGA_TRA_KNK | C_IGA_LGRD_2 |

**FUNCTION DESCRIPTION:**

General information:

In order to obtain a soft engine torque built - up following instationary correction (IGA_TRA_KNK), the nominal ignition angle is reached with the general gradient limitation C_IGA_LGRD_2.

Description:



### 1.3.3.7 Gradient limitation for ignition angle with knock detected

**Input data:**

| | | | |
|---|---|---|---|
| KNK_INT_CYL_[CYL] | IGA_BAS | | |

**FUNCTION DESCRIPTION:**

**Formula section:**

**If** KNK_INT_CYL_[CYL] $\neq$ **0**
**and** $IGA\_BAS_n \leq IGA\_BAS_{n-1}$
**then** $IGA\_BAS\_LGRD_n = IGA\_BAS_n$
**Endif.**



### 1.3.3.8 Gradient limitation for transition Part Load (PL) -> Idle Speed (IS)

**Input data:**

| | | | |
|---|---|---|---|
| LV_PL | LV_IS | | |

**FUNCTION DESCRIPTION:**

In case of transition Part Load PL -> Idle Speed IS, a specific change limitation C_IGA_LGRD_PL_IS is applied to IGA_BAS_LGRD.

**If** Transition PL -> IS
**Then**
a change limitation C_IGA_LGRD_PL_IS is applied on IGA_BAS_LGRD until target is reached

**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| C_IGA_LGRD_PL_IS | 1 | 01...7FFFH | 0,00146...48 | 48 / 32767 | °CRK |
| Ignition angle gradient limitation in case of transition PL->IS | | | | | |

### 1.3.3.9 General gradient limitation for ignition angle

**Input data:**

| | | | |
|---|---|---|---|
| MAF | N | IGA_BAS | |

**FUNCTION DESCRIPTION:**

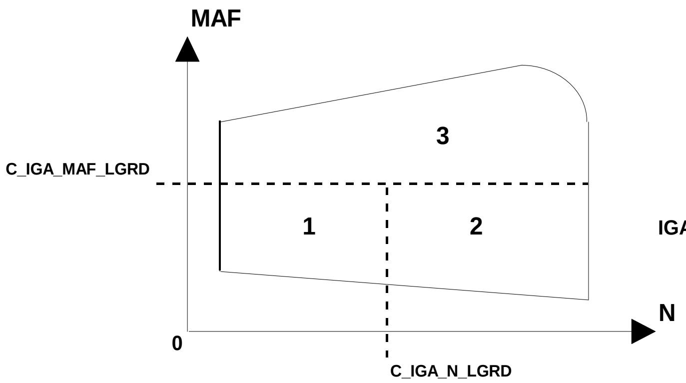
General information:

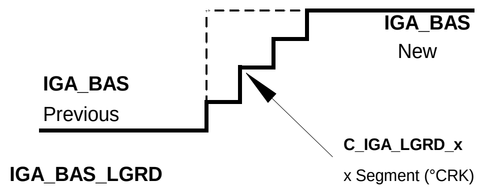
In specific conditions different from the previous described conditions, a general gradient limitation C_IGA_LGRD_x is applied to the nominal ignition angle in order to limit ignition angle variations.
It´s applied only in advance direction and is different for 3 engine operating areas (MAF, N).

**Formula section:**

**If** MAF ≥ C_IGA_MAF_LGRD
**then** C_IGA_LGRD_x = C_IGA_LGRD_3
**else**
  **If** N ≥ C_IGA_N_LGRD
  **then** C_IGA_LGRD_x = C_IGA_LGRD_2
  **else** C_IGA_LGRD_x = C_IGA_LGRD_1

Description:



## Calibration data:

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| C_IGA_LGRD_1 | 1 | 01...7FFFH | 0,00146...48 | 48 / 32767 | °CRK |
| Ignition angle gradient limitation for area 1 - (x Segment). | | | | | |
| C_IGA_LGRD_2 | 1 | 01...FFH | 0,375...95,625 | 0,375 | °CRK |
| Ignition angle gradient limitation for area 2 - (x Segment). | | | | | |
| C_IGA_LGRD_3 | 1 | 01...FFH | 0,375...95,625 | 0,375 | °CRK |
| Ignition angle gradient limitation for area 3 - (x Segment). | | | | | |
| C_IGA_N_LGRD | 1 | 01...1FE0H | 1...8160 | 1 | rpm |
| Engine speed threshold for ignition angle gradient limitation choice. | | | | | |
| C_IGA_MAF_LGRD | 1 | 01...FFH | 5,45...1389 | 5,45 | mg/TDC |
| Mass air flow threshold for ignition angle gradient limitation choice. | | | | | |

## 1.4 Knock control

### 1.4.1 General - Knock correction ( IGA_KNK_[CYL] )

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| IGA_KNK_[CYL] | V | 0...80H | -48...0 | 0.375 | °CRK |
| Cylinder individual ignition angle knock correction. | | | | | |
| IGA_MV_KNK | V | 0...80H | -48...0 | 0.375 | °CRK |
| Ignition angle knock correction mean value. | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| LV_KNK_ACT | LV_KNK_1_ERR | LV_KNK_2_ERR | LV_CAM_ERR_LIH |
| LV_TRA_KNK_ACT | LV_IGA_ADJ_TQR | C_IGA_LGRD_3 | LV_CRK_ERR_LIH |
| LV_IGA_CH | LV_TPS_FL | IGA_CH | |

#### 1.4.1.1 Conditions for knock control in normal operation or in limp home

**Formula section:**

**If** LV_KNK_ACT **= 1** (Active) *(knock control active)*
**then**
- **If** LV_KNK_i_ERR **= 0** *(no error currently present on knock acquisition (sensor n°i) )*
- **and** LV_CAM_ERR_LIH **= 0** *(no limp home for camshaft sensor)*
- **and** LV_CRK_ERR_LIH **= 0** *(no limp home for crankshaft sensor)*
- **then** *Normal* Operation for Knock Control
- **else** *Limp Home* Operation for Knock Control

#### 1.4.1.2 Ignition angle correction out of knock detection area

**Formula section:**

**If** LV_KNK_ACT **= 0** (Passive) *(knock control passive)*
**then**

$$IGA\_KNK\_[CYL]_n = IGA\_KNK\_[CYL]_{n-1} + C\_IGA\_LGRD\_3$$

**until** IGA_KNK_[CYL] **= 0.**

#### 1.4.1.3 Ignition angle knock correction mean value ( IGA_MV_KNK )

General information:

Application recurrence **: 720 °CRK.**

**Formula section:**

$$\text{IGA\_MV\_KNK} = 1 / \text{NC\_CYL\_NO} * \sum_{\text{CYL} = \mathbf{1}}^{\textbf{NC\_CYL\_NO}} \text{IGA\_KNK\_[CYL}$$

#### 1.4.1.4 Relative knock corrections limitation

General information:

Application recurrence **: 720 °CRK.**

**Formula section:**

**If** IGA_KNK_[CYL] **>** ( IGA_MV_KNK **+** C_IGA_DIF_MAX_MIN_KNK )
**then** IGA_KNK_[CYL] **=** ( IGA_MV_KNK **+** C_IGA_DIF_MAX_MIN_KNK )

**If** IGA_KNK_[CYL] **<** ( IGA_MV_KNK **-** C_IGA_DIF_MAX_MIN_KNK)
**then** IGA_KNK_[CYL] **=** ( IGA_MV_KNK **-** C_IGA_DIF_MAX_MIN_KNK )

#### 1.4.1.5 Absolute knock corrections limitation

General information:

To prevent the ignition angle from a too large correction in the retard sense, the knock correction is limited to a maximum value. This maximum value is performed also for diagnosis functions.

Application recurrence **: 720 °CRK.**

**Formula section:**

Limit MAXI **=** IP_IGA_MAX_KNK__N_32__MAF * IP_IGA_TCO_FAC_KNK__TCO
**with**
Limit MAXI ≤ **0**
**and**
IGA_KNK_[CYL] ≥ Limit MAXI

**If** LV_IGA_CH **= 1** (Active)
*(catalyst heating function active - ignition angle intervention)*
**and** LV_TPS_FL **= 0** (Passive)
*(no full load throttle position detected)*
**then** Limit MAXI **=** Limit MAXI - IGA_CH

## Calibration data:

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| IP_IGA_MAX_KNK__N_32__MAF | 8 x 4 | 0...80H | -48...0 | 0.375 | °CRK |
| Maximum ignition angle knock correction versus engine operating point. | | | | | |
| IP_IGA_TCO_FAC_KNK__TCO | 8 | 00...FFH | 0...0.997 | 3.895E-3 | - |
| Weighting factor versus coolant temperature for determination of maximum ignition angle knock correction. | | | | | |
| C_IGA_DIF_MAX_MIN_KNK | 1 | 0...80H | 0...48 | 0.375 | °CRK |
| Maximum difference between the individual knock corrections and the ignition angle knock correction mean value. | | | | | |
| NC_CYL_NO | 1 | 0...FFH | 0...255 | 1 | - |
| Number of Cylinders - Non adjustable calibration. | | | | | |

## Applicative Value :

NC_CYL_NO = **06**H = 6 cylinders

### 1.4.2 Knock control in normal operation



**Input data:**

| | | | |
|---|---|---|---|
| IGA_KNK_[CYL] | N_KNK | LV_IGA_ADJ_TQR | NL_THD_KNK_[CYL] |
| MAF_KNK | LV_TRA_KNK_ACT | KNK_INT_CYL_[CYL] | |
| LV_KNK_ACT | KNKS_[CYL] | ID_IGA_AD_[CYL]__N_KNK__MAF_KNK | |

**Formula section:**

**1 -** *Knock ignition angle correction calculation according to knock ignition angle adaptation.*

**If** LV_KNK_ACT **= 0** (Passive) → **1** (Active) ( knock control begins active )
**then**

IGA_KNK_[CYL] **=** ID_IGA_AD_[CYL]__N_KNK__MAF_KNK

**2 -** Knock ignition angle correction calculation in case of knock detected **:**



**If** LV_KNK_ACT **= 1** (Active) ( knock control continuously active )
**then**
**If** new operating point is detected by the system (N_KNK, MAF_KNK)
**then**
**If** ID_IGA_AD_[CYL]__N_KNK__MAF_KNK
**<** ( IGA_KNK_[CYL] **-** C_IGA_AD_DIF_MAX)
**then**

$$IGA\_KNK\_[CYL]_n = ( IGA\_KNK\_[CYL]_{n-1} - C\_IGA\_AD\_DIF\_MAX)$$

**else**
**If** ID_IGA_AD_[CYL]__N_KNK__MAF_KNK
**>** ( IGA_KNK_[CYL] **+** C_IGA_AD_DIF_MAX)
**then**

$$IGA\_KNK\_[CYL]_n = ( IGA\_KNK\_[CYL]_{n-1} + C\_IGA\_AD\_DIF\_MAX)$$

**else**

$$IGA\_KNK\_[CYL]_n = ID\_IGA\_AD\_[CYL]\_\_N\_KNK\_\_MAF\_KNK$$

(noise level threshold calculation for knock detection)

**If** KNKS_[CYL ≥ NL_THD_KNK_[CYL]

**then**

**If** KNK_INT_CYL_[CYL] **= 1** (Intensity 1)

( knock is detected with intensity 1 )

**then**

$$IGA\_KNK\_[CYL]_n = IGA\_KNK\_[CYL]_{n-1} - ID\_IGA\_DEC\_1\_KNK\_\_N\_KNK$$

**else** ← ( KNK_INT_CYL_[CYL] **= 2** (Intensity 2) :
knock is detected with intensity 2 )

$$IGA\_KNK\_[CYL]_n = IGA\_KNK\_[CYL]_{n-1} - ID\_IGA\_DEC\_2\_KNK\_\_N\_KNK$$

**else** ← ( KNK_INT_CYL_[CYL] **= 0** (No) : no knock detected )

**If** LV_TRA_KNK_ACT **= 0** (Passive)

(no ignition instationary correction requested )

**then**

$$IGA\_KNK\_[CYL]_n = IGA\_KNK\_[CYL]_{n-1} + ID\_IGA\_INC\_KNK\_\_N\_KNK$$

**else**

$$IGA\_KNK\_[CYL]_n = IGA\_KNK\_[CYL]_{n-1}$$



**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| ID_IGA_DEC_1_KNK__N_KNK | 3 | 01...7FH | 0.375...47.625 | 0.375 | °CRK |
| Update of knock ignition angle correction when knock intensity 1 is detected ( x 720 °CRK ). | | | | | |
| ID_IGA_DEC_2_KNK__N_KNK | 3 | 01...7FH | 0.375...47.625 | 0.375 | °CRK |
| Update of knock ignition angle correction when knock intensity 2 is detected ( x 720 °CRK ). | | | | | |
| ID_IGA_INC_KNK__N_KNK | 16 | 01...7FFFH | 0.00146...48 | 0.00146 | °CRK |
| Update of knock ignition angle correction when no knock is detected ( x 720 °CRK ). | | | | | |
| C_IGA_AD_DIF_MAX | 1 | 0...7FH | 0...47.625 | 0.375 | °CRK |
| Maximum value for updating the knock ignition angle correction. | | | | | |

### 1.4.3 Knock control in limp home

General information:

For explanations, refer to the chapter " Knock Sensors Diagnosis ( KNKS1, KNKS2 ) " in the major chapter "Diagnosis Management ".

### 1.4.4 Knock adaptation



**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| LV_IGA_AD_ACT | V | 0...01H | 0...1 | 1 | - |
| Boolean information for knock adaptation loop 1 - ( Passive / Active ). | | | | | |
| LV_CYC_WUP_KNK | V | 0...01H | 0...1 | 1 | - |
| Boolean information for warm up cycle fulfilled | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| LV_KNK_ACT | LV_KNK_1_ERR | LV_KNK_2_ERR | LV_IS |
| LV_N_GRD_MAX_KNK | LV_TPS_GRD_TRA_KNK | LV_TPS_ERR | LV_MAF_ERR |
| LV_TCO_ERR | LV_TIA_ERR | LV_ISA_1_ERR | LV_ISA_2_ERR |
| LV_LSH_UP_1_ERR | LV_LSH_UP_2_ERR | LV_CAM_ERR | LV_CRK_ERR |
| LV_IGA_ADJ_TQR | LV_STATE_A_MIS | LV_STATE_B_MIS | MAF_KNK |
| LV_IGA_CH | LV_TPS_FL | LV_SCC_TQR | N_32 |
| LV_VLS_LIM_1_ERR | LV_VLS_LIM_2_ERR | IGA_MV_KNK | N_KNK |



General information:

The adaptation assists the knock ignition angle correction IGA_KNK_[CYL] during transition from an engine operating point to another one.
An indexed table ID_IGA_AD_[CYL] __N_KNK__MAF_KNK is provided for each cylinder.
They are updated with the value of IGA_KNK_[CYL] determined for each operating point by the knock control.

**Formula section:**

**If** LV_KNK_ACT **= 1** (Active)
*(knock control active)*
**and** LV_KNK_i_ERR **= 0**
*(no error currently present on knock sensors)*
**and** LV_IS **= 0**
*(engine operating state out of idle)*
**and** LV_N_GRD_MAX_KNK **= 0** (Passive)
*(no engine speed dynamics relative to knock control)*
**and** LV_TPS_GRD_TRA_KNK **= 0** (Active)
*(no load dynamics relative to knock control)*
**and** LV_TPS_ERR **= 0**
*(no error currently present on throttle position sensor)*
**and** LV_MAF_ERR **= 0**
*(no error currently present on mass air flow sensor)*
**and** LV_TCO_ERR **= 0**
*(no error currently present on coolant temperature sensor)*
**and** LV_TIA_ERR **= 0**
*(no error currently present on air temperature sensor)*
**and** LV_ISA_i_ERR **= 0**
*(no error currently present on idle charge actuator command signal (coil i))*
**and** LV_LSH_UP_i_ERR **= 0**
*(no error currently present on oxygen sensor upstream heater power stage)*
**and** LV_CAM_ERR **= 0**
*(no error currently present on camshaft sensor)*
**and** LV_CRK_ERR **= 0**
*(no error currently present on crankshaft sensor)*
**and** LV_DUR_IGC_[CYL]_ERR **= 0**
*(no error currently present on the corresponding ignition output)*
**and** LV_IV_[CYL]_ERR **= 0**
*(no error currently present on corresponding injector power stage)*
**and** LV_STATE_A_MIS **= 0**
*(no misfire status CARB A (catalyst damage))*
**and** LV_STATE_B_MIS **= 0**
*(no misfire status CARB B (increase emissions))*

**and** MAF_KNK ≥ ID_MAF_MIN_AD_KNK__N_32
**and** LV_IGA_CH **= 0** (Passive)
*(no catalyst heating function with ignition angle intervention)*
**or** LV_TPS_FL **= 1** (Passive)
*(full load throttle position detected)*

**then**
LV_IGA_AD_ACT **= 1** (Active)
*(knock adaptation loop 1 authorized)*

**and**

| |
|---|
| ID_IGA_AD_[CYL]__N_KNK__MAF_KNK **=** IGA_KNK_[CYL] |

**else**
LV_IGA_AD_ACT **= 0** (Passive)

**Remark :**

**-** *Storing the adaptation values ( ID_IGA_AD_[CYL] ) from knock adaptation loop in non volatile memory with ECU in power-latch* **:**

The adaptation values from the indexed tables ID_IGA_AD_[CYL] are initialized to 0 if one of the following conditions are fullfilled:

-Virginal ECU
-Request from service tester
-EEPROM read failure

Each time during power latch: it is the mean value IGA_MV_KNK which is stored for each operating point. Thus, the 6 adaptation indexed tables ID_IGA_AD_[CYL] are equal.

All indexed tables ID_IGA_AD_[CYL] are increased by C_IGA_INC_AD degrees up to the maximum 0 **if**:

- LV_CYC_WUP_KNK = 1
- TCO was above 71°C at the last engine stop (vehicle was driven until engine warm)
- TCO has increased by more than 21°C since last engine stop

Thus, it is possible to slowly reduce high values once learnt, without the necessity to approach these points in steady state.

LV_CYC_WUP_KNK:

| | | | |
|---|---|---|---|
| Conditions to reset: | System reset | | |
| Conditions to set: | **If** | LV_CYC_WUP = 1 | |
| | **then** | LV_CYC_WUP_KNK = 1 | |

**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| ID_MAF_MIN_AD_KNK__N_32 | 16 | 0...FFH | 0...1389 | 5.45 | mg/TDC |
| Minimum engine load to take into account knock adaptation. | | | | | |
| ID_IGA_AD_[CYL]__N_KNK__MAF_KNK | 16 x 4 | 0...80H | -48...0 | 0.375 | °CRK |
| Cylinder individual ignition angle knock adaptation. | | | | | |
| C_IGA_INC_AD | 1 | 0...10H | 0...6 | 0.375 | °CRK |
| Offset on ignition angle knock adaptation value when engine stopped. | | | | | |

| | |
|---|---|
| Document: | **Injection** |
| Project: | **Engine Management System HMC_V6** |
| Version: | a |
| Date: | 17-Dec-97 |
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| Construction protocol-No.: | |
| Software version: | 650H0000 |

| | Name | Department | Phone | Date | Sign |
|---|---|---|---|---|---|
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## Version list

| Version | Date | Author | Comment, Description |
|---|---|---|---|
| | | | |

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## 1.1 General

### 1.1.1 Total formulas

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| TIPR | V | 0...FFFFH | 0...262,14 | 4 µsec | msec |
| Pre injection time calculation. | | | | | |
| TI_i | V | 0...FFFFH | 0...262,14 | 4 µsec | msec |
| Injection time calculation for bank i (i = 1 or 2) | | | | | |
| TI_CYL_[CYL] | V | 0...FFFFH | 0...262,14 | 4 µsec | msec |
| Cylinder individual injection time calculation (i = 1,2,3,4,5,6) | | | | | |
| TI_SAM | V | 0...FFFFH | 0...262,14 | 4 µsec | msec |
| Multiplexed cylinder individual injection time calculation | | | | | |
| TI_AS_[CYL] | V | 40...C0H | 0,5...1,5 | 0,0078 | - |
| Cylinder indiviual multiplicative factor set via application system (i = 1,2,3,4,5,6) | | | | | |
| TI_MV | V | 0...FFFFH | 0...262,14 | 4 µsec | msec |
| Injection time mean value for injection phase determination. | | | | | |
| TI_FAC_COR | - | 0...FFFFH | 0...16 | 0,000245 | - |
| Global injection time correction factor. | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| TIPR_CST | IP_TI_LGRD_AST__TCO | TI_AD_ADD_MMV_COR_i | TI_AD_FAC_MMV_COR_i |
| TI_PUR | TI_CAST | TI_LAM_i | C_TI_AD_ADD_MAX |
| TI_FL | TI_IS | TI_CO_IS | C_TI_N_AD_ADD_MAX(_AT) |
| TI_AE | TI_TPS_AE | TI_MAF_AE | N |
| TI_COP | TI_CST | TI_ADD_DLY | TIB |
| LV_ES | LV_ST | LV_PL | LV_IS |
| LV_TI_AST | LV_COP | LV_VS_MAX | C_TI_COP_COR |
| TI_WUP_COR | TI_ST_REST | LAM_TRA | C_TI_VS_MAX_COR |
| TI_ADD_REAC_SCC_[CYL] | TI_FAC_ALTI | TI_AS_[CYL] | CONF_LAM |

**Remark :**

i = **1** for bank 1.
i = **2** for bank 2**.**

#### 1.1.1.1 Cranking injection time

##### 1.1.1.1.1 First injection at engine stopped (LV_ES)

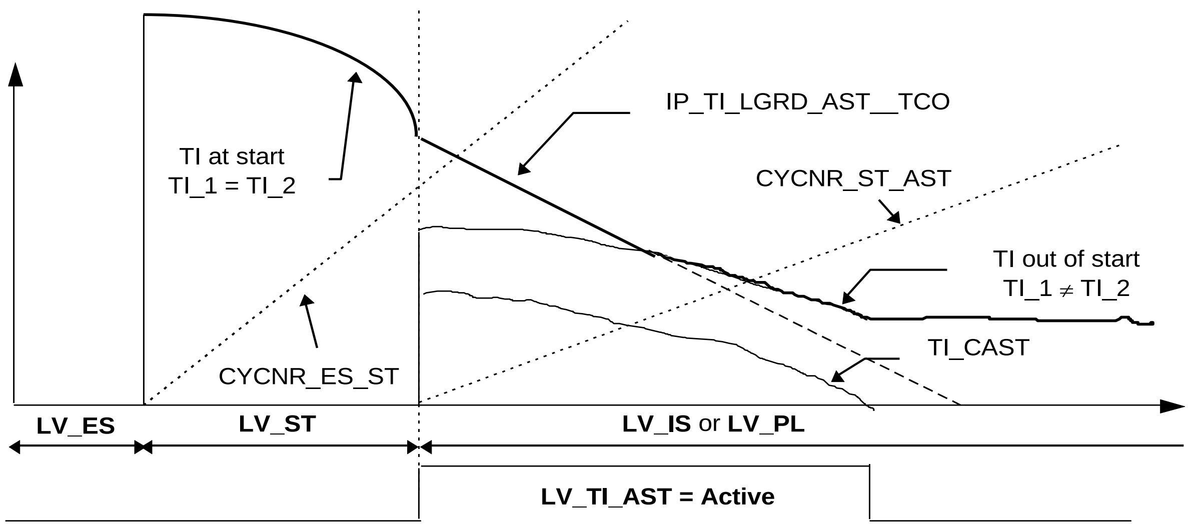
| | | | |
|---|---|---|---|
| TIPR | **=** | **(** TIPR_CST | Pre injection time. |
| | | ***** TI_ST_REST | Restart correction factor |
| | | ***** TI_AS_[1]**)** | Application system intervention cylinder 1. |
| | | ***** TI_FAC_ALTI | Altitude correction |

Application recurrence **: 200 msec**

##### 1.1.1.1.2 Injection time at start (LV_ST)

| | | | |
|---|---|---|---|
| TI_i | **=** | **(** TI_CST | Cranking injection time. |
| | | ***** TI_ST_REST **)** | Re-start correction factor. |
| | | ***** TI_FAC_ALTI | Altitude correction |

Application recurrence **: Segment**



### 1.1.1.2 Nominal injection time (out of start)

#### 1.1.1.2.1 Closed loop variant

**If** CONF_LAM $\neq$ 0
**then**

| | | |
|---|---|---|
| TI_i **=** | **[** TIB | Basic injection time. |
| ***** **(** 1 **+** | TI_AD_FAC_MMV_COR_i | Multiplicative adaptive correction |
| **+** | TI_LAM_i | Lambda control correction. |
| **+** | LAM_TRA **)** | Evaporative emissions control. |
| **+** | TI_AD_ADD_MMV_COR_i **]** | Adaptive additive correction. |
| ***** | TI_FAC_COR | Global correction factor. |

Application recurrence **: Segment**

⇒ *See drawing on next page.*

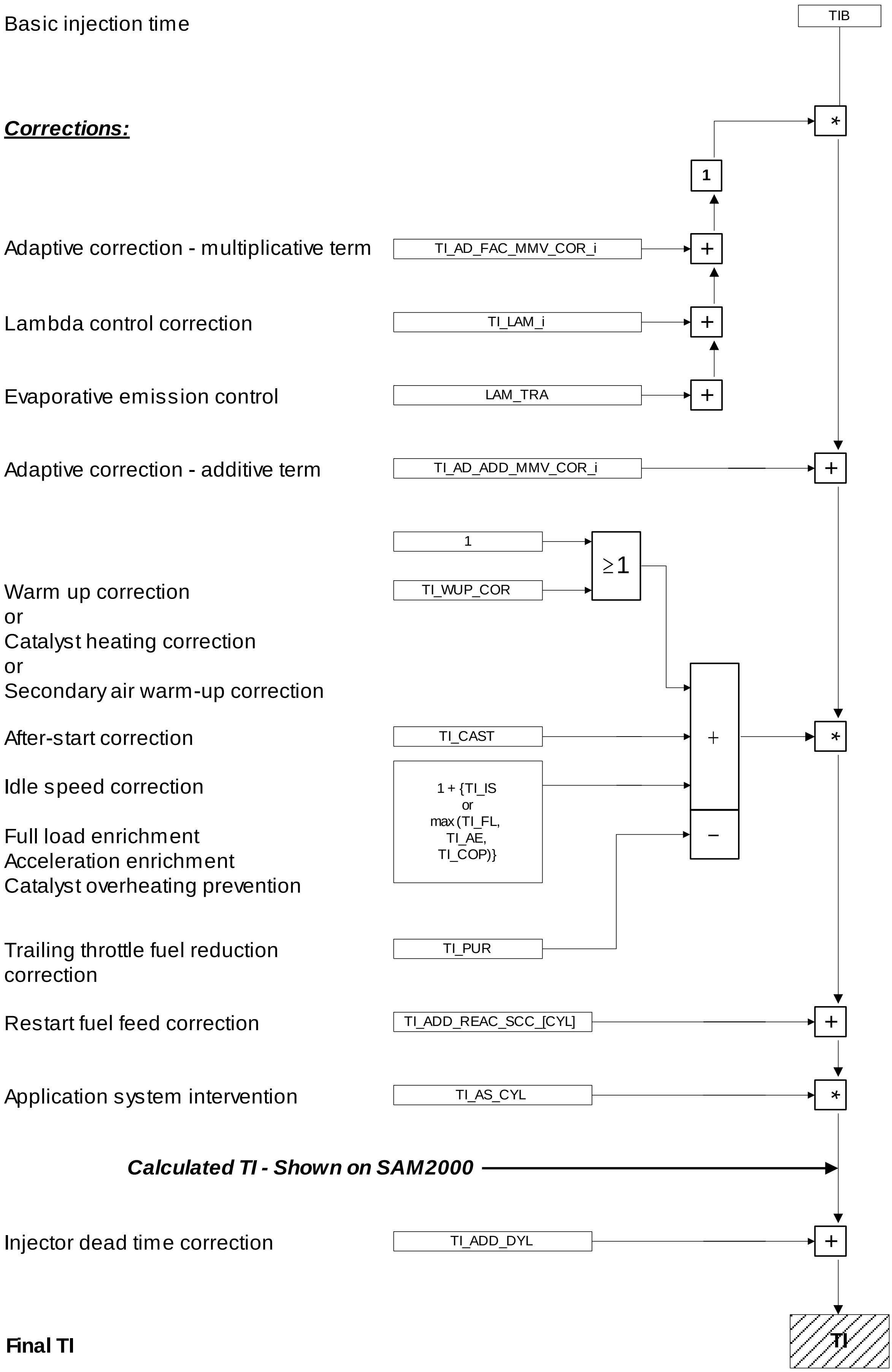
**With:**

TI_AD_ADD_MMV_COR_1 = C_TI_N_AD_ADD_MAX * TI_CO_IS / N

TI_AD_ADD_MMV_COR_1 is limited to C_TI_AD_ADD_MAX.

**Remark:**

The minimum injection time for TI_i is equal to C_TI_MIN.


Basic injection time
TIB
Corrections:
1
Adaptive correction - multiplicative term
TI_AD_FAC_MMV_COR_i
Lambda control correction
TI_LAM_i
Evaporative emission control
LAM_TRA
Adaptive correction - additive term
TI_AD_ADD_MMV_COR_i
1
≥1
Warm up correction
or
Catalyst heating correction
or
Secondary air warm-up correction
TI_WUP_COR
After-start correction
TI_CAST
Idle speed correction
1 + {TI_IS
or
max (TI_FL,
TI_AE,
TI_COP)}
Full load enrichment
Acceleration enrichment
Catalyst overheating prevention
Trailing throttle fuel reduction
correction
TI_PUR
Restart fuel feed correction
TI_ADD_REAC_SCC_[CYL]
Application system intervention
TI_AS_CYL
Calculated TI - Shown on SAM2000
Injector dead time correction
TI_ADD_DYL
Final TI
TI

#### 1.1.1.2.2 Open loop variant

**If** CONF_LAM = 0
**then**

| | | | |
|---|---|---|---|
| TI_i | **=** | **[ (**TIB | Basic injection time. |
| | ***** | **(** 1 **-** (IP_TI_NOT_CAT__N__MAF * IP_TI_FAC_NOT_CAT__TCO)**)** | Correction for fuel leaning |
| | **+** | TI_AD_ADD_MMV_COR_1**]** | Multiplicative adaptive correction |
| | ***** | TI_FAC_COR | Global correction factor. |

Application recurrence **: Segment**

**With:**

TI_AD_ADD_MMV_COR_1 = C_TI_N_AD_ADD_MAX * TI_CO_IS / N

TI_AD_ADD_MMV_COR_1 is limited to C_TI_AD_ADD_MAX.

**Remark:**

The minimum injection time for TI_i is equal to C_TI_MIN.

### 1.1.1.2.3 Global injection time correction ( TI_FAC_COR )

**If** LV_COP **= 1** *(catalyst overheating prevention active)*
**and** at least 1 cylinder in fuel shut-off
**then**

**If** LV_VS_MAX **= 0** *(vehicle speed limitation not active)*

**then** TI_FAC_COR **=** ( 1 - C_TI_COP_COR )
**else** TI_FAC_COR **=** [ 1 - max ( C_TI_COP_COR, C_TI_VS_MAX_COR ) ]

**else**
**If** LV_VS_MAX **= 1** *(vehicle speed limitation active)*
**then** TI_FAC_COR **=** ( 1 - C_TI_VS_MAX_COR )
**else**

**If** at least 1 cylinder in fuel shut-off
**then** TI_FAC_COR **= 1**
**else** the following calculation is performed :

| | | | |
|---|---|---|---|
| TI_FAC_COR **=** | | TI_WUP_COR | Warm-up correction **or**<br>Catalyst heating correction **or**<br>Rich Mixture Warm-up correction |
| | **+** | TI_CAST | Post-start correction. |
| | **-** | TI_PUR | Trailing throttle fuel reduction correction. |
| | **+ {** 1 + **[** | TI_IS | Idle speed correction. |
| | | **or** | |
| | **max** | **(**TI_FL, | Full load enrichment. |
| | | TI_AE | Acceleration enrichment. |
| | | TI_COP**)]** **}** | Catalyst overheating prevention. |

Application recurrence **: Segment**

**Remarks :**

| | | |
|---|---|---|
| TI_AE **=** | TI_TPS_AE | Transient correction on throttle variations. |
| **+** | TI_MAF_AE | Transient correction on engine load variations. |

#### 1.1.1.3 Injection time mean value for injection phase determination ( TI_MV )

TI_MV **=** ( TI_1 + TI_2 ) / 2 + TI_ADD_DLY

Application recurrence **: Segment**

#### 1.1.1.4 Cylinder individual injection time

TI_CYL_[CYL] takes in account the cylinder individual corrections:

TI_CYL_[CYL] **=** ( TI_i + TI_ADD_REAC_SCC_[CYL] ) * TI_AS_[CYL]

TI_AS_[CYL] is a cylinder individual factor set via the application system.

**Remark :**

[CYL] = cylinder number
i = cylinder bank number

Depending on the cylinder number, i is equal to 1 or 2.

#### 1.1.1.5 Multiplexed cylinder individual injection time

TI_SAM takes alternatively the value TI_CYL_[CYL] depending on the cycle number.

**<u>Calibration data:</u>**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| C_TI_MIN | 1 | 0...FFFFH | 0...262,14 | 4 µsec | msec |
| Minimum injection time. | | | | | |
| IP_TI_FAC_NOT_CAT__TCO | 16x16 | 0... FFH | 0...0,9961 | 1/256 | - |
| | | | | | |
| Injection time correction for open loop variant | | | | | |
| IP_TI_NOT_CAT__N_32__MAF | 6x6 | 0... FFFH | 0...1 | 2,44 E-4 | - |
| | | | | | |
| Injection time correction for open loop variant | | | | | |

### 1.1.2 Injection phase SOI ( Start ), EOI ( End )



**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| SOI | V | 00...64H | 180...-420 | 6 | ° CRK |
| Start of nominal injection time. | | | | | |
| EOI | V | 14...3CH | -300...-540 | 6 | ° CRK |
| End of nominal injection time. | | | | | |
| SOI_TIPR | V | 00...64H | 180...-420 | 6 | ° CRK |
| Start of first injection | | | | | |
| EOI_TIPR | V | 0...28H | -540...-300 | 6 | ° CRK |
| End of first injection time. | | | | | |
| LV_TIPR_SEQ | - | 0...1H | 0...1 | 1 | - |
| Boolean information for first injection time: sequential after synchronisation (yes/no) | | | | | |
| LV_TIPR_EOI_STOP | - | 0...1H | 0...1 | 1 | - |
| Boolean information for first injection time termination at NC_MAX_EOI | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| TI_MV | N_32 | TCO | LV_CRK_ERR_LIH |
| LV_ST | TI_1 | TI_2 | TIPR |
| SOI_AS | | | |



**FUNCTION DESCRIPTION:**

General information:

In order to optimize engine emissions and performances, the injection phase is related to the engine operating state and to the engine working point. With the pre-injection a spontaneous engine start is ensured because A/F-mixture is offered as early as possible. But at very low start temperatures the undefined position of the first injection can lead to problems. Because of this the first injections are carried out sequential below the temperature C_TCO_MAX_TIPR_SEQ.

With the configuration byte C_TIPR_END it can be adjusted wether a pre-injection will be terminated at NC_MAX_EOI or not.

For graphical description of the first injection please refer to the output chapter.

**Formula section:**

* Start of injection :

***** *Start injection time (LV_ST = 1)* **:**

SOI **=** IP_SOI_ST__N_32__TI_MV **+** SOI_AS

***** *First injection configuration* **:**

Application recurrency: Transition to engine stop (LV_ES = 1)

**If** C_TIPR_END = 0
**then** LV_TIPR_EOI_STOP = 0
(First injection time will **not** be terminated at NC_MAX_EOI during synchronisation)
**else** LV_TIPR_EOI_STOP = 1

**If** C_TCO_MAX_TIPR_SEQ ≥ TCO
**then** LV_TIPR_SEQ =1
(First injection will be carried out sequential after synchronisation)
**else** LV_TIPR_SEQ = 0
(TIPR is carried out in semi full group)

***** *Nominal injection time (out of start)* **:**

- for injection time TI_i out of start

**If** LV_CRK_ERR_LIH **=** 1
*(camshaft signal missing - refer to “ Diagnosis Management “ )*
**then** SOI **=** C_SOI_CAM_DIAG
**else** SOI **=** IP_SOI__N_32__TI_MV **+** IP_SOI_TCO__TCO **+** SOI_AS

***** *First injection time (TIPR)* **:**

SOI_TIPR = IP_SOI_ST__N_32__TI_MV + SOI_AS
with N_32 = 0 and TI_MV = TIPR

* <u>End of injection</u> :

***** *Nominal injection time* **:**

- for injection time TI_i

**If** LV_CRK_ERR_LIH = 1
*(camshaft signal missing - refer to “ Diagnosis Management “ )*
**or** engine operating state start (LV_ST)
**or** N_32 **>** C_EOI_N_MAX
**then** EOI **=** NC_MAX_EOI
**else** EOI **=** IP_EOI__N_32 **+** SOI_AS

***** *First injection time* **:**

EOI_TIPR = IP_EOI_TIPR__TCO

## Calibration data:

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| IP_SOI_ST__N_32__TI_MV | 4 x 4 | 00...64H | 180...-420 | 6 | ° CRK |
| | | | | | |
| Start of injection phase at start for nominal injection time TI_i. | | | | | |
| IP_SOI__N_32__TI_MV | 6 x 6 | 00...64H | 180...-420 | 6 | ° CRK |
| | | | | | |
| Start of injection phase out of start for nominal injection time TI_i. | | | | | |
| IP_SOI_TCO__TCO | 8 | 1C...E4H | 600...-600 | 6 | ° CRK |
| | | | | | |
| Start of injection phase offset versus coolant temperature, out of start for nominal injection time TI_i. | | | | | |
| IP_EOI__N_32 | 6 | 14...3CH | -300...-540 | 6 | °CRK |
| | | | | | |
| End of injection phase for nominal injection time TI_i. | | | | | |
| C_SOI_CAM_DIAG | 1 | 00...64H | 180...-420 | 6 | ° CRK |
| Start of injection phase out of start for nominal injection time TI_i with camshaft signal missing. | | | | | |
| C_EOI_N_MAX | 1 | 00...FFH | 0...8160 | 32 | rpm |
| Engine speed threshold to select maximum EOI (NC_MAX_EOI). | | | | | |
| NC_MAX_EOI | 1 | 14...3CH | -300...-540 | 6 | ° CRK |
| Maximum end of injection phase - Non adjustable calibration. | | | | | |
| IP_EOI_TIPR | 8 | 00...28H | -540...-300 | 6 | ° CRK |
| | | | | | |
| End of injection phase for first injection | | | | | |
| C_TIPR_END | 1 | 0...1H | 0...1 | 1 | - |
| Configuration byte for TIPR-termination at NC_MAX_EOI - position | | | | | |
| C_TCO_MAX_TIPR_SEQ | 1 | 0...FEH | -48...142,5 | 0,75 | ° C |
| Maximum coolant temperatur for sequential TIPR-application | | | | | |

## Applicative Value :

NC_MAX_EOI = **3C**H = -540 °CRK

### 1.1.3 Re-start correction factor ( TI_ST_REST )

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| TI_ST_REST | - | 80...FFH | 0,5...0,9961 | 0,0039 | - |
| Re-start correction factor for cranking injection time. | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| TCO | LV_REST | | |

**FUNCTION DESCRIPTION:**

General information:

In order to improve engine re-start, a correction factor is applied for cranking injection time calculation (pre injection time and injection time at start). This factor is multiplicative and decreases the injection time.



**Formula section:**

**If** LV_REST = 1 (Active) *(re-start function active)*
**then** TI_ST_REST = IP_TI_ST_REST__TCO

**If** LV_REST = 0 (Passive) *(re-start function passive)*
**then** TI_ST_REST = 1

**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| IP_TI_ST_REST__TCO | 8 | 80...FFH | 0,5...0,9961 | 0,0039 | - |
| | | | | | |
| Re-start correction factor for cranking injection time. | | | | | |

## 1.2 Calculation of injection time corrections

### 1.2.1 Calculation of cranking injection time corrections

#### 1.2.1.1 First injection time ( TIPR_CST )

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| TIPR_CST | - | 0...FFFFH | 0...262,14 | 4 µsec | msec |
| Pre injection time basic value. | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| LV_ES | LV_ST | TCO | LV_ST_ES |
| MAF_FAC_ALTI_MMV | | | |

**FUNCTION DESCRIPTION:**

General information:

In order to improve engine cranking times, a pre injection takes place on each cylinder bank as soon as one tooth is detected.

*(refer to chapter " Fuel injection output " in the major chapter " Outputs ")*

**Formula section:**

TIPR_CST **=** IP_TIPR_CST(_AT)__TCO

In case of transition from start (LV_ST) to engine stopped (LV_ES) and therefore LV_ST_ES=1, the next pre injection time will be weighted by a multiplicative factor :

**If** LV_ST_ES = 1
**then** TIPR_CST **=** IP_TIPR_CST(_AT)__TCO ***** IP_ TIPR_ FAC_ST_ES__TCO

The pre-injection is corrected with the altitude correction factor MAF_FAC_ALTI_MMV. For total formula see chapter 1.1.1.1.2.

## Calibration data:

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| IP_TIPR_CST(_AT)__TCO | 8 | 0...FFFFH | 0...262,14 | 4 µsec | msec |
| | | | | | |
| Pre injection time basic value. | | | | | |
| IP_TIPR_FAC_ST_ES(_AT)__TCO | 8 | 80...FFH | 0,5...0,9961 | 0,0039 | - |
| | | | | | |
| Weighting factor of pre injection time basic value in case of transition from LV_ST to LV_ES. | | | | | |
| IP_TI_FAC_ALTI__MAF_FAC_ALTI_MMV | 8 | 80...FFH | 0,5...0,9961 | 0,0039 | - |
| | | | | | |
| Weighting factor of pre injection time basic value due to altitude correction. | | | | | |

### 1.2.1.2 Injection time at start ( TI_CST )



**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| TI_CST | - | 0...FFFFH | 0...262,14 | 4 µsec | msec |
| Cranking injection time basic value. | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| LV_ES | LV_ST | TCO_ST | LV_SYN_ENG |
| LV_TI_AST | N | TI_1 | TI_2 |
| CYCNR_ES_ST | | | |

**FUNCTION DESCRIPTION:**



General information:

As soon as synchronisation is fulfilled in engine operating state start (LV_ST), each cylinder is supplied with a specific fuel quantity for starting. This quantity is weighted by a de-activation factor in order to avoid engine flooding.

**Formula section:**

**If** engine operating state start (LV_ST)
**and** LV_SYN_ENG = 1 *(synchronisation effective)*
**then**

TI_CST = IP_TI_CST(_AT)__N__TCO_ST *
IP_TI_DEAC_CST(_AT)__CYCNR_ES_ST__TCO_ST

**Remark :**

* CYCNR_ES_ST indicates the number of segments since engine stop; it is reset at transition from LV_ES to LV_ST.

* The start fuel quantity (LV_ST) returned to the post - start fuel quantity (LV_TI_AST) is performed using change limitation IP_TI_LGRD_AST__TCO
Like cranking injection time TI_i is identical for bank 1 & 2 during engine operating state start (LV_ST), the change limitation IP_TI_LGRD_AST__TCO is applied as " individual " correction for TI_i during post-start function (LV_TI_AST) because TI_1 ≠ TI_2.

* For case 1 of the restart strategy the CYCNR_ES_ST counter will start with the old value freezed at the previous transition LV_ST to LV_ES.

The injection time at start is corrected with the altitude correction factor MAF_FAC_ALTI_MMV. For total formula see chapter 1.1.1.1.2.

**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| IP_TI_CST(_AT)__N__TCO_ST | 5 x 8 | 0...FFFFH | 0...262,14 | 4 µsec | msec |
| | | | | | |
| Cranking injection time basic value. | | | | | |
| IP_TI_DEAC_CST(_AT)__CYCNR_ES_ST__TCO_ST | 4 x 6 | 00...FFH | 0...0,997 | 3,895E-3 | - |
| | | | | | |
| Cranking injection time deactivation factor. | | | | | |
| IP_TI_LGRD_AST__TCO | 8 | 08...07F8H | 0,0427...10,88 | 0,00533 | msec |
| | | | | | |
| Change limitation between cranking injection time and nominal injection time (x Segment). | | | | | |

## 1.2.2 Calculation of nominal injection time corrections

### 1.2.2.1 Basic injection time ( TIB )

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| TIB | - | 0...FFFFH | 0...262,14 | 4 µsec | msec |
| Basic injection time. | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| LV_ES | LV_ST | N_32 | MAF |

**FUNCTION DESCRIPTION:**

General information:

The basic injection time is depending on engine working point (N_32, MAF).
It is applied for nominal injection time calculation TI_i out of engine stopped (LV_ES) and out of start (LV_ST).

Application recurrence **: Segment**

**Formula section:**

TIB **=** IP_TIB__N__MAF

**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| IP_TIB__N__MAF | 16 x 12 | 0F...FFFH | 0...262,14 | 4 µsec | msec |
| | | | | | |
| Basic injection time. | | | | | |

### 1.2.3 Injector dead time correction ( TI_ADD_DLY )



**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| TI_ADD_DLY | - | 0...FFH | 0...8,16 | 0,0032 | msec |
| Injector dead time correction. | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| TI_[CYL] | VB | | |

**FUNCTION DESCRIPTION:**

General information:

The injection time TI_[CYL applied to the corresponding injector, is weighted by an additive correction TI_ADD_DLY in order to compensate the battery voltage dependent injector pick - up time.
*( refer to chapter " Fuel injection output " in major chapter " Outputs " )*

Application recurrence **: 10 msec.**

**Formula section:**

TI_ADD_DLY **=** IP_TI_ADD_DLY__VB

**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| IP_TI_ADD_DLY__VB | 8 | 0...FFH | 0...8,16 | 0,032 | msec |
| | | | | | |
| Injector dead time correction. | | | | | |

### 1.2.3.1 Cold post-start correction ( TI_CAST )

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| TI_CAST | V | 0...3F40H | 0...3.953 | 16 / 65536 | - |
| Cold post-start correction. | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| LV_TI_AST | LV_ST | TCO_ST | TIA |
| CYCNR_ST_AST | | | |

**FUNCTION DESCRIPTION:**

General information:

This enrichment is performed following engine operating start (LV_ST) in order to ensure the first combustion in cold conditions.

Application recurrence **: Segment**

**Formula section:**

**If** LV_TI_AST = 1 (Active) *(cold post-start function active)*
**then**

TI_CAST **=** IP_TI_CAST(_AT)__TIA__TCO_ST *****
IP_TI_DEAC_CAST(_AT)__CYCNR_ST_AST__TCO_ST * IP_TI_AST_REST__TCO

**Remark :**

* CYCNR_ST_AST indicates the number of segments since start; it is reset at the transition LV_ST to LV_TI_AST.

* The post-start fuel quantity is initialized with the value coming from the interpolated table IP_TI_CAST(_AT)__TIA__TCO_ST as soon as LV_TI_AST = 1 (Active). Then, this initialized value is deactivated by IP_TI_DEAC_CAST(_AT)__CYCNR_ST_AST__TCO_ST.

* IP_TI_AST_REST__TCO is applied to the post-start correction in case of restart.

## Calibration data:

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| IP_TI_CAST(_AT)__TIA__TCO_ST | 6 x 8 | 0...FFH | 0...3.984 | 0.0156 | - |
| Initialized value for post-start enrichment factor. | | | | | |
| IP_TI_DEAC_CAST(_AT)__CYCNR_ST_AST__TCO_ST | 6 x 8 | 0...FFH | 0...0.9961 | 0.0039 | - |
| Post-start enrichment deactivation factor. | | | | | |
| IP_TI_AST_REST__TCO | 8 | 80...FFH | 0.5...0.9961 | 0.0039 | - |
| Restart correction factor . | | | | | |

### 1.2.3.2 Warm-up correction ( TI_WUP )

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| TI_WUP | - | 1000...2FC0H | 1...2,9844 | 16 / 65536 | - |
| Warm-up correction for nominal injection time. | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| LV_SCC_TQR | N_32 | MAF | TCO |
| TCO_ST | | | |

**FUNCTION DESCRIPTION:**

General information:

The warm-up injection time correction is performed when the corresponding warm-up phase is detected in order to ensure the increased fuel requirements for a cold engine.

Application recurrence **: Segment**

**Formula section:**

**If** LV_SCC_TQR **= 0** (Passive) *(no fuel shut-off active due to ASR or GS)*

**then** TI_WUP **=** 1 **+** IP_TI_WUP(_AT)__N_32__MAF
***** IP_TI_TCO_WUP(_AT)__TCO__TCO_ST

**If** LV_SCC_TQR **= 1** (Active) *(fuel shut-off active due to ASR or GS)*

**then** TI_WUP **=** 1 **+** IP_TI_WUP(_AT)__N_32__MAF
***** IP_TI_TCO_WUP_ASR__TCO__TCO_ST

Remark: For further information about torque intervention and effects on the system please refer to the chapter „Traction Control System“.

**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| IP_TI_WUP(_AT)__N_32__MAF | 8 x 8 | 0...FFH | 0...0,9961 | 0,0039 | - |
| Warm-up correction versus engine operating point. | | | | | |
| IP_TI_TCO_WUP(_AT)__TCO__TCO_ST | 8 x 3 | 0...FFH | 0...1,9922 | 0,00782 | - |
| Warm-up deactivation factor without TQR intervention. | | | | | |
| IP_TI_TCO_WUP_ASR__TCO__TCO_ST | 6 x 6 | 0...FFH | 0...1,9922 | 0,00782 | - |
| Warm-up deactivation factor with TQR intervention. | | | | | |

### 1.2.3.3 Catalyst heating correction ( TI_CH )

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| TI_CH | - | 0800...37C0 H | 0,5...3,4844 | 16 / 65536 | - |
| Catalyst heating correction for nominal injection time. | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| LV_IS | TCO | T_AST | N_32 |
| MAF | LV_TI_CH | LV_MAF_ERR | |

**FUNCTION DESCRIPTION:**

General information:

The catalyst heating correction for nominal injection time is performed when the corresponding warm-up phase is detected (LV_TI_CH = 1) in order to ensure a catalyst warm-up as quickly as possible and to operate the engine with low emissions.

This is an alternative to the warm-up function.

The engine can run with a lean mixture at high loads and engine speeds, even in cold engine conditions.

Application recurrence **: Segment**

**Formula section:**

This Function is performed if LV_MAF_ERR = 0.

* In idle (LV_IS) :

TI_CH **=** IP_TI_CH__N_32__MAF ***** IP_TI_TCO_CH_IS__TCO
**+** IP_TI_FAC_CH__TCO__T_AST

* Out of idle :

TI_CH **=** IP_TI_CH__N_32__MAF ***** IP_TI_TCO_CH__TCO
**+** IP_TI_FAC_CH__TCO__T_AST

**Remark :**
The transition from idle to out of idle calculation is made without change limitation.

## Calibration data:

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| IP_TI_CH__N_32__MAF | 8 x 8 | 0...FFH | 0...0,9961 | 0,0039 | - |
| | | | | | |
| Catalyst heating correction for nominal injection time versus engine operating point. | | | | | |
| IP_TI_TCO_CH__TCO | 8 | 00...FFH | 0...1,922 | 7,509E-3 | - |
| | | | | | |
| Catalyst heating correction for nominal injection time versus coolant temperature out of idle. | | | | | |
| IP_TI_TCO_CH_IS__TCO | 8 | 00...FFH | 0...1,922 | 7,509E-3 | - |
| | | | | | |
| Catalyst heating correction for nominal injection time versus coolant temperature in idle (LV_IS). | | | | | |
| IP_TI_FAC_CH__TCO__T_AST | 8 x 8 | 0800...1800H | 0,5...1,5 | 16 / 65536 | - |
| | | | | | |
| Minimum value of catalyst heating correction for nominal injection time. | | | | | |

### 1.2.3.4 Catalyst overheating prevention ( TI_COP )



**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| TI_COP | V | 0...FFH | 0...0,5 | 0,00196 | - |
| Injection time correction for catalyst overheating prevention. | | | | | |
| LV_COP | V | 0...01H | 0...1 | 1 | - |
| Boolean for catalyst overheating prevention detection - ( Passive / Active ). | | | | | |
| IGA_COP | V | 80...00H | -48...0 | 0,375 | °CRK |
| Ignition angle correction used as set point for catalyst overheating correction. | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| TCO | N_32 | MAF | TCO_ST |
| ID_TCO_LAM_MIN__TCO_ST | TI_FAC_COR | LV_LSCL_1 | LV_LSCL_2 |
| IGA_TIA_TCO | C_TI_VS_MAX_COR | LV_VS_MAX | IGA_MV_KNK |

**FUNCTION DESCRIPTION:**

General information:

The catalyst overheating prevention function is provided in order to avoid an overheating phenomena in the catalyst. The emission temperatures drop through mixture enrichment.
The injection time correction is calculated depending on engine operating point and ignition through knock control ( IGA_MV_KNK ) and temperature ( IGA_TIA_TCO ) corrections.

Application recurrence **: 720 °CRK**

**Application conditions:**

*Activation:*

The injection time correction TI_COP proceeds over a ramp for activation.
Thus, TI_COP is increased with C_TI_COP_INC every 720 °CRK.

**If** engine operating state in part load (LV_PL)
**and** TCO **>** ID_TCO_LAM_MIN__TCO_ST
**and** MAF ≥ IP_MAF_MIN_COP__N_32__IGA_COP
**and** IGA_COP ≤ C_IGA_MIN_COP
**then** LV_COP **= 1** (Active)

*Deactivation:*

The injection time correction TI_COP proceeds over a ramp for deactivation.
Thus, TI_COP is decreased with C_TI_COP_INC every 720 °CRK.

**If** MAF **<** IP_MAF_MIN_COP__N_32__IGA_COP - C_MAF_MIN_HYS_COP
**or** IGA_COP **>** C_IGA_MIN_COP
**then** LV_COP **= 0** (Passive) as soon as TI_COP = 0.

**Remark :**

| | | |
|---|---|---|
| **If** | | LV_COP **= 1** (Active) *(catalyst overheating prevention active)* |
| **and** | | engine operating state engine stopped (LV_ES) |
| **or** | | engine operating state start (LV_ST) |
| **or** | | engine operating state fuel cut-off (LV_PUC) |
| | **then** | TI_COP is decreased to **0** without change limitation. |

*Limitation :*

**0** ≤ TI_COP ≤ **0.5**

**Formula section:**

TI_COP **=** IP_TI_COP__N_32__MAF **+** IP_TI_COP_IGA__IGA_COP

with :

IGA_COP = IGA_MV_KNK + IGA_TIA_TCO



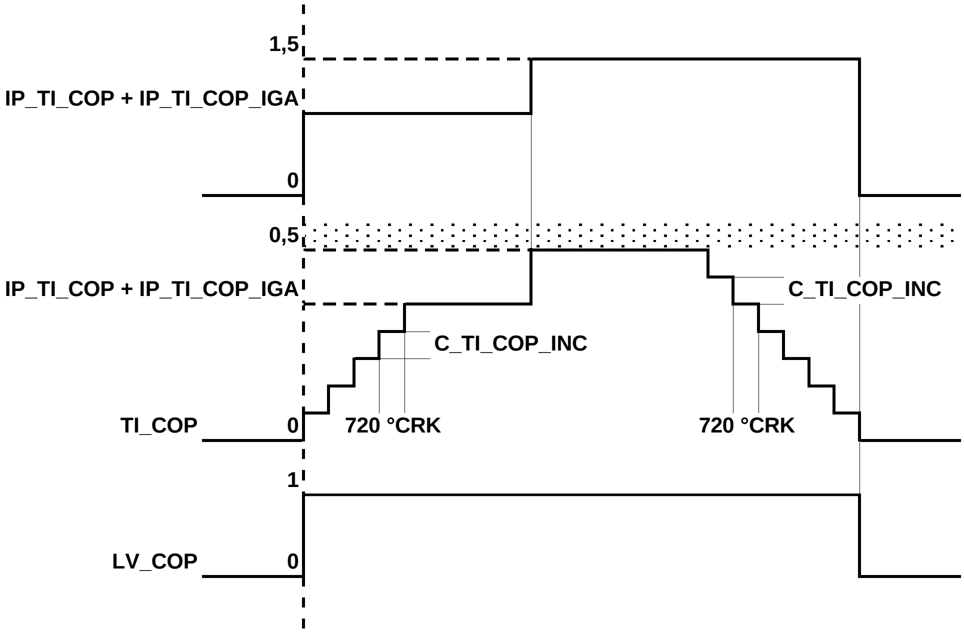
**Remark :**

The global correction factor calculation TI_FAC_COR for the nominal injection time out of start is depending of the catalyst overheating prevention function :

| | | | |
|---|---|---|---|
| **If** | | LV_COP **= 1** (Active) | *(catalyst overheating prevention active)* |
| **and** | | at least 1 cylinder in fuel shut-off | |
| **then** | | | |
| | **If** | LV_VS_MAX **= 0** (Passive) | *(vehicle speed limitation passive)* |
| | **then** | TI_FAC_COR **=** ( 1 - C_TI_COP_COR ) | |
| | **else** | TI_FAC_COR **=** [ 1 - max ( C_TI_COP_COR, C_TI_VS_MAX_COR ) ] | |

In this engine operating configuration, TI_COP is still updated but not used for injection time calculation, until regular TI_FAC_COR calculation will be performed again.

Description:




## Calibration data:

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| IP_MAF_MIN_COP__N_32__IGA_COP | 6 x 4 | 0...FFH | 0...1389 | 5,4471 | mg/TDC |
| | | | | | |
| Minimum mass air flow threshold for catalyst overheating prevention activation. | | | | | |
| IP_TI_COP__N_32__MAF | 6 x 6 | 0...FFH | 0...0,996 | 0,0039 | - |
| | | | | | |
| Injection time correction versus engine operating point for catalyst overheating prevention. | | | | | |
| IP_TI_COP_IGA__IGA_COP | 4 | 0...FFH | -0,5...0,496 | 0,0039 | - |
| | | | | | |
| Injection time correction versus ignition angle correction through knock control for catalyst overheating prevention. | | | | | |
| C_MAF_MIN_HYS_COP | 1 | 0...FFH | 0...1389 | 5,4471 | mg/TDC |
| Hysteresis for minimum mass air flow threshold for catalyst overheating prevention deactivation. | | | | | |
| C_TI_COP_INC | 1 | 0...80H | 0...0,5 | 0,0039 | - |
| Injection time change limitation in case of activation or deactivation of catalyst overheating prevention function. | | | | | |
| C_TI_COP_COR | 1 | 0...1000H | 0...1 | 0,000244 14 | - |
| Injection time correction in case of catalyst overheating prevention activation with fuel shut-off out of vehicle speed limitation. | | | | | |
| C_IGA_MIN_COP | 1 | 80...00H | -48...0 | 0,375 | °CRK |
| Ignition angle correction threshold through knock control for catalyst overheating prevention deactivation. | | | | | |

### 1.2.3.5 Full load enrichment correction ( TI_FL )

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| TI_FL | V | 0...FFH | 0...0,9961 | 0,0039 | - |
| Full load enrichment factor for nominal injection time. | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| LV_PL | LV_FL | N | |

**FUNCTION DESCRIPTION:**

General information:

This enrichment is performed following engine operating state part load (LV_PL) with full load detected (LV_FL) in order improve performances and to ensure temperature limitation for outlet valves, catalyst converter and exhaust gas.

Application recurrence **: Segment** *(when full load is detected : LV_FL = FL)*

**Formula section:**

**If** LV_FL **= 1** (FL) *(full load function active)*
**then** TI_FL **=** IP_TI_FL__N

**If** LV_FL **= 0** ( - ) *(full load function inactive)*
**then** TI_FL **=** 0

**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| IP_TI_FL__N | 16 | 00...FFH | 0...0,997 | 3,895E-3 | - |
| | | | | | |
| Full load enrichment factor for nominal injection time. | | | | | |

### 1.2.3.6 Throttle acceleration enrichment correction ( TI_TPS_AE )

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| TI_TPS_AE | V | 0...1FE0H | 0...1,992 | 16 / 65536 | - |
| Throttle acceleration enrichment factor for nominal injection time. | | | | | |
| LV_TPS_AE | V | 0...01H | 0...1 | 1 | - |
| Boolean for the duration of throttle acceleration enrichment factor application - ( Passive / Active ). | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| ID_TPS_GRD_BOL_AE__N_32__TPS | TCO | MAF | N_32 |
| ID_TPS_GRD_ADD_AE__TCO | TPS_GRD | LV_AE | |

**FUNCTION DESCRIPTION:**

General information:

The acceleration quality is depending on the throttle position TPS taken during the transient phase and the throttle gradient TPS_GRD. When the engine load is changing during transient, there is a difference between the mass air flow measurement and the real mass air flow in the cylinders. The transient phase behaviour is depending on response time and fuel wall wetting phenomena.

The engine richness cannot be constant on each transient phase segment, that's why a temporary correction is applied on injection time. This correction TI_TPS_AE is quick and time limited to counteract the lean peak.

Application recurrence **: Segment**



**Formula section:**

** First triggering - Initialisation :*

**If** LV_AE **= 1** (AE) *(acceleration enrichment function active)*
**then**

**TI_TPS_AE =** IP_TI_TPS_FAC_AE(_AT)__TCO__TPS_GRD *****
ID_MAF_TPS_FAC_AE(_AT)__MAF

**and** initialisation of IP_TPS_SUM_CYCNR_AE
(maximum duration for TI_TPS_AE re-triggering)
**and** initialisation of C_TPS_CYCNR_MIN_AE
(timer for TI_TPS_AEre-triggering )
**and** initialisation of IP_TPS_CYCNR_AE(_AT)__N_32
(duration of TI_TPS_AE decrementation)
**and** LV_TPS_AE **= 1** ( Active )

**Remark :**
The value from ID_MAF_TPS_FAC_AE(_AT)__MAF is set only when acceleration enrichment is detected for the first time.

Then, TI_TPS_AE is updated with IP_TI_TPS_FAC_AE(_AT)__TCO__TPS_GRD using the recurrence of TPS_GRD calculation ( **Segment** recurrence if N < 2000 rpm else **10 msec**. ).

* New triggering :

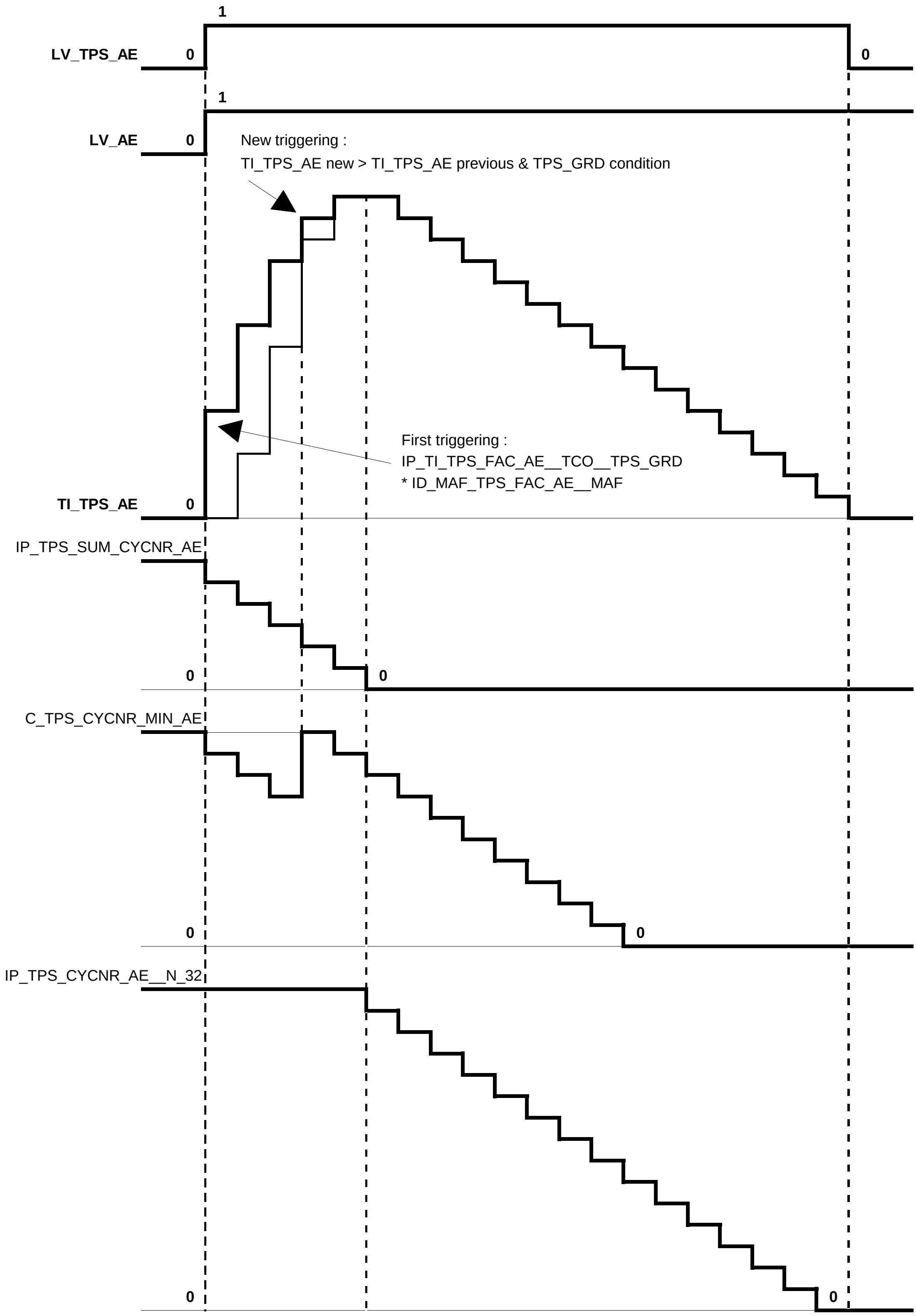
**If** LV_AE **= 1** (AE) *(acceleration enrichment function active)*
**and** LV_TPS_AE **= 1** (Active) ( TI_TPS_AE ≠ 0 )
**and** IP_TPS_SUM_CYCNR_AE not elapsed
**then**
**If** TPS_GRD ≥ ID_TPS_GRD_BOL_AE__N_32__TPS + ID_TPS_GRD_ADD_AE__TCO
**and** TPS_GRD ≥ 0
**and** TI_TPS_AEnew calculation ≥ TI_TPS_AE previous calculation
**then** TI_TPS_AE new calculation is applied
**and** C_TPS_CYCNR_MIN_AE is initialized again
**else** TI_TPS_AE is performed until IP_TPS_SUM_CYCNR_AE is reached.

* Decrementation :

When IP_TPS_SUM_CYCNR_AE is reached, then TI_TPS_AE is in linear way decremented to 0 during IP_TPS_CYCNR_AE(_AT)__N_32 segments.

**Remark :**
When the re-triggering timer (set with C_TPS_CYCNR_MIN_AE) has elapsed and when the decrementation timer (set with IP_TPS_CYCNR_AE(_AT)__N_32) has also elapsed, then LV_TPS_AE **= 0** ( Passive ) and TI_TPS_AE = 0.

Description:



## Calibration data:

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| IP_TI_TPS_FAC_AE(_AT)__TCO__TPS_GRD | 6 x 6 | 00...FFH | 0...3,98 | 1,562E-2 | - |
| | | | | | |
| Basic factor for throttle acceleration enrichment correction. | | | | | |
| ID_MAF_TPS_FAC_AE(_AT)__MAF | 4 | 00...FFH | 0...0,997 | 3,895E-3 | - |
| | | | | | |
| Initialisation value versus MAF for acceleration enrichment correction calculation. | | | | | |
| IP_TPS_CYCNR_AE(_AT)__N_32 | 4 | 01...FFH | 1...255 | 1 | - |
| | | | | | |
| Duration of TI_TPS_AE reset. | | | | | |
| C_TPS_CYCNR_MIN_AE | 1 | 01...FFH | 1...255 | 1 | - |
| Re-triggering timer for throttle acceleration enrichment correction. | | | | | |
| IP_TPS_SUM_CYCNR_AE__N_32 | 4 | 01...20H | 1...32 | 1 | - |
| | | | | | |
| Maximum duration of TI_TPS_AE updating calculation. | | | | | |

### 1.2.3.7 Load acceleration enrichment correction ( TI_MAF_AE )



**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| TI_MAF_AE | V | 0...FDFFH | 0...15,8745 | 16 / 65536 | - |
| Load acceleration enrichment factor correction for nominal injection time. | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| MAF_RATIO_AE | TCO | ID_TPS_GRD_ADD_AE__TCO | MAF |
| TPS_GRD | TPS | ID_TPS_GRD_BOL_AE__N_32__TPS | LV_AE |
| N_32 | | | |

**FUNCTION DESCRIPTION:**



General information:

The acceleration quality is depending on the wall wetting phenomena and the injection time correction factor TI_MAF_AE is representative of it.

The engine richness cannot be constant on each transient phase segment, that's why a temporary correction is applied on injection time. This correction TI_MAF_AE is working together with the throttle acceleration enrichment correction and must compensate the lean trail.

Application recurrence **: Segment**

**Formula section:**

** First triggering - Initialisation :*

**If** LV_AE **= 1** (AE) *(acceleration enrichment function active)*
**then** the corresponding mass air flow filtering factor MAF_CRLC is set
**and** the calculation of MAF_RATIO_AE is performed
**and**

**TI_MAF_AE =** IP_TI_FAC_AE(_AT)__N_32__MAF *****
IP_TI_FAC_TRA_AE(_AT)__MAF_RATIO_AE__TCO

**and** TI_CYCNR_AE **= 0** - Initialisation
(timer for TI_MAF_AE re-triggering - CYC calculation)
**and** initialisation of IP_TI_FAC_x_AE_RST__CYC
(deactivation factor of TI_MAF_AE )
**If** TCO **<** C_TCO_AE_RST
**then** IP_TI_FAC_x_AE_RST__CYC **=** IP_TI_FAC_1_AE_RST(_AT)__CYC
**else** IP_TI_FAC_x_AE_RST__CYC **=** IP_TI_FAC_2_AE_RST(_AT)__CYC

**Remark :**

***** The value from IP_TI_FAC_AE(_AT)__N_32__MAF is set only on the first triggering of the load acceleration enrichment correction.
Then, TI_MAF_AE is updated with IP_TI_FAC_TRA_AE(_AT)__MAF_RATIO_AE__TCO using the segment recurrence.

***** The timer for TI_MAF_AE re-triggering is calculating as following :

$$\mathbf{CYC_n =} 1 - TI\_CYCNR\_AE_n \mathbf{/} IP\_TI\_CYCNR\_AE(\_AT)\_\_N\_32\_\_TCO$$

The value from IP_TI_CYCNR_AE(_AT)__N_32__TCO is set only on the first triggering of the load acceleration enrichment correction.

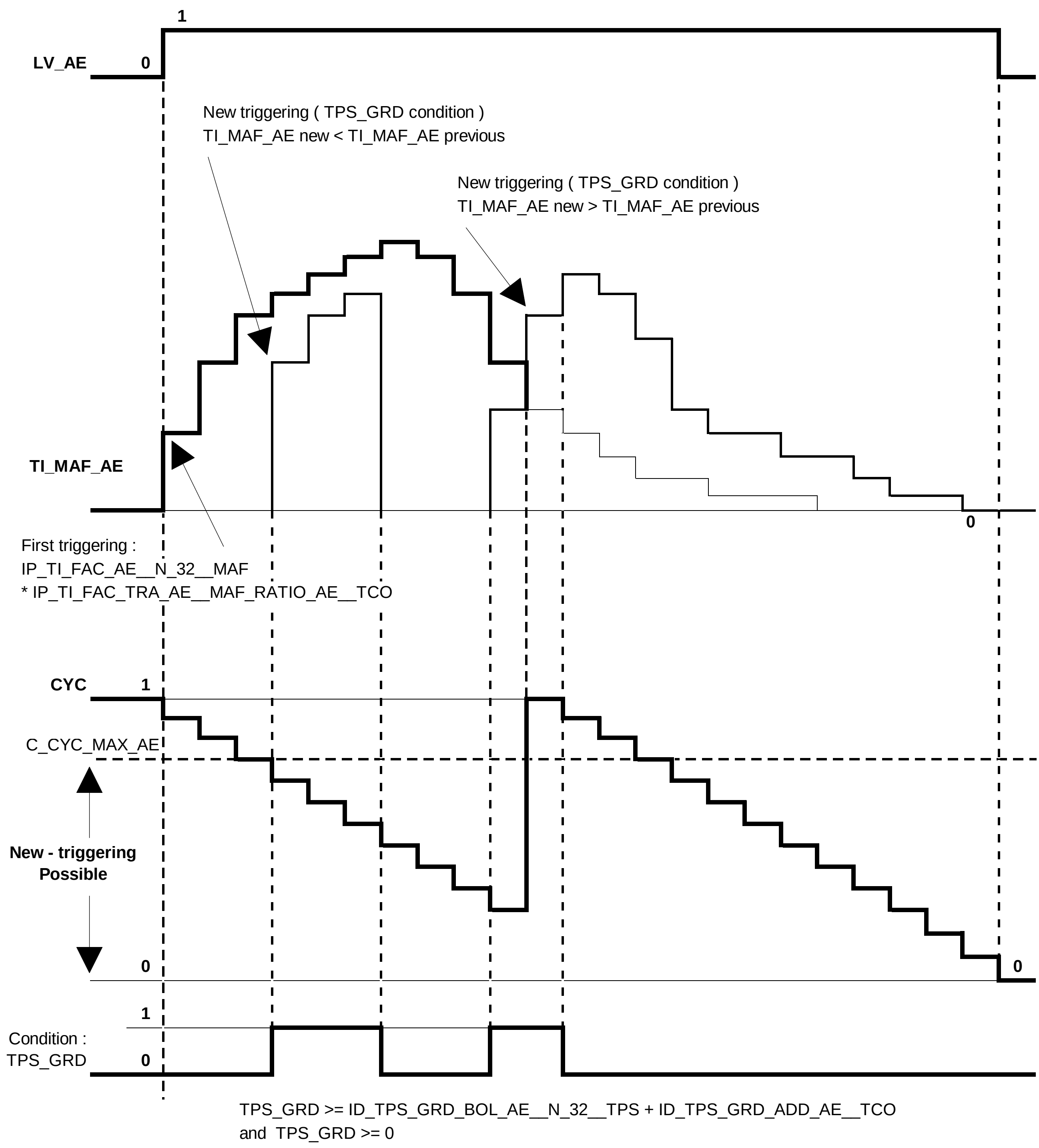
* New triggering :

**If** LV_AE **= 1** (AE) *(acceleration enrichment function active)*
**and** $CYC_n \leq$ C_CYC_MAX_AE
**then**
**If** TPS_GRD ≥ ID_TPS_GRD_BOL_AE__N_32__TPS+ ID_TPS_GRD_ADD_AE__TCO
**and** TPS_GRD ≥ 0
**and** TI_MAF_AE new calculation ≥ TI_MAF_AE previous calculation
**then** the first triggering is performed again with TI_MAF_AE new calculation
**else** TI_MAF_AE is continuously calculated as following :

**TI_MAF_AE = ** IP_TI_FAC_AE(_AT)__N_32__MAF *****
IP_TI_FAC_TRA_AE(_AT)__MAF_RATIO_AE__TCO * IP_TI_FAC_x_AE_RST__CYC

**and** $TI\_CYCNR\_AE_n = TI\_CYCNR\_AE_{n-1} + 1$
(n is the segment recurrence)
until TI_MAF_AE **= 0** is reached

Description:



## Calibration data:

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| IP_TI_FAC_AE(_AT)__N_32__MAF | 4 x 4 | 0...FFH | 0...1,9922 | 2 / 256 | - |
| | | | | | |
| Initialisation factor for load acceleration enrichment correction, versus engine operating point. | | | | | |
| IP_TI_FAC_TRA_AE(_AT)__MAF_RATIO_AE__TCO | 4 x 6 | 0...7FFFH | 0...7,9995 | 8 / 32768 | - |
| | | | | | |
| Basic factor for load acceleration enrichment correction. | | | | | |
| IP_TI_CYCNR_AE(_AT)__N_32__TCO | 4 x 6 | 01...FFFFH | 1...65535 | 1 | - |
| | | | | | |
| Re-triggering timer for load acceleration enrichment correction. | | | | | |
| IP_TI_FAC_1_AE_RST(_AT)__CYC | 6 | 00...FFH | 0...0,997 | 3,895E-3 | - |
| | | | | | |
| Load acceleration enrichment deactivation factor if TCO < C_TCO_AE_RST. | | | | | |
| IP_TI_FAC_2_AE_RST(_AT)__CYC | 6 | 00...FFH | 0...0,997 | 3,895E-3 | - |
| | | | | | |
| Load acceleration enrichment deactivation factor if TCO ( C_TCO_AE_RST. | | | | | |
| C_TCO_AE_RST | 1 | 0...FEH | -48...142,5 | 0,75 | - |
| Coolant temperature threshold for selection of load acceleration enrichment deactivation factor. | | | | | |
| C_CYC_MAX_AE | 1 | 00...FFH | 0...0,997 | 3,895E-3 | - |
| CYC value threshold for TI_MAF_AE re-triggering authorization. | | | | | |

### 1.2.3.8 Trailing throttle fuel reduction correction ( TI_PUR )

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| TI_PUR | V | 0...0FD0H | 0...0,9883 | 16 / 65536 | - |
| Trailing throttle fuel reduction correction for nominal injection time. | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| LV_PUR | N_32 | TCO | MAF |
| MAF_RATIO_PUR | | | |

**FUNCTION DESCRIPTION:**

General information:

In trailing throttle, a richness peak is sometimes met. That's why, in order to keep the engine richness 1, the injection time is reduced to compensate the increased fuel film evaporation due to decreased intake manifold pressure.

This function is similar to the load acceleration enrichment correction but takes place during decelerations instead of accelerations.

Application recurrence **: Segment**

**Formula section:**

** First triggering - Initialisation :*

**If** LV_PUR **= 1** (PUR) *(trailing throttle fuel reduction function active)*
**then** the corresponding mass air flow filtering factor MAF_CRLC is set
**and** the calculation of MAF_RATIO_PUR is performed
**and**

**TI_PUR =** IP_TI_FAC_PUR__N_32__MAF ***** IP_TI_FAC_TRA_PUR(_AT)__MAF_RATIO_PUR__TCO

**and** TI_CYCNR_PUR **= 0** - Initialisation
(timer for TI_PUR re-triggering - CYC calculation)
**and** initialisation of IP_TI_FAC_PUR_RST(_AT)__CYC
(deactivation factor of TI_PUR )

**Remark :**

***** The value from IP_TI_FAC_PUR__N_32__MAF is set only on the first triggering of the trailing throttle fuel reduction function.

Then, TI_PUR is updated with IP_TI_FAC_TRA_PUR(_AT)__MAF_RATIO_PUR__TCO using the segment recurrence.

***** The timer for TI_PUR re-triggering is calculating as following :

$$\mathbf{CYC_n =} 1 - TI\_CYCNR\_PUR_n \,\mathbf{/}\, IP\_TI\_CYCNR\_PUR(\_AT)\_\_N\_32\_\_TCO$$

The value from IP_TI_CYCNR_PUR(_AT)__N_32__TCO is set only on the first triggering of the trailing throttle fuel reduction function.

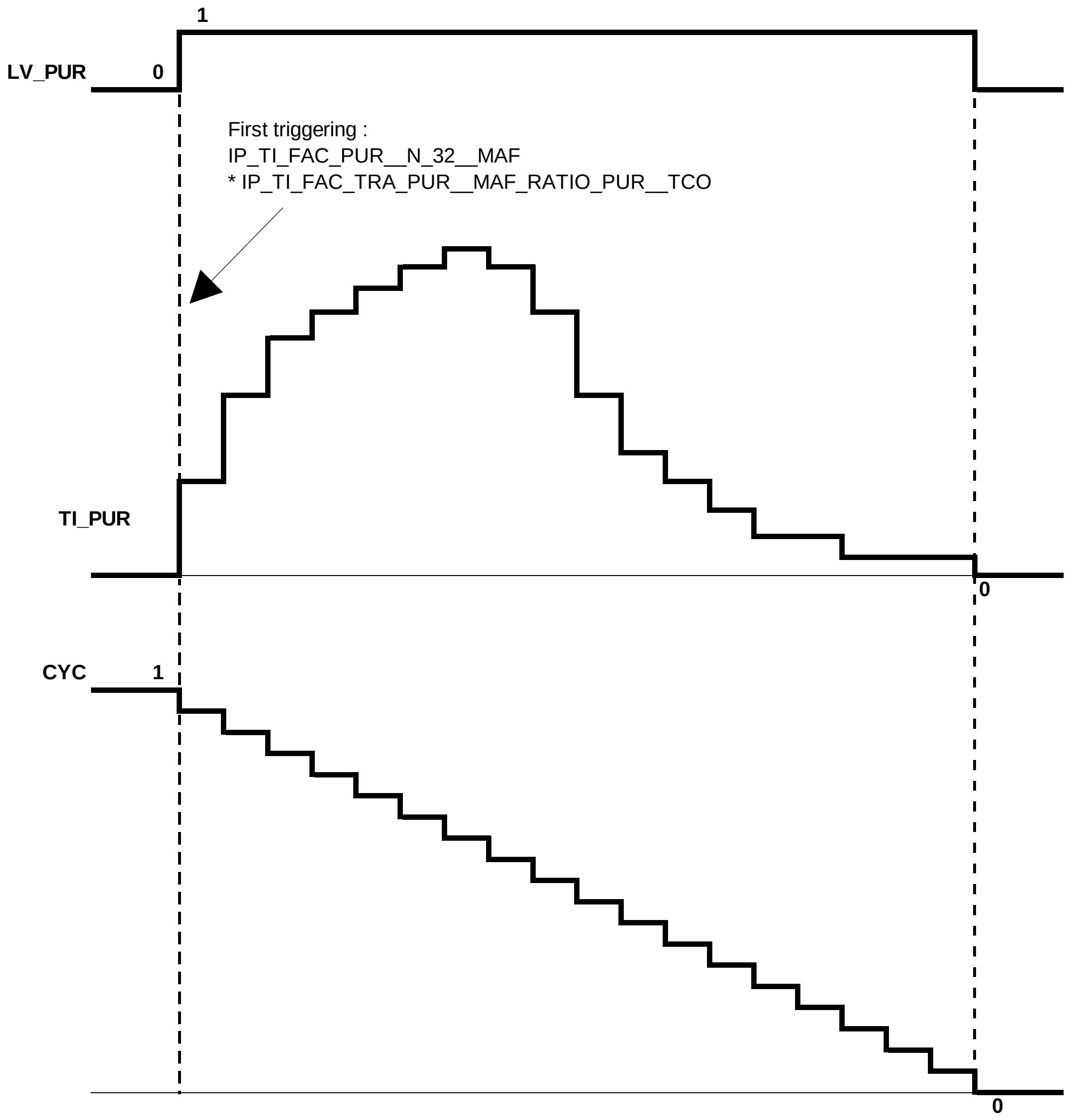
* New triggering :

**If** LV_PUR **= 1** (PUR) *(trailing throttle fuel reduction function active)*
**then** TI_PUR is continuously calculated as following :

**TI_PUR** **=** IP_TI_FAC_PUR__N_32__MAF
***** IP_TI_FAC_TRA_PUR(_AT)__MAF_RATIO_PUR__TCO
***** IP_TI_FAC_PUR_RST(_AT)__CYC

**and** $TI\_CYCNR\_PUR_n = TI\_CYCNR\_PUR_{n-1} + 1$
until TI_PUR **= 0** is reached (n is the segment recurrence)

## Description:



## Calibration data:

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| IP_TI_FAC_PUR(_AT)__N_32__MAF | 4 x 4 | 0...FFH | 0...0,9961 | 1 / 256 | - |
| | | | | | |
| Initialisation factor for trailing throttle fuel reduction correction, versus engine operating point. | | | | | |
| IP_TI_FAC_TRA_PUR(_AT)__MAF_RATIO_ PUR__TCO | 4 x 6 | 0...03FCH | 0...3,9844 | 1 / 256 | - |
| | | | | | |
| Basic factor for trailing throttle fuel reduction correction. | | | | | |
| IP_TI_CYCNR_PUR(_AT)__N_32__TCO | 4 x 4 | 01...FFFFH | 1...65535 | 1 | - |
| | | | | | |
| Re-triggering timer for trailing throttle fuel reduction correction. | | | | | |
| IP_TI_FAC_PUR_RST(_AT)__CYC | 6 | 0...FFH | 0...0,9961 | 1 / 256 | - |
| | | | | | |
| Trailing throttle fuel reduction deactivation factor. | | | | | |

### 1.2.3.9 Idle speed correction ( TI_IS )



**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| TI_IS | V | 0...FFH | -0,5...0,496 | 1 / 256 | - |
| Idle speed correction for nominal injection time. | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| LV_IS | LV_ISAPWM_IS_ACT | N_DIF_COR | |

**FUNCTION DESCRIPTION:**

General information:

In order to achieve an engine speed stabilization at idle (LV_IS), a mixture correction is performed as soon as the idle speed regulation is active.

Application recurrence **: Segment**

**Formula section:**

**If** engine operating state idle (LV_IS) active
**and** LV_ISAPWM_IS_ACT = 1 ( Active ) *(idle speed regulation correction active)*
**then** TI_IS = IP_TI_IS__N_DIF_COR
**else** TI_IS = 0

**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| IP_TI_IS__N_DIF_COR | 6 | 0...FFH | -0,5...0,496 | 1 / 256 | - |
| | | | | | |
| Idle speed correction for nominal injection time. | | | | | |

### 1.2.3.10 Altitude correction factor ( TI_FAC_ALTI )



**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| TI_FAC_ALTI | - | 80...FFH | 0,5...0,9961 | 0,0039 | - |
| Altitude injection time correction factor. | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| MAF_FAC_ALTI_MMV | | | |

**FUNCTION DESCRIPTION:**

General information:

The pre-injection time and injection time at start is corrected with the altitude correction factor TI_FAC_ALTI, which depends on the mass air flow correction factor MAF_FAC_ALTI_MMV. For total formula see chapters 1.1.1.1.1. and 1.1.1.1.2.



**Formula section:**

TI_FAC_ALTI = IP_TI_FAC_ALTI__MAF_FAC_ALTI_MMV

**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| IP_TI_FAC_ALTI__MAF_FAC_ALTI_MMV | 8 | 80...FFH | 0,5...0,9961 | 0,0039 | - |
| | | | | | |
| Weighting factor of pre injection time basic value due to altitude correction. | | | | | |

### 1.2.3.11 Acceleration enrichment correction ( TI_AE )

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| TI_AE | V | 0...FFFFH | 0...15,9998 | 16 / 65536 | - |
| Acceleration enrichment factor correction for nominal injection time. | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| TI_TPS_AE | TI_MAF_AE | LV_AE | |

**FUNCTION DESCRIPTION:**

General information:

The acceleration quality is depending on measurement response time and fuel wall wetting phenomena.

The injection time correction factor TI_AE is representative of them.

The engine richness cannot be constant on each transient phase segment, that's why this temporary correction is applied on nominal injection time. This correction TI_AE is the result of the throttle acceleration enrichment correction TI_TPS_AE and the load acceleration enrichment correction TI_MAF_AE.

Application recurrence **: Segment**

**Formula section:**

**TI_AE =** TI_TPS_AE + TI_MAF_AE

**Remark :**
The calculation is made independently of the acceleration enrichment information (LV_AE).

### 1.2.4 Cylinder fuel shut-off

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| PAT_INH_IV | V | 00...maxH | 0...max | 1 | - |
| Fuel shut-off pattern index - max = NC_INI_INH_SWI_IV_SHIFT_NR. | | | | | |
| INH_SWI_IV | - | 0...1FFFH | 0...8191 | 1 | - |
| Fuel shut-off pattern for 6 cylinders engine. | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| PAT_INH_IV_VS_MAX | PAT_INH_IV_N_MAX | PAT_INH_IV_TQR | LV_IGK |
| PAT_INH_IV_PUC_REAC | | | |

**FUNCTION DESCRIPTION:**

General information:

For the following auxiliary functions injection must be disabled for individual cylinders :

- engine speed limitation
- vehicle speed limitation
- torque reduction requested by TCS (Traction Control System).
- Fuel cut-off
- Rewetting in Part Load

*(refer to the chapter “ Fuel injection output “ in the major chapter “ Outputs “)*

Application recurrence **: Segment**

**Formula section:**

**If** ignition key is detected off (LV_IGK = 0 ( Passive ))

**then** $PAT\_INH\_IV_n$ = NC_INI_INH_SWI_IV_SHIFT_NR

**else** $PAT\_INH\_IV_n$ = max { PAT_INH_IV_N_MAX, *(engine speed limitation)*
PAT_INH_IV_VS_MAX, *(vehicle speed limitation)*
PAT_INH_IV_TQR *(torque red. req. by TCS or TCU)*
PAT_INH_IV_PUC_REAC *(Progressive PUC Phase and Rewetting in PL)*

**If** $PAT\_INH\_IV_n > PAT\_INH\_IV_{n-1}$

**then** $INH\_SWI\_IV = ID\_PAT\_INH\_IV\_\_PAT\_INH\_IV_n + 8000H$

**else** $INH\_SWI\_IV = ID\_PAT\_INH\_IV\_\_PAT\_INH\_IV_n$

## Description:

| Pattern Index | Pattern Decimal | Pattern Binary | | | | | | | | | | | | | Firing order for 6 cyl. engine | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PAT_INH_IV | INH_SWI_IV | 1 | 2 | 3 | 4 | 5 | 6 | 1 | 2 | 3 | 4 | 5 | 6 | 1 | 2 | 3 | 4 | 5 | 6 | 1 | 2 | 3 | 4 | 5 | 6 | 1 | 2 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 4096 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 | 4160 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 | 4368 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 4 | 4680 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 |
| 5 | 4682 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 |
| 6 | 5290 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 |
| 7 | 5461 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 |
| 8 | 6617 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 1 |
| 9 | 7021 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 1 |
| 10 | 7095 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 1 |
| 11 | 7927 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 |
| 12 | 8190 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |
| 13 | 8191 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

## Calibration data:

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| ID_PAT_INH_IV__PAT_INH_IV | 14 | 0...1FFFH | 0...8191 | 1 | - |
| Fuel shut-off pattern for 6 cylinders engine. | | | | | |
| NC_INI_INH_SWI_IV_SHIFT_NR | 1 | 0...FFH | 0...255 | 1 | - |
| Non adjustable calibration - Length of the pattern for fuel injection shut-off. | | | | | |

## Applicative Value :

NC_INI_INH_SWI_IV_SHIFT_NR = **0D**H = 13 dec.

#### 1.2.4.1 Progressive fuel cut-off (PUC) and rewetting in Part Load (PL)

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| PAT_INH_IV_PUC_REAC | V | 00...maxH | 0...max | 1 | - |
| Fuel shut-off pattern for progressive fuel cut-off phase (PUC) and rewetting in Part Load (PL) | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| LV_PUC | NC_CYL_NO | NC_INI_INH_SWI_IV_SHIFT_NR | N_32 |
| LV_PU | LV_PL | GR_MT | TCO |
| LV_TCO_ERR | | | |

**FUNCTION DESCRIPTION:**

General information:

In order to have smooth decelerations and accelerations, cylinders are progressively:

- switched OFF when “Trailing Throttle Fuel Cut Off (PUC)” is detected.
- switched ON when a transition “Trailing Throttle Fuel Cut Off (PUC)” to Part Load (PL) is detected.

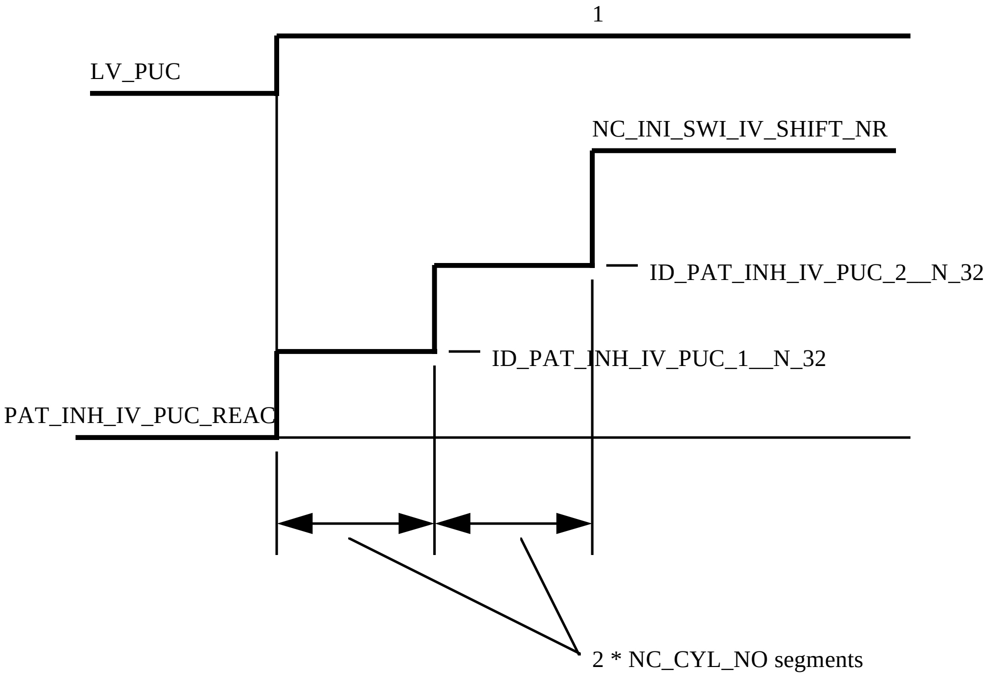
Progressive cylinder cut-off and rewetting mainly depends on Engine Speed and Gear Ratio.

**Formula section:**

*- Progressive cylinder shut-off :*

**If** Transition LV_PU -> LV_PUC is detected
**Then** Following sequence is started:

1. PAT_INH_IV_PUC_REAC = ID_PAT_INH_IV_PUC_1__N_32
   during 2 * NC_CYL_NO segments
2. PAT_INH_IV_PUC_REAC = ID_PAT_INH_IV_PUC_2__N_32
   during 2 * NC_CYL_NO segments
3. PAT_INH_IV_PUC_REAC = NC_INI_SWI_IV_SHIFT_NR





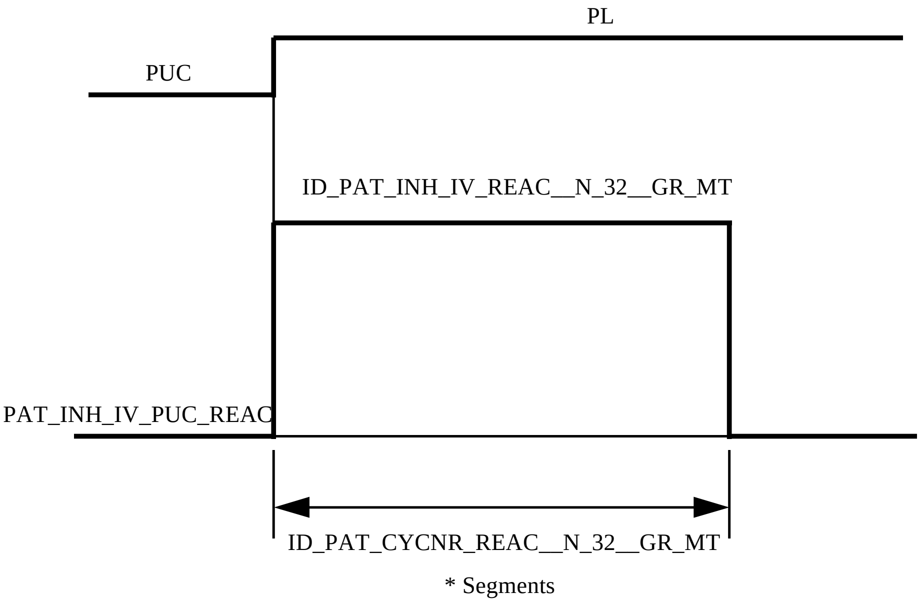

*- Progressive cylinder rewetting :*

**If** Transition LV_PUC **->** LV_PL is detected
**and** TCO **>** C_TCO_PAT_REAC_MIN
**and** LV_TCO_ERR **=** 0

**Then** Following sequence is started **and** active if LV_PL **=** 1

1. PAT_INH_IV_PUC_REAC is set to ID_PAT_INH_IV_REAC__N_32__GR_MT during ID_PAT_CYCNR_REAC_N_32__GR_MT segments
2. PAT_INH_IV_PUC_REAC = 0

**Else**
PAT_INH_IV_PUC_REAC = 0 immediately




## Calibration data:

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| ID_PAT_INH_IV_PUC_1__N_32 | 6 | 0...maxH | 0...max | 1 | - |
| | | | | | |
| Fuel shut-off pattern in case of “Trailing Throttle Fuel Cut-Off - max = NC_INI_INH_SWI_IV_SHIFT_NR | | | | | |
| ID_PAT_INH_IV_PUC_2__N_32 | 6 | 0...maxH | 0...8191 | 1 | - |
| | | | | | |
| Fuel shut-off pattern in case of “Trailing Throttle Fuel Cut-Off - max = NC_INI_INH_SWI_IV_SHIFT_NR | | | | | |
| ID_PAT_INH_IV_REAC__N_32__GR_MT | 6*6 | 0...maxH | 0...max | 1 | - |
| | | | | | |
| Fuel shut-off pattern in case of transition PUC->PL - max = NC_INI_INH_SWI_IV_SHIFT_NR | | | | | |
| ID_PAT_CYCNR_REAC_N_32__GR_MT | 6*6 | 0...FFH | 0...255 | 1 | Segment |
| | | | | | |
| Number of cycles to activate Fuel shut-off pattern in case of transition PUC->PL | | | | | |
| C_TCO_PAT_REAC_MIN | 1 | 0...FEH | -48...142,5 | 0,75 | °C |
| Minimum coolant temperature to activate progressive injection rewetting at transition to PL | | | | | |

### 1.2.5 Individual cylinder re-start fuel feed ( TI_ADD_REAC_SCC_[CYL] )

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| TI_ADD_REAC_SCC_[CYL] | V | 8000...7FFFH | -131,072 ...131,068 | 4 µsec | msec |
| Individual cylinder re-start fuel feed. | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| TCO | N_32 | TIB | |

**FUNCTION DESCRIPTION:**

General information:

This function is provided to make sure that the cylinder fuel feed which is re-started after an individual fuel shut-off begins to ignite safely and without misfires ensuring a fast torque build-up. The corresponding cylinder must be supplied with an additional fuel quantity for the following reasons :

- increased cylinder fill due to lack of residual exhaust gas
- removal of the wall-applied fuel film during cylinder shut-off.

There is no differentiation as to whether fuel feed is re-started after any one of the engine operating states.

*(refer to the chapter “ Fuel injection output “ in the major chapter “ Outputs “)*

Application recurrence **: Segment**

**Formula section:**

***** *Simulation of wall - applied fuel film removal ( calculation )* ***:***

TI_DIF_WF_[CYL] is set only if cylinder individual **fuel shut-off** is requested from basis software layer.
It works like a **negative offset** for **TI_ADD_REAC_SCC_[CYL**] and performs the simulation of wall - applied fuel film removal.

TI_DIF_WF_[CYL] = TIB * ID_TI_TCO_NEG_WF__TCO

As long as the corresponding cylinder is in fuel shut-off, an engine speed related additional fuel quantity ID_TI_INC_WF__N_32 is incremented cyclically at intervals of **720°** CRK until the cylinder fuel shut-off is terminated or TI_DIF_WF_[CYL] = 0.

** Additional injection quantity for re-starting fuel feed ( application ) :*

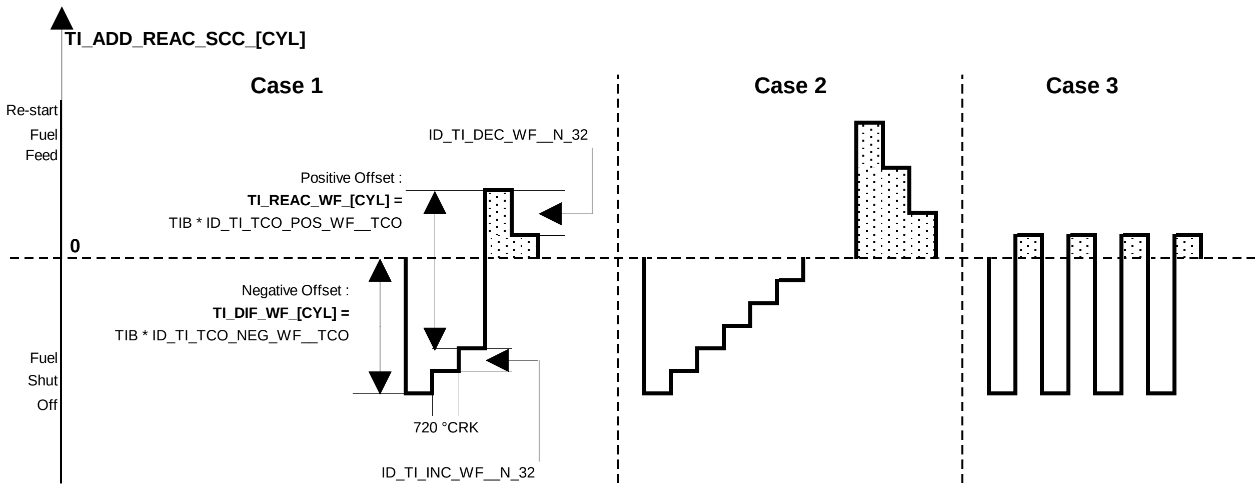
TI_REAC_WF_[CYL] is set only if cylinder re-start **fuel feed** is requested from basis software layer.
It works like a **positive offset** for **TI_ADD_REAC_SCC_[CYL]** and performs the wall - applied fuel film, which is not not completely removed.
Due to residual exhaust gas, an additive injection time compensation is performed only during the first triggering of the re-start fuel feed.

| TI_REAC_WF_[CYL] = TIB * ID_TI_TCO_POS_WF__TCO + ID_TI_N_POS_RG__N_32 |
|---|

For reduction, an engine speed related decrement ID_TI_DEC_WF__N_32 is used until TI_ADD_REAC_SCC_[CYL] = 0.

Description:





**Case 1 :** Re-start fuel feed is performed after 3 x 720 °CRK in fuel shut-off.
The wall - applied fuel film has not been removed totally.

The re-starting fuel quantity TI_ADD_REAC_SCC_[CYL] starts with the negative value TI_DIF_WF_[CYL]. The additional injection is defined by the positive offset TI_REAC_WF_[CYL]:

**TI_ADD_REAC_SCC_[CYL] = TI_REAC_WF_[CYL]**

The additional injection quantity is reset after 2 x 720 °CRK.

**Case 2 :** Following cylinder fuel shut-off, the wall - applied fuel film has been totally removed.

The re-starting fuel quantity TI_ADD_REAC_SCC_[CYL] is performed with the maximum value possible with TI_REAC_WF_[CYL]:

**TI_ADD_REAC_SCC_[CYL] = TI_REAC_WF_[CYL]**



The re-starting fuel feed injection is reset after 3 x 720 °CRK.

**Case 3 :** It shows alternating cylinder operation.
An additional injection quantity is supplied every combustion cycle (720 °CRK).

**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| ID_TI_TCO_NEG_WF__TCO | 8 | 0...FFFFH | 0...3,9999 | 4 / 65536 | - |
| | | | | | |
| Basic amount of wall - applied fuel film. | | | | | |
| ID_TI_TCO_POS_WF__TCO | 8 | 0...FFFFH | 0...3,9999 | 4 / 65536 | - |
| | | | | | |
| Basic amount of fuel at fuel feed re-starting | | | | | |
| ID_TI_N_POS_RG__N_32 | 8 | 0...FFFFH | 0...262,14 | 4 µsec | msec |
| | | | | | |
| First triggering fuel offset on re-start fuel feed for residual exhaust gas compensation. | | | | | |
| ID_TI_INC_WF__N_32 | 8 | 0...FFFFH | 0...262,14 | 4 µsec | msec |
| | | | | | |
| Incrementation for wall - applied fuel film removing simulation. | | | | | |
| ID_TI_DEC_WF__N_32 | 8 | 0...FFFFH | 0...262,14 | 4 µsec | msec |
| | | | | | |
| Fuel decrementation after re-starting fuel feed. | | | | | |

## 1.3 Lambda control (A/F regulation loop)

### 1.3.1 General

The lambda control adjusts the air-fuel mixture applied to the engine to the stoichiometric ratio corresponding to lambda **= 1**.

The lambda controller TI_LAM_i is a **P / I** controller. The reference variable for this controller is supplied by an exhaust gas probe, the oxygen sensor.

#### 1.3.1.1 Conditions for lambda control

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| LV_LSCL_i | V | 0...01H | 0...1 | 1 | - |
| Boolean for close loop enabled for bank n° 1/2 - ( OFF / ON ). | | | | | |
| LV_LAM_ACT_i | V | 0...01H | 0...1 | 1 | - |
| Boolean for lambda controller operability in its own limits for bank n° 1/2 - ( Passive / Active ). | | | | | |
| LV_LAM_i_READY | V | 0...01H | 0...1 | 1 | - |
| Boolean for lambda controller non operability for bank n° 1/2 - ( Passive / Active ). | | | | | |
| LV_AUTH_LAM_CYCNR | V | 0...01H | 0...1 | 1 | - |
| Boolean for lambda controller authorized again following A/F regulation in open loop - ( Passive / Active ). | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| LV_ES | LV_ST | LV_PUC | LV_FL |
| LV_TI_AST | LV_COP | LV_LEARN_CP | LV_SCC_LAM_ASR |
| LV_LSH_PHA_MAX_RATE | LV_IGA_AST | LV_AUTH_LAM_SA | LV_OPL_VS_MAX |
| LV_VLS_UP_i_ERR | LV_CPS_ERR | LV_DUR_IGC_[CYL]_ERR | LV_STATE_A_MIS |
| LV_TCO_ERR | LV_MAF_ERR | LV_LSH_UP_i_ERR | LV_IV_[CYL]_ERR |
| LV_CPS_ERR | LV_CPS_MECHA_ERR | LV_LAM_LIM_i_ERR | N_32 |
| TI_LAM_i | MAF_KGH | TCO | TI_AD_FAC_MMV_i |
| LAM_MV_i | CPPWM | TI_AD_ADD_MMV_REL_i | LAM_MV_DYW_i |
| LV_AFR_i | C_T_MIN_LS | C_T_LAM_MAX_STATE | PAT_INH_IV |
| LV_LS_i | L_INH_IV_[CYL] | | |

#### 1.3.1.1.1 Closing conditions



**<u>Application conditions:</u>**

The conditions to close the A/F regulation loop for a cylinder bank **n° i** are :

**If** LV_ES **= 0** *(engine stopped inactive)*
**and** LV_ST **= 0** *(engine operating state start inactive)*
**and** LV_LSH_PHA_MAX_RATE **= 1** *(O2 sensor full rate heating phase finished)*
**and** LV_TI_AST = LV_IGA_AST **= 0** (Passive) *(auxiliary function post start inactive)*
**and** LV_AUTH_LAM_SA **= 0** (Passive) *(secondary air function inactive)*
**then**
  **If** LV_VLS_UP_i_ERR **= 0**
  *(no error currently present on O2 sensor signal acquisition)*
  **and** LV_IV_[CYL]_ERR **= 0**
  *(no error currently present on injection power stage)*
  **and** LV_DUR_IGC_[CYL]_ERR **= 0**
  *(no error concerning the corresponding ignition output)*
  **and** LV_STATE_A_MIS **= 0**
  *(no misfire status CARB A (catalyst damage))*
  **and** MAF_KGH **>** C_LAM_MAF_KGH_MIN_DIAG
  **or** LV_LSH_UP_i_ERR **= 0**
  *(no error currently present on upstream O2-sensor heater power stage)*
  **then**
    **If** L_INH_IV_[CYL] **= 0** *(no fuel shut-off)*
    **and** PAT_INH_IV **= 0** *(fuel shut-off pattern index state)*
    **and** LV_SCC_LAM_ASR **= 0** *(no ASR intervention)*
    **and** LV_FL **= 0** (Passive) *(auxiliary function full load inactive)*
    **and** LV_OPL_VS_MAX **= 0** (Passive) *(no A/F regulation loop opened due to vehicle speed limitation)*
    **then** C_LAM_CYCNR initialisation

| | | | |
|---|---|---|---|
| **If** | | N_32 **>** C_LAM_N_MIN | |
| | **and** | LV_AUTH_LAM_CYCNR **= 0** (Passive) | |
| | | *(timer C_LAM_CYCNR has elapsed after A/F regulation in open loop)* | |
| | **and** | TCO **>** ID_TCO_LAM_MIN_IS__TCO_ST | in idle (LV_IS) |
| | **or** | TCO**>** ID_TCO_LAM_MIN__TCO_ST | out of idle |
| | | *(condition checked only once)* | |
| | | **then** | |

| | | |
|---|---|---|
| **If** | | LV_COP **= 0** (Passive) |
| | | *(catalyst overheating prevention function inactive)* |
| | **and** | LV_LS_i **= 1** (Active) |
| | | *(A/F regulation oxygen sensor operability effective)* |
| | **or** | C_T_MIN_LS expired |
| | | *(A/F regulation loop closed and LV_LS_i = 0)* |
| | **then** | |

| | |
|---|---|
| **LV_LSCL_i = 1** (ON) | *(A/F regulation loop closed)* |

### 1.3.1.1.2 Lambda controller status definition following A/F regulation in open loop (LV_AUTH_LAM_CYCNR)

General information:

This boolean information (LV_AUTH_LAM_CYCNR) is used as condition for closing again the A/F regulation loop following the A/F regulation previously opened.

**Application conditions:**

The A/F regulation loop will be closed again when C_LAM_CYCNR seconds have been performed following the conditions to leave LV_LSCL_i **= 0** (OFF).

Thus, the lambda controller will be authorized again only if N_32 **>** C_LAM_N_MIN.

### 1.3.1.1.3 Lambda controller status definition relative to the A/F regulation loop (LV_LAM_ACT_i , LV_LAM_i_READY)



<u>General information:</u>

Two boolean information (LV_LAM_ACT_i and LV_LAM_i_READY) are built using the boolean information LV_LSCL_i relative to the A/F regulation loop.

- The first one (LV_LAM_ACT_i) indicates an A/F regulation loop closed and a lambda controller TI_LAM_i running in its own limitation.

- The second one (LV_LAM_i_READY) indicates the operability status of the lambda controller TI_LAM_i

**Application conditions:**

*Activation:*

| | | |
|---|---|---|
| **If** | LV_LSCL_i **= 1** (ON) | (A/F regulation loop closed) |
| **and** | LV_LAM_LIM_i_ERR **= 1** | (error currently present on lambda controller) |
| **then** | **LV_LAM_i_READY = 0** (Passive) | |

Deactivation :

| | | |
|---|---|---|
| **If** | LV_LSCL_i **= 0** (OFF) | (A/F regulation loop opened) |
| **or** | **(**LV_LSCL_i **= 1** (ON) | (A/F regulation loop closed) |
| **and** | LV_AFR_i = 0 (Lean) → 1 (Rich) | |
| **or** | LV_AFR_i = 1 (Rich) → 0 (Lean) | |
| **and** | LV_LAM_LIM_i_ERR **= 0)** (no error currently present on lambda controller) | |
| **then** | **LV_LAM_i_READY = 1** (Active) | |

**Formula section:**

| | | |
|---|---|---|
| **If** | LV_LSCL_i **= 1** (ON) | *(A/F regulation loop closed)* |
| **and** | LV_LAM_i_READY **= 1** (Active) | *(lambda controller ready to operate)* |
| **then** | **LV_LAM_ACT_i = 1** (Active) | |
| **else** | **LV_LAM_ACT_i = 0** (Passive) | |

#### 1.3.1.1.4 Opening conditions



**Application conditions:**

The conditions to open the A/F regulation loop for a cylinder bank **n° i** are :

| | | |
|---|---|---|
| **If** | LV_ES **= 1** | *(engine stopped active)* |
| **or** | LV_ST **= 1** | *(engine operating state start active)* |
| **or** | LV_LSH_PHA_MAX_RATE **= 0** | *(O2 sensor full rate heating phase not expired)* |
| **or** | LV_TI_AST **= 1** (Active) | *(auxiliary function post start (TI correction) active)* |
| **or** | LV_IGA_AST **= 1** (Active) | *(auxiliary function post start (IGA correction) active)* |
| **or** | LV_AUTH_LAM_SA **= 1** (Active) | *(secondary air function active)* |

**then**

| | |
|---|---|
| **LV_LSCL_i = 0** (OFF) | *(A/F regulation loop opened)* |

**and**

TI_LAM_i reaches its default value (**0** dec : **8000**H),
using the last **I -** component calculated.

**else**

| | |
|---|---|
| **If** | LV_VLS_UP_i_ERR **= 1**<br>*(error currently present on O2 sensor signal acquisition)* |
| **or** | LV_IV_[CYL]_ERR **= 1**<br>*(error currently present on corresponding injection power stage)* |
| **or** | LV_DUR_IGC_[CYL]_ERR **= 1**<br>*(error currently present on the corresponding ignition output)* |
| **or** | LV_STATE_A_MIS **= 1**<br>*(misfire status CARB A (catalyst damage))* |
| **or** | MAF_KGH ≤ C_LAM_MAF_KGH_MIN_DIAG<br>**and** LV_LSH_UP_i_ERR **= 1**<br>*(error currently present on upstream O2 sensor heater power stage)* |

**then**

| | |
|---|---|
| **LV_LSCL_i = 0** (OFF) | *(A/F regulation loop opened)* |

**and**

**If** LV_MAF_ERR **= 1**
*(error currently present on mass air flow sensor)*
**or** LV_MAF_PLAUS_ERR **= 1**
*(error currently present on mass air flow signal)*
**or** LV_LAM_LIM_i_ERR **= 1**
*(error currently present on lambda controller)*
**or** LV_VLS_UP_i_ERR **= 1**
*(error currently present on O2 sensor signal acquisition)*
**or** LV_TCO_ERR **= 1**
*(error currently present on coolant temperature sensor)*
**or** LV_TCO_PLAUS_ERR **= 1**
*(error currently present on coolant temperature signal)*
**or** LV_CPS_ERR **= 1**
*(error currently present on evaporative emission control valve power stage)*
**or** LV_DUR_IGC_[CYL]_ERR **= 1**
*(error currently present on the corresponding ignition output)*
**or** LV_IV_[CYL]_ERR **= 1**
*(error currently present on corresponding injection power stage)*
**or** LV_STATE_A_MIS **= 1**
*(misfire status CARB A (catalyst damage))*
**or** LV_CPS_MECHA_ERR **= 1**
*(control valve mechanical error during evaporative system monitoring )*

**then**

$TI\_LAM\_i_{n}$ **=** $TI\_LAM\_i_{n-1} + (TI\_AD\_FAC\_MMV\_i_{n-1} + TI\_AD\_ADD\_MMV\_REL\_i_{n-1})$

**and**

$LAM\_MV\_i_{n}$ **=** $LAM\_MV\_i_{n-1} + (TI\_AD\_FAC\_MMV\_i_{n-1} + TI\_AD\_ADD\_MMV\_REL\_i_{n-1})$

**and**

$LAM\_MV\_DYW\_i_{n}$ **=** $LAM\_MV\_DYW\_i_{n-1} + (TI\_AD\_FAC\_MMV\_i_{n-1} + TI\_AD\_ADD\_MMV\_REL\_i_{n-1})$

**else**

TI_LAM_i reaches its default value (**0** dec : **8000**H),
using the last **I -** component calculated.

**else**

**If** L_INH_IV_[CYL] **= 1** *(fuel shut-off active)*
**or** PAT_INH_IV ≠ **0** *(fuel shut-off pattern index)*
**or** LV_SCC_LAM_ASR **= 1** *(ASR intervention)*
**or** LV_FL **= 1** (Active) *(auxiliary function full load active)*
**or** LV_OPL_VS_MAX **= 1** (Active) *(A/F regulation loop opened due to VS limitation)*

**then**

**If** LV_LEARN_CP **= 1**
*(LEARNING mode from evaporative emission control in process (CPPWM ≠ 0))*
**then**
RAMP opening mode and LEARNING mode are aborted
**and** C_T_LAM_MAX_STATE is started

**else**

**LV_LSCL_i = 0** (OFF) *(A/F regulation loop opened)*

**and** C_LAM_CYCNR is initialized
**and**

**If** LV_PUC **= 1** *(trailing throttle fuel cut-off active)*
**then** TI_LAM_i **= 0** dec. ( **8000**H )

**Endif**

**else**

**If** N_32 ≤ C_LAM_N_MIN
**or** C_LAM_CYCNR not expired
**or** TCO ≤ ID_TCO_LAM_MIN_IS__TCO_ST in idle (LV_IS)
**or** TCO ≤ ID_TCO_LAM_MIN__TCO_ST out of idle
**then**

**LV_LSCL_i = 0** (OFF) *(A/F regulation loop opened)*

**and**

TI_LAM_i reaches its default value (**0** dec : **8000**H),
using the last **I -** component calculated.

## Calibration data:

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| ID_TCO_LAM_MIN_IS__TCO_ST | 6 | 0...FEH | -48...142,5 | 0,75 | °C |
| | | | | | |
| Minimum coolant temperature to close the A/F regulation loop in idle. | | | | | |
| ID_TCO_LAM_MIN__TCO_ST | 6 | 0...FEH | -48...142,5 | 0,75 | °C |
| | | | | | |
| Minimum coolant temperature to close the A/F regulation loop out of idle | | | | | |
| C_LAM_N_MIN | 1 | 0...FFH | 0...8160 | 32 | rpm |
| Minimum engine speed to close the A/F regulation loop. | | | | | |
| C_LAM_MAF_KGH_MIN_DIAG | 1 | 0...FFFFH | 0...16383,75 | 0,25 | kg/h |
| Minimum mass air flow threshold for validation of the upstream O2 sensor heater power stage. | | | | | |
| C_LAM_CYCNR | 1 | 01...FFFFH | 0,01...655,35 | 0,01 | sec |
| Authorization delay for closing again the A/F regulation loop following A/F regulation loop opened. | | | | | |

### 1.3.2 Variables related to A/F regulation oxygen sensors signal voltages ( VLS_i )

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| VLS_MMV_MAX_i | V | 0...FFH | 0...4,9805 | 5 / 256 | V. |
| Moving mean maximum oxygen sensor n° 1 voltage. | | | | | |
| VLS_MMV_MIN_i | V | 0...FFH | 0...4,9805 | 5 / 256 | V. |
| Moving mean minimum oxygen sensor n° 1 voltage. | | | | | |
| VLS_TOL_i | V | 0...FFH | 0...4,9805 | 5 / 256 | V. |
| VLS_MMV_MIN_i corrected voltage. | | | | | |
| VLS_BOL_i | V | 0...FFH | 0...4,9805 | 5 / 256 | V. |
| VLS_MMV_MAX_i corrected voltage. | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| VLS_i | TI_LAM_i | LV_ES | TCO |
| LV_LS_i | LV_VLS_UP_i_ERR | LV_FL | LV_LSCL_i |
| LV_LAM_ACT_i | | | |

**FUNCTION DESCRIPTION:**

General information:

The different variables are calculated using the oxygen sensor voltage VLS_i in order to **:**

- define the lean / rich thresholds
- manage the A/F regulation oxygen sensor heater controller.

**Remark :** **i = 1** for injection bank n° **1**
**i = 2** for injection bank n° **2**

Application recurrence **: 20 msec.**

**Formula section:**

** Initialisation :*

**If** engine stopped (LV_ES) active
**and** TCO ≥ C_LAM_TCO_VLS_MIN_INI
**then** VLS_MMV_MAX_i **=** VLS_MMV_MIN_i **=** VLS_TOL_i **=** VLS_BOL_i
**=** C_VLS_INI_MIN
**else** VLS_MMV_MAX_i **=** VLS_MMV_MIN_i **=** VLS_TOL_i **=** VLS_BOL_i
**=** C_VLS_INI

* Calculation :

**If** engine stopped (LV_ES) not active
  **and** LV_VLS_UP_i_ERR **= 0** (no error currently present on oxygen sensor signal acquisition)

**then**
  **If** LV_LS_i **= 0** (oxygen sensor non operability for A/F regulation)
  **then** no calculation
  **else**
    **If** VLS_TOL_i ≤ VLS_i ≤ VLS_BOL_i
      (case **n° 2** - refer to the following “ Description “)
    **or** LV_LAM_ACT_i **= 0**
      (the condition for lambda controller active (LV_LSCL_i = 1) and injection time correction ( TI_LAM_i ) not on limit is not fulfilled)
    **then** no calculation
    **else**
      **If** VLS_i **<** VLS_TOL_i
        (case **n° 1** - refer to the following “ Description “)
      **then**

$$VLS\_MMV\_MIN\_i_n = VLS\_MMV\_MIN\_i_{n-1} * (1 - C\_VLS\_CRLC) + VLS\_i_n * C\_VLS\_CRLC$$

$$VLS\_TOL\_i_n = VLS\_MMV\_MIN\_i_n + C\_VLS\_MMV\_HYS$$

    **else**
      **If** VLS_i **>** VLS_BOL_i
        (case **n° 3** - refer to the following “ Description “)
      **then**

$$VLS\_MMV\_MAX\_i_n = VLS\_MMV\_MAX\_i_{n-1} * (1 - C\_VLS\_CRLC) + VLS\_i_n * C\_VLS\_CRLC$$

$$VLS\_BOL\_i_n = VLS\_MMV\_MAX\_i_n - C\_VLS\_MMV\_HYS$$

      (special treatment in case of full load detection (LV_FL))
    **If** VLS_BOL_i ≤ VLS_TOL_i
    **then**

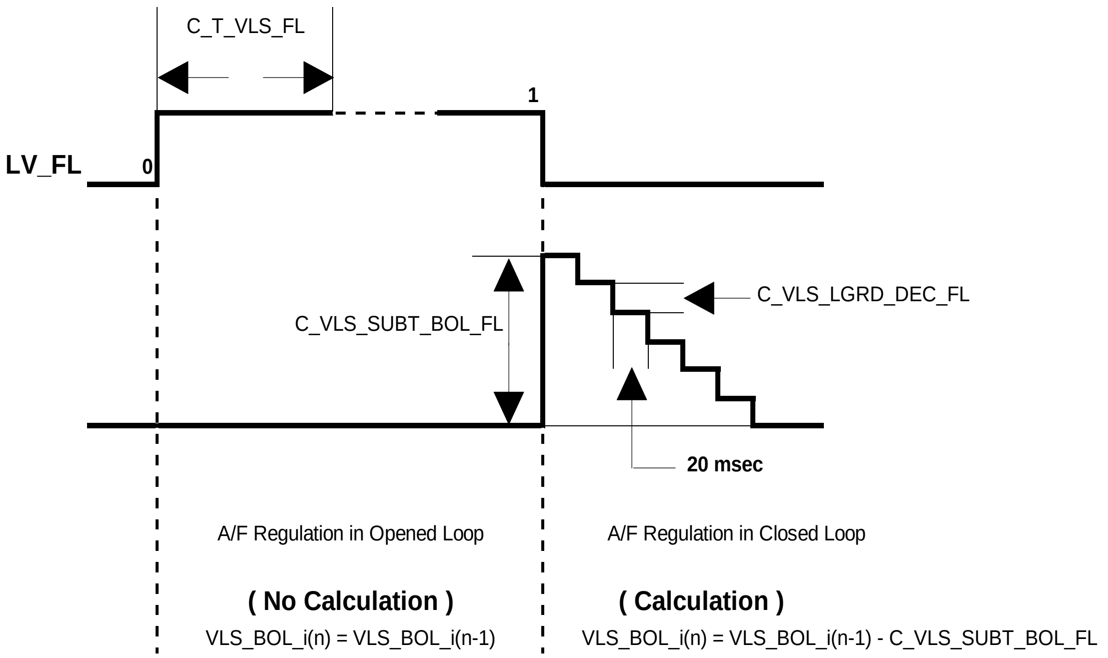
$$VLS\_BOL\_i = VLS\_TOL\_i = ( VLS\_MMV\_MAX\_i + VLS\_MMV\_MIN\_i ) / 2$$

* Special treatment in case of full load detection :

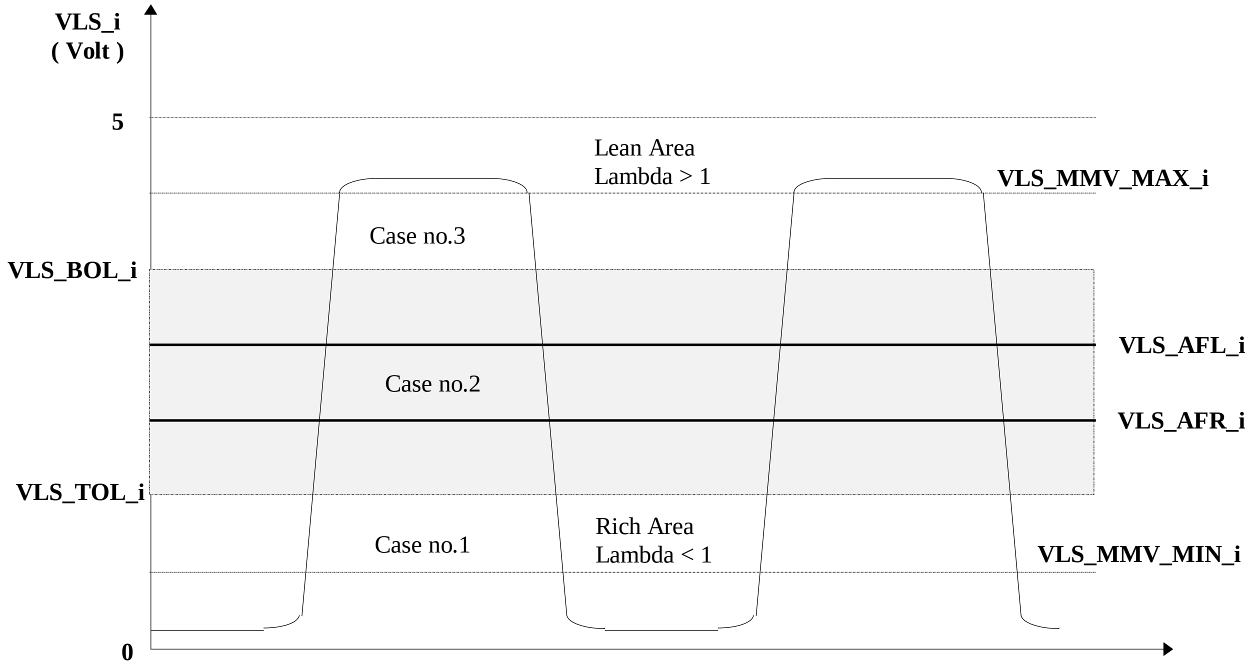
In this case, VLS_MMV_MAX_i cannot be calculated and a correction is made on VLS_BOL_i determination after leaving full load operation.

| | |
|---|---|
| **If** | LV_FL **= 1** (FL) during at least C_T_VLS_FL seconds |
| **then** | when exiting (LV_FL) |
| | VLS_BOL_$i_n$ **=** VLS_BOL_$i_{n-1}$ **-** C_VLS_SUBT_BOL_FL |

(C_VLS_SUBT_BOL_FL will be removed using change limitation C_VLS_LGRD_DEC_FL)



Description:




## Calibration data:

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| C_LAM_TCO_VLS_MIN_INI | 1 | 0...FFH | -48...142,5 | 0,75 | °C |
| Coolant temperature threshold for initialisation of the variables related to A/F regulation oxygen sensors signal voltages. | | | | | |
| C_VLS_INI_MIN | 1 | 0...FFH | 0...4,9805 | 5 / 256 | V. |
| Initialization of VLS_MMV_MAX_i, VLS_MMV_MIN_i, VLS_BOL_i, VLS_TOL_i depending on coolant temperature threshold. | | | | | |
| C_VLS_INI | 1 | 0...FFH | 0...4,9805 | 5 / 256 | V. |
| Initialization of VLS_MMV_MAX_i, VLS_MMV_MIN_i, VLS_BOL_i, VLS_TOL_i depending on coolant temperature threshold. | | | | | |
| C_VLS_CRLC | 1 | 00...FFH | 0...0,997 | 3,895E-3 | - |
| Correlation factor for VLS_MMV_MAX_i and VLS_MMV_MIN_i calculation. | | | | | |
| C_VLS_MMV_HYS | 1 | 0...FFH | 0...4,9805 | 5 / 256 | V. |
| Hysteresis for VLS_TOL_i and VLS_BOL_i calculation. | | | | | |
| C_T_VLS_FL | 1 | 01...FFH | 1...255 | 1 | sec. |
| Minimum duration of full load (LV_FL) for VLS_BOL_i correction application. | | | | | |
| C_VLS_SUBT_BOL_FL | 1 | 0...FFH | 0...4,9805 | 5 / 256 | V. |
| Offset applied on VLS_BOL_i calculation when exiting from full load (LV_FL). | | | | | |
| C_VLS_LGRD_DEC_FL | 1 | 01...FFH | 0,0195...4,9805 | 5 / 256 | V. |
| Change limitation for C_VLS_SUBT_BOL_FL removing. | | | | | |

### 1.3.2.1 Rich and lean mixture voltage thresholds ( VLS_AFR_i, VLS_AFL_i )

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| VLS_AFR_i | V | 0...FFH | 0...4,9805 | 5 / 256 | V. |
| Oxygen sensor voltage threshold for rich mixture detection. | | | | | |
| VLS_AFL_i | V | 0...FFH | 0...4,9805 | 5 / 256 | V. |
| Oxygen sensor voltage threshold for lean mixture detection. | | | | | |
| LV_AFR_i | V | 0...01H | 0...1 | 1 | - |
| Boolean for A/F ratio state for oxygen sensor i - ( Lean / Rich ). | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| VLS_MMV_MIN_i | VLS_MMV_MAX_i | C_LAM_TCO_VLS_MIN_INI | TCO |
| VLS_i | LV_VLS_LIM_i_ERR | C_VLS_INI | C_VLS_INI_MIN |
| LV_VLS_UP_i_ERR | | | |

**FUNCTION DESCRIPTION:**

General information:

Application recurrence **: 20 msec.**

**Formula section:**

** Initialisation :*

**If** engine stopped (LV_ES) active
**and** TCO ≥ C_LAM_TCO_VLS_MIN_INI
**then** VLS_AFR_i **=** VLS_AFL_i **=** C_VLS_INI_MIN
**else** VLS_AFR_i **=** VLS_AFL_i **=** C_VLS_INI

** Calculation :*

The calculation is performed as soon as all the conditions for calculation of the variables related to A/F regulation oxygen sensor signal voltage are met.

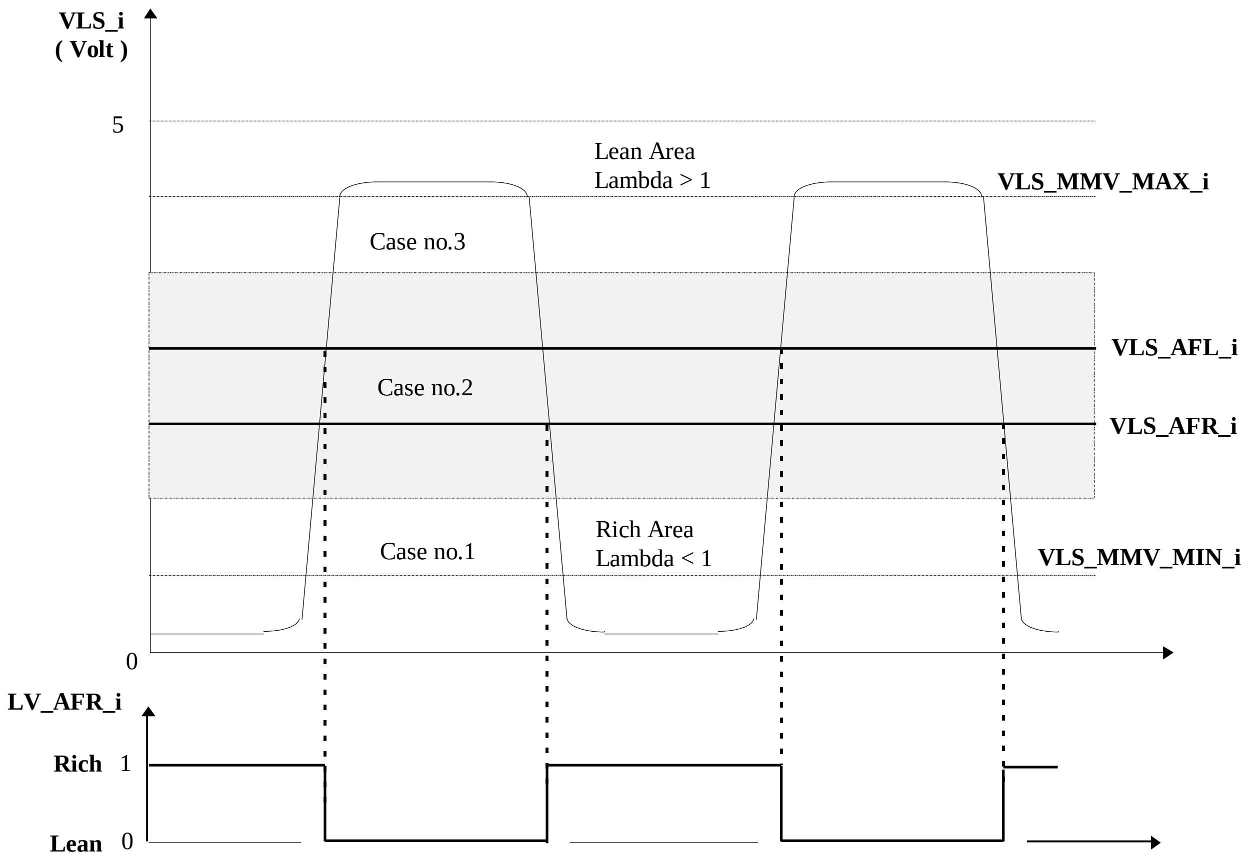
**If** LV_VLS_LIM_i_ERR **= 0**
*(no error currently present on oxygen sensor signal voltage excursion diagnosis)*
**and** LV_VLS_UP_i_ERR **= 0**
*(no error currently present on oxygen sensor signal voltage diagnosis)*
**then**

VLS_AFR_i **=** VLS_MMV_MIN_i + ( VLS_MMV_MAX_i - VLS_MMV_MIN_i ) * C_VLS_FAC_AFR
VLS_AFL_i **=** VLS_MMV_MIN_i + ( VLS_MMV_MAX_i - VLS_MMV_MIN_i ) * C_VLS_FAC_AFL

* Rich or Lean mixture detection :

| | | | |
|---|---|---|---|
| **If** | { LV_AFR_i **= 1** ( Rich ) | **and** | VLS_i **>** VLS_AFL_i } |
| **then** | LV_AFR_i **= 0** ( Lean ) → Lambda **> 1** | | |
| **If** | { LV_AFR_i **= 0** ( Lean ) | **and** | VLS_i **<** VLS_AFR_i } |
| **then** | LV_AFR_i **= 1** ( Rich ) → Lambda **< 1** | | |

Description:




**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| C_VLS_FAC_AFR | 1 | 00...FFH | 0...0,997 | 3,895E-3 | - |
| Weighting factor to calculate oxygen sensors signal voltages VLS_AFR_i for rich mixture detection. | | | | | |
| C_VLS_FAC_AFL | 1 | 00...FFH | 0...0,997 | 3,895E-3 | - |
| Weighting factor to calculate oxygen sensors signal voltages VLS_AFL_i for lean mixture detection. | | | | | |

### 1.3.2.2 A/F regulation oxygen sensors operability ( LV_LS_i )

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| LV_LS_i | V | 0...01H | 0...1 | 1 | - |
| Boolean for A/F regulation oxygen sensor operability - ( 0 / 1 ). | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| LV_ES | TCO | LV_VLS_LIM_i_ERR | LV_VLS_UP_i_ERR |
| TI_LAM_i | C_VLS_INI | C_LAM_MAX | C_VLS_INI_MIN |
| C_LAM_TCO_VLS_MIN_INI | | | |

**FUNCTION DESCRIPTION:**

General information:

In engine operating state engine stopped (LV_ES), the A/F regulation oxygen sensors are initialized to non operable condition (LV_LS_i **= 0**).

As soon as the engine operating state engine stopped is exited, the system checks whether the oxygen sensors signal voltages have dropped below a voltage threshold.

Application recurrence **: 20 msec.**

**Formula section:**

** Non operability :*

**If** engine stopped (LV_ES) active
**or** LV_VLS_LIM_i_ERR **= 1**
(error currently present on oxygen sensor signal voltage excursion diagnosis)
**then** LV_LS_i **= 0**

* Operability :

**If** engine stopped (LV_ES) not active
**and** LV_VLS_UP_i_ERR **= 0**
(no error currently present on oxygen sensors signal voltages acquisition diagnosis)
**and** VLS_i signal voltage has dropped below :
C_VLS_INI **if** TCO **<** C_LAM_TCO_VLS_MIN_INI
**or** C_VLS_INI_MIN **if** TCO ≥ C_LAM_TCO_VLS_MIN_INI
**then** LV_LS_i **= 1**

**Remark :** Special treatment if LV_LSCL_i **= 1** (ON) and LV_LS_i **= 0** (Passive)

If one of the oxygen sensor is not operable (LV_LS_i = 0) when the timer C_T_MIN_LS has elapsed (C_T_MIN_LS starts when the preliminary heating phase for oxygen sensor is finished) and if the A/F regulation loop is authorized to be closed, then the corresponding lambda controller TI_LAM_i is started with the maximum limit C_LAM_INI_MAXinstead of C_LAM_MAX

Following the first lean to rich transition of the corresponding oxygen sensor, this limit is set again to C_LAM_MAX and LV_LS_i **= 1** (Active).

The condition C_LAM_INI_MAX ≤ C_LAM_MAX must be met.

**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| C_T_MIN_LS | 1 | 01...FFH | 1...255 | 1 | sec |
| Minimum duration before closing the A/F regulation loop if the oxygen sensors are not ready. | | | | | |
| C_LAM_INI_MAX | 1 | 8000...D000H | 0...31,25 | 100 / 65536 | % |
| Maximum value of the lambda controller TI_LAM_i when LV_LSCL_i = 1 (ON) and LV_LS_i = 0 (Passive). | | | | | |

### 1.3.3 Variables related to A/F regulation oxygen sensors heater ( LSHPWM_i )



**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| LSHPWM_i | V | 00...FFH | 0...99.609 | 0.3891 | % |
| Upstream oxygen sensors heating duty cycle. | | | | | |
| LSHPWM_LGRD_i | V | 0...FFFFH | 0...99.6 | 0.0015 | % |
| Basic upstream oxygen sensors heating duty cycle with gradient limitation. | | | | | |
| VLS_DIF_i | V | 0...FFH | -5...4.9609 | 10 / 256 | V. |
| Variable representative of the upstream oxygen sensors tip-temperature. | | | | | |
| LSHPWM_FAC_i | V | 00...FFH | 0...1.992 | 7.782E-3 | - |
| Upstream oxygen sensors heater controller. | | | | | |
| LSHPWM_CYCNR | V | 0...FFH | 0...65535 | 1 | - |
| Time delay for limited heating after Start (LV_ST). | | | | | |
| LV_LSH_PHA_AST | V | 0...01H | 0...1 | 1 | - |
| Boolean for oxygen sensor preliminary heating phase (after start). | | | | | |
| LV_LSH_PHA_MAX_RATE | V | 0...01H | 0...1 | 1 | - |
| Boolean for oxygen sensor full rate heating phase. | | | | | |



**Input data:**

| | | | |
|---|---|---|---|
| LV_ES | LV_ST | LV_PUC | TIA_ST |
| VLS_MMV_MAX_i | LV_LS_i | LV_LAM_ACT_i | TI_LAM_i |
| VLS_MMV_MIN_i | LV_LSH_UP_i_ERR | LV_VB_JUMP | C_T_MIN_LS |
| MAF_KGH | VB | C_VB_MIN_JUMP | N_32 |
| MAF | TCO_ST | | |

**FUNCTION DESCRIPTION:**

General information:

The control of each heater is performed individually.

In order to avoid big temperature gradients after start, the oxygen sensors are heated preliminary => factor applied on the normal heating.

Following this pre-heating phase, the sensors are fully heated in order to reach their service temperature.

Then, the normal duty cycles LSHPWM_i are based on:
- a pre-control value (cylinder bank individual) weighted by battery voltage
- a heater controller (cylinder bank individual) based on the moving mean minimum and maximum oxygen sensors voltages.

**-** Application recurrence **:**

- Engine stopped: **100 msec.** to start pre-heating phase
- Engine running: **1 sec.** for pre-heating phase duration
  **C_T_PER_LSH sec.** for LSHPWM_i calculation

### 1.3.3.1 Initialization

**Application conditions:**

| | |
|---|---|
| **If** | engine stopped (LV_ES) active |
| **or** | LV_VB_JUMP **= 1** (Active) *(battery over voltage at start detected)* |
| **then** | LSHPWM_i **=** NC_LSHPWM_MIN_DIAG |
| **and** | LSHPWM_FAC_i **=** C_LSHPWM_FAC_INI |
| **and** | LSHPWM_CYCNR **= 0** |
| **and** | A/F regulation - P jump counter (C_LSHPWM_LAM_P_SUM_FAC) is reset. |

**Remark :**
Following over voltage event (LV_VB_JUMP **= 1** (Active) → **0** (Passive) ) detected at start, the oxygen sensor preliminary heating phase is performed again.

### 1.3.3.2 Oxygen sensors duty cycle gradient limitation ( LSHPWM_LGRD_i )

General information:

The target duty cycle LSHPWM_i to be applied to the oxygen sensor heater is:

LSHPWM_LGRD_i = IP_LSHPWM_i__N_32__MAF * IP_LSHPWM_VB_FAC__VB

If the engine operating point (N_32, MAF) or VB change, a gradient limitation is applied to the previous value to reach the new value.

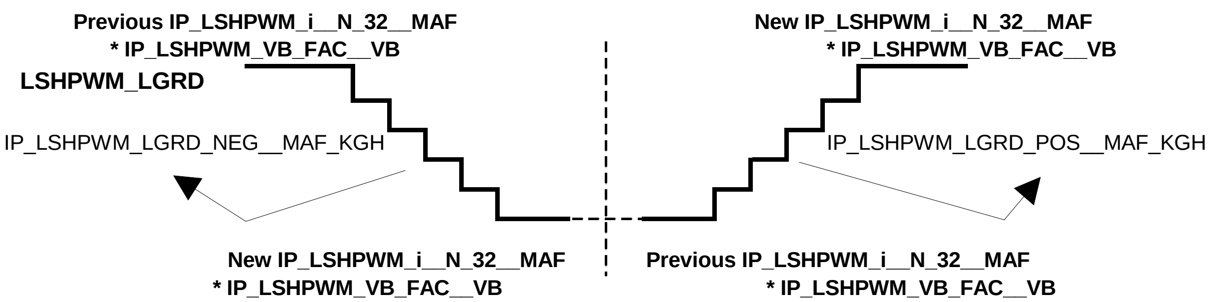
If the new value is lower, then IP_LSHPWM_LGRD_NEG__MAF_KGH is used; else if the new value is higher, then IP_LSHPWM_LGRD_POS__MAF_KGH is used.

Therefore, the internal variable LSHPWM_LGRD_i is used temporary by the software for calculation of the duty cycle LSHPWM_i.

At transition engine stop (LV_ES) to engine start (LV_ST) LSHPWM_LGRD_i is initialized with C_LSHPWM_INI_i :

LSHPWM_LGRD_i = C_LSHPWM_INI_i

Description:



### 1.3.3.3 Oxygen sensors preliminary heating phase ( LV_LSH_PHA_AST )

**Application conditions:**

*Activation:*

| | | |
|---|---|---|
| **If** | | LV_ES → LV_ST |
| | | (transition from engine stopped to start) |
| | **or** | LV_VB_JUMP **= 1** (Active) → **0** (Passive) |
| | | (battery over voltage at start removed) |
| **then** | | LSHPWM_CYCNR = IP_LSHPWM_CYCNR__TIA_ST |
| | | (timer initialization) |

$$\boxed{LSHPWM\_CYCNR_n = LSHPWM\_CYCNR_{n-1} - IP\_DEC\_CYCNR\_LSH\_\_MAF\_KGH}$$

*(timer decrementation)*

**and**

$$\boxed{LSHPWM\_i = LSHPWM\_LGRD\_i * C\_LSHPWM\_T\_FAC + C\_LSHPWM\_i\_AS}$$

**Remark :**
During oxygen sensor preliminary heating phase, the weighting factor LSHPWM_FAC_i (calculation of LSHPWM_i in basis heating phase) is kept with its initialization value C_LSHPWM_FAC_INI.

*- Deactivation :*

| | | |
|---|---|---|
| **If** | | engine stopped (LV_ES) detected |
| | **or** | LV_VB_JUMP = 0 (Passive) → 1 (Active) |
| | **or** | LSHPWM_CYCNR = 0 |
| **then** | | LV_LSH_PHA_AST = 1 |

*- Limitation :*

$$\boxed{NC\_LSHPWM\_MIN\_DIAG \le LSHPWM\_i \le NC\_LSHPWM\_MAX\_DIAG}$$

#### 1.3.3.4 Oxygen sensors full rate heating phase ( LV_LSH_PHA_MAX_RATE )

**<u>Application conditions:</u>**

*Activation:*

| | | |
|---|---|---|
| **If** | | LV_LSH_PHA_AST **= 0 → 1** |
| **then** | | the timer IP_T_MAX_LSH_ST__TCO_ST is started |
| | **and** | the timer C_T_MIN_LS is started<br>(refer to chapter“ A/F regulation oxygen sensors operability ( LV_LS_i ) “) |
| | **and** | |

LSHPWM_i **=** NC_LSHPWM_MAX_DIAG

*Deactivation:*

| | | |
|---|---|---|
| **If** | | IP_T_MAX_LSH_ST__TCO_ST has elapsed |
| **then** | | LV_LSH_PHA_MAX_RATE **= 1** |
| | **and** | A/F regulation - P jump counter<br>(C_LSHPWM_LAM_P_SUM_FAC) initialized. |
| | **and** | |

LSHPWM_i = LSHPWM_LGRD_i + C_LSHPWM_i_AS

*(without weighting factor C_LSHPWM_T_FAC).*

#### 1.3.3.5 Oxygen sensors heater controller

##### 1.3.3.5.1 A/F regulation in open loop ( LV_LSCL_i = 0 (OFF) )

| | | |
|---|---|---|
| **If** | | LV_LAM_ACT_i **= 0** (Passive)<br>*(lambda controller TI_LAM_i not ready to operate)* |
| | **or** | LV_LSH_i_ERR **= 1**<br>*(error currently present on upstream oxygen sensor heater power stage)* |
| | **or** | A/F regulation - P jump counter<br>(C_LSHPWM_LAM_P_SUM_FAC) in process |
| | **or** | LSHPWM_LGRD_i **<** NC_LSHPWM_LGRD_MIN |
| **then** | | the weighting factor LSHPWM_FAC_i of the heater controller LSHPWM_i reaches the default value **1** using change limitation C_LSHPWM_DIF_PUC |

#### 1.3.3.5.2 A/F regulation in closed loop ( LV_LSCL_i = 1 (ON) )

**If** LV_LAM_ACT_i **= 1** (Active)
*(A/F regulation loop closed and lambda controller TI_LAM_i running)*
**and** LV_LSH_UP_i_ERR **= 0**
*(no error currently present on upstream oxygen sensor heater power stage)*
**and** A/F regulation - P jump counter (C_LSHPWM_LAM_P_SUM_FAC) has reached **0**
**and** LSHPWM_LGRD_i ≥ NC_LSHPWM_LGRD_MIN
**then**

VLS_DIF_i **=** ( VLS_MMV_MAX_i + VLS_MMV_MIN_i) - C_VLS_SP

*(representative value of oxygen sensor probe temperature)*

**and**

**If** VLS_DIF_i < 0
**then** $\text{LSHPWM\_FAC\_i}_{n} = \text{LSHPWM\_FAC\_i}_{n-1} - \text{IP\_LSHPWM\_DIF\_I\_i\_\_VLS\_DIF\_i}$

**If** VLS_DIF_i > 0
**then** $\text{LSHPWM\_FAC\_i}_{n} = \text{LSHPWM\_FAC\_i}_{n-1} + \text{IP\_LSHPWM\_DIF\_I\_i\_\_VLS\_DIF\_i}$

**Remark :**

**-** *Limitation **:***

C_LSHPWM_FAC_MIN ≤ LSHPWM_FAC_i ≤ C_LSHPWM_FAC_MAX

**<u>Formula section:</u>**

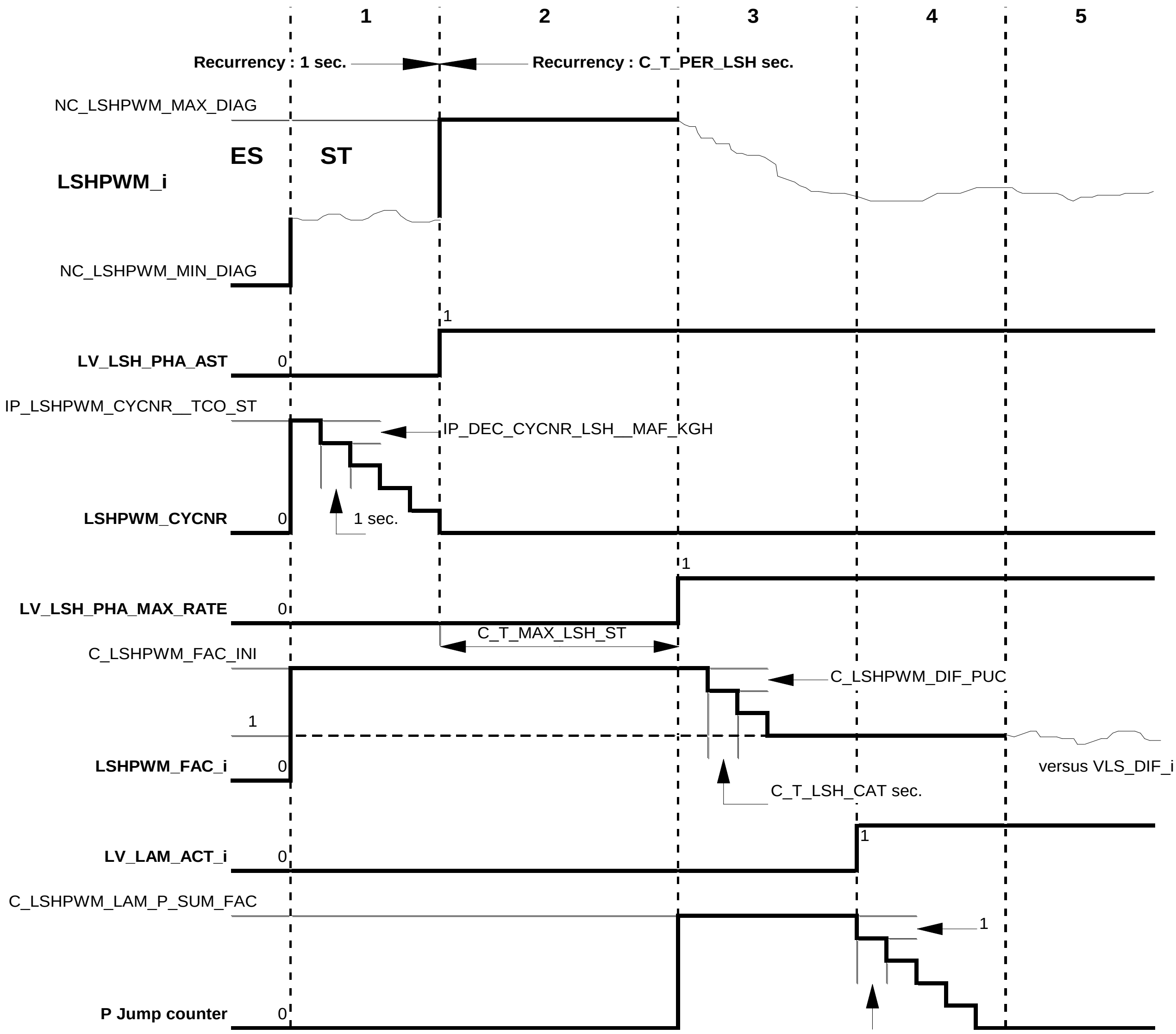
**-** *Duty cycle LSHPWM_i calculation **:***

LSHPWM_i **=** LSHPWM_LGRD_i * LSHPWM_FAC_i + C_LSHPWM_i_AS

**Remark :**

- If LSHPWM_i reaches the maximum value, then the last calculated LSHPWM_FAC_i component is maintained while the heater controller moves in the opening direction.
- If LSHPWM_i reaches the minimum value, then the last calculated LSHPWM_FAC_i component is maintained while the heater controller moves in the closing direction.

Description:




**1 :** LSHPWM_i = LSHPWM_LGRD_i * C_LSHPWM_T_FAC + C_LSHPWM_i_AS

**2 :** LSHPWM_i = NC_LSHPWM_MAX_DIAG

**3, 4 :** LSHPWM_i = LSHPWM_LGRD_i * 1 + C_LSHPWM_i_AS

**5 :** LSHPWM_i = LSHPWM_LGRD_i * LSHPWM_FAC_i + C_LSHPWM_i_AS

## Calibration data:

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| IP_LSHPWM_CYCNR__TIA_ST | 6 | 0...FFFFH | 0...65535 | 1 | - |
| | | | | | |
| Cycle counter for preliminary heating phase. | | | | | |
| IP_DEC_CYCNR_LSH__MAF_KGH | 6 | 0...FFFFH | 0...65535 | 1 | - |
| | | | | | |
| Decrementation of the cycle counter for preliminary heating phase. | | | | | |
| IP_LSHPWM_1__N_32__MAF | 6 x 6 | 0...FFH | 0...99.61 | 100 / 256 | % |
| | | | | | |
| Basic upstream O2 sensor heating Bank n°1 | | | | | |
| IP_LSHPWM_2__N_32__MAF | 6 x 6 | 0...FFH | 0...99.61 | 100 / 256 | % |
| | | | | | |
| Basic upstream O2 sensor heating Bank n°2 | | | | | |
| IP_LSHPWM_VB_FAC__VB | 6 | 0...FFH | 0...3.9844 | 0.0156 | - |
| | | | | | |
| Battery voltage weighting factor for basic upstream O2 sensors heating | | | | | |
| IP_LSHPWM_LGRD_POS__MAF_KGH | 6 | 01...FFFFH | 0.0015...99.998 | 0.0015 | % |
| | | | | | |
| Gradient limitation for upstream O2 sensors heating in increasing direction. | | | | | |
| IP_LSHPWM_LGRD_NEG__MAF_KGH | 6 | 01...FFFFH | 0.0015...99.998 | 0.0015 | % |
| | | | | | |
| Gradient limitation for upstream O2 sensor heating in decreasing direction. | | | | | |
| IP_LSHPWM_DIF_I_1__VLS_DIF_1 | 8 | 00...FFH | 0...1.922 | 7.509E-3 | - |
| | | | | | |
| LSHPWM_FAC_i integral correction for upstream O2 sensor Bank n° 1. | | | | | |
| IP_LSHPWM_DIF_I_2__VLS_DIF_2 | 8 | 00...FFH | 0...1.922 | 7.509E-3 | - |
| | | | | | |
| LSHPWM_FAC_i integral correction for upstream O2 sensor Bank n° 2. | | | | | |
| C_LSHPWM_DIF_PUC | 1 | 00...FFH | 0...1.992 | 7.782E-3 | - |
| LSHPWM_FAC_i gradient limitation in case of un-controlled oxygen sensor heater. | | | | | |
| C_LSHPWM_FAC_MIN | 1 | 0...80H | 0...1.9922 | 2 / 256 | - |
| LSHPWM_FAC_i minimum limit. | | | | | |
| C_LSHPWM_FAC_MAX | 1 | 80...FFH | 1...1.9922 | 2 / 256 | - |
| LSHPWM_FAC_i maximum limit. | | | | | |
| C_VLS_SP | 1 | 0...FFH | 0...9.96 | 10 / 256 | V. |
| VLS_i variation target value for heating regulation. | | | | | |
| C_T_PER_LSH | 1 | 01...32H | 0.1...5 | 0.1 | sec |
| LSHPWM_i calculation recurrence. | | | | | |
| IP_T_MAX_LSH_ST__TCO_ST | 6 | 01...FFH | 1...255 | 1 | sec |
| | | | | | |
| Time counter for full rating heating (LSHPWM_i = NC_LSHPWM_MAX_DIAG %) following pre-heating phase. | | | | | |
| C_LSHPWM_T_FAC | 1 | 0...80H | 0...0.9961 | 2 / 256 | - |
| Weighting factor for basic control duty cycle during preliminary heating phase. | | | | | |
| C_LSHPWM_1_AS | 1 | 80...7FH | -50...49.609 | 0.3891 | % |
| Specific heating duty cycle by application system for oxygen sensor n° 1. | | | | | |
| C_LSHPWM_2_AS | 1 | 80...7FH | -50...49.609 | 0.3891 | % |
| Specific heating duty cycle by application system for oxygen sensor n° 2. | | | | | |
| C_LSHPWM_INI_1 | 1 | 00...FFH | 0...99.6 | 0.3891 | % |
| Initialisation-value of LSHPWM_LGRD_1 at transition LV_ES to LV_ST. | | | | | |
| C_LSHPWM_INI_2 | 1 | 00...FFH | 0...99.6 | 0.3891 | % |
| Initialisation-value of LSHPWM_LGRD_2 at transition LV_ES to LV_ST. | | | | | |
| C_LSHPWM_LAM_P_SUM_FAC | 1 | 0...FFH | 0...255 | 1 | - |
| Number of P jumps from TI_LAM_i to start oxygen sensor controller. | | | | | |

## Calibration data:

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| C_LSHPWM_FAC_INI | 1 | 40...C0H | 0.5...1.5 | 2 / 256 | - |
| LSHPWM_FAC_i initialization value. | | | | | |
| NC_LSHPWM_MIN_DIAG | 1 | 0...FFH | 0...99.610 | 100 / 256 | % |
| Minimum O2 sensor heater duty cycle - Non applicative value. | | | | | |
| NC_LSHPWM_MAX_DIAG | 1 | 0...FFH | 0...99.610 | 100 / 256 | % |
| Maximum O2 sensor heater duty cycle - Non applicative value. | | | | | |
| NC_LSHPWM_LGRD_MIN | 1 | 0...FFH | 0...99.610 | 100 / 256 | % |
| Minimum gradient limitation O2 sensor heater duty cycle - Non applicative value. | | | | | |

## Applicative Values :

NC_LSHPWM_MIN_DIAG = **06**H = 2,3438 %
NC_LSHPWM_MAX_DIAG = **F9**H = 97,2656 %
NC_LSHPWM_LGRD_MIN = **19**H = 9,7652 %

### 1.3.4 Lambda control ( TI_LAM_i )



**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| TI_LAM_1 | V | 0...FFH | -50...49.609 | 0.3891 | % |
| Lambda control injection time correction for bank 1 | | | | | |
| TI_LAM_2 | V | 0...FFH | -50...49.609 | 0.3891 | % |
| Lambda control injection time correction for bank 2 | | | | | |
| T_LAM_DLY_POS_1 | V | 8000...7FFFH | -2560...2559.9 | 0.078 | ms |
| Total LAM-p-jump delay time from lean to rich transition for bank 1 | | | | | |
| T_LAM_DLY_POS_2 | V | 8000...7FFFH | -2560...2559.9 | 0.078 | ms |
| Total LAM-p-jump delay time from lean to rich transition for bank 2 | | | | | |
| T_LAM_DLY_NEG_1 | V | 8000...7FFFH | -2560...2559.9 | 0.078 | ms |
| Total LAM-p-jump delay time from rich to lean transition for bank 1 | | | | | |
| T_LAM_DLY_NEG_2 | V | 8000...7FFFH | -2560...2559.9 | 0.078 | ms |
| Total LAM-p-jump delay time from rich to lean transition for bank 2 | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| N | MAF | LV_IS | LV_PL |
| LV_LSCL_1 | LV_LSCL_2 | T_LAM_DLY_1 | T_LAM_DLY_2 |
| T_DLY_PUC_1 | T_DLY_PUC_2 | LV_AFR_1 | LV_AFR_2 |
| LV_SLOP_CP | | | |



**FUNCTION DESCRIPTION:**

General information:

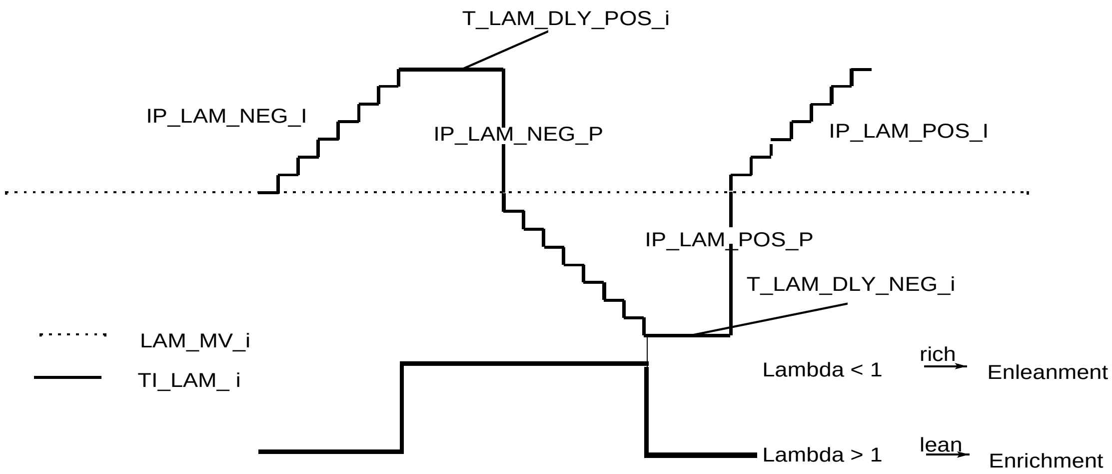
The A/F regulation loop adjusts the air / fuel mixture to richness 1. The lambda controller uses a P / I strategy. It is adjusted to produce a leaner or a richer mixture according to the oxygen sensor information of each cylinder bank.

The P / I values are different in idle (LV_IS) and out of idle.

- Application recurrence **: 10 msec.**

After entry in idle (LV_IS) from any other engine operating state, the P / I component of the lambda controller is switched to the P / I value for idle (LV_IS) after an adjustable number C_LAM_SUM_P_IS of P jumps.

Description:




## Application conditions:

*Activation:*

A/F regulation loop closed **( LV_LSCL_i = 1 (ON) )**

*Deactivation:*

A/F regulation loop opened **( LV_LSCL_i = 0 (OFF) )**

## Formula section:

*- Initialisation :*

From engine stopped (LV_ES) to start (LV_ST) or during system reset, the lambda controller TI_LAM_i is set to **0**.

*- In idle (LV_IS) :*

P component for transition from **lambda > 1 (Lean) ----> lambda < 1 (Rich) :**

$TI\_LAM\_i_n$ **=** $TI\_LAM\_i_{n-1}$ **-** C_LAM_NEG_P_IS * C_LAM_FAC_P

P-jump delay time for transition from **lambda > 1 (Lean) ----> lambda < 1 (Rich) :**

**If** T_LAM_DLY_NEG_i **>** 0
**then** T_LAM_DLY_POS_i **=** C_T_LAM_DLY_POS_IS
**else** T_LAM_DLY_POS_i **=** C_T_LAM_DLY_POS_IS - C_T_LAM_DLY_NEG_IS + T_DLY_PUC_i + T_LAM_DLY_i

I component for **lambda < 1 (Rich) :**

$TI\_LAM\_i_n$ **=** $TI\_LAM\_i_{n-1}$ **-** C_LAM_NEG_I_IS * C_LAM_FAC_I_i

Exception:

**If** LV_SLOP_CP = 1 (Canister purge in Ramp-mode)

**then** $TI\_LAM\_i_n$ **=** $TI\_LAM\_i_{n-1}$ **-** IP_LAM_NEG_I__N__MAF * C_LAM_FAC_I_i

P component for transition from **lambda < 1 (Rich) ----> lambda > 1 (Lean) :**

$TI\_LAM\_i_n$ **=** $TI\_LAM\_i_{n-1}$ **+** C_LAM_POS_P_IS * C_LAM_FAC_P

P-jump delay time for transition from **lambda < 1 (Rich) ----> lambda > 1 (Lean) :**
T_LAM_DLY_NEG_i = C_T_LAM_DLY_NEG_IS - T_DLY_PUC_i - T_LAM_DLY_i
T_LAM_DLY_NEG_i minimum limit is 0.

I component for **lambda > 1 (Lean) :**

$TI\_LAM\_i_n$ **=** $TI\_LAM\_i_{n-1}$ **+** C_LAM_POS_I_IS * C_LAM_FAC_I_i

Exception:

**If** LV_SLOP_CP = 1 (Canister purge in Ramp-mode)

**then** $TI\_LAM\_i_n$ **=** $TI\_LAM\_i_{n-1}$ **-** IP_LAM_POS_I__N__MAF * C_LAM_FAC_I_i



*- Out of idle :*

P component for transition from **lambda > 1 (Lean) ----> lambda < 1 (Rich) :**

$TI\_LAM\_i_n$ **=** $TI\_LAM\_i_{n-1}$ **-** IP_LAM_NEG_P__N__MAF * C_LAM_FAC_P

P-jump delay time for transition from **lambda > 1 (Lean) ----> lambda < 1 (Rich) :**

**If** T_LAM_DLY_NEG_i > 0

**then** T_LAM_DLY_POS_i = IP_T_LAM_DLY_POS__N__MAF

**else** T_LAM_DLY_POS_i = IP_T_LAM_DLY_POS__N__MAF -
IP_T_LAM_DLY_NEG__N__MAF + T_DLY_PUC_i + T_LAM_DLY_i

I component for **lambda < 1 (Rich) :**

$TI\_LAM\_i_n$ **=** $TI\_LAM\_i_{n-1}$ **-** IP_LAM_NEG_I__N__MAF * C_LAM_FAC_I_i

P component for transition from **lambda < 1 (Rich) ----> lambda > 1 (Lean) :**

$TI\_LAM\_i_n$ **=** $TI\_LAM\_i_{n-1}$ **+** IP_LAM_POS_P__N__MAF * C_LAM_FAC_P

P-jump delay time for transition from **lambda < 1 (Rich) ----> lambda > 1 (Lean) :**
T_LAM_DLY_NEG_i = IP_T_LAM_DLY_NEG__N__MAF - T_DLY_PUC_i - T_LAM_DLY_i

T_LAM_DLY_NEG_i minimum limit is 0.

I component for **lambda > 1 (Lean) :**

$TI\_LAM\_i_n$ **=** $TI\_LAM\_i_{n-1}$ **+** IP_LAM_POS_I__N__MAF * C_LAM_FAC_I_i

**Remark :**
The interpolated table IP_LAM_xx_yy__N__MAF have common list of data points.

## Calibration data:

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| IP_LAM_POS_P__N__MAF | 8 * 8 | 0...7FH | 0...0.49609 | 1 / 256 | - |
| Basic value of TI_LAM proportional component out of idle during transition lambda < 1 (Rich) --> lambda > 1 (Lean). | | | | | |
| IP_LAM_NEG_P__N__MAF | 8 * 8 | 0...7FH | 0...0.49609 | 1 / 256 | - |
| Basic value of TI_LAM proportional component out of idle during transition lambda > 1 (Lean) --> lambda < 1 (Rich). | | | | | |
| IP_LAM_POS_I__N__MAF | 8 * 8 | 0...7FH | 0...0.49609 | 1 / 256 | - |
| Basic value of TI_LAM integral component out of idle when lambda > 1 (Lean). | | | | | |
| IP_LAM_NEG_I__N__MAF | 8 * 8 | 0...7FH | 0...0.49609 | 1 / 256 | - |
| Basic value of TI_LAM integral component out idle when lambda < 1 (Rich). | | | | | |
| C_LAM_FAC_P | 1 | 00...FFH | 0...0.997 | 3.895E-3 | - |
| Scale factor for TI_LAM proportional component. | | | | | |
| C_LAM_FAC_I_1 | 1 | 00...FFH | 0...0.997 | 3.895E-3 | - |
| Scale factor for TI_LAM integral component for bank n° 1 | | | | | |
| C_LAM_FAC_I_2 | 1 | 00...FFH | 0...0.997 | 3.895E-3 | - |
| Scale factor for TI_LAM integral component for bank n° 2 | | | | | |
| C_LAM_POS_P_IS | 1 | 0...7FH | 0...0.49609 | 1 / 256 | - |
| Basic value of TI_LAM proportional component in idle during transition lambda < 1 (Rich) --> lambda > 1 (Lean). | | | | | |
| C_LAM_NEG_P_IS | 1 | 0...7FH | 0...0.49609 | 1 / 256 | - |
| Basic value of TI_LAM proportional component in idle during transition lambda > 1 (Lean) --> lambda < 1 (Rich). | | | | | |
| C_LAM_POS_I_IS | 1 | 0...7FH | 0...0.49609 | 1 / 256 | - |
| Basic value of TI_LAM integral component in idle when lambda > 1 (Lean). | | | | | |
| C_LAM_NEG_I_IS | 1 | 0...7FH | 0...0.49609 | 1 / 256 | - |
| Basic value of TI_LAM integral component in idle when lambda < 1 (Rich). | | | | | |
| C_LAM_ SUM_P_IS | 1 | 0...FFH | 0...255 | 1 | - |
| Lambda controller P jump delay to have idle P/I values. | | | | | |
| IP_T_LAM_DLY_POS__N__MAF | 8*8 | 0...3FFFH | 0...1279.9 | 0.078 | ms |
| Basic LAM-p-jump delay for transition from lean to rich | | | | | |
| IP_T_LAM_DLY_NEG__N__MAF | 8*8 | 0...3FFFH | 0...1279.9 | 0.078 | ms |
| Basic LAM-p-jump delay for transition from rich to lean | | | | | |
| C_T_LAM_DLY_POS_IS | 1 | 0...3FFFH | 0...1279.9 | 0.078 | ms |
| Basic LAM-p-jump delay for transition from lean to rich in idle | | | | | |
| C_T_LAM_DLY_NEG_IS | 1 | 0...3FFFH | 0...1279.9 | 0.078 | ms |
| Basic LAM-p-jump delay for transition from rich to lean in idle | | | | | |

### 1.3.4.1 Lambda controller limits

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| TI_LAM_MAX_1 | - | 0...FFH | -50...49.609 | 0.3891 | % |
| Upper lambda controller limit for bank 1 | | | | | |
| TI_LAM_MAX_2 | - | 0...FFH | -50...49.609 | 0.3891 | % |
| Upper lambda controller limit for bank 2 | | | | | |
| TI_LAM_MIN_1 | - | 0...FFH | -50...49.609 | 0.3891 | % |
| Lower lambda controller limit for bank 1 | | | | | |
| TI_LAM_MIN_2 | - | 0...FFH | -50...49.609 | 0.3891 | % |
| Lower lambda controller limit for bank 2 | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| TI_AD_FAC_MMV_1 | TI_AD_FAC_MMV_2 | LV_LEARN_CP | CPPWM |

**FUNCTION DESCRIPTION:**

General information:

The limits for the lambda controller are C_LAM_MAX and C_LAM_MIN.
If the lambda adaptation value TI_AD_FAC_MMV_i ≠ **0**, these limits are changed.

**Formula section:**

*TI_AD_FAC_MMV_i* ***> 0 :***

- TI_LAM_MIN_i = C_LAM_MIN
- TI_LAM_MAX_i :

**If** LV_LEARN_CP = 1
(LEARNING mode from evaporative emission control in process (CPPWM ≠ 0)
**then** TI_LAM_MAX_i = C_LAM_MAX
**else**
**If** TI_AD_FAC_MMV_i < C_LAM_MAX
**then** TI_LAM_MAX_i = C_LAM_MAX - TI_AD_FAC_MMV_i
**else** TI_LAM_MAX_i = 0

*TI_AD_FAC_MMV_i < 0 :*

- TI_LAM_MAX_i = C_LAM_MAX
- TI_LAM_MIN_i :

**If** LV_LEARN_CP = 1
(LEARNING mode from evaporative emission control in process (CPPWM ≠ 0)
**then** TI_LAM_MIN_i = C_LAM_MIN
**else**
**If** C_LAM_MIN < TI_AD_FAC_MMV_i
**then** TI_LAM_MIN_i = C_LAM_MIN - TI_AD_FAC_MMV_i
**else** TI_LAM_MIN_i = 0

## Calibration data:

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| C_LAM_MIN | 1 | 3000...8000H | -31.25...0 | 100 / 65536 | % |
| Minimum TI_LAM value. | | | | | |
| C_LAM_MAX | 1 | 8000...D000H | 0...31.25 | 100 / 65536 | % |
| Maximum TI_LAM value. | | | | | |

### 1.3.4.2 LAM_i and LAM_MV_i calculation



**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| LAM_1 | - | 0...FFH | -50...49.609 | 100 / 256 | % |
| TI_LAM value after a P jump for bank n° 1 | | | | | |
| LAM_2 | - | 0...FFH | -50...49.609 | 100 / 256 | % |
| TI_LAM value after a P jump for bank n° 2 | | | | | |
| LAM_MV_1 | V | 0...FFH | -50...49.609 | 100 / 256 | % |
| TI_LAM average value for bank n° 1 | | | | | |
| LAM_MV_2 | V | 0...FFH | -50...49.609 | 100 / 256 | % |
| TI_LAM average value for bank n° 2 | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| TI_LAM_1 | TI_LAM_2 | LV_AFR_1 | LV_AFR_2 |



**FUNCTION DESCRIPTION:**

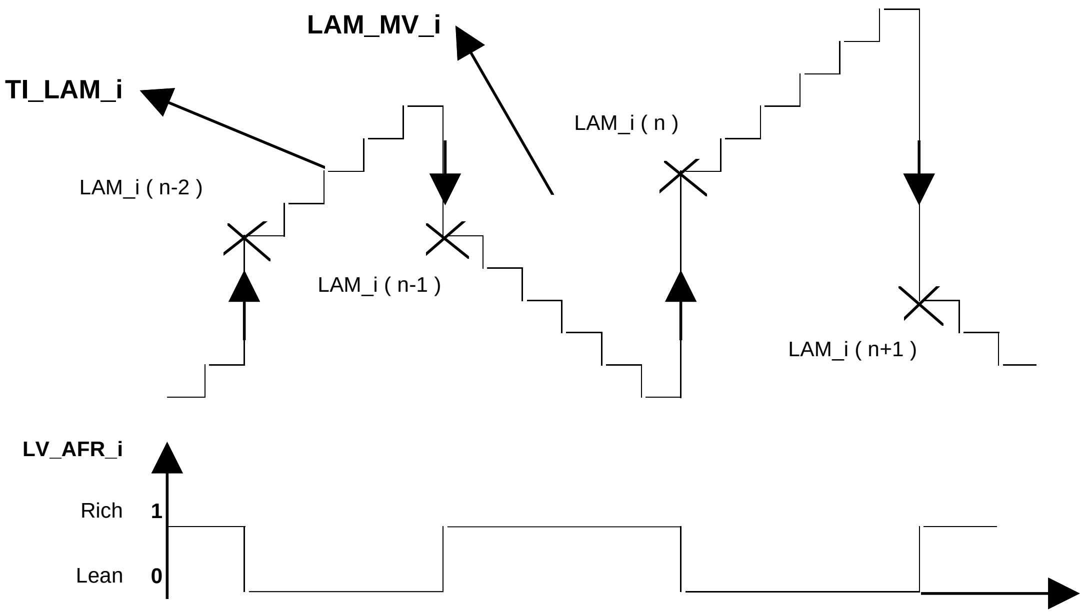
General information:

Various functions, e.g. lambda adaptation and control of the evaporative emissions control system, require the lambda controller mean value LAM_MV_i.

LAM_i (used for LAM_MV_ calculation) is the TI_LAM_i value after each P jump of the lambda controller.

- Application recurrence **: P Jump**

Description:






**Formula section:**

$LAM\_MV\_i_n = ( LAM\_i_{n-1} + LAM\_i_n ) / 2$

### 1.3.4.3 Conditions for limited dynamics

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| MAF_MV_1 | V | 0...FFH | 0...1389 | 5.45 | mg/TDC |
| MAF average value for bank n° 1 | | | | | |
| MAF_MV_2 | V | 0...FFH | 0...1389 | 5.45 | mg/TDC |
| MAF average value for bank n° 2 | | | | | |
| N_MV_1 | V | 0...FFH | 0...8160 | 32 | rpm |
| N average value for bank n° 1 | | | | | |
| N_MV_2 | V | 0...FFH | 0...8160 | 32 | rpm |
| N average value for bank n° 2 | | | | | |
| LAM_MV_DYW_1 | V | 00...FFH | -50...49.609 | 0.3891 | % |
| LAM_MV average value for bank n° 1 | | | | | |
| LAM_MV_DYW_2 | V | 00...FFH | -50...49.609 | 0.3891 | % |
| LAM_MV average value for bank n° 2 | | | | | |
| LV_N_MAF_DYW_1 | V | 0...01H | 0...1 | 1 | - |
| Boolean for limited dynamics N, MAF for bank n° 1 - ( Passive / Active ). | | | | | |
| LV_N_MAF_DYW_2 | V | 0...01H | 0...1 | 1 | - |
| Boolean for limited dynamics N, MAF for bank n° 2 - ( Passive / Active ). | | | | | |
| LV_LAM_DYW_1 | V | 0...01H | 0...1 | 1 | - |
| Boolean for limited dynamics LAM for bank n° 1 - ( Passive / Active ). | | | | | |
| LV_LAM_DYW_2 | V | 0...01H | 0...1 | 1 | - |
| Boolean for limited dynamics LAM for bank n° 2 - ( Passive / Active ). | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| MAF | N | LAM_MV_1 | LAM_MV_2 |
| LV_LEARN_CP | | | |

**FUNCTION DESCRIPTION:**

General information:

Limited dynamics conditions for a variable exist if the current value stays around its mean value within a tolerance window. This check is made each P jump of the lambda controller.

Variables checked :

**MAF**
**N**
**LAM_MV_i**

Mean variables :

**MAF_MV_i**
**N_MV_i**
**LAM_MV_DYW_i**

**Formula section:**

*- Limited dynamics conditions for engine operating point ( N, MAF ) :*

```
If              | MAF - MAF_MV_i | < C_MAF_DYW
     and        | N - N_MV_i | < C_N_DYW
then            LV_N_MAF_DYW_i = 1 (Active)
else            LV_N_MAF_DYW_i = 0 (Passive)
     and        MAF_MV_i = MAF
     and        N_MV_i = N
     and        LAM_MV_DYW_i = LAM_MV_i
Endif.
```

*- Limited dynamics conditions for lambda controller ( LAM_MV_i ) :*

```
If              | LAM_MV_i - LAM_MV_DYW_i | < C_LAM_MV_DYW
     and        LV_LEARN_CP = 0
                (LEARNING mode from evaporative emission control over)
then            LV_LAM_DYW_i = 1 (Active)
else            LV_LAM_DYW_i= 0 (Passive)
     and        LAM_MV_DYW_i = LAM_MV_i
     and        MAF_MV_i = MAF
     and        N_MV_i = N
Endif.
```

**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| C_MAF_DYW | 1 | 0...FFH | 0...1389 | 5.45 | mg/TDC |
| MAF window for limited dynamics. | | | | | |
| C_N_DYW | 1 | 0...1FE0H | 0...8160 | 1 | rpm |
| N window for limited dynamics. | | | | | |
| C_LAM_MV_DYW | 1 | 00...FFH | 0...99.609 | 0.3891 | % |
| LAM_MV window for limited dynamics. | | | | | |

### 1.3.5 Lambda adaptation ( TI_AD_ADD_MMV_COR_i, TI_AD_FAC_MMV_COR_i )



**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| TI_AD_ADD_MMV_i | V/S | 8000...7FFFH | -131.07...131.06 | 4 µsec | msec |
| Additive adaptative factor for bank n° i | | | | | |
| TI_AD_FAC_MMV_i | V/S | 00...FFFFH | -50...49.998 | 1.526E-3 | % |
| Multiplicative adaptative factor for bank n° i | | | | | |
| TI_AD_ADD_MMV_REL_i | V | 8000...7FFFH | -50...49.998 | 1.526E-3 | msec |
| Relative additive adaptative factor for bank n° i | | | | | |
| TI_AD_ADD_MMV_COR_i | V | 8000...7FFFH | -131.07...131.06 | 4 µsec | msec |
| Additive adaptative factor for bank n° i weighted by coolant temperature during warm -up. | | | | | |
| TI_AD_FAC_MMV_COR_i | V | 00...FFFFH | -50...49.998 | 1.526E-3 | % |
| Multiplicative adaptative factor for bank n° i weighted by coolant temperature during warm -up | | | | | |
| LV_TI_AD_ACT_i | V | 0...01H | 0...1 | 1 | - |
| Boolean for TI adaptation activation for bank n° i ( Passive / Active ). | | | | | |
| TI_AD_ACT_i | V | 0...04H | 0...4 | 1 | - |
| Information for TI adaptation calculation type for bank n° i - ( 0 : Passive, 1 : ADD_ACT, 3 : FAC_ACT ) | | | | | |



**Input data:**

| | | | |
|---|---|---|---|
| TCO | TIA | N | MAF |
| TI_LAM_i | TIB | CPPWM | MAF_KGH |
| LAM_MV_i | LAM_MV_DYW_i | LV_LSCL_i | C_FAC_MIN_P_CP |
| LV_PL | LV_IS | LV_AUTH_LAM_AD_CP | LV_STB_PHA_CP |
| LV_LAM_DYW_i | LV_N_MAF_DYW_i | LV_AUTH_LAM_i_AD_LEARN_CP | LV_LAM_LIM_i_ERR |
| LV_TPS_ERR | LV_TPS_PLAUS_ERR | LV_MAF_ERR | LV_MAF_PLAUS_ERR |
| LV_ISA_i_ERR | LV_ISA_MECHA_ERR | LV_CAM_ERR | LV_TIA_ERR |
| LV_SAV_ERR | LV_SAV_MECHA_ERR | LV_TCO_ERR | LV_TCO_PLAUS_ERR |
| LV_CPS_ERR | LV_CPS_MECHA_ERR | LV_VLS_LIM_ERR | LV_FSD_ERR |

**FUNCTION DESCRIPTION:**

General information:

In order to compensate serial production tolerances of components, adaptative corrections (additive and multiplicative) are calculated, versus the TI_LAM_i values.
They must be centered to 0 dec. **(80H).**

- Application recurrence **: 20 msec.**

### 1.3.5.1 Application conditions ( LV_TI_AD_ACT_i )



**If** TCO **>** C_TI_TCO_AD_MIN
**and** TIA **<** C_TI_TIA_AD_MAX
**and** MAF_KGH **<** C_TI_MAF_AD_MAX
**and** LV_LSCL_i **= 1** *(A/F regulation loop closed)*
**and** LV_LAM_LIM_i_ERR **= 0** *(no error currently present on Lambda controller)*
**and** LV_TPS_ERR **= 0**
*(no error currently present on throttle position sensor)*
**and** LV_TPS_PLAUS_ERR **= 0**
*(no plausibility error currently present on throttle position sensor)*
**and** LV_MAF_ERR **= 0**
*(no error currently present on mass air flow sensor)*
**and** LV_MAF_PLAUS_ERR **= 0**
*(no plausibility error currently present on mass air flow sensor)*
**and** LV_ISA_i_ERR **= 0**
*(no error currently present on idle charge actuator command signal)*
**and** LV_ISA_MECHA_ERR **= 0**
*(no mechanical error currently present on idle speed actuator)*
**and** LV_CAM_ERR **= 0**
*(no error currently present on camshaft sensor)*
**and** LV_TIA_ERR **= 0**
*(no error currently present on air temperature sensor)*
**and** LV_TCO_ERR **= 0**
*(no error currently present on coolant temperature sensor)*
**and** LV_TCO_PLAUS_ERR **= 0**
*(no plausibility error currently present on coolant temperature sensor)*
**and** LV_VLS_LIM_ERR **= 0**
*(no error currently present on O2-sensor voltage excursion)*
**and** LV_FSD_ERR **= 0**
*(no error currently present on fuel system)*
**and** LV_CPS_ERR **= 0**
*(no error currently present on canister purge solenoid)*
**and** LV_CPS_MECHA_ERR **= 0**
*(no mechanical error currently present on canister purge solenoid)*
**and** LV_SAV_ERR **= 0**
*(no error currently present on secondary air valve power stage)*
**and** LV_SAV_MECHA_ERR **= 0** (Passive)
*(diagnosis inactive for mechanical error detection on secondary air valve)*
**and** LV_LAM_DYW_i **= 1** (Active)
*(steady state defined by limited dynamics conditions for lambda controller)*
**and** LV_AUTH_LAM_AD_CP **= 1** (Active)
*(lambda adaptation authorized by evaporative emissions control process)*
**or** LV_AUTH_LAM_i_AD_LEARN_CP **= 1** (Active)
*(lambda adaptation authorized by evaporative emissions control process)*
**and** LV_AUTH_LAM_i_AD_LEARN_CP **= 1** (Active)
*(lambda adaptation authorized by evaporative emissions control process)*
**or** LV_N_MAF_DYW_i **= 1** (Active)
*(steady state defined by limited dynamics cond. for engine op. point)*
**then** LV_TI_AD_ACT_i **= 1** (Active)
**else** LV_TI_AD_ACT_i **= 0** (Passive)

### 1.3.5.2 Learning area ( TI_AD_ACT_i )

**If** LV_TI_AD_ACT_i **= 1** (Active)
*(application conditions for lambda adaptation are fulfilled)*

**then**

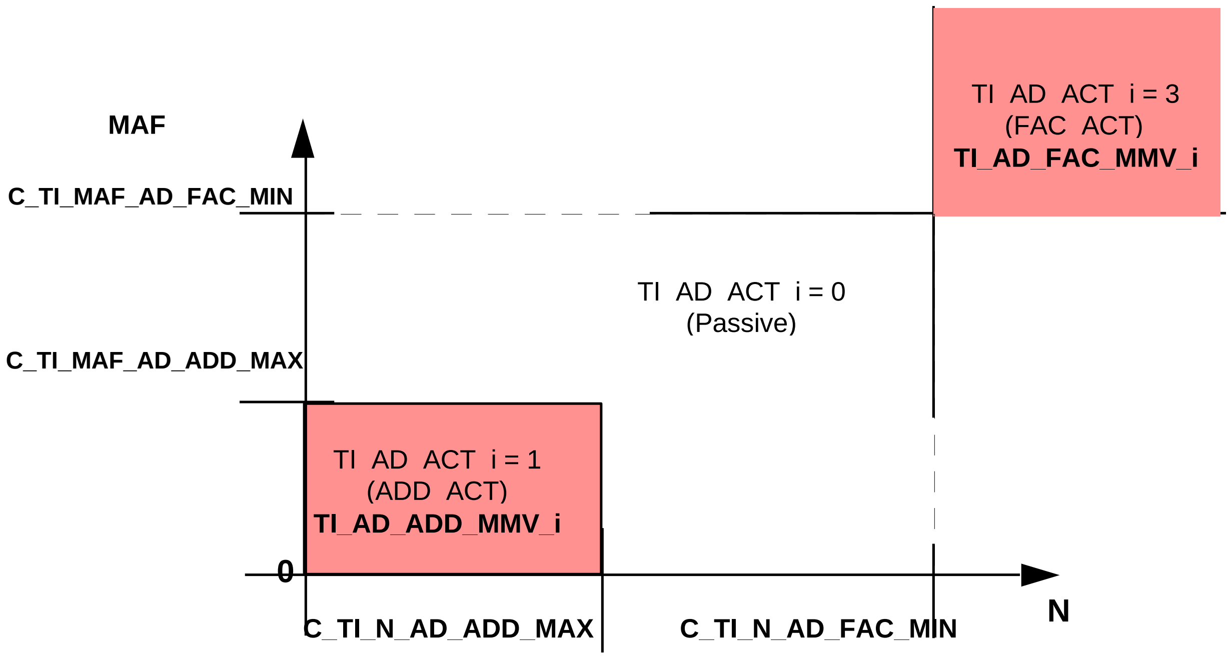
  **If** N**<** C_TI_N_AD_ADD_MAX(_AT)
  **and** MAF**<** C_TI_MAF_AD_ADD_MAX(_AT)
  **then** TI_AD_ACT_i **= 1** (= ADD_ACT)
  *(additive adaptation correction calculation for injection time authorized)*

  **else**

    **If** N **>** C_TI_N_AD_FAC_MIN(_AT)
    **and** MAF **>** C_TI_MAF_AD_FAC_MIN(_AT)
    **then** TI_AD_ACT_i **= 3** (= FAC_ACT)
    *(multiplicative adaptation correction calculation for injection time authorized)*

**else** TI_AD_ACT_i **= 0** (Passive)

<u>Description:</u>



### 1.3.5.3 Lambda adaptation calculation period

Once the activation conditions are active ( LV_TI_AD_ACT_i **= 1** (Active) ), the adaptation calculation takes place when a number of P - Jumps are performed by the lambda controller:

| | | |
|---|---|---|
| - in idle (LV_IS = 1) | : | C_LAM_AD_SUM_P_IS |
| - out of idle | : | C_LAM_AD_SUM_P |

Another adaptation calculation occurs when the number of P - Jumps is reached.
When the activation conditions are exited ( LV_TI_AD_ACT_i **= 0** (Passive) ), the current number of P - Jumps is reset.

**Remark :**
If LV_AUTH_LAM_i_AD_LEARN_CP **= 1** (Active) (lambda adaptation authorized by evaporative emissions control process during LEARNING mode with CPPWM = 0) and the number of P - Jumps from lambda controller is more than C_FAC_MIN_P_CP, then the adaptation calculation is performed.

### 1.3.5.4 Correlation factor for lambda adaptation calculation

- **Canister purge in Stand-by-mode:** Lambda adaptation possible, correlation factor is:
  C_TI_AD_COR_CRLC_XX = C_TI_AD_COR_CRLC_IS if LV_IS = 1
  C_TI_AD_COR_CRLC_XX = C_TI_AD_COR_CRLC if LV_IS = 0

- **Canister purge in Min-mode:** Lambda adaptation possible if CPPWM = 0, correlation factor is:
  C_TI_AD_COR_CRLC_XX = C_TI_AD_COR_CRLC_IS if LV_IS = 1
  C_TI_AD_COR_CRLC_XX = C_TI_AD_COR_CRLC if LV_IS = 0

- **Canister purge in Normal-mode:** Lambda adaptation possible, correlation factor is:
  C_TI_AD_COR_CRLC_XX = C_TI_AD_COR_CRLC_CP

- **Canister purge in Ramp-mode:** Lambda adaptation is not possible, Exception: with LAM_MV_BEG determination at FAC_CP = 0; weighting factor is
  C_TI_AD_COR_CRLC_XX = C_TI_AD_COR_CRLC_LD

### 1.3.5.5 Lambda adaptation calculation ( TI_AD_ADD_MMV_i, TI_AD_FAC_MMV_i )

**If** LV_TI_AD_ACT_i **= 1**
*(application conditions for lambda adaptation are fulfilled)*
**and** TI_AD_ACT_i = 1 (ADD_ACT)
*(additive adaptation correction calculation for injection time authorized)*
**then**

$$TI\_AD\_ADD\_MMV\_i_n = TI\_AD\_ADD\_MMV\_i_{n-1} + [\ C\_TI\_AD\_COR\_CRLC\_xx * LAM\_MV\_DYW\_i * TIB * N / C\_TI\_N\_AD\_ADD\_MAX(\_AT)\ ]$$

**and**

$$TI\_AD\_ADD\_MMV\_REL\_i_n = [\ TI\_AD\_ADD\_MMV\_i_n * C\_TI\_N\_AD\_ADD\_MAX(\_AT) / N\ ] / TIB$$

**and**

$K = [\ TI\_AD\_ADD\_MMV\_REL\_i_n - TI\_AD\_ADD\_MMV\_REL\_i_{n-1}\ ]$

$TI\_LAM\_i_n = TI\_LAM\_i_{n-1} - K$

$LAM\_MV\_i_n = LAM\_MV\_i_{n-1} - K$

$LAM\_MV\_DYW\_i_n = LAM\_MV\_DYW\_i_{n-1} - K$

**else**

**If** LV_TI_AD_ACT_i = 1
*(application conditions for lambda adaptation are fulfilled)*
**and** TI_AD_ACT_i = 3 (FAC_ACT)
*(multiplicative adaptation correction calculation for injection time authorized)*
**then**

$$TI\_AD\_FAC\_MMV\_i_n = TI\_AD\_FAC\_MMV\_i_{n-1} + [\ C\_TI\_AD\_COR\_CRLC\_xx * LAM\_MV\_DYW\_i\ ]$$

**and**

$K = [\ TI\_AD\_FAC\_MMV\_i_n - TI\_AD\_FAC\_MMV\_i_{n-1}\ ]$

$TI\_LAM\_i_n = TI\_LAM\_i_{n-1} - K$

$LAM\_MV\_i_n = LAM\_MV\_i_{n-1} - K$

$LAM\_MV\_DYW\_i_n = LAM\_MV\_DYW\_i_{n-1} - K$

### 1.3.5.6 Lambda adaptation correction during warm-up



General information:

In order to avoid mixture problems when the engine has not reached its service temperature, the lambda adaptation values (additive and multiplicative) can be decreased versus TCO and their own value (applied when engine runs with its service temperature).

It is performed by weighting the adaptative factors as long as the lambda adaptation is disabled due to the coolant temperature threshold C_TI_TCO_AD_MIN.

**Formula section:**

**If** TCO **<** C_TI_TCO_AD_MIN
**then**

TI_AD_ADD_MMV_i$_n$ = TI_AD_ADD_MMV_i$_{n-1}$
* IP_TI_AD_ADD_FAC__TCO__TI_AD_ADD_MMV

and

TI_AD_FAC_MMV_i$_n$ = TI_AD_FAC_MMV_i$_{n-1}$
* IP_TI_AD_FAC_FAC__TCO__TI_AD_FAC_MMV

**Endif.**

**If** TCO ≥ C_TI_TCO_AD_MIN
**then**

TI_AD_ADD_MMV_COR_i$_n$ **=** TI_AD_ADD_MMV_i$_n$ * C_TI_N_AD_ADD_MAX(_AT) / N

**and**

TI_AD_FAC_MMV_COR_i$_n$ **=** TI_AD_FAC_MMV_i$_n$

**else**

TI_AD_ADD_MMV_COR_i$_n$ **=** TI_AD_ADD_MMV_i$_n$ * C_TI_N_AD_ADD_MAX(_AT) / N
* IP_TI_AD_ADD_FAC__TCO__TI_AD_ADD_MMV

**and**

TI_AD_FAC_MMV_COR_i$_n$ **=** TI_AD_FAC_MMV_i$_n$
* IP_TI_AD_FAC_FAC__TCO__TI_AD_FAC_MMV

**Endif.**

### 1.3.5.7 Lambda adaptation limitation



General information:

In order to avoid big injection time deviation and to detect system failure, the lambda adaptation values are limited. The limitation takes place following calculation of the lambda adaptation values.

C_TI_AD_ADD_MIN ≤ TI_AD_ADD_MMV_COR_i ≤ C_TI_AD_ADD_MAX

C_TI_AD_FAC_MIN ≤ TI_AD_FAC_MMV_COR_i ≤ C_TI_AD_FAC_MAX

## Calibration data:

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| C_TI_TCO_AD_MIN | 1 | 0...FEH | -48...142.5 | 0.75 | °C |
| Minimum coolant temperature for adaptative learning. | | | | | |
| C_TI_TIA_AD_MAX | 1 | 0...FEH | -48...142.5 | 0.75 | °C |
| Maximum air temperature for adaptive learning | | | | | |
| C_TI_MAF_AD_MAX | 1 | 0...FFFFH | 0...16383.75 | 0.25 | kg/h |
| Maximum MAF for adaptative learning. | | | | | |
| C_TI_N_AD_ADD_MAX(_AT) | 1 | 01...1FE0H | 1...8160 | 1 | rpm |
| Maximum engine speed for additive adaptative learning. | | | | | |
| C_TI_MAF_AD_ADD_MAX(_AT) | 1 | 0...FFH | 0...1389 | 5.447 | mg/TDC |
| Maximum MAF for additive adaptative learning. | | | | | |
| C_TI_N_AD_FAC_MIN(_AT) | 1 | 01...1FE0H | 1...8160 | 1 | rpm |
| Minimum engine speed for multiplicative adaptative learning. | | | | | |
| C_TI_MAF_AD_FAC_MIN(_AT) | 1 | 0...FFH | 0...1389 | 5.447 | mg/TDC |
| Minimum MAF for multiplicative adaptative learning. | | | | | |
| C_LAM_AD_SUM_P_IS | 1 | 01...FFH | 1...255 | 1 | - |
| P component jump delay between two adaptative learning in idle. | | | | | |
| C_LAM_AD_SUM_P | 1 | 0...FFH | 0...255 | 1 | - |
| P component jump delay between two adaptative learning out of idle. | | | | | |
| C_TI_AD_COR_CRLC | 1 | 00...FFH | 0...0.997 | 3.895E-3 | - |
| Correlation factor for adaptative learning out of idle with LV_AUTH_LAM_AD_CP = 1 or LV_AUTH_LAM_i_AD_LEARN_CP = 0. | | | | | |
| C_TI_AD_COR_CRLC_IS | 1 | 00...FFH | 0...0.997 | 3.895E-3 | - |
| Correlation factor for adaptative learning in idle with LV_AUTH_LAM_AD_CP = 1 or LV_AUTH_LAM_i_AD_LEARN_CP = 0. | | | | | |
| C_TI_AD_COR_CRLC_CP | 1 | 00...FFH | 0...0.997 | 3.895E-3 | - |
| Correlation factor for adaptative learning in NORMAL operation of evaporative emissions control. | | | | | |
| C_TI_AD_COR_CRLC_LD | 1 | 00...FFH | 0...0.997 | 3.895E-3 | - |
| Correlation factor for adaptative learning with LV_AUTH_LAM_i_AD_LEARN_CP = 0. | | | | | |
| IP_TI_AD_ADD_FAC__TCO__TI_AD_ADD_MMV | 5 x 5 | 00...FFH | 0...0.997 | 3.895E-3 | - |
| Multiplicative factor on additive adaptative learning during warm-up. | | | | | |
| IP_TI_AD_FAC_FAC__TCO__TI_AD_FAC_MMV | 5 x 5 | 00...FFH | 0...0.997 | 3.895E-3 | - |
| Multiplicative factor on multiplicative adaptative learning during warm-up. | | | | | |
| C_TI_AD_FAC_MIN | 1 | 3000...8000H | -31.25...0 | 100 / 65536 | % |
| Minimum value of lambda adaptation multiplicative factor. | | | | | |
| C_TI_AD_FAC_MAX | 1 | 8000...D000H | 0...31.25 | 100 / 65536 | % |
| Maximum value of lambda adaptation multiplicative factor. | | | | | |
| C_TI_AD_ADD_MIN | 1 | 7B1E...8000H | -5...0 | 4 µsec | msec |
| Minimum value of lambda adaptation additive factor. | | | | | |
| C_TI_AD_ADD_MAX | 1 | 8000...84E2H | 0...+5 | 4 µsec | msec |
| Maximum value of lambda adaptation additive factor. | | | | | |

### 1.3.6 Downstream fuel trim regulation by LAM - P - Jump delay time

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| VLS_DIF_DLY_i | V | 80...7FH | -2,5...2,48 | 0,0196 | V |
| difference between setpoint and actual downstream LS signal | | | | | |
| T_DLY_P_i | V | 0000...FFFFH | 0...1279,98 | 0,0195 | ms |
| LAM -P-jump delay time from P-share | | | | | |
| T_DLY_I_i | V | 0000...FFFFH | 0...1279,98 | 0,0195 | ms |
| LAM -P-jump delay time from I-share | | | | | |
| T_DLY_AD_i | V/S | 0000...FFFFH | 0...1279,98 | 0,0195 | ms |
| LAM -P-jump delay time from AD-share | | | | | |
| T_LAM_DLY_i | V | 0000...FFFFH | 0...1279,98 | 0,0195 | ms |
| LAM -P-jump delay time from downstream trim controller | | | | | |
| FAC_CAT_DLY_i | V | 0...FFH | 0 ...0,996 | 3,9e-3 | - |
| weight factor for P-share regarding catalyst conversion capability | | | | | |
| MAF_INT_DLY_i | V | 0...FFFFH | 0...11650,66 | 0,178 | g |
| integral of air mass flow since LAM activation | | | | | |
| LV_LAM_DLY_i | V | 0...01H | 0...1 | 1 | - |
| Status for downstream fuel trim regulation activation | | | | | |
| LV_T_DLY_AD_i | V | 0...01H | 0...1 | 1 | - |
| Status for downstream fuel trim adaptative term calculation | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| VLS_CAT_i | CAT_DIAG_TRIM_i | N_32 | MAF |
| TEMP_MMV_SUB_CAT | TI_LAM_i | TI_AD_FAC_MMV_i | TI_AD_ADD_MMV_REL_i |
| TI_LAM_MIN_i | TI_LAM_MAX_i | LV_LDC_CAT_i | LV_LSCL_i |
| MAF_KGH | LV_VLS_DOWN_i_ERR | LV_ACT_INT_PUC_i | LV_LSH_DOWN_HP_i_ERR |
| LV_MAF_ERR | LV_MAF_PLAUS_ERR | LV_TPS_ERR | LV_TPS_PLAUS_ERR |
| LV_CRK_ERR | LV_CAM_ERR | LV_SAV_ERR | LV_SAV_MECHA_ERR |
| LV_SAS_ERR | LV_TCO_ERR | LV_CPS_ERR | LV_CPS_MECHA_ERR |
| LV_LSH_UP_i_ERR | LV_LSH_DOWN_i_ERR | LV_VLS_UP_i_ERR | LV_FSD_i_ERR |
| LV_VLS_FREQ_i_ERR | LV_VLS_SLOP_i_ERR | LV_VLS_LIM_i_ERR | LV_VLS_DOWN_LIM_i_ERR |
| LV_LAM_STOP | LV_MIS_[CYL]_ERR | | |

**FUNCTION DESCRIPTION:**

General information:

Downstream fuel trim regulation target is to keep a constant dynamic lambda during all the life of the vehicle.

According to downstream O2 sensor voltage, a P-jump time delay is applied on the lambda regulation. This time delay contains three parts:

- integral part: T_DLY_I_i
- proportional part: T_DLY_P_i
- adaptative part: T_DLY_AD_i

The downstream O2 sensor voltage represents the target dynamic lambda. Any deviation from this target, is entered in the P-I-AD regulation.

If two separate catalyst systems are concerned then :
i = 1, for cylinder bank 1
i = 2, for cylinder bank 2

Application recurrency: 20ms

**Application conditions:**

*Activation:* (LV_LAM_DLY_i **=** 1)

1) No relevant diagnosis entry:

| | | | |
|---|---|---|---|
| | LV_MAF_ERR **=** 0 | **and** | LV_MAF_PLAUS_ERR **=** 0 |
| **and** | LV_TPS_ERR **=** 0 | **and** | LV_TPS_PLAUS_ERR **=** 0 |
| **and** | LV_CRK_ERR **=** 0 | **and** | LV_CAM_ERR **=** 0 |
| **and** | LV_SAV_ERR **=** 0 | **and** | LV_SAV_MECHA_ERR **=** 0 |
| **and** | LV_SAS_ERR **=** 0 | **and** | LV_TCO_ERR **=** 0 |
| **and** | LV_CPS_ERR **=** 0 | **and** | LV_CPS_MECHA_ERR **=** 0 |
| **and** | LV_LSH_UP_i_ERR **=** 0 | **and** | LV_LSH_DOWN_i_ERR **=** 0 |
| **and** | LV_LSH_DOWN_HP_i_ERR **=** 0 | | |
| **and** | LV_VLS_UP_i_ERR **=** 0 | **and** | LV_VLS_DOWN_i_ERR **=** 0 |
| **and** | LV_VLS_LIM_i_ERR **=** 0 | **and** | LV_VLS_DOWN_LIM_i_ERR **=** 0 |
| **and** | LV_VLS_FREQ_i_ERR **=** 0 | **and** | LV_VLS_SLOP_i_ERR **=** 0 |
| **and** | LV_LAM_STOP **=** 0 | **and** | LV_MIS_[CYL]_ERR **=** 0 |
| **and** | LV_FSD_i_ERR **=** 0 | | |

2) TEMP_MMV_SUB_CAT **>** C_LAM_TEMP_MIN_CAT_DLY
*(Catalyst is working)* *(Hysteresis C_LAM_TEMP_HYS_CAT_DLY is applied when the function is started)*

3) **and** TI_LAM_MIN_i **<** TI_LAM_i + TI_AD_FAC_MMV_i + TI_AD_ADD_MMV_REL_i **<** TI_LAM_MAX_i
*(LAM-current value is not limited)*

4) **and** CAT_DIAG_TRIM_i **<** C_CAT_DIAG_MAX_DLY
(this condition is considered only if CAT_DIAG_TRIM_i < 256)
**and** CAT_DIAG_i **<** C_CAT_DIAG_MAX_DLY
*(Catalyst efficiency is in the valid area)*

5) **and** LV_LDC_CAT_i **=** 1 *(Limited dynamic is fulfilled)*

6) **and** LV_LSCL_i **=** 1 *(Lambda regulation active)*

7) **and** After each activation of the Lambda regulation :

MAF_INT_DLY_i **>** C_MAF_INT_MIN_DLY **if** LV_ACT_INT_PUC_i **= 0**

MAF_INT_DLY_i **>** C_MAF_INT_MIN_DLY_PUC **if** LV_ACT_INT_PUC_i **= 1**

*MAF_INT_DLY_i calculation:*

At each transition LV_LSCL_i 0->1, MAF_INT_DLY_i is initialised to 0 and then calculated like this:

$$\text{MAF\_INT\_DLY\_i}_{n} = \text{MAF\_INT\_DLY\_i}_{n-1} + \text{MAF\_KGH} * \text{NC\_FAC\_MAF\_INT}$$

(NC_FAC_MAF_INT = 20ms/3,6)

*Deactivation:* (LV_LAM_DLY_i **=** 0)

The function is deactivated if one of the activation condition is not true.

**Formula section:**

- VLS_DIF_DLY_i calculation :

VLS_DIF_DLY_i **=** IP_VLS_SP_DLY__N_32__MAF **-** VLS_CAT_i

- T_DLY_P_i calculation :

The P-share of the controller is calculated only in a specific N/MAF-areas:
C_MAF_LAM_DLY_P_MIN **<** MAF **<** C_MAF_LAM_DLY_P_MAX
**and** C_N_LAM_DLY_P_MIN **<** N_32 **<** C_N_LAM_DLY_P_MAX

When this conditions are not fulfilled or LV_LAM_DLY = 0, the corresponding P-share is initialized with 0.

T_DLY_P_i **=** IP_T_DLY_P__VLS_DLY_i
***** IP_FAC_DLY_P__MAF_KGH
***** IP_FAC_CAT_DLY__CAT_DIAG_TRIM_i

*Remark:* IP_FAC_CAT_DLY is constant for the present driving cycle, even if there is a new CAT_DIAG determination.

- T_DLY_I_i calculation :

The I-share of the controller is calculated only in a specific MAF-area:
IP_MAF_LAM_DLY_I_MIN__N_32 **<** MAF **<** IP_MAF_LAM_DLY_I_MAX__N_32

When this conditions are not fulfilled or LV_LAM_DLY = 0, the corresponding I-share is initialized with 0.

$$\text{T\_DLY\_I\_i}_{n} = \text{T\_DLY\_I\_i}_{n-1} + \text{IP\_CRLC\_DLY\_I\_\_MAF\_KGH} * \text{IP\_T\_DLY\_I\_\_VLS\_DIF\_DLY\_i}$$

T_DLY_I_i is limited with following limits:

C_T_DLY_I_MIN **<** T_DLY_I_i **<** C_T_DLY_I_MAX

- T_DLY_AD_i calculation :

The AD-share of the controller is calculated only in a specific MAF-area:
IP_MAF_LAM_DLY_AD_MIN__N_32 **<** MAF **<** IP_MAF_LAM_DLY_AD_MAX__N_32

If AD-share calculation is active, then the flag LV_T_DLY_AD_i is set to 1.

$T\_DLY\_AD\_i_n = T\_DLY\_AD\_i_{n-1} + C\_CRLC\_DLY\_AD * T\_DLY\_I\_i$

Additionnaly, T_DLY_AD_i is decreased by C_T_DLY_AD_DEC ms each second if LV_T_DLY_AD_i **=** 1

T_DLY_AD_i is limited with following limits:

C_T_DLY_AD_MIN **<** T_DLY_AD_i **<** C_T_DLY_AD_MAX

At the end of the driving cycle, T_DLY_AD_i is stored in the flash memory. At the beginning of the next driving cycle, T_DLY_AD_i is initialized with this stored value. After ECU reset, T_DLY_AD_i is initialized with 0.

- Global T_LAM_DLY_i calculation :

T_LAM_DLY_i **=** ( T_DLY_P_i **+** T_DLY_I_i **+** T_DLY_AD_i )
***** IP_FAC_LAM_DLY__N_32__MAF

**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| C_LAM_TEMP_MIN_CAT_DLY | - | 0...FEH | -33...990 | 4 | °C |
| minimum catalyst temperature model threshold for fuel trim regulation function activation | | | | | |
| C_LAM_TEMP_HYS_CAT_DLY | - | 0...FEH | -33...990 | 4 | °C |
| Hysteresis on minimum catalyst temperature model threshold for fuel trim regulation function activation | | | | | |
| C_MAF_INT_MIN_DLY_PUC | - | 0...FFFFH | 0...11650,66 | 0,178 | g |
| threshold for MAF integral while restart of LAM after PUC | | | | | |
| C_MAF_INT_MIN_DLY | - | 0...FFFFH | 0...11650,66 | 0,178 | g |
| threshold for MAF integral while restart of LAM after inactive | | | | | |
| C_CAT_DIAG_MAX_DLY | - | 0...FFFFH | 0...255,996 | 3,9e-3 | - |
| threshold of catalyst conversion capability for activation | | | | | |
| IP_VLS_SP_DLY__N_32__MAF | 4 * 4 | 0...3FFH | 0...4,9805 | 4,87e-3 | V |
| | | | | | |
| setpoint for downstream fuel trim controller | | | | | |
| C_MAF_LAM_DLY_P_MIN | - | 0...FFFFH | 0...1389 | 0,021 | mg/stroke |
| min MAF threshold for activation P-share | | | | | |
| C_MAF_LAM_DLY_P_MAX | - | 0...FFFFH | 0...1389 | 0,021 | mg/stroke |
| max MAF threshold for activation P-share | | | | | |
| C_N_LAM_DLY_P_MIN | - | 0...FFH | 0...8160 | 32 | 1/min |
| min N threshold for activation P-share | | | | | |
| C_N_LAM_DLY_P_MAX | - | 0...FFH | 0...8160 | 32 | 1/min |
| max N threshold for activation P-share | | | | | |

## Calibration data:

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| IP_T_DLY_P__VLS_DIF_DLY_i | 12 | 0...FFFFH | -640...639,98 | 0,0195 | ms |
| LAM - P - jump delay time from P-share | | | | | |
| IP_FAC_DLY_P__MAF_KGH | 6 | 0...FFH | 0...0,996 | 3,9e-3 | - |
| weight factor for P-share regarding engine load and speed conditions | | | | | |
| IP_FAC_CAT_DLY__CAT_DIAG_TRIM_i | 6 | 0...FFH | 0...0,996 | 3,9e-3 | - |
| weight factor for P-share regarding catalyst conversion capability | | | | | |
| IP_MAF_LAM_DLY_I_MIN__N_32 | 6 | 0...FFFFH | 0...1389 | 0,021 | mg/stroke |
| min MAF threshold for activation I-share | | | | | |
| IP_MAF_LAM_DLY_I_MAX__N_32 | 6 | 0...FFFFH | 0...1389 | 0,021 | mg/stroke |
| max MAF threshold for activation I-share | | | | | |
| IP_T_DLY_I_VLS__DIF_DLY_i | 12 | 0...FFFFH | -640...639,98 | 0,0195 | ms |
| LAM - P - jump delay time from I-share | | | | | |
| IP_CRLC_DLY_I__MAF_KGH | 6 | 0...FFH | 0...0,996 | 3,9e-3 | - |
| correlation constant for I-share calculation | | | | | |
| C_T_DLY_I_MIN | - | 0000...FFFFH | 0...1279,98 | 0,0195 | ms |
| min. limit of I-share | | | | | |
| C_T_DLY_I_MAX | - | 0000...FFFFH | 0...1279,98 | 0,0195 | ms |
| max. limit of I-share | | | | | |
| IP_MAF_LAM_DLY_AD_MIN__N_32 | 6 | 0...FFFFH | 0...1389 | 0,021 | mg/stroke |
| min MAF threshold for calculation AD-share | | | | | |
| IP_MAF_LAM_DLY_AD_MAX__N_32 | 6 | 0...FFFFH | 0...1389 | 0,021 | mg/stroke |
| max MAF threshold for calculation AD-share | | | | | |
| C_T_DLY_AD_DEC | - | 8000...7FFFH | -640...639,98 | 0,0195 | ms |
| Decrement for AD-share | | | | | |
| C_T_DLY_AD_MIN | - | 0000...FFFFH | 0...1279,98 | 0,0195 | ms |
| min. limit of AD-share | | | | | |
| C_T_DLY_AD_MAX | - | 0000...FFFFH | 0...1279,98 | 0,0195 | ms |
| max. limit of AD-share | | | | | |
| C_CRLC_DLY_AD | - | 0...FFH | 0...0,996 | 3,9e-3 | - |
| correlation constant for AD-share calculation | | | | | |
| IP_FAC_LAM_DLY__N_32__MAF | 8*8 | 0...FFH | 0...0,996 | 3,9e-3 | - |
| normalization factor for total LAM -P-jump delay time regarding engine load and speed conditions | | | | | |

### 1.3.7 Catalyst enrichment function after PUC phase (CAT - purge function)



**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| MAF_INT_PUC_i | V | 0...FFFFH | 0...11650,67 | 0,178 | g |
| integral of air mass flow while PUC active | | | | | |
| MAF_INT_DLY_PUC_i | V | 0...FFFFH | 0...11650,67 | 0,178 | g |
| rest of the integral of air mass flow until catalyst purge deactivation | | | | | |
| T_DLY_PUC_i | V | 0...3FFFH | 0...1279,9 | 0,078 | ms |
| LAM-P-jump delay time of the catalyst purge function | | | | | |
| LV_ACT_INT_PUC_i | V | 0...1H | 0...1 | 1 | - |
| status of catalyst purge activation | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| TCO | CAT_DIAG_TRIM_i | LV_PUC | VLS_CAT_i |
| MAF_KGH | LV_LSH_CAT_PHA_MAX_RATE | | |

**FUNCTION DESCRIPTION:**

General information:

After a fuel cut-off phase (PUC), the catalyst is full with oxygen. The target of this function is to make the lambda regulation a little more rich than normal in order to purge the oxygen contained in the catalyst.

The rich lambda shift is made with a P-jump delay T_DLY_PUC_i.

In order to evaluate the quantity of oxygen contained in the catalyst, air flow during fuel cut-off is integrated by the counter MAF_INT_PUC. The purge phase duration is calculated according to this counter.

If two seperate catalyst systems are concerned then
i = 1, for cylinder bank 1
i = 2, for cylinder bank 2

**Application conditions:**

*Activation:* -> LV_ACT_INT_PUC_i **=** 1

- **-** TCO **>** C_TCO_DLY_PUC_MIN
- **- and** LV_PUC = 1 **->** LV_PUC **=** 0
- **- and** MAF_INT_PUC_i **>** C_MAF_INT_PUC_MIN
- **- and** MAF_INT_DLY_PUC_i **>** 0
- **- and** LV_LSH_CAT_PHA_MAX_RATE **= 1**

*Deactivation:* -> LV_ACT_INT_PUC_i **=** 0

**-** MAF_INT_DLY_PUC_i **=** 0
**- or** VLS_CAT_i **<** C_VLS_CAT_DLY_MAX_PUC <u>for the first time</u>
**- or** LV_PUC **=** 1

**<u>Formula section:</u>**

<u>- MAF_INT_PUC_i calculation:</u>

**If** LV_PUC **=** 1
and MAF_INT_PUC_i **<** max. value (11650,7g)

**Then**
$MAF\_INT\_PUC_n\_i = MAF\_INT\_PUC_{n-1}\_i + MAF\_KGH * NC\_FAC\_MAF\_INT$

*Remark:*
- MAF_INT_PUC is calculated each 20ms
- MAF_INT_PUC is initialized with 0 at each PUC phase detection

<u>- MAF_INT_DLY_PUC_i calculation:</u>

. At each transition LV_PUC = 1 **->** LV_PUC = 0, MAF_INT_DLY_PUC_i is initialized with IP_MAF_INT_DLY_PUC__MAF_INT_PUC_i and limited to C_MAF_INT_DLY_PUC_MAX.

. If the catalyst balance function is deactivated by the interruption of the lambda controller due to another PUC phase the initialisation is:
$MAF\_INT\_DLY\_PUC\_i_{new} = IP\_MAF\_INT\_DLY\_PUC + MAF\_INT\_DLY\_PUC\_i_{old}$

As long as LV_PUC **=** 0, MAF_INT_DLY_PUC is decreased to 0:

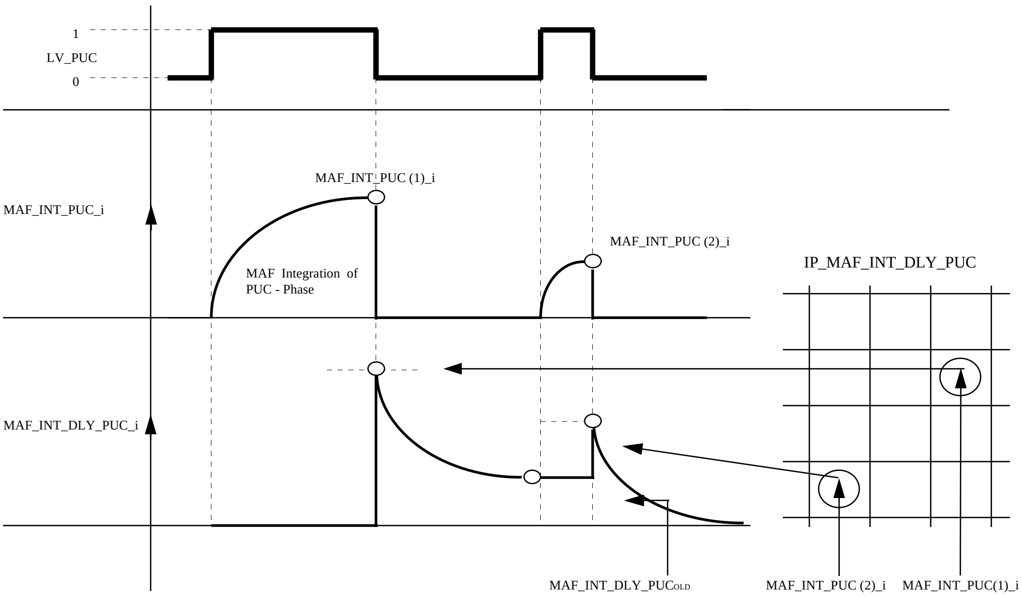
$$MAF\_INT\_DLY\_PUC\_i_n = MAF\_INT\_DLY\_PUC\_i_{n-1} - (MAF\_KGH * NC\_FAC\_MAF\_INT * IP\_FAC\_CAT\_DLY\_PUC)$$

If VLS_CAT_i < C_VLS_CAT_DLY_MAX_PUC then MAF_INT_DLY_PUC_i is reseted to 0.

*Remark:* MAF_INT_DLY_PUC is calculated each 20ms

<u>- T_DLY_PUC_i calculation:</u>

**If** LV_ACT_INT_PUC **=** 1
**Then**
T_DLY_PUC_i **=** IP_T_DLY_PUC__MAF_KGH
**Else**
T_DLY_PUC_i **=** 0




## Calibration data:

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| C_TCO_DLY_PUC_MIN | - | 0...FEH | -48...142,5 | 0,75 | °C |
| | | | | | |
| min. TCO threshold for activation | | | | | |
| C_MAF_INT_PUC_MIN | - | 0...FFFFH | 0...11650,67 | 0,178 | g |
| min. MAF_INT_PUC threshold for activation | | | | | |
| C_VLS_CAT_DLY_MAX_PUC | - | 0...FFH | 0...4,98 | 0,0195 | V |
| max. VLS threshold for deactivation | | | | | |
| IP_MAF_INT_DLY_PUC__MAF_INT_PUC_i | 6 | 0...FFFFH | 0...11650,67 | 0,178 | g |
| | | | | | |
| initialisation value for the rest of the air mass flow for deactivation | | | | | |
| C_MAF_INT_DLY_PUC_MAX | - | 0...FFFFH | 0...11650,67 | 0,178 | g |
| limit value for the rest of the air mass flow for deactivation | | | | | |
| IP_T_DLY_PUC__MAF_KGH | 6 | 0...3FFFH | 0...1279,9 | 0,078 | ms |
| | | | | | |
| basic LAM-P-jump delay time of the catalyst purge function | | | | | |
| IP_FAC_CAT_DLY_PUC__CAT_DIAG_TRIM_i | 6 | 0...FFH | 0...0,996 | 3.9e-3 | - |
| | | | | | |
| weight factor of catalyst diagnosis result | | | | | |

NC_FAC_MAF_INT = 20ms/3,6

### 1.3.7.1 Oxygen-sensor heater downstream from catalyst



**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| LSHPWM_CAT_i | V | 00...FFH | 0...99.609 | 0.3891 | % |
| Downstream oxygen sensors heating duty cycle | | | | | |
| LSHPWM_CAT_LGRD_i | V | 00...FFFFH | 0...99.998 | 1.526E-3 | % |
| Basic downstream oxygen sensors heating duty cycle with gradient limitation. | | | | | |
| LV_LSH_CAT_PHA_MAX_RATE | V | 0...01H | 0...1 | 1 | - |
| Boolean to indicate if pre-heating and full heating phases for downstream O2 sensors are finished. | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| TEMP_MMV_SUB_CAT | VB | N | MAF |
| LV_ES | LV_ST | LV_VB_JUMP | |

**FUNCTION DESCRIPTION:**



General information:

Downstream O2 senors heating strategy is working like for the upstream but without heater controller.

In order to avoid big temperature gradient after start, heater power is reduced until the catalyst system has reached its service temperature. Then, heating power is maximum during a time delay in order to reach quickly the target tip-temperature.

After this two phases, heating power is normally calculated from a basic map (cylinder bank individual) weighted by a battery voltage correction. A gradient limitation is applied in negative and positive directions.

Application recurrence **:**
- Engine stopped: 1 sec.
- Engine running: C_T_PER_LSH_CAT sec.

**Formula section:**

- LSHPWM_CAT_LGRD_i calculation:

The basic heater power is:
IP_LSHPWM_CAT_i__N_32__MAF * IP_LSHPWM_VB_FAC_CAT__VB

The result of this multiplication is the target value for LSHPWM_CAT_LGRD_i.

Like for the upstream O2 sensors, a gradient limitation is applied to LSHPWM_CAT_LGRD_i.

If the target value is lower, C_LSHPWM_LGRD_NEG_CAT is used. Otherwise, if the target value is higher, C_LSHPWM_LGRD_POS_CAT is used.

At transition engine stop (LV_ES) to engine start (LV_ST) LSHPWM_CAT_LGRD_i is initialized with C_LSHPWM_CAT_INI_i :

LSHPWM_CAT_LGRD_i = C_LSHPWM_CAT_INI_i

<u>- Heating phases</u>

O2 sensors heating phases are divided in 4 parts:

- Stand-by phase
- Pre-heating phase
- Full heating phase
- Normal heating phase

This phases are performed in a sequential order.

<u>- Stand-by phase:</u>

**If** Engine stopped (LV_ES) active **or** LV_VB_JUMP **= 1** (Active)
**then**
LSHPWM_CAT_i **=** NC_LSHPWM_MIN_DIAG

<u>- Pre-heating phase:</u>

**If** a) Engine stopped (LV_ES) not active **and** LV_VB_JUMP **= 0** (Not active) )
b) **and** TEMP_MMV_SUB_CAT **<** C_TEMP_MIN_SUB_CAT_ST
**then**
LSHPWM_CAT_i **=** LSHPWM_CAT_LGRD_i ***** C_LSHPWM_T_FAC_CAT
**+** C_LSHPWM_CAT_i_AS
**else**
"Full-heating" phase is started

<u>- Full-heating phase:</u>

**If** Pre-heating phase is finished
(TEMP_MMV_SUB_CAT **>** C_TEMP_MIN_SUB_CAT_ST)
**then**
LSHPWM_CAT_i **=** NC_LSHPWM_MAX_DIAG
**during** C_T_MAX_LSH_CAT_ST seconds

When this Full-heating phase is finished, the flag LV_LSH_CAT_PHA_MAX_RATE is set to 1.

<u>- Normal heating phase:</u>

**If** Full heating phase is finished
(time C_T_MAX_LSH_CAT_ST elapsed)

**then**

LSHPWM_CAT_i **=** LSHPWM_CAT_LGRD_i **+** C_LSHPWM_CAT_i_AS

**Remark:** At the end of the full-heating phase, LSHPWM_CAT_LGRD_i is set to NC_LSHPWM_MAX_DIAG and decreased to the target LSHPWM_CAT_i with the specific change limitation C_LSHPWM_LGRD_MAX_CAT

## Calibration data:

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| IP_LSHPWM_CAT_1__N_32__MAF | 6*6 | 0...FFH | 0...99.6 | 0.389 | % |
| | | | | | |
| Basic downstream O2 sensor heating Bank n°1 | | | | | |
| IP_LSHPWM_CAT_2__N_32__MAF | 6*6 | 0...FFH | 0...99.6 | 0.389 | % |
| | | | | | |
| Basic downstream O2 sensor heating Bank n°2 | | | | | |
| IP_LSHPWM_VB_FAC_CAT__VB | 6 | 0...FFH | 0...3.9844 | 0.0156 | - |
| | | | | | |
| Battery voltage weighting factor for basic downstream O2 sensors heating | | | | | |
| C_LSHPWM_LGRD_POS_CAT | - | 00...FFFFH | 0...99.998 | 1.526E-3 | % |
| limited gradient for LSHPWM_CAT while incrementation | | | | | |
| C_LSHPWM_LGRD_NEG_CAT | - | 00...FFFFH | 0...99.998 | 1.526E-3 | % |
| limited gradient for LSHPWM_CAT while decrementation | | | | | |
| C_LSHPWM_LGRD_MAX_CAT | - | 00...FFFFH | 0...99.998 | 1.526E-3 | % |
| limited gradient for LSHPWM_CAT after full heating phase | | | | | |
| C_LSHPWM_CAT_INI_1 | 1 | 00...FFH | 0...99.6 | 0.3891 | % |
| Initialisation-value of LSHPWM_CAT_LGRD_1 at transition LV_ES to LV_ST. | | | | | |
| C_LSHPWM_CAT_INI_2 | 1 | 00...FFH | 0...99.6 | 0.3891 | % |
| Initialisation-value of LSHPWM_CAT_LGRD_2 at transition LV_ES to LV_ST. | | | | | |
| C_T_PER_LSH_CAT | - | 1...FFH | 1...255 | 1 | sec |
| time interval for LSHPWM_CAT calculation | | | | | |
| C_TEMP_MIN_SUB_CAT_ST | - | 0...FFH | -33...990 | 4 | °C |
| Catalyst temperature threshold for ending pre-heating phase | | | | | |
| C_T_MAX_LSH_CAT_ST | - | 1...FFH | 1...255 | 1 | sec |
| Full heating phase duration | | | | | |
| C_LSHPWM_T_FAC_CAT | 1 | 1...FFH | 0.04...0.996 | 1/256 | - |
| Weighting factor for basic downstream O2 sensors heating during pre-heating phase | | | | | |

## Applicative Values:

NC_LSHPWM_MIN_DIAG = 2,34%
NC_LSHPWM_MAX_DIAG = 97,26%

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Project: **Engine Management System**

**HMC_V6**

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Construction protocol-No.:

Software version: 650H0000

| | Name | Department | Phone | Date | Sign |
|---|---|---|---|---|---|
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| 2. Check | Gessner S. | AT PT SI TSA 11 | 5398 | 09.12.97 | |
| Responsible | Brückner D. | AT PT SI TSA 16 | 4279 | 09.12.97 | |

## Version list

| Version | Date | Author | Comment, Description |
|---|---|---|---|
| | | | |

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## 1.1 General

### 1.1.1 Total formulas

#### 1.1.1.1 Calculated idle charge actuator opening ( ISAPWM )

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| ISAPWM | V | 00...FFFFH | 0...99,998 | 1,526E-3 | % |
| Calculated idle speed valve opening. | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| ISAPWM_TPS | ISAPWM_TCO_DRI_ACIN | ISAPWM_IS | ISAPWM_DHP |
| ISAPWM_SAP | ISAPWM_TRA_SAP | ISAPWM_CFA | ISAPWM_TRA_CFA |
| ISAPWM_AD_MMV_IS | ISAPWM_DRI_AD_MMV_IS | ISAPWM_AS | ISAPWM_FAC_ST |
| ISAPWM_CH | ISAPWM_TRA_ACCIN | ISAPWM_ACCIN | ISAPWM_TIA_FAC |
| NC_ISAPWM_N_MAX | LV_ES | LV_ST | ISAPWM_N_SP_IS_ASA |
| ISAPWM_LOAD_EL | ISAPWM_LOAD_EL_TRA | ISAPWM_DRI_TRA | |

**FUNCTION DESCRIPTION:**

General information:

The ISAPWM takes any value from **0** to **100 %.**

The linear opening ratio is converted to standard conditions TIA = 20 °C (intake air temperature) by means of air-density correction ISAPWM_TIA_FAC.

A special ISAPWM calculation is used in case of Engine Stopped or Start. When engine operating state Start is exited, the normal ISAPWM is reached with a change limitation.

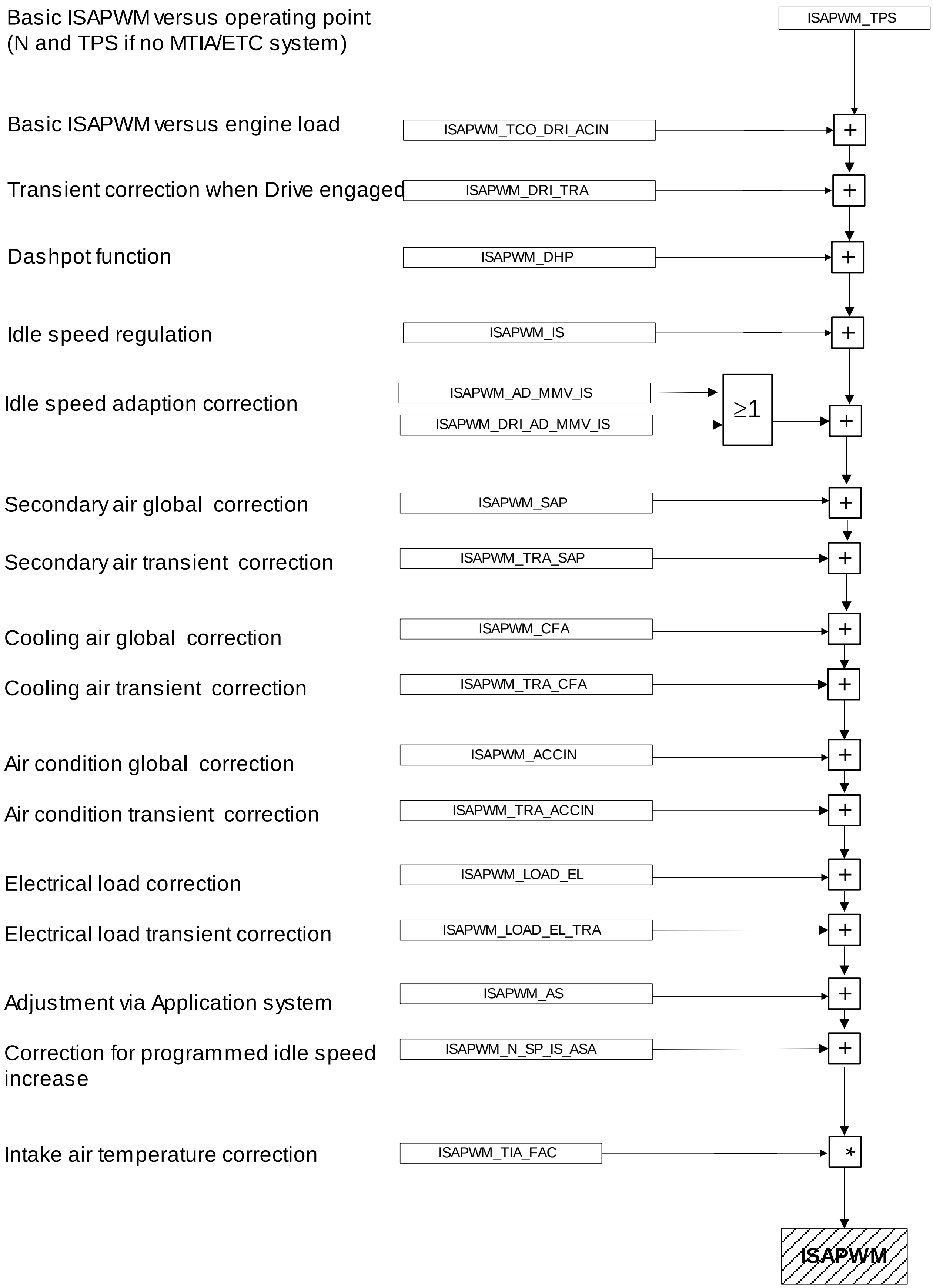
**If** N **<** NC_ISAPWM_N_MAX the application recurrence is **10 msec**, otherwise **40 msec.**

**Formula section:**

**If** ( LV_ES **=** 1 **or** LV_ST **=** 1 )
**Then**
ISAPWM **=** IP_ISAPWM_ST__N__TCO
**Else**

| | | | |
|---|---|---|---|
| ISAPWM | **= (** | ISAPWM_TPS | Basic ISAPWM versus engine operating point. |
| | **+** | ISAPWM_TCO_DRI_ACIN | Basic ISAPWM versus engine load. |
| | **+** | ISAPWM_DRI_TRA | Transient correction when Drive is engaged |
| | **+** | ISAPWM_IS | Global idle speed regulation. |
| | **+** | ISAPWM_DHP | Dashpot correction. |
| | **+** | ISAPWM_CH | Catalyst heating function correction |
| | **+** | ISAPWM_SAP | Secondary air global correction. |
| | **+** | ISAPWM_TRA_SAP | Secondary air transient correction. |
| | **+** | ISAPWM_CFA | Fans global correction. |
| | **+** | ISAPWM_TRA_CFA | Fans transient correction. |
| | **+** | ISAPWM_AD_MMV_IS | Idle speed adaptation correction without DRIVE engaged. |
| **or** | **+** | ISAPWM_DRI_AD_MMV_IS | Idle speed adaptation correction with DRIVE engaged. |
| **or** | **+** | ISAPWM_ACCIN | Air condition global correction. |
| | **+** | ISAPWM_TRA_ACCIN | Air condition transient correction. |
| | **+** | ISAPWM_LOAD_EL | Electrical load correction. |
| | **+** | ISAPWM_LOAD_EL_TRA | Electrical load transient correction. |
| | **+** | ISAPWM_AS | Adjustment via application system. |
| | **+** | ISAPWM_N_SP_IS_ASA ) | Correction for programmed idle speed increase |
| | ***** | ISAPWM_TIA_FAC | Intake air temperature correction. |

Transition from ISAPWM in Start to ISAPWM out of Start is performed with the change limitation IP_ISAPWM_LGRD_ST__TCO.


Basic ISAPWM versus operating point (N and TPS if no MTIA/ETC system)
ISAPWM_TPS
Basic ISAPWM versus engine load
ISAPWM_TCO_DRI_ACIN
Transient correction when Drive engaged
ISAPWM_DRI_TRA
Dashpot function
ISAPWM_DHP
Idle speed regulation
ISAPWM_IS
Idle speed adaption correction
ISAPWM_AD_MMV_IS
ISAPWM_DRI_AD_MMV_IS
≥1
Secondary air global correction
ISAPWM_SAP
Secondary air transient correction
ISAPWM_TRA_SAP
Cooling air global correction
ISAPWM_CFA
Cooling air transient correction
ISAPWM_TRA_CFA
Air condition global correction
ISAPWM_ACCIN
Air condition transient correction
ISAPWM_TRA_ACCIN
Electrical load correction
ISAPWM_LOAD_EL
Electrical load transient correction
ISAPWM_LOAD_EL_TRA
Adjustment via Application system
ISAPWM_AS
Correction for programmed idle speed increase
ISAPWM_N_SP_IS_ASA
Intake air temperature correction
ISAPWM_TIA_FAC
*
ISAPWM

## Calibration data:

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| IP_ISAPWM_ST__N__TCO | 5 * 8 | 0...FFFFH | 0...99,998 | 0,001526 | % |
| | | | | | |
| Idle speed valve opening during Start | | | | | |
| IP_ISAPWM_LGRD_ST__TCO | 6 | 01...FFH | 0,024...6,226 | 0,0244 | % |
| | | | | | |
| Idle speed valve opening change limitation when exiting from Start | | | | | |

#### 1.1.1.2 Applied idle charge actuator duty cycle ( ISAPWM_ISA )

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| ISAPWM_ISA | V | 00...FFFFH | 0...99,998 | 1,526E-3 | % |
| Applied idle charge actuator duty cycle. | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| NC_ISAPWM_N_MAX | ISAPWM | LV_IGK | N |
| VB | | | |

**FUNCTION DESCRIPTION:**

General information:

The duty cycle ISAPWM_ISA represents the command for the idle - charge actuator.
The map IP_ISAPWM_COR_ISA__ISAPWM__VB linearizes the idle - charge actuator characteristic.

Furthermore, the opening range ( **0...100 %** ) is compressed to the working range of the idle charge actuator.

**If** N **<** NC_ISAPWM_N_MAX, the application recurrence is **10 msec**, otherwise **40 msec.**

**Formula section:**

ISAPWM_ISA **=** IP_ISAPWM_COR_ISA__ISAPWM__VB Characteristic linearization.

**Remark :**
In case of ignition key off (LV_IGK = Passive), the idle charge actuator is driven by **ISAPWM = 0**.

**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| IP_ISAPWM_COR_ISA__ISAPWM__VB | 8*6 | 00...FFFFH | 0...99,998 | 1,526E-3 | % |
| Idle charge actuator characteristic linearization | | | | | |

### 1.1.1.3 ISA-opening during powerlatch

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| PWL_DLY_CTR | 1u | 0...FFH | 0...255 | 1 | - |
| Powerlatch delay counter | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| LV_IGK | LV_ES | | |
| | | | |

**FUNCTION DESCRIPTION:**

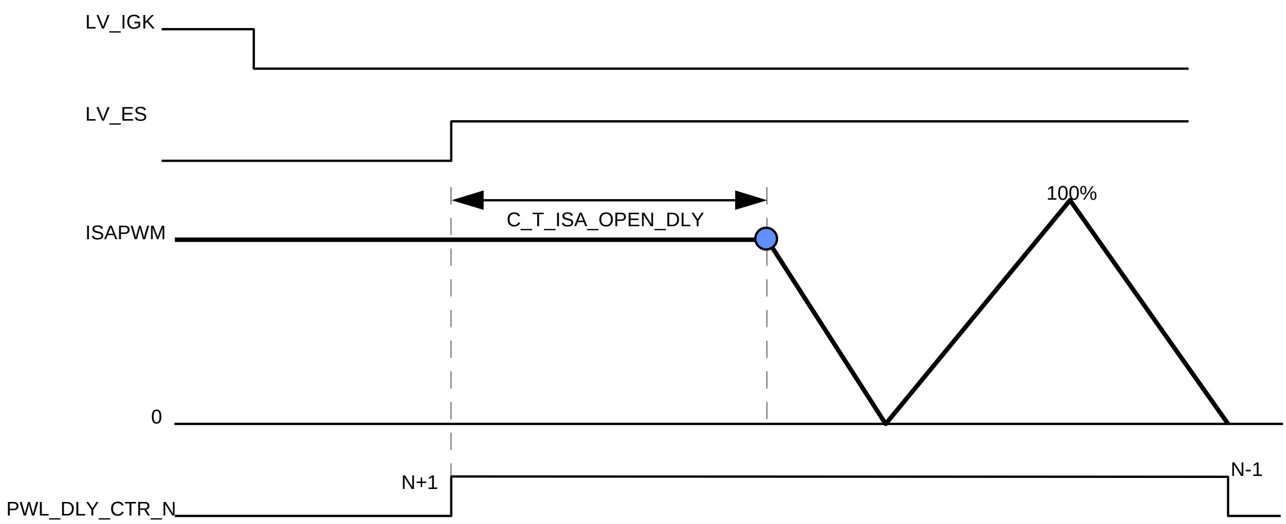
General information:

In order to clean the idle speed valve from deposits it is opened by ramp to 100% duty cycle during powerlatch. The opening ramp starts after a delay time to equalize the intake manifold pressure before.

**Formula section:**

**If** LV_IGK = 0
**and** LV_ES = 1
**then** PWL_DLY_CTR = PWL_DLY_CTR +1
**and**
**if** C_T_ISA_OPEN_DLY is elapsed

**then** ISA is closed and opened afterwards to 100%. After reaching 100% it is closed again. All transitions use the change limitation C_LGRD_ISA_PWL.
When 0% are reached at the end, the PWL_DLY_CTR = PWL_DLY_CTR - 1.
(See diagram)



## Calibration data:

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| C_T_ISA_OPEN_DLY | 1u | 00...FFH | 0...255 | 1 | s |
| Delay to open ISA after engine stop. | | | | | |
| C_LGRD_ISA_PWL | 2u | 1...FFFFH | 1,5E-3...100 | 1,526E-3 | %/10ms |
| Change limitation to open and close ISA during powerlatch | | | | | |

## 1.2 Basic idle - charge actuator opening vs. engine point ( ISAPWM_TPS )

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| ISAPWM_TPS | V | 0...FFFFH | -9,9218 ...80,0767 | 0,0015 | % |
| Basic idle - charge actuator opening versus engine operating point. | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| N_32 | LV_IGA_CH | TPS | TCO |
| T_AST | LV_DRI | | |

**FUNCTION DESCRIPTION:**

General information:

This term determines the vacuum in the intake pipe while the throttle is closed (vacuum limitation at trailing throttle).

The change of ISAPWM via the throttle position TPS affects the throttle progression.

An offset is applied when catalyst heating function is active. This offset is used to take into account the ignition angle reduction in part Load.

- The application recurrency is **40 msec**.

**Application conditions:**

Available for all engine operating states.

**Formula section:**

- **If** LV_IGA_CH **=** 0 **and** LV_DRI **=** 0
  **then** ISAPWM_TPS **=** IP_ISAPWM_TPS__N_32__TPS
- **If** LV_IGA_CH **=** 0 **and** LV_DRI **=** 1
  **then** ISAPWM_TPS **=** IP_ISAPWM_TPS_DRI__N_32__TPS
- **If** LV_IGA_CH **=** 1 **and** LV_DRI **=** 0
  **then** ISAPWM_TPS **=** IP_ISAPWM_TPS__N_32__TPS
  **+** IP_ISAPWM_TPS_CH__N_32__TPS ***** IP_ISAPWM_FAC_CH__TCO__T_AST
- **If** LV_IGA_CH **=** 1 **and** LV_DRI **=** 1
  **then** ISAPWM_TPS **=** IP_ISAPWM_TPS_DRI__N_32__TPS
  **+** IP_ISAPWM_TPS_CH__N_32__TPS ***** IP_ISAPWM_FAC_CH__TCO__T_AST

## Calibration data:

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| IP_ISAPWM_TPS__N_32__TPS | 7 x 5 | 0...FFH | -19,9...79,7 | 0,39 | % |
| | | | | | |
| Basic idle - charge actuator opening versus operating point in Neutral or M/T | | | | | |
| IP_ISAPWM_TPS_DRI__N_32__TPS | 7 x 5 | 0...FFH | -19,9...79,7 | 0,39 | % |
| | | | | | |
| Basic idle - charge actuator opening versus operating point in Drive | | | | | |
| IP_ISAPWM_TPS_CH__N_32__TPS | 7 x 5 | 0...FFH | -50...49,93 | 0,39 | % |
| | | | | | |
| Basic idle - charge actuator opening versus operating point if LV_IGA_CH = 1 | | | | | |
| IP_ISAPWM_FAC_CH__TCO__T_AST | 8 x 8 | 0...FFH | 0...0,996 | 1 / 256 | - |
| | | | | | |
| Factor for catalyst heating correction | | | | | |

## 1.3 Basic idle charge actuator opening versus engine load ( ISAPWM_TCO_DRI_ACIN )



**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| ISAPWM_TCO_DRI_ACIN | V | 00...FFFFH | 0...99.998 | 1.526E-3 | % |
| Basic idle - charge actuator opening versus engine load. | | | | | |
| ISAPWM_DRI_TRA | V | 8000...7FFFH | -50...49.998 | 1.526E-3 | % |
| Transient idle - charge actuator opening when LV_DRI_ISAPWM state changes. | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| LV_IS | TCO | LV_DRI_ISAPWM | LV_ACIN |
| NC_ISAPWM_N_MAX | N | TEMP_AT | MAF_FAC_ALTI_MMV |
| ISAPWM_LOAD_AT_FAC | | | |

**FUNCTION DESCRIPTION:**



General information:

In order to take into account the engine load variations in Idle (LV_IS), four interpolated tables are used :

- IP_ISAPWM : for coolant temperature influence (no additional load).
- IP_ISAPWM_DRI : for coolant and A/T fluid temperatures and AT torque converter load influence with DRIVE engaged (LV_DRI_ISAPWM = 1).
- IP_ISAPWM_ACIN : for coolant temperature influence and air condition selected (LV_ACIN = ACIN).
- IP_ISAPWM_DRI_ACIN : for coolant and A/T fluid temperatures and AT torque converter load influence and air condition selected (LV_ACIN = ACIN) with DRIVE engaged (LV_DRI_ISAPWM = 1).

**If** N **<** NC_ISAPWM_N_MAX, the application recurrence is **10 msec**, otherwise **40 msec**.

The altitude influence is taken into consideration by the addition of IP_ISAPWM_ALTI.

A transient term ISAPWM_DRI_TRA is added when Drive is engaged and dis-engaged.

**Application conditions:**

Available for all engine operating states.

**Formula section:**

1) Basic opening ISAPWM_TCO_DRI_ACIN

| | | |
|---|---|---|
| **- If** | LV_DRI_ISAPWM = 0 | M/T or A/T not in DRIVE |
| **and** | LV_ACIN = 0 | air condition not selected |
| **then** | ISAPWM_TCO_DRI_ACIN = | IP_ISAPWM(_AT)__TCO + IP_ISAPWM_ALTI__MAF_FAC_ALTI_MMV |

| | | |
|---|---|---|
| **- If** | LV_DRI_ISAPWM = 1 | A/T in DRIVE |
| **and** | LV_ACIN = 0 | air condition not selected |
| **then** | ISAPWM_TCO_DRI_ACIN = | (IP_ISAPWM_DRI__TCO__TEMP_AT +IP_ISAPWM_ALTI__MAF_FAC_ALTI_MMV) * ISAPWM_LOAD_AT_FAC |

| | | |
|---|---|---|
| **- If** | LV_DRI_ISAPWM = 0 | M/T or A/T not in DRIVE |
| **and** | LV_ACIN = 1 | air condition selected |
| **then** | ISAPWM_TCO_DRI_ACIN = | IP_ISAPWM_ACIN(_AT)__TCO + IP_ISAPWM_ALTI__MAF_FAC_ALTI_MMV |

| | | |
|---|---|---|
| **- If** | LV_DRI_ISAPWM = 1 | A/T in DRIVE |
| **and** | LV_ACIN = 1 | air condition selected |
| **then** | ISAPWM_TCO_DRI_ACIN = | (IP_ISAPWM_DRI_ACIN__TCO__TEMP_AT + IP_ISAPWM_ALTI__MAF_FAC_ALTI_MMV) * ISAPWM_LOAD_AT_FAC |

*- Specific change limitations :*

a) Automatic Transmission (with or without air condition selected) :

a.1 - Switch **NEUTRAL** position to **DRIVE** position

To counteract the effect of the temperature, dependent on the converter, which locks the clutch when the DRIVE position is engaged, the idle - charge actuator opening is increased using the gradient limitation IP_ISAPWM_DRI_LGRD_INC__TCO.

a.2 - Switch **DRIVE** position to **NEUTRAL** position

When the transmission is shifted to NEUTRAL position, the idle - charge actuator opening is decreased using the gradient limitation IP_ISAPWM_DRI_LGRD_DEC__TCO.

b) Air Condition :

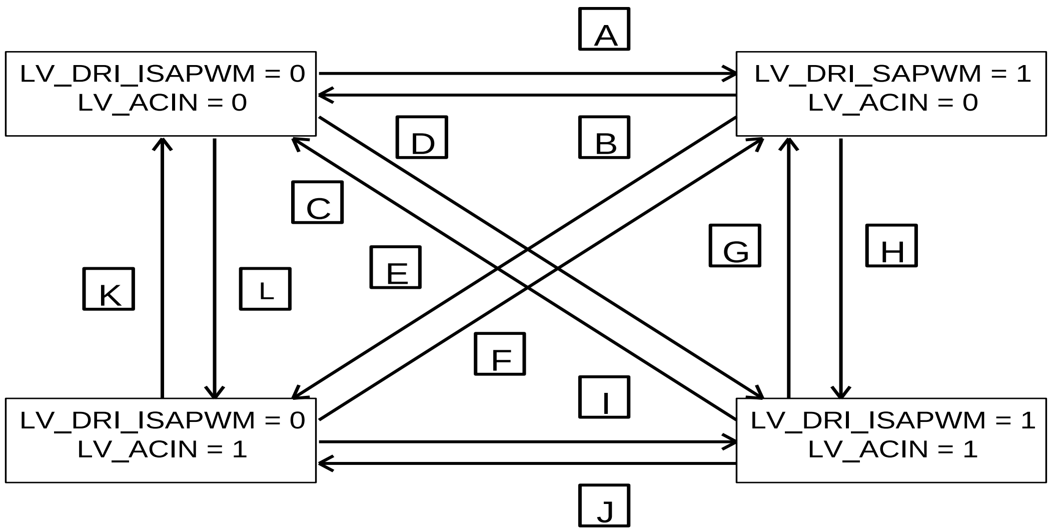
b.1 - Air condition selected from **ON** (LV_ACIN = ACIN) to **OFF** (LV_ACIN = -)

As the engine speed does not increase in a single step when air condition is selected, the idle - charge actuator opening change using a gradient limitation C_ISAPWM_ACIN_LGRD_DEC_IS.

b.2 - Air condition selected from **OFF** (LV_ACIN = -) to **ON** (LV_ACIN = ACIN)

The idle - charge actuator opening is decreased using the gradient limitation C_ISAPWM_ACIN_LGRD_INC_IS.

The following drawing represents all the possible transitions :




The following table resumes which gradient limitation is effective during the different transitions :

| | | |
|---|---|---|
| IP_ISAPWM_DRI_LGRD_INC__TCO | is written | DRI_INC |
| IP_ISAPWM_DRI_LGRD_DEC__TCO | is written | DRI_DEC |
| C_ISAPWM_ACIN_LGRD_DEC_IS | is written | ACIN_DEC |
| C_ISAPWM_ACIN_LGRD_INC_IS | is written | ACIN_INC |

**Remark :** **(+)** is a positive value and **(-)** is a negative value.

| Transition | Actual ISAPWM **<** Target ISAPWM | Actual ISAPWM ≥ Target ISAPWM |
|---|---|---|
| A | + DRI_INC | - DRI_INC |
| B | + DRI_DEC | - DRI_DEC |
| C | + DRI_DEC + ACIN_DEC | - DRI_DEC - ACIN_DEC |
| D | + DRI_INC + ACIN_INC | - DRI_INC - ACIN_INC |
| E | + ACIN_INC | - DRI_DEC |
| F | + DRI_INC | - ACIN_DEC |
| G | + ACIN_DEC | - ACIN_DEC |
| H | + ACIN_INC | - ACIN_INC |
| I | +DRI_INC | - DRI_INC |
| J | + DRI_DEC | - DRI_DEC |
| K | + ACIN_DEC | - ACIN_DEC |
| L | + ACIN_INC | - ACIN_INC |



2) Transient opening ISAPWM_DRI_TRA

**If** LV_DRI_ISAPWM = 0
**then**
ISPAWM_DRI_TRA is set to 0 without change limitation
**else**
**If** Transition LV_DRI_ISAPWM = 0 **->** 1
**then**
**if** LV_ACIN = 0
**then**
ISAPWM_DRI_TRA is set to IP_ISAPWM_DRI_TRA_1__TCO with change limitation C_ISAPWM_DRI_INC_TRA and reseted to 0 with change limitation C_ISAPWM_DRI_DEC_TRA
**else** ( LV_ACIN = 1 )
ISAPWM_DRI_TRA is set to IP_ISAPWM_DRI_TRA_2__TCO with change limitation C_ISAPWM_DRI_INC_TRA and reseted to 0 with change limitation C_ISAPWM_DRI_DEC_TRA
**else**
ISAPWM_DRI_TRA **=** 0

## Calibration data:

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| IP_ISAPWM(_AT)__TCO | 6 | 00...FFH | 0...99.609 | 0.3891 | % |
| Basic idle - charge opening with M/T or A/T in NEUTRAL. | | | | | |
| IP_ISAPWM_DRI__TCO__TEMP_AT | 6 * 4 | 0...FFH | 0...99.61 | 0.39 | % |
| Basic idle - charge opening with A/T in DRIVE or REVERSE. | | | | | |
| IP_ISAPWM_ACIN(_AT)__TCO | 6 | 0...FFH | 0...99.61 | 0.39 | % |
| Basic idle - charge opening with M/T or A/T in NEUTRAL and air condition is selected. | | | | | |
| IP_ISAPWM_DRI_ACIN__TCO__TEMP_AT | 6 * 4 | 0...FFH | 0...99.61 | 0.39 | % |
| Basic idle - charge opening with A/T in DRIVE or REVERSE and air condition is selected. | | | | | |
| IP_ISAPWM_ALTI__MAF_FAC_ALTI_MMV | 6 | 0...FFH | 0...99.61 | 0.39 | % |
| Basic idle - charge opening correction for altitude influence. | | | | | |
| IP_ISAPWM_DRI_LGRD_INC__TCO | 6 | 01...FFH | 0.098...24.902 | 0.098 | % |
| Idle charge - actuator opening increase gradient limitation with DRIVE or REVERSE engaged. | | | | | |
| IP_ISAPWM_DRI_LGRD_DEC__TCO | 6 | 01...FFH | 0.098...24.902 | 0.098 | % |
| Idle charge - actuator opening decrease gradient limitation with DRIVE or REVERSE engaged. | | | | | |
| C_ISAPWM_ACIN_LGRD_DEC_IS | 1 | 01...FFH | 0.098...24.902 | 0.098 | % |
| Idle charge - actuator opening gradient limitation when air condition is switched Off. | | | | | |
| C_ISAPWM_ACIN_LGRD_INC_IS | 1 | 01...FFH | 0.098...24.902 | 0.098 | % |
| Idle charge - actuator opening gradient limitation when air condition is switched On. | | | | | |
| IP_ISAPWM_DRI_TRA_1__TCO | 6 | 00...FFH | 0...49.8 | 0.195 | % |
| ISAPWM_DRI_TRA set value when Drive is engaged with LV_ACIN = 0 | | | | | |
| IP_ISAPWM_DRI_TRA_2__TCO | 6 | 00...FFH | 0...49.8 | 0.195 | % |
| ISAPWM_DRI_TRA set value when Drive is engaged with LV_ACIN = 1 | | | | | |
| C_ISAPWM_DRI_INC_TRA | 1 | 01...FFH | 0.0244...6.225 | 0.0244 | % |
| ISAPWM_DRI_TRA increase change limitation | | | | | |
| C_ISAPWM_DRI_DEC_TRA | 1 | 01...FFH | 0.0244...6.225 | 0.0244 | % |
| ISAPWM_DRI_TRA reset change limitation | | | | | |

## 1.4 Idle charge actuator opening with air condition compressor ( ISAPWM_ACCIN, ISAPWM_TRA_ACCIN )

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| ISAPWM_ACCIN | V | 00...FFFFH | 0...99,998 | 1,526E-3 | % |
| Idle - charge actuator opening correction with air condition compressor. | | | | | |
| ISAPWM_TRA_ACCIN | V | 8000...7FFFH | -50...49,998 | 1,526E-3 | % |
| Idle - charge actuator opening correction with air condition compressor instationary. | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| TIA | N_32 | LV_ACCIN | LV_RLY_ACCOUT_CTRL |
| N_SP_IS | N | MAF_ALTI_COR | ISAPWM_ACCIN_AD_MMV_IS |
| NC_ISAPWM_N_MAX | LV_PRS_ACC | LV_DRI_ISAPWM | MAF_FAC_ALTI_MMv |

**FUNCTION DESCRIPTION:**

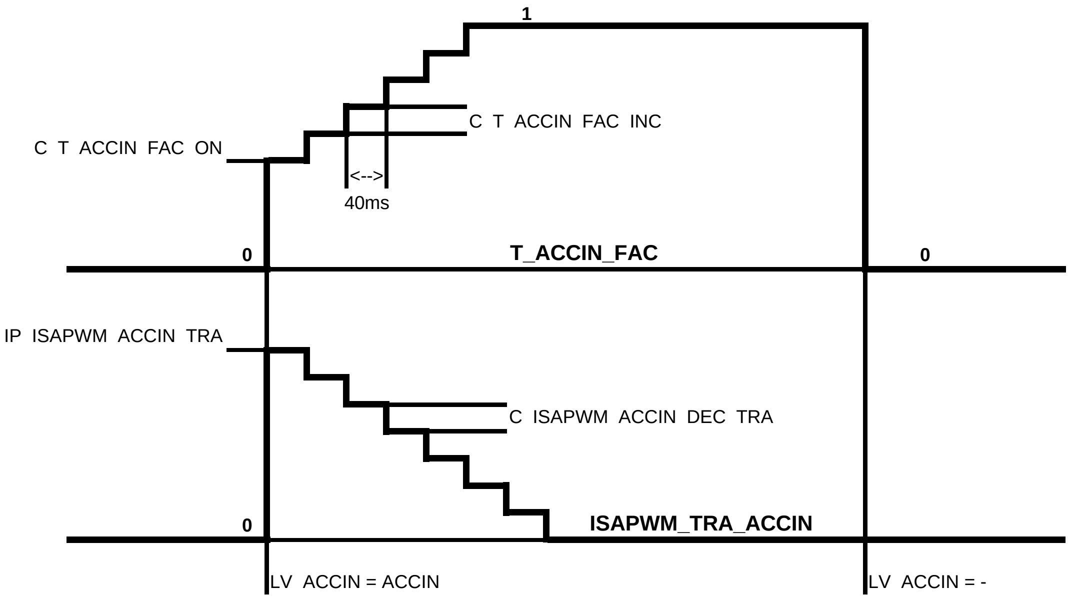
General information:

The increased duty cycle for the air condition compressor ISAPWM_ACCIN must cover the compressor's power requirements depending on the engine speed, the intake air temperature, the pressure level in the A/C circuit and the mass air flow corrected by the altitude.
To ensure rapid intake pipe filling and to accelerate the air condition compressor initially from its position OFF, an additional duty cycle ISAPWM_TRA_ACCIN is used.

**If** N **<** NC_ISAPWM_N_MAXthe application recurrence is **10 msec**, otherwise **40 msec.**

Description:

<




*a) - **ISAPWM_ACCIN** calculation :*

The basic pre-control is the sum resulting from the addition of IP_ISAPWM_ACCIN__TIA__LV_PRS_ACC, the idle speed adaptation ISAPWM_ACCIN_AD_MMV_IS with air-condition compressor and IP_ISAPWM_DRI_ACCIN_ALTI__MAF_FAC_ALTI_MMV.

If the air - condition compressor is enabled or disabled, the resulting value is taken over without limitation gradient.

If LV_PRS_ACC value changes, the new IP_ISAPWM_ACCIN value is applied with the change limitation C_ISAPWM_ACCIN_LGRD.

This basic pre - control is weighted by multiplication of two values :

**1 - IP_ISAPWM_ACCIN_N_MAF__Nxx__MAF_ALTI_COR**

This index table includes the inter-relationship between the engine speed (power consumption) and the mass air flow corrected to sea-level (differential pressure at idle - charge actuator).

**Remark :**
In order not to disturb the idle speed stabilization in the engine operating state idle (LV_IS), the nominal idle speed **N_SP_IS** is taken into account as set point (**Nxx**) for this interpolated table; else (out of idle) **N.**

### 2 - T_ACCIN_FAC

It is used for emulating the slow load build - up after the air - condition compressor has been enabled.
It is calculated as follows :

| | |
|---|---|
| * with air condition compressor **OFF** :<br>(LV_RLY_ACCOUT_CTRL = 0) | T_ACCIN_FAC is set to **0**. |
| * with air condition compressor **ON** :<br>(LV_RLY_ACCOUT_CTRL = 1) | T_ACCIN_FAC is set to C_T_ACCIN_FAC_ON and afterwards T_ACCIN_FAC is incremented by the value C_T_ACCIN_FAC_INC at intervals of **40 msec**, until the value **1** has been reached. |

**<u>Formula section:</u>**

* With air condition compressor **OFF** (LV_RLY_ACCOUT_CTRL = 0) :

ISAPWM_ACCIN = **0**

* With air condition compressor **ON** (LV_RLY_ACCOUT_CTRL = 1) :

```
ISAPWM_ACCIN = ( IP_ISAPWM_ACCIN__TIA__LV_PRS_ACC
               + ISAPWM_ACCIN_AD_MMV_IS )
               * IP_ISAPWM_ACCIN_N_MAF__Nxx__MAF_ALTI_COR
               * T_ACCIN_FAC
```

* With air condition compressor **ON** (LV_RLY_ACCOUT_CTRL = 1) and **DRIVE** engaged (LV_DRI_ISAPWM = 1) :

```
ISAPWM_ACCIN = ( IP_ISAPWM_ACCIN__TIA__LV_PRS_ACC
               + ISAPWM_ACCIN_AD_MMV_IS
               + IP_ISAPWM_DRI_ACCIN_ALTI__MAF_FAC_ALTI_MMV)
               * IP_ISAPWM_ACCIN_N_MAF__Nxx__MAF_ALTI_COR
               * T_ACCIN_FAC
```

**Remark :**

ISAPWM_ACCIN_AD_MMV_IS is the idle speed adaptation with air condition compressor.

The nominal idle speed N_SP_IS is taken into account as set point (Nxx) for these interpolated tables in idle (LV_IS); else (out of idle) N.

*b) - **ISAPWM_TRA_ACCIN** calculation :*

ISAPWM_TRA_ACCIN is set to IP_ISAPWM_ACCIN_TRA__Nxx when air condition compressor is enabled and reset to zero using the change limitation C_ISAPWM_ACCIN_DEC_TRA.

**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| IP_ISAPWM_ACCIN__TIA__LV_PRS_ACC | 4 * 2 | 0...FFH | 0...99,61 | 0,39 | % |
| Idle - charge actuator opening corr. with A/C compressor versus intake air temperature and A/C pressure level | | | | | |
| IP_ISAPWM_DRI_ACCIN_ALTI__MAF_FAC_ALTI_MMV | 6 | 0...FFH | 0...99,61 | 0,39 | % |
| Idle - charge actuator opening corr. with A/C compressor and DRIVE versus altitude correction factor. | | | | | |
| IP_ISAPWM_ACCIN_N_MAF__N__MAF_ALTI_COR | 4 * 4 | 0...FFH | 0...15,94 | 0,0625 | - |
| Idle - charge actuator opening correction with air condition compressor versus operating point. | | | | | |
| C_ISAPWM_ACCIN_LGRD | 1 | 01...FFH | 0,024...6,226 | 0,0244 | % |
| IP_ISAPWM_ACCIN change limitation. | | | | | |
| C_T_ACCIN_FAC_ON | 1 | 00...FFH | 0...0,997 | 3,895E-3 | - |
| T_ACCIN_FAC first set value. | | | | | |
| C_T_ACCIN_FAC_INC | 1 | 01...FFH | 0,00024...0,0622 | 0,00024 | - |
| T_ACCIN_FAC increase value. | | | | | |
| IP_ISAPWM_ACCIN_TRA__N | 4 | 0...FFH | -50...49,6 | 0,39 | % |
| ISAPWM_TRA_ACCIN set value when air condition compressor is enabled out of idle. | | | | | |
| IP_ISAPWM_ACCIN_TRA__N_SP_IS | 4 | 0...FFH | -50...49,6 | 0,39 | % |
| ISAPWM_TRA_ACCIN set value when air condition compressor is enabled in idle. | | | | | |
| C_ISAPWM_ACCIN_DEC_TRA | 1 | 01...FFH | 0,0244...6,225 | 0,0244 | % |
| ISAPWM_TRA_ACCIN reset change limitation. | | | | | |

## 1.5 Basic idle charge actuator opening corr. with catalyst heating (ISAPWM_CH)

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| ISAPWM_CH | V | 00...FFFFH | 0...99,998 | 1,526E-3 | % |
| Basic idle - charge actuator opening correction with catalyst heating function | | | | | |
| ISAPWM_IGA_CH | V | 0...FFFFH | 0...99,9985 | 0,0015 | % |
| Basic idle - charge actuator opening correction related to ignition angle decrease | | | | | |
| ISAPWM_N_SP_ADD_CH | V | 0...FFFFH | 0...99,9985 | 0,0015 | % |
| Basic idle - charge actuator opening correction related to nominal idle speed increase | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| LV_IGA_CH | LV_N_SP_ADD_CH | LV_IS | N_SP_ADD_CH |
| LV_DRI | TCO | IGA_CH | DRI_N_SP_ADD_CH |

**FUNCTION DESCRIPTION:**

General information:

The catalyst heating function can influence:

- basic IGA in Idle
- nominal idle speed N_SP_IS

To take into account this corrections, a catalyst heating term ISAPWM_CH is added to the basic idle speed charge actuator opening.

ISAPWM_CH is the sum of two terms:

- ISAPWM_IGA_CH is related to IGA
- ISAPWM_N_SP_ADD_CH is related to N_SP_IS

**Formula section:**

** ISAPWM_IGA_CH:*

**If** LV_IGA_CH **= 1 and** LV_IS **= 1**
**then** ISAPWM_IGA_CH **=** IP_ISAPWM_IGA__TCO__IGA_CH
**else** ISAPWM_IGA_CH **=** 0

** ISAPWM_N_SP_ADD_CH:*

**If** LV_N_SP_ADD_CH **= 1 and** LV_IS **= 1**
**then**
**If** M/T or A/T in Drive (LV_DRI **=** 0):
**then** ISAPWM_N_SP_ADD_CH **=** IP_ISAPWM_N__TCO__N_SP_ADD_CH

**If** A/T in Drive (LV_DRI **=** 1):
**then** ISAPWM_N_SP_ADD_CH **=**
IP_ISAPWM_DRI_N__TCO__DRI_N_SP_ADD_CH

**else** ISAPWM_N_SP_ADD_CH **=** 0

** ISAPWM _CH:*

ISPAWM_CH **=** ISAPWM_IGA_CH **+** ISAPWM_N_SP_ADD_CH

The change limitation C_ISAPWM_LGRD_CH is always applied to ISAPWM_CH.



**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| IP_ISAPWM_IGA__TCO__IGA_CH | 8 * 8 | 0...FFH | 0...99,61 | 0,39 | % |
| | | | | | |
| Basic idle charge actuator correction with catalyst heating function (related to IGA) | | | | | |
| IP_ISAPWM_N__TCO__N_SP_ADD_CH | 8 * 6 | 0...FFH | 0...99,61 | 0,39 | % |
| | | | | | |
| | | | | | |
| IP_ISAPWM_DRI_N__TCO__DRI_N_SP_ADD_CH | 8 * 6 | 0...FFH | 0...99,61 | 0,39 | % |
| | | | | | |
| Basic idle charge actuator correction with catalyst heating function (related to N_SP_ADD_CH) | | | | | |
| C_ISAPWM_LGRD_CH | 1 | 01...FFH | 0,0977...24,902 | 0,098 | % |
| Gradient limitation for ISAPWM_CH | | | | | |

## 1.6 Dashpot function ( ISAPWM_DHP )



**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| ISAPWM_DHP | V | 00...FFFFH | 0...99,998 | 1,526E-3 | % |
| Dashpot correction. | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| ISAPWM | N_32 | TPS | |

**FUNCTION DESCRIPTION:**

General information:

In order to improve driveability on trailing throttle, the desired torque reduction is slower than this is allowed by the actual closing speed of the throttle.



An additive value on ISAPWM is set by the IP_ISAPWM_DHP(_AT)__N_32__TPS value.

The deceleration of the torque reduction is achieved by the gradient limitation IP_ISAPWM_LGRD__N_32 which acts in the closing direction for IP_ISAPWM_DHP(_AT)__N_32__TPS.

The gradient limitation depends on the engine speed.

In the opening direction of the idle - charge actuator, new values derived from IP_ISAPWM_DHP(_AT)__N_32__TPS are integrated without gradient limitation.

The application recurrency is **40 msec.**

**Application conditions:**

Dashpot function is available for all engine operating states.

**Formula section:**

**If** $ISAPWM\_DHP_{(n)} \geq ISAPWM\_DHP_{(n-1)}$
**then** ISAPWM_DHP **=** IP_ISAPWM_DHP(_AT)__N_32__TPS
**else** ISAPWM_DHP is decreased with the IP_ISAPWM_LGRD__N_32 gradient limitation.

## Calibration data:

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| IP_ISAPWM_DHP(_AT)__N_32__TPS | 7 x 5 | 0...FFH | 0...99,61 | 0,39 | % |
| | | | | | |
| Basic ISAPWM value for dashpot.. | | | | | |
| IP_ISAPWM_LGRD__N_32 | 5 | 01...FFH | 0,098...24,902 | 0,098 | % |
| | | | | | |
| ISAPWM gradient limitation for ISAPWM_DHP in the closing direction. | | | | | |

## 1.7 Idle speed regulation correction ( ISAPWM_IS )



**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| ISAPWM_IS | V | 8000...7FFFH | -50...49,998 | 1,526E-3 | % |
| Global idle speed regulation | | | | | |
| ISAPWM_P_IS | V | 80...7FH | -50...49,9985 | 0,39 | % |
| Proportional idle speed regulation term. | | | | | |
| ISAPWM_I_IS | V | 8000...7FFFH | -50...49,998 | 1,526E-3 | % |
| Integral idle speed regulation term. | | | | | |
| ISAPWM_D_IS | V | 8000...7FFFH | -50...49,998 | 1,526E-3 | % |
| Derivative idle speed regulation term. | | | | | |
| LV_ISAPWM_IS_ACT | V | 0...01H | 0...1 | 1 | - |
| Boolean for idle speed regulation ISAPWM_IS active (passive / active). | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| N | NC_ISAPWM_N_MAX | ISAPWM | LV_IS |
| LV_ST | N_DIF_COR | N_GRD | TCO |
| LV_ES | ISAPWM_AD_COR_IS | N_SP_IS | MAF_FAC_ALTI_MMV |



**FUNCTION DESCRIPTION:**

General information:

At idle (LV_IS), a PID controller is superimposed on the ISAPWM idle pre - control to compensate deviations from the nominal engine speed.

The **I** controller can be adjusted to react more quickly or slowly to the approach and deviation from the nominal engine speed.

The **D** component additionally takes effect in case of very large negative engine speed gradients.

If the conditions for PID are triggered, the **P** and **I** components are calculated. For **D** component calculation, there are specific conditions.

In idle, once the idle speed regulation is triggered, ISAPWM_IS is calculated including P, I and D-components. If idle speed regulation is not triggered, ISAPWM_IS is calculated only with the I-component.

**If** N **<** NC_ISAPWM_N_MAX, the application recurrence is **10 msec**, otherwise **40 msec.**

**<u>Application conditions:</u>**

**1 -** *Activation conditions :*

∗ The idle speed regulation is switched on at idle (LV_IS) after the transition from start (LV_ST), if one of the following conditions is met :

a) N_DIF_COR ≥ 0 **and** N_GRD ≤ 0
**or**
b) N_DIF_COR **<** 0
**and**

in case of an engine speed increase by more than C_ISAPWM_N_ADD_ON, after an engine speed decrease during at least two consecutive segments **(240 °CRK)**.

∗ The idle speed regulation is switched on at idle (LV_IS) after transition from the remaining engine operating states if one of the following conditions is met :

a) N_DIF_COR ≥ 0
**or**
b) N_DIF_COR **<** 0 **and** *"Stable Engine Speed"* is detected.

*"Stable Engine Speed"* description :

The engine speed is stored ($N_{stored}$) upon entry in idle, and a timer C_T_MIN_RIS is started. When the timer has elapsed, the engine speed is compared to the stored speed.

**If** $N \geq N_{stored}$ - C_N_DIF_MIN_IS
**then** the idle speed regulation is switched on
**else** the process is repeated until the idle speed regulation is enabled or the state idle is exited.

When these conditions are performed then **LV_ISAPWM_IS_ACT** is set to **1 (Active).**

**2 -** *Deactivation condition :*

The idle speed regulation is switched off if LV_IS is exited. Then **LV_ISAPWM_IS_ACT** is set to **0 (Passive).**

**Formula section:**

**1 -** *Initialization :*

At engine stopped (LV_ES) or start (LV_ST) :

| | |
|---|---|
| ISAPWM_I_IS | = IP_ISAPWM_INI_I_ST__TCO__MAF_FAC_ALTI_MMV |
| ISAPWM_P_IS | = 0 |
| ISAPWM_D_IS | = 0 |
| ISAPWM_AD_COR_IS | = ISAPWM_I_IS |

**2 - ISAPWM_IS** *calculation :*

ISAPWM_IS = ( ISAPWM_P_IS + ISAPWM_I_IS + ISAPWM_D_IS )
* IP_ISAPWM_TCO_FAC_IS__TCO

with : IP_ISAPWM_TCO_FAC_IS__TCO idle controller temperature weighting

and :

a) ISAPWM_P_IS = IP_ISAPWM_P_IS__N_DIF_COR
(proportional component)

b) **If** $|N\_DIF_{(n)}| - |N\_DIF_{(n-3)}|$ **<** 0
**then** $ISAPWM\_I\_IS_{(n)}$ = $ISAPWM\_I\_IS_{(n-1)}$ + IP_ISAPWM_POS_I_IS__N_DIF_COR
(integral component towards nominal idle speed N_SP_IS)
**else** $ISAPWM\_I\_IS_{(n)}$ = $ISAPWM\_I\_IS_{(n-1)}$ + IP_ISAPWM_NEG_I_IS__N_DIF_COR
(integral component away from nominal idle speed N_SP_IS)

**Remark :** The I component is computed every **40 msec.**, independently of engine speed.

c) ISAPWM_D_IS = IP_ISAPWM_D_IS__N_GRD
(derivative component)

## Calibration data:

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| C_ISAPWM_N_ADD_ON | 1 | 0...1FE0H | 0...8160 | 1 | rpm |
| Minimum engine speed increase for idle controller after start. | | | | | |
| C_T_MIN_RIS | 1 | 0...FFFFH | 0,01...655,35 | 0,01 | sec |
| Engine speed variation check period if N_DIF_COR < 0. | | | | | |
| C_N_DIF_MIN_IS | 1 | 0...1FE0H | 0...8160 | 1 | rpm |
| Maximum engine speed decrease to stop idle speed regulation | | | | | |
| IP_ISAPWM_P_IS__N_DIF_COR | 12 | 00...FFH | -50...49,609 | 0,3891 | % |
| | | | | | |
| P component of idle controller. | | | | | |
| IP_ISAPWM_POS_I_IS__N_DIF_COR | 8 | 00...FFFFH | -50...49,998 | 1,526E-3 | % |
| | | | | | |
| I component of idle controller towards N_SP_IS. | | | | | |
| IP_ISAPWM_NEG_I_IS__N_DIF_COR | 8 | 00...FFFFH | -50...49,998 | 1,526E-3 | % |
| | | | | | |
| I component of idle controller away from N_SP_IS. | | | | | |
| IP_ISAPWM_D_IS__N_GRD | 4 | 00...FFH | -50...49,609 | 0,3891 | % |
| | | | | | |
| D component of idle controller. | | | | | |
| IP_ISAPWM_TCO_FAC_IS__TCO | 4 | 00...FFH | 0...1,922 | 7,509E-3 | - |
| | | | | | |
| Idle controller temperature weighting. | | | | | |
| IP_ISAPWM_INI_I_ST__TCO__MAF_FAC_ALTI_MMV | 6 x 4 | 00...FFFFH | -50...49,609 | 0,3891 | % |
| | | | | | |
| Initialisation value at start for I component of idle controller. | | | | | |

### 1.7.1 Idle speed regulation limits



<u>**Input data:**</u>

| | | | |
|---|---|---|---|
| LV_IS | VS | ISAPWM_I_IS | LV_ACIN |
| LV_INF | LV_ST | ISAPWM_AD_COR_IS | ISAPWM |
| LV_CT | N_32 | C_N_MAX_INF | N_GRD |
| LV_PU | ISAPWM_D_IS | ISAPWM_P_IS | C_T_MIN_D_ISA |

#### 1.7.1.1 I component limits

<u>General information:</u>

The application recurrence is **40 msec.**

** In idle (LV_IS) :*



a) **If** VS = 0
**or** ( VS ≠ 0 **and** C_T_MAX_IS not elapsed )
**then** C_ISAPWM_MIN_I_IS **< ISAPWM_I_IS <** C_ISAPWM_MAX_I_IS

b) **If** VS ≠ 0
**and** ( C_T_MAX_IS elapsed **or** transition to idle (LV_IS) )
**and** air condition not selected (LV_ACIN = -)
**then** C_ISAPWM_VS_MIN_I_IS **< ISAPWM_I_IS <** C_ISAPWM_VS_MAX_I_IS

c) **If** VS ≠ 0
**and** ( C_T_MAX_IS elapsed **or** transition to idle (LV_IS) )
**and** air condition selected (LV_ACIN = ACIN)
**then**
C_ISAPWM_VS_ACCIN_MIN_I_IS **< ISAPWM_I_IS <** C_ISAPWM_VS_ACCIN_MAX_I_IS

**Remark :**
- The duration C_T_MAX_IS is only used when there is a transition from VS = 0 to VS ≠ 0 in idle.
- No gradient limitation on I - component is applied in idle (LV_IS).

- In the closing direction, if ISAPWM reached 0% then ISAPWM_I_IS remains unchanged.
- In the opening direction, if ISAPWM reached 100% then ISAPWM_I_IS remains unchanged.

** Out of idle :*

**If** engine operating state start (LV_ST) is not active
**and** the conditions for ISAPWM_I_IS when rapid engine speed drop are not met
**then** the I controller is controlled to ISAPWM_AD_COR_IS using the gradient limitation C_ISAPWM_LGRD.

*"Engine speed drop"* description :
This function can be activated in and out of idle.

**If** LV_CT = 1
**and** N_32 < C_N_MAX_INF
**and** N_GRD < C_ISAPWM_N_GRD_I_ADD
**then** $ISAPWM\_I\_IS_{(n)} = ISAPWM\_I\_IS_{(n-1)} + C\_ISAPWM\_I\_ADD$

In this case, ISAPWM_I_IS is not limited.

** Exit from idle :*

$ISAPWM\_I\_IS_{(n} = ISAPWM\_I\_IS_{(n-1)} + ISAPWM\_D\_IS_{(n-1)} + ISAPWM\_P\_IS_{(n-1}$
$ISAPWM\_D\_IS_{(n} = 0$
$ISAPWM\_P\_IS_{(n)} = 0$

### 1.7.1.2 D component limits

(refer to " Intercept Function " in the major chapter " Engine Operating States ")

A D component becomes effective to support the idle speed regulation in case of a large negative engine speed gradient.

This D component, which can be applied in idle (LV_IS) or in trailing throttle (LV_PU), takes effect below an engine speed threshold, in order to facilitate an engine intercept without drop below the nominal idle speed.

*Activation conditions :*

Intercept function active (LV_INF = INF).

*Deactivation conditions :*

Intercept function not active (LV_INF = -) and the timer C_T_MIN_D_ISA has elapsed.

If one of the disabled conditions are met, the D component is reset to 0 using C_ISAPWM_LGRD_Dchange limitation.

In idle (LV_IS) the D - component is activated only once.

## Calibration data:

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| C_ISAPWM_MIN_I | 1 | 8000...7FFFH | -50...49,998 | 1,526E-3 | % |
| Minimum integral component out of idle. | | | | | |
| C_ISAPWM_MAX_I | 1 | 8000...7FFFH | -50...49,998 | 1,526E-3 | % |
| Maximum integral component out of idle. | | | | | |
| C_ISAPWM_ACCIN_MIN_I | 1 | 8000...7FFFH | -50...49,998 | 1,526E-3 | % |
| Minimum integral component out of idle with air condition compressor active. | | | | | |
| C_ISAPWM_ACCIN_MAX_I | 1 | 8000...7FFFH | -50...49,998 | 1,526E-3 | % |
| Maximum integral component out of idle with air condition compressor active. | | | | | |
| C_ISAPWM_LGRD | 1 | 01...FFH | 0,098...24,902 | 0,098 | % / 40ms |
| Idle controller change limitation. | | | | | |
| C_ISAPWM_MIN_I_IS | 1 | 8000...7FFFH | -50...49,998 | 1,526E-3 | % |
| Minimum integral component in idle and vehicle stopped. | | | | | |
| C_ISAPWM_MAX_I_IS | 1 | 8000...7FFFH | -50...49,998 | 1,526E-3 | % |
| Maximum integral component in idle and vehicle stopped. | | | | | |
| C_ISAPWM_VS_MIN_I_IS | 1 | 8000...7FFFH | -50...49,998 | 1,526E-3 | % |
| Minimum integral component in idle and vehicle running. | | | | | |
| C_ISAPWM_VS_MAX_I_IS | 1 | 8000...7FFFH | -50...49,998 | 1,526E-3 | % |
| Maximum integral component in idle and vehicle running. | | | | | |
| C_ISAPWM_VS_ACCIN_MIN_I_IS | 1 | 8000...7FFFH | -50...49,998 | 1,526E-3 | % |
| Minimum integral component in idle with vehicle running and air condition compressor active. | | | | | |
| C_ISAPWM_VS_ACCIN_MAX_I_IS | 1 | 8000...7FFFH | -50...49,998 | 1,526E-3 | % |
| Maximum integral component in idle with vehicle running and air condition compressor active. | | | | | |
| C_T_MAX_IS | 1 | 01...FFFFH | 0,01...655,35 | 0.01 | s |
| Time delay to detect vehicle running. | | | | | |
| C_ISAPWM_N_GRD_I_ADD | 1 | 80...00H | -4096...0 | 32 | rpm/sec |
| Minimum engine speed gradient to have rapid engine speed drop. | | | | | |
| C_ISAPWM_I_ADD | 1 | 00...FFFFH | 0...99,998 | 1,526E-3 | % |
| Integral component correction in case of rapid engine speed drop. | | | | | |
| C_ISAPWM_LGRD_D | 1 | 01...FFH | 0.098...24,902 | 0,098 | % / 40ms |
| Derivative component change limitation. | | | | | |

## 1.8 Idle speed adaptation ( ISAPWM_xx_AD_MMV_IS )

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| ISAPWM_AD_MMV_IS | V/S | 8000...7FFFH | -50...49.998 | 1.526E-3 | % |
| Adaptive value without DRIVE engaged | | | | | |
| ISAPWM_DRI_AD_MMV_IS | V/S | 8000...7FFFH | -50...49.998 | 1.526E-3 | % |
| Adaptive value with DRIVE engaged | | | | | |
| ISAPWM_ACCIN_AD_MMV_IS | V/S | 8000...7FFFH | -50...49.998 | 1.526E-3 | % |
| Adaptive value with air conditioner compressor active | | | | | |
| ISAPWM_MMV_IS | V | 8000...7FFFH | -50...49.998 | 1.526E-3 | % |
| Idle speed regulation average value | | | | | |
| ISAPWM_AD_IS | V/S | 8000...7FFFH | -50...49.998 | 1.526E-3 | % |
| Non filtered adaptive value of idle speed regulation | | | | | |
| ISAPWM_AD_COR_IS | V/S | 8000...7FFFH | -50...49.998 | 1.526E-3 | % |
| Corrected adaptive value of idle speed regulation | | | | | |
| LV_ISAPWM_AD_DYW_IS | V | 0...01H | 0...1 | 1 | - |
| Boolean for constant ISAPWM conditions to allow idle speed adaptation (- / ISAPWM). | | | | | |
| LV_N_AD_DYW_IS | V | 0...01H | 0...1 | 1 | - |
| Boolean for constant N conditions to allow idle speed adaptation (- / N). | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| ISAPWM_TRA_ACCIN | LV_VS_ERR | LV_DRI | IP_ISAPWM_ACCIN_N_MAF__N_SP_IS__MAF_ALTI_COR |
| LV_ES | LV_ST | LV_IS | LV_CT |
| N | N_32 | TCO | VB |
| VS | LV_RLY_ACCOUT_CTRL | LV_CPS_MECHA_ERR | ISAPWM_IS |
| LV_TPS_ERR | LV_TPS_PLAUS_ERR | LV_MAF_ERR | LV_MAF_PLAUS_ERR |
| LV_TCO_ERR | LV_TCO_PLAUS_ERR | LV_IV_[CYL]_ERR | LV_TIA_ERR |
| LV_VLS_LIM_i_ERR | N_SP_IS | LV_LAM_LIM_i_ERR | NC_ISAPWM_N_MAX |
| LV_ISA_i_ERR | LV_STATE_A_MIS | LV_ISA_MECHA_ERR | LV_TIMEOUT_TCU1_ERR |
| LV_DUR_IGC_[CYL]_ERR | LV_CPS_ERR | LV_VLS_UP_i_ERR | |

### 1.8.1 General information

Unmetered air and other effects of ageing cause deviations in the duty cycle between the basic idle-charge actuator opening and the idle speed regulation value.
This deviation must be detected and corrected by an offset :

M/T Car or A/T Car not in DRIVE (LV_DRI = -) **--->** **ISAPWM_AD_MMV_IS**
(stored in a non volatile memory)
A/T with DRIVE engaged (LV_DRI = DRI) **--->** **ISAPWM_DRI_AD_MMV_IS**
(stored in a non volatile memory)
LV_RLY_ACCOUT_CTRL = 1 (A/C active) **--->** **ISAPWM_ACCIN_AD_MMV_IS**
(partially stored in a volatile memory)

**If** N **<** NC_ISAPWM_N_MAX, the application recurrence is **10 msec**, otherwise **40 msec.**

** Initialization :*
The adaptation values are initialized when the engine is started for the first time or by the after-sales customer service :

ISAPWM_AD_MMV_IS = **00**H
ISAPWM_DRI_AD_MMV_IS = **00**H
ISAPWM_ACCIN_AD_MMV_IS = **00**H

** Adaptation values applicability :*
The determined adaptation value causes a partial shift of the basic idle-charge actuator opening.
But adaptation with air condition compressor is subject to the following conditions :

a) - it must be ensured that the weighting table IP_ISAPWM_ACCIN_N_MAF__N_SP_IS__MAF_ALTI_COR contains the value 1 within the index table area which allows adaptation.

b) - adaptation should be possible only after the load increase factor has reached **1**, and ISAPWM_TRA_ACCIN the value **0** (this must be ensured by application).



### 1.8.2 Adaptation conditions

a) Engine operating state engine stopped (LV_ES) or start (LV_ST) not active.

b) The presence of a diagnosis error, influencing the idle detection or the idle air quantity is not permitted :

| | | |
|---|---|---|
| | LV_TPS_ERR = 0 | (throttle position sensor) |
| **and** | LV_TPS_PLAUS_ERR = 0 | |
| **and** | LV_TCO_ERR = 0 | (coolant temperature sensor) |
| **and** | LV_TCO_PLAUS_ERR = 0 | |
| **and** | LV_MAF_ERR = 0 | (mass air flow sensor) |
| **and** | LV_MAF_PLAUS_ERR = 0 | |
| **and** | LV_TIA_ERR = 0 | (intake air temperature sensor) |
| **and** | LV_VS_ERR = 0 | (vehicle speed signal) |
| **and** | LV_IV_[CYL]_ERR = 0 | (injector valves 0...5) |
| **and** | LV_DUR_IGC_[CYL]_ERR = 0 | (ignition) |
| **and** | LV_ISA_i_ERR = 0 | (idle speed actuator) |
| **and** | LV_ISA_MECHA_ERR = 0 | |
| **and** | LV_TIMEOUT_TCU1_ERR = 0 | (timeout from TCU) |
| **and** | LV_STATE_A_MIS = 0 | (misfire CARB A) |
| **and** | LV_CPS_ERR = 0 | (canister purge solenoid) |
| **and** | LV_CPS_MECHA_ERR = 0 | |
| **and** | LV_VLS_UP_i_ERR = 0 | (upstream O2 sensor signal) |
| **and** | LV_VLS_LIM_i_ERR = 0 | (lambda probe voltage excursion) |
| **and** | LV_LAM_LIM_i_ERR = 0 | (lambda controller at limit) |

c) Throttle closed (LV_CT = 1) for more than ID_CYCNR_IS__N_32 seconds.
(in order to allow the throttle to settle after closing)

d) The coolant temperature must lie within following limits:
- d1) For ISAPWM_AD_MMV_IS and ISAPWM_DRI_AD_MMV_IS:
  C_TCO_AD_MIN_IS ≤ TCO ≤ C_TCO_AD_MAX_IS
- d2) For ISAPWM_ACCIN_AD_MMV_IS:
  C_TCO_ACCIN_AD_MIN_IS ≤ TCO ≤ C_TCO_AD_MAX_IS

e) No nominal engine speed increase at idle (LV_IS) must be effective due to an insufficient battery voltage VB.

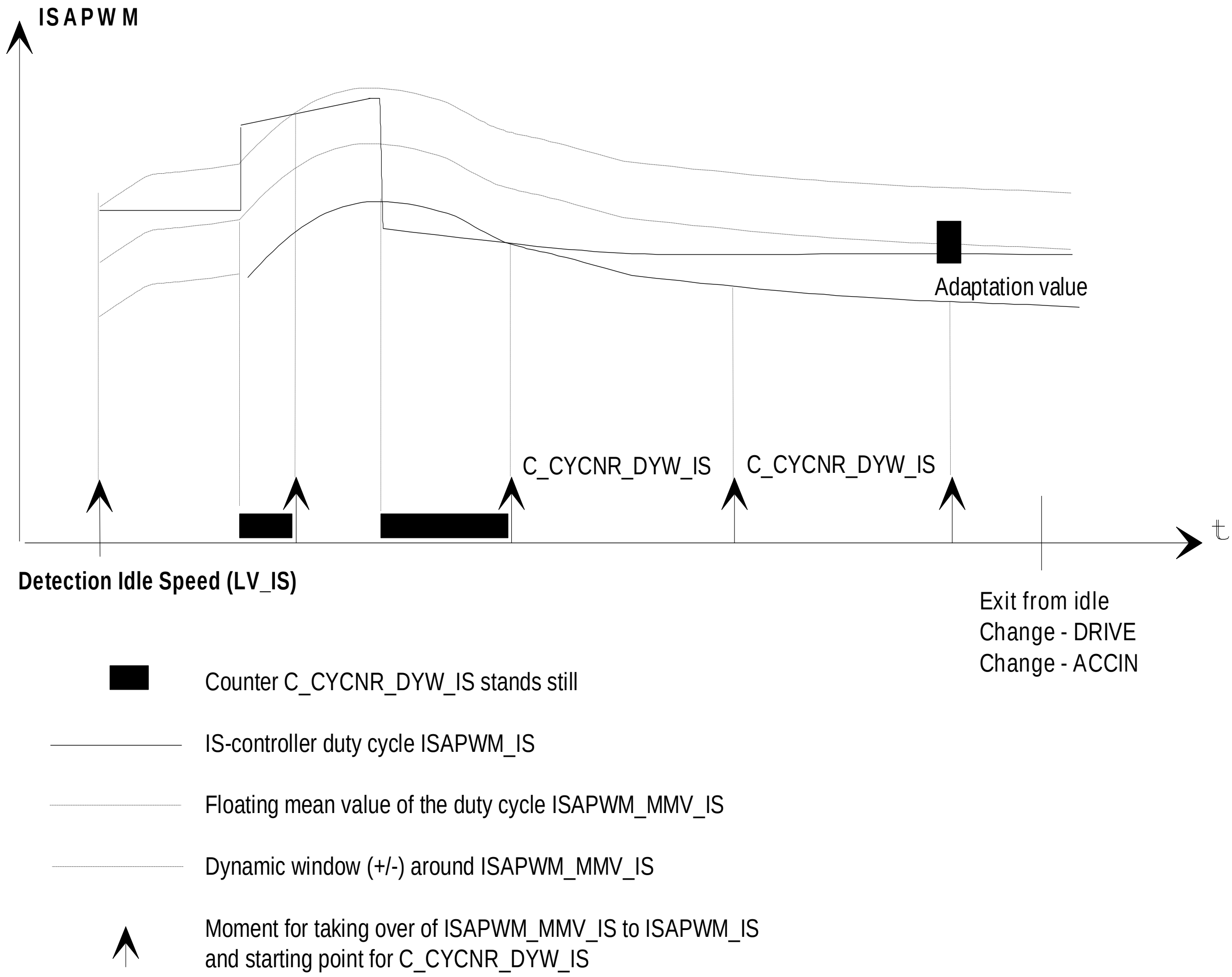
f) VS = 0

## 1.8.3 Adaptation sequence

### 1.8.3.1 Adaptation process

The aim is the determination of a steadily settled idle speed regulation ISAPWM_IS.





* ***ISAPWM_MMV_IS*** *calculation :*

The moving mean value of the idle speed regulation correction is defined as :

$$ISAPWM\_MMV\_IS_{(n)} = ISAPWM\_MMV\_IS_{(n-1)} + ( ISAPWM\_IS_{(n)} - ISAPWM\_MMV\_IS_{(n-1)} ) * C\_ISAPWM\_CRLC\_IS$$

When entering in the engine operating state idle (LV_IS), the first value of the idle speed regulation is used as moving mean value.

A dynamic window is placed around ISAPWM_IS and N at intervals of 40 ms :

**If** during C_CYCNR_DYW_IS, the following conditions are true :
a) - | ISAPWM_IS - ISAPWM_MMV_IS | **<** C_ISAPWM_AD_DYW_IS
⇔ **LV_ISAPWM_AD_DYW_IS = 1** (ISAPWM)
**and** b) - | N - N_SP_IS | < C_N_AD_DYW_IS
⇔ **LV_N_AD_DYW_IS = 1** (N)
**then** ISAPWM_AD_IS = ISAPWM_MMV_IS

This process is repeated again as often as the adaptation conditions are true.

* ***ISAPWM_AD_COR_IS*** *calculation :*

When exiting from idle, this value represents the target for the I component of the idle speed regulation.

**If** idle adaptation calculation is not yet performed
(no update of idle adaptation calculation)
**then** ISAPWM_AD_COR_IS = ISAPWM_AD_IS
**else** ISAPWM_AD_COR_IS = ISAPWM_AD_IS * (1 - C_AD_CRLC_IS)

After use, ISAPWM_AD_IS is set to **0**.

### 1.8.3.2 Adaptation calculation

*a) Air condition compressor is **OFF** (LV_RLY_ACCOUT_CTRL = 0)*

A new ISAPWM_xx_AD_MMV_IS calculation is performed for the concerned adaptative term according to the following conditions :

| | | | |
|---|---|---|---|
| **If** | LV_IS = 1 | | (engine operating state Idle) |
| **If** | | A/T shift NEUTRAL **--->** DRIVE | |
| | **and** | air condition compressor is **OFF** | (LV_RLY_ACCOUT_CTRL = 0) |
| **or** | | M/T or A/T in NEUTRAL position | |
| | **and** | air condition compressor is switched **ON** | (LV_RLY_ACCOUT_CTRL 0->1) |
| **or** | | Change of operating state from IS → PL | |
| | **and** | air condition compressor is **OFF** | (LV_RLY_ACCOUT_CTRL = 0) |
| | **and** | M/T or A/T in NEUTRAL position | |
| **then** | | | |

$$\mathrm{ISAPWM\_AD\_MMV\_IS}_{(n)} = \mathrm{ISAPWM\_AD\_MMV\_IS}_{(n-1)} + \mathrm{ISAPWM\_AD\_IS}_{(n)} * \mathrm{C\_AD\_CRLC\_IS}$$

| | | | |
|---|---|---|---|
| **If** | LV_IS = 1 | | (engine operating state Idle) |
| **If** | | A/T shift DRIVE **--->** NEUTRAL | |
| | **and** | air condition compressor is **OFF** | (LV_RLY_ACCOUT_CTRL = 0) |
| **or** | | A/T in DRIVE position | |
| | **and** | air condition compressor is switched **ON** | (LV_RLY_ACCOUT_CTRL 0->1) |
| **or** | | Change of operating state from IS → PL | |
| | **and** | air condition compressor is **OFF** | (LV_RLY_ACCOUT_CTRL = 0) |
| | **and** | A/T in DRIVE position | |
| **then** | | | |

$$\mathrm{ISAPWM\_DRI\_AD\_MMV\_IS}_{(n)} = \mathrm{ISAPWM\_DRI\_AD\_MMV\_IS}_{(n-1)} + \mathrm{ISAPWM\_AD\_IS}_{(n)} * \mathrm{C\_AD\_CRLC\_IS}$$

*b) Air condition compressor is **ON** (LV_RLY_ACCOUT_CTRL = 1)*

A new ISAPWM_ACCIN_AD_MMV_IS calculation is performed according to the following conditions :

| | | | |
|---|---|---|---|
| **If** | LV_IS = 1 | | (engine operating state Idle) |
| | **and** | air condition compressor is switched **OFF** | (LV_RLY_ACCOUT_CTRL 1->0) |
| **or** | | Change of operating state from IS → PL | |
| | **and** | air condition compressor is **ON** | (LV_RLY_ACCOUT_CTRL = 1) |
| **then** | | | |

$$\mathrm{ISAPWM\_ACCIN\_AD\_MMV\_IS}_{(n)} = \mathrm{ISAPWM\_ACCIN\_AD\_MMV\_IS}_{(n-1)} + \mathrm{ISAPWM\_AD\_IS}_{(n)} * \mathrm{C\_AD\_CRLC\_IS}$$

Contrary to ISAPWM_AD_MMV_IS and ISAPWM_DRI_AD_MMV_IS the air condition compressor adaptation value is not stored completely in the non volatile memory at the end of the controller holding phase.

As the demand may have changed after the following engine start (influence of ambient temperature), the value ISAPWM_ACCIN_AD_MMV_IS is reduced by multiplication of C_ISAPWM_ACCIN_AD_FAC before it is stored in the non volatile memory.

#### 1.8.3.3 Adaptation limits

a) For **ISAPWM_AD_MMV_IS** and **ISAPWM_DRI_AD_MMV_IS** the limitation is:

C_ISAPWM_AD_MIN_IS ≤ ISAPWM_AD_MMV_IS ≤ C_ISAPWM_AD_MAX_IS

C_ISAPWM_AD_MIN_IS ≤ ISAPWM_DRI_AD_MMV_IS ≤ C_ISAPWM_AD_MAX_IS

b) For **ISAPWM_ACCIN_AD_MMV_IS** the limitation is:

C_ISAPWM_ACCIN_AD_MIN_IS ≤ **ISAPWM_ACCIN_AD_MMV_IS** ≤
C_ISAPWM_ACCIN_AD_MAX_IS

c) For **ISAPWM_AD_COR_IS** the limitation is:

* *Air condition compressor **OFF** (LV_RLY_ACCOUT_CTRL = 0):*

C_ISAPWM_MIN_I ≤ ISAPWM_AD_COR_IS ≤ C_ISAPWM_MAX_I

* *Air condition compressor **ON** (LV_RLY_ACCOUT_CTRL = 1):*

C_ISAPWM_ACCIN_MIN_I ≤ ISAPWM_AD_COR_IS ≤ C_ISAPWM_ACCIN_MAX_I

## Calibration data:

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| ID_CYCNR_IS__N_32 | 4 | 01...FFH | 0.04...10.2 | 0.04 | sec |
| Delay to allow idle adaptation when LV_CT is true. | | | | | |
| C_TCO_AD_MIN_IS | 1 | 0...FEH | -48...142.5 | 0.75 | °C |
| Minimum coolant temperature for idle adaptation without air condition compressor. | | | | | |
| C_TCO_ACCIN_AD_MIN_IS | 1 | 0...FEH | -48...142.5 | 0.75 | °C |
| Minimum coolant temperature for idle adaptation with air condition compressor. | | | | | |
| C_TCO_AD_MAX_IS | 1 | 0...FEH | -48...142.5 | 0.75 | °C |
| Maximum coolant temperature for idle adaptation. | | | | | |
| C_ISAPWM_CRLC_IS | 1 | 00...FFH | 0...0.997 | 3.895E-3 | - |
| Filtering factor for ISAPWM_MMV_IS. | | | | | |
| C_CYCNR_DYW_IS | 1 | 01...FFH | 1...255 | 1 | - |
| Minimum time for (N, ISAPWM) steady state condition to calculate a new ISAPWM_AD_IS (x 40 msec) | | | | | |
| C_ISAPWM_AD_DYW_IS | 1 | 0...FFFFH | 0...99.9985 | 0.0015 | % |
| Steady state threshold for ISAPWM_IS to learn ISAPWM_AD_IS. | | | | | |
| C_N_AD_DYW_IS | 1 | 0...FFH | 0...255 | 1 | rpm |
| Steady state threshold for engine speed to learn ISAPWM_AD_IS. | | | | | |
| C_AD_CRLC_IS | 1 | 00...FFH | 0...0.997 | 3.895E-3 | - |
| Filtering factor for adaptive term. | | | | | |
| C_ISAPWM_ACCIN_AD_FAC | 1 | 00...FFH | 0...0.997 | 3.895E-3 | - |
| Reduction factor for ISAPWM_ACCIN_AD_MMV_IS when stored in non volatile memory. | | | | | |
| C_ISAPWM_AD_MIN_IS | 1 | 8000...0000H | -50...0 | 0.0015 | % |
| Minimum adaptive value without air condition compressor. | | | | | |
| C_ISAPWM_AD_MAX_IS | 1 | 0...7FFFH | 0...49.9985 | 0.0015 | % |
| Maximum adaptive value without air condition compressor. | | | | | |
| C_ISAPWM_ACCIN_AD_MIN_IS | 1 | 8000...0000H | -50...0 | 0.0015 | % |
| Minimum adaptive value with air condition compressor. | | | | | |
| C_ISAPWM_ACCIN_AD_MAX_IS | 1 | 0...7FFFH | 0...49.9985 | 0.0015 | % |
| Maximum adaptive value with air condition compressor. | | | | | |
| C_ISAPWM_MIN_I | 1 | 8000...7FFFH | -50...49.998 | 1.526E-3 | % |
| Minimum integral component out of idle without air condition compressor. | | | | | |
| C_ISAPWM_MAX_I | 1 | 8000...7FFFH | -50...49.998 | 1.526E-3 | % |
| Maximum integral component out of idle without air condition compressor. | | | | | |
| C_ISAPWM_ACCIN_MIN_I | 1 | 8000...7FFFH | -50...49.998 | 1.526E-3 | % |
| Minimum integral component out of idle with air condition compressor. | | | | | |
| C_ISAPWM_ACCIN_MAX_I | 1 | 8000...7FFFH | -50...49.998 | 1.526E-3 | % |
| Maximum integral component out of idle with air condition compressor. | | | | | |

## 1.9 Intake air temperature correction ( ISAPWM_TIA_FAC )



**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| ISAPWM_TIA_FAC | V/S | 00...FFH | 0...1,922 | 7,509E-3 | - |
| Intake air temperature correction. | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| TIA | | | |

**FUNCTION DESCRIPTION:**

General information:

The linear opening ratio ISAPWM is converted to standard condition TIA = 20 °C (intake air temperature) by means of air-density correction ISAPWM_TIA_FAC.

The application recurrence is **500 msec.**



**Application conditions:**

Available for all engine operating states.

**Formula section:**

ISAPWM_TIA_FAC = IP_ISAPWM_TIA_FAC__TIA

**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| IP_ISAPWM_TIA_FAC__TIA | 6 | 0...FFH | 0...1,9922 | 0,0078 | - |
| | | | | | |
| Intake air temperature correction factor | | | | | |

## 1.10 Idle-charge Actuator Adaptation ( AD_MMV_ISA, ADD_ISA )

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| AD_MMV_ISA | V | 00...FFFFH | 0...2,000 | 3,052E-5 | - |
| Idle-charge actuator adaptation. | | | | | |
| ADD_ISA | V | 00...FFFFH | 0...2,000 | 3,052E-5 | - |
| Target air mass and measured air mass comparison in idle. | | | | | |
| AD_INI_COR_ISA | V/S | 00...FFH | 0...1,992 | 7,782E-3 | - |
| Initialization of idle-charge actuator adaptation. | | | | | |
| LV_MAF_AD_MAX_ISA | V | 0...01H | 0...1 | 1 | - |
| Boolean for critical pressure ratio detection (- / MAF_MAX). | | | | | |
| LV_AD_PREV_ISA | V | 0...01H | 0...1 | 1 | - |
| Boolean to inform if an idle - charge actuator adaptation has previously occurred (- / YES). | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| TPS | TIA | ISAPWM | N_32 |
| MAF | MAF_KGH | MAF_ALTI_COR | C_MAF_MAX_ISA |
| ISAPWM_TIA_FAC | ID_CYCNR_IS__N | LV_CT | LV_ES |
| LV_TPS_ERR | LV_TPS_PLAUS_ERR | LV_MAF_ERR | LV_MAF_PLAUS_ERR |
| LV_TIA_ERR | LV_ISA_i_ERR | LV_ISA_MECHA_ERR | |

### 1.10.1 Adaptation conditions

These conditions are checked with a recurrence of **300 msec**.

a) - The presence of an error influencing the idle detection or the idle air quantity is not permitted :

| | | |
|---|---|---|
| | LV_TPS_ERR = 0 | (throttle position sensor) |
| **and** | LV_TPS_PLAUS_ERR = 0 | (throttle position sensor - plausibility) |
| **and** | LV_MAF_ERR = 0 | (mass air flow sensor) |
| **and** | LV_MAF_PLAUS_ERR = 0 | (mass air flow sensor - plausibility) |
| **and** | LV_TIA_ERR = 0 | (air intake temperature sensor) |
| **and** | LV_ISA_i_ERR = 0 | (idle speed actuator - electrical) |
| **and** | LV_ISA_MECHA_ERR = 0 | (idle speed actuator - mechanical) |

b) - Throttle closed (LV_CT = CT) since more than ID_CYCNR_IS__N seconds.

c) - The calculated idle - charge actuator opening must be within the following limits :

C_ISAPWM_AD_MIN_ISA ≤ ISAPWM ≤ C_ISAPWM_AD_MAX_ISA

d) - The idle - charge actuator adaptation must be performed with a critical pressure ratio at the throttle **(sound velocity).**

This condition is met dependent on the engine speed up to an air mass flow of IP_MAF_AD_MAX_ISA__N_32.

- The influence of the altitude is compensated using the mass air flow corrected to sea level **MAF_ALTI_COR** in the calculation.

- The influence of the density due to the ambient air temperature is compensated by multiplication by **ISAPWM_TIA_FAC.**

The critical pressure ratio status is performed with the following conditions :

**If** MAF_ALTI_COR * ISAPWM_TIA_FAC **<** IP_MAF_AD_MAX_ISA__N_32

**then** LV_MAF_AD_MAX_ISA = 1 (MAF_MAX)
**else** LV_MAF_AD_MAX_ISA = 0 ( - ).

**Remark :**
Once an adaptation of the idle-charge characteristic has occurred, LV_AD_PREV_ISA is set to 1 (YES).

### 1.10.2 Adaptation of the idle-charge actuator characteristic



When the adaptation conditions are true, the air mass measured is converted to kg/h at intervals of **300 msec** and reduced to the reference conditions for the idle - charge actuator.

* ***ADD_ISA*** *calculation :*
The comparison of the target air mass and the measured air mass results in the correction factor for idle - charge actuator adaptation :

ADD_ISA = **Fehler!**

ADD_ISA = **Fehler!**

**Remark :**

- The air flow through the idle - charge actuator and the throttle body when they are completely closed is represented by C_MAF_AD_ISA and C_MAF_MAX_ISA.
- The target air mass is reduced to the reference conditions by using ISAPWM_TIA_FAC in the calculation.



* ***AD_MMV_ISA*** *calculation :*

The duty cycle correction AD_MMV_ISA is formed by means of the moving mean value :

$AD\_MMV\_ISA_{(n)} = AD\_MMV\_ISA_{(n-1)} * [\ 1 + C\_AD\_CRLC\_ISA * (\ ADD\_ISA_{(n)} - 1\ )\ ]$

- A proportional change in the air mass cannot be transferred proportionally to the idle - charge actuator control due to linearization of the characteristic. Then it must be :
  C_AD_CRLC_ISA **<** 1.

- In order to provide sufficient air for all conditions possible, the idle - charge actuator adaptation has a lower limit. This is defined in terms of the value C_AD_DIF_MMV_ISA which specifies the maximum interval to the initialization characteristic of the idle - charge actuator adaptation.
  AD_MMV_ISA ≥ IP_AD_INI_ISA__TIA - C_AD_DIF_MMV_ISA

### 1.10.3 Initialization of idle-charge actuator adaptation



At a new start, after the controller has been reset, the correction AD_MMV_ISAof the idle - charge actuator characteristic is initialized as following :

AD_MMV_ISA = IP_AD_INI_ISA__TIA * AD_INI_COR_ISA

* ***AD_INI_COR_ISA*** *initialization :*
It is saved in a non - volatile memory from previous engine running.
It is initialized to **1** following a restart, if the car is new or by the after - sales customer service or if a bad saving has been previously performed.

* ***AD_INI_COR_ISA*** *calculation conditions :*
a) - The presence of the following errors is not permitted :

| | | |
|---|---|---|
| | LV_TPS_ERR = 0 | (throttle position sensor) |
| **and** | LV_TPS_PLAUS_ERR = 0 | |
| **and** | LV_MAF_ERR = 0 | (mass air flow sensor) |
| **and** | LV_MAF_PLAUS_ERR = 0 | |
| **and** | LV_TIA_ERR = 0 | (air intake temperature sensor) |
| **and** | LV_ISA_i_ERR = 0 | (idle - charge actuator / mechanical) |
| **and** | LV_ISA_MECHA_ERR = 0 | |

b) - The engine is stopped (LV_ES - power latch phase) and the post-start function was previously over.



The calculation is made only once.
If the above - mentioned conditions are not fulfilled, the old value is taken in account :
$AD\_INI\_COR\_ISA_{(n)} = AD\_INI\_COR\_ISA_{(n-1)}$

* ***AD_INI_COR_ISA*** *calculation :*

Previously, when the engine is stopped (power latch phase), to take in account the typical variances of the idle - charge actuator during operation, the value AD_INI_COR_ISA is calculated for the next starting as following :

AD_INI_COR_ISA = **Fehler!**

with C_AD_ADD_MMV_ISA a variable applicable to influence the idle - charge actuator adaptation value at start.

## Calibration data:

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| C_ISAPWM_AD_MIN_ISA | 1 | 00...FFH | 0...99,609 | 0,3891 | % |
| Minimum ISAPWM for idle-charge actuator characteristic adaptation. | | | | | |
| C_ISAPWM_AD_MAX_ISA | 1 | 00...FFH | 0...99,609 | 0,3891 | % |
| Maximum ISAPWM for idle-charge actuator characteristic adaptation. | | | | | |
| IP_MAF_AD_MAX_ISA__N_32 | 3 | 0...FFH | 0...1389 | 5,44 | mg/TDC |
| | | | | | |
| Maximum air flow for idle-charge actuator characteristic adaptation. | | | | | |
| C_MAF_AD_ISA | 1 | 0...FFH | 0...63,75 | 0,25 | kg/h |
| Air flow through the throttle body in normal conditions. | | | | | |
| C_AD_CRLC_ISA | 1 | 00...FFH | 0...0,997 | 3,895E-3 | - |
| Correlation factor for calculation of AD_MMV_ISA. | | | | | |
| C_AD_DIF_MMV_ISA | 1 | 00...FFH | 0...1,992 | 7,782E-3 | - |
| Maximum difference between the idle-charge actuator adaptation and the initialization characteristic. | | | | | |
| IP_AD_INI_ISA__TIA | 6 | 00...FFH | 0...1,922 | 7,509E-3 | - |
| | | | | | |
| Initialization of the idle-charge actuator. | | | | | |
| C_AD_ADD_MMV_ISA | 1 | 00...FFH | 0...1,992 | 7,782E-3 | - |
| Offset for the idle-charge actuator adaptation value at start. | | | | | |

## 1.11 Fans correction ( ISAPWM_CFA, ISAPWM_TRA_CFA )

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| ISAPWM_CFA | V | 00...FFFFH | 0...99,998 | 1,526E-3 | % |
| Idle charge - actuator opening correction for cooling and condenser fans. | | | | | |
| ISAPWM_TRA_CFA | V | 8000...7FFFH | -50...49,998 | 1,526E-3 | % |
| Idle charge - actuator opening correction when STATE_CFA_IS is changing. | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| STATE_CFA_IS | LV_ACCIN | VS_STATE_CFA | LV_PRS_ACC |

**FUNCTION DESCRIPTION:**

General information:

Its purpose is to correct the cooling and condenser fans power requirements.
It depends on fans state : **OFF / LOW / MIDDLE / HIGH**.

When a fan is switched on or its speed changes, an additional duty cycle is applied in order to ensure a rapid intake pipe filling. This is performed by the ISAPWM_TRA_CFA term.
It is used also when a cooling fan is switched OFF or its speed decreases.

The application recurrence is **40 msec**.

**Application conditions:**

Available for all engine operating states.

**Formula section:**

a) - ***ISAPWM_CFA*** *calculation :*

| | STATE_CFA_IS | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| LV_ACCIN = 0 | C_ISAPWM_0_1_CFA | C_ISAPWM_0_2_CFA | C_ISAPWM_0_3_CFA |
| LV_ACCIN = 1 | C_ISAPWM_1_1_CFA | C_ISAPWM_1_2_CFA | C_ISAPWM_1_3_CFA |

b) - ***ISAPWM_TRA_CFA*** *calculation:*

**1 - VS_STATE_CFA= 0**

**1.1 -** STATE_CFA_IS values increases :

**If** LV_PRS_ACC **= 0**
**then** ISAPWM_TRA_CFA is set to C_ISAPWM_INC_0_CFA and reseted using change limitation C_ISAPWM_LGRD_0_CFA
**else** ISAPWM_TRA_CFA is set to C_ISAPWM_INC_1_CFA and reseted using change limitation C_ISAPWM_LGRD_1_CFA

**1.2 -** STATE_CFA_ISvalues decreases :

ISAPWM_TRA_CFA is set to C_ISAPWM_DEC_CFA (positive or negative value) and reset to zero using C_ISAPWM_LGRD_DEC_CFAchange limitation.

**2 - VS_STATE_CFA ≠ 0**

ISAPWM_TRA_CFA = 0

**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| C_ISAPWM_0_1_CFA | 1 | 0...FFH | 0...24,902 | 0,098 | % |
| Idle charge - actuator opening correction when LV_ACIN = 0 and STATE_CFA_IS = 1 | | | | | |
| C_ISAPWM_0_2_CFA | 1 | 0...FFH | 0...24,902 | 0,098 | % |
| Idle charge - actuator opening correction when LV_ACIN = 0 and STATE_CFA_IS = 2 | | | | | |
| C_ISAPWM_0_3_CFA | 1 | 0...FFH | 0...24,902 | 0,098 | % |
| Idle charge - actuator opening correction when LV_ACIN = 0 and STATE_CFA_IS = 3 | | | | | |
| C_ISAPWM_1_1_CFA | 1 | 0...FFH | 0...24,902 | 0,098 | % |
| Idle charge - actuator opening correction when LV_ACIN = 1 and STATE_CFA_IS = 1 | | | | | |
| C_ISAPWM_1_2_CFA | 1 | 0...FFH | 0...24,902 | 0,098 | % |
| Idle charge - actuator opening correction when LV_ACIN = 1 and STATE_CFA_IS = 2 | | | | | |
| C_ISAPWM_1_3_CFA | 1 | 0...FFH | 0...24,902 | 0,098 | % |
| Idle charge - actuator opening correction when LV_ACIN = 1 and STATE_CFA_IS = 3 | | | | | |
| C_ISAPWM_INC_0_CFA | 1 | 0...FFH | 0...24,902 | 0,098 | % |
| ISAPWM_TRA_CFA set value when STATE_CFA_IS increases and LV_PRS_ACC = 0 | | | | | |
| C_ISAPWM_INC_1_CFA | 1 | 0...FFH | 0...24,902 | 0,098 | % |
| ISAPWM_TRA_CFA set value when STATE_CFA_IS increases and LV_PRS_ACC = 1 | | | | | |
| C_ISAPWM_LGRD_0_CFA | 1 | 0...FFH | 0...24,902 | 0,098 | % |
| ISAPWM_TRA_CFA reset change limitation after STATE_CFA increase and LV_PRS_ACC = 0 | | | | | |
| C_ISAPWM_LGRD_1_CFA | 1 | 0...FFH | 0...24,902 | 0,098 | % |
| ISAPWM_TRA_CFA reset change limitation after STATE_CFA increase and LV_PRS_ACC = 1 | | | | | |
| C_ISAPWM_DEC_CFA | 1 | 80...7FH | -12,5...12,402 | 0,098 | % |
| ISAPWM_TRA_CFA set value if STATE_CFA_IS decreased | | | | | |
| C_ISAPWM_LGRD_DEC_CFA | 1 | 0...FFH | 0...24,902 | 0,098 | % |
| ISAPWM_TRA_CFA reset change limitation after STATE_CFA decrease | | | | | |

## 1.12 ISAPWM-correction for programmed idle speed increase



**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| ISAPWM_N_SP_IS_ASA | V | 0...FFFFH | 0...99,998 | 1,526E-3 | % |
| Correction for programmed idle speed increase | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| N_SP_IS_ADJ_ASA | TCO | | |

**FUNCTION DESCRIPTION:**

General information:

- The application recurrency is **40 msec**.

**Application conditions:**

The nominal idle speed can be increased via the serial interface by N_SP_IS_ADJ_ASA which is weighted with a TCO-depending factor. To compensate the air which is needed more, compared to the normal nominal idle speed, the pre-control of the idle charge actuator is additive corrected with ISAPWM_N_SP_IS_ASA.

**If** LV_IS = 1.

**then** ISAPWM_N_SP_IS_ASA =

IP_ISAPWM_N_SP_IS_ASA__N_SP_IS_ADJ_ASA * IP_ISAPWM_FAC_N_SP_IS_ASA__TCO

**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| IP_ISAPWM_N_SP_IS_ASA__N_SP_IS_ADJ_ASA | 6 | 0...FFH | 0...99,6 | 0,39 | % |
| | | | | | |
| Correction for programmed idle speed increase | | | | | |
| IP_ISAPWM_FAC_N_SP_IS_ASA__TCO | 6 | 0...FFH | 0...0,996 | 1/256 | - |
| | | | | | |
| TCO-correction factor for programmed idle speed increase | | | | | |

## 1.13 Electrical load correction ( ISAPWM_EL_LOAD, ISAPWM_EL_LOAD_TRA )

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| ISAPWM_EL_LOAD | V | 0...FFH | 0...24,902 | 0,098 | % |
| Idle charge - actuator opening correction for electrical load. | | | | | |
| ISAPWM_EL_LOAD_TRA | V | 80...7FH | -12,5...12,402 | 0,098 | % |
| Idle charge - actuator opening correction when LV_EL_LOAD is changing. | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| LV_EL_LOAD | | | |

**FUNCTION DESCRIPTION:**

General information:

The target is to correct the additionnal load on the engine when an electric load is active (head lamps, rear window defrost or brake light).

When one of this electric load is switched on, an additional duty cycle is applied in order to ensure a rapid intake pipe filling. This is performed by the ISAPWM_EL_LOAD_TRA term.

The application recurrence is **40 msec**.



**Application conditions:**

Available for all engine operating states.

**Formula section:**

1. ISAPWM_EL_LOAD calculation:

**If** LV_EL_LOAD **= 1**
**Then** ISAPWM_EL_LOAD **=** C_ISAPWM_EL_LOAD
**Else** ISAPWM_EL_LOAD **=** 0

2. ISAPWM_EL_LOAD_TRA calculation:

**If** Transition LV_EL_LOAD : 0 -> 1
**Then** ISAPWM_EL_LOAD _TRA is set to C_ISAPWM_EL_LOAD_TRA_INC and reseted to 0 using change limitation C_ISAPWM_EL_LOAD_TRA_LGRD.

**If** Transition LV_EL_LOAD : 1 -> 0
**Then** ISAPWM_EL_LOAD_TRA is set to C_ISAPWM_EL_LOAD_TRA_DEC and reseted to 0 using change limitation C_ISAPWM_EL_LOAD_TRA_LGRD.

## Calibration data:

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| C_ISAPWM_EL_LOAD | 1 | 0...FFH | 0...24,902 | 0,098 | % |
| Idle charge actuator correction with electrical load (LV_EL_LOAD = 1) | | | | | |
| C_ISAPWM_EL_LOAD_TRA_INC | 1 | 80...7FH | -12,5...12,402 | 0,098 | % |
| Idle charge actuator correction with LV_EL_LOAD transition 0->1 | | | | | |
| C_ISAPWM_EL_LOAD_TRA_DEC | 1 | 80...7FH | -12,5...12,402 | 0,098 | % |
| Idle charge actuator correction with LV_EL_LOAD transition 1->0 | | | | | |
| C_ISAPWM_EL_LOAD_TRA_LGRD | 1 | 0...7FH | 0...12,402 | 0,098 | % |
| ISAPWM_EL_LOAD_TRA reset change limitation | | | | | |

## 1.14 Automatic gearbox converter load correction

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| ISAPWM_LOAD_AT_FAC | v | 0...FFH | 0...1 | 1/256 | - |
| Correction factor for ISAPWM versus AT-load and TCO | | | | | |
| LOAD_AT | v | 0...FFH | 0...1 | 1/256 | - |
| Torque converter load | | | | | |
| N_CONV | v | 0...FFH | 0...8160 | 1 | rpm |
| Speed of the torque converter turbine. | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| N | LV_DRI_ISAPWM | ISAPWM_TCO_DRI_ACIN | TCO |

**FUNCTION DESCRIPTION:**

General information:

To improve deceleration and to increase the vacuum in the surge tank during deceleration the ISA is corrected versus the load of the torque converter of the automatic gearbox. This load is calculated by the ratio between turbine speed of the torque converter and the engine speed. The turbine speed of the converter N_CONV is sent via CAN by the TCU. With TCO and LOAD_AT as input values a factor ISAPWM_LOAD_AT_FAC is calculated.
If N < NC_ISAPWM_N_MAX, the application recurrence is 10 ms otherwise 40 ms.

**Formula section:**

LOAD_AT = N_CONV / N

In case of an error at the converter speed acquisition the TCU sends the identifier FFFFH via the CAN. Then the ISAPWM_LOAD_AT_FAC is set to 1

**Application conditions:**

IF LV_DRI_ISAPWM = 1
Then ISAPWM_LOAD_AT_FAC = IP_ISAPWM_LOAD_AT_FAC__LOAD_AT__TCO
Else ISAPWM_LOAD_AT_FAC = 1

**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| IP_ISAPWM_LOAD_AT_FAC__LOAD_AT__TCO | 6x6 | 0...FFH | 0...1 | 1/256 | - |
| | | | | | |
| Automatic gearbox converter load correction factor | | | | | |

Document: **Auxiliary functions**

Project: **Engine Management System**

**HMC_V6**

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| | Name | Department | Phone | Date | Sign |
|---|---|---|---|---|---|
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| Responsible | Brückner D. | AT PT SI TSA 16 | 4279 | 09.12.97 | |

## Version list

| Version | Date | Author | Comment, Description |
|---|---|---|---|
| | | | |

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# 1 Torque reduction for automatic gearshift



**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| T_GS_DLY_DIAG | V | 0...FFFFH | 0...655.35 | 0.01 | s |
| Diagnosis time during gearshift | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| TQI_GS_REQ | LV_GS_REQ | LV_ST | LV_ES |
| TQI | TQI_ASR_REQ | LV_DRI | TQ_STND |
| IP_TQI__N_32__MAF | IP_FAC_LAM_TQI__LAM_SUB__IGA_DIF_REF_AV | LV_IS | TQI_TCU_CAN |

**FUNCTION DESCRIPTION:**



General information:

At a car with automatic transmission the engine torque during gearshift event is reduced by retarding of spark advance or, if this is not enough, by cylinder shut-off. The reduced torque is requested by the TCU. The apportionment of the torque reduction between spark retard and cylinder shut-off is done by the torque management control logic, which is described in the chapter „Traction Control - Torque Intervention".

The gearshift respectively the duration of the torque reduction request is watched by a timer T_GS_DLY_DIAG. If the timer reaches the limit C_T_GS_DLY_DIAG, the torque reduction will be ramped to zero and not performed anymore during the current driving cycle.

Application recurrence: **10 ms**

**Application conditions:**

| | | |
|---|---|---|
| **If** | LV_IS = 0 | *(not idle speed)* |
| **and** | LV_ES = 0 | *(not engine stop)* |
| **and** | LV_ST = 0 | *(not engine start)* |
| **and** | LV_DRI = 1 | *(Drive or reverse gear selected)* |
| **and** | TQI_GS_REQ < TQI | *(actually torque reduction requested)* |
| **and** | TQI_GS_REQ < TQI_ASR_REQ | *(req. torque for GS below ASR-torque)* |
| **and** | TQI_TCU_CAN < 100% (TQ_STND) | *(GS requested torque below TQI)* |
| **and** | T_GS_DLY_DIAG < C_T_GS_DLY_DIAG | *(diagnosis time not exceeded)* |
| **then** | LV_CDN_GS = 1 | *(torque reduction is possible)* |
| **else** | LV_CDN_GS = 0 | *(no torque reduction possible)* |

**Formula section :**

The torque during gearshift TQR_REL_GS_NV is calculated from the torque reduction control logic as described in chapter „Traction Control - Torque Intervention“.

**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| C_T_GS_DLY_DIAG | INT | 0...FFFFH | 0...655.35 | 0.01 | s |
| Diagnosis timer threshold for gearshift | | | | | |

# 2 Air condition compressor control

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| LV_RLY_ACCOUT | V | 0...01H | 0...1 | 1 | - |
| Boolean of air condition compressor relay (OFF / ON). | | | | | |
| LV_RLY_ACCOUT_CTRL | V | 0...01H | 0...1 | 1 | - |
| Boolean to activate ISAPWM correction related to air condition compressor relay | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| LV_ACIN | LV_ACCIN | LV_ST | LV_FL |
| LV_PL | LV_IS | N_32 | TCO |
| VS | C_TCO_5_CFA | C_TCO_HYS_4_CFA | LV_CT |
| TPS_GRD | | | |

**FUNCTION DESCRIPTION:**

General information:

The air condition compressor relay LV_RLY_ACCOUT is controlled by the ECU. It is enabled and disabled versus LV_ACIN and LV_ACCIN information. In order to keep a stable engine speed when A/C compressor is activated or dis-activated, idle speed valve correction are triggered in advance with LV_RLY_ACCOUT_CTRL.

**Remind :** LV_ACIN : Air condition selected
LV_ACCIN : Air condition requested

Application reccurency **= 40 ms**

**Application conditions:**

** Initialization :*

LV_RLY_ACCOUT and LV_RLY_ACCOUT_CTRL are set to 0 in the engine operating state engine stopped (LV_ES).

* *Activation* ( **LV_RLY_ACCOUT = ON** ) :

**If** corresponding “Variant Coding” dedicated
**and** engine operating states engine stopped (LV_ES) not active
**and** engine operating state start (LV_ST) not active
**and** air condition selected (LV_ACIN = ACIN)
**and** air condition requested (LV_ACCIN = ACCIN)
**and** LV_RLY_ACCOUT= OFF since more than C_ACCIN_DLY_5 seconds
**and** TCO ≤ C_TCO_5_CFA
**then** LV_RLY_ACCOUT_CTRL is enabled immediately
LV_RLY_ACCOUT is enabled after IP_ACCIN_DLY_2__N_32 seconds.

* *Deactivation* ( **LV_RLY_ACCOUT = OFF** ) :

If one of the deactivation conditions are true, LV_RLY_ACCOUT and LV_RLY_ACCOUT_CTRL are disabled whatever the activation conditions are.

1 - **If** engine operating state start (LV_ST) active
**then** LV_RLY_ACCOUT_CTRL is disabled **during** C_ACCIN_DLY_4 seconds
LV_RLY_ACCOUT is disabled **during** IP_ACCIN_DLY_2 + C_ACCIN_DLY_4

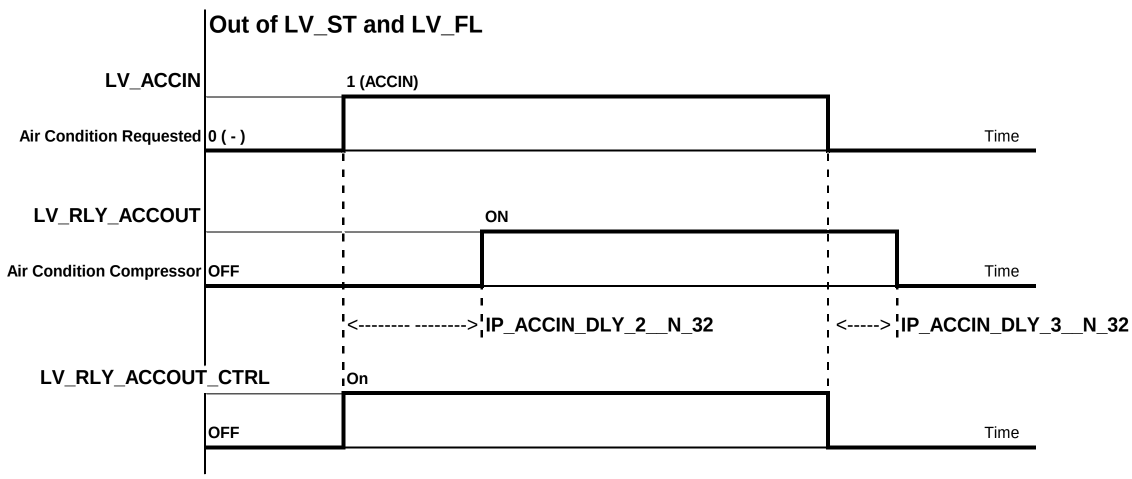
2 - **If** acceleration enrichment due to full load (LV_FL) active
**and** VS **<** C_ACCIN_VS_MAX
**then** LV_RLY_ACCOUT_CTRL and LV_RLY_ACCOUT are disabled immediately
**during** C_ACCIN_DLY_1 seconds.

3 - **If** LV_ACCIN **=** 0 ( - )
**then** LV_RLY_ACCOUT_CTRL is disabled immediately
LV_RLY_ACCOUT is disabled **after** IP_ACCIN_DLY_3__N_32 seconds.

4 - **If** TCO **>** C_TCO_5_CFA
**then** LV_RLY_ACCOUT_CTRL is disabled immediately
LV_RLY_ACCOUT is disabled **after** IP_ACCIN_DLY_3__N_32 seconds
**until** TCO ≤ C_TCO_5_CFA - C_TCO_HYS_4_CFA

5 - **If** TPS_GRD **>** C_TPS_GRD_ACCIN_OFF *( vehicle take-off detection )*
**and** LV_CT **=** 0
**and** VS **<** C_VS_ACCIN_OFF
**and** N_32 **<** C_N_ACCIN_OFF
**then** LV_RLY_ACCOUT_CTRL and LV_RLY_ACCOUT are disabled immediately
**during** C_ACCIN_DLY_6 seconds

Description:



## Calibration data:

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| C_ACCIN_VS_MAX | 1 | 0...FFH | 0...255 | 1 | km/h |
| Maximum vehicle speed to deactivate the air condition compressor in full load (LV_FL). | | | | | |
| C_TPS_GRD_ACCIN_OFF | 1 | 0...FFH | 0...2988 | 11,71 | °TPS/sec |
| TPS_GRD threshold to detect vehicle take off | | | | | |
| C_VS_ACCIN_OFF | 1 | 0...FFH | 0...255 | 1 | km/h |
| Vehicle speed threshold to detect vehicle take off | | | | | |
| C_N_ACCIN_OFF | 1 | 0...FFH | 0...8160 | 32 | rpm |
| Engine speed threshold to detect vehicle take off | | | | | |
| C_ACCIN_DLY_1 | 1 | 01...FFH | 0,1...25,5 | 0,1 | sec |
| Time delay to deactivate air condition compressor in full load (LV_FL) | | | | | |
| IP_ACCIN_DLY_2__N_32 | 3 | 01...FFFFH | 0,01...655,35 | 0,01 | sec |
| | | | | | |
| Time delay to activate air condition compressor when LV_ACCIN = 1. | | | | | |
| IP_ACCIN_DLY_3__N_32 | 3 | 01...FFFFH | 0,01...655,35 | 0,01 | sec |
| | | | | | |
| Time delay to deactivate air condition compressor when LV_ACCIN = 0. | | | | | |
| C_ACCIN_DLY_4 | 1 | 01...FFH | 0,1...25,5 | 0,1 | sec |
| Time delay to deactivate air condition compressor after Start. | | | | | |
| C_ACCIN_DLY_5 | 1 | 01...FFH | 0,1...25,5 | 0,1 | sec |
| Time delay between two air condition activations. | | | | | |
| C_ACCIN_DLY_6 | 1 | 01...FFH | 0,1...25,5 | 0,1 | sec |
| Time delay between to deactivate air condition compressor in case of vehicle take off. | | | | | |

# 3 Variable intake manifold control

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| LV_VIM | V | 0...01H | 0...1 | 1 | - |
| Boolean for variable intake manifold control state (CLOSED / OPEN). | | | | | |
| LV_VIM_CTRL | V | 0...01H | 0...1 | 1 | - |
| Boolean for variable intake manifold control target state (CLOSED / OPEN). | | | | | |
| T_VIM | V | 0...FFH | 0...25.5 | 0.1 | s |
| Time counter for operation of variable intake manifold control. | | | | | |
| N_32_VIM | V | 0...FFH | 0...8160 | 32 | rpm |
| Engine speed used for variable intake manifold control. | | | | | |
| TPS_VIM | V | 0...FFH | 0...119.5 | 0,4686 | °TPS |
| Throttle angle used for variable intake manifold control. | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| N_32 | TPS | LV_ES | LV_ST |
| LV_ENG_RUN_IS_PL | VB | | |



**FUNCTION DESCRIPTION:**

General information:

The variable intake system is designed to vary the inertia supercharging effect in order to improve the engine torque and the performances. At low engine speed the engine draws the intake air through long tubes to optimize the torque output, whereas at high engine speed shorter tubes are used to increase the power.

Description:

The VIM is initialized to closed position (LV_VIM=0, LV_VIM_CTRL=0) for engine stop (LV_ES =1) and start (LV_ST=1). To operate the VIM a DC-motor, whose speed depends on VB, is activated if LV_VIM_CTRL changes (0 to 1 or 1 to 0). The duration of opening/closing is determined by a counter, which makes a gradually operation possible.

At transition of LV_VIM_CTRL from 0 to 1, which indicates opening (i.e. forward motor speed) the time-counter $T\_VIM_{(n)}$ is increased each 100 msec until it reaches IP_T_VIM__VB, which takes into consideration the dependency on VB.
For closing (i.e. reverse motor speed) the same time-counter is increased until IP_T_VIM__VB at transition of LV_VIM_CTRL from 1 to 0. If the opening time should be different from the closing time, the difference can be calibrated by the correction factor C_T_VIM_FAC, which is apllied to IP_T_VIM__VB if LV_VIM_CTRL = 0.

To avoid too many shiftings, hysteresis on N_32 and TPS are used in both directions.

The application recurrence is **100 msec**.

**Application conditions:**

Available for all engine operating states.

**Formula section:**

** N_32_VIM-calculation:*

**If** LV_ES = 1
**or** LV_ST = 1

**then** N_32_VIM = N_32
**else**

**If** |N_32_VIM - N_32| > C_N_HYS_VIM
**then** N_32_VIM = N_32

| | | |
|---|---|---|
| **If** | LV_VIM =  and LV_VIM_CTRL = 0 | ( VIM closing period) |
| **or** | LV_VIM = 0 and LV_VIM_CTRL = 1 | ( VIM opening period) |
| **then** | N_32_VIM is not updated | |

** TPS_VIM-calculation:*

**If** LV_ES = 1
**or** LV_ST = 1

**then** TPS_VIM = TPS
**else**

**If** |TPS_VIM - TPS| > C_TPS_HYS_VIM
**then** TPS_VIM = TPS

| | |
|---|---|
| **If** | LV_VIM = 1 and LV_VIM_CTRL = 0 ( VIM closing period) |
| **or** | LV_VIM = 0 and LV_VIM_CTRL = 1 ( VIM opening period) |
| **then** | TPS_VIM is not updated |

** VIM-Activation for normal operation:*

**If** LV_ES = 1
**or** LV_ST = 1
**or** VS < C_VS_MIN_VIM

**then** LV_VIM_CTRL = 0
**else** LV_VIM_CTRL = ID_VIM__N_32_VIM__TPS_VIM

**Remark:**
If VB < C_VB_MIN_VIM then the variable intake manifold is not operated.

** VIM-Activation for anti-sticking operation :*

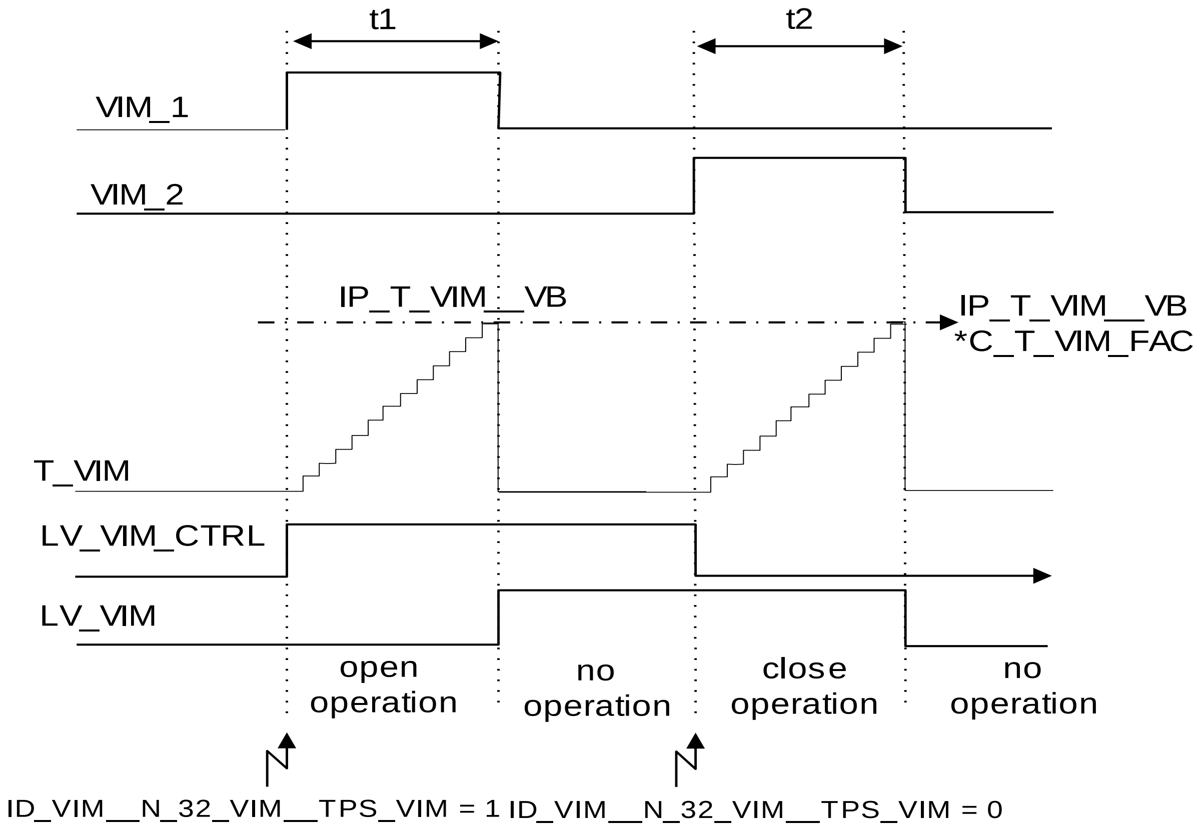
*To avoid valve sticking, it is necessary to open and close the valve only one time after ignition key off is detected during power latch period.*

**If** LV_IGK=0 ( Ignition key off)
**and** LV_ENG_RUN_IS_PL = 1
**and** VB > C_VB_MIN_VIM

**then** LV_VIM_CTRL = 1 during T_VIM period ( VIM opening) and sequentially
LV_VIM_CTRL = 0 during T_VIM period ( VIM closing)

**else** (LV_IGK = 1 detected during VIM operating)
stop activation of VIM immediately
close VIM after engine cranking (LV_ST = 0 and LV_ES = 0)






VIM_1 : opening comand from ECU
VIM_2 : closing comand from ECU

t1 : opening time
t2 : closing time

## Calibration data:

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| ID_VIM__N_32_VIM__TPS_VIM | 8 x 8 | 0...01H | 0...1 | 1 | - |
| Variable intake manifold state versus operating point (N, TPS) | | | | | |
| IP_T_VIM__VB | 6 | 0...FFH | 0...25,5 | 0,1 | s |
| Time to operate variable intake manifold versus VB | | | | | |
| C_N_HYS_VIM | 1 | 0...FFH | 0...8160 | 32 | rpm |
| Engine speed hysteresis to determine variable intake manifold state. | | | | | |
| C_TPS_HYS_VIM | 1 | 0...FFH | 0...119,5 | 0,47 | °TPS |
| Throttle angle hysteresis to determine variable intake manifold state. | | | | | |
| C_T_VIM_FAC | 1 | 0...FFH | 0...1,992 | 0,0078 | - |
| Correction factor for Variable intake manifold closing time . | | | | | |
| C_VB_MIN_VIM | 1 | 0...FFH | 0...25.8984 | 0,10116 | V |
| Battery voltage threshold to determine variable intake manifold state. | | | | | |
| C_VS_MIN_VIM | 1 | 0...FFH | 0...255 | 1 | km/h |
| Vehicle speed threshold to determine variable intake manifold state. | | | | | |

# 4 Evaporative emission control

## 4.1 General



**Input data:**

| | | | |
|---|---|---|---|
| LV_ES | LV_ST | LV_TI_AST | LV_IGA_AST |

The evaporative emission control is closely related to the A/F regulation loop and lambda adaptation.

In some engine operating states, these functions must be controlled in a specific manner.

In the case of A/F regulation loop for an engine with two separate exhaust - system branches, the evaporative emission control mostly interacts with only one of the two lambda controllers (i.e. determination of the charcoal canister saturation degree).

The desired cylinder group is selected using the applicative constant C_CONF_CP , please refer to chapter „General".

Application recurrence **: 100 msec.**
The application recurrence is independent to the control frequency of the CPS.

General information:

The evaporative emission control includes the following partial functions :

** Steady operation :*

- **STB_CP operation** : no purging (evaporative emission control valve closed).
- **MIN operation** : purging with a flow rate for an unknown degree of charcoal canister saturation.
- **NORMAL operation** : purging with a flow rate adapted to the degree of charcoal canister saturation.

** Transient operation :*

- **RAMP mode** : opening and closing the evaporative emission control valve.
- **LEARNING mode** : determination of the charcoal canister saturation degree.

The charcoal - canister purge is performed in all engine operating states except :

- engine stopped (LV_ES)
- engine operating state start (LV_ST)
- post - start function (LV_TI_AST or LV_IGA_AST) is enabled and not over.

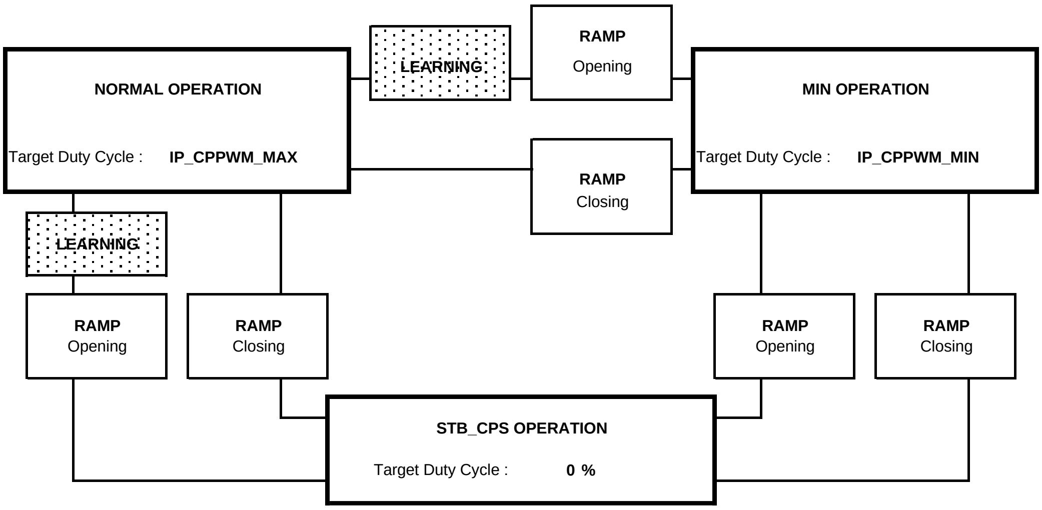
The duty cycle used to adjust the evaporative emission control valve (CPS) is formed of a pre-control value and a correction value during normal operation.

The degree of the charcoal-canister saturation is determined by a defined shift of this correction value by means of evaluating the A/F regulation loop signal.

The unmetered A/F mixture supplied to the engine via the evaporative emission control valve is limited to an applicable value when determining the degree of the charcoal-canister saturation. This is used to control the maximum enrichment of the mixture supplied to the engine.

**Remark :** **If** CONF_LAM = 0
**then** charcoal-canister purge is possible only during MIN operation, due to the fact that the degree of saturation cannot be determined.

<u>Description:</u>



## 4.2 Evaporative emission control valve duty cycle ( CPPWM_CPS )



### Output data:

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| CPPWM_CPS | V | 00...FFH | 0...99.609 | 0.3891 | % |
| Evaporative emission control duty cycle corrected with the characteristic of the valve. | | | | | |

### Input data:

| | | | |
|---|---|---|---|
| CPPWM | VB | LV_STB_PHA_CP | |

### FUNCTION DESCRIPTION:

General information:

The control duty cycle CPPWM_CPS is formed from the opening value duty cycle calculated CPPWM (%), the valve characteristic correction IP_CPPWM_CPS__CPPWM and the battery voltage correction IP_CPPWM_CPS_VB_ADD__VB. To be sure the canister purge valve is closed in Stand-By mode, battery voltage correction is not taken in account in Stand-By mode.



### Formula section:

**If** LV_STB_PHA_CP = 0

**Then**

CPPWM_CPS = IP_CPPWM_CPS__CPPWM + IP_CPPWM_CPS_VB_ADD__VB

**Else**

CPPWM_CPS = IP_CPPWM_CPS__CPPWM

### Calibration data:

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| IP_CPPWM_CPS__CPPWM | 5 | 00...FFH | 0...99.609 | 0.3891 | % |
| Evaporative emission control valve characteristic correction vs. CPPWM. | | | | | |
| IP_CPPWM_CPS_VB_ADD__VB | 8 | 0...FFH | -5...4.961 | 10 / 256 | % |
| Evaporative emission control valve characteristic correction vs. VB. | | | | | |

## 4.3 Evaporative emission control in steady operation ( CPPWM )

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| CPPWM | 1 | 00...FFH | 0...99.609 | 0.3891 | % |
| Evaporative emission control duty cycle calculated. | | | | | |

## 4.4 Evaporative emission control state STB_CP operation

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| LV_STB_PHA_CP | V | 0...01H | 0...1 | 1 | - |
| Evaporative emission control state : STB_CP operation. | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| TCO | LAM_TRA | FAC_CP | CPPWM |
| LV_AUTH_LAM_AD_CP | MAF_FAC_ALTI_MMV | PAT_INH_IV | LV_CPS_ERR |
| L_INH_IV_[CYL] | LV_SOV_MECHA_ERR | LV_SOV_ERR | LV_IS |

**FUNCTION DESCRIPTION:**

General information:

The evaporative emission control valve duty cycle CPPWM and the injection time correction LAM_TRA are not computed in this evaporative emission control state.

**Application conditions:**

* ***STB_CP*** *operation (LV_STB_PHA_CP)* ***:***

**If** TCO ≤ C_TCO_MIN_CP
**or** LV_CPS_ERR **= 1** *(error currently present on evap. emission control valve)*
**or** A/F regulation loop limit reached (lean or rich) for more than C_LAM_MAX_CYCNR
**or** LV_SOV_ERR **= 1** *(error currently present on the shut-off valve)*
**or** LV_SOV_MECHA_ERR **= 1** *(mechanical problem detected on the shut-off valve)*
**or** L_INH_IV_[CYL] **= 1** *(cylinder shut - off active)*
**or** PAT_INH_IV ≠ **0** *(fuel shut-off pattern index status)*
**or** **(**LV_IS = 1
**and** MAF_FAC_ALTI_MMV **<** C_MAF_FAC_ALTI_IS_CP**)** *(high altitude)*

**then** LV_STB_PHA_CP = 1

**Remark :** All these conditions (except the two latest conditions) use the **RAMP** mode in the closing way to reach **STB_CP** operation state.

**Formula section:**

**If** LV_STB_PHA_CP **= 1**

**then** FAC_CP **= 0**
**and** CPPWM **= 0**
**and** LAM_TRA **= 0**
**and** LV_AUTH_LAM_AD_CP **= 1** (Active)

### 4.5 Evaporative emission control state MIN operation

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| LV_MIN_PHA_CP | V | 0...01H | 0...1 | 1 | - |
| Evaporative emission control state : MIN operation. | | | | | |



**Input data:**

| | | | |
|---|---|---|---|
| LV_ISA_i_ERR | LV_LSH_UP_i_ERR | MAF_ALTI_COR | LV_STATE_A_MIS |
| LV_TPS_ERR | LV_TPS_PLAUS_ERR | LV_IV_[CYL]_ERR | CONF_CP |
| LV_MAF_ERR | LV_MAF_PLAUS_ERR | LV_TCO_ERR | LV_TCO_PLAUS_ERR |
| LV_VLS_LIM_i_ERR | LV_TIA_ERR | LV_DUR_IGC_[CYL]_ERR | LV_LSCL_i |
| LV_VLS_UP_i_ERR | CONF_LAM | | |

**FUNCTION DESCRIPTION:**

General information:

The evaporative emission control state **MIN** operation is used when the charcoal - canister must be purged even if the degree of saturation is unknown.

The opening of the evaporative emission control valve is designed to maintain optimal vehicle handling and emission values.

**Application conditions:**

***MIN** operation (LV_MIN_PHA_CP) :*

**If** ~~variant with evaporative emission control, without A/F regulation loop~~(CONF_CP = 1 **and** CONF_LAM = 0)

**or** LV_TCO_ERR**= 1** ← *(error currently present on coolant temp. sensor)*
**or** LV_TCO_PLAUS_ERR**= 1** ← *(plaus. error currently present on coolant temp. sensor)*
**or** LV_TIA_ERR **= 1** ← *(error currently present on air temperature sensor)*
**or** LV_ISA_i_ERR **= 1** ← *(error currently present on idle charge actuator)*
**or** LV_TPS_ERR **= 1** ← *(error currently present on throttle position sensor)*
**or** LV_TPS_PLAUS_ERR **= 1** ← *(error currently present on throttle position sensor)*
**or** LV_MAF_ERR **= 1** ← *(error currently present on mass air - flow sensor)*

**or** LV_MAF_PLAUS_ERR **= 1** ← *(error currently present on mass air - flow sensor)*
**or** LV_VLS_UP_i_ERR **= 1** ← *(error currently present on lambda - probe voltage)*
**or** LV_VLS_LIM_i_ERR **= 1** ← *(error currently present on lambda - probe voltage excursion)*
**or** LV_IV_[CYL]_ERR **= 1** ← *(error currently present on injector output)*
**or** LV_DUR_IGC_[CYL]_ERR **= 1** ← (*error currently present on corresponding ignition output)*
**or** LV_LSH_UP_i_ERR = 1 ← (*error currently present on upstream oxygen sensor heater)*
**or** LV_STATE_A_MIS **= 1** ← (*misfire status CARB A (catalyst damage))*
**or** LV_LSCL_i = 0 ← (*lambda regulation loop of the related bank open)*

**then** LV_MIN_PHA_CP = 1

## Formula section:

A canister purge solenoid CPS with non - linear characteristic needs an altitude compensation. Therefore, a load threshold can be determined to start the correction calculation for CPPWM.

**If** LV_MIN_PHA_CP = 1
**then**

**If** MAF_ALTI_COR **>** IP_MAF_ALTI_COR_MAX_CPS__N_32

**then**

| |
|---|
| CPPWM **=** IP_CPPWM_ALTI_COR_MIN__N_32__MAF_ALTI_COR + C_CPPWM_AS |

*(the applied duty cycle must be altitude - compensated, in order to prevent a prohibitive high lambda deviation due to evaporative emission control)*

**else**

| |
|---|
| CPPWM **=** IP_CPPWM_MIN__N_32__MAF + C_CPPWM_AS |

*(the applied duty cycle needs no altitude compensation)*

### 4.6 Evaporative emission control state NORMAL operation



**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| LV_NORMAL_PHA_CP | V | 0...01H | 0...1 | 1 | - |
| Evaporative emission control state : NORMAL operation. | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| FAC_CP | MAF_ALTI_COR | | |

**FUNCTION DESCRIPTION:**

General information:

The **NORMAL** operation is used when the determination of the degree of charcoal - canister saturation is finished and neither **MIN** operation or **STB_CP** operation are required.

For **NORMAL** operation the duty cycle CPPWM to be applied results from a pre-control map, which is altitude compensated in a defined load range.



**Application conditions:**

*Activation:*

**If** none of the activation conditions for **STB_CP** operation **true**
**and** none of the activation conditions for **MIN** operation **true**
**and** determination of the charcoal - canister saturation degree **not required**.

**then** LV_NORMAL_PHA_CP = 1

**Formula section:**

**If** LV_NORMAL_PHA_CP = 1
**then**

**If** MAF_ALTI_COR **>** IP_MAF_ALTI_COR_MAX_CPS__N_32

**then**

CPPWM **=** (IP_CPPWM_ALTI_COR_MAX__N_32__MAF_ALTI_COR + C_CPPWM_AS) * FAC_CP

*(the applied duty cycle must be altitude - compensated, in order to prevent a prohibitive high lambda deviation due to evaporative emission control)*

**else**

CPPWM = ( IP_CPPWM_MAX__N_32__MAF + C_CPPWM_AS ) * FAC_CP

*(the applied duty cycle needs no altitude compensation)*

## Calibration data:

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| IP_CPPWM_ALTI_COR_MIN__N_32__MAF_ALTI_COR | 7 x 8 | 0...FFH | 0...99.61 | 0.39 | % |
| Evaporative emission control duty cycle in MIN operation. | | | | | |
| IP_CPPWM_ALTI_COR_MAX__N_32__MAF_ALTI_COR | 7 x 8 | 0...FFH | 0...99.61 | 0.39 | % |
| Evaporative emission control duty cycle in NORMAL operation. | | | | | |
| IP_MAF_ALTI_COR_MAX_CPS__N_32 | 3 | 0...FFH | 0...1389 | 5.4471 | mg/TDC |
| Mass air flow threshold to apply the altitude compensation on CPPWM calculation. | | | | | |
| C_CPPWM_AS | 1 | 80...7FH | -50...49.609 | 0.3891 | % |
| Global correction for CPS duty cycle control with Application System. | | | | | |
| C_MAF_FAC_ALTI_IS_CP | 1 | 0...FFH | 0...1.992 | 7.78 E-3 | - |
| Mass air flow threshold of MAF_FAC_ALTI_MMV in idle for activation conditions of STB_CP operation. | | | | | |
| C_LAM_MAX_CYCNR | 1 | 0...FFH | 0...255 | 1 | msec |
| Time delay of the A/F regulation loop on limit for activation conditions of STB_CP operation (x 20 msec). | | | | | |
| C_TCO_MIN_CP | 1 | 0...FEH | -48...142.5 | 0.75 | ° C |
| Coolant temperature threshold for activation conditions of STB_CP operation. | | | | | |
| IP_CPPWM_MIN__N_32__MAF | 7 x 8 | 0...FFH | 0...99.61 | 0.39 | % |
| Evaporative emission control duty cycle in MIN operation. | | | | | |
| IP_CPPWM_MAX__N_32__MAF | 7 x 8 | 0...FFH | 0...99.61 | 0.39 | % |
| Evaporative emission control duty cycle in NORMAL operation. | | | | | |

## 4.7 Evaporative emission control duration ( T_CP )

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| T_CP | V | 01...FFFFH | 0.1...6553.5 | 0.1 | sec |
| Evaporative emission control duration. | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| LV_ST | LV_PL | LV_IS | LV_AUTH_LAM_AD_CP |
| LAM_MV_BEG | | | |

**FUNCTION DESCRIPTION:**

General information:

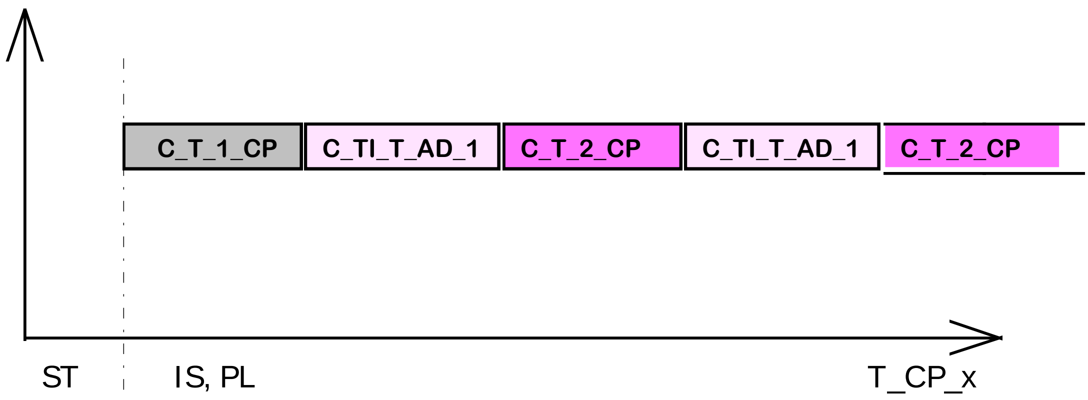
The evaporative emission control process is divided into time ranges : Injection time adaptation and canister purge are active alternatively.

Time range T_CP starts following the transition from the engine operating state Start (LV_ST) to Idle (LV_IS) or Part Load (LV_PL) with C_T_1_CP (Canister purge active). This time range is followed by the alternating time ranges C_TI_T_AD_1 (Injection time adaptation active) and C_T_2_CP (Canister purge active).

At the beginning of the C_TI_T_AD_1 time ranges, the evaporative emission control valve is closed via the **RAMP** mode and the lambda adaptation can be performed (LV_AUTH_LAM_AD_CP **= 1** (Active)).

The maximum duration of **NORMAL** operation is therefore time T_CP minus the time required to determine the charcoal - canister saturation degree (**LEARNING** mode).

Under certain conditions, **NORMAL** operation is intercepted when **STB_CP** operation or **MIN** operation is required or for instance, when a determination of the charcoal - canister saturation degree is required.



This pre-defined time sequence for injection time adaptation and canister purge can be modified in case of big TI_LAM deviation. If LAM_MV_BEG is out of pre-defined limits, injection time adaptation is immediately activated.

**If** $|$LAM_MV_BEG$|$ **>** C_LAM_MV_BEG_MAX
**Then**
T_CP is reseted and swiches to the next sequence (injection time adaptation C_TI_T_AD_1)

**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| C_T_1_CP | 1 | 01...FFFFH | 0.1...6553.5 | 0.1 | sec |
| Duration after start to perform the evaporative emission control process. | | | | | |
| C_T_2_CP | 1 | 01...FFFFH | 0.1...6553.5 | 0.1 | sec |
| Duration to perform a purging phase on NORMAL or MIN operation. | | | | | |
| C_TI_T_AD_1 | 1 | 01...FFFFH | 0.1...6553.5 | 0.1 | sec |
| Duration to perform the lambda adaptation without purging evaporative emission. | | | | | |
| C_LAM_MV_BEG_MAX | 1 | 8000...FFFFH | 0...49.998 | 1.526E-3 | % |
| Maximum LAM_MV_BEG absolute value to perform canister saturation degree determination | | | | | |

## 4.8 Evaporative emission control in transient operation ( FAC_CP )

### 4.8.1 Evaporative emission control mode : RAMP mode

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| FAC_CP | V | 00...FFH | 0...1.000 | 3.906E-3 | - |
| Opening or closing ramp slope of the evaporative emission control valve. | | | | | |
| FAC_BEG_CP | V | 00...FFH | 0...1.000 | 3.906E-3 | - |
| Ramp slope initialisation of the evaporative emission control valve. | | | | | |
| LV_SLOP_CP | V | 0...01H | 0...1 | 1 | - |
| Evaporative emission control state : RAMP mode. | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| IP_CPPWM_MAX__N__MAF | IP_CPPWM_MIN__N__MAF | CPPWM | LV_LAM_LIM_CDN |



**FUNCTION DESCRIPTION:**

General information:

The **RAMP** mode serves as a transition function between the three different steady states of the evaporative emission control process (**STB_CP** operation, **NORMAL** operation, **MIN** operation) in the opening or closing way.

The duty cycle CPPWM during **RAMP** mode is calculated like in **NORMAL** operation with the difference that FAC_CP is variable by decrement or increment.

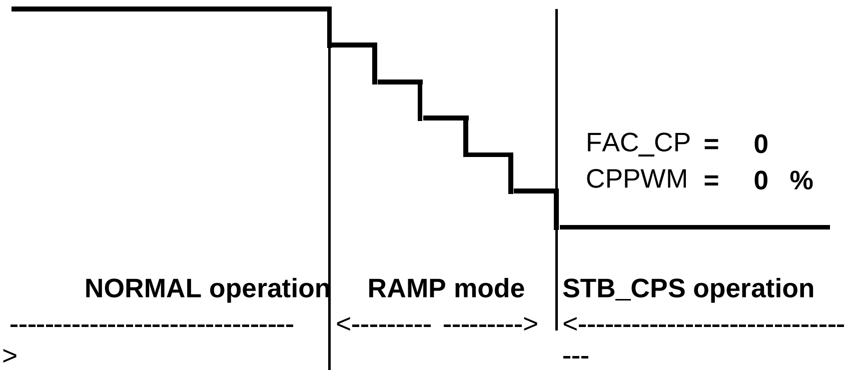
During **RAMP** mode LV_SLOP_CP = 1.

**Application conditions:**

- Exit to : **STB_CP** operation

## Closing ramp :

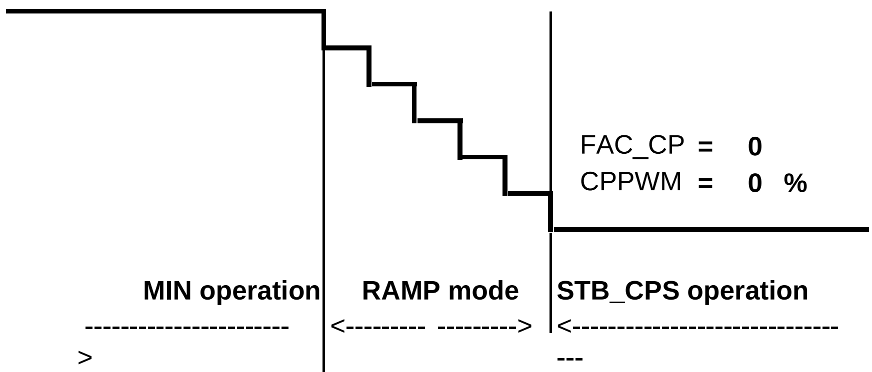
CPPWM ----> **IP_CPPWM_MAX__N__MAF**




FAC_CP (n) = FAC_CP (n-1) - IP_FAC_DEC_CP__MAF_KGH * IP_FAC_FAC_DEC

## Closing ramp :

CPPWM ----> **IP_CPPWM_MIN__N__MAF**




FAC_CP (n) = FAC_CP (n-1) - IP_FAC_DEC_CP__MAF_KGH

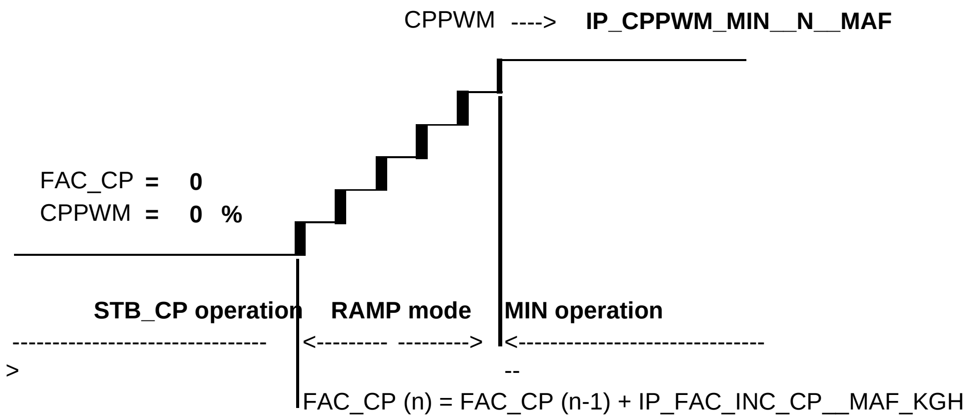
$CPPWM_{(n)}$ **=** $CPPWM_{(n-1)}$ * FAC_CP

If no value FAC_CP is available upon entry in **RAMP** mode (i.e. previous operation state was **MIN** operation), FAC_CP is computed with FAC_BEG_CP as follows :

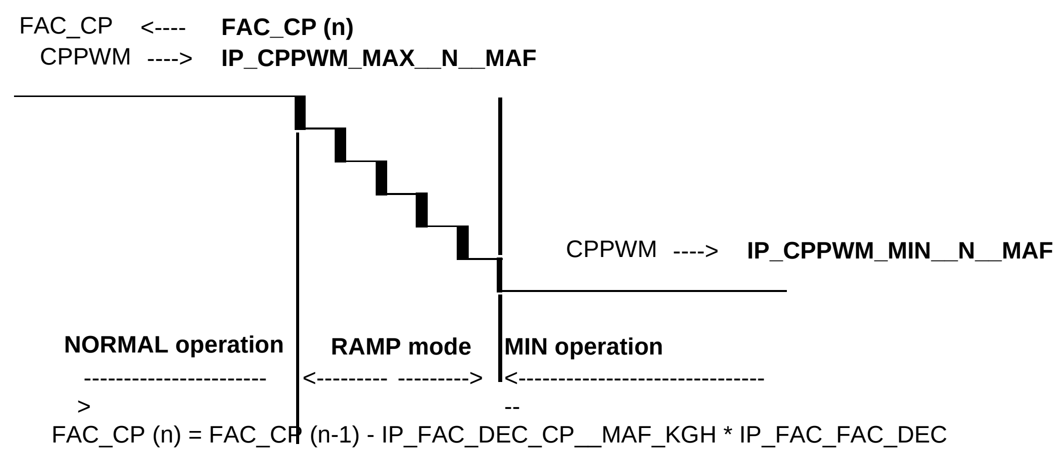
FAC_BEG_CP**=** $CPPWM_{(n-1)}$ / IP_CPPWM_MAX__N__MAF

- Exit to : **MIN** operation

**Opening ramp :**




**Closing ramp :**




$CPPWM_{(n)} = CPPWM_{(n-1)} * FAC\_CP$

**<u>Formula section:</u>**

** Opening ramp :*
$FAC\_CP_{(n)} = FAC\_CP_{(n-1)} + IP\_FAC\_INC\_CP\_\_MAF\_KGH$

* Closing ramp :
$FAC\_CP_{(n)} = FAC\_CP_{(n-1)} - IP\_FAC\_DEC\_CP\_\_MAF\_KGH$

Remark: the closing ramp decrement is multiplied with a factor, if a saturation degree is available, that means Normal-mode was active before closing ramp.

**Remark :**

- The decrement and increment are applied as a function of mass air flow and are mutually independent.

- If the lambda controller reaches its own limits (LV_LAM_LIM_CDN = 1), then FAC_CP is weighted with C_COR_FAC_INC_CP only during **LEARNING** mode with **RAMP** opening.

- The decrement of the closing ramp is multiplied with a saturation-degree-depending factor to make the closing time shorter with lower saturation degrees.

- If the CPPWM reaches during closing ramp C_CPPWM_CLOSE then CPPWM is closed immediately and FAC_CP and LAM_TRA are set to 0.

**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| IP_FAC_INC_CP__MAF_KGH | 8 | 00...FFH | 0...1.000 | 3.906E-3 | - |
| Incrementation of the ramp slope for opening the evaporative emission control valve CPS. | | | | | |
| IP_FAC_DEC_CP__MAF_KGH | 8 | 00...FFH | 0...1.000 | 3.906E-3 | - |
| Decrementation of the ramp slope for closing the evaporative emission control valve CPS. | | | | | |
| C_COR_FAC_INC_CP | 1 | 00...FFH | 0...0.996 | 3.891E-3 | - |
| Weighting factor for FAC_CP when the lambda controller reaches its limits. | | | | | |
| IP_FAC_FAC_DEC | 6 | 0...FFH | 0...31,875 | 0,125 | - |
| LAM_MV_DIF_CP | | | | | |
| Factor for closing ramp decrement, depending on saturation degree. | | | | | |
| C_CPPWM_CLOSE | 1 | 0...FFH | 0...99,6 | 0,3891 | % |
| Threshold for immediately closing CPS | | | | | |

## 4.9 Evaporative emission control mode : LEARNING mode

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| LAM_MV_DIF_CP | V | 00...FFFFH | -50...49.998 | 1.526E-3 | % |
| Degree of the charcoal - canister saturation. | | | | | |
| LAM_MV_DIF_CP_LD | V | 00...FFFFH | -50...49.998 | 1.526E-3 | % |
| Degree of the charcoal - canister saturation for fuel system diagnosis inhibition. | | | | | |
| LV_LEARN_CP | V | 0...01H | 0...1 | 1 | - |
| Evaporative emission control state : LEARNING mode. | | | | | |
| LAM_MV_BEG | V | 0...FFFFH | -50...49.998 | 1.526E-3 | % |
| Value of LAM_MV at the beginning of RAMP mode | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| TI_LAM_i | LAM_MV_i | LAM_MV_DIF_COR_CP | CPPWM |
| FAC_BEG_CP | IP_CPPWM_MIN__N__MAF | LAM_TRA | LV_PUC |
| LV_FL | IP_CPPWM_MAX__N__MAF | T_CP | FAC_CP |
| IP_LAM_CP__N_32__MAF_ALTI_COR | LV_AUTH_LAM_i_AD_LEARN_CP | N_32 | MAF_ALTI_COR |

**FUNCTION DESCRIPTION:**

**Application conditions:**

Target duty cycle : **NORMAL** operation (IP_CPPWM_MAX__N__MAF)

The determination of the charcoal-canister saturation degree is **required** and **possible** in **STB_CP** operation and **MIN** operation.

**If**

*The determination of the charcoal - canister saturation degree is **required** :*

**If** ( time range T_CP starts ( T_CP **=** C_T_2_CP ) and **STB_CP** operation or **MIN** operation has been triggered before )
**or** TI_LAM_i$_{(n)}$ **<** C_LAM_MIN_CP is detected in **NORMAL** operation
**or** $|$LAM_MV_DIF_COR_CP$_{(n)}|$ **>** C_LAM_MV_DIF_COR_MAX_CP is detected in **NORMAL** operation.

*The determination of the charcoal - canister saturation degree is **possible** if :*

**If** LV_LAM_ACT_i **= 1** (Active)
*(lambda controller operability in its own limits)*
**and** LV_LS_i **= 1** (Active)
*(A/F regulation oxygen sensor operability effective)*
**and** LV_N_MAF_DYW_i **= 1** (Active)
*(engine speed and load dynamics condition status)*
**and** C_CPPWM_AD_MIN **<** IP_CPPWM_MAX__N__MAF **<** C_CPPWM_AD_MAX
*(determination of the charcoal - canister saturation degree only in useful load range)*
**and** IP_LAM_CP__N_32__MAF_ALTI_COR ≥ C_LAM_TRA_STATE_MIN
*(consideration of altitude influence for purging capability)*

**then** LV_LEARN_CP = 1

## General information:

The determination of the charcoal - canister saturation degree is performed according to the following actions :

**1 -** determination of the A/F regulation loop value LAM_MV_BEG **=** LAM_MV$_{(n)}$ with the evaporative emission control valve completely or partially closed.
(stabilisation for LAM_MV_BEG determination with waiting for C_FAC_MIN_P_CP - p-jumps
and
injection time adaptation LV_AUTH_LAM_i_AD_LEARN_CP **= 1** (Active) )

**2 -** defined opening of the evaporative emission control valve (**RAMP** mode).

**3 -** determination of the A/F regulation loop value LAM_MV$_{(n)}$ with the evaporative emission control valve open.

( LAM_MV$_{(n)}$ - LAM_MV_BEG ) is representative of the charcoal-canister saturation degree

This determination operates only in a quasi - stationary suitable operating point for the engine. (refer to the section " *Activation of the learning mode* ")

The tuning of the ramp slope must assume that the A/F ratio controller can compensate the deviation of the lambda, which results from the purge flow rate through the evaporative emission control valve.

The determination of the charcoal - canister saturation degree is most accurate when the evaporative emission control valve is completely closed at the beginning.

However, in some cases, it makes sense to only close the evaporative emission control valve to duty cycle in **MIN** operation, in order to obtain the necessary charcoal - canister purge rate.

## Application conditions:

- First determination of the charcoal - canister saturation degree :

The first determination of the charcoal - canister saturation degree begin only from **STB_CP** operation (CPPWM = 0 %) and within T_CP, as long as C_SUM_STATE_MAX has been reached (maximum number of attempts to determine the charcoal - canister saturation degree).

The corresponding counter is incremented when a determination of the charcoal - canister saturation degree has been aborted after computation of LAM_MV_BEG.

- Initialisation value FAC_BEG_CP of FAC_CP for each determination of the charcoal - canister saturation degree :

**.** From **STB_CP** operation **:**
FAC_BEG_CP **= 0**

**.** From **MIN** operation (only when C_SUM_STATE_MAX has been reached)
FAC_BEG_CP **=** $CPPWM_{(n-1)}$ / IP_CPPWM_MAX__N__MAF

**Formula section:**



- Sequence for determination of charcoal - canister saturation degree :

1 - Activation conditions for **LEARNING** mode enabled

2 - Determine LAM_MV_BEG

3 - Opening evaporative emission control valve using **RAMP** mode.
The opening **RAMP** cannot be stopped until there is a minimum opening of the evaporative emission control valve in order to get a reliable result :

$FAC\_CP_{(n)} / (FAC\_CP_{(n)} - FAC\_BEG\_CP) \leq C\_FAC\_CP\_LD\_MAX$

If during **LEARNING** mode this condition is fulfilled, there are several possibilities to stop the **RAMP** mode :

**If** FAC_CP **= 1**
**or** [ $FAC\_CP_{(n)}$ / ($FAC\_CP_{(n)}$ - FAC_BEG_CP)] **<=** C_FAC_CP_LD_MAX
**and** A/F regulation loop limit is reached

**or** $|TI\_LAM_{(n)} + LAM\_TRA - LAM\_MV\_BEG|$
$\geq$ IP_LAM_DIF_MAX_CP__N_32__MAF_ALTI_COR

4 - The lambda deviation is shifted to LAM_TRA for the first time if :
( LAM_MV_BEG- TI_LAM$_{(n)}$ ) **>** C_LAM_DIF_MAX_TRA

The lambda controller is shifted of the equivalent LAM_TRA.
This process is activated every time the lambda deviation is more than C_LAM_DIF_MAX_TRA.
There will be a deviation of the lambda controller if the charcoal - canister is not totally empty.
Thus, it is possible to minimize the lambda deviation if there is any load condition changing during the **RAMP** opening.

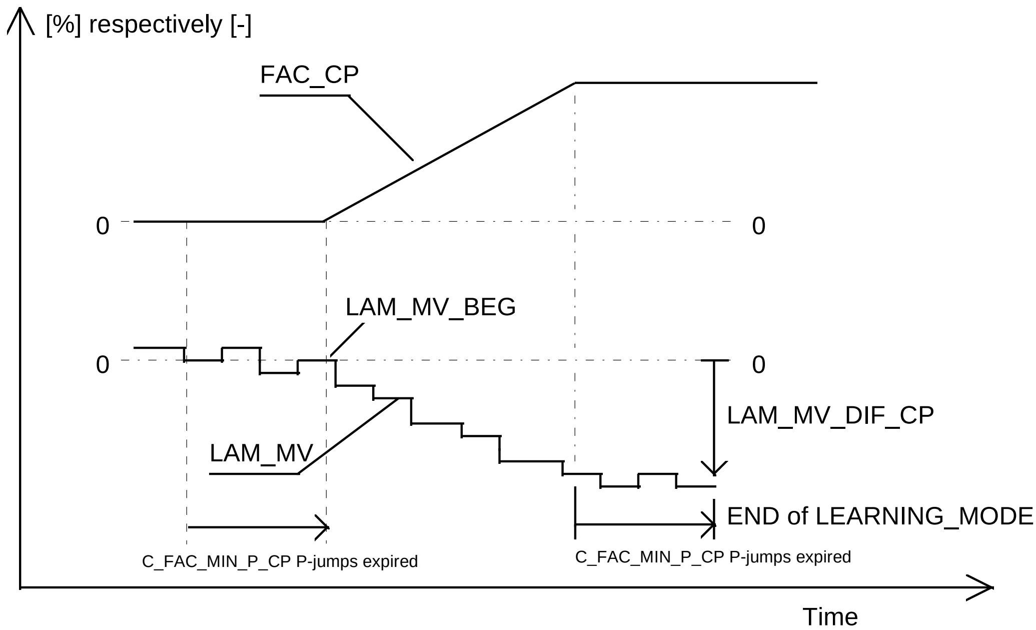
5 - At the end of **RAMP** operation, stabilisation (limited LAM (n) dynamics condition) for C_FAC_MIN_P_CP * P-jumps of the A/F regulation loop.

| |
|---|
| LAM_MV_DIF_CP$_{(n)}$ = ( LAM_MV$_{(n)}$ + LAM_TRA - LAM_MV_BEG ) x [ FAC_CP$_{(n)}$ / (FAC_CP$_{(n)}$ - FAC_BEG_CP) ] |

6 - Limitation of positive lambda deviation :
LAM_MV_DIF_CP$_{(n)}$ ≤ C_LAM_MV_DIF_MAX_1_CP

7 - Fuel system diagnosis interface :
LAM_MV_DIF_CP_LD **=** LAM_MV_DIF_CP$_{(n)}$

8 - LAM_MV_DIF_COR_CP is initialized with 0 at the end of the ramp.



**Remark :**

- The opening ramp is complete at the latest when FAC_CP = 1.

- If the A/F regulation loop is open during the **RAMP** mode (trailing throttle fuel cut off (LV_PUC full load (LV_FL) ...), the **RAMP** mode is aborted, FAC_CP and TI_LAM are retained and a timer C_T_LAM_MAX_STATE is started.
If the A/F regulation loop is closed again before expiration of this timer, the **RAMP** is continued.

Otherwise, depending of the activation conditions, the evaporative emission control valve is totally closed to **STB_CP** operation ( CPPWM = 0 % ) without **RAMP** mode or partially to **MIN** operation ( IP_CPPWM_MIN__N__MAF ) with **RAMP** mode.

- If a new determination of the charcoal - canister saturation degree is requested then LAM_MV_MMV**=** LAM_MV_BEG **=** LAM_MV and LAM_MV_DIF_COR_CP **= 0.**



**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| C_SUM_STATE_MAX | 1 | 0...FFH | 0...255 | 1 | - |
| Maximum number of attempts to determine the charcoal - canister saturation degree. | | | | | |
| C_FAC_MIN_P_CP | 1 | 0...FFH | 0...255 | 1 | - |
| Counter to validate the limited N / MAF dynamics condition. | | | | | |
| C_T_LAM_MAX_STATE | 1 | 01...FFH | 0.1...25.5 | 0.1 | sec. |
| Maximum value of the timer to enable again the ramp when A/F regulation loop has been opened. | | | | | |
| C_LAM_MV_DIF_MAX_1_CP | 1 | B000...5000H | -31.25...31.25 | 0.0015 | % |
| LAM_MV_DIF_CP high threshold in RAMP mode for LEARNING mode | | | | | |
| IP_LAM_DIF_MAX_CP | 7*8 | 1...FFFFH | 0...99,6 | 0.0015 | % |
| LAM_DIF_CP high threshold in RAMP mode for LEARNING mode. | | | | | |
| C_LAM_DIF_MAX_TRA | 1 | 8000...D000H | 0...31.25 | 0.0015 | % |
| LAM_DIF condition to shift LAM_TRA during LEARNING mode. | | | | | |
| C_FAC_CP_LD_MAX | 1 | 0100...0500H | 1...5 | 1 / 256 | - |
| Minimum factor for reliable opening of the evaporative emission control valve. | | | | | |
| C_LAM_TRA_STATE_MIN | 1 | 01...4000H | 0.00...0.25 | 0.000015 3 | - |
| Weighting factor threshold for the injection time correction LAM_TRA. | | | | | |
| C_CPPWM_AD_MAX | 1 | 00...FFH | 0...99.609 | 0.3891 | % |
| High threshold of the purging duty cycle for activation conditions of LEARNING mode. | | | | | |
| C_CPPWM_AD_MIN | 1 | 00...FFH | 0...99.609 | 0.3891 | % |
| Low threshold of the purging duty cycle for activation conditions of LEARNING mode. | | | | | |
| C_LAM_MIN_CP | 1 | 3000...8000H | -31.25...0 | -0.00153 | % |
| LAM threshold for activation conditions of LEARNING mode. | | | | | |
| C_LAM_MV_DIF_COR_MAX_CP | 1 | 8000...D000H | 0...31.25 | 0.00153 | % |
| LAM_MV_DIF_COR_CP threshold for activation conditions of LEARNING mode. | | | | | |

## 4.10 Injection time correction with evaporative emission control ( LAM_TRA )



### Output data:

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| LAM_TRA | V | 0...FFH | -50...49.609 | 0.39 | % |
| Injection time correction. | | | | | |
| LAM_MV_i | V | 0...FFH | -50...49.609 | 0.39 | % |
| Moving average value of LAM. | | | | | |
| LAM_MV_MMV | V | 4000...C000H | -25...24.9985 | 0.0015 | % |
| Moving average value of LAM_MV. | | | | | |
| LAM_MV_MMV_DIF | V | 00...FFFFH | -50...49.998 | 1.526E-3 | % |
| LAM_MV_MMV deviation in NORMAL operation used for updating injection time correction LAM_TRA. | | | | | |
| LAM_MV_DIF_COR_CP | V | 3000...D000H | -31.25...31.25 | 0.00153 | % |
| LAM_MV_MMV-deviation during Normal-operation for request of a new learning | | | | | |

### Input data:

| | | | |
|---|---|---|---|
| LAM_MV_DIF_CP | IP_CPPWM_MAX__N__MAF | CPPWM | C_LAM_TRA_STATE_MIN |
| MAF | C_LAM_MV_DIF_COR_MAX_CP | TI_LAM | C_LAM_DIF_MAX_TRA |
| MAF_KGH | IP_CPPWM_MIN__N__MAF | MAF_ALTI_COR | IP_CPPWM_ALTI_COR_MAX__N_32__MAF_ALTI_COR |
| LAM_MV_BEG | LV_LS_i | LV_N_MAF_DYW_i | LV_LAM_ACT_i |
| N_32 | | | |



### FUNCTION DESCRIPTION:

General information:

The injection time correction due to the mixture influence from the evaporative emission control is performed only in the **NORMAL** operation state, following the **LEARNING** mode.

During tuning activity in **NORMAL** operation, a variable set value is determined for the A/F regulation loop controller.

This set value is stored in a table IP_LAM_CP__N_32__MAF_ALTI_COR depending on engine operating point.

It corresponds to the real lambda deviation if the evaporative emission control valve is controlled with IP_CPPWM_ALTI_COR_MAX__N_32__MAF_ALTI_COR or IP_CPPWM_MAX__N_32__MAF and the charcoal - canister totally saturated.

For the calculation of LAM_TRA the result of the **LEARNING** mode LAM_MV_DIF_CP is weighted for different load condition.

**Formula section:**

*1 - Injection time correction :*

LAM_TRA **=** LAM_MV_DIF_CP$_{(n)}$ * IP_LAM_CP$_{(0)}$ / IP_LAM_CP$_{(n)}$

(0) : current value

(n) : last determination of LAM_MV_DIF_CP

**If** MAF_ALTI_COR **>** IP_MAF_ALTI_COR_MAX_CPS__N_32

**then** IP_LAM_CP = IP_LAM_CP__N_32__MAF_ALTI_COR

**else** IP_LAM_CP = IP_LAM_CP__N_32__MAF

The calculation of LAM_TRA is activated the first time during **LEARNING** mode and is continued until the end of **NORMAL** operation.

At the end of **NORMAL** operation, LAM_TRA is decremented step by step.
*(refer to “Injection time correction LAM_TRA during RAMP operation”)*

All changes of LAM_TRA which are not compensated by shift of the lambda controller in the opposite direction are limited in speed by the gradient limitation IP_LAM_TRA_LGRD__MAF_KGH.

*2 - Weighting of the injection time correction :*

2.1 - Injection time correction LAM_TRA during **RAMP** operation :

**a -** During opening **RAMP** and the first **LEARNING** mode, the following calculations are performed if ( LAM_MV_BEG - LAM$_{(n)}$ ) **>** C_LAM_DIF_MAX_TRA :

LAM_MV_DIF_CP **=** C_LAM_DIF_MAX_TRA

**and** LAM_TRA**=** LAM_MV_DIF_CP$_{(n)}$ * IP_LAM_CP$_{(0)}$ / IP_LAM_CP$_{(n)}$

TI_LAM$_{(n)}$ , LAM_MV$_{(n)}$ and LAM_MV_MMV$_{(n)}$ are shifted in the opposite direction.

**b -** The next time where ( LAM_MV_BEG - TI_LAM$_{(n)}$ ) **>** C_LAM_DIF_MAX_TRA the following calculation is activated :

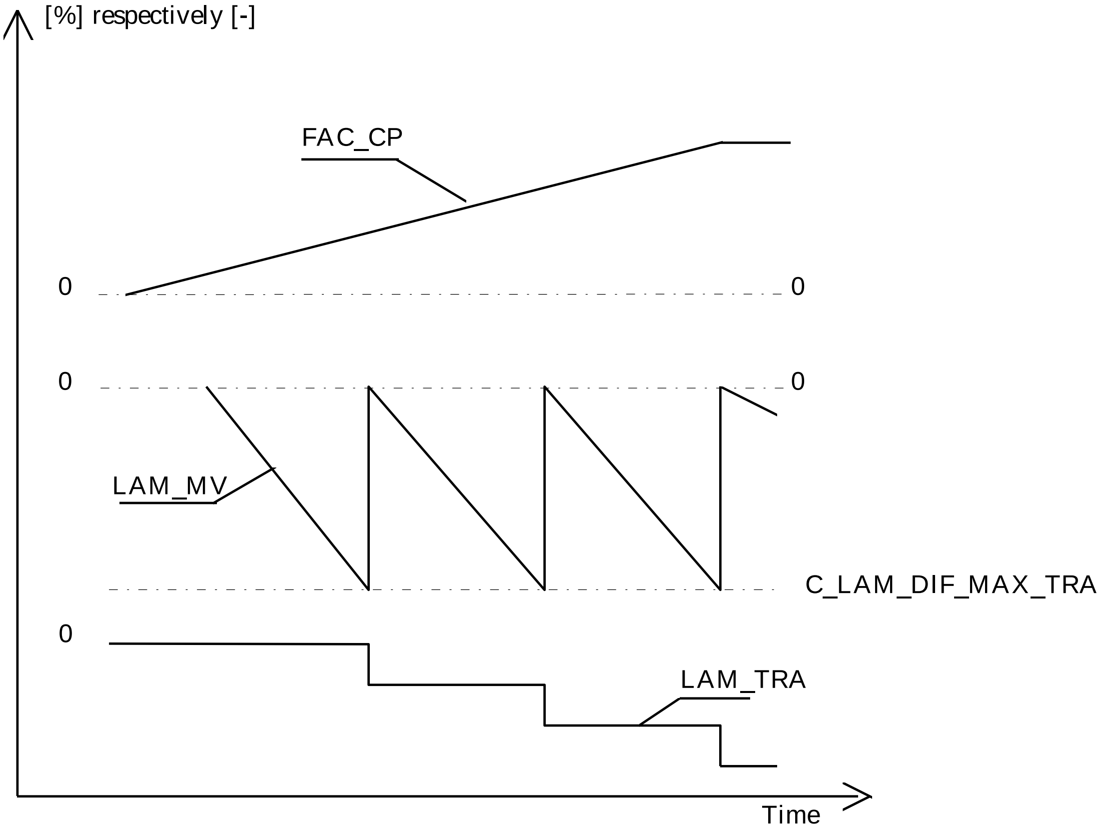
**1 -** LAM_TRA **=** ( LAM_MV_DIF_CP$_{(n)}$ * IP_LAM_CP$_{(0)}$ / IP_LAM_CP$_{(n)}$ ) - C_LAM_DIF_MAX_TRA

**2 -** IP_LAM_CP(n) is updated and LAM_MV_DIF_CP **=** LAM_TRA.

The same algorithm is performed as long as the lambda deviation is higher than C_LAM_DIF_MAX_TRA.

LAM_TRA during RAMP mode.





### 2.2 - Injection time correction LAM_TRA during **NORMAL** operation :

When the charcoal - canister saturation degree changes during **NORMAL** operation, the injection time correction LAM_TRA must be corrected.
This change is detected by observing the A/F regulation loop controller mean value LAM_MV at suitable operating points.

For this purpose, the floating average LAM_MV_MMV of the lambda - controller mean value LAM_MV is calculated under the following conditions :

**NORMAL** operation active

**and** limited lambda dynamics condition exists for more than one P jump
**and** C_MAF_LAM_BOL_TRA **<** MAF_KGH **<** C_MAF_LAM_TOL_TRA
**and** CPPWM **> 0**
**and** IP_LAM_CP__N_32__MAF_ALTI_COR ≥ C_LAM_TRA_STATE_MIN

**then** At the beginning of **NORMAL** operation :
- LAM_TRA is applied
- Initialisation of LAM_MV_MMV and LAM_MV_BEG with LAM_MV
- Initialisation of LAM_MV_DIF_COR_CP with 0

$$LAM\_MV\_MMV_{(n)} = LAM\_MV\_MMV_{(n-1)} + (LAM\_MV_{(n)} - LAM\_MV\_MMV_{(n-1)}) * C\_LAM\_MV\_CRLC$$

During **NORMAL** operation :
- Calculation of LAM_MV_MMV_DIF :

$$LAM\_MV\_MMV\_DIF_{(n)} = LAM\_MV\_BEG - LAM\_MV\_MMV_{(n)}$$

- Calculation of LAM_MV_ DIF_COR_CP :

$$LAM\_MV\_DIF\_COR\_CP_{(n)} = LAM\_MV\_DIF\_COR\_CP_{(n-1)} - LAM\_MV\_MMV\_DIF_{(n)}$$

**If** $|LAM\_MV\_MMV\_DIF_{(n)}|$ **>** C_LAM_MV_MMV_DIF_CP
**then** $LAM\_MV\_DIF\_CP_{(n)} = LAM\_MV\_DIF\_CP_{(n-1)} - LAM\_MV\_MMV\_DIF_{(n)}$
**and** LAM_TRA is corrected by applying $LAM\_MV\_DIF\_CP_{(n)}$ ,
shifting $TI\_LAM_{(n)}$, $LAM\_MV_{(n)}$ and $LAM\_MV\_MMV_{(n)}$.
So that the result is $LAM\_MV\_MMV\_DIF_{(n)}$ **= 0**.

In this way, the process can repeat itself several times within **NORMAL** operation.

**Limitation :**

The total correction of LAM_MV_DIF_CP (LAM_MV_MMV_DIF **=** LAM_MV_DIF_COR_CP) within one **NORMAL** operation cycle is stored and compared to a limit.

**If** $|$LAM_MV_DIF_COR_CP$|$ **>** C_LAM_MV_DIF_COR_MAX_CP
**then** the **NORMAL** operation state is disabled, and a new determination of the degree of charcoal - canister saturation is required.

2.3 - Injection time correction LAM_TRA during **RAMP** closing :

Beginning with the closing , LAM_TRA is also decremented step by step and the maximum decrement is C_LAM_DIF_MAX_TRA.

**a -** $|$LAM_TRA$|$ ≤ C_LAM_DIF_MAX_TRA

In this case, the injection time correction LAM_TRA is set to 0 just from the beginning of the **RAMP** closing.

**b -** $|$LAM_TRA$|$ **>** C_LAM_DIF_MAX_TRA

In this case, the injection time correction LAM_TRA is computed as following :

$$\boxed{\text{LAM\_TRA} = (\text{LAM\_MV\_DIF\_CP}_{(n)} * \text{IP\_LAM\_CP}_{(0)} / \text{IP\_LAM\_CP}_{(n)}) + \text{C\_LAM\_DIF\_MAX\_TRA}}$$

For the further steps IP_LAM_CP$_{(n)}$ is updated and LAM_MV_DIF_CP$_{(n)}$ is set to the new LAM_TRA value.

This results in a deviation of the lambda controller in the positive direction. With the gradually **RAMP** closing, the lambda controller will reach the value LAM_MV_BEG from the beginning of the **LEARNING** mode.
If this value is reached, the LAM_TRAwill be decremented in the same way like the first **RAMP** closing.
Latest, if the final duty cycle of the **RAMP** closing is reached, or the **RAMP** mode is finished in any other way, the remaining LAM_TRA value is set to 0.

For each shift of LAM_TRA, the values of LAM$_{(n)}$ , LAM_MV$_{(n)}$ , LAM_MV_MMV$_{(n)}$ are switched in the opposite direction.

## Calibration data:

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| C_MAF_LAM_BOL_TRA | 1 | 0...FFFFH | 0...16383.75 | 0.25 | kg / h |
| MAF low threshold to weight the injection time correction LAM_TRA. | | | | | |
| C_MAF_LAM_TOL_TRA | 1 | 0...FFFFH | 0...16383.75 | 0.25 | kg / h |
| MAF high threshold to weight the injection time correction LAM_TRA. | | | | | |
| C_LAM_MV_CRLC | 1 | 0...FFH | 0...0.996 | 0.0039 | - |
| Correlation factor for LAM_MV_MMV calculation. | | | | | |
| C_LAM_MV_MMV_DIF_CP | 1 | 8000...D000H | 0...31.25 | 0.001275 | % |
| Intermediate threshold for updating injection time correction in NORMAL operation. | | | | | |
| IP_LAM_TRA_LGRD__MAF_KGH | 8 | 01...4000H | 0.000015...0.25 | 0.000015 | - |
| Gradient limitation for LAM_TRA. | | | | | |
| IP_LAM_CP__N_32__MAF_ALTI_COR | 7 x 8 | 01...FFFFH | 0...1 | 0.000015<br>3 | - |
| Weighting factor for the injection time correction LAM_TRA. | | | | | |
| IP_LAM_CP__N_32__MAF | 7 x 8 | 01...FFFFH | 0...1 | 0.000015<br>3 | - |
| Weighting factor for the injection time correction LAM_TRA. | | | | | |

## 4.11 Influence of the evaporative emission control on lambda adaptation

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| LV_AUTH_LAM_AD_CP | V | 0...01H | 0...1 | 1 | - |
| Boolean information for lambda adaptation out of LEARNING mode. | | | | | |
| LV_AUTH_LAM_1_AD_LEARN_CP | V | 0...01H | 0...1 | 1 | - |
| Boolean information for lambda adaptation during LEARNING mode with CPPWM = 0 for lambda controller n° 1. | | | | | |
| LV_AUTH_LAM_2_AD_LEARN_CP | V | 0...01H | 0...1 | 1 | - |
| Boolean information for lambda adaptation during LEARNING mode with CPPWM = 0 for lambda controller n° 2. | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| LV_STB_PHA_CP | LV_MIN_PHA_CP | LV_NORMAL_PHA_CP | LV_SLOP_CP |
| LV_LEARN_CP | CPPWM | | |



**FUNCTION DESCRIPTION:**

These boolean information are in direct relationship with the determination of the correlation factor C_TI_AD_COR_CRLC_xx for lambda adaptation calculation.

If the **LEARNING** mode is active, during stabilisation of the lambda controller, lambda adaptation can be performed only if CPPWM **= 0.**
In this case, LV_AUTH_LAM_i_AD_LEARN_CP is set to **1**.

In the other modes, out of **LEARNING** mode, the flag LV_AUTH_LAM_AD_CP is set to **1** and LV_AUTH_LAM_i_AD_LEARN_CP is set to **0**.

# 5 Cooling and condenser fans control



**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| STATE_CFA | V | 0...03H | 0...3 | 1 | - |
| Cooling and condenser fans state (0,1,2,3). | | | | | |
| STATE_CFA_IS | V | 0...03H | 0...3 | 1 | - |
| Cooling and condenser fans state for idle - charge actuator opening corrections (0,1,2,3). | | | | | |
| STATE_CFA_1 | - | 0...03H | 0...3 | 1 | - |
| Intermediate cooling and condenser fans state for STATE_CFA and STATE_CFA_IS calculation (0,1,2,3) | | | | | |
| LV_RLY_FAN_L | V | 0...01H | 0...1 | 1 | - |
| Logic output from ECU for cooling and condenser fans control (LOW) - (OFF / ON). | | | | | |
| LV_RLY_FAN_H | V | 0...01H | 0...1 | 1 | - |
| Logic output from ECU for cooling and condenser fans control (HIGH) - (OFF / ON). | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| VS_STATE_CFA | TCO | LV_ACIN | LV_IGK |
| LV_ES | TIA | LV_ACCIN | LV_IS |
| LV_TCO_ERR | LV_PRS_ACC | LV_RLY_ACCOUT | LV_ES |



**FUNCTION DESCRIPTION:**

General information:

The cooling and condenser fans activation is controlled by the ECU, using two logic outputs : LV_RLY_FAN_L (LOW) **and** LV_RLY_FAN_H (HIGH)

They are set **ON** or **OFF** depending on :

- coolant temperature TCO
- air condition request LV_ACCIN
- vehicle speed state VS_STATE_CFA
- Pressure in the A/C circuit LV_PRS_ACC

Each fan is controlled with 3 speeds : **LOW, MIDDLE, HIGH**

The computation of the variable STATE_CFA determines the level of the two logic outputs LV_RLY_FAN_L and LV_RLY_FAN_H. The fan speed depends on these outputs and the air condition request switch state (LV_ACCIN).

If the pressure in the A/C circuit is high (LV_PRS_ACC = 1) then cooling and condenser fans speed is set to high in order to fastly decrease the pressure.

The application recurrence is **40 msec**.

Description:

| | LV_RLY_FAN_H | 0 | | | 1 | | | |
|---|---|---|---|---|---|---|---|---|
| **LV_RLY_FAN_L** | | | | | | | | **LV_ACCIN** |
| | 0 | OFF | | OFF | MIDDLE | | MIDDLE | 0 |
| | | | 0 | | | 2 | | |
| | | OFF | | OFF | MIDDLE | | MIDDLE | 1 |
| | 1 | LOW | | OFF | HIGH | | MIDDLE | 0 |
| | | | 1 | | | 3 | | |
| | | LOW | | LOW | HIGH | | HIGH | 1 |
| | | Cooling Fan | STATE_CFA (_IS) | Condenser Fan | Cooling Fan | STATE_CFA (_IS) | Condenser Fan | |

The states of LV_RLY_FAN_L, LV_RLY_FAN_H, LV_ACCIN correspond to **logical** state :

Logical state **0** ⇔ **OFF** ⇔ **+12 Volt** present on the corresponding pin - out of the ECU
Logical state **1** ⇔ **ON** ⇔ **Ground** present on the corresponding pin - out of the ECU

**Remark :**

LV_ACIN : air condition selected
LV_ACCIN : air condition requested
LV_RLY_ACCOUT : air condition compressor active.

## Application conditions:

- STATE_CFA_IS calculation:

STATE_CFA_IS is used to activate the idle speed valve corrections.

**If** Engine operating state LV_ES **= 1**
**and** TCO **>** C_TCO_ON_CFA_ES
**then** A timer is started and STATE_CFA_IS = STATE_CFA_1
When the timer has reached ID_CFA_ON_ES__TIA__TCO,
STATE_CFA_IS is set back to 0.

**else**
**If** Engine operating state LV_ST = 1
**then** STATE_CFA_IS **= 0** during C_T_OFF_CFA_ST seconds
**else**
**If** LV_TCO_ERR **= 1** *(error currently present on coolant temperature sensor)*
**or** ( LV_PRS_ACC **= 1** **and** LV_ACIN **= 1** )
**then** STATE_CFA_IS **= 3** *(high pressure in A/C circuit)*
**else** STATE_CFA_IS **=** STATE_CFA_1 *(low pressure in A/C circuit)*

**Endif**
**Endif**
**Endif.**

- STATE_CFA calculation:

STATE_CFA is equal to STATE_CFA_IS except if STATE_CFA_IS value is updated. Then a time delay is applied to increase or decrease STATE_CFA.

**If** STATE_CFA_IS (n) **=** STATE_CFA_IS (n-1) *(STATE_CFA_IS stays constant)*
**then** STATE_CFA **=** STATE_CFA_IS
**else**
**If** STATE_CFA_IS (n) **>** STATE_CFA_IS (n-1) *(STATE_CFA_IS increases)*
**then** STATE_CFA **=** STATE_CFA_IS after the time delay C_T_RTD_INC_x_CFA
(**If** LV_PRS_ACC **=** 1
**then** C_T_RTD_INC_x_CFA **=** C_T_RTD_INC_1_CFA
**else** C_T_RTD_INC_x_CFA **=** C_T_RTD_INC_0_CFA
**else** (*STATE_CFA_IS decreases)*
STATE_CFA **=** STATE_CFA_IS after the time delay C_T_RTD_DEC_CFA

- STATE_CFA_1 calculation:

**1 - LV_ACCIN = 0 and VS_STATE_CFA = 0**

1.1 - **If** LV_ACCIN or VS_STATE_CFA values were different just before
**then**

**If** TCO **<** C_TCO_3_CFA
**then** STATE_CFA_1 **= 0**

**If** C_TCO_3_CFA ≤ TCO **<** C_TCO_4_CFA
**then** STATE_CFA_1 **= 1**

**If** C_TCO_4_CFA ≤ TCO **<** C_TCO_5_CFA
**then** STATE_CFA_1 **= 2**

**If** TCO ≥ C_TCO_5_CFA
**then** STATE_CFA_1 **= 3**

1.2 - **If** LV_ACCINand VS_STATE_CFA values remain the same
**then**

*Conditions to increase STATE_CFA_1 :*

**If** TCO ≥ C_TCO_3_CFA **and** STATE_CFA_1 = 0
**then** STATE_CFA_1 **= 1**

**If** TCO ≥ C_TCO_4_CFA **and** STATE_CFA_1 = 1
**then** STATE_CFA_1 **= 2**

**If** TCO ≥ C_TCO_5_CFA **and** STATE_CFA_1 = 2
**then** STATE_CFA_1 **= 3**

*Conditions to decrease STATE_CFA_1 :*

**If** TCO ≤ (C_TCO_3_CFA - C_TCO_HYS_1_CFA) **and** STATE_CFA_1 = 1
**then** STATE_CFA_1 **= 0**

**If** TCO ≤ (C_TCO_4_CFA - C_TCO_HYS_2_CFA) **and** STATE_CFA_1 = 2
**then** STATE_CFA_1 **= 1**

**If** TCO ≤ (C_TCO_5_CFA - C_TCO_HYS_3_CFA) **and** STATE_CFA_1 = 3
**then** STATE_CFA_1 **= 2**

**2 - LV_ACCIN = 0 and VS_STATE_CFA = 1**

2.1 - **If** LV_ACCIN or VS_STATE_CFA values were different just before
**then**

**If** TCO **<** C_TCO_2_CFA
**then** STATE_CFA_1 **= 0**

**If** C_TCO_2_CFA ≤ TCO **<** C_TCO_4_CFA
**then** STATE_CFA_1 **= 1**

**If** TCO ≥ C_TCO_4_CFA
**then** STATE_CFA_1 **= 3**

2.2 - **If** LV_ACCIN and VS_STATE_CFA values remain the same
**then**

*Conditions to increase STATE_CFA_1 :*

**If** TCO ≥ C_TCO_2_CFA **and** STATE_CFA_1 = 0
**then** STATE_CFA_1 **= 1**

**If** TCO ≥ C_TCO_4_CFA **and** STATE_CFA_1 = 1
**then** STATE_CFA_1 **= 3**

*Conditions to decrease STATE_CFA_1 :*

**If** TCO ≤ (C_TCO_2_CFA - C_TCO_HYS_1_CFA) **and** STATE_CFA_1 = 1
**then** STATE_CFA_1 **= 0**

**If** TCO ≤ (C_TCO_4_CFA - C_TCO_HYS_2_CFA) **and** STATE_CFA_1 = 3
**then** STATE_CFA_1 **= 1**

**3 - LV_ACCIN = 0 and VS_STATE_CFA = 2**

3.1 - **If** LV_ACCIN or VS_STATE_CFA values were different just before
**then**

**If** TCO **<** C_TCO_4_CFA
**then** STATE_CFA_1 **= 0**

**If** TCO ≥ C_TCO_4_CFA
**then** STATE_CFA_1 **= 3**

3.2 - **If** LV_ACCIN and VS_STATE_CFA values remain the same
**then**

*Conditions to increase STATE_CFA_1 :*

**If** TCO ≥ C_TCO_4_CFA **and** STATE_CFA_1 = 0
**then** STATE_CFA_1 **= 3**

*Conditions to decrease STATE_CFA_1 :*

**If** TCO ≤ (C_TCO_4_CFA - C_TCO_HYS_2_CFA) **and** STATE_CFA_1 = 3
**then** STATE_CFA_1 **= 0**

**4 - LV_ACCIN = 1 and VS_STATE_CFA = 0**

4.1 - **If** LV_ACCIN or VS_STATE_CFA values were different just before.
**then**

**If** TCO **<** C_TCO_1_CFA
**then** STATE_CFA_1 **= 0**

**If** C_TCO_1_CFA ≤ TCO **<** C_TCO_4_CFA
**then** STATE_CFA_1 **= 1**

**If** C_TCO_4_CFA ≤ TCO **<** C_TCO_5_CFA
**then** STATE_CFA_1 **= 2**

**If** TCO ≥ C_TCO_5_CFA
**then** STATE_CFA_1 **= 3**

4.2 - **If** LV_ACCIN and VS_STATE_CFA values remain the same
**then**

*Conditions to increase STATE_CFA_1 :*

**If** TCO ≥ C_TCO_1_CFA **and** STATE_CFA_1 = 0
**then** STATE_CFA_1 **= 1**

**If** TCO ≥ C_TCO_4_CFA **and** STATE_CFA_1 = 1
**then** STATE_CFA_1 **= 2**

**If** TCO ≥ C_TCO_5_CFA **and** STATE_CFA_1 = 2
**then** STATE_CFA_1 **= 3**

*Conditions to decrease STATE_CFA_1 :*

**If** TCO ≤ C_TCO_1_CFA **and** STATE_CFA_1 = 1
**then** STATE_CFA_1 **= 0**

**If** TCO ≤ (C_TCO_4_CFA - C_TCO_HYS_2_CFA) **and** STATE_CFA_1 = 2
**then** STATE_CFA_1 **= 1**

**If** TCO ≤ (C_TCO_5_CFA - C_TCO_HYS_4_CFA) **and** STATE_CFA_1 = 3
**then** STATE_CFA_1 **= 2**

**5 - LV_ACCIN = 1 and VS_STATE_CFA = 1**

5.1 - **If** LV_ACCIN or VS_STATE_CFA were different just before
**then**

**If** TCO **<** C_TCO_1_CFA
**then** STATE_CFA_1 **= 0**

**If** C_TCO_1_CFA ≤ TCO **<** C_TCO_4_CFA
**then** STATE_CFA_1 **= 1**

**If** TCO ≥ C_TCO_4_CFA
**then** STATE_CFA_1 **= 3**

5.2 - **If** LV_ACCIN and VS_STATE_CFA remain the same
**then**

*Conditions to increase STATE_CFA_1 :*

**If** TCO ≥ C_TCO_1_CFA **and** STATE_CFA_1 = 0
**then** STATE_CFA_1 **= 1**

**If** TCO ≥ C_TCO_4_CFA **and** STATE_CFA_1 = 1
**then** STATE_CFA_1 **= 3**

*Conditions to decrease STATE_CFA_1 :*

**If** TCO ≤ (C_TCO_4_CFA - C_TCO_HYS_2_CFA) **and** STATE_CFA_1 = 3
**then** STATE_CFA_1 **= 1**

**If** TCO ≤ C_TCO_1_CFA **and** STATE_CFA_1 = 1
**then** STATE_CFA_1 **= 0**

**6 - LV_ACCIN = 1 and VS_STATE_CFA = 2**

6.1 - **If** LV_ACCIN or VS_STATE_CFA values were different just before
**then**

**If** TCO **<** C_TCO_4_CFA
**then** STATE_CFA_1 **= 0**

**If** TCO ≥ C_TCO_4_CFA
**then** STATE_CFA_1 **= 3**

6.2 - **If** LV_ACCIN and VS_STATE_CFA values remain the same
**then**

*Conditions to increase STATE_CFA_1 :*

**If** TCO ≥ C_TCO_4_CFA **and** STATE_CFA_1 = 0
**then** STATE_CFA_1 **= 3**

*Conditions to decrease STATE_CFA_1 :*

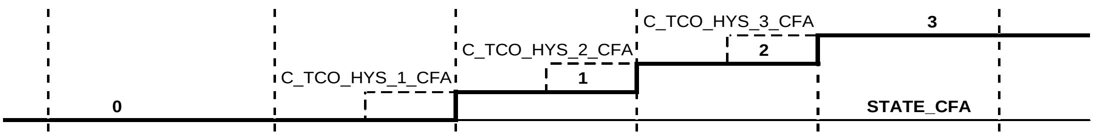
**If** TCO ≤ (C_TCO_4_CFA - C_TCO_HYS_2_CFA) **and** STATE_CFA_1 = 3
**then** STATE_CFA_1 **= 0**

**Remark :**
C_TCO_1_CFA ≤ C_TCO_2_CFA ≤ C_TCO_3_CFA ≤ C_TCO_4_CFA ≤ C_TCO_5_CFA

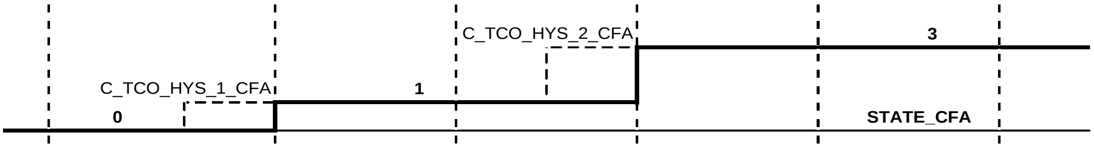
## Calibration data:

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| C_TCO_1_CFA | 1 | 0...FFH | -48...142,5 | 0,75 | °C |
| Coolant temperature threshold for fans control. | | | | | |
| C_TCO_2_CFA | 1 | 0...FFH | -48...142,5 | 0,75 | °C |
| Coolant temperature threshold for fans control. | | | | | |
| C_TCO_3_CFA | 1 | 0...FFH | -48...142,5 | 0,75 | °C |
| Coolant temperature threshold for fans control. | | | | | |
| C_TCO_4_CFA | 1 | 0...FFH | -48...142,5 | 0,75 | °C |
| Coolant temperature threshold for fans control. | | | | | |
| C_TCO_5_CFA | 1 | 0...FFH | -48...142,5 | 0,75 | °C |
| Coolant temperature threshold for fans control. | | | | | |
| C_TCO_HYS_1_CFA | 1 | 0...FFH | 0...191,25 | 0,75 | °C |
| Coolant temperature hysteresis for STATE_CFA transition 1->0. | | | | | |
| C_TCO_HYS_2_CFA | 1 | 0...FFH | 0...191,25 | 0,75 | °C |
| Coolant temperature hysteresis for STATE_CFA transition 2->1 or 2->0. | | | | | |
| C_TCO_HYS_3_CFA | 1 | 0...FFH | 0...191,25 | 0,75 | °C |
| Coolant temperature hysteresis for STATE_CFA transition 3->2. | | | | | |
| C_TCO_HYS_4_CFA | 1 | 0...FFH | 0...191,25 | 0,75 | °C |
| Coolant temperature hysteresis for STATE_CFA transition 3->2. | | | | | |
| C_T_RTD_INC_0_CFA | 1 | 0...FFH | 0...10,24 | 0,040 | sec |
| Time delay before increasing STATE_CFA if LV_PRS_ACC = 0 | | | | | |
| C_T_RTD_INC_1_CFA | 1 | 0...FFH | 0...10,24 | 0,040 | sec |
| Time delay before increasing STATE_CFA if LV_PRS_ACC = 1 | | | | | |
| C_T_RTD_DEC_CFA | 1 | 0...FFH | 0...10,24 | 0,040 | sec |
| Time delay before decreasing STATE_CFA | | | | | |
| C_T_OFF_CFA_ST | 1 | 0...FFH | 0...255 | 1 | sec |
| Time to deactivate fans during engine operating state start (LV_ST) detection. | | | | | |
| C_TCO_ON_CFA_ES | 1 | 0...FFH | -48...142,5 | 0,75 | °C |
| Minimum coolant temperature to start fans under power latch. | | | | | |
| ID_ON_CFA_ES__TCO__TIA | 5 x 5 | 0...FFH | 0...255 | 1 | sec |
| | | | | | |
| Activation duration of the fans under power latch. | | | | | |

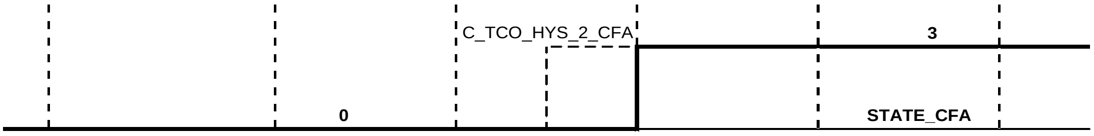
**. LV_ACCIN = 0 and VS_STATE = 0**



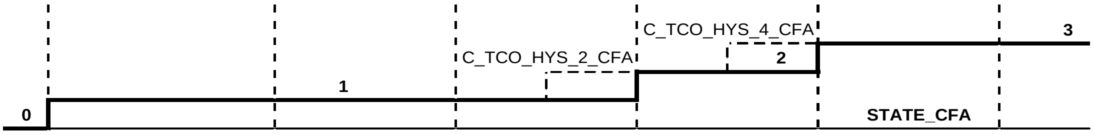

**. LV_ACCIN = 0 and VS_STATE = 1**



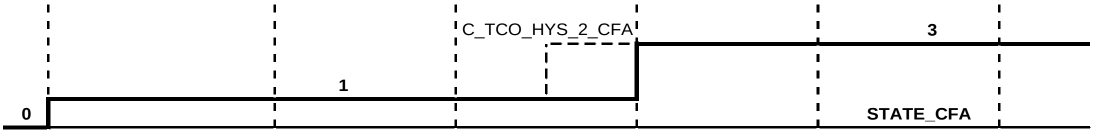

**. LV_ACCIN = 0 and VS_STATE = 2**



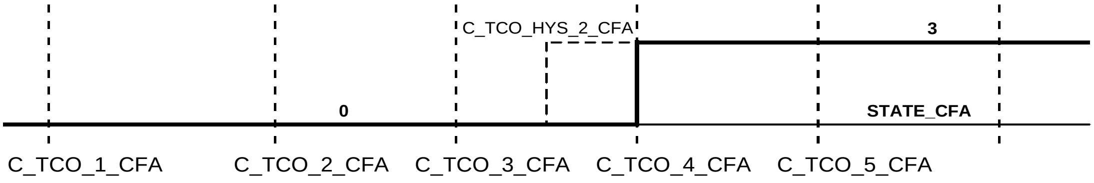

**. LV_ACCIN = 1 and VS_STATE = 0**




**. LV_ACCIN = 1 and VS_STATE = 1**




**. LV_ACCIN = 1 and VS_STATE = 2**



# 6 Engine speed limitation



**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| LV_N_MAX | V | 0...01H | 0...1 | 1 | - |
| Boolean for engine speed limitation | | | | | |
| LV_N_MAX_FCUT | V | 0...01H | 0...1 | 1 | - |
| Boolean for engine speed limitation in case of vehicle stopped | | | | | |
| N_MAX_THD | V | 0...FFH | 0...8160 | 32 | rpm |
| Maximum engine speed threshold for cylinder shut - off. | | | | | |
| N_MAX_MAX | V | 0...FFH | 0...8160 | 32 | rpm |
| Maximum engine speed threshold for immediate cylinders cut - off. | | | | | |
| PAT_INH_IV_N_MAX | V | 0...maxH | 0...max | 1 | - |
| Fuel shut-off pattern index in case of maximum engine speed - max = NC_INI_INH_SWI_IV_SHIFT_NR. | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| LV_ISA_i_ERR | LV_VS_ERR | TPS | N_32 |
| LV_MAF_ERR | VS | LV_ISA_MECHA_ERR | LV_TPS_ERR |
| NC_INI_INH_SWI_IV_SHIFT_NR | LV_CT | TCO | LV_DRI |
| LV_CRK_ERR | LV_TCO_ERR | LV_VS_ERR | LV_TPS_PLAUS_ERR |
| LV_MAF_PLAUS_ERR | LV_CRK_ERR_LIH | | |

**FUNCTION DESCRIPTION:**

General information:

This fuel shut - off allows to protect the engine against overspeed.
There are two kinds of overspeed fuel shut-off :

**1 -** the injectors are shut - off progressively, according to the cylinder shut - off pattern PAT_INH_IV_N_MAX. This corresponds to engine speed threshold N_MAX_THD.
N_MAX_THD is defined according to the present failures (ISAPWM,TPS, MAF...)

**2 -** the injectors are cut-off immediately. This corresponds to engine speed threshold N_MAX_MAX. Injectors are shut-off immediately if progressive fuel shut-off was no sufficient (engine speed still increasing) or if engine speed stays high during a long time with vehicle stopped.

**Application conditions:**

1) LV_N_MAX_FCUT determination :

In order to prevent the catalyst system from over-heating, it is detected if engine speed stays high with vehicle stopped during a pre-defined time.

At each engine Start, LV_N_MAX_FCUT is initialised to 0.

LV_N_MAX_FCUT is set to 1 **if** during C_T_N_MAX_FCUT seconds:

- LV_CT **=** 0
- **and** VS **=** 0
- **and** TCO **>** C_TCO_N_MAX_FCUT
- **and** N_32 **>** C_N_FCUT
- **and** LV_DRI **=** 0
- **and** LV_CRK_ERR **=** 0
- **and** LV_TCO_ERR **=** 0
- **and** LV_VS_ERR **=** 0

LV_N_MAX_FCUT is set back to 0 **if**:

- LV_CT **=** 1
- **or** VS **>** 0
- **or** TCO **<** C_TCO_N_MAX_FCUT
- **or** LV_DRI **=** 1
- **or** LV_CRK_ERR **=** 1
- **or** LV_TCO_ERR **=** 1
- **or** LV_VS_ERR **=** 1

2) N_MAX_MAX calculation :

If there is a risk to damage the catalyst, maximum engine speed is reduced.

**If** LV_N_MAX_FCUT **=** 1

**then** N_MAX_MAX **=** C_N_MAX_FCUT

**else** N_MAX_MAX **=** C_N_MAX_MAX

3) N_MAX_THD calculation :

Normal maximum engine speed can be modified due some present failures.

**- If** ( LV_ISA_1_ERR = 1 **or** LV_ISA_MECHA_ERR = 1 )
*(Idle speed actuator coil 1 - only if short to ground detected or*
*Idle speed actuator mechanical error - only if ISA stuck open detected)*
**then**
**If** ( LV_TPS_ERR **=** 1 **or** LV_TPS_PLAUS_ERR **=** 1 )
*(an error is currently present on the throttle position sensor)*
**then** N_MAX_THD_1 **=** C_N_MAX_TPS_ISAPWM_DIAG
**else** N_MAX_THD_1 **=** IP_N_MAX_ISAPWM_DIAG__TPS
**else** N_MAX_THD_1 **=** 8160 rpm

**- If** ( LV_TPS_ERR = 1 **or** LV_TPS_PLAUS_ERR = 1 )
**and** ( LV_MAF_ERR = 1 **or** LV_MAF_PLAUS_ERR = 1 )
*(an error is currently present on the throttle position sensor and on the mass air flow sensor )*
**then** N_MAX_THD_2 **=** C_N_MAX_TPS_DIAG
**else** N_MAX_THD_2 **=** 8160 rpm

**- If** LV_VS_ERR = 1
*(an error is currently present on vehicle speed)*
**then** N_MAX_THD_3 **=** C_N_MAX_VS_DIAG
**else** N_MAX_THD_3 **=** 8160 rpm

**- If** LV_CRK_ERR_LIH = 1
*(Limp home for crankshaft sensor active)*
**then** N_MAX_THD_4 **=** C_N_MAX_CRK_DIAG
**else** N_MAX_THD_4 **=** 8160 rpm

```
N_MAX_THD  =  Min.  (  N_MAX_THD_1,
                       N_MAX_THD_2,
                       N_MAX_THD_3,
                       N_MAX_THD_4,
                       N_MAX_MAX,
                       C_N_MAX )
```

4) Progressive cylinder shut-off in case of over speed :

**If** N_32 **>** N_MAX_THD
**then :**
- LV_N_MAX is set to **1**
- Cylinder shut-off level (PAT_INH_IV_N_MAX) is increased by 1 each ID_N_MAX_CYCNR__VS cycles **until:**
- N_32 **<** N_MAX_THD **-** C_N_MAX_HYS
- **or** PAT_INH_IV_N_MAX reaches its maximum value (13)

5) Immediate cylinder fuel cut-off in case of over speed :

**If** N_32 **>** N_MAX_MAX
**then :**
- LV_N_MAX is set to 1
- All the injectors are cut-off immediately (PAT_INH_IV_N_MAX = 13)



6) Progressive cylinders rewetting

**If** N_32 **<** N_MAX_THD **-** C_N_MAX_HYS
**and** LV_N_MAX_FCUT **= 0**
**then :**
- Cylinder shut - off level (PAT_INH_IV_N_MAX) is decreased by 1 each ID_N_MAX_CYCNR__VS cycles until it reaches 0
- LV_N_MAX is set back to 0 when PAT_INH_IV_N_MAX = 0

7) Immediate cylinders rewetting

**If** N_32 **<** N_MAX_THD **-** C_N_MAX_HYS_MAX
**then :**
- Cylinder shut - off level (PAT_INH_IV_N_MAX) is set to 0
- LV_N_MAX is set to 0

## Calibration data:

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| C_N_MAX | 1 | 0...FFH | 0...8160 | 32 | rpm |
| Engine speed threshold for engine speed limitation (fuel shut - off cylinder by cylinder). | | | | | |
| C_N_MAX_MAX | 1 | 0...FFH | 0...8160 | 32 | rpm |
| Engine speed threshold for engine speed limitation (fuel cut - off all cylinders) if LV_N_MAX_FCUT = 0 | | | | | |
| C_N_MAX_HYS | 1 | 0...FFH | 0...8160 | 32 | rpm. |
| Engine speed hysteresis to enable again the injection. | | | | | |
| C_N_MAX_HYS_MAX | 1 | 0...FFH | 0...8160 | 32 | rpm |
| Engine speed hysteresis to enable all the injectors. | | | | | |
| C_N_MAX_TPS_DIAG | 1 | 0...FFH | 0...8160 | 32 | rpm |
| Maximum engine speed (limitation) in case of simultaneous failure on TPS and MAF. | | | | | |
| C_N_MAX_TPS_ISAPWM_DIAG | 1 | 0...FFH | 0...8160 | 32 | rpm |
| Maximum engine speed (limitation) in case of error currently present on ISA and TPS. | | | | | |
| IP_N_MAX_ISAPWM_DIAG__TPS | 3 | 0...FFH | 0...8160 | 32 | rpm |
| | | | | | |
| | | | | | |
| Maximum engine speed (limitation) in case of error currently present on ISA. | | | | | |
| C_N_MAX_VS_DIAG | 1 | 0...FFH | 0...8160 | 32 | rpm |
| Maximum engine speed (limitation) in case of error currently present on VS signal. | | | | | |
| C_N_MAX_CRK_DIAG | 1 | 0...FFH | 0...8160 | 32 | rpm |
| Maximum engine speed (limitation) in case of crankshaft sensor Limp-Home active. | | | | | |
| ID_N_MAX_CYCNR__VS | 5 | 01...FFH | 1...255 | 1 | - |
| | | | | | |
| Number of cycles to increase by 1 the cylinder shut - off level in case of over speed fuel shut - off. | | | | | |
| C_T_N_MAX_FCUT | - | 01...FFFFH | 0,1...6553,5 | 0,1 | sec. |
| Time to detect LV_N_MAX_FCUT | | | | | |
| C_TCO_N_MAX_FCUT | - | 00...FEH | -48...142,5 | 0,75 | °C |
| Minimum coolant temperature to detect LV_N_MAX_FCUT | | | | | |
| C_N_FCUT | - | 00...FFH | 0...8160 | 32 | rpm |
| Minimum engine speed to detect LV_N_MAX_FCUT | | | | | |
| C_N_MAX_FCUT | - | 00...FFH | 0...8160 | 32 | rpm |
| Engine speed threshold for engine speed limitation (fuel cut - off all cylinders) if LV_N_MAX_FCUT = 1 | | | | | |

# 7 Vehicle speed limitation





## Output data:

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| LV_VS_MAX | V | 0...01H | 0...1 | 1 | - |
| Boolean for vehicle speed limitation ( Passive / Active ). | | | | | |
| LV_OPL_VS_MAX | V | 0...01H | 0...1 | 1 | - |
| Boolean for A/F regulation loop opened because of vehicle speed limitation ( Passive / Active). | | | | | |
| PAT_INH_IV_VS_MAX | V | 0...maxH | 0...max | 1 | - |
| Fuel shut-off pattern index in case of vehicle speed limitation - max = NC_INI_INH_SWI_IV_SHIFT_NR. | | | | | |

## Input data:

| | | | |
|---|---|---|---|
| VS | NC_INI_INH_SWI_IV_SHIFT_NR | LV_LSCL_1 | N_32 |
| C_TI_VS_MAX_COR | LV_LSCL_2 | VS_MAX | |

## FUNCTION DESCRIPTION:

General information:

If the vehicle speed exceeds the vehicle speed limitation, the following actions are taken with the priorities :

**1 -** deactivation of all enrichments.
**2 -** A/F regulation loop opened and mixture leaning
**3 -** injectors shut - off progressively according to the cylinder shut - off pattern PAT_INH_IV_VS_MAX
**4 -** when all cylinders are shut - off, the fuel pump is switched off.

These measures are cancelled following a definite process if the vehicle speed decreases under the vehicle speed limitation minus an hysteresis.

In order to avoid engine stall when the driver releases the clutch with cylinders shut - off due to vehicle speed limitation, the injection is enabled below the engine speed **3000 rpm**.

The application recurrence is **1 sec**.

## Application conditions:

*Activation:*

**If** VS ≥ VS_MAX
**and** N_32 **>** 3000 rpm
**then** **LV_VS_MAX = 1** (Active).

*Deactivation:*

**If** VS **<** VS_MAX - C_VS_MAX_HYS
**or** N_32 ≤ 3000 rpm
**then** **LV_VS_MAX = 0** (Passive).

## Formula section:

* **LV_VS_MAX = 1** (Active) - Vehicle speed limitation activation :

**1 -** All the enrichments are cancelled.
**2 -** A/F regulation loop is opened (LV_LSCL_1 = LV_LSCL_2 = 0) and mixture is leaned using (1 - C_TI_VS_MAX_COR).
**3 -** The cylinder shut - off level is set to 1 and increased by 1 every C_VS_MAX_CYCNR cycles.
**4 -** When all the cylinders are shut-off, the fuel pump is switched off.

* **LV_VS_MAX = 0** (Passive) **-** Vehicle speed limitation deactivation :

**1 -** The fuel pump is switched on (if it has been switched off before).
**2 -** The cylinder shut - off level is decreased by 1 every C_VS_MAX_CYCNR cycles.
**3 -** Once all the injectors are switched on again, all enrichments are enabled.
**4 -** A/F regulation loop is closed after C_LAM_CYCNR seconds.

**Remark :**

**If** N_32 ≤ 3000 rpm.
**then** the fuel pump is switched on (if it has been switched off before), all the cylinders are switched on, all enrichments are enabled and A/F regulation loop is closed after C_LAM_CYCNR seconds. These actions are performed together.

## Calibration data:

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| C_VS_MAX_HYS | 1 | 0...FFH | 0...255 | 1 | km/h |
| Hysteresis on maximum vehicle speed. | | | | | |
| C_VS_MAX_CYCNR | 1 | 0...FFH | 0...255 | 1 | sec. |
| Time delay between two cylinders shut-off or reset during vehicle speed limitation ( x 1 sec). | | | | | |
| C_LAM_CYCNR | 1 | 01...FFFFH | 0,01...655,35 | 0,01 | sec. |
| Time delay before closing the A/F regulation loop. | | | | | |

# 8 Traction Control

## 8.1 Interface Description

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| TQI_ASR_REQ | V | 0...3FH | 0...630 | 10 | Nm |
| Torque reduction requested for ASR from TCS control unit | | | | | |
| TQI_GS_REQ | V | 0...3FH | 0...630 | 10 | Nm |
| Torque reduction requested for gear shift from TCU | | | | | |
| LV_ASR_REQ | V | 0...1H | 0...1 | 1 | - |
| Boolean for ASR intervention requested by the TCS control unit | | | | | |
| LV_GS_REQ | V | 0...1H | 0...1 | 1 | - |
| Boolean for GS intervention requested by the transmission control unit | | | | | |
| TQ_STND_CAN | - | 0...3FH | 0...630 | 10 | Nm |
| standard torque to which all torque reduction requests are related (CAN-value) | | | | | |
| TQI_CAN | V | 0...FFH | 0...99.61 | 0.391 | % |
| indicated engine torque without torque intervention (CAN-value) | | | | | |
| TQI_ACOR_CAN | V | 0...FFH | 0...99.61 | 0.391 | % |
| indicated engine torque during torque intervention (CAN-value) | | | | | |
| TQFR_CAN | V | 0...FFH | 0...99.61 | 0.391 | % |
| engine friction torque (CAN_value) | | | | | |
| ACK_TCS_CAN | - | 0...1H | 0...1 | 1 | |
| acknowledge bit from EMS (CAN-value) | | | | | |
| TQ_COR_STAT_CAN | - | 0...3H | 0...3 | 1 | |
| status of torque intervention from EMS (CAN-value) | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| TQI_TCS_CAN | TQI_TCU_CAN | TCS_REQ_CAN | SWI_GS_CAN |
| TQ_STND | TQI | TQI_INTV | TQFR |
| LV_ACK_TCS | STATE_TQ_INTV | | |

### 8.1.1 General information

The communication between the engine management system and the TCS control unit as well as the transmission control unit is done via the CAN bus.

This function description refers only to the torque management related CAN data. For a detailed description of the CAN functions please refer to the separate CAN specification.

To clearly distinguish between variables which are used for EMS internal calculation and variables that are available on the CAN all CAN-related variables are marked with the extension „*_CAN*“ at their name. However, in this chapter only the EMS internal variable names are used.

### 8.1.2 CAN Communication Signals

#### 8.1.2.1 EMS Input Signals from the CAN

| **Input as CAN data (from the CAN)** | | **Input to EMS internal functions** |
|---|---|---|
| **TQI_TCS_*CAN*** **[%]** | Torque reduction request for ASR from TCS control unit<br><br>TQI_ASR_REQ = **Fehler!** | **TQI_ASR_REQ** **[Nm]** |
| **TQI_TCU_*CAN*** **[%]** | Torque reduction request for Gear-Shift from TCU<br>TQI_GS_REQ = **Fehler!** | **TQI_GS_REQ** **[Nm]** |
| **TCS_REQ_*CAN*** | Status-Bit = High, if ASR is requested | **LV_ASR_REQ** |
| **SWI_GS_*CAN*** | Status-Bit = High, if GS is requested | **LV_GS_REQ** |

#### 8.1.2.2 EMS Output Signals to the CAN

| Output from EMS internal functions | | Output to CAN |
|---|---|---|
| **TQ_STND** **[Nm]** | Standard engine torque in Nm, to which the percentage torque quantities TQx_yyy are related.<br>--> see subchapter Torque Model | **TQ_STND_*CAN*** **[Nm]** |
| **TQI** **[Nm]** | Indicated engine torque corresponding to the torque requested from the driver; including knock control, catalyst overheating protection and other ignition angle corrections; torque interventions are not included.<br>--> see subchapter Torque Model<br><br>TQI_CAN = **Fehler!*** 100% | **TQI_*CAN*** **[%]** |
| **TQI_INTV** **[Nm]** | Indicated engine torque during torqe intervention.<br>--> see subchapter Torque Model<br><br>TQI_ACOR_CAN = **Fehler!*** 100% | **TQI_ACOR_*CAN*** **[%]** |
| **TQFR** **[Nm]** | Engine friction torque<br>--> see subchapter Torque Model<br><br>TQFR_CAN = **Fehler!*** 100% | **TQFR_*CAN*** **[%]** |
| **LV_ACK_TCS** | Monitoring of the messages from the TCS control unit. The engine management system checks whether at least one new message from the TCS control unit has been transmitted within 500 ms. If so, the bit is set; else the bit is reset. | **ACK_TCS_*CAN*** |
| **STATE_TQ_INTV** | Status of torque intervention.<br>Check-back signal from the engine management system about to which extent a torque reduction is actually performed. | **TQ_COR_STAT_*CAN*** |

### 8.1.3 Status of Torque Intervention (STATE_TQ_INTV)



**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| STATE_TQ_INTV | V | 0...3H | 0...3 | 1 | |
| status torque intervention from EMS | | | | | |
| TQ_INTV_REL_ERR | V | 0...FFH | 0...0.996 | 0.0039 | 100% |
| relative error as difference between actual torque and requested torque related to the standard torque | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| LV_ASR_REQ | LV_GS_REQ | TQI_INTV | TQI_ASR_REQ |
| TQI_GS_REQ | TQ_STND | LV_SCC_MOD | |

**FUNCTION DESCRIPTION:**



General information:

The engine management system uses the variable **STATE_TQ_INTV** to inform the transmission control unit and/or the traction system control unit about the state of the torque intervention. That means if and to which extent an ignition angle intervention and/or a cylinder shut-off intervention are admitted.

| Status | Bit 5 | Bit 4 | Meaning |
|---|---|---|---|
| 0 | 0 | 0 | The desired intervention regarding ignition angle retardation and cylinder shut-off is executed. (Default value) |
| 1 | 0 | 1 | The desired intervention regarding ignition angle retardation and cylinder shut-off is executed; however, the requested target torque can not be adjusted precisely (torque steps) |
| 2 | 1 | 0 | The torque reduction regarding the ignition angle retardation cannot be completely executed. A cylinder shut-off is not possible at this time. Therefore the residual torque (as difference between TQI_ASR_REQ and TQI_INTV) remains present and cannot be reduced. |
| 3 | 1 | 1 | Due to a failure detected by a diagnosis function of the engine management system, the desired torque intervention regarding the ignition angle and cylinder shut-off is no longer executed.<br>The torque intervention is terminated, the engine management system resets the requested engine torque to the TQI value using a ramp. |

Activation: LV_ASR_REQ = 1 or LV_GS_REQ = 1

Deactivation: LV_ASR_REQ = 0 and LV_GS_REQ = 0

**Formula section:**

Relative Error of torque reduction intervention

TQ_INTV_REL_ERR = **Fehler!**

Status of torque intervention:

Status **0**: **If** $|$TQ_INTV_REL_ERR$| \leq$ C_TQ_INTV_REL_ERR_MAX
**then** **STATE_TQ_INTV = 0**

Status **1**: **If** $|$TQ_INTV_REL_ERR$| >$ C_TQ_INTV_REL_ERR_MAX
**and** LV_SCC_MOD = 1
**then** **STATE_TQ_INTV = 1**

Status **2**: **If** $|$TQ_INTV_REL_ERR$| >$ C_TQ_INTV_REL_ERR_MAX
**and** LV_SCC_MOD = 0
**then** **STATE_TQ_INTV = 2**

Status **3**: **If** no torque intervention is possible
(for example due to a failure detected by a diagnosis function)
**then** **STATE_TQ_INTV = 3**
**and** **TQ_INTV_REL_ERR** is set to 100%

**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| C_TQ_INTV_REL_ERR_MAX | 1 | 0...FFH | 0...0.997 | 0.0039 | 100% |
| threshold for relative error of torque intervention for status output | | | | | |

## 8.2 Internal auxiliary quantities

### 8.2.1 Relative torque reduction by misfire detection (TQR_REL_SCC_MIS)

**<u>Output data:</u>**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| TQR_REL_SCC_MIS | V | 0...FFH | 0...0.996 | 0.0039 | 100% |
| actual performed relative torque reduction by cylinder shut-off due to detected misfire | | | | | |

**<u>Input data:</u>**

| | | | |
|---|---|---|---|
| MIS_NR_OFF_IV | | | |

**<u>FUNCTION DESCRIPTION:</u>**

The injection for misfiring cylinders is inhibited by the misfire detection function in order to prevent the catalyst from overheating. These fuel cut-off cylinders have to be considered for the calculation of the indicated engine torque without torque intervention (TQI) and the indicated engine torque during torque intervention (TQI_INTV).

TQR_REL_SCC_MIS = **Fehler!**

**<u>Calibration data:</u>**

| |
|---|
| **non adjustable value: NC_CYL_NO = 6** |

### 8.2.2 Actual performed relative torque reduction by fuel cut-off (TQR_REL_SCC_AV)



**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| TQR_REL_SCC_AV | V | 0...FFH | 0...0.996 | 0.0039 | 100% |
| actual performed relative torque reduction by any fuel cut-off action | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| TQR_REL_SCC_MIS | TQR_REL_SCC_OUT | | |

**FUNCTION DESCRIPTION:**

**TQR_REL_SCC_AV** is the actual performed relative torque reduction which can result from any fuel cut-off intervention including...

...fuel cut-off acivated by the misfire detection : **TQR_REL_SCC_MIS** **and/or**

...fuel cut-off by a cylinder shut-off pattern : **TQR_REL_SCC_OUT**

(from engine speed or vehicle speed limitation, torque reduction by TCU or TCS)

**Formula section:**

TQR_REL_SCC_AV = TQR_REL_SCC_OUT + TQR_REL_SCC_MIS -
(TQR_REL_SCC_OUT * TQR_REL_SCC_MIS)

### 8.2.3 Maximum relative torque reduction by spark retard (TQR_REL_MAX_IGA_N_MAF)



**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| TQR_REL_MAX_IGA_N_MAF | V | 0...FFH | 0...0.996 | 0.0039 | 100% |
| maximum possible relative torque reduction by spark retard | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| N_32 | MAF | TQR_REL_SCC_AV | |

**FUNCTION DESCRIPTION:**

The maximum allowed ignition angle spark retard (regarding exhaust gas temperature) for torque intervention is taken from IP_IGA_DIF_MAX_TQR__N_32__MAF and results in a maximum relative torque reduction of IP_TQR_REL_MAX_IGA__N_32__MAF.



In order to take into account the torque decreasing influence of a currently performed cylinder shut-off, the factor (**1 - TQR_REL_SCC_AV**) is applied.

**TQR_REL_MAX_IGA_N_MAF** is calculated each 10 msecs.

**Formula section:**

TQR_REL_MAX_IGA_N_MAF =
IP_TQR_REL_MAX_IGA__N_32__MAF * (1 - TQR_REL_SCC_AV)

**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| IP_TQR_REL_MAX_IGA__N_32__MAF | 8x8 | 0...FFH | 0...0.996 | 0.0039 | 100% |
| maximum possible relative torque reduction by spark retard | | | | | |

### 8.2.4 Actual relative torque reduction by spark retard (TQR_REL_IGA_AV)

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| IGA_DIF_REF_AV | V | 0...FFH | 0...-95.625 | 0.375 | ° CRK |
| applied relative ignition angle retardation to calculate the resulting torque reduction (difference between the reference IGA and the average of the actual IGAs of all cylinders) | | | | | |
| TQR_REL_IGA_AV | V | 0...FFH | 0...0.996 | 0.0039 | 100% |
| resulting actual value of the relative torque reduction by spark retard | | | | | |
| FAC_IGA_TQR | - | 0...FFH | 0...-95.625 | 0.375 | ° CRK |
| relative actual retardation related to the maximum possible spark retard | | | | | |

**Input data:**

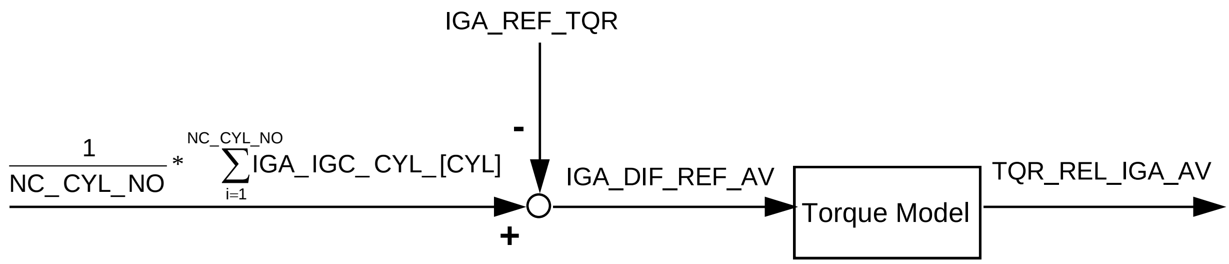
| | | | |
|---|---|---|---|
| IGA_IGC_CYL_[CYL] | IGA_REF_TQR | N_32 | MAF |
| TQR_REL_MAX_IGA_N_MAF | NC_CYL_NO | LV_ES | IP_FAC_TQR__FAC_IGA_TQR |

**FUNCTION DESCRIPTION:**

General information:

**TQR_REL_IGA_AV** includes every spark retard intervention refering to the reference ignition angle IGA_REF_TQR.

Signal flow diagram:




Activation: LV_ES = 0

Deactivation: LV_ES = 1

**Formula section:**

$$\text{IGA\_DIF\_REF\_AV} = \left[\frac{1}{\text{NC\_CYL\_NO}} * \sum_{i=1}^{\text{NC\_CYL\_NO}} \text{IGA\_IGC\_CYL\_[CYL]}\right] - \text{IGA\_REF\_TQR}$$

(limited to $\leq$ 0 °CRK)

$$\text{FAC\_IGA\_TQR} = \frac{\text{IGA\_DIF\_REF\_AV}}{\text{IP\_IGA\_DIF\_MAX\_TQR\_\_N\_32\_\_MAF}}$$

TQR_REL_IGA_AV = IP_FAC_TQR__FAC_IGA_TQR * TQR_REL_MAX_IGA_N_MAF

**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| IP_IGA_DIF_MAX_TQR__N_32__MAF | 8x8 | 0...FFH | 0...-95.625 | 0.375 | °CRK |
| maximum allowed spark retard for torque reduction | | | | | |
| IP_FAC_TQR__FAC_IGA_TQR | 8 | 0...FFH | 0...0.996 | 0.0039 | 100% |
| relative standard inverse ignition cog | | | | | |

## 8.3 Torque model

### 8.3.1 Standard torque (TQ_STND)

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| TQ_STND | V | 0...3FH | 0...630 | 10 | Nm |
| standard engine torque | | | | | |

The standard engine torque **TQ_STND** is taken from C_TQ_STND and transmitted by the engine management system to the CAN stations (TCS control unit and TCU).

It is the reference torque to which the torque reduction quantities are related. The result are relative torque quantities as percentage which are put on the CAN.

**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| C_TQ_STND | 1 | 0...3FH | 0...630 | 10 | Nm |
| standard engine torque | | | | | |

### 8.3.2 Frictional torque (TQFR)

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| TQFR | V | 0...FFH | 0...-255 | 1 | Nm |
| engine friction torque | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| N_32 | MAF | TCO | LV_RLY_ACCOUT |
| LV_PRS_ACC | LV_ES | | |

**FUNCTION DESCRIPTION:**

General information:

The frictional torque is a negative quantity. The following influences are considered in this model:

- N_32 engine speed
- MAF mass air flow
- TCO coolant temperature
- ACC air condition compressor on/off

## Application conditions:

*Activation:* LV_ES = 0

*Deactivation:* TQFR = 0 at engine operating state LV_ES = 1

## Formula section:

**If** LV_RLY_ACCOUT = 0

**then** TQFR = IP_TQFR__N_32__MAF *(Influence of engine speed / load)*
+ IP_TQFR_ADD _TCO__TCO *(Influence of coolant temperature)*

**If** LV_RLY_ACCOUT = 1
**and** LV_PRS_ACC = 0

**then** TQFR = IP_TQFR__N_32__MAF *(Influence of engine speed / load)*
+ IP_TQFR_ADD_TCO__TCO *(Influence of coolant temperature)*
+ C_TQFR_ADD_ACC_L *(Influence of air condition compressor with low system pressure)*

**If** LV_RLY_ACCOUT = 1
**and** LV_PRS_ACC = 1

**then** TQFR = IP_TQFR__N_32__MAF *(Influence of engine speed / load)*
+ IP_TQFR_ADD_TCO__TCO *(Influence of coolant temperature)*
+ C_TQFR_ADD_ACC_H *(Influence of air condition compressor with high system pressure)*

## Calibration data:

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| IP_TQFR__N_32__MAF | 8x2 | 0...FFH | 0...-255 | 1 | Nm |
| basic engine friction torque | | | | | |
| IP_TQFR_ADD_TCO__TCO | 8 | 0...FFH | +128...-127 | 1 | Nm |
| coolant temperature correction for friction torque calculation | | | | | |
| C_TQFR_ADD_ACC_H | 2 | 0...FFH | 0...-255 | 1 | Nm |
| Air condition compressor correction for friction torque calculation (High system pressure) | | | | | |
| C_TQFR_ADD_ACC_L | 2 | 0...FFH | 0...-255 | 1 | Nm |
| Air condition compressor correction for friction torque calculation (Low system pressure) | | | | | |

### 8.3.3 Indicated engine torque (TQI)

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| TQI | V | 0...FFH | 0...510 | 2 | Nm |
| indicated engine torque | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| N_32 | MAF | TQR_REL_SCC_EMS | TQR_REL_IGA_EMS |
| IP_FAC_LAM_TQI__LAM_SUB__IGA_DIF_REF_AV | LV_ES | LV_PUC | IGA_DIF_REF_AV |
| LAM_SUB | | | |

**FUNCTION DESCRIPTION:**

General information:

The indicated engine torque **TQI** refers to the drivers wish and is calculated from the mass air flow and engine speed. Additionally a lambda correction factor and a factor coming from spark retard and fuel cut-off is applied.
For the TQI calculation only spark retard interventions from EMS internal functions (e.g. knock correction, catalyst heating, anti jerk, etc.) or fuel cut-off due to engine speed limitation, vehicle speed limitation or misfire detection is considered.
However, the TQI calculation is independent from torque influence from ASR or gear shift.
The table **IP_FAC_LAM_TQI__LAM_SUB__IGA_DIF_REF_AV** is used to correct the indicated torque as a function of **LAM_SUB** and **IGA_DIF_REF_AV**.

**Application conditions:**

*Activation:* LV_ES = 0, LV_PUC = 0
*Deactivation:* TQI = 0 at engine operating states PUC and ES

**Formula section:**

**TQI =** IP_TQI__N_32__MAF *(Influence of engine speed / load)*
* IP_FAC_LAM_TQI__LAM_SUB__IGA_DIF_REF_AV *(Influence of Lambda)*
* [1 - (TQR_REL_IGA_EMS *(Influence of spark retard by EMS)*
+TQR_REL_SCC_EMS) ] *(Influence of cylinder shut-off effected by EMS)*
*(N_MAX, VS_MAX, PUC and misfire)*

**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| IP_TQI__N_32__MAF | 8x2 | 0...FFH | 0...510 | 2 | Nm |
| Basis indicated engine torque | | | | | |
| IP_FAC_LAM_TQI__LAM_SUB__IGA_DIF_REF_AV | 6x6 | 0...FFH | 0...1.992 | 0.0078 | - |
| Lambda correction for indicated engine torque<br>*Remark: In the application system this map is named IP_FAC_LAM_TQI__LAM_SUB__IGA_DIF* | | | | | |

### 8.3.3.1 Lambda influence weighted by ignition angle



**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| LAM_SUB | V | 00...FFH | 0...1.992 | 7.782E-3 | - |
| Lambda substitute value | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| TIB | TI_MV | | LV_ES |
| TI_AD_FAC_MMV | TI_AD_ADD_MMV | | |

**FUNCTION DESCRIPTION:**

With increasing retardation of the ignition angle the lambda dependence of the indicated engine torque TQI is enhanced.

*Activation:* LV_ES = 0

*Deactivation:* LV_ES = 1



**Formula section:**

$$\textbf{LAM\_SUB} = \frac{TI\_AD\_FAC\_MMV * TIB + TI\_AD\_ADD\_MMV}{TI\_MV}$$

Remark: TIB and TI_MV are without dead time.

### 8.3.3.2 Influence of ignition angle

**Input data:**

| | | | |
|---|---|---|---|
| FAC_IGA_TQR | FAC_TQR | | |

Description:

The influence of the ignition angle on the indicated engine torque TQI is modeled via a general (relative) ignition cog. There are two tables for the relation between an ignition angle retard adjustment (compared to the absolute reference ignition angle IGA_REF_TQR) and the related relative reduction of the engine torque:

- **IP_FAC_TQR__FAC_IGA_TQR** to calculate the relative torque reduction for a differential ignition angle adjustment (relation IGA --> TQR)
- **IP_FAC_IGA_TQR__FAC_TQR** to calculate the ignition angle adjustment for a torque reduction request (relation TQI --> IGA)

For the calculation of TQI all ignition angle adjustments, such as knock control, catalyst heating, etc., are considered. ASR and GS are not included in the calculation of TQI.

**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| IP_FAC_IGA_TQR__FAC_TQR | 8 | 0...FFH | 0...0.996 | 0.0039 | 100% |
| relative standard ignition cog | | | | | |
| IP_FAC_TQR__FAC_IGA_TQR | 8 | 0...FFH | 0...0.996 | 0.0039 | 100% |
| relative standard inverse ignition cog | | | | | |

#### 8.3.3.2.1 Reference ignition angle (IGA_REF_TQR)

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| IGA_REF_TQR | V | 0...FFH | -23...72.5 | 0.375 | °CRK |
| Reference ignition angle for torque intervention | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| IGA_BAS | IGA_EGR | | |

**FUNCTION DESCRIPTION:**

The reference ignition angle **IGA_REF_TQR** for this model approach is an absolute ignition angle, which is approximately identical to the ignition angle existing at maximum torque.

**Formula section:**

**IGA_REF_TQR =** IGA_BAS Basic ignition angle without EGR
**or**
IGA_EGR Basic ignition angle with EGR active

### 8.3.3.2.2 Relative Torque Reduction by EMS internal Spark Retard (TQR_REL_IGA_EMS)



**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| IGA_DIF_REF_EMS | V | 0...FFH | 0...-95.625 | 0.375 | ° CRK |
| difference between actual ignition angle and torque reference ignition angle | | | | | |
| FAC_IGA_TQR | - | 0...FFH | 0...-95.625 | 0.375 | ° CRK |
| relative EMS internal ignition angle retardation related to the maximum possible spark retard | | | | | |
| TQR_REL_IGA_EMS | V | 0...FFH | 0...0.996 | 0.0039 | 100% |
| Relative torque reduction by EMS internal spark retard | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| IGA_CYL_[CYL] | IGA_REF_TQR | LV_ES | NC_CYL_NO |
| IP_IGA_DIF_MAX_TQR__N_32__MAF | TQR_REL_MAX_IGA_N_MAF | IP_FAC_TQR__FAC_IGA_TQR | |



**FUNCTION DESCRIPTION:**

**TQR_REL_IGA_EMS** represents the EMS internal relative torque reduction by ignition angle retard adjustment (e.g. catalyst heating, knock control, transient spark retard, anti jerk function, etc.) related to the reference ignition angle IGA_REF_TQR.

**IGA_DIF_REF_EMS** is the current differential ignition angle relative to IGA_REF_TQR without ASR and GS intervention.

**Application conditions:**

*Activation:* not ES (LV_ES = 0)

*Deactivation:* ES (LV_ES = 0)

**Formula section:**

$$\textbf{IGA\_DIF\_REF\_EMS} = \left[\frac{1}{NC\_CYL\_NO} * \sum_{i=1}^{NC\_CYL\_NO} IGA\_CYL\_[CYL]\right] - IGA\_REF\_TQR$$

(limited to ≤ 0 °CRK)

$$\textbf{FAC\_IGA\_TQR} = \frac{IGA\_DIF\_REF\_EMS}{IP\_IGA\_DIF\_MAX\_TQR\_\_N\_32\_\_MAF}$$

**TQR_REL_IGA_EMS** = IP_FAC_TQR__FAC_IGA_TQR * TQR_REL_MAX_IGA_N_MAF

### 8.3.3.3 Relative Torque Reduction by EMS internal Fuel Cut-Off (TQR_REL_SCC_EMS)

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| PAT_INH_IV_MAX_N_VS | V | 0...DH | 0...13 | 1 | - |
| maximum choice of pattern index between engine speed and vehicle speed limitation | | | | | |
| TQR_REL_SCC_EMS | V | 0...FFH | 0...0.996 | 0.0039 | 100% |
| relative torque reduction by EMS internal fuel cut-off functions | | | | | |
| TQR_REL_SCC_N_VS | V | 0...FFH | 0...0.996 | 0.0039 | 100% |
| maximum relative torque reduction by engine speed and vehicle speed limitation fuel cut-off functions | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| ID_TQR_REL_SCC__PAT_INH_IV | PAT_INH_IV_N_MAX | PAT_INH_IV_VS_MAX | TQR_REL_SCC_MIS |

**FUNCTION DESCRIPTION:**

General information:

Cylinder shut-offs by N_MAX and VS_MAX limitations are based on the same cylinder shut-off patterns as the TCS function. The effect of these cylinder shut-offs on the engine torque is included in the calculation by the internal quantity **TQR_REL_SCC_EMS**.
If a cylinder shut-off is requested by several functions at the same time, this results in a maximum selection of the pattern index requests **PAT_INH_IV_MAX_N_VS** and the resulting relative torque reduction **TQR_REL_SCC_N_VS**.

If the misfire detection inhibits a certain cylinder, it will remain inhibited until switched back on by the misfire detection. A cylinder which is shut-off due to misfire is ignored by the TCS shut-off pattern. This shut-off cylinder influences the TQI and is considered in the engine torque model by the relative torque reduction TQR_REL_SCC_MIS.

**Formula section:**

**PAT_INH_IV_MAX_N_VS =** max (PAT_INH_IV_N_MAX, PAT_INH_IV_VS_MAX)

**TQR_REL_SCC_N_VS =** ID_TQR_REL_SCC__PAT_INH_IV_MAX_N_VS

The total effect of the resulting relative torque reduction by EMS internal fuel shut-off functions and misfiring cylinder inhibition is given by following interference formula:

**TQR_REL_SCC_EMS =** TQR_REL_SCC_N_VS + TQR_REL_SCC_MIS - (TQR_REL_SCC_N_VS * TQR_REL_SCC_MIS)

This formula is only valid for rolling pattern and steady state fuel shut-off of one or more individual cylinder (like misfire cylinder inhibition).

## 8.4 Exhaust gas temperature model

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| TEG_STAT | V | 0...7FF0H | 0...2047 | 0.0625 | °C |
| steady state exhaust gas temperature | | | | | |
| TEG_MMV_SUB | V | 0...7FF0H | 0...2047 | 0.0625 | °C |
| dynamic exhaust gas temperature | | | | | |
| POW_DIF | V | 0...FD03H | 0...69.08 | 1.067E-03 | kW |
| Power representing the increase of the exhaust gas temperature due to spark retardation | | | | | |
| CRLC_TEG | - | 0...FFFFH | 0...0.999985 | 1.525E-05 | - |
| Correlation constant for exhaust gas temperature calculation | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| N | N_32 | MAF | MAF_KGH |
| VS | PAT_INH_IV | LAM_SUB | TCO |
| TQR_REL_IGA_AV | LV_ES | TQI | |

**FUNCTION DESCRIPTION:**

General information:

The exhaust gas temperature model calculates a theoretical exhaust gas temperature **TEG_MMV_SUB** upstream of the catalytic converter. This temperature serves as a decision criterion for the torque reduction logic module to apportion the desired torque reduction into an IGA- and a SCC-component.

The following input variables are used by the first order model approach to calculate the **TEG_MMV_SUB** in intervals of 1 second:

| | |
|---|---|
| - N_32 | engine speed |
| - MAF, MAF_KGH | mass air flow |
| - VS | vehicle speed |
| - POW_DIF | differential power representing the exhaust gas temperature increase by spark retardation |
| - PAT_INH_IV | fuel shut-off pattern index |
| - LAM_SUB | lambda substitute value |

The calculated temperature **TEG_MMV_SUB** is initialized at engine start, using the actual measured coolant temperature TCO.

**Application conditions:**

*Activation:* not ES (LV_ES = 0)

*Deactivation:* ES (LV_ES = 0)

### 8.4.1 Stationary exhaust gas temperature (TEG_STAT)



**Formula section:**

**TEG_STAT =**

| | |
|---|---|
| [ 1 - ID_TEG_FAC_SCC__PAT_INH_IV ] | influence of cylinder shut-off |
| * [ ( IP_TEG__N_32__MAF | basic stationary exhaust gas temperature |
| + IP_TEG_ADD_IGA__POW_DIF ) | Temperature rise due to retarded ignition angle |
| * IP_TEG_FAC_LAM__LAM_SUB | Lambda dependence of exhaust gas temperature |
| * IP_TEG_FAC_VS__VS ] | influence of cooling air as a function of driving speed |
| + ID_TEG_FAC_SCC__PAT_INH_IV | influence of cylinder shut-off |
| * ( TCO + IP_TEG_STAT_ADD_SCC__MAF_KGH) | correction for stationary exhaust gas temperature at fuel shut-off |



**Temperature increase by spark retard:**

This model approach relates the temperature increase to the retarded ignition angle. It is assumed that this decrease of the engine power is directly turned into heat.
The connection between the rise of the exhaust gas temperature and the applied relative spark retard is given by the differential power POW_DIF, which represents the amount of reduced torque that is turned into heat. It is calculated using the actual relative torque reduction by spark retard TQR_REL_IGA_AV, the engine speed N and the indicated engine torque TQI.

**Formula section:**

**POW_DIF =** TQI * N * TQR_REL_IGA_AV

### 8.4.2 Dynamic Exhaust Gas Temperature (TEG_MMV_SUB)



<u>Filter constants:</u>

If TEG_STAT > TEG_MMV_SUB then **CRLC_TEG =** ID_CRLC_TEG_INC__MAF_KGH

If TEG_STAT ≤ TEG_MMV_SUB then **CRLC_TEG =** ID_CRLC_TEG_DEC__MAF_KGH

<u>Exhaust gas model temperature:</u>

$$\mathbf{TEG\_MMV\_SUB_n} = TEG\_MMV\_SUB_{n-1} + CRLC\_TEG * (TEG\_STAT - TEG\_MMV\_SUB_{n-1})$$



**<u>Calibration data:</u>**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| IP_TEG__N_32__MAF | 8x8 | 0...7FF0H | 0...2047 | 0.0625 | °C |
| basic table of the exhaust gas temperature | | | | | |
| ID_TEG_FAC_SCC__PAT_INH_IV | 14 | 0...FFH | 0...1.992 | 0.0078 | - |
| influence of fuel cut-off on the exhaust gas temperature | | | | | |
| IP_TEG_FAC_LAM__LAM_SUB | 6 | 0...FFH | 0...1.992 | 0.0078 | - |
| influence of lambda on the exhaust gas temperature | | | | | |
| IP_FAC_VS_TEG__VS | 6 | 0...FFH | 0...1.992 | 0.0078 | - |
| influence of the vehicle speed on the exhaust gas temperature | | | | | |
| IP_TEG_ADD_IGA__POW_DIF | 4 | 0...7FF0H | 0...2047 | 1 | °C |
| temperature rise due to retarded ignition angle | | | | | |
| ID_CRLC_TEG_INC__MAF_KGH | 6 | 0...FFFFH | 0...1.000 | 1.53E-5 | - |
| correlation constant for exhaust gas temperature increase | | | | | |
| ID_CRLC_TEG_DEC__MAF_KGH | 6 | 0...FFFFH | 0...1.000 | 1.53E-5 | - |
| correlation constant for exhaust gas temperature decrease | | | | | |
| IP_TEG_STAT_ADD_SCC__MAF_KGH | 6 | 0...FFH | -100...300 | 1.569 | °C |
| temperature rise due to cylinder shut-off | | | | | |

## 8.5 Torque Intervention for ASR and Gear Shift

### Output data:

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| TQR_REL_IGA_OUT | V | 0...FFH | 0...0.996 | 0.0039 | 100% |
| Relative output torque reduction by spark retard | | | | | |
| TQR_REL_SCC_OUT | V | 00...FFH | 0...0.997 | 0.0039 | 100% |
| Relative output torque reduction by fuel cut-off | | | | | |
| LV_CDN_ASR | - | 0...1H | 0...1 | 1 | - |
| logical value for possible ASR intervention | | | | | |
| LV_CDN_GS | V | 0...1H | 0...1 | 1 | - |
| logical value for possible gear shift | | | | | |
| TQR_REL_OUT | V | 0...FFH | 0...0.996 | 0.0039 | 100% |
| General output of torque reduction | | | | | |
| T_GS_DLY_DIAG | V | 0...FFFFH | 0...655.35 | 0.01 | s |
| Diagnosis time during gear-shift | | | | | |

### Input data:

| | | | |
|---|---|---|---|
| LV_IV_[CYL]_ERR | LV_MAF_ERR | LV_CPS_ERR | N |
| N_SP_IS | TQI_TCS_CAN | TQ_STND | TQI |
| TQR_AS | LV_ASR_REQ | LV_ES | LV_ST |
| LV_IS | LV_DRI | TQI_TCU_CAN | TQR_REL_IGA_OUT |



### FUNCTION DESCRIPTION:

General information:

The torque intervention logic of the engine management system determines the valid target torque TQI_ASR_REQ or TQI_GS_REQ, which can be requested by the traction control system or the transmission control unit.
This target torque can be reached by ignition angle adjustment and/or cylinder shut-off.

The indicated engine torque is linearly decreased by cylinder shut-off, depending on the number of shut-off cylinders respectively the index of the shut-off pattern. The transitions are performed by a steady ignition angle adjustment.

The torque intervention logic module decides about the applied apportionment of IGA and SCC components to reach the requested target torque (TQI_ASR_REQ or TQI_GS_REQ) based on the following conditions:

| | |
|---|---|
| - Engine operating point | (N, MAF) |
| - Operating states | (WUP, catalyst protection) |
| - Exhaust gas temperature | (TEMP_MMV_SUB) |
| - Engine speed and TCO limits | (VS, TCO) |

The torque resulting from the torque model as actual target torque for the intervention (TQI_INTV) is put on the CAN by the engine management system. The torque intervention logic adjusts to a reduced torque which is the closest to the requested torque.
Under limit conditions (for example when a high exhaust gas temperature is present or when the catalyst overheating protection is active or due to the minimum cylinder shut-off pattern ID_NR_PAT_MIN__LAM_SUB__TEG_DIF) it is possible that the requested torque can not be adjusted.

Output variables are the torque intervention to be executed via ignition angle adjustment **TQR_REL_IGA_OUT** and via cylinder shut-off **TQR_REL_SCC_OUT**.

Three operating modes are available for a torque reduction intervention:

| | |
|---|---|
| - IGA | ignition angle adjustment exclusively |
| - SCC/IGA | cylinder shut-off in combination with ignition angle adjustment |
| - SCC | cylinder shut-off exclusively |

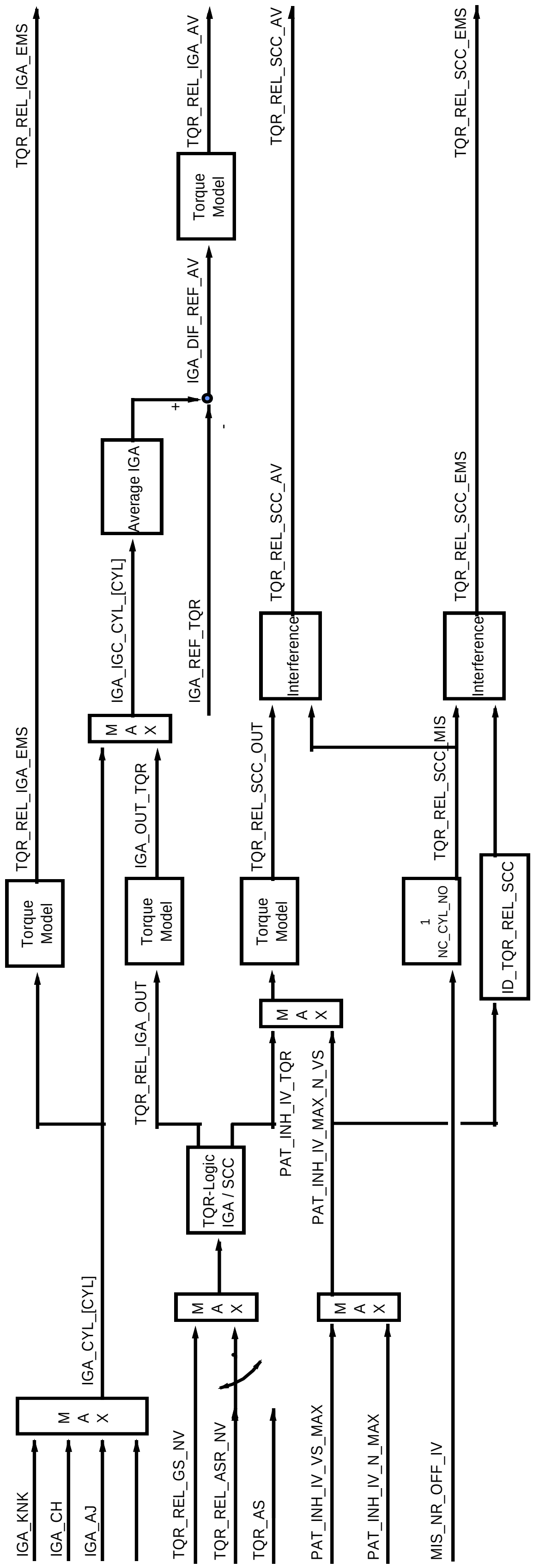
The ignition angle adjustment mode allows a quick torque reaction resulting in a good driveability. However, it can cause an increase of the exhaust gas temperature and is therefore only admissible up to a certain exhaust gas temperature.

The combination mode of cylinder shut-off and ignition angle adjustment is less critical regarding the exhaust gas temperature and permits extended torque interventions, but with the disadvantage of a worse driveability.

If a maximum exhaust gas temperature is exceeded during the combined intervention, the ignition angle intervention is no longer accepted, but only the cylinder shut-off will be effective.

### 8.5.1 Overview of the possible torque interventions





### 8.5.2 Conditions for ASR- and GS-intervention



Conditions for a ASR intervention:

| | | |
|---|---|---|
| **If** | LV_IV_[CYL]_ERR = 0 | *(no error at the injectors)* |
| **and** | LV_MAF_ERR = 0 | *(no error at the mass air flow sensor)* |
| **and** | LV_CPS_ERR = 0 | *(no error at the canister purge solenoid)* |
| **and** | N > N_SP_IS + C_N_ADD_ASR | *(engine speed threshold)* |
| **and** | **[** TQI_TCS_CAN < 100% (TQ_STND) | *(ASR-req. torque below TQ_STND)* |
| | **and** TQI_ASR_REQ < TQI | *(ASR-requested torque below TQI)* |
| | **and** LV_ASR_REQ = 1 | *(ASR intervention requested by control unit)* |
| | **]** **or** TQR_AS > 0 | *(torque intervention by application system)* |
| **then** | **LV_CDN_ASR = 1** | *(ASR intervention possible)* |
| **else** | **LV_CDN_ASR = 0** | *(ASR intervention not possible)* |



Conditions for a Gear-Shift intervention:

| | | |
|---|---|---|
| **If** | LV_ES = 0 | |
| **and** | LV_ST = 0 | |
| **and** | LV_IS = 0 | |
| **and** | LV_DRI = 1 | *(With A/T: Drive selected)* |
| **and** | TQI_TCU_CAN < 100% (TQ_STND) | *(GS-requested torque below TQ_STND)* |
| **and** | TQI_GS_REQ < TQI | *(GS-requested torque below TQI)* |
| **and** | TQI_GS_REQ < TQI ASR REQ | *(req. torque for GS below ASR-request)* |
| **and** | T_GS_DLY_DIAG < C_T_GS_DLY_DIAG | *(GS duration below limit)* |
| **then** | **LV_CDN_GS = 1** | *(Gear shift intervention possible)* |
| **else** | **LV_CDN_GS = 0** | *(Gear shift intervention not possible)* |

**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| C_N_ADD_ASR | 1 | 0...FFH | 0...8160 | 32 | rpm |
| engine speed offset to nominal speed value for activation of ASR | | | | | |
| C_T_GS_DLY_DIAG | 1 | 0...FFFFH | 0...655.35 | 0.01 | s |
| Diagnosis timer threshold for gear shift | | | | | |

### 8.5.3 Torque Reduction Intervention

#### 8.5.3.1 Relative Nominal Torque Reduction for ASR (TQR_REL_ASR_NV)



**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| TQR_REL_ASR_NV | V | 0...FFH | 0...0.996 | 0.0039 | 100% |
| Nominal torque reduction for ASR | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| LV_CDN_ASR | TQI_ASR_REQ | IP_TQI__N_32__MAF | IP_FAC_LAM_TQI__LAM_SUB__IGA_DIF_REF_AV |

**Application conditions:**

**If** LV_CDN_ASR = 1

**then** TQR_REL_ASR_NV =

1 - **Fehler!**

**else** TQR_REL_ASR_NV = 0

### 8.5.3.2 Relative Nominal Torque Reduction for GS (TQR_REL_GS_NV)

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| TQR_REL_GS_NV | V | 0...FFH | 0...0.997 | 0.0039 | 100% |
| Torque Reduction for Gear Shift | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| LV_CDN_GS | TQI_GS_REQ | IP_TQI__N_32__MAF | IP_FAC_LAM_TQI__LAM_SUB__IGA_DIF_REF_AV |

**Application conditions:**

**If** LV_CDN_GS = 1

**then** TQR_REL_GS_NV =

1 - **Fehler!**

**else** TQR_REL_GS_NV = 0

### 8.5.3.3 Determination of the Torque Reduction Amount

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| TQR_REL_NV | V | 0...FFH | 0...0.997 | 0.0039 | 100% |
| Torque reduction input for torque model based on ASR- and GS-request | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| TQR_REL_GS_NV | TQR_REL_ASR_NV | | |

General information:

A torque intervention for gear shift and ASR can happen at the same time. The intervention is done according to the lowest requested torque.

**Formula Section:**

**TQR_REL_NV =** MAX (TQR_REL_GS_NV, TQR_REL_ASR_NV)

### 8.5.3.4 Selection of the Torque Reduction Mode



**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| LV_IGA_ADJ_MOD | V | 0...1H | 0...1 | 1 | - |
| Boolean for ignition angle adjustment for torque reduction | | | | | |
| LV_SCC_MOD | V | 0...1H | 0...1 | 1 | - |
| Boolean for fuel cut-off for torque reduction | | | | | |
| LV_TEG_MAX | V | 0...1H | 0...1 | 1 | - |
| Boolean for maximum allowed exhaust gas temperature exceeded | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| TCO | TQR_REL_NV | TQR_REL_MAX_IGA_N_MAF | TEG_MMV_SUB |

General Information:

A hysteresis is used for determination of the torque reduction mode.

```
If      TCO > C_TCO_MIN_SCC
then    if      [ TQR_REL_NV > TQR_REL_MAX_IGA_N_MAF
          or      N_32 > C_N_MAX_IGA_TQR ]
        then    LV_SCC_MOD = 1
        else    if      TEG_MMV_SUB > C_TEG_THD_2
                then    LV_SCC_MOD = 1
                else    if      TEG_MMV_SUB < C_TEG_THD_1
                        then    LV_SCC_MOD = 0
else    LV_SCC_MOD = 0

If      N_32 < C_N_MAX_IGA_TQR
then    if      [ LV_TEG_MAX = 0 and TEG_MMV_SUB < C_TEG_MAX]
          or    [ LV_TEG_MAX = 1 and TEG_MMV_SUB < C_TEG_THD_2]
        then    LV_IGA_ADJ_MOD = 1
        else    if      TEG_MMV_SUB > C_TEG_MAX
                then    LV_IGA_ADJ_MOD = 0
                and     LV_TEG_MAX = 1
else    LV_IGA_ADJ_MOD = 0
  and   LV_TEG_MAX = 0
```

Reset of LV_TEG_MAX:

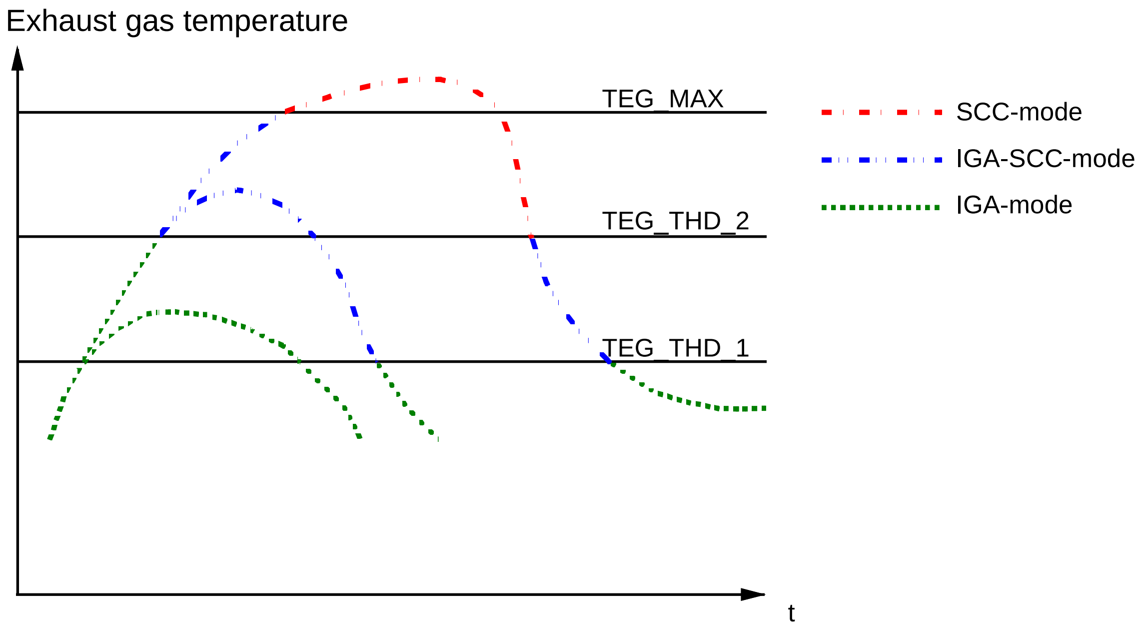
**If** TQR_REL_NV = 0

**then** LV_TEG_MAX = 0

**and** LV_SCC_MOD = 0

**and** LV_IGA_ADJ_MOD = 0

### 8.5.3.5 Exhaust gas temperature logic




The above diagram represents possible exhaust gas temperatures **TEG_MMV_SUB** during an ASR intervention with the three operating modes available for torque reduction.

**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| C_TCO_MIN_SCC | 1 | 0...FEH | -48...142.50 | 0.55 | °C |
| exhaust gas temperature threshold 1 | | | | | |
| C_TEG_THD_1 | 1 | 0...7FF0H | 0...2047 | 0.0625 | °C |
| exhaust gas temperature threshold 1 | | | | | |
| C_TEG_THD_2 | 1 | 0...7FF0H | 0...2047 | 0.0625 | °C |
| exhaust gas temperature threshold 2 | | | | | |
| C_TEG_MAX | 1 | 0...7FF0H | 0...2047 | 0.0625 | °C |
| maximum allowable exhaust gas temperature | | | | | |
| C_N_MAX_IGA_TQR | 1 | 0...FF0H | 0...8160 | 32 | rpm |
| maximum allowed engine speed for ignition angle intervention | | | | | |

### 8.5.3.6 Ignition Angle Adjustment (IGA_ADJ) Mode

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| TQR_REL_IGA_OUT | V | 0...FFH | 0...0.997 | 0.0039 | 100% |
| relative torque reduction by ignition angle adjustment | | | | | |
| TQR_REL_SCC_OUT | V | 0...FFH | 0...0.996 | 0.0039 | 100% |
| relative torque reduction by fuel cut-off | | | | | |
| PAT_INH_IV_TQR | V | 0...DH | 0...13 | 1 | - |
| index pattern for cylinder shut-off for torque reduction | | | | | |
| LV_IGA_ADJ_TQR | V | 0...1H | 0...1 | 1 | - |
| Boolean for torque reduction by spark retard | | | | | |
| LV_SCC_TQR | V | 0...1H | 0...1 | 1 | - |
| Boolean for torque reduction by fuel cut-off | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| LV_IGA_ADJ_MOD | LV_SCC_MOD | TQR_REL_NV | TQR_REL_MAX_IGA_N_MAF |



**FUNCTION DESCRIPTION:**

General information:

In the ignition angle adjustment mode, the required torque reduction TQR_REL_NV is performed exclusively via spark retard. Torque interventions by ignition angle intervention are clearly preferred as they do not affect the driveability.

Vehicle take-off or slip occurring during cornering require a very quick torque intervention. In such cases, a new ASR request is executed exclusively by spark retard up to the possible extent (limitations by exhaust gas temperature or ignition angle).

- The following function is effected by the ignition angle adjustment:
  - Knock adaptation is inhibited

**Application conditions:**

*Activation / Deactivation*

**If** LV_IGA_ADJ_MOD = 1
**and** LV_SCC_MOD = 0
**then** TQR_REL_IGA_OUT = Min (TQR_REL_NV, TQR_REL_MAX_IGA_N_MAF)
**and** LV_IGA_ADJ_TQR = 1
**and** LV_SCC_TQR = 0
**and** TQR_REL_SCC_OUT = 0
**and** PAT_INH_IV_TQR = 0

### 8.5.3.7 Cylinder Shut-Off (SCC) Mode



**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| TQR_REL_IGA_OUT | V | 00...FFH | 0...0.997 | 0.0039 | 100% |
| relative torque reduction by spark retard | | | | | |
| TQR_REL_SCC_OUT | V | 0...FFH | 0...0.996 | 0.0039 | 100% |
| relative torque reduction by fuel cut-off | | | | | |
| PAT_INH_IV_TQR | V | 0...DH | 0...13 | 1 | - |
| index of fuel cut-off pattern for torque reduction | | | | | |
| LV_IGA_ADJ_TQR | V | 0...1H | 0...1 | 1 | - |
| Boolean for torque reduction by spark retard | | | | | |
| LV_SCC_TQR | V | 0...1H | 0...1 | 1 | - |
| Boolean for torque reduction by fuel cut-off | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| LV_SCC_MOD | LV_IGA_ADJ_MOD | ID_PAT_INH_IV_MIN__LAM_SUB__TEG_DIF | |



**FUNCTION DESCRIPTION:**

General information:

With this mode the torque reduction request TQR_REL_NV is answered exclusively by a cylinder shut-off.

With the used cylinder shut-off pattern the engine torque can be only adjusted in steps. However, as a shut-off pattern of 13 is used, the steps are very small and therefore the torque reduction performance and the driveability are not effected excessively.

- The following functions are effected by the cylinder shut-off:
  - Lambda control loop is opened
  - Catalyst overheating protection function
  - Warm-up enrichment is switched to separate ASR warm-up enrichment
  - Full load enrichment is inhibited
  - Cold post-start enrichment is inhibited
  - Knock adaptation is inhibited
  - CPS is closed
  - EGR valve is closed
  - Fuel leaning function during cylinder shut-off is enabled

## Application conditions:

*Activation / Deactivation*

**If** LV_SCC_MOD = 1
**and** LV_IGA_ADJ_MOD = 0
**then** PAT_INH_IV_TQR = Max (ID_PAT_INH_IV_MIN__LAM_SUB__TEG_DIF, ID_PAT_INH_IV_TQR__TQR_REL_NV)

**If** PAT_INH_IV_TQR > 0
**then** LV_SCC_TQR = 1
**and** TQR_REL_SCC_OUT = ID_TQR_REL_SCC__PAT_INH_IV_TQR
**and** TQR_REL_IGA_OUT = 0
**and** LV_IGA_ADJ_TQR = 0
**else** TQR_REL_SCC_OUT = 0
**and** LV_SCC_TQR = 0

## Calibration data:

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| ID_TQR_REL_SCC__PAT_INH_IV_TQR | 14 | 0...FFH | 0...0.996 | 0.0039 | 100% |
| relative torque reduction by fuel cut-off pattern<br>*Remark: In the application system the name of this map is ID_TQR_REL_SCC__PAT_INH_IV* | | | | | |
| ID_PAT_INH_IV_TQR__TQR_REL_NV | 6x6 | 0...DH | 0...13 | 1 | |
| Cylinder shut-off pattern number for torque reduction | | | | | |

### 8.5.3.8 Torque Reduction by Single Cylinder Shut-Off (SCC) and Ignition Angle Adjustment (IGA_ADJ) Mode

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| TQR_REL_IGA_OUT | V | 00...FFH | 0...0.997 | 0.0039 | 100% |
| relative torque reduction by ignition angle adjustment | | | | | |
| TQR_REL_SCC_OUT | V | 0...FFH | 0...0.997 | 0.0039 | 100% |
| relative torque reduction by fuel cut-off | | | | | |
| TQR_REL_MAX_IGA_TEG | V | 0...FFH | 0...0.997 | 0.0039 | 100% |
| maximum relative torque reduction by ignition angle adjustment regarding exhaust gas temperature | | | | | |
| PAT_INH_IV_TQR | V | 0...DH | 0...13 | 1 | - |
| index for fuel cut-off pattern for torque reduction | | | | | |
| LV_IGA_ADJ_TQR | V | 0...1H | 0...1 | 1 | - |
| Boolean for torque reduction by spark retard | | | | | |
| LV_SCC_TQR | V | 0...1H | 0...1 | 1 | - |
| Boolean for torque reduction by fuel cut-off | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| LV_SCC_MOD | LV_IGA_ADJ_MOD | ID_PAT_INH_IV_TQR__TQR_REL_NV | TQR_REL_MAX_IGA_N_MAF |
| TEG_DIF | N | TQI | TQR_REL_NV |

**FUNCTION DESCRIPTION:**

General information:

In case of this torque reduction mode the requested torque is executed by a combination of cylinder shut-off and ignition angle retard adjustment.
This mode is activated if the ignition angle adjustment mode can no longer be kept alone and if the following conditions are met.

**Application conditions:**

**If** LV_SCC_MOD = 1

**and** LV_IGA_ADJ_MOD = 1

**then**

a) Determination of the torque reduction portion by cylinder shut-off

PAT_INH_IV_TQR = Max (ID_PAT_INH_IV_MIN__LAM_SUB__TEG_DIF,
ID_PAT_INH_IV_TQR__TQR_REL_NV)

**If** PAT_INH_IV_TQR > 0

**then** TQR_REL_SCC_OUT = ID_TQR_REL_SCC__PAT_INH_IV_TQR

**and** LV_SCC_TQR = 1

**else** TQR_REL_SCC_OUT = 0

**and** LV_SCC_TQR = 0

b) Determination of the torque reduction portion by ignition angle adjustment

**If** TQR_REL_NV - TQR_REL_SCC_OUT > 0

**then** TQR_REL_MAX_IGA_TEG = **Fehler!**

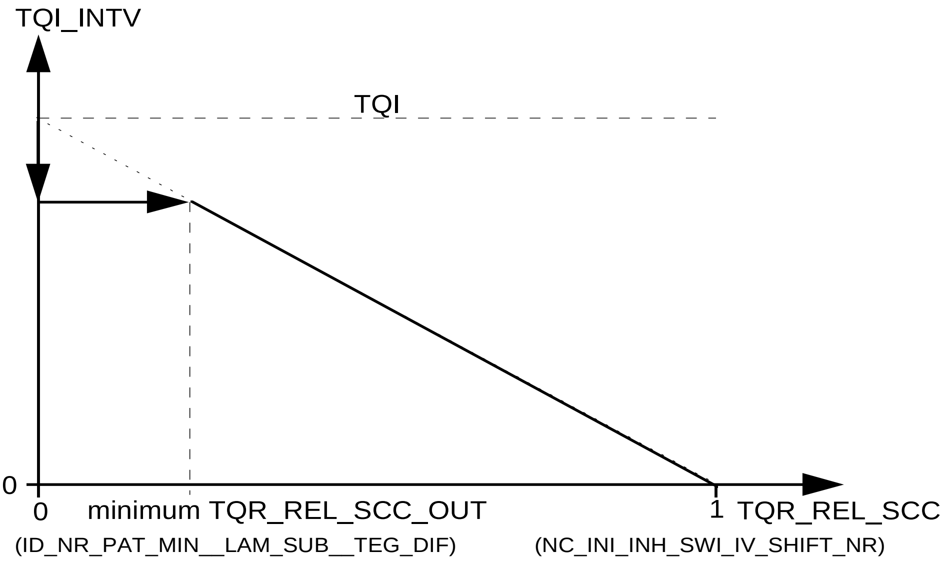
**and** TQR_REL_IGA_OUT = Min (TQR_REL_NV - TQR_REL_SCC_OUT,
TQR_REL_MAX_IGA_N_MAF,
TQR_REL_MAX_IGA_TEG)

**and** LV_IGA_ADJ_TQR = 1

**else** TQR_REL_IGA_OUT = 0

**and** LV_IGA_ADJ_TQR = 0

When the requested torque reduction TQR_REL_NV increases (or either TQI_ASR_REQ or TQI_GS_REQ decreases), the retard adjustment of the ignition angle TQR_REL_IGA_OUT moves to a maximum value, which is given by ID_TQR_REL_SCC__PAT_INH_IV_TQR.
The maximum ignition angle retard adjustment is limited by TQR_REL_MAX_IGA_N_MAF, or TQR_REL_MAX_IGA_TEG.
To avoid an excessive rise of the exhaust gas temperature, there is a minimum cylinder shut-off pattern ID_NR_PAT_MIN__LAM_SUB__TEG_DIF. A hysteresis function enables the return to the "zero pattern" using TQR_REL_SCC_OUT = 0. The cylinder shut-off is only canceled if the torque request condition TQR_REL_NV = 0 is present.




**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| C_TEG_FAC_IGA | 1 | 0...FFFFH | 0...0.1 | 1.53E-6 | |
| factor temperature increase of spark retard | | | | | |
| ID_TQR_REL_SCC__PAT_INH_IV | 14 | 0...FFH | 0...0.996 | 0.0035 | |
| relative torque reduction by fuel cut-off pattern | | | | | |
| ID_PAT_INH_IV_MIN__LAM_SUB__TEG_dif | 6x6 | 0...DH | 0...13 | 1 | |
| Minimum pattern number for torque reduction | | | | | |

### 8.5.3.9 Minimum Torque Reduction Pattern

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| TEG_DIF | V | 0...FFF0H | -2048...2047 | 0.0625 | °C |
| Difference between calculated and maximum allowed exhaust gas temperature | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| TEG_MMV_SUB | C_TEG_MAX | | |

**FUNCTION DESCRIPTION:**

In case of a cylinder shut-off, all stationary mixture enrichments have to be terminated. To prevent the exhaust gas temperature from increasing even more by a cylinder shut-off after an active catalyst overheating prevention enrichment, only activation of cylinder shut-off patterns PAT_INH_IV_TQR ≥ ID_PAT_INH_IV_MIN__LAM_SUB__TEG_DIF are admitted. This minimum allowed cylinder shut-off pattern is selected as a function of TEG_DIF and of the lambda substitute value LAM_SUB.

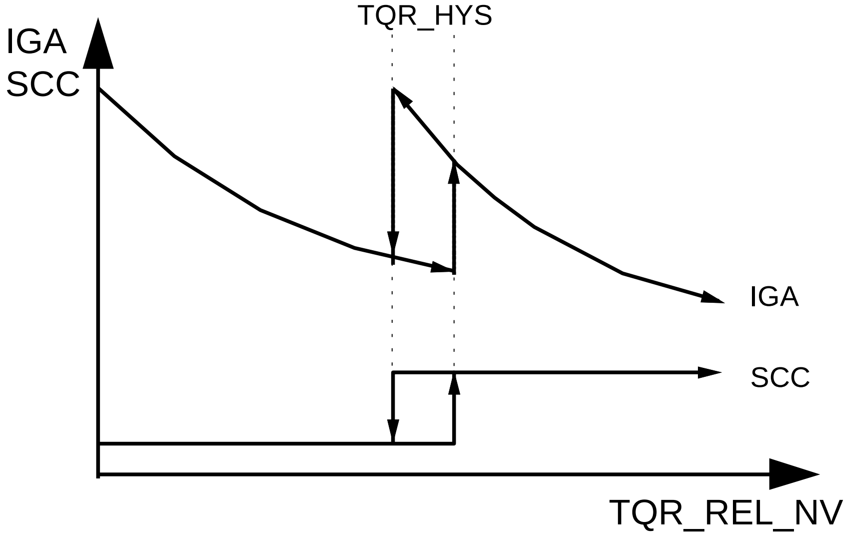
The differential temperature TEG_DIF is calculated at intervals of a second.

TEG_DIF = TEG_MMV_SUB - C_TEG_MAX

### 8.5.3.10 Hysteresis between Cylinder Shut-Off and Ignition Angle Adjustment

**FUNCTION DESCRIPTION:**

The switch point to a different shut-off pattern is expanded to a switch range using the hysteresis C_TQR_HYS. This way, a permanent switching between the IGA_ADJ and SCC modes is avoided, if the desired torque TQI_ASR_REQ fluctuates around a certain operating point.




Hysteresis between cylinder shut-off (SCC) and ignition angle adjustment (IGA)

**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| C_TQR_HYS | 1 | 00...FFH | 0...0.997 | 3.895E-3 | |
| Hysteresis between ignition angle adjustment and cylinder shut-off | | | | | |

### 8.5.4 Torque Intervention by the Application System



**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| TQR_AS | V | 00...FFH | 0...0.997 | 0.0039 | 100% |
| torque reduction request by application tool | | | | | |

**Application conditions:**

*Activation:*

The constant **C_TQR_AS** is implemented to assist in the application process.

If **C_TQR_AS > 0** then the requested torque is determined by the maximum selection of TQR_REL_ASR_NV, TQR_REL_GS_NV or TQR_AS.

*Deactivation:* C_TQR_AS = 0



**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| C_TQR_AS | 1 | 00...FFH | 0...0.997 | 3.895E-3 | |
| application assistance relative torque reduction | | | | | |

## 8.6 Execution of a Torque Intervention

### 8.6.1 Ignition Angle Retard Adjustment (IGA_ADJ_TQR)

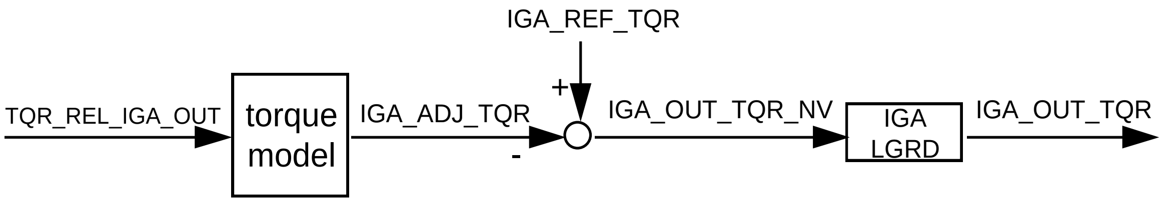
**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| IGA_ADJ_TQR | V | 0...FFH | 0...-95.625 | 0.375 | °CRK |
| ignition angle adjustment for torque intervention | | | | | |
| IGA_OUT_TQR_NV | V | 0...FFH | 72...-23.625 | 0.375 | °CRK |
| applied ignition angle for torque intervention without gradient limitation | | | | | |
| IGA_OUT_TQR | V | 0...FFH | 72...-23.625 | 0.375 | °CRK |
| applied ignition angle for torque intervention with gradient limitation | | | | | |
| FAC_TQR | V | 0...FFH | 0...0.997 | 0.0039 | 100% |
| relative torque reduction by ignition angle adjustment | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| TQR_REL_IGA_OUT | TQR_REL_MAX_IGA_N_MAF | IGA_REF_TQR | IP_FAC_IGA_TQR__FAC_TQR |

Signal flow diagram:




**Formula section:**

**If** TQR_REL_IGA_OUT > 0

**then** FAC_TQR = TQR_REL_IGA_OUT / TQR_REL_MAX_IGA_N_MAF

**and** IGA_ADJ_TQR =

IP_FAC_IGA_TQR__FAC_TQR * IP_IGA_DIF_MAX_TQR__N_32__MAF

**and** IGA_OUT_TQR_NV = IGA_REF_TQR - IGA_ADJ_TQR

**and** IGA_OUT_TQR = IGA_OUT_TQR_NV - C_IGA_LGRD_TQR

Ignition angle retard adjustments are effected without limitation gradient,
advance adjustments are effected with the gradient limitation C_IGA_LGRD_TQR.

**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| IP_IGA_DIF_MAX_TQR__N_32__MAF | 8x8 | 0...FFH | 0...-95.625 | 0.375 | °CRK |
| maximum spark retard for torque reduction | | | | | |
| C_IGA_LGRD_TQR | 1 | 0...FFH | 0...95.625 | | °CRK/Seg |
| limitation gradient for ignition angle adjustment | | | | | |

### 8.6.2 Selection of Cylinder Shut-Off Patterns

Remark:

The selection of the applied cylinder shut-off pattern is described in the chapter „Injection“ in the subchapter „Cylinder Fuel Cut-Off“.

## 8.7 Auxiliary functions

### 8.7.1 ASR Warm-up

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| TI_WUP_COR | V | 0...7F0H | 0...0.496 | 0.00244 | |
| warm-up enrichment correction | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| TCO | TCO_ST | LV_SCC_TQR | |

General information:

In order to protect the catalyst from overheating by a secondary air effect at fuel cut-off mode (which can happen especially at cold engine temperatures) because of a high wall film in the intake manifold, a more lean warm-up-enrichment is necessary.

To ensure an uninterrupted engine operation (without misfires) in the warm-up phase, the warm-up enrichment cannot be foregone completely in the SCC mode.

Description:

With a cylinder shut-off active, there is a switch from the normal warm-up injection time IP_TI_TCO_WUP__TCO__TCO_ST to IP_TI_TCO_WUP_ASR__TCO__TCO_ST which is leaner than the normal one.

**Application conditions:**

*Activation:* LV_SCC_TQR = 1

*Deactivation:* LV_SCC_TQR = 0

**Formula section:**

TI = TIB
:
*(1 + TI_WUP_COR)
:

**TI_WUP_COR = IP_TI_WUP__N__MAF * IP_TI_TCO_WUP_ASR__TCO__TCO_ST**

**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| IP_TI_TCO_WUP_ASR__TCO__TCO_ST | 8x3 | 0...FFH | 0 ...1.992 | 0.0078 | |
| TI warm up correction during ASR intervention | | | | | |

### 8.7.2 Leaning Function for Cylinder Shut-Off outside the Warm-Up Mode

**Input data:**

| | | | |
|---|---|---|---|
| MAF_KGH | LV_SCC_TQR | | |

General information:

To protect the catalytic converter against the secondary air effect (air + excess fuel) in the cylinder shut-off mode, **ID_TI_SCC__MAF_KGH** can be used to obtain an adjustable enleaning of the active cylinders via MAF_KGH.

**Application conditions:**

*Activation:* LV_SCC_TQR = 1

*Deactivation:* LV_SCC_TQR = 0

**Formula section:**

TI = TIB
:
* ( 1- **ID_TI_SCC__MAF_KGH)**
:

**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| ID_TI_SCC__MAF_KGH | 6 | 0...FFH | 0...0.5 | 0.00196 | |
| fuel leaning during cylinder shut-off mode for torque intervention | | | | | |

### 8.7.3 Inhibition of Lambda closed loop control



**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| T_DLY_LAM_TQR | V | 0...FFH | 0...25.5 | 0.1 | s |
| delay time for lambda control activation after cylinder shut-off for torque intervention | | | | | |
| LV_SCC_LAM_TQR | V | 0...1H | 0...1 | 1 | - |
| Boolean for Lambda control loop opened due to cylinder shut-off for torque intervention | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| LV_SCC_TQR | | | |

General Information:

During cylinder shut-off phases due to torque reduction (LV_SCC_TQR = 1) the closed loop lambda control is stopped immediately and LV_SCC_LAM_TQR is set.
When the cylinder shut-off mode is ended (LV_SCC_TQR = 0), the timer T_DLY_LAM_TQR is started with **C_T_DLY_LAM_TQR**. As soon as this timer has run out, LV_SCC_LAM_TQR is reset.



**Formula Section:**

**If** LV_SCC_TQR = 1
**then** LV_SCC_LAM_TQR = 1

**If** LV_SCC_TQR = 0
**and** T_DLY_LAM_TQR = 0
**then** LV_SCC_LAM_TQR = 0

**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| C_T_DLY_LAM_TQR | 1 | 0...FFH | 0...25.5 | 0.1 | s |
| delay time for lambda control activation after cylinder shut-off for torque intervention | | | | | |

### 8.7.4 Inhibition of EGR during Cylinder Shut-Off



**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| T_DLY_EGR_TQR | V | 0...FFH | 0...25.5 | 0.1 | s |
| delay time for EGR valve opening after cylinder shut-off for torque intervention | | | | | |
| LV_SCC_EGR_TQR | V | 0...1H | 0...1 | 1 | - |
| Boolean for EGR valve closed due to cylinder shut-off for torque intervention | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| LV_SCC_TQR | | | |

During fuel cut-off phases due to torque reduction (LV_SCC_TQR = 1) the EGR has to be closed suddenly.
After fuel cut-off action the EGR-valve is opened after a delay time **C_T_DLY_EGR_TQR.**



**Formula Section:**

**If** LV_SCC_TQR = 1
**then** LV_SCC_EGR_TQR = 1

**If** LV_SCC_TQR = 0
**and** T_DLY_EGR_TQR = 0
**then** LV_SCC_EGR_TQR = 0

**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| C_T_DLY_EGR_TQR | 1 | 0...FFH | 0...25.5 | 0.1 | s |
| delay time for EGR valve opening after cylinder shut-off for torque intervention | | | | | |

### 8.7.5 Cylinder-specific fuel mixture enrichment on restarting fuel-feed

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| TI_ADD_REAC_SCC_[CYL] | V | 0...FFFFH | 0...262.14 | 0.004 | ms |
| fuel enrichment for restarting cylinders | | | | | |
| TI_DIF_WF_[CYL] | V | 0...FFFFH | -131.07...131.07 | 0.004 | ms |
| calculated amount of wall film | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| TIB | TCO | N_32 | |

General information:

In order to provide a sufficient fuel feed when reactivating a cylinder after a shut-off (complete combustion without misfire) and to ensure a fast torque build-up, the cylinder is supplied with an additional fuel quantity:

- To consider the increased cylinder fill due to the lack of residual exhaust gas
- To consider the removal of the wall-applied fuel film during cylinder shut-off

The additional fuel quantity is calculated individually for each re-activated cylinder.
When the cylinder is restarted, there is no difference depending on the previous operating states.

**Formula section:**

TI = :
:
+ TI_ADD_REAC_SCC_[CYL]

#### 8.7.5.1 Calculation of the Wall-Applied Fuel Film Removal

To simulate the wall-applied fuel film removal, the cylinder-specific variable **TI_DIF_WF_[CYL]** is used. When the cylinder is shut off, **TI_DIF_WF_[CYL]** is set to the current negative basic injection period TIB, which is multiplied by the adjustable factor **ID_TI_TCO_NEG_WF__TCO**.
As long as the cylinder is shut off, an engine-speed related additional fuel quantity **ID_TI_INC_WF__N_32** is incremented cyclically at intervals of 720° CRK, until either the cylinder is reactivated or the wall film is completely removed.

Directly after cylinder shut-off:

**TI_DIF_WF_[CYL] = - TIB * ID_TI_TCO_NEG_WF__TCO**

During the following cylinder shut-off period:

**$\text{TI\_DIF\_WF\_[CYL]}_k$ = $\text{TI\_DIF\_WF\_[CYL]}_{k-1}$ + ID_TI_INC_WF__N_32**



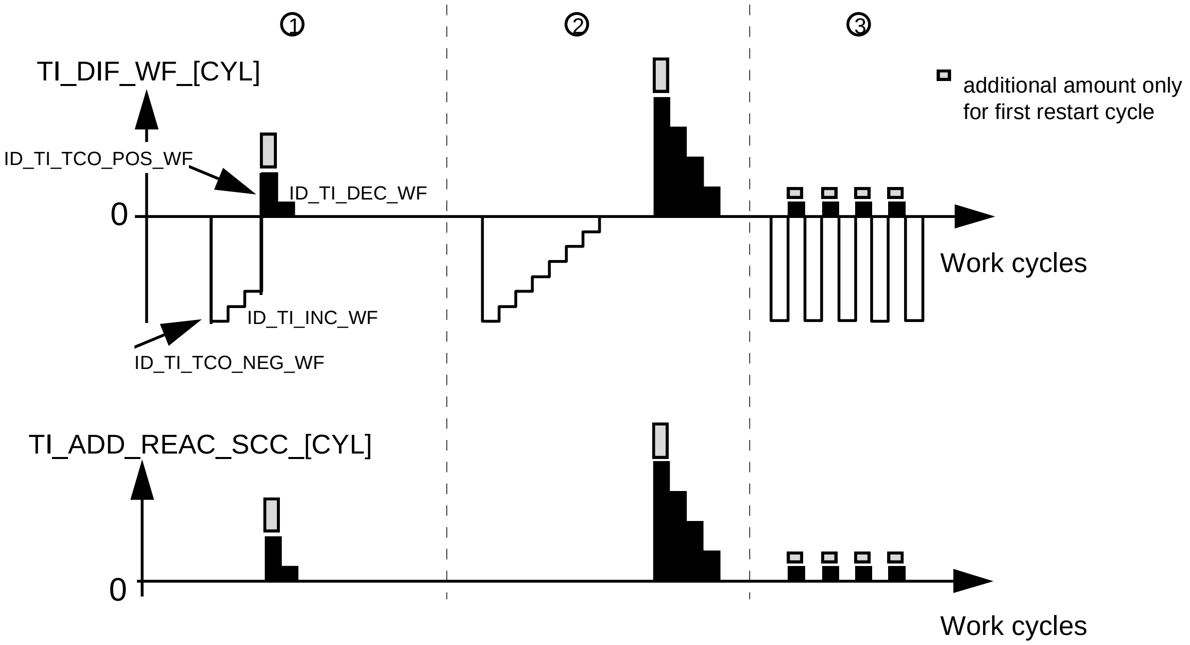
#### 8.7.5.2 Additional Injection Quantity for Re-Activation of the Cylinder

The fuel quantity represented by **TI_ADD_REAC_SCC_[CYL]** is provided additionally as restart fuel feed for each cylinder. It is calculated based on the simulated wall-applied fuel film portion **TI_DIF_WF_[CYL]** and the current basic injection time **TIB,** multiplied by the basic amount of fuelat restarting **ID_TI_TCO_POS_WF__TCO**.
Because of the higher load of the restarting cylinders due to missing residual gas, every first restart cycle an additional amount of fuel **ID_TI_N_POS_RG__N_32** is injected.
For the restart fuel reduction which is calculated during cylinder shut-off, an engine-speed related decrement **ID_TI_DEC_WF__N_32** is used until the additional reactivation amount **$\text{TI\_ADD\_REAC\_SCC\_[CYL]}_k$** is decremented to zero.

**TI_ADD_REAC_SCC_[CYL] = TI_DIF_WF_[CYL]**
**+ TIB * ID_TI_TCO_POS_WF__TCO**
**+ ID_TI_N_POS_RG** *(applied only for first restart cycle)*

**$\text{TI\_ADD\_REAC\_SCC\_[CYL]}_k$ = $\text{TI\_ADD\_REAC\_SCC\_[CYL]}_{k-1}$ - ID_TI_DEC_WF__N_32**

### 8.7.5.3 Case studies




Case 1:
In this example the cylinder is activated again after three shut-off cycles. The wall-applied fuel film has not been removed completely. Therefore the re-starting fuel quantity TI_ADD_REAC_SCC_[CYL] takes into account the residual wall film as a negative value represented by TI_DIF_WF_[CYL]. The additional reactivation injection quantity TI_ADD_REAC_SCC_[CYL] is reset after two cycles.

Case 2:
After a longer cylinder shut-off the wall-applied fuel film is removed completely. The cylinder is re-activated with the maximum quantity for TI_ADD_REAC_SCC_[CYL]

Case 3:
This example shows alternating cylinder operation. Here an additional injection quantity is supplied with every combustion cycle.

**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| ID_TI_INC_WF__N_32 | 8 | 0...FFFFH | 0...262.14 | 0.004 | ms |
| increase of wall film | | | | | |
| ID_TI_DEC_WF__N_32 | 8 | 0...FFFFH | 0...262.14 | 0.004 | ms |
| decrease of wall film | | | | | |
| ID_TI_TCO_POS_WF__TCO | 8 | 0...FFFFH | 0...4 | 0.00006 | - |
| basic amount of fuel at restarting | | | | | |
| ID_TI_TCO_NEG_WF__TCO | 8 | 0...FFFFH | 0...4 | 0.00006 | - |
| basic amount of wall film | | | | | |
| ID_TI_N_POS_RG__N_32 | 8 | 0...FFFFH | 0...262.14 | 0.004 | ms |
| Residual exhaust gas compensation | | | | | |

## 8.8 Torque during an torque intervention (TQI_INTV)



**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| TQI_INTV | V | 0...FFH | 0...510 | 2 | Nm |
| indicated engine torque during torque reduction intervention | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| IP_TQI__N_32__MAF | IP_FAC_LAM_TQI__LAM_SUB__IGA_DIF_REF_AV | TQR_REL_SCC_AV | TQR_REL_IGA_AV |
| LV_ES | | | |

The variable **TQI_INTV** represents the indicated engine torque during a torque reduction intervention.



**Application conditions:**

*Activation:* not ES

*Deactivation:* ES

**Formula section:**

**TQI_INTV =** IP_TQI__N_32__MAF *(indicated engine torque)*

* IP_FAC_LAM_TQI__LAM_SUB__IGA_DIF_REF_AV *(lambda correction)*

***** [ 1 - (TQR_REL_SCC_AV *(torque reduction by the actual cylinder shut-off)*

\+ TQR_REL_IGA_AV) ] *(torque reduction by the ignition angle adjustment)*

## 8.9 ASR Statistics Counters

**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| T_SCC_S | V | 0...1770H | 0...60 | 0.01 | s |
| short time counter for SCC | | | | | |
| T_SCC_L | V | 0...FFFFH | 0...65535 | 1 | min |
| long time counter for SCC | | | | | |
| ASR_STAT_0...15 | V | 0...FFFFH | 0...65535 | 1 | |
| ASR statistical array | | | | | |
| T_ASR_CTR | V | 0...FFFFH | 0...65535 | 1 | s |
| ASR statistical counter | | | | | |
| TQR_ASR_MAX | V | 0...FFH | 0...255 | 1 | % |
| depth of ASR intervention | | | | | |

**Input data:**

| | | | |
|---|---|---|---|
| TQR_REL_ASR_NV | TQR_REL_SCC_AV | | |



### 8.9.1 Cylinder Shut-Off Time Counter T_SCC_S and T_SCC_L

The cylinder shut-off time counter records all cylinder shut-off periods resulting from ASR requests. It is to demonstrate the connection between the cylinder shut-off period and the extent of additional aging of the catalytic converter.

There are two counters:

a) The short-time counter **T_SCC_S** (0...60 sec) is incremented in steps of 10 ms and reset to zero each 60 sec

b) The long-time counter **T_SCC_L** (0...65535 min) is incremented in steps of one.

The contents of both the counters are stored in the EEPROM and are available after the ignition is switched off.

**Reset:**
The contents of the SCC time counter can be reset to zero by the procedure resetting the adaptation values via SAMS 2000 application tool.

**Enabling condition for SCC time counter:**

**TQR_REL_SCC_AV > 0**

In this context, the value of the ignition angle intervention **TQR_REL_IGA_AV** is not considered.

### 8.9.2 Event Frequency Counter - Intervention Statistics ASR_STAT_0...15

16 event frequency counters **ASR_STAT_0...15** which are arranged in the form of a 4x4 matrix array record ASR requests by their duration and depth of action.

The measure of the depth of action **TQR_ASR_MAX** is the requested torque reduction **TQR_REL_ASR_NV**. The duration of intervention is recorded by the ASR time counter **T_ASR_CTR** (resolution: 10 ms), which starts beginning with a valid ASR request (**TQR_REL_ASR_NV** > 0) and is stopped when the ASR request is terminated (**TQR_REL_ASR_NV** = 0).

During an active ASR phase, the maximum of (**TQR_REL_IGA_AV + TQR_REL_SCC_AV**) is stored. Once the ASR intervention is terminated, the maximum of **TQR_REL_IGA_AV** and **TQR_REL_SCC_AV** as well as **T_ASR_CTR** are stored in the array. If the maximum of 255 is reached for T_ASR_CTR, it remains unchanged until it is reset by hand.

**Reset:**
The contents of the statistic counter can be reset to zero by the procedure resetting the adaptation values via SAMS 2000 application tool.

The data points of the event frequency counter cannot be adjusted in the scope of the application, only via a software intervention.

**Arrangement of event frequency counters**

| Depth of action TQR<br>TQR_ASR_MAX | **ASR_CAN_STAT_0...15** | | | |
|---|---|---|---|---|
| 0% ... < 25% | _0 | _1 | _2 | _3 |
| 25% ... < 50% | _4 | _5 | _6 | _7 |
| 50% ... < 75% | _8 | _9 | _10 | _11 |
| 75 % | _12 | _13 | _14 | _15 |
| Duration of intervention in sec<br>T_ASR_CTR | 0...0.5 | > 0.5 ... 2 | > 2 ... 8 | > 8 |

## 8.10 Torque Reduction Emergency Operation

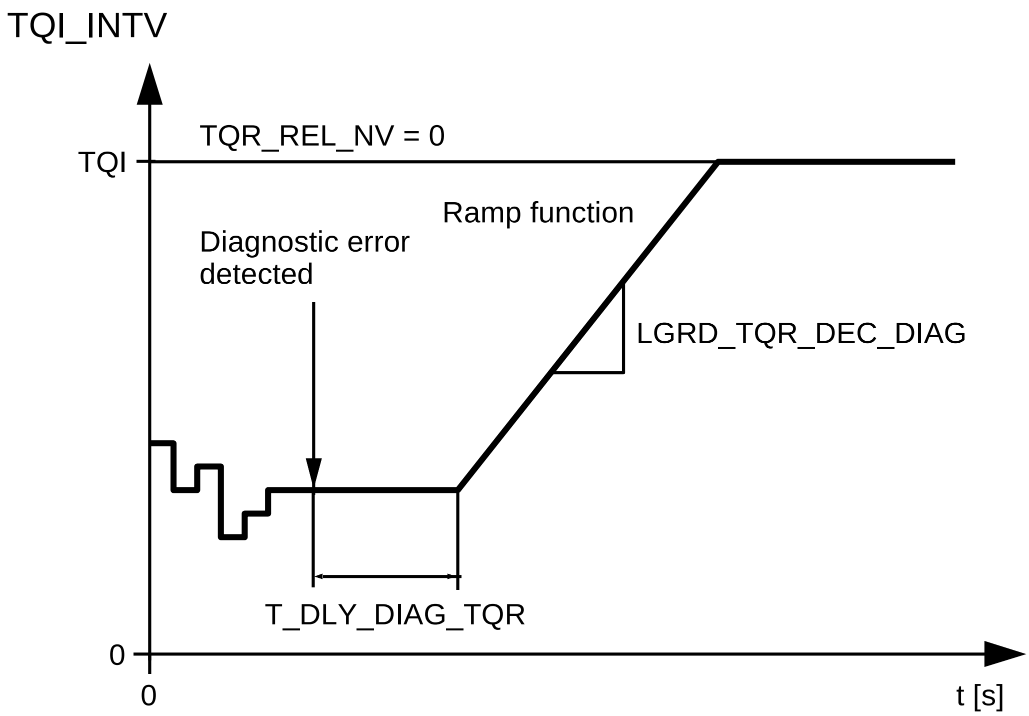
**Output data:**

| Name | Mode | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| T_DLY_DIAG_TQR | V | 0...FFH | 0...2.55 | 0.01 | s |
| delay time for starting the emergency ramp | | | | | |

If a transmission error or a mixture-related component error (MAF-Sensor, Canister purge valve, injection valves ...) occurs during an active torque reduction phase, the current torque reduction is continued for the time **T_DLY_DIAG_TQR** and subsequently reset to **TQR_REL_NV = 0** using **LGRD_TQR_DEC_DIAG**.

The emergency operation is carried out if an error is detect on one of the following components:

- Injection valve
- MAF-sensor
- Canister purge valve
- CAN component (bus-off or timeout)




**Calibration data:**

| Name | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|
| C_LGRD_TQR_DEC_DIAG | 1 | 1...FFH | 0.004...1.02 | 0.04 | 1/100ms |
| limiting gradient for TQR-emergency ramp | | | | | |
| C_T_DLY_DIAG_TQR | 1 | 0...FFH | 0...2.55 | 0.01 | s |
| delay time for emergency ramp | | | | | |

# 9 Fuel pump relay control



**Input data:**

| | | | |
|---|---|---|---|
| LV_ES | LV_IGK | | |

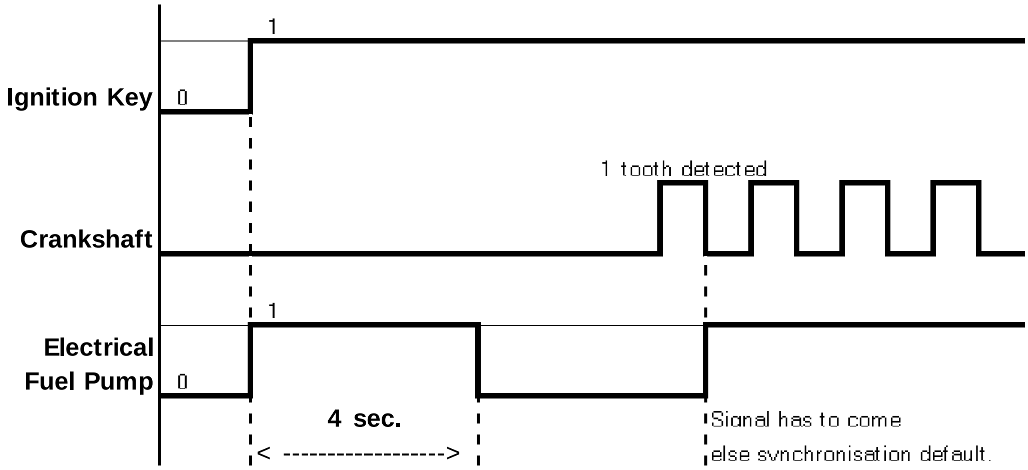
**FUNCTION DESCRIPTION:**

General information:

The fuel pump is switched **ON** for **4 sec.** during the transition from the control unit initialization to engine operating state engine stopped (LV_ES = 1) with ignition key **ON** ( LV_IGK = active).

Following ignition key **OFF** (LV_IGK = passive), the fuel pump is switched **OFF** after a waiting period C_T_EFP.

Description:




**Calibration data:**

| Name | Type | Dim | Hex. limits | Phys. limits | Resol. | Unit |
|---|---|---|---|---|---|---|
| C_T_EFP | 2U | 1 | 01... FFFFH | 0,1... 6553,5 | 0,1 | sec. |
| Time delay to shut - off the electric fuel pump relay after ignition key OFF. | | | | | | |