The following modules of the *funktionsrahmen*/function sheet relating to the Bosch Motronic ME7.1 ECU as fitted to the Audi R4-5V T transversely mounted 132 kW 1.8T engine have been translated by Nefmoto forum member “TTQS” in support of the guide to understanding remapping and in response to forum technical queries. They are also available on the Nefmoto wiki:

Module Reference	**English Title**	**Relevant to**
ARMD 10.40	Torque-Based Anti-Jerk Function	Diagnosis of undesired torque/ignition angle intervention [User-requested translation]
ATM 33.50	Exhaust Gas Temperature Model	Understanding exhaust gas temperature control in support of tuning high load & WOT fuelling (See LAMBTS 2.120)
ATR 1.60	Exhaust Gas Temperature Control	Understanding exhaust gas temperature control in support of tuning high load & WOT fuelling (See LAMBTS 2.120)
BGSRM 17.10	Cylinder Charge Detection, Intake Manifold Model	Calibration of KISRM when changing total engine displacement (e.g. via reboring cylinders or fitting shorter conrods) or a new intake manifold with a different volume (interfaces with module FUEDK 21.90)
FUEDK 21.90	Cylinder Charge Control (Calculating Target Throttle Angle)	Understanding how Motronic implements calculation of target throttle plate angles (interfaces with module BGSRM 17.10)
GGHFM 57.60	MAF Meter System Pulsations	Understanding MAF sensor linearization curve (MLHFM) and sensor correction map (KFKHFM) when recalibrating MAF sensor
KRDY 17.120	Dynamic Knock Control	Understanding the knock control function and implementation for WOT & high load output calibration
KRRA 15.130	Knock Control with Individual Cylinder Retard	Understanding the knock control function and implementation for WOT & high load output calibration
LAMBTS 2.120	Lambda for Component Protection	Tuning of high load & WOT fuelling (one of several methods being to calibrate lambda for component protection)
LAMFAW 7.100	Driver’s Requested Lambda	Understanding the appropriate deployment of the ‘basic fuelling map’ LAMFA with respect to enrichments
LAMKO 9.80	Lambda Coordination	Understanding the priority order for calculating the lambda target and which variables provide the lambda target under normal conditions with respect to tuning high load & WOT fuelling
LDRLMX 3.100	Calculation of LDR Maximum Cylinder Charge rlmax	Calibration of WOT output via LDRXN
LDRPID 25.10	Charge Pressure Regulation PID Control	Understanding charge pressure PID control algorithms with respect to recalibration of boost pressure
LRSHK 9.20	Continuous Post-Catalyst Lambda Control	Understanding how pre- and post-cat lambda control integrate when experiencing fault conditions with either system (not tuning related).
MDBAS 8.30	Calculation of the Basic Parameters for the Torque Interface	Understanding the basic Motronic torque interface and the optimum torque map KFMIOP
MDFAW 12.260	Driver Requested Torque	Understanding how the Motronic torque-oriented structure is implemented including charge and crank-synchronous paths, overrun fuel cut-off/reinstatement, calibration of the accelerator pedal map KFPED
MDFUE 8.50	Setpoint for Air Mass from Load Torque	Understanding how the Motronic torque-oriented structure is implemented and conversion of optimum torque to cylinder charge via map KFMIRL
MDKOG 14.70	Torque Coordination for Overall Interventions	Understanding how torque demands are co-ordinated in the Motronic torque-oriented structure and torque-intervention processes
MDZW 1.120	Calculating Torque at the Desired Ignition Angle	Understanding how the Motronic torque-oriented structure is implemented including the torque influence on the ignition angle and anti-judder feature
RKTI 11.40	Calculation of Injection Time ti from Relative Fuel Mass rk	Calibrating for injector battery voltage correction, different fuel pump pressure and different injector flow rates via KRKTE, correction of errors due to pulsation in returnless fuel systems
SLS 88.150	Secondary Air Control	Understanding secondary air system effects
ZUE 282.130	Fundamental Function - Ignition	Understanding correction of the fundamental ignition timing angle for warm-up angle and the cylinder-specific knock control angle to give the earliest possible

		(or basic) ignition angle and phase angle error correction to give the actual ignition angle
ZWGRU 23.110	Fundamental Ignition Angle	Understanding the fundamental ignition angle and provision for any necessary camshaft timing

ARMD 10.20 Torque-based Anti Jerk Function

See the *funktionsrahmen* for the following diagrams:

armd-armd	Main function
armd-kifz	Subfunction KIFZ (amplification of vehicle model)
armd-flrar	Subfunction FLRAR (amplification factor for modelling of external load)
armd-fdar	Subfunction FDAR (amplification factor for anti-jerk intervention)
armd-nmoti	Subfunction NMOTI
armd-ndfil	Subfunction NDFIL (filtered engine speed difference)
armd-frgar	Subfunction FRGAR
armd-iniarv	Subfunction INIARV
armd-kupgw	Subfunction KUPGW
armd-dmar	Subfunction DMAR (delta torque anti-jerk)
armd-varss	Subfunction VARSS

ARMD 10.40 Function Description

Function purpose

The anti-jerk function detects oscillations of the power train and damps them out by applying opposing-phase torque interventions. The torque intervention is converted into an ignition angle offset by the torque interface.

Desired phase position of the torque intervention

In order to damp the power train oscillation efficiently, the torque intervention should counteract engine speed oscillations. Thereby the same effect is achieved as if the attenuation coefficient of the drive shaft is increased.

Operation pattern of anti-jerk function

Basic idea: a reference speed without oscillation and corresponding to the driver's demand is evaluated. The difference between desired and actual engine speed isolates the oscillation. A counteracting delta torque is set which is proportional to this oscillation.
The function is realized by a simple vehicle model consisting of an integrator with the constant kifz_w. The input to this integrator is the difference between the driver's predetermined clutch torque mkar_w and the load torque mlast_w. The output from the integtrator is the modelled engine speed nmod_w. The engine speed difference ndiff_w between the modelled engine speed nmod_w and the actual engine speed nmot_w now forms the basis for the torque intervention as well as for the calculation of the load torque. The load torque is evaluated proportional to the engine speed difference and the factor flrar is taken from the corresponding characteristic line. The engine speed difference ndiff_w contains another offset besides the oscillation part. This offset is filtered on a 50 ms scan timescale through a discrete second order low pass filter. (Coefficients of the nominator polynomial are denoted A0, A1 and A2 and of the denominator polynomial 1, B1 and B2.
The filtered offset ndfil_w is substracted from the differential engine speed and gives the engine speed oscillation ndar_w.
Proportionally to this engine speed and using the factor fdar, a delta torque as a torque intervention is calculated. If this intervention lays between the limits KFDMDARU and KFDMDARO, it is set to zero.

Activation Conditions

The model is always active, just the intervention can be switched off.

Application Notes

Conditions for calibration of anti-jerk

The basic calibration of the vehicle must have been done. This includes the transition compensation and all functions for the torque interface.

1. Evaluation of the integrator constant kifz_w and flrar

Coarse application:
Drive on the road (flat surface, no hills) at a constant speed in respective gear with the anti-jerk function deactivated (fdar=0). Then execute a change in load and register the calculated coupling torque mkar_w and the engine speed nmot_w.
Evaluation of integrator constant as follows: at a load step the torque jump is approximately delta M (in %) and the speed approximately rises with constant gradient gradn (in RPM/s). Kifz_w is then calculated from the expression gradn/(delta M). A typical value for second gear is 4.6 × 100/MDNORM [RPM/(s×%)].

Fine application:
Driving on flat surface. Set the product kifz_w × flrar to a fixed value (recommendation: 15). Realization of load jumps with registration of mkar_w, mlast_w, nmot_w and ndiff_w. Vary the couple kifz_w and flrar (maintaining the product constant!) until ndiff_w remains approximately constant during a load jump.
In principle the following process is valid for the amplification factor flrar: high factors cause a reduction of the offset ndfil_w, but also a big phase advance of ndiff_w.

2. Evaluation of filter parameters

For a low pass filter with 50 ms scan rate, the transmission function has the form G(z) = Z(z)/N(z) where

$Z(z) = A0 + A1\times z^{-1} + A2\times z^{-2}$
$N(z) = 1 + B1\times z^{-1} + B2\times z^{-2}$.

Select one of the low pass filters listed in the table below, according to the appearing jerk frequency:

TP No.	Limit freq.	A0	A1	A2	B1	B2
1	0.67 Hz	0.0095	0.0191	0.0095	-1.7056	0.7437
2	0.80 Hz	0.0134	0.0267	0.0134	-1.6475	0.7009
3	1.00 Hz	0.0201	0.0402	0.0201	-1.5610	0.6414

Low pass filter No. 3 is recommended. The attenuation of the jerk frequency is determined by the margin between the jerk frequency and the filter cut-off frequency. The bigger the filter cut-off frequency, the smaller the time the filter needs to stabilize.
Warning: modification of a single coefficient of G(z) is not permitted!

3. Evaluation of fdar
Recommendation is fdar = 0.67 × 100/MDNORM (%/RPM). Increase of attenuation by enlargement of fdar, reduction of fdar decreases the attenuation.

4. Thresholds KFDMDARO and KFDMDARU
In case the delta torque for the intervention is within these thresholds, it is set to zero. This avoids undesired ignition angle instability. Typical values are: KFDMDARU = -5 × 100/MDNORM [%], KFDMDARO = 5 × 100/MDNORM [%].

Abbreviations

A0	Transmission coefficient
A1	Transmission coefficient
A2	Transmission coefficient
B1	Transmission coefficient
B2	Transmission coefficient
CWARMD	Code word anti jerk function
DMARMX	Maximum limit of the steady-state torque interventions of the anti-jerk function
DNFILO	Upper threshold of filter output gradient ndfil
DVFZAR	Hysteresis for vehicle speed limit during anti-jerk
FLRAWG	Integrator gain factor of the load controller during AT (throttle plate closed)
FLRHG	Integrator gain factor of the load controller
FRARAWG	Integrator gain factor during AT (throttle plate closed)
FRARHG	Integrator gain factor
KFDMDADP	Upper threshold for torque-intervention during dashpot
KFDMDARO	Upper threshold for torque intervention
KFDMDAROS	Upper threshold for steady-state torque intervention
KIFZGAWG	Integrator gain factor in the vehicle model with AT (throttle plate closed)
KIFZGHG	Integrator gain factor in the vehicle model with HG
NARAO	Upper engine speed threshold for anti-jerk function active
NARASTG	RPM threshold in higher gear for anti-jerk active
NARLLGA	Speed threshold for anti-jerk at idle
NDFILOG	Threshold for filter output ndfil

NDIFFOG	Threshold engine speed difference for initialization of anti-jerk during braking
NVG	Factor to calculate engine speed initialization
NVMNG	Minimum speed / velocity ratio
NVMXG	Maximum speed / velocity ratio
SMK08MDSW	Anti-jerk torque dependent basic point (number =8)
TAREIN	Blocking time for anti-jerk function
TMAR	Lower engine temperature threshold for anti-jerk release
TMLAST	Blocking time until the initialization of the anti-jerk is triggered at deceleration
TVARS	Delay time until anti-jerk is inactive again
TVARSS	Delay time for anti-jerk becoming inactive again in steady-state conditions
TVKUPAR	Delay time for clutch for anti-jerk function
TVKUPHS	Delay time for clutch switch during shifting in higher gear
TVKUPRS	Delay time for clutch switch during shifting in lower gear
TZSPINI	Blocking time for filter initialisation
VARAU	Minimum vehicle speed for anti-jerk active
WPEDU	Pedal lower threshold value for anti-jerk function
B_AR	Condition: anti-jerk active
B_ARGF	Condition: anti-jerk transition window
B_AUTGET	Condition: automatic gearbox
B_BREMS	Condition: brake operated
B_DASHV	Condition: dashpot delayed
B_FGR	Condition: driver's set engine torque determined by cruise control
B_GFEN	Condition: transition window
B_GWHS	Condition: gear change on manual transmission vehicle
B_HPNMOT	Condition: high-point speed oscillation
B_INIAR	Condition: initialization of anti-jerk function
B_INIAR1	Condition: provisional initialization of anti-jerk function
B_INIARV	Condition: initialization of the filter function is delayed
B_KUPGW	Condition: clutch applied until shifting of geanti-jerk is detected
B_KUPPL	EGAS Condition: clutch is disengaged
B_LL	Condition: idle
B_LSD	Condition: limitation of positive torque gradient active
B_SA	Condition: fuel cut-off
B_STEND	Condition: end of start reached
B_TPNMOT	Condition: low-point speed oscillation
B_TVARS	Condition: anti-jerking function dynamically active
B_TVARSS	Condition: anti-jerking function steady-state active
B_WK	Condition: converter lockup clutch closed
DMAR_W	Delta torque anti-jerk
FDAR	Amplification factor for anti-jerk intervention
FLRAR	Amplification factor for modelling of external load
GANGI	Engaged gear
KIFZ_W	Amplification of vehicle model
MDBES_W	Acceleration torque
MDVERL_W	Resistant torque of the engine
MIFA_W	Desired indicated engine torque
MISOLV_W	Indicated resultant nominal torque before torque limitation
MKAR_W	Calculated clutch torque for anti-jerk function
MLAST_W	Estimated load moment
NDAR_W	RPM difference for torque control
NDFIL_W	Filtered engine speed difference
NDIFFOG_W	Threshold engine speed difference for reset of anti-jerk during braking
NDIFF_W	Engine speed difference for ISC amplification
NMODIV_W	Engine speed for initialising ARMD calculated from velocity
NMOD_W	Engine speed from model

NMOT_W	Actual engine speed
NVQUOT_W	Quotient engine speed / vehicle speed
TMOT	Engine temperature
VFZG	Vehicle speed (km/h)
VFZG_W	Vehicle speed (km/h, word)
WPED_W	Normalised throttle pedal angle (word)

ATM 33.50 (Exhaust Gas Temperature Model)

Refer to the *funktionsrahmen* for the following diagrams:

atm-main	
atm-atm-b1	Exhaust gas temperature model (cylinder bank 1) overview
atm-tmp-stat	TMP_STAT engine speed & relative cylinder charge map and corrected for temperature for acceleration, intake air temp., catalyst heating, catalyst warming, ignition angle, lambda and cold engine
atm-dynamik	Temperature dynamic for exhaust gas and catalytic converter temperature (in and near the catalytic converter)
atm-tabgm	Temperature dynamic: exhaust gas, exhaust pipe wall effect, from the exhaust gas temperature tabgm
atm-tkatm	Temperature dynamic for the temperature near the catalytic converter
atm-exotherme	Exothermic temperature increase near the catalyst from measurement sites tabgm to tikatm
atm-tikatm	Temperature dynamic for the temperature in the catalytic converter
atm-exoikat	Exothermic temperature increase in the catalyst from measurement sites tabgm to tikatm
atm-kr-stat	Exhaust gas temperature in the exhaust manifold under steady-state conditions
atm-kr-dyn	Exhaust gas temperature in the exhaust manifold under dynamic conditions
atm-tmp-start	Calculation of the exhaust gas or exhaust pipe wall temperature at engine start
atm-tpe-logik	Calculation of the dew point at the pre-cat and post-cat lambda probes
atm-sp-nachl	Storage of the dew point conditions at engine switch off
atm-mean	Calculation of etazwist average values
atm-tmp-umgm	If no ambient temperature sensor is available, calculate a substitute from ambient temperature (tans)
atm-mst	If tabst_w is not correct tabstatm = maximum value, request for delay B_nlatm as a function of engine speed and tatu-threshold)

ATM 33.50 (Exhaust Gas Temperature Model) Function Description

The simulated exhaust gas temperatures tabgm and tabgkrm (for SY_TURBO = 1) and catalytic converter temperatures tkatm and tikatm are used for the following purposes:

1. Monitoring the catalyst. If the catalytic converter falls below its starting temperature, then a fault can be detected.
2. For lambda control on the probe after the catalytic converter. This control is only activated after engine start, when the catalyst has exceeded its start-up temperature.
3. For the probe heater control after engine start. If the simulated dew point is exceeded, the probe heater is turned on.
4. Monitoring the heated exhaust gas oxygen (HEGO) sensor (i.e. lambda probe) heating system. If the exhaust gas temperature exceeds 800°C for example, then the lambda probe heater will be switched off, so that the probe is not too hot.
5. For fan motor control.
6. For switching on component protection.

This function provides only a rough approximation of the exhaust gas and catalytic converter temperature profiles, whereas throughout the application especially the four monitoring areas (dew point profiles in the exhaust gas, catalytic converter monitoring, enabling and shutting off lambda probe heating and high temperatures for component protection) should be considered to be critical.

1. Basic function
Steady-state temperature (tatmsta): the same applies for takrstc
With the engine speed/relative cylinder charge map KFTATM the steady-state exhaust gas temperature before the catalyst is set. This temperature is corrected for ambient temperature or simulated ambient temperature from the characteristic ATMTANS:

during boost with the constant TATMSA,
during catalyst heating with the constant TATMKH; catalyst warming with the constant TATMKW
with the ignition-angle efficiency map KFATMZW temperature as a function of ML and ETAZWIST
with the desired lambda map KFATMLA temperature as a function of ML and LAMSBG_W
for a cold engine block (TMOT – TATMTMOT) with TATMTMOT = 90°C.

The catalyst temperature (exothermic) is corrected for

Temperature increase with the characteristic KATMEXML or KATMIEXML as a function of air mass
Temperature reduction with KLATMZWE or KLATMIZWE as a function of etazwimt (ignition angle influence)

Lambda influence with KLATMLAE or KLATMILAE as a function of lambsbg_w
Temperature set at TKATMOE or TIKATMOE at tabgm <TABGMEX or B_sa = 1

Different temperature increases are applied for the temperature in the catalytic converter tikatm and the temperature after the catalytic converter tkatm due to exothermic reaction and cooling and different ignition angles and lambda-corrections.

The time-based influence of the exhaust gas temperature before the catalytic converter:
Using a PT1 filter (filter time constant ZATMAML) the dynamics of the exhaust gas temperature are simulated and with a PT1 filter (time constant ZATMRML) the dynamics of the inlet manifold wall temperature are simulated.
The exhaust gas temperature and inlet manifold wall temperature are weighted by the division factor FATMRML.

The catalytic converter temperature tkatm is calculated from the exhaust gas temperature tabgm along with the PT1 filter (filter time constant ZATMKML).

The temperature in the catalyst tikatm is modelled from the exhaust gas temperature tabgm via three filters (time constant ZATMIKML) using the heat transfer principle. Due to a thrust caused by the small air mass flow in the catalytic converter, there is a possible exhaust gas temperature increase due to the greater influence on the matrix temperature by the exhaust gas throughput. This thrust-based temperature increase can be modelled by the positive B_sa side with a temperature, which is composed of the catalyst temperature tikatm and an offset TATMSAE, will be initialised. The time constants of the PT1-filter ZATMIKML are represented by air-mass-dependent characteristic curves.

The initial values for the exhaust and catalyst temperature at engine start can be calculated from the temperatures at switch-off and delay times. The starting values for the exhaust gas and catalyst temperatures should approximate to the manifold wall temperatures at the probe insertion points a few minutes after switch-off. The filter for the exhaust gas temperature is stopped by setting B_stend = 0. The filter for the manifold wall temperature is stopped when B_atmtpa = 1. The filter for the catalyst temperature will be enabled only when B_atmtpk = 1.

2. Dew Point Detection
Initial values for the exhaust gas temperature tabgmst and catalyst temperature tkatmst
When stopping the engine (C_nachl 0 $\rightarrow$ 1) the temperatures tabgm and tkatm are stored.
When starting the engine, the initial temperatures tabgmst and tkatmst are calculated from the switch-off temperature (corrected for ambient temperature) and a factor obtained from maps KFATMABKA or KFATMABKK as a function of tabstatm and tatu.
During power fail the switch-off temperature will be determined from the constant TATMSTI.
For test condition (B_faatm = 1), the initial temperatures are given by the constants TASTBFA and TKSTBFA.

Integrated Heat Quantity iwmatm_w
The dew point end time is approximately proportional to the heat quantity after engine start. The heat quantity = Integral (temp. $\times$ air mass $\times$ C_p) is calculated from the steady-state exhaust gas temperature tatmsta plus TATMWMK multiplied by the air mass. The result of the integration multiplied by the heat capacity at constant pressure C_p (approximately 1 kJ/kgK) gives the heat quantity.

Dew point end for the pre-cat lambda probe B_atmtpa and post-cat lambda probe B_atmtpk
The calculated exhaust gas temperature at engine start tabgmst approximates to the exhaust pipe wall temperature. If the exhaust pipe wall temperature is greater than 60°C for example then no condensation occurs. The values in the map KFWMABG for these temperatures are less than 14 kJ, so the dew point end is detected immediately, or after only a few seconds.

For catalytic converter heating with thermal reaction (B_trkh = 1) the values in maps KFWMABG or KFWMKAT are multiplied by the factor WMKATKH or WMABGKH respectively. Thus, the dew point end-times are very short for this mode of operation.

Repeated starts (extension of the dew point-end-times)
If the engine had not reached the dew point end (B_atmtpa = 0 and B_atmtpf = 0) then when the engine restarts, the counter zwmatmf is increased by 1. After several periods of very short engine running (e.g. 3), the counter zwmatmf value would be set equal to 3. With a constant FWMABGW = 0.25 for example, the values in the map KFWMABG increase by a factor equal to (zwmatmf $\times$

KFWMABG + 1) = 1.75. When the engine starts, the dew point end time from the last engine run is detected and the counter zwmatmf is reset.

Storage of the dew point end condition in the delay

For the determination of repeat start dew point end the conditions B_atmtpa in the flag B_atmtpf and B_atmtpk in the flag B_atmtpl are saved at engine switch-off due to a regular switch-off using the ignition or stall (B_stndnl). The function of dew point end for the post-cat lambda probe B_atmtpk is analogous to the function for B_atmtpa.

3. Calculation of a simulated ambient temperature from the intake air temperature (tans) if no ambient temperature sensor is available.

The simulated temperature tatu will be used for calculating the temperature correction via the characteristic ATMTANS and for determining the starting temperatures tabgmst and tkatmst. The intake air temperature (tans) is corrected with the constant DTUMTAT and under certain conditions stored in continuous RAM. If for example at engine start, the temperature tatu > tans, then the temperature value tatu is set on the lower tans value.

With the constant TATMWMK (negative value) the difference in dew point end between catalyst heating and no catalyst heating can be increased.
When catalytic converter heating is active B_khtr = 1 and the bit B_atmtpa can be set equal to 1 immediately after engine start. This is possible only when no problematic condensation is formed during catalyst heating.
With the system constants SY_STERVK = 1 cylinder bank 2 can be applied separately for stereo systems.
For SY_TURBO = 1 the exhaust gas temperature tabgm is essentially identical in addition to the modeled temperature in the manifold tabgkrm.

ATM 33.50 Application Notes

1. Installation locations for temperature sensors in this application, running in the direction of flow:

- In probe installation position before catalytic converter-
  1. Exhaust gas temperature (pipe centre) for the high temperatures at high loads for probe heater switch off
  2. Manifold wall temperature for the determination of the dew-end times. (Condensation protection)
- Before the catalytic converter
  3. Exhaust gas temperature (pipe centre) for the catalyst start-up temperature
- In the catalytic converter
  4. Ceramic temperature in and after catalytic converter (in the last third of the catalytic converter or behind the adjoining matrix) to determine the air-mass-dependent time constants.
- After the catalytic converter
  5. Pipe wall temperature at probe installation site for the determination of the dew-end times (condensation protection).

Temperature measuring point 3 can be omitted if the distance from probe to catalytic converter is smaller than about 30 cm. The temperature drop from probe installation site to catalytic converter can then be neglected.

For the application of the functional data the modelled temperatures will always be compared with the measured temperatures and the functional data amended until a sufficiently high accuracy is achieved. In so doing, it will be the actual catalyst temperature, the temperature increase due to the exothermic reaction is not considered in the model.

2. Map KFTATM
For the determination of the steady-state temperature for example, before the catalytic converter the temperature corrections should not function. The cooling capacity of the wind on the dynamometer or on the measuring wheel can be simulated only very roughly at the higher engine load range. The map values can be determined on the rolling road dynamometer, but should be corrected on an appropriate test drive.

3. Temperature Corrections
- TATMSA
Boost can cause low exhaust temperatures that fall below the starting temperature of the catalyst. The longer the time period for the thrust condition, the lower the exhaust and catalyst temperatures. For catalyst diagnosis during boost, the exhaust gas temperature model is more likely to calculate a lower value than the measured temperature.

- ATMTANS
At low ambient temperatures, exhaust gas temperature can fall below the catalyst start-up temperature. Therefore, the model temperature is only corrected at the low temperature range.
- TATMKH
As long as the catalyst-heating measures are effective, higher exhaust temperatures will result.
- TATMKW
The catalyst operating temperature will not be not reached during prolonged idling, so the exhaust gas temperature can be raised by the catalyst warming function.
- KFATMZW
The temperature increase as a result of ignition angle retardation can be determined on a rolling road dynamometer. First, on the dynamometer, the characteristic field values KFTATM are applied without ignition angle correction. Ignition angles are then modified so that allowed etazwist values will result in the map. Through the corresponding air mass, the temperature increase will then be displayed in the map KFATMZW.
- KFATMLA
The exhaust temperature is reduced by enrichment. The application is similar to KFATMZW, except that the ignition angle efficiency is changed instead of the enrichment factor.
- TATMTMOT
The map KFTATM is applied with a warm engine. Thus, the model exhaust gas temperature has smaller deviations during cold start. For this operating mode, the temperature is corrected with the difference of the cold engine temperature and the warm engine temperature.
TATMTMOT should be about 90 to 100°C.

4. Maps ZATMAML, ZATMRML, FATMRML, ZATMKML, ZATMKKML, ZATMIKML und ZATMIKKML
The air-mass-dependent time constants ZATMAML, ZATMRML (temperature measuring points 1 or 3), and ZATMKML, ZATMKKML, ZATMIKML, ZATMIKKML (temperature measuring point 4), can help to more accurately determine “spikes in the air mass” during sudden load variations. Thereby "air mass jumps" at full load and in particular during boost can be avoided. For example, for an air mass jump from 30 kg/hr to 80 kg/hr, the measured time constant is applied to the air mass flow of 80 kg/hr. For large air mass jumps during idle, the time constants ZATMKKML and ZATMIKKML can be input instead of ZATMKML or ZATMIKML if required.

5. Block EXOTHERME:
- KATMEXML
The exothermic temperature is a function of air mass flow (warming by realizing emissions, reducing warming via a larger air mass). First KATMEXML applies, then KLATMZWE, KLATMLAE.
- KLATMZWE
When ignition angle retardation increases the temperature before the catalyst, the catalyst temperature drops.
- KLATMLAE
For lambda < 1 (richer), the air mass is lacking to improve emissions so the catalyst temperature decreases.
- TABGMEX
If the temperature before the catalyst tabgm < TABGMEX (catalyst switch-off temperature) then the temperature correction = TKATMOE.
- TKATMOE
Temperature correction during boost or through tabgm> TABGMEX
- TATMSAE
Temperature increase in the boost in the catalyst in terms of tkatm
Block EXOIKAT:
- KATMIEXML, KLATMIZWE, KLATMILAE, TIKATMOE
Application depends on the application for Block EXOTHERME
- TATMSAE
Temperature increase in the thrust in the catalyst in terms of tikatm

6. Dew point end times for exhaust gas temperatures vary greatly between the centre of the exhaust pipe and the pipe wall. Dew point end times for the tube wall temperatures before the catalyst (temperature measuring points 2) or after the catalyst (temperature measuring points 5) should be used. These times are usually due to delaying control readiness for too long, in which case the temperature gradients at the probe mounting location must be examined more closely. To avoid probe damage by “water hammer”, the sensor heater must be fully turned on until the dew point temperature is exceeded or the dew point end time is detected thus condensation will no longer occur.

When the switch-off time in the ECU delay is calculated, then the switch-off time tabst_w after ECU delay will be incorrect. At engine start after ECU delay, the switch-off time tabstatm therefore, will be set to the maximum value of 65,535 (i.e. $2^{16}-1$). The ECU delay requirement for the time TNLATM when engine speed > TNLATMTM & tumg (tatu) > TNLATMTU.

8. For blocks KR_STAT and KR_DYN as appropriate, the descriptions in points 3 and 4 shall apply.

Typical Values:

KFTATM: x: engine speed/RPM, y: relative cylinder charge/%, z: temperature/°C

	800	1200	1800	2400	3000	4000	5000	6000
15	380	400	420	450	480	520	550	580
22	400	420	450	480	520	550	580	610
30	420	450	480	520	550	580	610	650
50	450	480	520	550	580	610	650	700
70	470	520	550	580	610	660	700	750
100	490	550	580	610	650	700	750	790
120	510	560	610	650	700	750	790	840
140	530	580	650	700	750	790	840	900

KFATMZW: x: temperature/°C, y: ml_w/kg/hr, z: etazwimt

	20	40	80	150	250	400
1.00	0.0	0.0	0.0	0.0	0.0	0.0
0.95	15	40	50	60	70	75
0.90	15	60	80	100	125	140
0.80	20	80	120	150	180	200
0.70	25	100	150	190	210	220
0.60	30	115	175	210	230	245

KFATMLA: x: temperature/°C, y: ml_w/kg/hr, z: lamsbg_w

	20	40	80	150	250	400
1.15	5	10	30	50	60	70
1.00	0.0	0.0	0.0	0.0	0.0	0.0
0.95	5	10	20	30	40	45
0.90	15	25	40	50	60	75
0.80	30	40	60	70	85	100
0.70	40	60	80	90	100	120

KFWMABG: x: energy/kJ, y: tabgmst/°C, z: tmst/°C

	–40	0	15	25	30	55	60
–40	200	160	150	140	100	60	30
0	180	150	120	110	80	50	20
15	160	140	60	55	30	40	0.45
25	140	120	30	30	15	10	0.45
60	120	30	20	15	10	5	0.45

KFWMKAT values correspond to KFWMABG × 5
In the heat quantity maps KFWMABG and KFWMKAT a value of 0.0 is never required! It should always have at least the value to be entered; the 2 sec corresponds to idle after cold start. Only then does the repeat-start counter operate after several starts where the dew point was not reached.

ZATMAML ml_w/kg/hr, Time constant/sec 10, 30 ; 20, 20 ; 40, 13 ; 80, 5 ; 180, 4 ; 400, 3 ; 600, 2 ;
ZATMKML ml_w/kg/hr, Time constant/sec 10, 150 ; 20, 60 ; 40, 35 ; 80, 20 ; 180, 10 ; 400, 7 ; 600, 4 ;
ZATMIKML value represents approximately ZATMKML × 0.3
ZATMKKML for neutral input, the data must correlate to ZATMKML
ZATMIKKML for neutral input, the data must correlate to ZATMIKML
ZATMRML ml_w/kg/hr, Time constant/sec 10, 300 ; 20, 80 ; 40, 55 ; 80, 30 ; 180, 20 ; 400, 10 ; 600, 7 ;
FATMRML ml_w/kg/hr, Time constant/sec 10, 0.5 ; 20, 0.6 ; 40, 0.7 ; 80, 0.8 ; 180, 0.95 ; 400,0.95 ; 600, 0.96;
KATMEXML ml_w/kg/hr, Time constant/sec 10, 0 ; 20, 0 ; 40, 0 ; 80, 0 ; 180, 0 ; 400, 0 ;

KLATMZWE etazwimt, Factor 1, 0 ; 0.95, 0 ; 0.9, 0 ; 0.8, 0 ; 0.7, 0 ; 0.6, 0 ;
KLATMLAE lamsbg_w, Factor 1.15, 0 ; 1 , 0 ;0.95, 0 ; 0.9, 0 ; 0.8, 0 ; 0.7, 0 ;
TATMTP: 52°C
TKATMOE: 0°C
TATMSAE: 0°C
KATMIEXML ml_w/kg/hr, Time constant/sec 10, 0 ; 20, 0 ; 40, 0 ; 80, 0 ; 180, 0 ; 400, 0 ;
KLATMIZWE etazwimt, Factor 1, 0 ; 0.95, 0 ; 0.9, 0 ; 0.8, 0 ; 0.7, 0 ; 0.6, 0 ;
KLATMILAE lamsbg_w, Factor 1.15, 0 ; 1 , 0 ;0.95, 0 ; 0.9, 0 ; 0.8, 0 ; 0.7, 0 ;
TIKATMOE: 0°C

KFATMABKA: x: tatu/°C, y: tabstatm_w/seconds, z: no units

	10	50	180	360	600	1000
–40	0.95	0.70	0.50	0.30	0.15	0.00
–15	0.95	0.70	0.50	0.30	0.15	0.00
0	0.95	0.70	0.50	0.30	0.15	0.00
15	0.95	0.70	0.50	0.30	0.15	0.00
40	0.95	0.70	0.50	0.30	0.15	0.00

KFATMABKK: x: tatu/°C, y: tabstatm_w [s], z: no units

	10	50	180	360	600	1000
–40	0.90	0.60	0.40	0.25	0.15	0.00
–15	0.90	0.60	0.40	0.25	0.15	0.00
0	0.90	0.60	0.40	0.25	0.15	0.00
15	0.90	0.60	0.40	0.25	0.15	0.00
40	0.90	0.60	0.40	0.25	0.15	0.00

ATMTANS tatu/°C, Temp./°C –40, 60 ; –10, 20 ; 20, 0 ;
TATMSA: 100°C
TATMKH: 80°C
TATMTRKH: 200°C
TATMKW: 100°C
TATMTMOT: 90°C
TATMSTI: 20°C
TASTBFA: 40°C
TKSTBFA: 40°C
TATMWMK: –80°C
WMABGKH: Factor of 1.0
WMKATKH Factor of 1.0
FWMABGW Factor of 0.25
FWMKATW Factor of 0.25
DTUMTAT: 20°C
VTUMTAT: 40 km/h
NTUMTAT: 1800 rpm
IMTUMTAT: 1 kg
TUMTAIT: 20°C
TNLATMTM: 80°C
TNLATMTU: 5°C
TNLATM: 660 seconds

Only when SY_TURBO = 1:
For neutral input (tabgkrm_w = tabgm_w)
KFATMKR = KFTATM
KFATZWK = KFATMZW
KFATLAK = KFATMLA
TATMKRSA = TATMSA
ZATRKRML = ZATMRML
ZATAKRML = ZATMAML
FATRKRML = FATMRML
ATMTANS tans/°C, Temp./°C –40, 40 ; –20, 25 ; 0, 12 ; 20, 0 ; 60, –30

The functional data for cylinder bank 2 correspond to the functional data from cylinder bank 1 Note:
In order that ATM 22:20 for the application is backward compatible the default values should be entered thus: KATMEXML, KLATMZWE, KLATMLAE, TKATMOE = 0 and TABGMEX = 1220°C.

In order that ATM 33.10 remains application-neutral with ATM 22.50, TATMTRKH must be set equal to TATMKH and WMKATKH should be set equal to 1. Tikatm is not used in a function because the input can be used in the path in the exhaust gas temperature model without impact on safety, however, the default values for KATMIEXML, KLATMIZWE, KLATMILAE and TIKATMOE should be set equal to 0 and TABGMEX = 1220°C.

In DKATSP areas TMINKATS and TMAXKATS, a high accuracy is required for tikatm!

Parameter	**Description**
ATMTAKR	Correction for the manifold temperature
ATMTANS	Temperature correction for the exhaust gas temperature model
DTUMTAT	Offset: intake air temperature → ambient temperature
FATMRML	Factor for the difference between exhaust gas & exhaust pipe wall temperature
FATMRML2	Factor for the difference between exhaust gas & exhaust pipe wall temperature, cylinder bank 2
FATRKRML	Factor for the difference between exhaust gas & wall temperature in the manifold
FATRKRML2	Factor for the difference between exhaust gas & wall temperature in the manifold, cylinder bank 2
FWMABGW	Factor for heat quantity during repeated starts for pre-cat exhaust gas dew points
FWMABGW2	Factor for heat quantity during repeated starts for pre-cat exhaust gas dew points, cylinder bank 2
FWMKATW	Factor for heat quantities during repeated starts for dew points after main catalyst
FWMKATW2	Factor for heat quantities during repeated starts for dew points after main catalyst, cylinder bank 2
IMTUMTAT	Integration threshold air mass for determining ambient temperature from TANS
KATMEXML	Exothermic reaction temperature in catalyst, tkatm
KATMEXML2	Exothermic reaction temperature in catalyst, cylinder bank 2
KATMIEXML	Exothermic reaction temperature in catalyst, tikatm
KATMIEXML2	Exothermic reaction temperature in catalyst, tikatm, cylinder bank 2
KFATLAK	Map for lambda correction for manifold exhaust gas temperature
KFATLAK2	Map for lambda correction for manifold exhaust gas temperature, cylinder bank 2
KFATMABKA	Factor for exhaust gas temperature decrease as a function of stop time and ambient temperature
KFATMABKA2	Factor for exhaust gas temperature decrease as a function of stop time and ambient temperature, cylinder bank 2
KFATMABKK	Factor for reducing the catalyst temperature as a function of stop time and ambient temperature
KFATMABKK2	Factor for reducing the catalyst temperature as a function of stop time and ambient temperature, cylinder bank 2
KFATMKR	Map for steady-state manifold exhaust gas temperature as a function of engine speed and relative cylinder charge
KFATMKR2	Map for steady-state manifold exhaust gas temperature, cylinder bank 2
KFATMLA	Map for exhaust gas temperature correction as a function of lambda
KFATMLA2	Map for exhaust gas temperature correction as a function of lambda, cylinder bank 2
KFATMZW	Map for exhaust gas temperature correction as a function of igntion angle correction
KFATMZW2	Map for exhaust gas temperature correction as a function of ignition angle, cylinder bank 2
KFATZWK	Map for ignition angle correction for manifold gas temperature
KFATZWK2	Map for ignition angle correction for manifold gas temperature, cylinder bank 2
KFTATM	Map for exhaust gas temperature as a function of engine speed and relative cylinder charge
KFTATM2	Map for exhaust gas temperature as a function of engine speed and relative cylinder charge for cylinder bank 2
KFWMABG	Map for heat quantity threshold exhaust gas dew points
KFWMABG2	Map for heat quantity threshold exhaust gas dew points, cylinder bank 2
KFWMKAT	Map for heat quantity threshold dew points after catalyst
KFWMKAT2	Map for heat quantity threshold dew points after catalyst, cylinder bank 2
KLATMILAE	Exothermic temperature decrease through enrichment, tikatm
KLATMILAE2	Exothermic temperature decrease through enrichment, tikatm, Bank 2
KLATMIZWE	Exothermic temperature decrease in catalyst at later ignition angles, tikatm
KLATMIZWE2	Exothermic temperature decrease in catalyst at later ignition angles, tikatm, Bank 2
KLATMLAE	Exothermic temperature decrease through enrichment
KLATMLAE2	Exothermic temperature decrease through enrichment, cylinder bank 2
KLATMZWE	Exothermic temperature decrease in catalyst at later ignition angles, tkatm
KLATMZWE2	Exothermic temperature decrease in catalyst at later ignition angles, cylinder bank 2
NTUMTAT	Speed threshold for determining ambient temperature from TANS
SEZ06TMUB	Sample point distribution, ignition angle efficiency
SLX06TMUW	Sample point distribution, desired lambda
SLY06TMUW	Sample point distribution, desired lambda, cylinder bank 2
SML06TMUW	Sample point distribution, air mass, 6 sample points
SML07TMUW	Sample point distribution, air mass, 7 sample points
SMT06TMUW	Sample point distribution, air mass, 6 sample points

ST107TMUB	Sample point distribution, start temperature at front probe
ST207TMUB	Sample point distribution, start temperature at front probe, cylinder bank 2
ST307TMUB	Sample point distribution, start temperature at rear probe
ST407TMUB	Sample point distribution, start temperature at rear probe, cylinder bank 2
STM05TMUB	Sample point distribution, engine start temperature
STS06TMUW	Sample point distribution, exhaust gas mass flow
STU05TMUB	Sample point distribution, simulated ambient temperature
SY_STERVK	System constant condition: stereo before catalyst
SY_TURBO	System constant: turbocharger
TABGMEX	Exhaust gas temperature below the catalyst switch-off temperature
TASTBFA	Model temperature before pre-cat initial value via B_faatm requirement
TATMKH	Exhaust gas temperature correction via catalyst heating active
TATMKH2	Exhaust gas temperature correction via catalyst heating active, cylinder bank 2
TATMKRSA	Exhaust gas temperature correction in manifold via boost switch-off
TATMKW	Exhaust gas temperature correction with catalyst warming active
TATMSA	Exhaust gas temperature correction via boost cut-off
TATMSAE	Exothermic temperature increase in boost
TATMSAE2	Exothermic temperature increase in boost, cylinder bank 2
TATMSTI	Initial value for tabgm, tkatm intial value through power fail
TATMTMOT	Engine temperature warmer Motor, for temperature correction during cold start conditions
TATMTP	Exhaust gas dew point temperature
TATMTRKH	Exhaust gas temperature correction via thermal reaction catalyst heating
TATMTRKH2	Exhaust gas temperature correction via thermal reaction catalyst heating, cylinder bank 2
TATMWMK	Temperature offset for calculating heat quantities
TIKATMOE	Temperature correction in catalyst without exothermic reaction, tikatm
TKATMOE	Temperature correction near catalyst without exothermic reaction, tkatm
TKSTBFA	Model temperature post-cat initial value via B_faatm requirement
TNLATM	Minimum ECU delay time for exhaust gas temperature model – Abstellzeit
TNLATMTM	When tmot > threshold ECU delay requirement B_nlatm = 1
TNLATMTU	When tumg (tatu – ATM) > threshold ECU delay requirement
TUMTAIT	Initialising value for ambient temperature from TANS
VTUMTAT	Vehicle speed threshold for TANS $\rightarrow$ ambient temperature
WMABGKH	Factor for heat quantity correction via catalyst heating for dew points
WMABGKH2	Factor for heat quantity correction via catalyst heating for dew points, cylinder bank 2
WMKATKH	Factor for heat quantity correction via catalyst heating for dew points after catalyst
WMKATKH2	Factor for heat quantity correction via catalyst heating for dew points after catalyst, cylinder bank 2
ZATAKRML	Time constant for exhaust gas temperature model (manifold)
ZATAKRML2	Time constant for exhaust gas temperature model (manifold), cylinder bank 2
ZATMAML	Time constant for exhaust gas temperature model
ZATMAML2	Time constant for exhaust gas temperature model, cylinder bank 2
ZATMIKKML	Time constant for catalyst temperature model – Temperature in catalyst tikatm during cooling
ZATMIKKML2	Time constant for catalyst temperature model – Temperature in catalyst tikatm during cooling, bank 2
ZATMIKML	Time constant for catalyst temperature model – Temperature in catalyst, tikatm
ZATMIKML2	Time constant for catalyst temperature model – Temperature in catalyst, cylinder bank 2
ZATMKKML	Time constant for catalyst temperature model – catalyst temperature tkatm during cooling
ZATMKKML2	Time constant for catalyst temperature model – catalyst temperature tkatm during cooling, bank 2
ZATMKML	Time constant for catalyst temperature model – catalyst temperature tkatm
ZATMKML2	Time constant for catalyst temperature model – catalyst temperature, cylinder bank 2
ZATMRML	Time constant for exhaust gas temperature model – exhaust pipe wall temperature
ZATMRML2	Time constant for exhaust gas temperature model – exhaust pipe wall temperature Bank 2
ZATRKRML	Time constant for exhaust gas temperature model – manifold wall temperature
ZATRKRML2	Time constant for exhaust gas temperature model – manifold wall temperature, cylinder bank 2

Variable	**Description**
B_ATMLL	Condition for time constant during cooling at idle
B_ATMLL2	Condition for time constant during cooling at idle
B_ATMST	Condition for tabgmst, tkatmst initial value calculation
B_ATMST2	Condition for tabgmst, tkatmst calculation, cylinder bank 2
B_ATMTPA	Condition: dew point before catalyst exceeded
B_ATMTPA2	Condition: dew point 2 before catalyst exceeded
B_ATMTPF	Condition: dew point before catalyst exceeded (last trip)
B_ATMTPF2	Condition: dew point before catalyst exceeded (last trip) cylinder bank 2
B_ATMTPK	Condition: dew point after catalyst exceeded
B_ATMTPK2	Condition: dew point 2 after catalyst exceeded
B_ATMTPL	Condition: dew point after catalyst exceeded (last trip)
B_ATMTPL2	Condition: dew point after catalyst exceeded (last trip) cylinder bank 2
B_FAATM	Condition: functional requirements for dew point end times
B_KH	Condition: catalyst heating
B_KW	Condition: catalyst warming
B_LL	Condition: idle
B_NACHL	Condition: ECU delay

B_NACHLEND	Condition: ECU delay ended
B_NLATM	Condition: ECU delay exhaust gas temperature model probe protection
B_PWF	Condition: Power fail
B_SA	Condition: Overrun cut-off
B_ST	Condition: Start
B_STEND	Condition: End of start conditions achieved
B_STNDNL	Condition: Beginning of ECU delay or end of start conditions ($1 \rightarrow 0$)
B_TFU	Condition: Ambient temperature sensor available
B_TRKH	Condition: Catalyst heating, thermal reaction effective
B_UHRRMIN	Condition: timer with a relative number of minutes
B_UHRRSEC	Condition: timer with a relative number of minutes
DFP_TA	ECU internal error path number: intake air temperature TANS (charge air)
DFP_TUM	ECU Internal error path number: ambient temperature
ETAZWIMT	Actual ignition angle efficiency average for exhaust gas temperature model (200 ms)
ETAZWIST	Actual ignition angle efficiency
E_TA	Error flag: TANS
E_TUM	Error flag: ambient temperature tumg
IMLATM	Integral of air mass flows from engine start bis Max.wert
IMLATM_W	Integral of air mass flows from end of start conditions up to the maximum value, (Word)
IWMATM2_W	Heat quantity for Condensation - dew points exhaust gas/catalyst (word), cylinder bank 2
IWMATM_W	Heat quantity for Condensation - dew points exhaust gas/catalyst (word)
LAMSBG2_W	Desired lambda limit (word), cylinder bank 2
LAMSBG_W	Desired lambda limit (word)
ML_W	Filtered air mass flow (word)
NMOT	Engine speed
RL	Relative cylinder charge
TABGKRM2_W	Exhaust gas temperature in manifold from the model, cylinder bank 2
TABGKRM_W	Exhaust gas temperature in manifold from the model
TABGM	Exhaust gas temperature before catalyst from the model
TABGM2	Exhaust gas temperature before catalyst from the model, cylinder bank 2
TABGM2_W	Exhaust gas temperature before catalyst from the model (word) cylinder bank 2
TABGMAB	Exhaust gas temperature during engine switch-off
TABGMAB2	Exhaust gas temperature during engine switch-off (model) cylinder bank 2
TABGMST	Exhaust gas temperature at engine start
TABGMST2	Exhaust gas temperature at engine start, cylinder bank 2
TABGM_W	Exhaust gas temperature before catalyst from the model (word)
TABSTATM_W	Stop time in ECU delay for exhaust gas temperature model
TABSTMX_W	Stop time maximum query for exhaust gas temperature model
TABST_W	Stop time
TAKRKF	Steady-state manifold exhaust gas temperature without correction
TAKRKF2	Steady-state manifold exhaust gas temperature without correction, cylinder bank 2
TAKRSTC	Steady-state exhaust gas temperature in manifold in °C
TAKRSTC2	Steady-state exhaust gas temperature in manifold, cylinder bank 2
TANS	Intake air temperature
TATAKRML	Output from PT1 element: exhaust gas temperature influence on tabgkrm
TATAKRML2	Output from PT1 element: exhaust gas temperature influence on tabgkrm, cylinder bank 2
TATMAML	Output from PT1 element: exhaust gas temperature influence on tabgm
TATMAML2	Output from PT1 element: exhaust gas temperature influence on tabgm, cylinder bank 2
TATMKF	Exhaust gas temperature before catalyst from map KFTATM
TATMKF2	Exhaust gas temperature before catalyst from map KFTATM, cylinder bank 2
TATMRML	Output from PT1 element: exhaust pipe wall temperature effect from tabgm
TATMRML2	Output from PT1 element: exhaust pipe wall temperature effect from tabgm, cylinder bank 2
TATMSTA	Exhaust gas temperature before catalyst from the steady-state model
TATMSTA2	Exhaust gas temperature before catalyst from the steady-state model, cylinder bank 2
TATRKRML	Output from PT1 element: exhaust pipe wall temperature effect from tabgkrm
TATRKRML2	Output from PT1 element: exhaust pipe wall temperature effect from tabgkrm, cylinder bank 2
TATU	Intake air temperature or ambient temperature
TEXOIKM2_W	Exotherme temperature increase in catalyst for tikatm, cylinder bank 2
TEXOIKM_W	Exotherme temperature increase in catalyst for tikatm
TEXOM2_W	Exotherme temperature increase in catalyst for tkatm2, cylinder bank 2
TEXOM_W	Exotherme temperature increase in catalyst for tkatm
TIKATM	Exhaust gas temperature in catalyst from the model
TIKATM2	Exhaust gas temperature in catalyst from the model, cylinder bank 2
TIKATM2_W	Exhaust gas temperature in catalyst from the model, cylinder bank 2
TIKATM W	Exhaust gas temperature in catalyst from the model
TKATM	Catalyst temperature from the model
TKATM2	Catalyst temperature from the model, cylinder bank 2
TKATM2_W	Catalyst temperature from the model (word), cylinder bank 2
TKATMAB	Exhaust gas temperature after catalyst through engine switch-off (model)
TKATMAB2	Exhaust gas temperature after catalyst through engine switch-off (model), cylinder bank 2

TKATMST	Catalyst temperature model initial value as a function of switch-off value, switch-off time
TKATMST2	Catalyst temperature model initial value as a function of switch-off value, switch-off time, bank 2
TKATM_W	Catalyst temperature from the model (word)
TMOT	Engine temperature
TMST	Engine start temperature
TUMG	Ambient temperature
VFZG	Vehicle speed
ZWMATM	Counter for repeated starts and factor for heat quantity threshold
ZWMATM2	Counter for repeated starts and factor for heat quantity threshold, cylinder bank 2
ZWMATMF	Counter for repeated starts and factor for heat quantity threshold upstream
ZWMATMF2	Counter for repeated starts and factor for heat quantity threshold upstream, cylinder bank 2

ATR 1.60 (Exhaust Gas Temperature Control)

See the *funktionsrahmen* for the following diagrams:

atr-main	exhaust gas temperature control overview
atr-atrbb	detection of control range
atr-atrb	exhaust gas temperature control for cylinder bank 1
atr-atrerb	enabling exhaust gas temperature control for cylinder bank 1
atr-atrpi	exhaust gas temperature proportional/integral control for cylinder bank 1
atr-atrb2	exhaust gas temperature control for cylinder bank 2
atr-atrerb2	enabling exhaust gas temperature control for cylinder bank 2
atr-atrpi2	exhaust gas temperature proportional/integral control for cylinder bank 2
atr-atrnl	limp mode for exhaust gas temperature control
atr-atrko	coordination of the control output

ATR 1.60 Function Description

Task:
Protection of components (manifold, turbocharger, etc.) by controlling the exhaust gas temperature. By means of this control, the general enrichment at high load and speed ("full-load enrichment") can be reduced. When general mixture control is insufficient, the exhaust gas temperature control enrichment must also be invoked which leads to reduced fuel consumption.

Principle:
An excessively high exhaust gas temperature can be lowered by enriching the air-fuel mixture. Through this enrichment, more fuel enters the cylinder than is required for stoichiometric combustion of the fuel. The unburned fuel vaporises on the cylinder walls and cools them, whereby the exhaust gas temperature decreases. For this control, the exhaust gas temperature is measured using an exhaust gas temperature sensor or estimated by an exhaust gas temperature model.

As long as the exhaust temperature is below the threshold temperature, there is no control. Thus, there is only a "down regulation" of the exhaust temperature, not an "up regulation". If the desired temperature is reached or exceeded, the control switches. To achieve an enrichment of the mixture, the controller is adjusted to give a desired value of lambda in the "rich" region. This enrichment decreases the exhaust gas temperature, and the controller sets the desired exhaust temperature. When the exhaust temperature drops back below the threshold temperature, the controller takes back the enrichment. If enrichment is no longer required, control is switched off.

Overview of Codeword CATR:

Bit No.	7	6	5	4	3	2	1	0
								*

*If the value of bit 0 is set equal to 1, this enables exhaust gas temperature control.

ATRBB: Detection Control Range

This function detects the valid control range. Via the configuration byte CATR, the control can, in principle, be switched off. A valid range is usually present when the end of start conditions is detected (B_stend = 1), and the relative load (rl) lies above an applicable threshold rlatr. This control scheme is only available in the near-full load range (rl > rlatr) is active, since exhaust temperatures are only likely to be high in this range. Once the range is exited, control is switched off, e.g. in the transition to idle to shorten the duration of the enrichment.

The valid control range is indicated by the flag B_atrb = 1.

ATRERB: Enabling Exhaust Gas Temperature Control for Bank 1

The exhaust gas temperature control is a flip-flop on or off. The condition flag B_atr = 1 indicates that control is active. If the exhaust gas temperature (tabg) is greater than or equal to the applicable threshold value TABGSS, the control is switched on. The control is switched off when enrichment is no longer required. This is the case when the regulator output dlatr > 0. The controller output dlatr for the exhaust temperature control is then set to zero. It is possible to set a lean limit for the control scheme via the fixed value LATRO. If the current set-lambda without add. If the current desired lambda value without additional lamvoa parts above the limit LATRO (in the lean range) there will be no control. In addition, there is no control if any of the following conditions are met:

(a) No valid control range is detected (B_atrb = 0)
(b) Fuel injector cut-off condition is true (B_bevab = 1)
(c) The exhaust gas temperature sensor indicates an error (E_ats = 1)
(d) The exhaust gas temperature sensor is not ready (B_atsb = 0)
(e) Significant differences between the bank controller control variables were found (E_atrd = 1).

If the engine reaches the rich running limit (B_lagf = 1) while exhaust gas temperature control is active (B_atr = 1), a further enrichment attempt is prohibited by the control scheme (B_atrsp = 1). The current value of the controller output is recorded. However, an enrichment reduction is allowed.

ATRPI2: Exhaust Gas Temperature Proportional/Integral Control for Cylinder Bank 1

The exhaust gas temperature controller is configured as a PI controller, because the "delta lambda controller" intervenes additively. ATRP and ATRI are applied amplification factors for the P and I components. When control is switched off (B_atr = 0) the controller output is set to zero. The integral component in this case is set to equal the negative value of the proportional component (dlatri = –dlatrp), so it follows that the sum is zero. The controller output (dlatr) will be limited to "rich" by the applicable limit DLATRMN. In this case, the integrator is suspended. The exhaust gas temperature tabg falls below the threshold temperature TABGSS or the control is turned off (B_atr = 0), the integrator will be released. When the controller is inhibited (B_atrsp = 1), the last value of controller output (dlatr) is recorded. The integral part is calculated so that the controller output is constant even when a control error remains (dlatri = dlatr - dlatrp).

ATRERB2: Enabling Exhaust Gas Temperature Control for Cylinder Bank 2

As per cylinder bank 1

ATRPI2: Exhaust Gas Temperature Proportional/Integral Control for Cylinder Bank 2

As per cylinder bank 1

ATRNL: Limp Mode for Exhaust Gas Temperature Control

In the event that an exhaust gas temperature sensor fails or is not ready, a limp mode variable (dlatrnl) is provided. The delta lambda target of interest for the limp mode is in the characteristic DLATRNL.

ATRKO: Control Output Coordination

If there is no error in the exhaust gas temperature sensors before, the controller outputs dlatr or dlatr2 through the function outputs dlamatr or dlamatr2 are transferred to lambda coordination. Once a sensor failure (E_ats = 1 or E_ats2 = 1) or the sensors are not operational (B_atsb = 0), or significant bank differences of the controller variables (E_atrd = 1 or E_atrd2 = 1) is detected, the ATR-control range (B_atrb = 1) the limp mode variable dlatrnl are transferred to both banks of lambda coordination.

ATR 1.60 Application Notes

Requirements:
- Application of lambda control

Applications Tools:
VS100

Preassignment of the Parameters:
Erkennung Regelbereich:

- Codeword CATR = 01 (hexadecimal) = 1 (decimal) enable control
- Minimum load for exhaust gas temperature control map KFRLATR (x: engine speed/rpm, y: intake air temperature/°C, z:%)

2000	3000	4000	5000	6000

10
35
60
85
109

Enable exhaust gas temperature control for cylinder bank 1/bank 2:
- Threshold exhaust gas temperature for exhaust gas temperature control: TABGSS(2) = 1000°C
- Desired AFR upper limit for switching off exhaust gas temperature control: LATRO = 16.0

Exhaust gas temperature control for cylinder bank 1/bank 2:
- Threshold exhaust gas temperature for exhaust gas temperature control: TABGSS(2) = 1000°C
- Gain factor for proportional component exhaust gas temperature PI control: ATRP = 0.005 l/K
- Gain factor for integral component for exhaust gas temperature PI control: ATRI = 0.0005 l/(s × K)
- Lower limit for exhaust gas temperature control: DLATRMN = –0.3

Exhaust gas temperature control limp mode:
- Delta lambda exhaust gas temperature control limp mode:

Engine speed/rpm	2000	3000	4000	5000	6000
DLATRNL	–0.10	–0.13	–0.17	–0.20	–0.23

Procedure:

Switching off the Function:
To prohibit exhaust gas temperature control set codeword CATR [Bit 0] equal to 0.

Affected Functions:
%LAMKO through dlamatr_w and dlamatr2_w

Parameter	**Description**
ATRI	Gain factor (integral component), exhaust gas temperature control
ATRP	Gain factor (proportional component), exhaust gas temperature control
CATR	Configuration byte, exhaust gas temperature control
DLATRMN	Lower limit for exhaust gas temperature control
DLATRNLN	Delta lambda in limp mode, exhaust gas temperature control
KFRLATR	Minimum load for exhaust gas temperature control
LATRO	Desired lambda upper limit, exhaust gas temperature control
SY_STERVK	System constant condition flag for stereo pre-cat
TABGSS	Exhaust gas temperature threshold for exhaust gas temperature control
TABGSS2	Exhaust gas temperature threshold, exhaust gas temperature control, bank 2
Variable	**Description**
B_ATR	Condition flag for exhaust gas temperature control
B_ATR2	Condition flag for exhaust gas temperature control, cylinder bank 2
B_ATRB	Condition flag for valid operating range, exhaust gas temperature control
B_ATRNL	Condition flag for limp mode in exhaust gas temperature control
B ATRSP	Condition flag for exhaust gas temperature control disabled
B_ATRSP2	Condition flag for exhaust gas temperature control disabled, cylinder bank 2
B_ATSB	Condition flag for exhaust gas temperature sensor ready
B_BEVAB	Condition flag for fuel injector cut-off in cylinder bank 1
B_BEVAB2	Condition flag for fuel injector cut-off in cylinder bank 2
B_LALGF	Condition flag for "lambda rich" limit active
B_LALGF2	Condition flag for "lambda rich" limit active
B STEND	Condition flag for end of start conditions reached
DLAMATR2_W	Delta lambda for exhaust gas temperature control, cylinder bank 2
DLAMATR_W	Delta lambda for exhaust gas temperature control
DLATR2_W	Delta lambda for exhaust gas temperature control, cylinder bank 2
DLATRI2_W	Integral component, exhaust gas temperature PI control, cylinder bank 2
DLATRI_W	Integral component, exhaust gas temperature PI control
DLATRNL_W	Delta lambda in limp mode, exhaust gas temperature control
DLATRP2_W	Proportional component, exhaust gas temperature PI control, cylinder bank 2
DLATRP W	Proportional component, exhaust gas temperature PI control

ATR 1.60 (Exhaust Gas Temperature Control)

DLATR_W	Delta lambda, exhaust gas temperature control
E_ATRD	Error flag: cylinder bank difference, exhaust gas temperature control
E_ATRD2	Error flag: cylinder bank difference, exhaust gas temperature control bank 2
E_ATS	Error flag: exhaust gas temperature sensor
E_ATS2	Error flag: exhaust gas temperature sensor, cylinder bank 2
LAMVOA2_W	Lambda pilot control without additive parts, cylinder bank 2
LAMVOA_W	Lambda pilot control without additive parts
NMOT	Engine speed
RL	Relative cylinder charge
RLATR	Load threshold for exhaust gas temperature control
TABG2_W	Exhaust gas temperature, cylinder bank 2
TABG_W	Exhaust gas temperature
TANS	Intake air temperature

BGSRM 17.10 Function Description

See the *funktionsrahmen* for the following diagrams:

bgsrm-bgsrm	Function overview
bgsrm-bps	
bgsrm-brl	Calculation of the fresh and residual gas filling of the cylinders
bgsrm-brfges	Calculating total cylinder charge
bgsrm-bpirg	
bgsrm-bpirg1	
bgsrm-pirg	
bgsrm-rlsu	

Function Description

The aim of the function:

The intake manifold model calculates the fresh gas filling of the combustion chamber from the air mass flow into the intake manifold.

Description:

An integrator emulates the storage characteristic of the intake manifold. It integrates, with the integrator coefficient KISRM, the relative difference between the inlet relative fill rlroh_w and the outlet relative air fill rl_w and supplies, after correction with the intake manifold temperature via ftsr and the standard pressure 1013 mbar, the fresh gas partial pressure in the intake manifold.

This integrator is calculated in real time. This makes it possible to describe the increase in pumping capacity with increasing engine speed without parameter change.

External exhaust gas recirculation is taken into account by adding the partial pressure of residual gas psagr_w in the intake manifold (see function BGAGR). As a result there is now a measurable quantity available, namely the intake manifold pressure ps_w, that can be used to compare with the model in the application phase.

The partial pressure of fresh gas in the intake manifold is now limited to a maximum value such that the overall pressure in the intake manifold ps_w does not increase beyond psmx_w, and also so that in the MAF meter reverse flow range, the intake manifold pressure never oscillates to large values; thus the fresh gas filling rl_w is indirectly limited by the intake manifold pressure model.

During load variations-UT, an approximate pressure balance exists between the intake manifold and cylinder which means that there is also a linear relationship between cylinder filling and the intake manifold. Additionally, there is still the residual gas in the cylinder which must be described, since exhaust gas remains in the cylinder after the end of the exhaust event and a part of this residual gas temporarily flows back into the intake manifold, but is then sucked in again.

The camshaft overlap angle wnwue is characteristic of the crank angle, during which both inlet and also exhaust valves are opened and is thus a (nonlinear) measure of the average cross-sectional area, which represents an available flow of exhaust gas from the exhaust tract into the intake manifold. Since the exhaust gas mass throughput also depends on the transit time, engine speed must also be used as an input variable to describe the effect.

Hence it follows that there is a linear rl_w - ps_w connection with offset KFPIRG (as a function of engine speed and camshaft overlap angle) and gradient KFPSURL (as a function of engine speed and camshaft overlap angle).

Since the residual gas component pirg and the gradient fupsrl are dependent on the intake manifold changeover, the intake manifold position switches over as required by the corresponding map. To obtain fupsrl no abrupt changes in the residual gas component pirg and the gradient fupsrl, they are filtered by a lowpass filter with time constant ZVTPRGSU.

Exhaust gas pressure decreases with decreasing ambient pressure and therefore the residual gas component in the cylinder, therefore the offset pirg_w corrected with the altitude factor fho_w. For the gradient fupsrl_w, a correction takes place according to the combustion chamber temperature ftbr.

With external exhaust gas recirculation, the conversion of intake manifold pressure to cylinder filling supplies all of the air filling the cylinder rfges_w including the EGR component. The component part of residual gas filling of the cylinders rfagr_w is obtained from the ratio of residual gas partial pressures in the intake manifold psagr_w to intake manifold pressure ps_w. The remaining filling part describes the fresh gas filling of the cylinders rl_w.

rl_w is the key parameter for incorporating all the filling-dependent effects and is the basic variable for pilot control of the fuel injection.

The extracted fresh gas mass flow rate mlw is obtained from the product of rl_w, speed and the conversion factor umsrln_w.

In contrast to previous tl-filter applications, the time constant of the relative load-transient effect is no longer explicitly applied via a characteristic curve, but this is implicit in the equilibrium of the intake manifold pressure models and the (predictable) value of KISRM. The value for KISRM is also switched depending on the intake manifold setting.

Application Notes

Requirements:

"- Conversion for air mass flow rate applied in rl (see function BGMSZS)"

"- Applied temperature compensation (see function BGTEMPK)"

Application tools:

for intake manifold pressure model equilibrium conditions:

"- Slow manifold pressure measurement in the collector'

dynamic comparison of intake manifold pressure with the intake manifold pressure model for measurement:

"- Throttle plate actuator"

"- Fast-measurement in the intake manifold collector (sensor time constant <10 ms, sampling rate <4 ms)"

Default values for the parameters:

"- Maximum allowable ratio manifold pressure/pressure before throttle”

FPVMXN = 1.20

"- In the cylinder internal residual gas partial pressure KFPRG"

50 mbar at the smallest wnwue, 300 mbar at largest wnwue small, with increasing engine speed is less

"- Gradient rl (ps) characteristic KFURL"

0.105%/mbar at the smallest wnwue, 0.142%/mbar at the largest wnwue, with increasing speed is less

"- Gradient of intake manifold pressure integrator KISRM"

KISRM = zkorr/[(Vs/VH) x z]

where

z is the number of cylinders (4 – 8)

VH is the total stroke volume of all the cylinders (i.e. engine displacement)

Vs is the intake volume from throttle plate through to the inlet valves, typically 1.5 to 3.0 x VH

zkorr is a correction factor for numerical stability: 0.90 when z = 4, 0.92 when z = 5, 0.95 when z = 6 or 1.00 when z > 6.

e.g. if z = 4 with Vs/VH = 2.2, KISRM = 0.1023

Switching off the Function:

"- From the intake manifold dynamics emulation: KISRM = 1.0"

Procedure:

"- Steady state for each engine speed nmot and camshaft overlap angle wnwue"

At about 4 to 5 points of relative load rl, determine measured intake manifold pressure, calculate a straight line through these points, then determine the intake manifold pressure offset KFPRG (at rl = 0) and KFURL from the gradient of the line.

"- After steady-state application of the intake manifold pressure model takes place, throttle plate jumps should be (e.g. rl = 26% to 60%)"

and comparing intake manifold pressures measured by the fast intake manifold pressure sensor with intake manifold pressures emulated in the ECU ps_w, the dynamic correctness of the air-filling model must be proven. Existing small deviations can possibly be corrected through minor changes in KISRM; but the intake manifold pressure dynamics and thus the rl-dynamics should be described satisfactorily with the calculated value of KISRM.

Affected functions:

All functions that use the charge signal rl, almost all!

Abbreviations

Parameter	Description
CWBGSRM	Code word in BGSRM
FPVMXN2	Maximum pressure ratio factor with secondary load signal
KFPBRK	Correction factor for the combustion chamber pressure
KFPBRKNW	Correction factor for the combustion chamber pressure during active camshaft control
KFPRG	Internal exhaust gas partial pressure dependent on adjustable camshaft when sumode = 0
KFPRGSU	Internal exhaust gas partial pressure dependent on adjustable camshaft when sumode = 1
KFPRG2SU	Internal exhaust gas partial pressure dependent on adjustable camshaft when sumode = 2
KFPRG3SU	Internal exhaust gas partial pressure dependent on adjustable camshaft when sumode = 3
KFURL	Conversion factor from ps to rl dependent on adjustable camshaft when sumode = 0
KFURLSU	Conversion factor from ps to rl dependent on adjustable camshaft when sumode = 1
KFURL2SU	Conversion factor from ps to rl dependent on adjustable camshaft when sumode = 2
KFURL3SU	Conversion factor from ps to rl dependent on adjustable camshaft when sumode = 3
KISRM	Integrator coefficient for intake manifold model (dynamic)
KISRMSU	Integrator coefficient for intake manifold model when sumode = 1
KISRM2SU	Integrator coefficient for intake manifold model when sumode = 2
KISRM3SU	Integrator coefficient for intake manifold model when sumode = 3
PRGNM	Internal exhaust gas partial pressure dependent on engine speed
PRGSUNM	Internal exhaust gas partial pressure dependent on engine speed when there is intake manifold changeover flap switching (1 flap)
PRG2SUNM	Internal exhaust gas partial pressure dependent on engine speed when there is intake manifold changeover flap switching (2 flaps)
PRG3SUNM	Internal exhaust gas partial pressure dependent on engine speed when there is intake manifold changeover flap switching (1+2 flaps)
SY_NWS	System constant: camshaft control: none, binary or continuously variable
URLNM	Conversion factor from ps to rl dependent on engine speed, nmot_w
URLSUNM	Conversion factor from ps to rl dependent on engine speed, nmot_w when there is intake manifold changeover flap switching (1 flap)
URL2SUNM	Conversion factor from ps to rl dependent on engine speed, nmot_w when there is intake manifold changeover flap switching (2 flaps)
URL3SUNM	Conversion factor from ps to rl dependent on engine speed, nmot_w when there is intake manifold changeover flap switching (1+2 flaps)
ZVTPRGSU	Low pass filter time constant for intake manifold flap dynamic
AGRR	Exhaust gas recirculation rate
AGRR W	Exhaust gas recirculation rate (word)
B_HFM	Condition flag: MAF sensor measurement range
B_MXRLROH	Condition flag: maximum range for rlroh is fulfilled
B_NWS	Condition flag: camshaft control
B_NWVS	Condition flag: camshaft adjustment (binary or continuous) present
B_SUMOD1	Condition flag: intake manifold changeover sumode = 1
B_SUMOD2	Condition flag: intake manifold changeover sumode = 2
B_SUMOD3	Condition flag: intake manifold changeover sumode = 3
DPSFG W	Delta-fresh gas partial pressure in the intake manifold
DRL_W	Delta cylinder charge (Word)
FHO_W	Correction factor for altitude (word)
FNWUE	Weighting factor camshaft overlap angle (inlet)
FPBRKDS_W	Factor for determining the combustion chamber pressure
FTBR_W	Factor for correcting the combustion chamber temperature
FTSR	Correction factor for the intake manifold air temperature
FUPSRL_W	Conversion factor system-related pressure on filling (16-bit)
FVISRM_W	Intake manifold integrator gain factor
ML	Air mass flow
ML_W	Air mass flow, filtered (Word)
NMOT W	Engine speed
PBR_W	Calculated combustion chamber pressure
PIRGRO_W	Raw value of residual gas partial pressure for internal exhaust gas recirculation (16-Bit)
PIRG_W	Residual gas partial pressure for internal exhaust gas recirculation (16-Bit)
PRG_W	Raw value of residual gas partial pressure for internal exhaust gas recirculation when there is no intake manifold changeover flap switching
PRGSU_W	Raw value of residual gas partial pressure for internal exhaust gas recirculation when there is

	intake manifold changeover flap switching (1 flap)
PRG2SU_W	Raw value of residual gas partial pressure for internal exhaust gas recirculation when there is intake manifold changeover flap switching (2 flaps)
PRG3SU_W	Raw value of residual gas partial pressure for internal exhaust gas recirculation when there is intake manifold changeover flap switching (1+2 flaps)
PSAGR_W	Partial pressure through external residual gas (residual air + inert gas)
PSFG_W	Fresh gas partial pressure in the intake manifold (word)
PSMX_W	Intake manifold maximum pressure limit for modelling intake manifold pressure
PSRLRO_W	Raw value for system-related conversion factor pressure from cylinder charge
PS_W	Manifold absolute pressure, MAP (Word)
PU_W	Ambient pressure
PVDKDS_W	Pressure before the throttle plate from the pressure sensor (word)
RFAGR_W	Relative cylinder charge from exhaust gas recirculation (word)
RFGES_W	Total relative cylinder charge (inclusive of exhaust gas recirculation) 16-Bit
RL	Relative air charge
RLROH W	Relative air charge: raw value from the load sensor (word)
RL_W	Relative air charge (word)
SUMODE	Status of the intake manifold switching
UMSRLN_W	Conversion factor for cylinder charge in mass flow
URL_W	Factor for converting pressure from cylinder charge at the default position of the intake manifold flap
URLSU_W	Factor for converting pressure from cylinder charge when there is intake manifold changeover flap switching (1 flap)
URL2SU_W	Factor for converting pressure from cylinder charge when there is intake manifold changeover flap switching (2 flaps)
URL3SU_W	Factor for converting pressure from cylinder charge when there is intake manifold changeover flap switching (1+2 flaps)
WNWISA_W	Actual exhaust camshaft angle
WNWSRM_W	Choice between wnwue and wnwisa for addressing the map for PIRG and fupsrl
WNWUE W	Camshaft overlap angle

FUEDK 21.90 (Cylinder Charge Control (Calculating Target Throttle Angle))

See the *funktionsrahmen* for the following diagrams:

fuedk-fuedk	FUEDK overview
fuedk-brlpssol	BRLPSSOL: target intake manifold pressure
fuedk-umpspi	UMPSPI: calculation of reference pressure upstream of the throttle
fuedk-bmldkns	BMLDKNS: normalised target air mass flow at throttle
fuedk-bwdksgv	BWDKSGV: target throttle angle
fuedk-filter	FILTER: median-filter
fuedk-wdksugdt	WDKSUGDT: difference of target throttle angle compared to 95% charge (turbocharged engine)
fuedk-wdksugds	WDKSUGDS: difference of target throttle angle compared to 95% charge (normally-aspirated engine)
fuedk-wdksgv	WDKSGV: throttle angle
fuedk-bde-wdksgv	WDKSGV: petrol direct injection throttle angle
fuedk-wdkappl	WDKAPPL: calibration interface
fuedk-nachlauf	NACHLAUF: calculation of target throttle angle when SKl15 = off
fuedk-init	INIT: initialization of function

FUEDK 21.90 Function Description

The purpose of this function is to calculate the target throttle plate angles for either a turbocharged or a normally-aspirated engine with an intake manifold (lambda = 1 mode), or direct injection (also lambda > 1). The control is via the system constants SY_TURBO and SY_BDE. The main input variables are the target relative cylinder charge and the required correction from cylinder charge control. Various other signals, such as correction factors for pressure and temperature or information about the fuel tank breather and exhaust gas recirculation are taken from the intake manifold model of cylinder charge detection or the target value for exhaust gas recirculation (in direct injection mode). For these reasons, there is a close connection between calculation of the target throttle plate angle and cylinder charge detection.

Sub-function BRLPSSOL: Calculation of the target intake manifold pressure (pssol_w) and correction of target fresh air charge upstream of the throttle plate (rlfgks_w)

In petrol direct injection engines, the target relative cylinder charge rlsol_w is reduced by the relative air charge from external and internal exhaust gas recirculation. In the case of engines with fuel injection to the intake manifold (lambda = 1) no air is contained in the internally or externally recirculated exhaust gas. The relative residual gas charge = 0 and is therefore not taken into account. A comparison between actual cylinder charge (rl_w) and target cylinder charge (rlsol_w) is made via the variable drlfue from the function FUEREG (cylinder charge control). The variable rlfgks_w represents the proportion of fresh air that flows through the throttle plate or the fuel tank breather to the engine. The target intake manifold pressure for direct injection engines is calculated from the target fresh air charge through the throttle plate and fuel tank breather and the total charge (air and inert gas) from the residual gas (i.e. internal and external exhaust gas recirculation) together. The total charge corresponding to the intake manifold pressure is calculated with the conversion factor fupsrl_w. For engines with fuel injection into the intake manifold, the target relative cylinder charge rlsol_w is increased by the relative charge from the external exhaust gas recirculation feed. The total charge corresponding to the intake manifold pressure is calculated with the conversion factor fupsrl_w. Correcting with the internal exhaust gas recirculation partial pressure (pirg_w) gives the target intake manifold pressure pssol_w. Additionally, in direct injection engines, the correction of the internal residual gases (ofpbrint_w) is still added and then pssol_w is obtained.

Sub-function UMSPI: Calculation of the target reference pressures upstream of the throttle plate for a turbocharged engine (pvdkr_w):

Turbocharged engine:

Target reference pressure pvdkr_w see the following description

Air density correction factor frhodkr_w = ftvdk × pvdkr_w ÷ 1013 mbar.

The target reference pressure for the pressure upstream of the throttle plate (pvdkr_w) for a turbocharged engine is formed from the maximum range of ambient pressure (pu_w) and the target boost pressure (plsol_w) or the actual pressure upstream of the throttle plate (pvdk_w). The target boost pressure is given by pssol_w ÷ vpsspls_w, whereby vpsspls_w is the required pressure ratio from the boost pressure control. When vpsspls_w > 0.95, the throttle plate is linearly actuated, with boost pressure regulation active, in order to minimise the pressure drop at the throttle plate (see sub-function WDKSUGDT). The air mass dependent characteristic KLDPDK takes the pressure drop across the throttle plate into account. In so doing, this gives a larger value for the target boost pressure than the actual boost pressure being implemented in the boost pressure control. The actual pressure can be ramped up towards the target pressure via the characteristic FUEPMLD. When the predicated boost pressure difference pdpld exceeds the threshold DPUPS, then a switch is made to the actual pressure pvdk_w, because this condition represents a boost pressure error (B_ldrugd = false). In the transition from ambient pressure to dev basic boost pressure, the actual boost pressure is filtered with the low-pass filter, because pressure pulsations will be experienced in this range because of non-clean waste-gate closure.

Sub-function BMLDKNS: Calculation of the normalised target air mass flows through the throttle plate (msndkoos_w)

The target air mass flow mlsol_w is calculated by multiplying the corrected target cylinder charge rlfgks_w by umsrln_w. Since the engine cylinder charge at start is obtained from the intake manifold, initially, no throttle opening would be required (umsrln_w = KUMSRL $\times$ nmot = 0). A minimum air flow through the throttle is predetermined by the threshold KUMSRL $\times$ NRLMN so that the throttle does not close at the start and then open when the engine picks up speed. The threshold NRLMN is set to 400 rpm since that is assumed to be the engine speed at start. The threshold NRLMNLLR is disabled so that the throttle will be closed during a speed drop, for instance when starting up.

The target air mass flow is reduced by the air mass flow which is directed into the intake manifold through the fuel tank breather (mste) since this amount must be made up via the throttle. The normalized air mass flow through the throttle (msndks_w) is calculated by dividing the target air mass flow through the throttle (msdks_w) by the corrected density, KLAF. The throttle valve actuator air bleed (msndko_w) will still be subtracted from this air mass flow via an adaptation in the function BGMSZS to obtain the normalized air mass that will flow through the throttle (msndkoos_w).

The discharge characteristic, KLAF, is addressed with the target pressure ratio psspvdkb_w. This target pressure ratio comprises the minimum of psspvdk_w = pssol_w $\div$ pvdkr_w (turbo) or psspvdk_w = pssol_w $\div$ pvdk_w (normally-aspirated engine) and PSPVDKUG together. This means that the target throttle angle only up to the unrestricted range, psspvdkb_w = 0.95 = PSPVDKUG, is calculated via KLAF. The remaining 5% is calculated in the sub-function WDKSUGDS for a normally-aspirated engine and in the sub-function WDKSUGDT for a turbocharged engine. If psspvdk_w > PSPVDKUG, condition flag B_klafbg will be set indicating that the characteristic KLAF is limited.

Sub-function BWDKSGV: Target throttle angle (wdksgv_w)

In this sub-function, the target angle (wdksgv_w) for controlling the throttle plate is calculated from the normalized target air mass (msndkoos_w). Up to the throttle angle for unrestricted operation wdkugd_w (output from the speed-dependent characteristic WDKUGDN from the function %BGMSZS) the target angle is determined via the map KFWDKMSN. This is the inverse map of KFMSNWDK (from the function %BGMSZS) and is calibrated to the built-in throttle actuator. If the calculated value of the normalized target air mass flow from KFWDKMSN is greater than the angle wdkugd_w, then the condition for unrestricted operating B_ugds = true.

If the target pressure ratio is greater than 0.95, the numeric basic stability of the normalized air mass flow and thus the target throttle angle can no longer be determined via the discharge characteristic KLAF. For the rest of the target throttle angle range beyond wdkugd_w to 100% for both a normally-aspirated and turbocharged engine, a different residual angle dwdksus_w or dwdksut_w is implemented. This residual value in the unrestricted range (naturally-aspirated: B_dwdksus = true and turbocharged: B_fkmsdks = true) is added to wdkugd_w. If applicable, the target throttle angle is limited by the maximum allowable target throttle angle KFWDKSMX and made available as wdksgv_w. This can be used for power reduction or attenuation of induction noise. To extend the life of the throttle-adjustment actuator, the normalized air mass flow (msndkoos_w) is smoothed via a median filter with small changes in rlsol_w in the sub-function FILTER. If the delta rlsol (drlsolmf = abs (rlsol_w – rlsol (t – 40 ms)) is less than the threshold DRLSOLMF, which means very small changes in the target torque, the filter is active (B_mfact = true). The actual value of msndkoos_w is cached in a five-value capacity input filter buffer. The values are stored in decreasing values in a five-value capacity output filter buffer. If the old filter value mlwdknf_w is not within the maximum and minimum value of the output filter buffers, it will be centered on the mean value of these buffers. Otherwise, mlwdknf_w is not changed. If the threshold drlsolmf_w > DRLSOLMF, then the filter output value mlwdknf_w is set directly to the filter input value msndkoos_w. In addition, the filter input value is transferred to the filter input buffer.

For special cases, for example start and warm-up conditions, it is necessary to predefine a torque calculation independently of the throttle angle. For this purpose, the input wdksom_w is used when B_wdksom is active.

With the switch B_tfwdksom, the filter time constant tfwdksom can be switched on. The low pass filter is required during the transition from “start angle” to “torque-based” operation. For engines with fuel injection to the intake manifold, the filter can also be switched on during the operation via the code word CWFUEDK (6 bits) with the variable time constant tfwdks_w. If the condition B_fkmsdks (B_ugds or B_klafbg for normally-aspirated engine and B_fkmsdks for a turbocharged enginer) is set, the charge control is disabled (see Section %FUEREG) and the alignment between MAF meter and throttle-based charge detection (fkmsdk) in the function BGMSZS%.

Turbocharged Engine: Sub-function WDKSUGDT

Because cylinder charge in the unrestricted region for a turbocharged engine is achieved via the boost pressure control, the throttle should be completely open in this region to avoid throttling losses. For this purpose, in the boost pressure control, the pressure ratio vpsspls_w is defined as target manifold pressure ÷ ambient pressure. If vpsspls_w > 0.95, i.e. vpsspls_w > PSPVDKUG, so begins the unrestricted area. The throttle plate residual value dwdksumx_w = difference between the unrestricted target angle wdkugd_w and 100% which is linearly scaled by the ratio (1 – vpsspls_w) ÷ (1 – PSPVDKUG). The value for PSPVDKUG is 0.95 (see function BGMSZS). If the throttle angle is controlled by the actual manifold pressure (CWFUEDK Bit 7 = true), the upper value is enabled only when the calculated target throttle angle from the torque structure is greater than the unrestricted angle. The angle can be unrestricted through tolerances of the MAF meter and pressure sensors, even if a demand of vpsspls_w = 1 is still greater than wdksbugd_w. Therefore, this tolerance can be applied in DWDKUGD. Then the upper value is enabled via a pressure ratio vpsspls_w > VPSSPLSWDK already at wdksbugd (angle calculated from the torque structure) > wdkugd minus DWDKUGD.
With active throttle plate residual value, the bit B_fkmsdks is set, which is either when B_klafbg is set or vpsspls_w ≥ PSPVDKUG or when CWFUEDK bit 7 = true only dependent on B_klafbg.

Normally-Aspirated Engine: Sub-function WDKSUGDS

Here a so-called pedal-crossover is introduced: Bit 4 of CWFUEDK = false: If the target pressure ratio psspvdk_w > PSPVDKUG (i.e. B_klafbg = true) or if B_ugds = true, then the pedal-crossover begins (B_dwdksus = true). mrfa_w is frozen at the beginning of the crossovers in mrfabug_w.

The throttle plate residual value dwdksumx_w (= difference between the unrestricted target angle wdkugd_w and the maximum permissible target angle from the map KFWDKSMN) is linearly scaled through the ratio for the pedal crossover between mrfabugd_w and mrfamx_w thus:

[mrfa_w – min(100%, mrfabugd)] ÷ [mrfamx_w – min(100%, mrfabugd)]

whenever B_dwdksus = true.

The value dwdksus_w is added to wdkugd_w and as the target angle wdksvin_w provided. wdksgv_w can be maximum WDKSMX. The end of the pedal-crossovers is reached when, for example, mrfa_w is once more smaller then mrfabugd_w or [milsol_w < FMIUGDS × mifafu_w] (0.95 × mifafu_w) or, for vehicles with continuously-variable transmissions (CVT), when B_mgbget = true.

For positive load changes corresponding to fast throttle-opening, a large increase of torque via the air path (mifal) is predetermined by the driver’s requested torque calculation function. This large increase is also conveyed to the throttle-side so that the unrestricted range is reached via the pressure ratio psspvdk. If the corresponding driver’s requested torque were to be saved, then this torque would be too small because it contains this large increase. Therefore, the saving is prevented via B_lsd until this dynamic action is once again reduced.

The map MRFARUGDN (reset threshold for linear pedal travel in the unrestricted throttle region) prevents the value 0 being stored in mrfabugd_w during startup when mrfa_w and psspvdk_w = 0 and > 0.95. This prevents pedal crossover that is activated when wped is in the region of 0.

Bit 4 CWFUEDK = true:

The pedal crossover does not depend on mrfabugd_w calculation but depends on the characteristic MRFARUGDN. Whether the pedal crossover is switched on or off depends on the same conditions as in bit 4 of CWFUEDK = false.

Sub-function WDKAPPL: Applications interface

If the applications interface is enabled, normal calculation of target throttle angles (which is the function of the torque interface) is disabled (via constant CWMDAPP). Instead, the target throttle angle depends only on the pedal value, or is even set to be constant. When the engine speed = 0 rpm, the target throttle angle depends directly on the pedal position (wped). Thus, for example in the workshop, a movement of the throttle valve actuator can be achieved via the throttle pedal. Via the system constant SY_TWDKS, a sub-program can be incorporated, which enables the tester to control the throttle by a predetermined angle cvwdk. In so doing, the tester must assign the target angle cvwdk and set the bit in B_cwdk.

When using this feature you must ensure that no acceleration of the vehicle takes place, e.g. through examination of brake switch, clutch switch, etc. Ensure that engine and vehicle speed = 0!

When the map FPWDKAPP is switched on, then when evtmod < EVTMODKMNDK an offset WDKSOFS is added to the curve. This prevents the wrong throttle learning, for example by freezing. With nmot_w = 0 and ignition on, the target value of the throttle angle should correspond to the emergency air point.

Subfunction NACHLAUF: Calculation of the target throttle angles for delayed accessory power only when SY_UBR = 1 (main relay installed) included.

For delayed accessory power, a throttle angle is determined independently of the torque structure. This angle wdksom_w is defined in the function WDKSOM. For systems with a built-in main relay, the throttle actuator also supplies the ECU-delayed accessory power with power and therefore this angle is set by the throttle actuator. This ensures a quieter engine output.

FUEDK 21.90 Application Notes

Normally-aspirated and Turbocharged engines:
KLAF: see cylinder charge detection
KFWDKMSN: the inverse of KFMSNWDK
KUMSRL: see cylinder charge detection

CWFUEDK bit allocation:
Bit 0: normally-aspirated engine, fkmsdk-correction via pedal upper travel
Bit 1: not used in this FDEF.
Bit 2: for start packet: if throttle angle from the torque structure > throttle angle from start packet, there is no filtering of tfwdksom
IT IS RECOMMENDED TO SET THIS BIT TO FALSE!
Bit 3: not used in this FDEF.
Bit 4: normally-aspirated engine, via pedal upper travel dwdksus_w is calculated via mrfabugd_w or mrfaugd:
IT IS RECOMMENDED TO SET THIS BIT TO FALSE!
Bit 5: B_ldrugd can only be set independently of B_llrein with a turbocharged engine
Bit 6: only for non-direct injection engine: low-pass filter before wdksgv_w is enabled either just at start or always
Bit 7: KLAF is calculated by filtered actual intake manifold pressure (for turbo) ÷ target intake manifold pressure (for normally-aspirated engine)

CWFUEDK=64	Bit 0	= false: functionality as per module FUEDK 18.20
	Bit 2	= false: functionality as per module FUEDK 21.50
	Bit 4	= false: functionality as per module FUEDK 18.20
	Bit 5	= false: functionality as per module FUEDK 18.20
	Bit 6	= true: as per module FUEDK 18.20, when Bit 6 = false → run time reduction
	Bit 7	= true: for turbo: calculation from KLAF with filtered actual intake manifold pressure = false: for normally-aspirated engines: calculation from KLAF with target intake manifold pressure as previously

CWRLAPPL: only for dynamometer (switching from pssol_w with and without influence from charge control)

EVTMODMNDK = 5°C
WDKSOFS = 5% (Emergency air point minus one value of KLFPWDKAPP) thus throttle target value when lambda = 1 and engine speed = 0 corresponds to the emergency air point.

FPWDKAPP

wped_w/%	1.5	6.25	11.0	15.63	23.43	31.25	39.0	46.87	54.69	62.5	70.3	78.13	82.86	85.94	89.84	93.75

wdksv_w/% 1.7 7.1 11.16 15.25 20.0 31.0 39.0 47.0 55.0 62.0 70.0 78.0 82.0 86.0 90.0 99.9

WDKSAPP 2%

TWDKSV:

pspvmin_w	0.990	0.992	0.996	0.998	1.00	1.02
	0.01	0.10	0.15	0.20	0.25	0.0

NMOTCVWDK = 2000 rpm

NRLMN: 400 rpm (defined via umsrln_w, the throttle opening in start). The throttle opening is limited by wdkugd_w.
NRLMNLLR: 100 rpm below idle speed (700 rpm)
ZKPSFIL = 0.02 s

KFWDKSMX: Engine speed sample points are selected as per WDKUGDN. It is important to note that for the throttle angle limit to reduce power, the sample points in the reduction range may be more closely distributed.
Upper sample point: the uppermost sample point for the altitude is selected so that it corresponds to the altitude at which the power reduction occurs. In the power reduction region, KFWDKSMX is less than 100% such that the desired maximum engine performance is thereby made through the restriction.
The lowest sample point is selected so that it corresponds to the altitude at which the lowest air density yields the natural power reduction to the desired performance standard. As a reference point, it is assumed that an altitude gain of 1000 m brings about a 10% power reduction (delta fho_w = -0.1). This sample point is recorded over the entire speed range KFWDKSMX = 100%.

Engine speed: 240, 760, 1000, 1520, 2000, 2520, 3000, 3520, 4000, 6000 rpm
fho_w: 0.8, 0.9, 1.0

Values: KFWDKSMX = 100% → angle limit is not active.

Determination of the activation threshold for the median filter:

1) Median-Filter switch-off: DRLSOLMF = 0;

Let the vehicle roll at idle to determine the maximum occurring drlsolmf_w. This is value 1.
Slowly pay out idling gas (low dynamics). The drlsolmf_w which occurs in this case determines value 2.
At idle, rotate the power steering to its end stop, The drlsolmf_w which occurs in this case detemines value 3.
Increase vehicle speed (accelerate under load with greater dynamics). The drlsolmf_w which occurs in this case determines value 4.
The threshold value DRLSOLMF is determined from the maximum of values 1 and 2 and the minimum of values 3 and 4.
It will lie in the mostly in value 4.

DRLSOLMF default value is: 2%

For the charge detection application on the engine dynamometer, speed or load sample points shall be reached automatically. The target specification in the function %MDFUE is achieved by specifying a constant rlsol or a target throttle pedal value. Thus, the predetermined rlsol will be implemented in a real rl with the same value, the charge control is used with a changed parameter set to balance rl - rlsol. This functionality is only effective if the system constant SY_RLAPP in the function PROKON is set to a value > 0. With bit 0 of CWRLAPPL, the functionality is then activated final. The link with the driving speed ensures that the balancing function can be activated only when the vehicle is stationary, or on the engine dynamometer.

Normally aspirated engine only:
MRFABUMX = 100%
MRFARUGDN (SNM12FEUB)
nmot_w
Values all at 80%
FMIUGDS: 0.95

Turbocharged engine only:

FUEPMLD

lditv w	3	6	10	20
Value	0.999	0.8	0.2	0

ZPVDKR

Stutzst. psspu w	0.9	1.0	1.1	1.2	1.3	1.4
Value/seconds	0	0	0	2	2	0

DPUPS: ≥ 250 mbar
DWDKUGD = 2% tolerance of wdkugd
KLDPDK: 0 mbar at all sample points
Application: to measure the pressure drop across the throttle plate, especially the magnitude of the air mass flow rate. From these 16 sample points, mlkge_w is determined and the associated pressure drop applied in the characteristic.

PLSOLAP: 0 mbar. In the applications phase, if a target boost pressure is predetermined, B_plsolap = Bit 5 of CWMDAPP is set to be true and the desired boost pressure is specified via PLSOLAP.

PSPVDKUG see function BGMSZS

When CWFUEDK Bit 7 = true:
TFWDKSOF = 0.1275 s
VPSSPLSWDK = 0.995 From this pressure ratio, the throttle should be opened to wdkugd, when the throttle angle from the torque structure is equal to wdkugd - DWDKUGD (tolerance)
WDKSHYS = 2%

Parameter	**Description**
CWFUEDK	Codeword FUEDK
CWRLAPPL	Codeword default rlsol_w during application phase
DPUPS	Pressure difference for changeover of reference pressure to the throttle plate
DRLSOLMF	Threshold delta rlsol for median filter
DWDKUGD	Delta to unrestricted throttle angle (tolerance)
EVTMODMNDK	No minimum temperature for the offset is added to throttle plate characteristic at engine speed = 0
FMIUGDS	Factor maximum torque for unrestricted operation
FPWDKAPP	Throttle plate characteristic dependent von throttle pedal only for the applications phase
FUEPMLD	Factor for smooth transition of averge pressure (reference pressure) for turbo
KFWDKMSN	Map for target throttle plate angle
KFWDKSMX	Maximum target throttle plate angle
KLAF	Air discharge characteristic
KLDPDK	Characteristic for pressure drop across throttle plate
KUMSRL	Conversion constant for mass flow in relative air charge
MRFABUMX	Maximum driver-target threshold for linear pedal travel in the unrestricted throttle range
MRFARUGDN	Reset threshold for linear pedal travel in the unrestricted throttle range
NMOTCVWDK	Maximum speed that is still allowed at the throttle plate angle specified by the tester
NRLMN	Minimum speed for calculating umsrln
NRLMNLLR	Minimum speed for calculating umsrln during idle
PLSOLAP	Application value for target boost pressure
PSPVDKUG	Ratio pspvdk unrestricted
SNM12FEUB	Sample point distribution for WDKSMX, WDKUGDN
SY_AGR	System constant: exhaust gas recirculation present
SY_BDE	System constant: Petrol Direct Injection
SY_CVT	System constant: CVT-transmission present
SY RLAPP	rlsol-control in applications phase possible
SY_TURBO	System constant: Turbocharger
SY_TWDKS	System constant: Default target throttle angle adjustment via the tester possible
SY_UBR	System constant: Voltage after main relay ubr exists
SY_VS	System constant: camshaft control: none, binary (on/off)
TFWDKSOF	Time for target throttle plate filtering
TWDKSV	Time constant for target throttle plate angle filtering
VPSSPLSWDK	Pressure ratio to enable the throttle crossover when throttle angle > unfiltered throttle angle threshold
WDKSAPP	Target throttle plate angle for application purposes
WDKSHYS	Throttle plate hysteresis threshold for activating/deactivating crossover

WDKSOFS	Offset applied to target throttle angle at low temperature
ZKPSFIL	Time constant for filtering intake manifold pressure for KLAF calculation in FUEDK
ZPVDKR	Time constant for pvdkr-filtering
Variable	**Description**
B_CWDK	Actuator test DCPIDCM
B_DWDKSUS	Delta target throttle plate angle from the start of the unrestricted range (normally-aspirated engine) active
B_EAGRNWS	Condition: Error in exhaust gas recirculation or camshaft → exhaust gas recirculation-cylinder charge for switching to the actual value
B_FKMSDKS	Integrator stop fkmsdk
B_FPWDKAP	Throttle control directly via the throttle pedal
B_KLAFBG	Input variable for KLAF is limited
B_LDRUGD	Condition: unrestricted, enable through boost pressure control
B_LLREIN	Condition: idle control active
B_LSD	Condition: Positive load shock absorption active
B_MFACT	Condition: Median filter active
B_MGBGET	Condition: Torque gradient limitation active
B_NMIN	Condition: Underspeed: n < NMIN
B_NSWO1	Condition: Speed > NSWO1
B_PLSOLAP	Changeover: target boost pressure at the application target boost pressure
B_STEND	Condition: end of start reached
B_TFWDKSOM	Time constant for filtering throttle plate angle without torque structure active
B_UGDS	Target throttle plate angle in the unrestricted range
B_WDKAP	Condition: throttle angle target value from application characteristic or in the start from start angle
B_WDKSAP	Throttle control via constant, Bit 1 has priority
B_WDKSOM	Target throttle plate angle without torque structure active
CVWDK	Actuator test control value DCPIDCM
DPDK_W	Pressure drop across throttle plate
DRLFUE_W	Load correction of cylinder charge control
DRLSOLMF_W	Delta target cylinder charge for median filter
DWDKSUMX_W	Delta target throttle plate angle from the start of the unrestricted range to maximum
DWDKSUS_W	Delta target throttle plate angle from the start of the unrestricted range (normally-aspirated engine)
DWDKSUT_W	Delta target throttle plate angle from the start of the unrestricted (turbocharged engine)
EVTMOD	Modelled intake valve temperature (temperature model)
FHO_W	Altitude correction factor (word)
FKLAFS_W	Discharge factor (KLAF) for determining wdks
FKMSDK_W	Correction factor mass flow next charge signal
FPBRKDS_W	Factor for determining the combustion chamber pressures
FRHODKR_W	Air-tight correction factor for corrected throttle throughput (word)
FRHODK_W	Air-tight correction for throttle throughput as a factor of (intake temperature and altitude) 16 Bit
FTVDK	Correction factor for temperature at the throttle plate
FUEPMLD_W	Factor for smooth transition of average pressure (reference pressure) at the turbo
FUPSRL_W	Conversion factor of system related pressure on cylinder charge (16-bit)
LDITV_W	Boost pressure control: duty cycle from integral controller (word)
MIFAFU_W	Driver-requested torque for cylinder charge
MILSOL_W	Driver-requested torque for cylinder charge
MLKGE_W	Input to map KLDPDK
MLSOL_W	Target air mass flow
MLWDKNF_W	Filterted, normalised air mass flow for determining target throttle-plate angle
ML_W	Filtered air mass flow (Word)
MRFABUGD_W	Relative driver-requested torque to the beginning of the unrestricted range
MRFAMX_W	Relative driver-requested torque, maximum value
MRFAUGD W	Relative driver-requested torque for upper pedal travel in the unrestricted region
MRFA_W	Relative driver-requested torque from vehicle speed limiter and throttle pedal
MSDKS_W	Target air mass flow through the throttle mechanism
MSNDKOOS_W	Normalised air mass flow for determining the target throttle plate angle
MSNDKO_W	Normalised bleed air mass flow through the throttle plate (word)
MSNDKS_W	Normalised target air mass flow through the throttle mechanism
MSTE	Fuel tank breather mass flow into the intake manifold
NMOT	Engine speed
NMOT W	Engine speed
PDPLD	Predicated delta pressure (actual target overshoot)
PIRGFUE_W	Partial pressure of residual gas, internal exhaust gas recirculation (for FUEDK)
PIRG_W	Partial pressure of residual gas, internal exhaust gas recirculation (16-Bit)
PLSOL	Target boost pressure
PLSOL_W	Target boost pressure (word)
PSFIL_W	Filtered intake manifold pressure for KLAF-calculation in FUEDK
PSPVDK_W	Quotient intake manifold pressure/pressure at the throttle plate (word)
PSPVMIN_W	Minimum selection from pspvdk and psspvdk
PSRLFUE_W	Conversion pressure from cylinder charge (for FUEDK)

PSSOL_W	Target intake manifold pressure
PSSPVDKB_W	Ratio of target intake manifold pressure to pressure at the throttle plate, restricted
PSSPVDK_W	Ratio of target intake manifold pressure to pressure at the throttle plate
PS W	Absolute intake manifold pressure (word)
PU_W	Ambient pressure
PVDKR_W	Reference pressure at the throttle plate
PVDK_W	Pressure at the throttle plate 16-Bit
RFAGR_W	Relative cylinder charge, exhaust gas recirculation (word)
RFRS_W	Target relative cylinder charge (inert gas + air) from internal and external exhaust gas recirculation
RFR_W	Relative cylinder charge (inert gas + air) über internal and external exhaust gas recirculation
RLFGKS_W	Corrected relative target fresh air charge (air that flows through the throttle plate and fuel tank breather)
RLFGS_W	Target relative fresh air charge (air that flows through the throttle plate and fuel tank breather)
RLRS_W	Target relative air charge uber internal and external exhaust gas recirculation
RLR_W	Relative air charge uber internal and external exhaust gas recirculation
RLSOL_W	Target cylinder charge
TFWDKSOM_W	Time constant for filtering throttle plate angle outwith the torque structure
TFWDKS_W	Time constant for wdks filtering
UMSRLN_W	Conversion factor air charge in mass flow
VFZG	Vehicle speed
VPSSPLS_W	Ratio of target intake manifold pressure to target boost pressure
VPSSPU_W	Ratio of ambient pressure to target intake manifold pressure
WDKSAP_W	Target throttle plate angle from the applications block
WDKSBUGD_W	Target throttle plate angle from the torque structure limited to the unrestricted angle
WDKSGV_W	Target throttle plate angle for the applications interface (filtered)
WDKSMX_W	Maximum target throttle plate angle
WDKSOM_W	Target throttle plate angle outwith the torque structure
WDKSV_W	Target throttle plate angle for the applications interface (unfiltered)
WDKUGD_W	Throttle plate angle, when 95% cylinder charge has been reached
WPED W	Normalised throttle pedal angle

GGHFM 57.60 (MAF Meter System Pulsations)

GGHFM 57.60 (MAF Meter System Pulsations) Function Description

The MAF sensor output is sampled at 1 millisecond intervals. The sampled voltage value is first linearized using the 512 value characteristic curve MLHFM (which contains only positive values) for further calculation of mass air flow. Therefore, when using a HFM5 sensor, an offset (defined by MLOFS) is required to take account of the reverse current region in the calculation of MLHFM values.

The calculated air mass values are then summed in a memory segment. Once a segment is nearly full, the simple arithmetic average of the cumulative value over the last segment is calculated, i.e. it is divided by the number of samples of the last segment and then the offset MLOFS is subtracted.

During idle conditions, a selection is made between the measured air mass flow and the maximum possible air mass flow at this operating point, mldmx_w (taken at a height of –500 m and a temperature of –40°C) weighted by the multiplication factor FKMSHFM. By this measure, short circuiting of U_{bat} output to the engine can be prevented. [See module DHFM 63.130 Diagnosis: MAF sensor signal plausibility check: *"With the HFM5 sensor, if the battery voltage is less than 11 V , no more information about the plausibility of the HFM signal is possible (basis: voltage levels of 0.5-2.0 V cause a short circuit between U_{bat} and U_{ref})..."*]

Then, the value is corrected via fpuk for pulsations and return flow (i.e. pressurized air dumped back to the intake tract on the overrun) and via fkhfm in areas with no pulsation and surging. When the turbo is on, the system constant SY_TURBO sets fpuk to 1.0 since there will not be any pulsations or return flow. The value mshfm_w is corrected in this case by the map KFKHFM.

Since different displacement elements of the engine hardware, such as the camshaft, intake manifold or charge movement flap can influence pulsation in the MAF sensor, the code words CWHFMPUKL1 and CWHFMPUKL2 determine which influencing factors are taken into account.

The air mass flow output is supplied as the 16-bit value mshfm_w. The RAM-cell mshfm_w is limited to zero. To take into account return flow (based on 1-segment) for turbo engines, the RAM-cell mshfms_w is provided, which is administered by the limiting value FW MLMIN.

The pulsation-correcting curve PUKANS corrects for the engine speed nmot so that intake air temperature-dependent displacements of actual pulsation areas are managed.

APP GGHFM 57.60 Application Notes

Pre-assignment of the Parameters

CWHFMPUKL1 = 1
CWHFMPUKL2 = 1
FLBKPUHFM = 0.5
FNWUEPUHFM = 0.5
KFKHFM = 1.0
KFPU = 1.0
KFPUKLP1 = 1.0
KFPUKLP12 = 1.0
KFPUKLP2 = 1.0
MLHFM = MAF sensor curve
MLMIN = –200 kg/h
MLOFS = 200 kg/h
PUKANS = 1.0

Application Procedure
1. Determine, input and review the MAF sensor linearization curve
2. Linearization curves depend on size and type (hybrid/sensor) of the MAF metering system deployed
3. For the HFM5 sensor, the curve with return flow, i.e., positive and negative air masses and use additional offset (MLOFS = 200 kg/h)
4. When using an alternative plug-in sensor, check the linearization curve is appropriate for the mounting position used.

Requirements for the Application of the Pulsation Map

Mixture pre-input path:

GGHFM 57.60 (MAF Meter System Pulsations)

1. Normalise all enrichment (input factors and input-lambda), i.e. feed forward control to obtain lambda = 1;
2. In fuel systems where there is no constant differential pressure over the fuel injectors (e.g. returnless fuel systems, i.e. in which the pressure regulator is not working against the intake manifold pressure as a reference) this must especially be ensured for the application of pulsation maps (connection of a pressure regulator on the intake manifold).
3. If this is not technically possible, i.e. the differential pressure across the fuel injectors was previously considered in a correction curve (see note to returnless fuel systems), then carry out the following:

Pre-input charge detection:
1. Determine the MAF sensor characteristic curve
2. Normalise the pulsation corrections first (set KFPU, KFPUKLP1, KFPUKLP2, KFPUKLP12 to 1.0)
3. Set the MAF correction map values to 1.0
4. Limit rlmax by disabling or setting PSMXN to its maximum values

The pulsation correction depends on T_{ans} in the characteristic PUKANS stored as a factor and is addressed with T_{ans}/°C. This characteristic is used for engine speed correction to address the pulsation map KFPU.

PUKANS = $\sqrt{(T_0/T_{ANS})}$ where T_0 and T_{ANS} are absolute temperatures (i.e. in Kelvin)

The base temperature T_0 is 0°C = 273 K i.e. ftans (0°C) = 1.0

To apply the curve with 8 data points for pulsation corrections:

T_{ANS}/°C	–40	–20	0	20	30	40	50	80
T_{ANS}/K	233	253	273	293	303	313	323	353
PUKANS	1.0824	1.0388	1.0000	0.9653	0.9492	0.9339	0.9194	0.8794

Application of the Pulse Maps KFPU, KFPUKLP1, KFPUKLP2, KFPUKLP12

The pulsation maps compensate for pulsation and reverse flow errors in the MAF meter system. There are four pulsation maps:

KFPU: the basic map
KFPUKLP1: pulsation-influencing adjustment element 1
KFPUKLP2: pulsation-influencing adjustment element 2
KFPUKLP12: pulsation-influencing adjustment elements 1 and 2

Parameterization of the code words CWHFMPUKL1 and CWHFMPUKL2:

Definition of adjustment element 1 for taking pulsation into account
CWHFMKLPU1:
1. 1 Intake manifold flap
2. Camshaft
3. Charge movement flap

Definition of adjustment element 2 for taking pulsation into account
CWHFMKLPU2:
1. 2 Intake manifold flap
2. Camshaft
3. Charge movement flap

Definition of the pulsation range:
MAF sensor voltage fluctuations with an amplitude of 0.5 V

Definition of the return-flow (i.e. pressurized air dumped back to the intake tract on the overrun) range:
MAF sensor voltage <1 V

Pulsation Map Adaptation:
Determining the pulsation or reverse flow region; possibly changing the sample-point resolution of pulsation maps to better cover the pulsation region.

The air mass in the intake manifold (ml_w) is compared with the calculated air mass in the exhaust gas via the characteristic curves KFPU, KFPUKLP1, KFPUKLP2 and KFPUKLP12. As an alternative to the calculated air mass in the exhaust, the air mass flow through a pulsation-damping volume to the air filter housing (e.g. a Helmholtz resonator device) can be measured instead.

Application of the MAF Correction Map KFKHFM:

In regions of no pulsation, the air mass comparison is carried out via the map KFKHFM. In this way, MAF-sensor errors caused, for example, by a problematic installation position can be corrected. For either, the balancing should maintain lambda of approximately 1.0, so the error in calculating the air mass in the exhaust gas is low. The residual errors (lambda deviation around 1.0) are interpreted as a mixture error and are compensated for by the characteristic curve FKKVS in the RKTI 11.40 module.

Definitions

Parameter	**Definition**
CWHFMPUKL1	Code word 1 for selecting one of the adjustment elements for MAF sensor-pulsation map
CWHFMPUKL2	Code word 2 for selecting one of the adjustment elements for MAF sensor-pulsation map
FLBKPUHFM	Switching threshold for the charge movement flap adjustment factor for MAF sensor pulsation
FNWUEPUHFM	Switching threshold for the camshaft adjustment factor in MAF sensor pulsation
KFKHFM	Correction map for MAF sensor
KFPU	Pulsations map
KFPUKLP1	Pulsations map with active adjustment element 1
KFPUKLP12	Pulsations map with active adjustment elements 1 and 2
KFPUKLP2	Pulsations map with active adjustment element 2
MLHFM	Characteristic curve for linearization of MAF voltage
MLMIN	MAF sensor minimum air mass
MLOFS	Curve offset for the HFM5 sensor
PUKANS	Pulsations correction depending on intake air temperature
SY_LBK	System constant for the charge movement flap
SY_NWS	System constant for the camshaft control system: none, binary (on/off) or variable
SY_SU	System constant for alternative intake manifold
SY_TURBO	System constant for the turbocharger
Variable	**Definition**
ANZHFMA_W	Number of MAF sensor samples in a synchronisation
B_PUKLP1	Switching of pulsations map with active adjustment element 1
B_PUKLP2	Switching of pulsations map with active adjustment element 2
B_SU	Intake manifold condition
B_SU2	Intake manifold condition, 2. Flap
FKHFM	MAF sensor correction factor
FLB_W	Charge flow factor
FNWUE	Weighting factor for inlet valve camshaft overlap
FPUK	MAF sensor correction factor in pulsation range
MLHFMAS_W	Cumulative air mass in a synchronisation
MLHFMA_W	Air masses sampled by the MAF sensor (16-Bit)
MLHFMM_W	Average of sampled air masses (16 bit value)
MSHFMS_W	Air mass flow output value taking return flow into account (signed value)
MSHFM_W	Air mass flow output value (16-Bit)
NMOT	Engine speed
NMOTKOR	Engine speed intake air temperature correction (zur Pulsations correction)
PUANS	Pulsations correction depending on intake air temperature (T_{ans})
RL	Relative air charge
TANS	Intake air temperature
UHFM_W	MAF sensor voltage
WDKBA	Throttle plate angle relative to its lower end stop

KRDY 17.120 Function Description
See the *funktionsrahmen* for the following diagrams:

krdy-krdy	KRDY: Overview of Dynamic Knock Control
krdy-bb-dyn	BB_DYN: Detection of Load- and Engine Speed Dynamic, Enable Adaptation
krdy-dlast	DLAST: Determination of the Load Gradient
krdy-bb-dyna	BB_DYNA: Detection of Load- and Engine Speed Dynamic for Steady-State Adaptation
krdy-dyn-adap	DYN_ADAP: Adaptation of Dynamic Response Derivation

Function Description

Dynamic Load Response

The dynamic load response is characterized by two phenomena:

- Increased knock tendency (at the equivalent temperature)

- Rapid increase in noise level which are by the following measures:

- Additional ignition retard (dynamic response derivation wkrdy at B_krldya = 1)

- Faster tracking of the reference level and increased knock detection thresholds (at B_krldy = 1, see module KRKE)

Detection of the Dynamic Load Response and Enabling the Dynamic Response Adaptation (BB_DYN)

The load dynamic response is triggered by the positive load difference drlkrdy (load gradient, see DLAST).

If the difference between two successive samples (drlkrdy) during an acceleration of the load signal is greater than the 1st dynamic detection threshold KFDYES, the timer is set to the initial value zldy AZKRLDYN and bit B_krldyv = 1.

As soon as drlkrdy < KFDYES, zldy is decremented by 1 increment per cycle. When zldy = 0, B_krldyv is reset.

(For the set / reset with B_krldy, the procedure is basically the same but with AZKELDYN as a starting value for the counter zldyke.) As long as zldy > 0 and TMKR < tmot ≤ TMDYNA, only the condition B_krldyv = 1 applies. Additionally, when tmot > TMDYNA, the condition B_krldya = 1 applies and thus a dynamic derivative wkrdy is output. The down-regulation of wkrdy starts with resetting B_krldyv. If wkrdy is down-regulated to 0, B_krldya will also be reset. At idle (B_ll), no dynamics are detected (e.g. LLR).

Set- and Reset Conditions for the Dynamic Load Response Bits

See the *funktionsrahmen* for the diagrams

Determination of the Load Gradients drlkrdy (DLAST)

To determine the load gradient, a load signal generated by the charge detection (rl or drl) or a predicted load signal (drlp or rlp) is used. Bit 0 of the code word CWKR is used to switch between actual and predicted load signal.

The dynamic load response must be detected in a 10 ms time interval and triggered. The instantaneously available load signals are calculated in real time.

The applicable speed threshold NKRUM describes the bounding range in which the time interval is less than 10 ms. Below the speed threshold NKRUM, drlkrdy comes from the real-time delta load signals from the detected or predicted load (drl or drlp). Above NKRUM, drlkrdy comes from the difference between the load signals rl or rlp sampled at 10 ms intervals. Because of this switchover, oversampling of rlp and rl is avoided in the range below NKRUM.

Influence of the Dynamic Load Response on Knock Detection

During active load dynamics B_krldy, the following functions take effect:

1. The cylinder-selective reference level calculations are carried out with the label KRFTP3 (see module KRKE) → Faster tracking of the reference level.

2. The knock detection thresholds kew(i)w can be increased by a factor FKELDY. The result is corrected knock detection thresholds kek(i) (see module KRKE).

Influence of the Dynamic Load Response on Knock Control

3. For each detected knocking combustion, the ignition angle is retarded by the value KRFKN on a cylinder-specific basis (see module KRRA).

KRDY 17.120 (Dynamic Knock Control)

When steady-state knock control adaptation is enabled, the stored ignition angle retards are read from the current adaptation map range each time. In contrast however, write access to the stead-state adaptation map, is forbidden (see module KRRA).

As long as tmot ≤ TMDYNA, there is no additional dynamic retarding of the ignition angle!

Dynamic Load Adaptation (DYN_ADAP)

If dynamic load response is triggered when tmot > TMDYNA → B_krldya, the following functions additionally take effect:

4. Adaptive dynamic retarding of the ignition angle for all cylinders (modules KRDY and KRRA). In addition to the steady-state cylinder-selective knock control retarding, the ignition angle for all cylinders is retarded when dynamic response is detected for the time zldy > 0, to wkrdya(stkrnx) + KLDYMNT(evtmod) = starting value of wkrdy. If zldy = 0, this additional dynamic retardation wkrdy is reduced by one increment per DYAVF combustion events.

5.1 If dynamic load response is triggered without exceeding the second dynamic response threshold (KFDYES < drlkrdy < KFDYES + KFDYESOF ≥ B_krldya), then the retard adaptation (BB_DYN) is enabled for the initial value (wkrdy) of the dynamic response retarding. I.e. by heavy knocking B_kldystk, a new adaptation of wkrdya is performed for the next dynamic procedure (wkrdya (new) = wkrdya (old) + DYADS limited to DYADMX). In the case of purely normal knock (B_kldynrm), and also if no knock occurs (DYN_ADAP) the adaptation value remains unchanged.

5.2 If the second dynamic response threshold is also exceeded (drlkrdy > KFDYES + KFDYESOF ≥ B_krldya & B_krldyf), then in addition to the measures from 4 and 5.1, the adaptation of the dynamic response retarding is enabled to advance (BB_DYN).

During the active dynamic phase (B_krldyf = 1), two counters zzwdykr and zzwdymd are started. For each set bit B_zwkraa = 1 (i.e. the ignition angle from knock control is output) zzwdykr is incremented. For each bit not set B_zwkraa = 0 (i.e. the ignition angle from the torque interface was output) zzwdymd is incremented. At the end of the dynamic phase (B_krldyf = 0) the ratio is zzwdykr / (zzwdykr + zzwdymd) is determined; the two counters zzwdykr and zzwdymd are then reset to zero (DYN_ADAP).

If no knocking combustion occurs during the active dynamic phase (B_krldyf = 1), which is detected by the knock detection threshold kek (see module KRKE, B_kl), and zzwdykr / (zzwdykr + zzwdymd) ≥ PZWKRA (adjustable constant), then the initial value of the adaptive dynamic response derivation wkrdya is adjusted towards advance by 1 increment but is limited to the value DYAMNV.

The RAM area wkrdya is divided into 5 speed ranges stkrnx.

stkrnx =	0	1	2	3	4
wkrdya					
Speed sample points	KRAN1	KRAN2	KRAN3	KRAN4	

<---------+ ---------> nmot (rpm)

Hysteresis KRANH

The engine speed ranges are identical to those of the steady-state adaptation characteristic map (see module KRRA). The engine speed limits apply with increasing engine speed. The engine speed hysteresis KRANH is deducted only with decreasing speed (same as module KRRA).

The dynamic response derivation is recalculated for each write to the RAM area wkrdya and then into the engine speed range which is valid at the time of triggering of the dynamic response trigger point (! B_krldya → B_krldya). It is then available as wkrdy for the next dynamic procedure which starts in this engine speed range.

When the ignition is turned off, all retardings are stored in the RAM area wkrdya until the engine is restarted.

After a ‘power cut’ of the RAM area, DYAMNV is initialized with wkrdya.

Engine Speed Dynamic Response

If the engine temperature tmot > TMKR and the engine speed gradient ngas w are larger than the engine speed dynamic response detection threshold DNKRDYSN then the timer zndy is set to the initial value AZKRNDYN.

If ngas_w < DNKRDYSN, zndy is decremented up to zero for each ignition event in cylinder 1. The condition B krndy=1 applies until zndy > 0.

As long as B krndy = 1 the following applies:

1. The cylinder-selective reference level calculations are performed with the label KRFTP2 (see module KRKE) → faster tracking of the reference level.

2. The knock detection thresholds ke(i)w are increased by the factor FKENDY. Corrected knock detection thresholds kek(i) result (see module KRKE).

3. For each detected knocking combustion, the ignition angle is retarded by the value KRFKN cylinder-selectively (see module KRRA).

When steady-state adaptation is enabled, the stored retardings are read from the current adaptation map range each time in case of range changes. Write access to the characteristic map of the steady-state adaptation is, however, forbidden (see module KRRA).

The triggering of the dynamic load response may also take place during active engine speed dynamic response and vice versa. It is decided in modules KRKE and KRRA respectively which of the introduced measures takes priority.

Application Notes

The application aim of dynamic load response is adjustment that optimizes performance with no audible “dynamic knocking” in the vehicle.

The adjustment should be performed under "worst-case conditions" (summer temperatures and fuel with lowest enabled octane number).

The following values taken from experience can be used for a rough adjustment:

TMKR approx. 40°C

TMDYNA approx. 80°C

AZKELDYN should be chosen so that error labels via the load-dependent noise recording are avoided

AZKRLDYN should be chosen in such a way that the dynamic condition approx. 300-600 ms applies.

Guidance values are: 2-5 working cycles (AS) at 1000 rpm and 15-25 working cycles at 6000 rpm.

DYADMX approx. -8 ... -10 degrees crankshaft (°KW)

FKELDYA 1.2 - 1.3

DYAVF should be chosen such that during each working cycle adjustment to advance is performed by approx. 4 increments at most (so DYAVF must be equal to or exceed no. of cylinders / 4, DYAVF is an integer and DYAVF > 0 is demanded!)

The greater the DYAVF then the smaller the down-regulation of speed will be

CWKR bit 0 = 1 as long as load prediction is not available or not stable

NKRUM = 4000 rpm for SY_ZYLZA = 3

NKRUM = 3000 rpm for SY_ZYLZA = 4

NKRUM = 2400 rpm for SY_ZYLZA = 5

NKRUM = 2000 rpm for SY_ZYLZA = 6

NKRUM = 1500 rpm for SY_ZYLZA = 8

NKRUM = 1200 rpm for SY_ZYLZA = 10

NKRUM = 1000 rpm for SY_ZYLZA = 12

The application aim of engine speed dynamic response is avoiding misdetections due to a very fast increase in engine speed resulting in abrupt noise increase (especially critical: gear shifting on powerful vehicles with automatic gearbox)

NGKRWN approx. 500 - 1000 rpm/s;

AZKRNDYN should be chosen such that the dynamic response condition approx. 300-600 ms applies.

Guidance values are: 2-5 working cycles at 1000 rpm and 15-25 working cycles at 6000 rpm.

Abbreviations

AZKELDYN	Ignition per cylinder for load dynamics → knock detection
AZKRLDYN	Number of ignition per cylinder during knock control load dynamic

AZKRNDYN	Number of ignition for knock control engine speed dynamic
CWKR	Code word for knock control
CWTIPIN	Codeword for tip-in function
DRLKRAN	Detection threshold dynamic load response for steady-state adaptation
DYADMXN	Maximum value of dynamic response derivation
DYADS	Additive retarding per cycle through adaptation dynamics
DYAFVS	Advance step for deactivation of dynamic response
DYAMNV	Minimum value of dynamic response derivation
DYAVF	Deactivation period for dynamics retardation
DZWTIN	Delta ignition angle at tip-in
FKELDYA	Correction factor for knock detection threshold for adaptation of load dynamics
KFDYES	Threshold for dynamic presetting values
KFDYMNT	Pilot-controlled dynamic derivation
KFDYRS	Dynamic derivation detection threshold
KFDYRSOF	Offset threshold for dynamic presetting values
NGKRAWN	Speed gradient threshold for dynamic detection KRRA
NGKRWN	Speed gradient threshold for dynamic detection
NKRUM	Revolution threshold for change of delta load signal for load dynamics
PZWKRA	Percentage frequency of ignition angle output by knock control during dynamic adaptation
TMDYNA	Engine temperature threshold to enable load dynamic adaptation
ZDRLKRA	Time constant for low-pass load gradient in knock control
ZNGKRA	Time constant for low-pass engine speed gradient
Variable	**Description**
B_DRLKRDY	Flag for n > NKRUM
B_KL	Condition: knock detected
B_KLDYNRM	Condition: normal knocking with adapted load dynamic
B_KLDYSTK	Condition: heavy knocking with adapted load dynamic
B_KRDWS	Condition: knock control safety ignition retarding
B_KRLDY	Condition: load dynamics for knock detection active
B_KRLDYA	Condition: load dynamics retard and dynamics adaptation active
B_KRLDYF	Condition: adaptation load dynamics retard towards advance enabled
B_KRLDYN	Condition: load dynamic for steady-state adaptation active
B_KRLDYV	Condition: threshold for additional load dynamics retard exceeded
B_KRNDY	Condition: speed dynamics for knock detection active
B_KRNDYN	Condition: engine speed dynamics for steady-state adaptation active
B_KUPPL	EGAS Condition: clutch is disengaged
B_LL	Condition: idle
B_MF	Condition: measurement window
B_TIPIN	Condition: tip-in detected
B_TMKR	Condition: engine temperature (tmot) for knock control reached
B_VNULL	Condition: vehicle at standstill
B_ZWKRAA	Condition: ignition angle is output from knock control
C_PWF	ECU condition: Power fail-initializing
DRLKRAV	Actual value of DRLKRAN
DRLKRDY	Load gradient for activating knock control load dynamics
DRLKRRA	Load gradient for selecting steady-state adaptation
DRLP_W	Delta predicted load for injection time calculation (word)
DRL_W	Charge change (Word)
DYESV	Current value of load dynamic response detection threshold
DYMNTV	Minimum additive dynamic derivation of KL
DYRSOFV	Actual value of the offset for load dynamics detection threshold
DYRSV	Actual value of the load dynamics detection threshold
EVTMOD	Modelled inlet valve temperature (temperature model)
GANGI	Engaged gear
KEK	Knock detection threshold corrected
LKRNEW	Value of load at time t

LKROLD	Value of load at time t-dt
NGAS_W	Engine speed gradient during one working cycle
NGKRAF_W	Instantaneous value of threshold speed dynamics
NGKRAV_W	Actual value of the engine speed dynamic threshold
NGKRV_W	Actual value of the engine speed dynamic threshold
NMOT	Engine speed
RL	Relative cylinder charge
RLP_W	Relative cylinder charge predicted for injection calculation (Word)
RL_W	Relative air charge (Word)
R_T10	10 ms time frame
R_T100	100 ms time frame
STKRNX	Speed range adaption map knock control
STUETZ	Engine speed adaptation range during triggering of the load dynamic
TMOT	Engine temperature
VIRKR	Ratio: integrator/ reference level knock control
WKRDY	Ignition retard during dynamic-function of knock control
WKRDYA	Adapted ignition timing for dynamic knock control
ZALDY	Ignition counter for deactivation of load dynamics
ZLDY	Ignition counter for load dynamic
ZLDYKE	Ignition counter for load dynamics → knock detection
ZNDY	Ignition counter for rpm-dynamics
ZZWDYKR	Ignition counter for knock control with bit B_zwkra = 1 set during dynamic knock control
ZZWDYMD	Ignition counter for knock control with bit B.zwkra = 0 not set during dynamic knock control
ZZYLKR	cylinder counter Knock Control

KRRA 15.130 (Knock Control with Adaptation for Individual Cylinder Retardation)

See the *funktionsrahmen* for the following diagrams:

krra-main	KRRA: knock control including steady state adaptation
krra-bbkrra	BBKRRA: release of knock control and adaptation
krra-bbkr	BBKR: release of knock control and adaptation
krra-bb-krdws	BB-KRDWS: condition for safety retard of ignition
krra-bb-lzf	BB-LZF: release of leading cylinder function
krra-lzist	LZIST: determination of led and leading cylinders
krra-uewkr	UEWKR: overwrite ignition retard of led cylinders
krra-wkral	WKRAL: Update of the cylinder selective ignition retard at adaptation area change (wkra --> wkr)
krra-wkrber	WKRBER: Calculation of ignition retard
krra-krvf	FRUEHVERST: Release of ignition advance adjustment
krra-wkri	WKRI: calculation of the average ignition retard
krra-begwkr	BEGWKR: limitation of ignition retard after reading adaptation map
krra-stkra	STKRA: Detection of load- and speed range
krra-kr-adap	KR_ADAP: Adaptation of ignition retard
krra-vswkr	VSWKR: Ignition adjustment with VS2x
krra-kr-freeze	KR-FREEZE: calculation of ignition retard for frozen knock control
krra-initialise	Initialise function

Note: The cylinder-specific variables wkr, dwkrz, wkra and zkrvf are indicated in the following description through a control variable (i) like in the ECU code, for example wkr(i). The corresponding RAM-cell which can be read via VS100 is marked by _i, for example: wkr_i.
The Knock Control cylinder counter zzylkr serves as control variable (except wkra). The following applies to it:

zzylkr = 1 ... SY_ZYLZA	ASCET-Model
zzylkr = 0 ... SY_ZYLZA-1	ECU-Code

See also the Application Notes section in this module.

KRRA 15.130 Function Description

Function of Knock Control

The KRRA module includes calculation of the cylinder-specific change of ignition angle of the knock control and adaptive calculation of the cylinder-specific retarding wkr(i) (WKRBER) with storage in an adaptation characteristic map wkra(i) (KR ADAP). The input values of the adaptation map are current cylinder number, engine speed and load (STKRA).

The value of the retarding dwkrz(i) which is passed on to the ignition comes to dependent on the operating condition (BBKC):

1. B_kr & !B_krdws & !B_llr	dwkrz(i) = wkr(i)
2. B_kr & B_krdws	dwkrz(i) = krdwsw KRDWS – Safety retarding see modules DKRS, DKRNT and DKRTP
3. B_kr & !B_krdws & B_llr	dwkrz(i) = wkrm wkrm – average retard over all cylinders
4. !B_kr & (!)B_krdws	dwkrz(i) = 0

Condition for active Knock Control without exhaust gas recirculation B_kr: ((rl > LKRN) v B_krldy) & (tmot > TMKR) & B_stend & (nmot > NKRF)

Condition for active Knock Control with exhaust gas recirculation B_kr: ((rl > LKRAGRN) v B_krldy) & (tmot > TMKR) & B_stend & (nmot > NKRF)

Condition for active adaptation: B_kra: B_kr & (tmot > TMKRA)

The lower speed threshold NKRF should prevent the engine stalling at low speed by Knock Control-Ignition Angle-intervention.

Co-ordination of the Ignition Angle for Torque Management

When knock control is active, the earliest cylinder-specific ignition angle results:

KFZW + dwkrz(i) + wkrdy (wkrdy is derived dynamically from module KRDY, included in module ZUE)

There are two types of control action:

1. Output ignition angle = KFZW + dwkrz(i) + wkrdy → B_zwkraa = 1 → knock control algorithm remains unchanged

2. Output ignition angle < KFZW + dwkrz(i) + wkrdy → B_zwkraa = 0 → advancing algorithm of wkr(i) is frozen and knock control adaptation is disabled (due to exhaust gas reasons, Stability Program operation, idle control, etc.)

In module ZUE the bit B zwkra is formed synchronously to the ignition angle output and it is then stored in the corresponding position in bit array zwkrafld. E.g. B_zwkraa is then determined from zwkrafld as follows:

SW cylinder counter

(zzylkr)	5	4	3	2	1	0	
B_zwkra	1	1	0	1	0	0	zwkrafld = $2^5 + 2^4 + 2^2 = 52$

B_zwkraa (zzylkr = 3) = 0 (= false)

Please note: Signs of the ignition angle (in degrees crankshaft (°KW)) according to mathematical convention.

KFZW > 0 (with TDC as the point of reference, ignition "before" DTC means mathematically positive angles KFZW)

dwkrz(i) ≤ 0 ("retard" timing with regard to the basis ignition angle means mathematically negative dwkrz(i))

Retarding of the ignition angle without adaptation (WKRBER)

If B_kr and !B_kra are set the knock control operates as follows:

If a knocking combustion (B_kl) is detected in module KRKE then the ignition angle of the corresponding cylinder i is adjusted by retarding it by an amount KRFKN per knock event. If the engine is in the Knock Control-steady-state operation, it is adjusted by retarding it by an amount KRFKLN per knock event. This cylinder-individual retarding is added independently of load and engine speed in the RAM-area wkr(i).

For engine smoothness reasons and in order to avoid spurious misfire detections, the retarding is limited in each calculation to a range around the mean value wkrm of the latest given SY_ZYLZA retardings wkr(i), given by wkrm plus/minus a freely selectable threshold.

This threshold DWKRMSN is a characteristic line over the engine speed.

Additionally the retarding is limited in wkr(i) towards retard to KRMXN and towards advance to 0° crank.

wkr is a RAM-area in which a RAM-cell is reserved for each cylinder.

If the “Knock Control active” operating range of the engine is left (!B kr) then the latest present retarding remains stored in wkr(i) until the “Knock Control active” range is entered again. The same applies for wkrm.

In the “Knock Control not-active” range of the engine zero is passed on to module ZUE as adjustment value dwkrz(i).

If the ignition is switched off, the retardings in wkr(i) are set equal to zero.

Advancing of the ignition angle (WKRBER & FRUEHVERST)

The retardings from wkr(i) are cancelled on a cylinder-specific basis if B_kr is set and if the cylinder-specific advancing counter zkrvf(i) has reached zero.

During each knock event B_kl, the cylinder-specific counter zkrvf(i) is populated with the value KRVFN. Each non-knocking combustion in cylinder i for which in addition B zwkraa = 1 applies (i.e. the given ignition angle was limited by Knock Control) decrements zkrvf(i) by 1. When zkrvf(i) = 0 is reached, the retarding in wkr(i) assigned to the corresponding cylinder is decremented by one quantization step and the counter is again populated with KRVFN.

During each timing towards advance, the wkr(i) are limited to the average value wkrm of the latest given retarding SY_ZYLZA minus a freely selectable threshold DWKRMSN or to the value zero.

If the “Knock Control active” operating range of the engine is left (!B_kr) the latest available counter values remain stored in zkrvf(i) until the “Knock Control active” range is entered again.

If the ignition is switched off, the counter values in zkrvf(i) are set equal to zero.

If changed engine operating conditions result in a reduced tendency to knock, a quicker advancing of the wkr(i) is performed until the first knock event occurs after the beginning of this quick advancing. In this case, the counters zkrvf(i) are started when KRVFSN < KRVFN. The condition for the start of the quick advancing is either the transition from reading adaptation values wkra(i) to wkr(i) or the termination of a dynamic phase or a negative load range shift.

There should be no quick advance during dynamic operation (B_krldya / B_krndy = 1).

KRRA 15.130 (Knock Control with Adaptation for Individual Cylinder Retardation)

Knock Control Steady-State Mode

In Knock Control steady-state mode, the ignition angle per knock event is retarded by the value KRFKLN or KRFKN. So that the knock frequency at different retards is not too high, the Knock Control steady-state mode advance adjustment speed adjusted by KRLVFKN.

The Knock Control steady-state operation is indicated by B_krstatb. This bit is set if |drl| < DRLKRSTMX and |ngfil| < NGKRSTMX for TVKRSTAT seconds.

Retarding of the ignition angle with adaptation (KR ADAP)

B_kra = B_kr & (tmot > TMKRA) $\rightarrow$ Adaptation active

B_krafrz = B_kra & ((rl < lkraw) || (tmot < TMKRAS) || (nmot < NKRAMIN) || (nmot > NKRAMX) || B_asr || B_nmax || B_vmax) $\rightarrow$ Learning the adaptation values is prohibited

The adaptation ensures that also for strongly map-dependent varying retardings the knock frequency does not increase in case of quick changes of the map ranges. For this purpose, when adaptation is active, the current retards under certain conditions are written in a load-speed-dependent adaptation map (see Storage) or overwritten with the values stored in the map (see Read). Read access to the adaptation map is only enabled when the engine temperature is stable and when there is a significant knock control demand (i.e. TMKRA $\geq$ TMKR), whereas the knock control must be activated even at low knock control demands (worst case conditions). Write accesses to the adaptation map are enabled until the second temperature threshold (TMKRAS $\geq$ TMKRA) and the second load threshold (LKRAN $\geq$ LKRN) are exceeded. This prevents, on the one hand, spurious adaptation due to retardings during warm-up and on the other hand, a learning of the adaptation value to 0 at lower loads.

A RAM cell is reserved in the adaptation map wkra for each load- and speed range per cylinder. The load and speed limits are removed for administration labels (KRAL1-3N or KRAN1-4). The values stored there will be used as the limiting values in case of increasing load or speed.

In case of decreasing load or engine speed, an adjustable hysteresis (KRALH, KRANH) is subtracted from these values.

The current load range is stored in stkrlx, the speed range in stkrnx.

When the ignition is switched off all values remain stored in wkra. If the supply voltage of the ECU is disconnected the values are lost. After the supply voltage of the ECU has been reconnected all values are set to 0.

DIAGRAM

For the indexing of the wkra(i) - RAM-cells the following specification is used in the SW:

i = zzylkr + (8 $\times$ stkrnx) + (40 $\times$ stkrlx zzylkr) = 0...7, so at the maximum, 8 cylinders can be represented

stkrnx = 0...4, 5 engine speed ranges

stkrlx = 0...3, 4 load ranges (value of 0 is notwithstanding the ASCET-Model!)

The wkra of the current adaptation range can be obtained from the RAM cells wkraa_i, i = 0 ... SY_ZYLZA-1.

Adaptation - Learning Conditions:

The following conditions update the adaptation map:

1. During each knock event, the ignition angle retard wkr of the cylinder in which the knock event occurred, is increased by an offset KRDWKLA then stored in the current load-speed range of the adaptation map when this sum (wkr + KRDWKLA) is later than the value stored in wkra.

2. If the current retard wkr(i) is at least KRDWA earlier than the last value stored in the adaptation map and advance adjustment counter zkrvf (i) = 0, the ignition angle retard is changed to KRDWSA towards advance in the adaptation map.

3. If the current retard wkr(i) = 0 and the advance adjustment counter zkrvf (i) = 0, wkra (i) is changed by KRDWSA towards advance.

The adaptation of the characteristic map is only performed during steady-state operation and during not active safety retarding (B krdws=0). When idle control is active, the steady-state adaptation is also blocked, because the control is via the average wkrm retardation.

In order to avoid the unjustified adaptation of large amounts of retardation, further writing to the adaptation map (combined into B_krafrz) is prohibited under the following conditions:

- tmot < TMKRAS error identifiers due to extraneous noise during warm-up
- nmot > NKRAMAX error identifiers due to extraneous noise from the dump valve
- nmot < NKRAMIN error identifiers due to extraneous noise from the drivetrain
- B_asr = 1 transient engine conditions via fast ignition angle-intervention, possibly error identifiers
- B_nmax = 1 ditto
- B_vmax = 1 ditto

Writing is also prohibited when

- rl < LKRAN

Adaptation – Read Conditions

During active adaptation the retarding of all cylinders wkr(i) is overwritten by the values from wkra(i) if one of the following conditions is fulfilled:

1. Transition from !B_kra to B_kra
2. Load range changes with dynamic response (B_krl/ndyn = 1)
3. Engine speed changes with dynamic response (B_krl/ndyn = 1)
4. Entering or exiting idle control

During overwriting of wkr(i) with wkra(i), ignition angle jumps towards advance can happen (e.g. adaptation has not yet settled in all adaptation ranges) which may give rise to undesirable results (judder, knock). For this reason, early ignition angle changes will be limited via overwriting KRDWAA. KRDWAA = 0 means that ignition angle jumps towards advance will be prevented. KRDWAA = KRMXN means that ignition angle jumps towards advance within the scope of the maximum Knock Control range are permitted.

Knock Control in the case of Active Dynamic Response (KRRA, KR_ADAP, BBKR)

In case of active dynamic response (B_krldy, B_krldya, B_krndy, see module KRDY) the further adaptation of the steady-state values wkra(i) is blocked. A change of the adaptation ranges leads to an updating of wkr(i) with the values adjusted in wkra(i).

Each knocking combustion (B_kl), like so far, leads to a retarding by KRFKN and is therefore added to the cylinder-individual retarding in wkr(i).

In addition to B_krldya, an adaptive dynamic derivative action wkrdy (see module KRDY) is added. For the fastest possible inclusion of this derivative action for dynamic response detection, an auxiliary bit B_wkrdyw set in module KRDY triggers the corresponding updating of all dwkrz_i included in wkrdy in the next KR-time frame. This algorithm is not shown in the ASCET images.

Knock Control during Active Idle Control (KRRA)

When idle control is active (B_llr = 1) cylinder-specific knock detection and control of the retardings wkr(i) still occurs. However, at ignition, the average retard wkrm is output (dwkrz(i) = wkrm for all i).

In this way, additional idle disturbance via Knock Control-ignition angle intervention is avoided. During activation or deactivation of idle control respectively, the adaptation map is read.

Knock Control Above NKRMAX (BBKR, WKRBER)

Errors can frequently occur at high speeds due to noise (e.g. valve lift). Therefore, in order to avoid unduly large amounts of retarding, there is a speed threshold, NKRMAX, above which the de facto knock control is disabled! Instead, wkr(i) is permanently overwritten with the adapted values of the current adaptation range wkra(i) + an offset. This offset (krfkw - KRDWKLA) is implemented so that a margin from krfkw to the knock limit in this adaptation range is maintained. However, the prerequisites for this are a nearly constant knock limit within the respective adaptation areas and the presence of a current adaptation value.

Please apply this function with the utmost care!

Optional Leading Cylinder (LZ)

The leading cylinder function is enabled:

- On exceeding a cylinder-specific speed threshold KRNLZ[i], above which the cylinder has poor knock detection, this cylinder is led by the cylinder with a good knock detection.

- For systems with two knock sensors, if an error has been detected for the knock sensors. (The one knock sensor associated cylinder are hereafter referred to as a group.) The cylinders of the group concerned are then led by the cylinders of the group having a good working knock sensor. On exceeding KRNLZ [i], the safety retardation will be activated for all of the cylinders. This mitigation measure will be turned off via the codeword CWKRNLR. If an error is detected, a sensor immediately activates the security retardation.

Leading Cylinder Function when Engine Speed > KRNLZ, Without Knock Sensor Error

The corresponding leading and led cylinders are selected via the elements LZFUER_0 to _k (k = SY_ZYLZA - 1), of the blocks of constants LZFUER. The leading cylinder (LZ) is indicated by set bits in the bytes to LZFUER_0 _k.

The elements i = 0 to k of the constants LZFUER are selected via the cylinder block counter zzylkr in Knock Control, i.e. LZFUER_i belongs to zzylkr = i the cylinder counter counts the combustion within an AS. The connection between zzylkr and physical cylinder is given by the firing sequence. Accordingly, the bits 0-7 of LZFUER_i refer to zzylkr indexed combustion.

During activation of the lead cylinder function in this case, the contents of LZFUER is copied into the RAM-array LZIST (loop from i = 0 ... SY_ZYLZA-1 on a 100 ms time frame). Thus LZIST will contain the most current association between leading and led cylinders.

For example:

6 cylinder engine with firing sequence zzylkr = 0 1 2 3 4 5

Physical cylinders: 1 4 3 6 2 5

Block of constants LZFUER

Led cyl. Bit 7 6 5 4 3 2 1 0 <-- (leading cylinder)

LZFUER_0 0 0 0 0 0 0 0 0 --> 00 --> physical cylinder 1 will not be led, i.e. separate knock detection

LZFUER_1 0 0 0 0 1 0 0 0 --> 08 --> physical cylinder 4 will be led by cylinder 6

LZFUER_2 0 0 0 0 1 0 0 1 --> 09 --> physical cylinder 3 will be led by phys. cylinder 6 or 1 (late selection)

LZFUER_3 0 0 0 0 0 0 0 0 --> 00 --> physical cylinder 6 will not be led, i.e. separate knock detection

LZFUER_4 0 0 0 0 1 0 0 0 --> 08 --> physical cylinder 2 will be led by cylinder 6

LZFUER_5 0 0 0 0 1 0 0 0 --> 08 --> physical cylinder 5 will be led by cylinder 6

A led cylinder may not be defined as a lead cylinder for itself, i.e. the bit i in LZFUER_i must be "0".

In the lead cylinder function, the following active measures are taken:

1. The knock detection will continue unchanged.

2. The knock control and adaptation of the leading cylinder continues unchanged.

3. For a led cylinder i, the retardation of the latest i assigned to leading cylinders j plus a cylinder-specific offset WKRLZOF_i is used as a late adjustment: wkr_i is overwritten in the background program with wkr_j + WKRLZOF_i. The adaptation continues unchanged. The adapted (and possibly incorrect) values for led cylinders arising because of 6 are not output.

If the code word CWKRLZFK = 1, the retard for the led cylinder is determined according to the following minimum selection:

wkr_i = MIN (wkr_i, wkr_j) + WKRLZOF_i

4. Detected knock for the led cylinders has no effect: the retardation per knock is set to zero for the cylinder.

If the code word CWKRLZFK = 1, wkr_i will be retarded according to krfkw in the led cylinders and also the cylinders in which knock is detected, regardless of the leading cylinder function.

5. An independent advance for led cylinder is suppressed: the step width of the counter zkrvf_i for the led cylinder i is set continuously in the background program KRVFN.

If the code word CWKRLZFK = 1, the step width counter zkrvf_i is not overwritten for the led cylinder i. Thus, an advance of wkr_i independent of the leading cylinder is possible. But because this results in an earlier ignition angle than with the leading cylinder, wkr_i will be overwritten with the ignition angle-adjustment of the leading cylinder. Thus, the earliest possible ignition angle for the led cylinder is given by the leading cylinder’s ignition angle + offset.

6. When reading from the adaptation maps, ignition angle changes towards advance are limited to 0° crank angle, rather than KRDWAA.

Leading Cylinder Function With Knock Sensor Error and Engine Speed < KRNLZ

If the knock sensor in group 2 is off (B_kseb2 = 1), then the cylinder of group 2 is led by group 1 according to the measures described in points 1 to 6 above. Instead of the individual cylinder offsets WKRLZOF_i, a global offset, WKRLZOFEKS is applied to the led cylinder. In this case, the content of LZB1 is copied into the RAM array LZIST (see above).

If the knock sensor in group 1 from (B_kseb1 = 1), then the cylinder of group 1 is led by group 2 according to the measures described in points 1 to 6 above. Instead of the individual cylinder offsets WKRLZOF_i, a global offset, WKRLZOFEKS is applied to the led cylinder. In this case, the content of LZB2 is copied into the RAM array LZIST (see above).

If both knock sensors are off (B_kseb1 = 1 & B_kseb2 = 1), the safety retardation is activated (B_krdws = 1).

Through the elements LZBi_0 to LZBi_k (k = SY_ZYLZA - 1) of the constant blocks LZBi (i = 1,2) the corresponding leading and led cylinders are selected. The leading cylinder (LZ) is indicated by set bits in the bytes LZBi_0 to LZBi_k.

The elements n = 0 to k of the constant block are selected by the cylinder counter zzylkr in the Knock Control function, i.e. LZBi_n is zzylkr = n. The cylinder counter counts the firing within an AS. The connection between zzylkr and the physical cylinder is given by the firing sequence. Accordingly, the bits 0-7 of LZBi_n refer to zzylkr by indexed combustion.

For example:

6 cylinder engine with firing sequence zzylkr = 0 1 2 3 4 5

Physical cylinders: 1 4 3 6 2 5

Constant block LZB1

Led cyl. Bit 7 6 5 4 3 2 1 0 <-- leading cylinder

LZB1_0 0 0 0 0 0 0 0 0 = 0

LZB1_1 0 0 0 1 0 1 0 1 = 21 --> physical cylinder 4 is led by the cylinders of group 1

LZB1_2 0 0 0 0 0 0 0 0 = 0

LZB1_3 0 0 0 1 0 1 0 1 = 21 --> physical cylinder 6 is led by the cylinders of group 1

LZB1_4 0 0 0 0 0 0 0 0 = 0

LZB1_5 0 0 0 1 0 1 0 1 = 21 --> physical cylinder 5 is led by the cylinders of group 1

Constant block LZB2

Led cyl. Bit 7 6 5 4 3 2 1 0 <-- leading cylinder

LZB2_0 0 0 1 0 1 0 1 0 = 42 --> physical cylinder 1 is led by the cylinders of group 2

LZB2_1 0 0 0 0 0 0 0 0 = 0

LZB2_2 0 0 1 0 1 0 1 0 = 42 --> physical cylinder 3 is led by the cylinders of group 2

LZB2_3 0 0 0 0 0 0 0 0 = 0

LZB2_4 0 0 1 0 1 0 1 0 = 42 --> physical cylinder is led by the cylinders of group 2

LZB2_5 0 0 0 0 0 0 0 0 = 0

A led cylinder may not be defined as a lead cylinder for itself, i.e. the bit i in LZBi_n must be "0".

Safety Retardation During Active Knock Control (KRRA)

The knock control system hardware (sensors and signal processing IC CC195) is continuously monitored using the diagnostic functions DKRNT, DKRTP and DKRS. When errors are detected, the corresponding error flags E_ * are set, resulting in setting B_krdws to trigger the safety retardation. Resetting of B_krdws after detection of error healing and hence the withdrawal of the safety retardation may only happen with "knock control not active" (to prevent torque jumps).

Other system errors that lead to triggering of the safety retardation are:

- Lack of synchronization (B_synph = 0)

For systems with two or more knock sensors (KSZA > 1), in the absence of general synchronization safety retardation will be switched on.

For systems with only one knock sensor (KSZA = 1) and without active leading cylinder function, knock detection in the absence of synchronization will be performed with the most sensitive knock detection threshold (B_krnl = 1 --> emergency knock detection – see also module KRKE), the knock control system continues unchanged.

The operation of the leading cylinder function sets the synchronization of the system (B_synph = 1) mandatory in advance. It follows that in absence of synchronization and active leading cylinder function in safety retardation (B_krdws = 1) it must be switched, regardless of how many knock sensors the system has.

In the absence of synchronization, an emergency operation of the engine by using dual ignition per SW (mirroring the ignition --> half firing interval) can occur. In the case of an odd number of cylinders, the required sychronisation between the Knock Control measurement windows and combustion is no longer necessarily given. It must, even for systems with a knock sensor, be switched to safety retardation. A value of > 1 is therefore input to KSZA.

- Emergency tachometer (B_nldg = 1)

During speed-sensor emergency operation, the measurement window cannot be output with the required accuracy. Therefore security retardation is activated. To prevent unnecessary setting of safety flags B_krdws after an ECU reset, the setting of c_inisyn is blocked for 3 seconds. If the Knock Control safety flag, B krdws, is set (see modules DKRS, DKRNT and DKRTP), dwkrz(i) and wkrma are overwritten by KRDWS if the knock control is active.

wkra(i), wkr(i) and wkrm are not updated as long as B krdws is set.

If B krdws is again reset dwkrz(i) is overwritten by wkr(i), wkrma by wkrm.

Application Notes

Cylinder-specific and load/engine speed range-dependent values are marked by (i) in the description corresponding to their realization in the ECU-code, e.g. wkr(i). The corresponding RAM-cell which can be read via VS100 is indicated in the ASCET-image by i, e.g. wkr i.

The cylinder counter zzylkr generated in module GGKS serves as control variable for the index i of the cylinder-individual RAM-cells (wkr(i), dwkrz(i), zkrvf(i), with the exception of wkra(i), see above).

Knock Control can be switched off via the label TMKR: TMKR > tmot --> !B_kr

For the application the following typical values are suggested:

KRFKN -3 °crank is a value for the retarding of the ignition angle. Experience shows that it is a sufficient value to safely run the engine at the knock limit with stabilized adaptation.

KRMXN -12 °crank is a value which is sufficient for most applications. When fixing this characteristic line it must be noted though that the engine can be operated absolutely knock-free with the programmed value under worst-case conditions (i.e. engine speed, ambient temperature and fuel with lowest octane number).

In the process attention must be paid to the maximum permitted exhaust gas temperature.

KRVFN approx. 4 sec/°KW advancing is a typical value. The control speed of Knock Control during quasi-steady-state engine running results from this characteristic line in connection with KRFKN. The aim here is to determine a time constant which is larger than the thermal time constant of the engine so as to avoid a thermal strain.

When adjusting KRVFN it must be taken into consideration that the thermal strain of the engine increases with increasing engine speed so that a larger period should be chosen for higher engine speeds.

KRVFN = 1 Inc. * n / (120 * x) with 1 Inc. in °KW

n in rpm

x in °KW/sec - "speed" for the advance adjustment

KRVFSN to be adjusted dependent of KRDWKLA in order to enable a quick advancing of the adaptation map values in case of changed operating conditions without provoking an increased knock frequency.

KRDWKLA = -3 °KW: approx. 1 sec/°KW advancing or approx. 1/4 × KRVFN

KRDWKLA = 0 °KW: approx. 2 sec/°KW advancing or approx. 1/2 × KRVFN

TMKR approx. 40°C is the value during which on many engines knocking combustions can already occur.

TMKRA: Below an engine temperature threshold TMKRA it is not useful to update wkra since experience has shown that within this operating range the knock tendency of the engine is very low. If adaptation would be permitted the necessary values learned in the normal operating range would be lost which means that the knock frequency is again increased when this operating range is reached again.

Usually this engine temperature threshold lies at TMKRA = 80°C.

LKRN approx. 30% rl is a typical value. The lowest load threshold during which knocking combustions can occur is stored in this characteristic line.

LKRAN can be parameterized with values > LKRN, so the adaptation will only happen when there is a significant Knock Control demand; LKRAN is ineffective when parameterized with values <= LKRN.

KRDWKLA 0 °KW <= |KRDWKLA| <= |KRFKN|

KRDWA |KRDWA| >= |KRDWKLA|

KRDWSA 0 °KW < |KRDWSA| und |KRDWSA| <= |KRDWA| - |KRDWKLA|

The following sets of parameters can be recommended:

KRDWKLA/°KW	KRDWA/°KW	KRDWSA/°KW	
0	2.25	2.25	=> Adaptation up to the knock limit
-1.5	3.0	1.5	=> Adaptation up to the knock limit + a safety margin of 1.5 °crank
-3.0	4.5	1.5	=> Adaptation up to the knock limit + a safety margin of 3 °crank

KRWKRAIN = 0 °crank ... KRMXN, when interpretation of the ignition angle-KF close to the knock limit a value < 0 °crank is recommended

KRDWAA = 0; ignition angle jumps towards advance via reading of the adaptation values are prevented

= min(KRMXN); ignition angle jumps towards advance are permitted within the scope of the maximum knock control range

0 > KRDWAA > min(KRMXN) ignition angle jumps towards advance are limited to KRDWAA

DWKRMSN approx. -3 °KW is a typical value to maintain the engine smoothness and to avoid misfire misdetection; if the values get smaller the cylinder-individual character of the knock control is increasingly lost.

KRDWSN around -12 °crank, knock must be avoided under worst case conditions

KRALH in order to avoid a judder at the range limits, a hysteresis was introduced for decreasing load.

Typical value for KRALH = 3%.

KRANH in order to avoid a judder at the range limits, a hysteresis was introduced for decreasing engine speed.

Typical value for KRANH = 120 rpm.

NKRAMIN equal to the speed, up to which error flags by mechanical noise and vibration arise from the drive train. If the function is not required then set NKRAMIN = 0

NKRAMAX equal to the speed above which there can be error flags (e.g., valve lift) which particularly applies when NKRAMAX > KRAN4 so actually in the upper speed range, values can be adapted, otherwise there is considerable risk of freezing the Knock Control by overwriting with NKRMAX. If the function is not required then set NKRAMAX to the maximum value.

NKRMAX equal to the speed above which there can be error flags (e.g., valve lift) which particularly applies when NKRMAX > KRAN4 and NKRMAX >= NKRAMAX so actually in the upper speed range, values can be adapted, otherwise there is considerable risk of freezing the Knock Control by overwriting with NKRMAX. If the function is not required then set NKRMAX to the maximum value.

CWKRNLR = 1 additional mitigation measure for systems with two knock sensors with knock sensor error is active. CWKRNLR = 0 ... is not active.

Particular attention when determining the ignition angle maps requires knowledge of the area in which an enrichment function (lambda <1) is active since the knock limit will shift because of the enrichment.

To ensure the stabilty of Knock Control is not jeopardized, the ignition angle structure and the enrichment function must be adjusted so that a uniform margin to the knock limit is maintained (<3° crank) across the entire operating range of the engine.

The existence of some values/RAMs is determined by the representation in ASCET (block hierarchy, course of control). They are not realized in the SW resp. they cannot be measured definitely by means of VS100 due to their special realization:

- B wkral cannot be measured definitely

- B krvf is not realized

- zkrvf(i)=0 cannot be measured, this state can only be detected indirectly via the performed RESET of the counter from zkrvf(i) = 1 to zkrvf(i) = KRVF(S)N

- zzylkral is not realized

Distinguishing between wkrm/wkrma

wkrm represents the mean value of the each time SY ZYLZA latest calculated wkr(i) (possibly incl. mean value vswzm) while wkrma represents the mean value of the dwkrz(i) (without wkrdy) which was passed on to the ignition during the SY ZYLZA latest combustions.

Adaptation characteristic map wkra

When choosing the map values a compromise has to be achieved between the possibly varying knock tendency of the engine at different load and engine speed ranges and the time by which the characteristic map is updated during normal driving.

If the adaptation map wkra is chosen to be too large (i.e. many relative load-engine speed-ranges) a longer period will be needed in order to update all ranges.

Thus in case of changed operating conditions which lead to a larger knock tendency it is inevitable that the knock frequency increases.

Generally a characteristic map with three load and five engine speed ranges is sufficient for wkra. In this map a RAM-cell is provided for each load/engine speed range per cylinder.

(Example 4-cylinder-engine: $3 \times 5 \times 4 = 60$ RAM-cells for wkra)

For the indexing of the wkra(i) - RAM-cells the following specification is used in the SW:

i = zzylkr + 8 × stkrnx + 40 × stkrlx (zzylkr = 0...7, so at the max. 8 cylinders can be represented)

The number of adaptation ranges can be varied according to special customer requirements but at the maximum to 4 × 8 load/engine speed ranges (change of above-mentioned indexing may possibly be necessary).

Cylinder-individual ignition angle timing with VS20

By means of VS20 a cylinder-individual additional timing vszw(i) can be performed (see also modules VS and VERST) so that the following applies:

dwkrz(i) = wkr(i) + wkrdy + vszwkr(i) if B kr & !B krdws

Label	Timing Range	Quantization	Initialization/neutral value
vszwkr_1	see module VS_VERST	0.75 °crank	0 °crank
Vszwkr_8	see module VS_VERST		

i = 0 ... SY ZYLZA - 1

Attention:

1. No automatic limitation of vszwkr(i) is performed - please pay attention to engine and catalyst protection during the timing!

2. The earliest possible ignition angle determined by the Knock Control is under all circumstances, i.e. it is possible that the minimum permitted ignition angle may be undershot (due to temperature reasons. see modules ZUE and ZWMIN). Please pay attention to engine and catalyst protection!

Abbreviations

CWKRLZFK	Code word: knock detection is not switched off for led cylinders
CWKRNLR	Code word: limp home in case of 1 out of 2 knock sensors fails
CWKRRA	Code word for the function KRRA

DRLKRSTMX	Maximum drl in Knock Control steady-state operation
DWKRMSN	Delta ignition angle Knock Control margin from mean retarding
KRAL1N	load range for Knock Control adaptation maps 1
KRAL2N	load range for Knock Control adaptation maps 2
KRAL3N	load range for adaptation Knock Control maps 3
KRALH	Load hysteresis for Knock Control adaptation maps
KRAN1	speed range for Knock Control adaptation maps, sample range 1
KRAN2	speed range for Knock Control adaptation maps, sample range 2
KRAN3	speed range for Knock Control adaptation maps, sample range 3
KRAN4	speed range for Knock Control adaptation maps, sample range 4
KRANH	Engine speed hysteresis for Knock Control adaptation maps
KRDWA	knock control difference current ignition angle to adaptation map
KRDWAA	Permissible ignition angle jump towards advance when reading adaptation values
KRDWKLA	The SV-learning value for KR adaptation after knocking detected
KRDWSA	The FV-learning value for KR adation when wkra-wkr > KRDWA
KRDWSN	knock control delta angle safety
KRFKLN	Retard per knock event at a slow advance
KRFKN	retard step knock occurrence
KRLMDY	Read if change of load range: always or only if dynamic active
KRMXN	maximum retard adjustment
KRNLZAR	cylinder individual speed limit for lead by leading cylinder
KRNMDY	Read if change of speed range: always or only if dynamic active
KRVFN	number of firings/cyl. or time for ignition advancing
KRVFSN	number of firings/cyl. or delay-time during fast ignition advancing of the Knock Control
KSZA	Knock sensor number
LKRAGRN	Load threshold knock control with Exhaust Gas Recirculation
LKRAN	Load threshold knock control adaptation
LKRN	load-signal threshold knock control
LZB1	Lead cylinder assignment: Bank 1 leads to Bank 2 with error KS 2
LZB2	Lead cylinder assignment: Bank 2 leads to Bank 1 with error KS 2
LZFUER	Lead cylinder assignment
NGKRSTMX	maximum speed gradient in the Knock Control steady-state operation
NKRAMAX	Upper engine speed limit for freezing Knock Control adaptation
NKRAMIN	Lower engine speed limit for freezing Knock Control adaptation
NKRF	Engine speed threshold for Knock Control release
NKRMAX	Upper engine speed limit for freezing Knock Control adaptation
SENZZYL0	
SNM16KRUB	Data point distribution engine speed, 16 data points
SY_ZYLZA	System constant: number of cylinders
TMKR	Engine-temperature threshold to enable Knock Control
TMKRA	Engine temperature threshold for adaptive Knock Control
TMKRAS	Temperature threshold for releasing write access to the adaptation map
TVKRSTAT	Knock Control delay time steady-state operation
WKRLZOF	Constant bloack: ignition retard offset for leed cylinder
WKRLZOFEKS	Ignition retard offset for led cylinders in case of knock sensor error
B_ADRKRA	Condition flag: Knock Control adaptation values reset errors in memory
B_AGR	Condition flag: Exhaust Gas Recirculation
B ASR	Condition flag: ASR active
B_KL	Condition flag: knock detected
B_KR	Condition flag for knock control active
B_KRA	condition for active Knock Control adaptation
B_KRAFRZ	Condition flag: Knock Control adaptation is frozen
B_KRDWS	Condition flag: knock control safety ignition retarding
B_KRFDKS	Condition flag: enable knock sensor diagnosis
B_KRFRZ	Condition flag: Knock Control adaptation is frozen
B_KRLDY	Condition flag: load dynamics for knock detection active

B_KRLDYA	Condition flag: load dynamics retard and dynamics adaptation active
B_KRLDYN	Condition flag: load dynamics for steady-state adaptation active
B_KRLZ	Condition flag: knock control lead-cylinder function active
B_KRNDY	Condition flag: speed dynamics for knock detection active
B_KRNDYN	Condition flag: speed dynamics for steady-state adaptation is active
B_KRNL	Condition flag: emergency operation of knock detection for emergency operation of phase sensor
B_KRNLR	Condition flag: emergency knock control for V6 or V8 with two knock sensors and error in one knock sensor
B_KRSTATB	Condition flag: steady-state Knock Control operation
B_KRVF	Condition flag: adjustment of Knock Control ignition timing to a less retarded value
B_KRWA	Condition flag: Knock Control at stop
B_KSEB1	Condition flag: KS-error Bank 1
B_KSEB2	Condition flag: KS-error Bank 2
B_LLR	Condition flag: idle control
B_NLDG	Condition flag: limp-home function speed sensor
B_NMAX	Condition flag: speed limit active
B_PWF	Condition flag: power fail
B_STEND	Condition flag: end of start
B_SYNPH	Condition flag: synchronization phase
B_TMKR	Condition flag: engine temperature (tmot) for knock control achieved
B_VMAX	Condition flag: VMAX control active
B_WKRAL	Condition flag: to read wkr from knock control adaptation map
B_ZWKRAA	Condition flag: ignition angle of the Knock Control is given
B_ZWKRUM	Condition flag: fast ignition advance Knock Control
DFP_KRNT	internal failure path number: knck control zero test
DFP_KROF	internal failure path number: knock control offset
DFP_KRTP	internal failure path number: knock control test pulse
DFP_KS1	internal failure path number: knock sensor 1
DFP_KS2	internal failure path number: knock sensor 2
DFP_KS3	internal failure path number: kncok sensor 3
DFP_KS4	internal failure path number: knock sensor 4
DRL_W	Change in cylinder fill
DWKR	cylinder-specific ignition-timing retardation
DWKRMSW	current value for mean value limitation of the retarding
DWKRZ	cyl.-spec. ignition-timing retardation with retardation for dynamics
E_KRNT	error flag: knock control zero test
E_KROF	Errorflag: knock control offset
E_KRTP	error flag: knock control test pulse
E_KS1	error flag: knock sensor 1
E_KS1H	auxiliary error flag KS1
E_KS2	error flag: knock sensor 2
E_KS2H	auxiliary error flag KS2
E_KS3	error flag: knock sensor 3
E_KS3H	auxiliary errorflag KS3
E_KS4	error flag: knock sensor 4
E_KS4H	auxiliary error flag KS4
KRAL1W	current value load adaptation range 1
KRAL2W	current value load adaptation range 2
KRAL3W	current value load adaptation range 3
KRDWSW	momentan characteristic-value for safety retard
KRFKW	current value of KRFKN
KRLZN	Cylinder-specific speed threshold of lead cylinder function exceeded
KRMXW	current value for retard limitation of the retarding
KRVFSW	initialization value for quick advancing
KRVFW	initialization value for normal advancing
LKRAW	Current value of the load threshold knock control-adaptation

LKRW	Current value of the load threshold knock control
LZIST	Array: instantaneous assignment of leading and led cylinders
NGFIL_W	Filtered speed gradient
NMOT	Engine speed
RL	Relative air charge
STKRAX	Index for Knock Control adaptation map
STKRLX	Load range adaptation map Knock Control
STKRNX	Speed range adaptation map Knock Control
TMOT	Engine temperature
TPNT_AKTIV	Activation of Knock Control functions
VSZWKR	Cylinder-specific adjustment of ignition angle by VS2x
VSZWM	Average value of adjustment ignition angle with VS2x
WKR	Cylinder-specific ignition retarding value knock control
WKRA	Adaptation map of wkr, speed- and load-dependent
WKRAA	Monitor for the wkra of the current adaptation ranges, wkra_0, _1…
WKRATST	wkra updated in real time
WKRM	Average value of individual ignition retarting by knocking
WKRMA	Average value of ignition retarding by KC, generally(limpe home with safety)
WKR_TST	cylinder-individual ignition angle retarding, druming
ZKRVF	counter determines the frequency of the cylinder-individual ignition angle adv.
ZWKRAFLD	bit pattern of the cylinder-individually stored B-zwkra
ZZYLKR	cylinder counter Knock Control

LAMBTS 2.120 (Lambda for component Protection)

See the *funktionsrahmen* for the following diagrams:

lambts main
lambts enable (Enabling conditions for Lambda-component protection and enabling through factor ftbts_w)
lambts lambtszw (Component protection due to changes in ignition angle)
lambts initialisation

Purpose:
Protection of components (exhaust manifold, turbocharger, etc.) through mixture enrichment.

Principle:
An excessively high exhaust gas temperature can be lowered by enriching the air-fuel mixture. Through this enrichment, more fuel enters the cylinder than would be required for stoichiometric combustion of the fuel. The unburned fuel vaporises on the cylinder walls and cools them which decreases the exhaust gas temperature.

LAMBTS: Overview

Target lambda can be enriched via the map KFLBTS which depends on the engine speed (nmot) and relative cylinder charge (rl). The enrichment is only effective when a modelled temperature tabgm_w, tkatm_w, tikatm_w or twistm_w in the sub-function LAMBTSENABLE exceeds its applicable threshold and the delay time TDLAMBTS + TVLBTS has expired. The system constant SY_ATMST defines whether twistm_w from the function %ATMST is available and the system constant SY_ATMLA defines whether twilam_w from the function %ATMLA is available.

The map KFLBTS describes the necessary steady-state enrichment, while the processes of the temperature model describe the dynamic state. This avoids early enrichment through a spike to a steady-state critical operating point.

The temperature hysteresis DTBTS or DTWISBTS prevents periodic switching on and off of the enrichment, if enrichment is set at a temperature below the cut-in temperature.

For projects with stereo exhaust systems, where the difference between the exhaust temperatures of the two cylinder banks at the same operating point can be very large, component protection can be applied separately to both cylinder banks via the maps KFLBTS and KFLBTS2 if the system constant SY_STERBTS = true.

A deterioration in ignition angle efficiency leads to an increase in exhaust gas temperature but this deterioration can be counteracted with a mixture enrichment (see sub-function DLAMBTSZW). The actual ignition angle is calculated from the ignition angle efficiency (etazwg), the basic ignition angle (zwgru) and the average ignition angle efficiency (etazwim). The difference of etazwg and etazwim results in the degradation efficiency (detazwbs). An additive enrichment depending on detazwbs can now be done via the map KFDLBTS. The enrichment can be reduced or eliminated in desired areas by means of the characteristic KFFDLBTS which is a function of engine speed and relative cylinder charge. Also, this enrichment is only effective when a modelled exhaust temperature exceeds its corresponding threshold.

The critical component temperatures can be exceeded for a brief time TVLBTS. First, however, the time TDLAMBTS must have expired. The low-pass filter ZDLBTS provides the option of smoothing an otherwise abrupt change in enrichment upon reaching a critical component temperature.

MEAN: Averaging the Efficiencies at the Actual Ignition Angle

Here is an averaging over 10 ms increments of the present ignition angle efficiencies over a 100 ms increments.

LAMBTS 2.120 Application Notes

Requirements:

* Application of the basic ignition angle (see %ZWGRU)
* Steady-state lambda - basic adaptation
* Application of knock control
* Application of the exhaust temperature model (see %ATM), including lambda-path and ignition angle path

LAMBTS 2.120 (Lambda for component Protection)

* Installation of a temperature sensor on the protected region of the exhaust system (e.g. exhaust manifold or catalytic converter)

Codewort LAMBTS

CWLAMBTS Bit No.	7	6	5	4	3	2	1	0
						Note 1	Note 2	Note 3

Note 1
If Bit 2 value = 1 then tabgkrm_w wird is used as the critical temperature
If Bit 2 value = 0 then tabgm_w w is used as the critical temperature

Note 2
If Bit 1 value = 1 then updating dlambts for transmission intervention applies
If Bit 1 value = 0 then dlambts for gear intervention is frozen

Note 3
If Bit 0 value = 1 then updating dlambts for dashpot applies
If Bit 0 value = 0 then dlambts for dashpot is frozen
Switch on only when system constant SY_TURBO is active

Example: Updating dlambts for dashpot and transmission protection frozen

→ CWLAMBTS Bit 0 = 1 and CWLAMBTS Bit 1 = 1
→ CWLAMBTS = $2^0 + 2^1 = 1 + 2 = 3$

Presetting of parameters (function inactive!)

Enrichment through switching off the lambda target value: KFLBTS = 1.0 (all engine speeds & all relative cylinder charges)
Critical exhaust gas temperature: TABGBTS = 900°C
Critical temperature near the catalytic converter: TKATBTS = 900°C
Critical temperature in the catalytic converter: TIKATBTS = 900°C
Critical cylinder head temperature: TWISTBTS = 200°C
Critical turbocharger temperature: TWILABTS = 950°C
Temperature hysteresis for component protection: DTBTS = 20°C
Temperature hysteresis for cylinder head temperature: DTWISBTS = 10°C
Temperature hysteresis for turbocharger turbine temperature: DTWISBTS = 20°C
Enrichment through switching off delta lambda target value: KFDLBTS = 0.0 (for all detazwbs)
Low-pass for deactivating enrichment: ZLBTS = 0.1 s
Low-pass for deactivating delta-enrichment: ZDLBTS = 0.1 s
Time delay for enabling component protection deactivation: TDLAMBTS = 0.0 s (only effective prior to ignition).
Time delay for deactivating enrichment: TVLBTS = 0.0 s
Weighting factor for normalizing the delta lambda target value: KFFDLBTS = 1.0 (alle nmot, alle rl)
component protection factor depending on tabgm_w: FBSTABGM = 1.0 (alle tabgm_w)
SY_ATMST = 0, when %ATMST is not available
SY_ATMLA = 0, when %ATMLA is not available

Procedure:

1.) Application of Steady-state Enrichment

* A temperature sensor is installed to measure the actual temperature at the thermal critical point.
* Enrichment independent enabling of the exhaust gas temperature model: TKATBTS = TIKATBTS = TABGBTS = TWISTBTS = 20°C for example.
* Enrichment path through ignition angle intervention switched off: e.g. KFDLBTS = 0.0 (all detazwbs)
* Knock control is enabled through the application of the characteristic KFLBTS by measuring the exhaust gas temperature at each operating point and where necessary by enrichment (KFLBTS values <1) on a non-critical limiting value.

2.) Application of Enrichment through Ignition Angle Adjustment

LAMBTS 2.120 (Lambda for component Protection)

In the application of the enrichment through ignition angle adjustment, steady-state enrichment via KFLBTS must be active.

Application of the enrichment map KFDLBTS:
* Set the ignition angle application without engine torque intervention condition (B_zwappl): CWMDAPP [bit 0] to be equal to 1
* Approach the operating point at which the largest overall enrichment was necessary in the map KFLBTS.
* Through ZWAPPL gradually retard the ignition angle and make enrichments for high exhaust gas temperature via KFDLBTS.
The characteristic field KFDLBTS should remain unchanged for the further application.

The characteristic field KFFDLBTS must be applied at the maximum latest ignition angle position (e.g. through ZWAPPL):
* Approach all operating points of KFFDLBTS and control exhaust temperature. Correct the enrichment.

3.) Application of the Temperature Threshold Values TABGBTS, TKATBTS, TIKATBTS, TWISTBTS

TABGBTS, tabgm and tabgkrm or refer to a location close to the lambda probe or exhaust manifold.
TKATBTS and tkatm refer to a location near the catalytic converter.
TIKATBTS and tikatm refer to a location in the catalytic converter.
TWISTBTS and twistm refer to the cylinder head. If SY_ATMST = 0 twistm does not exist in the project.

All thresholds are applied only when all components must be protected. If a component is not critical, the corresponding threshold is set to the maximum possible value.

* Double-check application of the exhaust temperature model, including the lambda and ignition angle paths.

* If the actual measured temperature reaches the critical component temperature, the modelled temperature must be transferred to the corresponding threshold value. Possible errors in the exhaust gas temperature model can be found by again in the emerging thresholds TABGBTS, TKATBTS, and TIKATBTS TWISTBTS.

* The choice of values for the temperature thresholds TABGBTS, TKATBTS, TIKATBTS and TWISTBTS must be checked “dynamically”. I.e. enrichment should not be used too late with a jump from a thermally non-critical to a thermally critical region, otherwise the component temperature will overshoot. In this case, a lower value for the corresponding threshold temperature should be selected.

* The temperature hysteresis DTBTS or DTWISBTS should be sufficiently large that the enrichment does not periodically turn on and off.

* A dead time TDLAMBTS > 0 s is permissible only in those projects in which a steady-state component critical temperature can be exceeded without damage on a one-off basis (total time that B_tatmbts is active), But normally, however TDLAMBTS = 0.0 s.

* A dead time TVLBTS > 0 s is permissible only in such projects in which a steady-state critical component temperature can be exceeded for brief periods any number of times with no damage. But normally, however, TVLBTS = 0.0 s.

* A delay with the time constants ZLBTS or ZDLBTS is only useful for projects where abrupt enrichment leads to a noticeable jump in torque. A delay in the enrichment will result in overshooting of the temperature components. If the overshoot is not tolerable, enrichment must be enabled from a lower component temperature.

Affected Functions:

%LAMKO via lambts_w

Parameter	Description
CWLAMBTS	Codeword: lambda component protection
DTBTS	Temperature hysteresis for component protection
DTWILABTS	Turbocharger temperature hysteresis for component protection
DTWISBTS	Cylinder head temperature hysteresis for component protection
ETADZW	Ignition angle efficiency depending on delta ignition angle
FBSTABGM	Component protection factor depending on modelled exhaust gas temperature

LAMBTS 2.120 (Lambda for component Protection)

KFDLBTS	Delta lambda target value for component protection
KFFDLBTS	Factor for delta lambda target value for component protection
KFLBTS	Lambda target value for component protection
KFLBTS2	Lambda target value 2 for component protection
SNM16GKUB	Sample point distribution for mixture control: 16 sample points for engine temperature
SRL12GKUW	Sample point distribution for mixture control: 12 sample points for relative cylinder charge (Word)
SY_ATMLA	System constant exhaust gas temperature modelling: turbocharger available
SY_ATMST	System constant exhaust gas temperature modelling: cylinder head available
SY_STERBTS	System constant component protection exhaust gas bank selection
SY_TURBO	System constant for turbocharger
TABGBTS	Exhaust gas temperature threshold for component protection
TDLAMBTS	Time delay for enabling one-off lambda component protection
TIKATBTS	Temperature threshold for component protection in the catalytic converter
TKATBTS	Temperature threshold for component protection near the catalytic converter
TVLBTS	Delay time for lambda target value for component protection
TWILABTS	Temperature threshold for component protection of the turbocharger
TWISTBTS	Temperature threshold for component protection of the cylinder head
ZDLBTS	Time constant delta lambda component protection
ZLBTS	Time constant lambda component protection

Variable	**Description**
B_DASH	Condition: Dashpot limit change active
B_GSAF	Condition: Transmission intervention switch requirement
B_TABGBTS	Condition: Exhaust gas temperature exceeded
B_TATMBTS	Condition: Threshold temperature in exhaust gas temperature model exceeded
B_TIKATBTS	Condition: Threshold temperature in catalytic converter exceeded
B_TKATBTS	Condition: Threshold temperature near catalytic converter exceeded
B_TWILABTS	Condition: Turbocharger threshold temperature exceeded
B_TWISTBTS	Condition: Cylinder head threshold temperature exceeded
DETAZWBS	Delta ignition angle efficiency for component protection
DLAMBTS_W	Delta lambda for component protection
DZWG	Delta ignition angle: basic ignition angle to optimum ignition angle
ETAZWG	Efficiency of the basic ignition angle
ETAZWIM	Average efficiency of the actual ignition angle
ETAZWIST	Actual ignition angle efficiency
FLBTS_W	Lambda component protection factor
LAMBTS_W	Lambda for component protection
LAMBTS2_W	Lambda for component protection for cylinder bank 2
LBTS_W	Lambda for component protection in steady-state map
LBTS2_W	Lambda for component protection in steady-state map for cylinder bank 2
NMOT	Engine speed
RL_W	Relative cylinder charge (Word)
SY_LAMBTS	System constant for component protection available
TABGBTS_W	Exhaust gas temperature for component protection
TABGKRM_W	Exhaust gas temperature in exhaust manifold from the model
TABGM_W	Exhaust gas temperature before the catalytic converter from the model (Word)
TIKATM W	Exhaust gas temperature in the catalytic converter from the model
TKATM W	Exhaust gas temperature near the catalytic converter from the model (Word)
TWILAM_W	Turbocharger casing temperature from the model
TWISTM_W	Cylinder head temperature from the model: Kelvin in VS100, actual in °C
ZWGRU	Basic ignition angle
ZWOPT	Optimum ignition angle

LAMFAW 7.100 (Driver's Requested Lambda)

See the *funktionsrahmen* for the following diagrams:
lamfaw-lamfaw
lamfaw-lamkr
lamfaw-lamwl
lamfaw-lamfadisable
lamfaw-lamrlmin
lamfaw-initialise

Function Description
The function LAMFAW brings about an enrichment of the fuel-air mixture via lamfa_w when the driver demands maximum torque via mrfa_w. This then corresponds to the full-load enrichment. The intervention to the mixture via lamfa_w can be delayed via the delay time TLAFA.
During turbocharger overboost, an additional enrichment is applied by a delta-lambda from the characteristic DLAMOB.

For the time TLAMFAS, an enrichment via the driver's request as a function of altitude (LAMFAS) can be prevented (see sub-function LAMFADISABLE). Triggering of this time will be initiated if B_kh = true, LAMFA <1.0 and the altitude at which the function is disabled (as defined in LAMFAS) has been reached.

In this way, a reproducible driving cycle can also be achieved at higher altitudes.
During a torque reduction, e.g. traction control intervention, engine speed limiter …, the enrichment via the map LAMFAW can be disabled by setting CWMFAW Bit 1 = true.
In the sub-function LAMKR, an enrichment can be implemented during ignition angle intervention.
The sub-function LAMWL can be used for the enrichment during warm-up. If this procedure is used, tank-venting via the function LAMKO is not switched off.
In the sub-function LAMRLMIN, an enrichment via LAMRLMN is active for low loads (rl). This serves to improve the combustion efficiency at low loads. If CWLAMFAW bit 2 is set, then the emergency fuel tank breather is disabled during lamrlmn-intervention.

Application Notes
A delay time TLAFA > 0 can only be applied when the mixture intervention via lamfa_w should be delayed.

Map LAMFA:

Engine speed sample points:
1000, 1400, 1800, 2200, 2600, 3000, 3400, 3800, 4200, 4600, 5000, 5400, 5800, 6200, 6600, 7000 rpm
mrfa_w sample points:
70, 80, 90, 100, 110, 120 %
Map values of 1.0

DLAMOB comprises the delta-lambda, so that an additional mixture enrichment is implemented in overboost mode.
Sampling points for engine speed: implemented as a group characteristic SNM06GKUB

Neutralization of the function by data:
LAMFA = 1.0 and DLAMOB = 0.0 $\rightarrow$ lamfa_w is then 1.0

The time TLAMFAS must be selected so that no large gradients are caused in the driver's requested enrichment (typically 240 s).

The characteristic LAMFAS contains values from 0 to 1. If the value is 0, enrichment via the altitude effect is active. Values other than 0 deactivate enrichment via LAMFA, if B_kh = true and LAMFA values are < 1.0.
The characteristic LAMFAS is not interpolated, which means that the characteristic initial value remains constant until a node is crossed.

For the fho-sample points of the characteristic LAMFAS, the following relationship applies: fho = 1 – altitude [m]/10,000 m
Since the variable fho has a quantization of 4/256 = 0.015625, this resolution must be considered when determining the switch-off. Similarly, there is a potential altitude deviation of $\pm$ 250 m because of the sensor tolerance.

For the calculation of the lower or upper threshold of fho, the following relationship applies for a nominal altitude cut-off threshold:

Lower altitude cut-off threshold:
fho [phys] = 1 – ((nominal altitude [m] – 250 m) /10000) → fho[Ink] = Integer (fho[phys] /0.015625) + 1Ink
→ fho upper limit [phys] = (1 – fho[Ink] × 0.015625)
→ Altitude upper limit = (1 – fho upper limit [phys]) × 10000

Upper altitude cut-off threshold:
fho [phys] = 1 – ((nominal altitude [m] + 250 m) /10000) → fho[Ink] = Integer (fho[phys] /0.015625)
→ fho lower limit [phys] = fho[Ink] × 0.015625
→ Altitude lower limit = (1 – fho lower limit [phys]) × 10000

This produces the following values:

Nominal altitude	2,200 m	1,600 m
Altitude upper limit	2,500 m	1,875 m
fho lower limit	0.75	0.8125
Altitude lower limit	1,875 m	1,250 m
fho upper limit	0.8125	0.875

The altitude upper limit is the fho lower limit!

Thus, the characteristic LAMFAS is parameterized as follows for the nominal altitude of 2,200 m:

fho	0.734375	0.7500	0.8125
Value	0	1	0
	Enrichment active	Enrichment inactive	Enrichment active

Switching off the altitude-dependent enrichment suppression: LAMFAS = 0, TLAMFAS = 0

Values for lambda intervention lamfawkr_w during ignition angle retardation:

ZKLAMFAW:	2 s	
ZKWLAFWL:	2 s	
DLAMFAW:	0.01	
KFLAMKR:	Engine speed sample points:	Group characteristic SNM06GKUB
	rl sample points:	Group characteristic SRL06GKUB
	Map values:	All are 1.0 → no weighting active
KFLAMKRL:	dzlamfaw sample points:	Group characteristic SDZ0 6GKUB
	rl sample points:	Group characteristic SRL06GKUB
	Map values:	All are 1.0 → lambda intervention not active
DLAMTANS:	Ambient temperature sample points: 50.25, 60, 70.5, 80.25 °C	
	Map values:	All are 0 → lambda intervention not active
KFLAFWL:	Engine speed sample points:	Group characteristic SNM06GKUB
	rl sample points:	Group characteristic SRL06GKUB
	Map values:	All are 0 → lambda intervention not active
	In the map, delta values are entered, –0.1 → lamfwl_w = 0.9!	
DLAMOB:	Engine speed sample points:	Group characteristic SNM06GKUB
	Map values:	All are 0 → no additional enrichment during overboost
	In the map, delta values are entered + 0.1 → lamfa = lamfaw – 0.1!	
RLLAMMN:	Engine speed sample points:	Group characteristic SNM06GKUB
	Map values:	0% → enrichment via LAMRLMN not active
LAMRLMN:	Engine speed sample points:	Group characteristic SNM06GKUB
	Map values:	1.0 → lambda = 1.0 (no enrichment)

CWLAMFAW Bit 0:	0: dzwlamfaw = min (0, dzwwl) 1: dzwlamfaw = min (0, (dzwwl + wkrma)). Default value = 0.
CWLAMFAW Bit 1:	0: LAMFAW also during torque reduction, e.g. via traction control, engine speed limiter, etc. active 1: no enrichment via LAMFAW during torque reduction (milsol < mifa)
CWLAMFAW Bit 2:	0: B_ldeffw is always false → emergency fuel tank breather also during lamrlmn_w-intervention active 1: B_ldeffw dependent on lamrlmn_w-activation, when B_ldeffw = true, emergency fuel tank breather disabled, i.e. fuel tank breather valve shuts.
CWLAMFAW Bit 3:	0: Disable driver's requested lambda activation through catalyst heating enabled

	1: Disable driver's requested lambda activation through catalyst heating not possible
CWLAMFAW Bit 4:	0: lamfwl_w dependent on B_stend and VZ1-term
	1: lamfwl_w not dependent on B_stend and VZ1-term

Group characteristic for engine speed sample points: SNM06GKUB: 760, 1520, 2560, 3520, 4560, 5520 rpm
Group characteristic for relative load sample points: SRL06GKUB: 20, 40, 60, 80, 90 %
Group characteristic for engine temperature sample points: STM0 8GKUB: –15, 0, 20, 40.5, 60, 75, 85.5, 105 °C
Group characteristic for dzwlamfaw sample points: SDZ06GKUB: –30, –20, –15, –10, –5, 0 degrees

Parameter	**Description**
CWLAMFAW	Codeword LAMFAW
DLAMFAW	Threshold value for activating enrichment via driver's request
DLAMOB	Delta lambda during overboost
DLAMTANS	Air temperature-dependent enrichment
GANGFAW	Gear threshold for deactivating driver's request at altitude
KFLAFWL	Offset engine target lambda
KFLAMKR	Weighting factor for enrichment during ignition angle retardation
KFLAMKRL	Enrichment during ignition angle retardation
LAMFA	Driver's requested lambda
LAMFAS	Disable driver's requested lambda
LAMRLMN	Lambda control when rl < RLLAMMN to improve the combustion efficiency
RLLAMMN	Minimum requested load threshold for enrichment due to combustion efficiency
SDZ06GKUB	Sample point distribution for KFLAMKRL
SNM06GKUB	Sample point distribution for KFLAMKR, DLAMOB
SRL06GKUB	Sample point distribution for KFLAMKRL, KFLAFWL, KFLAMKR
STM08GKUB	8 engine temperature sample point distribution for KFLAFWL
SY TURBO	System constant: turbocharger
TLAFA	Delay time with driver's requested lambda active
TLAMFAS	Delay time with driver's requested lambda at altitude active
TMSTFWMN	Minimum engine start temperature for deactivating driver's request at altitude
TMSTFWMX	Maximum engine start temperature for deactivating driver's request at altitude
TNSTFWMN	Minimum time after start for deactivating driver's request at altitude
TNSTFWMX	Maximum time after start for deactivating driver's request at altitude
ZKLAMFAW	Time constant filtering enrichment via driver's request
ZKWLAFWL	Time constant weighting offset engine target lambda
Variable	**Description**
B_KH	Condition flag: catalyst heating
B_LAMFAS	Condition flag: disable driver's requested lambda
B_LAMFASA	Condition flag: altitude-dependent disabling time for driver's requested lambda is required
B_LAMFASH	Condition flag: altitude-dependent disabling time for driver's requested lambda is active
B_LDEFFW	Condition flag: defined target lambda (cylinder bank 1) via driver's request
B_LDOB	Condition flag: overboost active
B_SAB	Condition flag: overrun fuel cut-off readiness
B_STEND	Condition flag: end of start conditions reached
DZWLAMFAW	Delta ignition angle during knock control intervention or warm-up for enrichment via lambda
DZWWL	Delta ignition angle during warm-up
FHO	Altitude correction factor
GANGI	Actual gear
LAMFAWKR_W	Driver's requested target lambda during ignition angle retardation (knock control), WL
LAMFAWS W	Driver's requested target lambda steady-state part
LAMFAW_W	Driver's requested target lambda part from map LAMFA
LAMFA_W	Driver's requested target lambda (word)
LAMFWL_W	Offset engine target lambda during warm-up
LAMRLMN_W	Target lambda control to improve the combustion efficiency at lower relative loads
MIFA_W	Indexed driver's requested engine torque
MILSOL_W	Driver's requested torque for cylinder charge path
MRFA_W	Relative driver's requested torque from cruise control and throttle pedal
NMOT	Engine speed
RL	Relative cylinder charge
TANS	Ambient air temperature
TMOT	Engine temperature
TMST	Engine start temperature
TNST_W	Time after end of start conditions
WKRMA	Average value of the individual cylinder ignition angle retardation (knock control), general (in emergency mode with safety margin)

LAMKO 9.80 Lambda Coordination

See the *funktionsrahmen* for the following diagrams:

lamko-main	Function overview
lamko-lamsel	Sub-function: lambda target selection for cylinder bank 1: LAMSEL
lamko-lamsel2	Sub-function: lambda target selection for cylinder bank 2: LAMSEL2
lamko-lamlim	Sub-function: LAMLIM: lambda limit engine running
lamko-lamkh	Sub-function: lambda intervention for catalyst heating in cylinder bank 1: LAMKH
lamko-lamkh2	Sub-function: lambda intervention for catalyst heating in cylinder bank 2: LAMKH2
lamko-lamdsk	Sub-function: lambda intervention for diagnosis (cylinder bank 1): LAMDSK
lamko-lamdsk2	Sub-function: lambda intervention for diagnosis (cylinder bank 2): LAMDSK2
lamko-lss1kor	Sub-function: lambda target correction via lambda probe (cylinder bank 1): LSS1KOR
lamko-lss2kor	Sub-function: lambda target correction via lambda probe (cylinder bank 2): LSS2KOR
lamko-init	Initialisation values:

Function Description

Lambda = 1.0 will be specified in the combustion chamber through the pilot control of fuel injection in module ESVST 4.20. The lambda coordination function LAMKO specifies which engine operating point the combustion chamber operates at lambda = 1.0. The position of the switch is a measure of the priority of the corresponding lambda intervention.

The highest priority is catalyst protection (LASOAB), followed by component protection or driver's desired value then catalyst clear out and catalyst heating.

Component protection for manifold(s), exhaust valve(s) and turbocharger(s) is implemented via the inputs lambts_w and lambts2_w. The input lambts2_w is only available if the system constant SY_STERBTS = true. This is only set for projects with stereo exhaust tracts which occurs when the two banks have very different exhaust gas temperatures for the engine same operating point.

For projects with exhaust gas temperature control via exhaust gas temperature sensors, correction control of the additive part dlamatr_w is included.

From start to end of warm-up lamnswl_w is active unless catalyst heating through secondary air is requested.

At the beginning of catalytic converter heating, a factor flakh from module LAKH for lamnswl_w is passed to lambda for catalyst heating lamkh_w. When catalyst heating is terminated it is passed back again with flakh to lamnswl_w. For systems with secondary air injection (B_slsfz), the lambda engine target (lamsbg_w) is calculated by means of the secondary air dilution arising from target lambda at the lambda probe lamsons_w via multiplication by the secondary air dilution factor flamsl_w.

The two sub-functions LSS1KOR and LSS2KOR correct the rounding error in the calculation of lamsons_w about 1.0 so that two-point lambda control is not unnecessarily shut down.

In normal operation, the lambda target (lamsbg) is provided by lamfa_w or lambts_w.

The two inputs lamlash_w and lamelsh_w are provided for diagnosis of the post-catalyst lambda probes. With these inputs, a change in the post-cat lambda probe voltage via a lambda intervention is implemented.

For catalyst diagnosis, lamdskt_w or lamdskt2_w are designated for the future of lambda intervention. This intervention is activated by condition flags B_lamdkt or B_dlamdkt2 whereas the intervention with index 2 is only available with SY_STERVK or SY_STERHK.

On catalyst clear-out, the target lambda is determined by lamka unless an even richer mixture is requested via lamnswl_w (especially when the engine is still cold).

Via the lambda intervention lamau_w, the exhaust emission test AU implements a lambda intervention for the catalyst check. For this purpose the system constant SY_AAU must be set in the project. The intervention is implemented when B_auakt = true.

At fuel injector switch off (B_evab, Bevab2 = true) the target lambda value is specified by the constant LASOAB. Thus, this can be achieved that in the associated exhaust tract of the deactivated cylinders so that no surplus hydrocarbons arise in the other cylinders when the entire cylinder bank is operated under lean conditions (e.g. LASOAB = 1.05) for catalyst protection.

For the torque calculation, the basic-lambda variable lambas is made available as the average of the two cylinder banks.

When a high lambda-dynamic situation occurs outside of warm-up, the catalytic converter heating range (B_lamnse = true) is no longer required and the computation time frame is transferred from 10 ms to 100 ms.

Then, via the switches, the actually selected lambda (lamsubg_w) is limited via either of the two lambda thresholds LAMLGFTM (or LAMFLGSL with secondary air operation) and LAMLGMTM to the rich and lean engine operating limits.

If the lambda requirements for diagnostic functions, catalyst clear out or catalyst heating are active, the fuel tank breather must be prohibited, so that it serves bit B_lamsdef or either B_ldef and B_ldef2 for twin cylinder bank systems.

IMPORTANT: It must be ensured that the lean operating limits LAMLGMTM & LAMLGMKT do not go in the direction of zero because it directly affects the injection!

Application Notes

Data for initial application:

CWLAMKH = 0

LASOAB 1.05

LAMLGFTM = LAMFLGSL = 0.77

Sample points for LAMFLGSL: imlatm = 2, 4, 6, 8, 10, 12 kg

LAMLGMTM sample points for tmot are not freely selectable, since the group line tmot is a function of ESWL

Value = 1.2

LAMSOSUF = 0.998779

LAMSOSOF = 1.001221 equivalent to 5 increments difference of 1.0

The inputs lamka_w and lamka2_w are inactive if the lambda value ≥ 2. The catalyst clear out function sets this value in the inactive case at lambda = 8.0.

CWLAMKH = 1 Minimum value of lamnswl_w or lamkhe_w to act

= 0 lamkhe acts directly

Abbreviations

Parameter	**Description**
CWLAMKH	Code word for lambda coordination during catalyst heating
LAMFLGSL	Lambda engine operating limit fett bei Sekundärlufteinblasung
LAMLGFKT	Rich lambda operating limit during short test
LAMLGFTM	Rich lambda operating limit
LAMLGMKT	Lean lambda operating limit during short test
LAMLGMTM	Lean lambda operating limit
LAMSOSOF	Lambda probe target upper limit for 1.0-window
LAMSOSUF	Lambda probe target lower limit for 1.0-window
LASOAB	Target lambda value during cylinder bank deactivation
STM12ESUB	Sample point distribution for engine temperature (tmot)
SY_AAU	System constant: calibrator specification of target lambda for exhaust emissions test (AU) is possible
SY_ATR	System constant: exhaust gas temperature control is available
SY_DKAT	System constant: status information about the system’s available catalyst diagnostics
SY_DLSHV	System constant: condition module DLSHV (post-catalyst probe swapping) available
SY_STERBTS	System constant: exhaust gas bank selective component protection
SY_STERHK	System constant: condition stereo lambda control post-catalyst
SY_STERVK	System constant: condition stereo lambda control pre-catalyst

Variable	**Description**
B_AUAKT	Condition flag: exhaust emissions test active
B_BEVAB	Condition flag: injector shut-off in cylinder bank 1
B_BEVAB2	Condition flag: injector shut-off in cylinder bank 2
B_DSLA	Adaptation phase: determining secondary air mass
B_FA	Condition flag: general function requirement
B_FALSH	Condition flag: function requirement post-catalyst lambda probe for cylinder bank 1
B_FALSH2	Condition flag: function requirement post-catalyst lambda probe for cylinder bank 2
B_FASLA	Condition flag: external requirement to activate secondary air
B_KH	Condition flag: catalyst heating
B_LALGF	Condition flag: rich lambda operating limit active (cylinder bank 1)
B_LALGF2	Condition flag: rich lambda operating limit active (cylinder bank 2)

B_LAMBTS	Lambda for component protection is active (cylinder bank 1)
B_LAMBTS2	Lambda for component protection is active (cylinder bank 2)
B_LAMDIAG	Target lambda for diagnostic function requirement
B_LAMDKT	Lambda target intervention for catalyst diagnose active
B_LAMDKT2	Lambda target intervention for catalyst diagnose active
B_LAMKA	Lambda for catalyst clear out active
B_LAMKA2	Lambda for catalyst clear out active
B_LAMKH	Condition flag: target lambda for catalyst heaing active
B_LAMKHE	No lambda requirement from module LAKH
B_LAMLASH	Condition flag for enleanment in module LAMKO (cylinder bank 1)
B_LAMLASH2	Condition flag for enleanment in module LAMKO (cylinder bank 2)
B_LAMLSHV	Condition flag for enleanment or enrichment in module LAMKO
B_LAMLSHV2	Condition flag for enleanment or enrichment in module LAMKO Bank 2
B_LAMNSE	Condition flag: end of lamns_w calculation
B_LAMNSWL	Lambda engine target for post-start and warm-up active
B_LAMSDEF	Condition flag: defined target lambda
B_LDEF	Condition flag: defined target lambda (cylinder bank 1)
B_LDEF2	Condition flag: defined target lambda (cylinder bank 2)
B_LDEFFW	Condition flag: defined target lambda (cylinder bank 1) via driver's request
B_SLS	Condition flag: secondary air control active
B_SLSFZ	Condition flag: secondary air control is installed in the vehicle
DLAMATR W	Delta target lambda from exhaust gas temperature regulation (cylinder bank 1)
DLAMATR2_W	Delta target lambda from exhaust gas temperature regulation (cylinder bank 2)
FLAMKH	Factor for controlling lambda-engine target during catalyst heaing
FLAMSL_W	Factor for lambda adjustment via secondary air (cylinder bank 1)
FLAMSL2_W	Factor for lambda adjustment via secondary air (cylinder bank 2)
IMLATM	Integrated air mass flow from engine start to the maximum value
LAMAU_W	Lambda for exhaust emission test
LAMBAS	Basic lambda
LAMBTS_W	Lambda for component protection (cylinder bank 1)
LAMBTS2_W	Lambda for component protection (cylinder bank 2)
LAMDKT_W	Target lambda for catalyst diagnostics (cylinder bank 1)
LAMDKT2_W	Target lambda for catalyst diagnostics (cylinder bank 2)
LAMELSH_W	Target lambda for electric probe diagnostics post-catalyst (Kurztrip, cylinder bank 1)
LAMELSH2_W	Target lambda for electric probe diagnostics post-catalyst (Kurztrip, cylinder bank 2)
LAMFA_W	Target driver's requested lambda (word)
LAMKA_W	Target lambda value catalyst clear out (cylinder bank 1)
LAMKA2_W	Target lambda value catalyst clear out (cylinder bank 2)
LAMKH_W	Lambda-engine target during catalyst heaing (word, cylinder bank 1)
LAMKH2 W	Lambda-engine target during catalyst heaing (word, cylinder bank 2)
LAMKHE_W	Lambda-engine target during catalyst heaing, effective (cylinder bank 1)
LAMKHE2_W	Lambda-enging target during catalyst heaing, effective (cylinder bank 2)
LAMLASH_W	Target lambda for test vibration check post-catalyst (cylinder bank 1)
LAMLASH2_W	Target lambda for test vibration check post-catalyst (cylinder bank 2)
LAMLGFMN	Lambda engine rich operating limit
LAMLGM	Lean lambda operating limit
LAMLSHV_W	Target lambda for test post-catalyst probe substitution (cylinder bank 1)
LAMLSHV2_W	Target lambda for test post-catalyst probe substitution (cylinder bank 2)
LAMNSWL_W	Lambda-engine target for post-start and warm-up
LAMS2_W	Target lambda (word)
LAMSBG_W	Target lambda limit (word, cylinder bank 1)
LAMSBG2_W	Target lambda limit (word, cylinder bank 2)
LAMSONS_W	Target lambda value based on the lambda probe installation location (cylinder bank 1)
LAMSONS2_W	Target lambda value based on the lambda probe installation location (cylinder bank 2)
LAMSOS_W	Target lambda value based on the lambda probe installation location (cylinder bank 1)
LAMSOS2_W	Target lambda value based on the lambda probe installation location (cylinder bank 2)
LAMSUBG_W	Unlimited target lambda (word, cylinder bank 1)
LAMSUBG2_W	Unlimited target lambda (word, cylinder bank 2)
LAMS_W	Target lambda (word)
LAMVOA_W	Lambda pilot control without additive part (cylinder bank 1)
LAMVOA2 W	Lambda pilot control without additive part (cylinder bank 2)
TMOT	Engine temperature

<u>LDRLMX 3.100 (Calculation of Maximum Cylinder Charge rlmax in Boost Pressure Control)</u>

See the *funktionsrahmen* for the following diagrams:

ldrlmx-main LDRLMX function definition
ldrlmx-fldrrx
ldrlmx-sstb
ldrlmx-set
ldrlmx-rlmx-w
ldrlmx-tsel
ldrlmx-frxta-w
ldrlmx-hierarchy
ldrlmx-initialise

<u>LDRLMX 3.100 Function Description</u>

The function LDRLMX calculates the allowed maximum cylinder charge.

In the main path, the maximum charge value dependent on engine speed is given by the characteristic LDRXN. This can be corrected, if necessary, through intervention of the workshop tester.

For this purpose, an additive overboost increase (drlmaxo, delta maximum cylinder charge during overboost) is applied via the knock-control intervention.

On the rlmx path, a multiplicative correction is applied via the characteristic field KFTARX as a function of engine speed and intake air temperature.

Subsequently, there is an intervention via the sub-function FLDRRX as a function of the mean ignition angle retardation in knock control (wkrma). This function consists of two parts, a quasi-steady state long-time part (permanent RAM) which takes the fuel octane rating into account, and a dynamic short-time part to take all other perturbations into account.
The low pass of the long-time part is active only above a speed-dependent load threshold RLKRLDA that is representative for fuel adaption. The characteristic field KFFLLDE sets the steady-state reduction.

The low pass of the short-time part works with the difference of the filtered long-time average value (wkrmstat) and the actual average value (wkrma). To avoid interference of opposing interventions from both the aforementioned parts, the minimum difference is limited to zero.
The associated drawdown value is determined by KFFSLDE.
The overboost path is corrected separately, by a dependence on the sum of both low-pass outputs (wkrmsu) and the speed of the associated drawdown is determined via KFFLDEO.
The time constants of the two parts are each separated into predetermined up-regulating and down-regulating speed-dependencies.

Further on down the main pathway, the maximum cylinder charge is limited by an external pressure dependency to avoid overloading the turbocharger at high altitudes.
This limit (maximum compressor pressure ratio) which is engine speed and tsel (tans ÷ tumc)-dependent is determined through KFLDHBN, by multiplying the external pressure by the maximum absolute pressure and then using pirg_w and fupsrl_w to convert to a cylinder charge level.
When an ambient temperature sensor is present, the map KFLDHBN is addressed with the ambient temperature through the system constant SY_TFUMG and CWRLMX = 1 and to the instrument cluster via CAN. If no ambient temperature sensor is available or CWRLMX = 0, the map KFLDHBN is addressed with tans.
Via the system constants SY_TFMO, SY_GGGTS the oil temperature (toel) or the cooling water temperature from the instrument cluster (tmki) are read by sensors, whose signal is evaluated in functions %GGTOL or %GGGTS. If the respective variables are available via the CAN (tolc or tmkic) then switching to the CAN-variables will occur or, in case of failure, to surrogate values.
If a system failure is detected, an additional engine speed dependent (pressure) limitation (LDPBN) comes into force, which is analogous to the altitude limitation on the cylinder charge level. Switching back only occurs when resetting the tripping fault and in idle mode (B_ll).
In the over-charge condition (E_ldo) an engine speed dependent limit (LDORXN) is switched in so that both the engine and the turbocharger adequately protected. Switching back also occurs only when resetting the error (E_ldo) and in idle-mode (B_ll).

<u>LDRLMX 3.100 Application Notes</u>

LDRXN: It must be ensured that even at speeds below the turbocharger response speed meaningful rlmax-values (about 10% above the value of throttle plate at full open test bench) can be specified. Above the turbocharger response speed, the regular allowable and desired rlmax values are defined in this characteristic.
LDORXN: maximum allowable cylinder charge, such that there is sufficient protection by an appropriately strong throttling of the throttle and turbocharger. (Remove the wastegate pressure hose during application!)
LDPBN: pressure relief in case of diagnosis (sudden torque drop should be no larger than about 15%).
KFLDHBN: Firstly, in the compressor performance map, acquire the regular full load line at speed sample points of KFLDHBN: as well as the maximum pressure ratio line (due to the surge limit, maximum turbocharger-speed or prohibited areas of poor efficiency) to define the operational limit.
Then one carries on the height gradients from the normal full load line starting, at any engine speed, up to an operating limit.
This increases with increasing altitude (decreasing ambient pressure) of the volume flow rate and the pressure ratio with 1013 ÷ ambient pressure.
This new intersection then defines the maximum pressure ratio for KFLDHBN at the respective engine speed.

Attention!
It must be ensured through appropriate application of RLKRLDA and LDRXN that the operating range of the long-time filter (rl > RLKRLDA) can always be reached!
Otherwise, it might happen that a very large decrease will be locked in the long-time part itself and no new adaptation can take place.
All other values are highly dependent on the project.
Basic data input
ATTENTION applicators, these data are extremely project-specific and must be verified in each project application!
Please note carefully or risk engine damage!
In order to achieve the same functionality as in LDRLMX 3.70 in the absence of CAN message from the instrument cluster, note the following.

SY_TFMO	SY_GGGTS	Remark
0	0	FKRXTOL and KFFKRXTM set = 1 ≥ frxt = 1
1	0	FKRXTOL set to a maximum value ≥ frxt = output KFFKRXTM
0	1	KFFKRXTM set to a maximum value ≥ frxt = output FKRXTOL

LDRXN : 140%

LDORXN: 15%

LDPBN: 1500 mbar

KFLDHBN: from low engine speed 1.9 to medium engine speed (2500 rpm) constant 2.5

FKRXTOL: 1.0 (1.0 does not limit the boost pressure control)

KFFKRXTM: 1.0 (1.0 does not limit the boost pressure control)

KFFLDEO: 1.0 (1.0 does not limit the boost pressure control)

KFFSLDE: 1.0 (1.0 does not limit the boost pressure control)

KFFLLDE: 1.0 (1.0 does not limit the boost pressure control)

KFFWLLDE: 1.0 (1.0 does not limit the boost pressure control)

KFTARX: data values of 1.0 below IAT of 75°C. Data values linearly reduced from 1.0 to 0.8 between 75°C and 120°C)

KFTARXZK: about 10% less than KFTARX

LDRXNZK: about 15% less than LDRXN

RLKRLDA: ca. 0.6 × LDRXN (the greatest possible relative load reduction must be greater than the value from RLKRLDA otherwise there will be a risk of dead lock!)

TLKRLDAB: ca. 3-5 seconds

TLKRLDAU: ca. 5-7 seconds

TSKRLDAB: 1-2 seconds

TSKRLDAU: 2-4 seconds

CWRLMX: 1 (Addressing of KFLDHBN via ambient temperature in instrument cluster (tumc)).
0 (Addressing of KFLDHBN via intake air temperature (tans)).

Parameter	**Description**
CWRLMX	Codeword for LDRLMX (boost pressure control)
FKRXTOL	Factor for correction of rlmax at higher engine oil temperature
KFFKRXTM	Factor for correction of rlmax at higher engine temperature
KFFLDEO	Factor for boost pressure intervention at overboost value via knock control
KFFLLDE	Factor for slow boost pressure control intervention at rlmax via knock control
KFFSLDE	Factor for fast boost pressure control intervention (lowering)
KFFWLLDE	Weighting factor for slow boost pressure intervention at rlmax via knock control
KFLDHBN	Boost pressure control upper limit (maximum compressor pressure ratio)
KFTARX	Map for maximum cylinder charge IAT correction factor
KFTARXZK	Map for maximum cylinder charge IAT correction factor during continuous knock
LDORXN	Maximum cylinder charge LDR during E_ldo (overboost error)
LDPBN	Charge pressure control P-limit when engine temperature is too high
LDRXN	Maximum cylinder charge (charge pressure control)
LDRXNZK	Maximum cylinder charge during continuous knock (charge pressure control)
RLKRLDA	RL-threshold for slow charge pressure control intervention (adaption)
SNM08LDUB	Sample point distribution for charge pressure control
SNM08LDUW	Sample point distribution for charge pressure control
SNM12LDUW	Sample point distribution for charge pressure control
STA08LDUB	Sample point distribution for charge pressure control
SWK08LDUW	Sample point distribution for charge pressure control
SWK108LDUW	Sample point distribution for charge pressure control
SWK208LDUW	Sample point distribution for charge pressure control
SY_ATR	System constant: exhaust gas temperature control available
SY_GGGTS	System constant: temperature transducer signal accuracy
SY_TFMO	System constant: TOEL-sensor present (Initial. GGTFM surrogate value)
SY_TFUMG	System constant: ambient temperature sensor present
SY TRLX	System constant: intervention for workshop tester for rlmax present
TLKRLDAB	Time constant for slow LDR-reduction
TLKRLDAU	Time constant for slow LDR-up regulation
TMOTMX	Engine temperature threshold for initial filling of the fuel system
TOELMX	Oil temperature threshold for engine protection during transmission emergency
TOLEWRLMX	Surrogate oil temperature value with faulty CAN-message
TSKRLDAB	Time constant for fast charge pressure control lowering
TSKRLDAU	Time constant for fast charge pressure control up-regulation
Variable	**Description**
B_ATRF	Condition: exhaust gas temperature control error
B_ATSB	Condition: exhaust gas temperature sensor operational
B_BRLMX	Condition: charge pressure control limit for maximum cylinder charge
B_CKIEN	Condition: CAN-transmission from instrument cluster enable
B_KFZK	Condition: map for knock protection
B_LL	Condition: idle
B_PWF	Condition: power fail
B_TMKIB	Condition: engine temperature from the instrument cluster operational
B_TOLCB	Condition: oil temperature from instrument cluster can be evaluated
B_TUMCB	Condition: error in CAN-ambient temperature information
DFP_ATS	ECU internal error path number: exhaust temperature sensor, cylinder bank 1
DFP_ATS2	ECU internal error path number: exhaust temperature sensor, cylinder bank 2
DFP_LDO	ECU internal error path number: overboost charge pressure control

DFP_TA	ECU internal error path number: intake air temperature TANS (-charge air)
DFP_TM	ECU internal error path number: engine temperature
DFP_TMKI	ECU internal error path number: engine temperature from the instrument cluster
DFP_TOL	ECU internal error path number: oil temperature
DRLMAXO	Delta maximum cylinder charge during overboost
DWKRM_W	Difference: wkrm – wkrmstat
E_ATS	Error flag: exhaust gas temperature sensor, cylinder bank 1
E_ATS2	Error flag: exhaust gas temperatur sensor, cylinder bank 2
E_LDO	Error flag: charge pressure characteristic; upper value exceeded
E_TA	Error flag: intake air temperature
E_TM	Error flag: engine temperature
E_TMKI	Error flag: engine temperature from the instrument cluster
E_TOL	Error flag: oil temperature
FLDRRX_W	Correction factor for maximum cylinder charge from knock control
FLDRXK_W	Factor for LDR rlmax-correction via the short-time part
FLDRXL_W	Factor for LDR rlmax-correction via the long-time part
FLDRXO_W	Factor for charge pressure lowering of the overboost values (drlmaxo)
FRXT	Factor for correction of rlmx as a function of tmki and tol
FRXTA_W	Factor for correction of rlmx as a function of intake air temperature
FUPSRL_W	Factor for system-related conversion of pressure to cylinder charge (16-Bit)
LDRLMS_W	Limiting value for maximum cylinder charge LDR for engine protection
LDRLTS_W	Limting value for maximum cylinder charge LDR for turbocharger protection
NMOT	Engine speed
NMOT W	Engine speed (word)
PIRG_W	Partial pressure of residual gas internal exhaust gas recirculation (16-Bit)
PU	Ambient pressure
RL	Relative cylinder charge
RLMAX_W	Maximum permitted charge at the turbo
RLMXKO_W	Maximum corrected cylinder charge (without limitations)
RLMX_W	Rohwert maximum cylinder charge
TANS	Intake air temperature
TMKI	Engine temperature from the instrument cluster
TMOT	Engine temperature
TMOTLDRLMX	Engine temperature in LDRLMX after selection (tmot/tmkic/tmki)
TOEL	Oil temperature
TOELLDRLMX	Oil temperature in LDRLMX after selection (tolc/toel/TOLEWRLMX)
TOLC	Oil temperature from instrument cluster message
TSEL	Selected temperature (tans/tumc)
TUMC	Ambient temperature from CAN-cluster
VFZG	Vehicle speed
VSRLMX	Additive cylinder charge correction for rlmx from the adjustment system
VSTRLX	Adjustable value of the maximum cylinder charge for the calibrator/tester
WKRMA	Average value of the individual cylinder ignition angle retardation (knock control), general (in emergency mode with safety margin)
WKRMDY_W	Dynamic average value of the individual cylinder ignition angle retardation
WKRMSTAT_W	Quasi-steady state average value of the individual cylinder ignition angle retardation
WKRMSU_W	Total value of the dynamic and static average value of the individual cylinder ignition angle retardation

LDRPID 25.10 (Charge Pressure Regulation PID Control)

See the *funktionsrahmen* for the following diagrams:

LDRPID Main
LDRPID PID Parameters
LDRPID PID Control
LDRPID BB PID
LDRPID STLD
LDRPID BBLDRPID
LDRPID LDIMXAK
LDRPID SSTB
LDRPID Initialise
LDRPID E-LDRA

LDRPID 25.10 Function Description

When charge pressure regulation (B_ldr) is active, the control error (lde) of the difference between ambient pressure (plsol) and the pressure upstream of the throttle (pvdkds) is calculated; when charge pressure regulation is inactive, lde is set to 0.

PID-Control:
This control scheme uses a type 3PR2 (three parameter controller with two output parameters to be optimised) PID controller with adaptive pilot-operated integral control. The integral component takes the form of min/max limitation within an applicable tolerance band to give adaptive tracking of duty cycle during steady-state running. To use the entire duty cycle range (which has very different gradients) it is necessary to linearise the control system software, so that the PID-controller gives a linear response. This is achieved with the map KFLDRL which closely regulates the wastegate controller duty cycle by applying an opposing non-linearity so that the regulator-controlled system appears linear.

The control algorithms are defined thus:

Proportional component	ldptv	= (LDRQ0DY (or LDRQ0S) − KFLDRQ2 (or 0)) × lde
Integral component	lditv	= lditv(i−1) + KFLDRQ1 (or LDRQ1ST) × lde(i−1)
Derivative component	ldrdtv	= (lde − lde(i−1)) × KFLDRQ2 (or 0)

where lde is the charge pressure regulation control error, i.e. (set point − process value) or (DV − MV)

There are basically two distinct operating modes:

1. !B_lddy: Quasi steady-state operation with PI control which gives a relatively weak control action. Derivation of the control parameters is carried out via oscillation testing on an engine dynamometer using the Ziegler-Nichols tuning method.

2. B_lddy: Dynamic performance with PID control which gives a strong control action. Derivation of the control parameters is carried out via oscillation testing on an engine dynamometer.

These operating states are distinguished via the control error, i.e., a positive deviation above a threshold activates the dynamic control intervention and it is only withdrawn when the deviation changes sign (i.e. the actual value exceeds desired value). The transient is managed with the aim of not causing overshoot over the entire region in the quasi steady-state mode.

In the quasi steady-state operation, the derivative component of the corresponding parameter is switched off to avoid unnecessary control signal noise. In the dynamic mode, a minimum settling time is obtained with the help of a strongly-intervening proportional component. The control is robust up to run and to further improve the transient response of the integral component, an adaptive limit is provided. This limiting factor is a function of engine speed (nmot), ambient pressure (plsol), altitude (pu), intake air temperature (tans) and the additively-superimposed 5 range adaptation.

These limits reliably prevent the integral controller causing overshoot. An integral output above the applicable upper safety limit (LDDIMXN) or below the lower limit (LDDIMN) will disable the steady-state integral function. The structures of the limits are interpreted as follows:

Real-Time Tracking and Adaptation:

LDRPID 25.10 (Charge Pressure Regulation PID Control)

1. Negative Tracking
1.1 In the quasi-steady state at full load condition (B_ldvl) with B_ldr (LDR active) after debounce time TLDIAN, the actual limiting value ldimxr is adjusted down to smaller duty cycle values with the increment LDIAN until the corrected value of the actual integral component (lditv) is achieved.

1.2 ldimxr will also be adjusted down if, during dynamic operation under full load, an overshoot greater than LDEIAU for a period longer than the debounce time TLDIAN occurs.

2. Positive Tracking
If the actual limiting value is too small order to correct fully, i.e. (a) deviation > LDEIAP (approx. –20 mbar), (b) lditv is at its end stop (i.e. ≥ ldimxr + ldimxak) or (c) closed-loop conditions (B_ldr) on the expiry of a engine speed-dependent debounce time TLDIAPN with increments LDDIAP per program run, the actual limiting value ldimxr is corrected to larger values until the current demand for integration is just met, and the prescribed safety margin to the integrator limiting value is maintained. The engine speed must always be above NLDIAPU. In addition to the aforementioned conditions, with only a slight MV-DV control error (lde < LDEIAPS, for example, 60 mbar), the debounce time previously tracked positive will be reduced by FTLDIAP.

3. Read Adaptation
When full load conditions B_ldr (lditv > 0) are met or when the sample points change, the adaptation range is read, whereby the change is confined between the current adaptation value and the current adjustment values LDMXNN or LDMXPN. Discontinuity in the driving behavior can be prevented via this method.

4. Write Adaptation
The stored adjustment value (write adaptation) occurs only after expiry of the debounce time TLDIAPN, detection of full load condition (B_ldvl) and above a speed threshold (NLDIAPU).

LDRPID 25.10 Application Notes

Determining the Variables

1. Linearization Map KFLDRL:
On the engine dynamometer, the course of the boost pressure pvdkds is determined as a function of duty cycle. These efforts should fully open the throttle plate such that the duty cycle (see CWMDAPP, code word for application without torque functions) is driven significantly above the normal maximum. Charge pressure can be driven out as far as possible (up to 300 mbar above the maximum boost pressure) to determine the course as completely as possible. This is done in 500 rpm increments starting at 1,500 rpm up to the maximum engine speed (Nmax). The necessary linearization values listed below at any speed graphically (or numerically) are determined as follows: In a graph of pvdkds as a function of ldtvm, the values lie on a straight line between the first measuring point (0%) and by the last measuring point (max. 95%). After that, e.g. starting at 10% duty cycle, the pressure values belonging to the linear relationship and the pressure values corresponding to the ldtvm value of the curve are determined.

These ldtvm values are now entered in each field in the characteristic curve KFLDRL at the appropriate reference point (here 10%). Ensure that the incoming duty cycle is equal to the outgoing at no later than 95% duty cycle (= LDTVMX). The application target is to achieve the widest possible linearization of the controlled system from the perspective of the regulator.

2. LDRQ0DY: by the process of so-called control variable specification, i.e. in the lowest speed within full load conditions B_ldr, the control value (duty cycle) should be equal to 100% for only a short time. Including the project-specific boundary condition emax, the maximum possible deviation (mean full load value – mean base boost pressure value) is obtained as follows:

LDRQ0DY = 100% / emax (%Duty Cycle ÷ 100 mbar)

3. KFLDRQ2: when n < 2500 rpm = 0; for n > 2500 in the range of medium-sized MV-DV control errors (lde) increase KFLDRQ2 incrementally up to maximum 0.6 (maximum 0.9) × LDRQ0DY. When n > 2500 rpm and lde < 100 mbar or lde > 500 mbar, reduce KFLDRQ2 on a sliding scale to 0 if benefits are observed. To counteract problems with overshooting caused solely by the engine/turbocharger (using oscillation testing with pure control) large KFLDRQ2 values in conjunction with slightly larger LDRQ0DY values should be tried.

4. Steady-state Control Parameters

4.1 LDRQ0S through an oscillation test with proportional control by the Ziegler-Nichols method on the engine dynamometer: full load operating points (possibly with overboost) in the speed range of the maximum engine torque (i.e. nMdmax –100/+300 RPM) with PI control (initially setting weak control action parameters!) to approach a control error equal to zero. Thereafter, by changing LDRQ1ST to be equal to 0 in proportional control and LDRQ0S appears to increase until distinct oscillation of controlled variable occurs. By so doing, the controlled variable will be suitable to read off an oscillation around the cycle time/period (Tcrit) (a clearly recognizable sine curve is required!). With the two measured values Tcrit and LDRQ0S(crit), the parameters LDRQ0S and LDRSTQ1 can be determined as follows:

Caution: UMDYLDR for this test is set to the maximum value!

LDRQ0S = 0.4 × LDRQ0S(crit.)

4.2 LDRSTQ1 = 0.5 × LDRQ0S(crit.) × T_0/T_{crit}; T_0 = sample time (usually = 0.05 s) for all parameters über n i.d.R. same values apply.
The three values determined below can (and should) be reduced if advantages are observed in driving performance. An increase is not acceptable for reasons of stability!

5. Determination of the Integral Limits:

KFLDIMX specifies the steady-state duty cycle values.
KFLDIOPU specifies the duty cycle correction values as a function of altitude (pu).
LDIATA specifies the correction values as a function of intake air temperature (tans).

Integral Limit Adaptation:
Detection of full-load charge pressure regulation occurs about 2% from the actual pedal stop B_ldvl.

LDEIAU: ca. –100 mbar
LDAMN: –15... –20 %
LDEIAO: 20...30 mbar
LDEIAP: ca. –20 mbar
LDEIAPS: ca. 60 mbar
TLDIAN: ca. 0.3 s
TLDIAPN: ca. 1.5 × respective T95-time
FTLDIAP: ca. 0.1...0.2
FTLDIA: ca. 0.5...1
NLDIAPU: response speed (highest full load pressure that can be regulated) as a function of pu + ca. 250/min

Caution: Ensure that the lowest learning cell in the altitude correction is writable otherwise, when starting from a low speed, the initial adaptation value of the lowest learning cell (= 0%) will be removed and the overlying cells for correcting the adjustment limit (false) will be overwritten!

STLDIA 1 > NLDIAPU (Max.)

LDMXNN: ca. –5%
LDMXNP: ca. 5%

6. UMDYLDR: ca. 5% of the maximum desired value.

7. Adjust KFLDRQ1 until the transient responses of the integral component resulting from load jumps from medium load to full load towards the end of the short-term attack time just reach the actual limiting value ldimx (at all speeds!). In this application, LDDIMXN increments should be no more than 2 to 3%!

8. LDDIMXN: about 15% below NLDIAPU (high speed) and about 3% above this speed (simultaneously fully regulating the safety margin)

9. LDDIMNN: apply in the case of transitory problems arising from lighter dynamic response of around 5%, otherwise use the maximum value to deaden/nullify the function.

Parameter	**Description**
CWLDIMX	Codeword for application procedures KFLDIMX/KFLDIOPU
FTLDIA	Factor for enabling debounce adaptation

FTLDIAP	Factor for debounce time for tracking positive integral adaptation
KFLDIMX	Map specifying the integral control limits for charge pressure regulation
KFLDIOPU	Correction for altitude influences on the duty cycle value
KFLDIWL	Correction charge pressure regulation integral limits during warm-up
KFLDRL	Map for linearising charge pressure as a function of duty cycle
KFLDRQ0	Map for PID control parameter Q0 (proportional coefficients) in charge pressure regulation
KFLDRQ1	Map for PID control parameter Q1 (integral coefficients) in charge pressure regulation
KFLDRQ2	Map for PID control parameter Q2 (derivative coefficients) in charge pressure regulation
KFRBGOF	Offset for the integral control limit in charge pressure regulation PID control
LDAMN	Minimum limiting value in charge pressure regulation integral adaptation
LDDIAN	Increment per program run for the negative tracking integral limit
LDDIAP	Increment per program run for the positive tracking integral limit
LDDIMNN	Safety margin integral control negative limit in charge pressure regulation
LDDIMXN	Safety margin integral control limit in charge pressure regulation
LDEIAO	Upper control error threshold for negative adjustment
LDEIAP	Control error threshold for positive adaptation integral control
LDEIAPS	Control error threshold for fast positive tracking
LDEIAU	Lower control error threshold for negative adjustment
LDHIA	Hysteresis for the charge pressure regulation integral adaptation curve
LDIATA	Integral limit correction as a function of intake air temperature (Tans) in charge pressure regulation PID control
LDMXNN	Maximum tracking limit for negative control adaptation in charge pressure regulation
LDMXNP	Maximum tracking limit for positive control adaptation with range change in charge pressure regulation
LDRQ0S	Control parameter Q0 in steady-state operation for charge pressure regulation PID control
LDRQ1ST	Control parameter Q1 in steady-state operation (integral coefficients) for charge pressure regulation PID control
LDRVL	Full load detection threshold in charge pressure regulation
NLDIAPU	Speed threshold for integral limits adaptation
SLD04LDUB	Sample point distribution for charge pressure regulation
SNG08LDUB	Sample point distribution for filtered speed gradient (ngfil) in charge pressure regulation
SNM08LDUB	Sample point distribution for charge pressure regulation
SNM08LDUW	Sample point distribution for charge pressure regulation
SNM16LDUB	Sample point distribution for charge pressure regulation
SNM16LDUW	Sample point distribution for charge pressure regulation
SPL08LDUW	Sample point distribution for charge pressure regulation
SPS08LDUW	Sample point distribution for charge pressure regulation
SPU08LDUB	Sample point distribution for charge pressure regulation
STA08LDUB	Sample point distribution for charge pressure regulation
STLDIA1	Sample point 1 for charge pressure regulation adaptation characteristic curve
STLDIA2	Sample point 2 for charge pressure regulation adaptation characteristic curve
STLDIA3	Sample point 3 for charge pressure regulation adaptation characteristic curve
STLDIA4	Sample point 4 for charge pressure regulation adaptation characteristic curve
STV10LDSW	Sample point distribution for charge pressure regulation
SY_TURBO	Turbocharger system constant
TLDIAN	Debounce time for tracking negative integral adaptation
TLDIAPN	Debounce time for tracking positive integral adaptation
TVLDMX	Upper duty cycle limit for charge pressure regulation
UMDYLDR	Cut-off threshold for dynamic charge pressure regulation

Variable	**Description**
B_ADRLDRA	Condition flag for deleting charge pressure adaptation values by deleting memory errors
B_LDDY	Condition flag for dynamic mode in charge pressure regulation
B_LDIMXA	Condition flag for adaptation limiting value in charge pressure regulation integral control
B_LDIMXN	Condition flag for negative correction ldimxr
B_LDIMXP	Condition flag for positive correction ldimxr
B_LDR	Condition flag for activating charge pressure regulation
B_LDVL	Condition flag for full load charge pressure regulation
B_PWF	Condition flag for power fail
B_STLDW	Condition flag for sample point change in charge pressure regulation adaptation
DFP_LDRA	Intake manifold error: boost deviation
E_LDRA	Errorflag: charge pressure control deviation
IMLATM	Integration of mass air flow from engine start to maximum value
IRBGOF_W	Offset for the LDRPID integral controller limit dependent on speed gradient
LDE	Charge pressure regulation control error (desired value – measured value)
LDIMN_W	Current value for the minimum limit in charge pressure regulation integral control
LDIMXA	Adaptation correction for the maximum limit in charge pressure regulation integral control
LDIMXAK_W	Current corrected limit in charge pressure regulation integral control
LDIMXRK_W	Maximum limiting value (corrected reference value) in charge pressure regulation integral control
LDIMXR_W	Actual reference value for the maximum limit in charge pressure regulation integral control
LDIMX W	Actual value of the maximum limit value in charge pressure regulation integral control

<u>LDRPID 25.10 (Charge Pressure Regulation PID Control)</u>

LDITV_W	Charge pressure regulation duty cycle from the integral controller (word)
LDPTV	Charge pressure regulation duty cycle from the proportional controller
LDRDTV	Charge pressure regulation duty cycle from the derivative controller
LDRKD_W	Charge pressure regulation (derivative control parameter)
LDRKI_W	Charge pressure regulation (integral control parameter)
LDRKP_W	Charge pressure regulation (proporational control parameter)
LDTV	Charge pressure regulation duty cycle
LDTVR_W	Charge pressure regulation duty cycle from the controller
NGFIL	Filtered speed gradient
NMOT	Engine speed
PLGRUS_W	Basic charge pressure desired value
PLSOL	Target (desired) charge pressure
PLSOLR_W	Relative target (desired) charge pressure (charge pressure regulation)
PLSOL_W	Target (desired) charge pressure
PU	Ambient pressure
PVDKDS	Pressure before the throttle pressure sensor
RLMAX_W	Maximum achievable cylinder charge with turbocharger
RLSOL_W	Target (desired) cylinder charge
STLDIA	Current sample point for charge pressure regulation adaptation
TMST	Engine starting temperature

LRSHK 9.20 (Continuous Post-Catalyst Lambda Control)

See the *funktionsrahmen* for the following diagrams:
lrshk-lrshk: function overview
lrshk-lrhkini: initialization of the post-catalyst lambda control
lrshk-lrhkebg: general switch conditions post-catalyst lambda control
lrshk-lrhkla: determination of the error signal to lambda level
lrshk-dlahksm: selection of fr-synchronous lambda averaging/filtering by average value/linearizing lrshk-lambda directly
lrshk-lrhkebp: cylinder bank-specific readiness switch
lrshk-lrhkb1: PI controller post-catalyst with activation condition, cylinder bank 1
lrshk-lrhkb2: PI controller post-catalyst with activation condition, cylinder bank 2
lrshk-lrhkeb: cylinder bank-specific enable of proportional and integral components, cylinder bank 1
lrshk-lrhkeb2: cylinder bank-specific enable of proportional and integral components, cylinder bank 2
lrshk-lrhkip: PI controller, cylinder bank 1
lrshk-lrhkip2: PI controller, cylinder bank 2
lrshk-lahkma: fr-synchronous averaging

Function Description

Control with the post-catalyst probe is superimposed on the pre-cat lambda control.

Control action on the pre-catalyst control is via the delta-lambda-correction variables dlahi_w and dlahp_w.

Post-catalyst Control:

This is switched off by setting bit 0 in word CLRSHK code to 1 (FALSE).

PI Control Action

Post-catalyst lambda control is achieved with a PI controller. Control action via the proportional component dlahp_w will be immediate because it has no "memory" of the correct sign with respect to the control position after a change of lambda probe voltage due to enrichment or enleanment by the delta-lambda intervention.

Via the integral component, post-catalyst control LRSHK is able to compensate, to a large extent, for exhaust gas deterioration, caused by a shift of the steady-state probe characteristic.

The LRSHK calculation is carried out continuously on the lambda level. This requires that the probe voltage ushk_w is linearized via the characteristic LALIUSH (lamsonh_w). A similar linearization is performed with the voltage target value USRHK (lamsolh_w). The pseudo-value lamsonh_w can continue to work via the project-specific codeword CLRSHK

(a) directly (→ default in continuous pre-catalyst control, intervention is possible every 10 ms)

(b) via a PT1 filter (→ project-specific)

(c) fr-synchronous averaged (→ default for two-point control, as the ratio can be added only before the fr-jump)

because lamhm_w will supply the control error dlashkm_w.

By assessing the characteristic curves KDLASHKP and KDLASHKI, the control error dlashkm_w can be corrected separately according to the catalyst properties before the calculation of the P and I components.

The resulting skewed control errors dlashkp_w or dlashki_w are now weighting with KPLRHML = f (ml) of the proportional component dlahp_w, or by weighting with KILRHML = f (ml) of the integral component dlahi_w.

In the case of aged catalysts, control oscillation of the pre-catalyst control imprinting itself on the post-catalyst probe voltage behaviour which, if proportional intervention is left unchanged, can lead to post-catalyst control oscillations. Moreover, catalyst ageing, which is associated with a decrease in the oxygen storage capacity, the need for the P action in post-catalyst control is less important. Therefore, in a further multiplication by the weighting factor from the characteristic PLRHAV = f(avkatf), the proportional component of the post-catalyst control is revoked for aged catalysts.

Effect on LRSHK of the Lambda Probe Diagnostics

Post-catalyst control takes over the additional delta Lambda offsets (dlahki_w → pre-catalyst actual value offset, dlahkp_w → pre-catalyst target value offset) from the former control in LRS 15.40. The magnitude of the intervention dlahi_w is a measure of probe ageing and is used in the diagnosis of lambda probe aging. A symmetric increase in the probe response time cannot be detected by dlahi_w.

Control Threshold from Map KFUSHK

If the post-catalyst probe reports that the mixture is, for example, too lean, dlahp_w will be negative according to the selected control direction and dlahi_w will become smaller. Thus, there is an enrichment until ushk goes back up to the control threshold usrhk. In contrast to the pre-cat control, a map is provided for the post-catalyst control threshold. Via the choice of threshold, a slight load or speed-dependent lambda offset can be achieved.

If catalyst diagnostics are required in the short test B_fakat = TRUE is switched to the threshold USRHKFA.

LRSHK Control Dynamics

The superimposed control is significantly slower than the control applied before the catalyst. Since at low air mass flow rates (low load or engine speed point), the post-catalyst probe voltage as a general rule can exhibit more erratic behaviour and oscillations, following low probe voltages it should not be evaluated so strongly here. The time constant of the post-catalyst control depends on the air mass flow rate ml (→ characteristic KILRHML). At high air mass flow rates, the integration rate should be selected higher as a general rule.

Activation Conditions

If post-catalyst control LRSHK is disabled, the learned integrator value dlahi_w up to that point is the output of the post-catalyst controller. Also, when stopping the engine over the value of the continuous RAM.

The activation conditions for the proportional and integral components are defined differently and are indicated by the bits B_lrhkp and B_lrhk.

The following conditions apply for the proportional component:

When pre-catalyst control readiness (B_lr = 1) is detected, LRSHK is enabled after the delay time TBLRH. This is only useful for lambda target values (lamsons_w = 1) of the pre-catalyst control.

Post-catalyst regulation is only activated above a certain catalyst temperature threshold (tkatm > TKATMLRH) and the operational readiness of the post-catalyst probe (B_sbbhk) is activated.

The following additional conditions apply for the integral component:

Thus, the integrator is only disabled when nmot or rl is in the ranges (NLRHU ≤ nmot ≤ NLRHO and RLRHUN(nmot) ≤ rL ≤ RLRHON(nmot)). The characteristic curves RLRHUN and RLRHON make it possible to select engine speed-dependent rL-limits on the control range. This allows the control range to be defined so that the operational ranges which give rise to incorrect adaptation of post-catalyst control are delineated. This can happen at operating points where, for example, air mass flow rates are too low.

After the overrun fuel cut-off, the catalyst is saturated with oxygen. The post-catalyst probe voltage will retain small, lean values for a certain time. In this phase, the system deactivates the section LRSKA of the post-catalyst control via bit B_lrka.

After the end of catalyst clear out, post-catalyst control is prohibited until the air mass MLNKAX has passed through the catalytic converter.

If the bit B_tehb corresponding to “tank venting high loading” is set, the integral component of LRSHK is deactivated because the integrator would learn wrong values in this case. The proportional component remains active in this case since it helps to reduce exhaust problems.

In addition, a series of diagnostic errors deactivates post-catalyst control.

Dynamic Overshoot of the Control Threshold after Catalyst Clear Out

After the end of catalyst clear out, the post-catalyst probe voltage oscillates significantly higher than the nominal value of 600 mV for typically 5 to 30 s. The probe voltage attains values of 750-800 mV. The overshoot depends on the catalytic properties. With catalyst types that do not exhibit this behavior, the excess can be applied away.

SCHEMATIC

The probe voltage characteristic ushk and the status bits B_sa (boost cut-off) and B_lrka (catalyst clear out) are illustrated schematically in the diagram above.

Thus the "time" (air mass MLNKAX) during which the post-catalyst control is prohibited can be kept as short as possible, the probe voltage behaviour after catalyst clear over time is described by a dynamic increase in the target value. The input of a quick PT1 filter is populated with LASHKAB and governed by the time constant ZLASHKAB to 0. The time constant is derived from the adopted course of the probe voltage.

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Through this function it is possible, in cases in which the catalyst clear out function has not been successful, or a situation in which the pre-catalyst control condition gives rise to a lean post-catalyst probe voltage, the probe voltage can be raised via LRSHK.

Application Notes

LRSHK Application Procedure:

Codeword CLRSHK

The codeword CLRSHK was introduced in order influence the treatment of the adaptation value dlahi_w within the application. The importance of the individual control bits in CLRSHK are described under the block comments.

Sensible combinations, in decimal, are listed below:

CLRSHK = odd: LRSHK is deactivated

CLRSHK = 16: dlahi_w will erase memory errors when reset with the value DLAHIINI, otherwise default status for LRSHK

CLRSHK = 24: dlahi_w is reset with the value DLAHIINI when the engine starts

Parameter LRSHK

The application of LRS must be completed

4 x 4 grid points are provided for map KFLASOHK:

Suggestion: mot: 1000, 1800, 2400 & 3000 rpm

rL: 14, 42, 56 & 70%

- Lower control limit e.g. NLRHU = 1200 rpm

Characteristic curve RLRHUN is dependent on n

- Upper control limit e.g. NLRHO = 3000 rpm

Characteristic curve RLRHON is dependent on n

The characteristic curves RLRHUN and RLRHON are strongly project-dependent. However, a characteristic with four sample points, which lie between NLRHU and NLRHO should be sufficient.

- TKATMLRH is chosen so as to control catalyst temperatures >300°C. There is a catalyst temperature model (module ATM) which yields catalyst temperatures, tkatm.

- TBLRH is dependent on the catalytic properties and should be at least 1 second to be selected. Via this label, the time that elapses after switching on the lambda control until the post-catalyst probe signal is correlated against the pre-catalyst control scheme is defined.

- KILRHML curve describes the rate of integration of the air mass in %/s.

Reference points for example engine with ml load: 450 kg/hr

ml: 8, 28, 88, 200, 400 kg/hr

KILRHML: 0.0015, 0.003, 0.0045, 0.006 and 0.0075 /s

Characteristic Curves KDLASHKI and KDLASHKP

The control error corresponding to project-specific lambda probes and catalytic converter properties can be defined via the characteristic curves KDLASHKI and KDLASHKP. So firstly, inaccuracies of the probe voltage linearization (LALIUSH) are corrected and secondly, the emissions characteristics of catalytic converters are considered.

Application of the Proportional Component in the LRSHK PI-Control Scheme:

The effective action of the proportional component of the post-catalyst control system is calculated as follows:

dlahp_w = dlashkl × KPLRHML (ml) × PLRHAV (avkatf)

The influence of catalyst ageing is included as a multiplier in the calculation (RAM cell dlahp_w) using a factor from the characteristic curve PLRHAV, as described above. For a new catalytic converter (avkatf at 0.0), PLRHAV is populated with the value 1.0. With increasing amplitude ratio (as the catalyst ages), PLRHAV is returned to 0.0.

The choice of parameters is determined mainly by the properties of the catalyst. When we ask questions in the application development function, please contact us.

Application of the Parameter MLNKAX:

The overshoot voltage of the lambda probe after the end of the catalyst clear out function is a project-specific phenomenon, which disrupts the LRSHK. Therefore, LRSHK should be blocked until the air mass MLNKAX has been enforced. Since there is no experience (especially with the new catalyst types), the definition of the parameters should be consulted in the responsible function for LRSKA.

Application of the Parameter KILRHML:

During application of the map KFLASO in module LRS, the post-catalyst control integration rate will be set by means of the curve KILRHML so that one sample point of the integrator control stroke dlahi_w of ±0.03 to ±0.04 is measured. During measurement, the air mass at the respective operating point is noted. After completion of the application of map KFLASO, the set values from KILRHML are plotted against air mass. The air mass is obtained from a scatter plot. The actual curve KILRHML in LRSHK is obtained by averaging the point cloud.

For more detailed information, please refer to the general application note in the module covering Continuous Lambda Control.

Abbreviations

Parameter	**Description**
CLRSHK	Codeword to enable LRSHK and select initialization
DLAHINI	Initial value of the integrator dlahi in LRSHK, Bank 1
DLAHINI2	Initial value of the integrator dlahi in LRSHK, Bank 2
KDLASHKI	Characteristic curve of dlashkm, weighting factor for integral component in LRHK, Bank 1
KDLASHKI2	Characteristic curve of dlashkm, weighting factor for integral component in LRHK, Bank 2
KDLASHKP	Characteristic curve of dlashkm, weighting factor for proportional component in LRHK, Bank 1
KDLASHKP2	Characteristic curve of dlashkm, weighting factor for proportional component in LRHK, Bank 2
KFUSHK	Probe voltage target value for post-catalyst control (instead KFUSRHK for Variantenk.)
KILRHML	Integral component for LRSHK
KPLRHML	Proportional component for LRSHK
LALIUSH	Lambda linearization, post-catalyst probe, Bank 1
LALIUSH2	Lambda linearization, post-catalyst probe, Bank 2
LALIUSRH	Lambda linearization, post-catalyst probe, target value, Bank 1
LALIUSRH2	Lambda linearization, post-catalyst probe, target value, Bank 2
LASHKAB	Initial value for dynamic target value increase (lamsolh) in LRHK
LRHIMN	Minimum limit of the integrator constant in LRHK
LRHIMX	Maximum limit of the integrator constant in LRHK
MLNKAX	Mass air threshold for activation readiness LRSHK integral component
NLRHO	Upper speed limit for post-catalyst control
NLRHU	Lower speed limit for post-catalyst control
PLRHAV	Catalyst ageing weighting factor for the proportional component in LRHK, Bank 1
PLRHAV2	Catalyst ageing weighting factor for the proportional component in LRHK, Bank 1
RLLRHON	Characteristic curve of nmot, rL upper control limit for the post-catalyst controller
RLLRHUN	Characteristic curve of nmot, rL lower control limit for the post-catalyst controller
RLLRHUFA	rL control limit for post-catalyst control functional requirement B_fakat
TBLRH	Deactivation time for post-catalyst control before it is enabled by pre-catalyst control
TKATMLRH	Switch threshold for model temperature for post-catalyst lambda control
USRHKFA	Probe voltage target value for control post-catalyst at function requirement, B_fakat
ZLASHKAB	Time constant for the dynamic speed regulation. Target value increase (dlasohkab) in LRHK
ZLASOHML	PT1-filter time constant for the pseudo post-catalyst lambda
Variable	**Description**
AVKATF	Filtered amplitude ratio laafh/laafv, Bank 1
AVKATF2	Filtered amplitude ratio laafh/laafv, Bank 2
B_DLAHINI	Condition flag: initialization of the LRSHK integral component, Bank 1
B_DLAHINI2	Condition flag: initialization of the LRSHK integral component, Bank 2
B_EDKVS	Condition flag: actual adaptation error thresholds exceeded, Bank 1
B EDKVS2	Condition flag: actual adaptation error thresholds exceeded, Bank 2
B_FAKAT	Condition flag: monitoring function requirement catalyst
B_FALSH	Functional requirement condition post-catalyst lambda probe, Bank 1
B_FALSH2	Functional requirement condition post-catalyst lambda probe, Bank 2
B_LR	LREB Condition: pre-catalyst lambda control, Bank 1
B_LR2	Condition: pre-catalyst lambda control, Bank 2
B_LRHK	Condition: post-catalyst lambda control, Bank 1
B_LRHK2	Condition: post-catalyst lambda control, Bank 2
B_LRHKB	Condition: post-catalyst lambda control, bank specific parameters, Bank 1
B_LRHKB2	Condition: post-catalyst lambda control, bank specific parameters, Bank 2

B_LRHKG	Condition: bank independent condition post-catalyst lambda control
B_LRHKP	Condition: enable condition proportional component post-catalyst lambda control, Bank 1
B_LRHKP2	Condition: enable condition proportional component post-catalyst lambda control, Bank 2
B_LRKA	Catalyst-clearing condition for stereo lambda control, Bank 1
B_LRKA2	Catalyst-clearing condition for stereo lambda control, Bank 2
B_LRSSP	Condition: lambda-control bit set if additional amplitude sign change
B_MDARV	Condition: critical dropout rate available
B_PWF	Power fail condition
B_SBBHK	Condition flag: post-catalyst lambda probe ready Bank 1
B_SBBHK2	Condition flag: post-catalyst lambda probe ready Bank 2
B_ST	Start condition
B_TEHB	Tank ventilation with high loading condition
C_FCMCLR	System status: error erasing memory
C_INI	ECU initialization condition
DLAHI_W	Integral component of LRSHK, Bank 1
DLAHI2_W	Integral component of LRSHK, Bank 2
DLAHINI2_W	Initialization value for integral component LRSHK, Bank 2
DLAHINI_W	Initialization value for integral component LRSHK, Bank 1
DLAHKAB_W	Dynamic elevation of the pseudo post catalyst lambda target value, Bank 1
DLAHKAB2_W	Dynamic elevation of the pseudo post-catalyst lambda target value, Bank 2
DLAHP_W	Proportional component of LRSHK, Bank 1
DLAHP2_W	Proportional component of LRSHK, Bank 2
DLASHKI_W	Delta Lambda weighted for integral component LRSHK, Bank 1
DLASHKI2_W	Delta Lambda weighted for integral component LRSHK, Bank 2
DLASHKM_W	Post-catalyst delta lambda control (actual value fr-synchronously averaged), Bank 1
DLASHKM2_W	Post-catalyst delta lambda control (actual value fr-synchronously averaged), Bank 2
DLASHKP_W	Delta-lambda weighted for proportional component LRSHK 5.30, Bank 1
DLASHKP2_W	Delta-lambda weighted for proportional component LRSHK 5.30, Bank 2
E_HSH	Error flag: post-catalyst lambda probe heating, Bank 1
E_HSH2	Error flag: post-catalyst lambda probe heating, Bank 2
E_HSV	Error flag: pre-catalyst lambda probe heating, Bank 1
E_HSV2	Error flag: pre-catalyst lambda probe heating, Bank 2
E_KAT	Error flag: catalytic conversion, Bank 1
E_KAT2	Error flag: catalytic conversion, Bank 2
E_LASH	Error flag: post-catalyst lambda probe ageing, Bank 1
E_LASH2	Error flag: post-catalyst lambda probe ageing, Bank 2
E_LM	Error flag: main load sensor
E_LSV	Error flag: pre-catalyst lambda probe, Bank 1
E_LSV2	Error flag: pre-catalyst lambda probe, Bank 2
E_SLS	Error flag: secondary air system, Bank 1
E_SLS2	Error flag: secondary air system, Bank 2
E_TES	Error flag: fuel tank breather system
E_TEVE	Error flag: fuel tank breather valve end stage, Bank 1
E_TEVE2	Error flag: fuel tank breather valve end stage, Bank 1
LAHKMZ	Status byte of the machine: fr-synchronous averaging pseudo lambda post-catalyst, Bank 1
LAHKMZ2	Status byte of the machine: fr-synchronous averaging pseudo lambda post-catalyst, Bank 2
LAMHF_W	Pseudo-linearized lambda post-catalyst, PT1 filtered, Bank 1, Word
LAMHF2_W	Pseudo-linearized lambda post-catalyst, PT1-filtered, Bank 2, Word
LAMHM_W	fr-synchronously averaged pseudo post-catalyst lambda value measured by the Nernst probe, Bank 1
LAMHM2_W	fr-synchronously averaged pseudo post-catalyst lambda value measured by the Nernst probe, Bank 2
LAMSOLH_W	Pseudo post-catalyst lambda target value, Bank 1
LAMSOLH2_W	Pseudo post-catalyst lambda target value, Bank 2
LAMSONH_W	Pseudo post-catalyst lambda value measured with Nernst probe (word), Bank 2
LAMSONH2_W	Pseudo post-catalyst lambda value measured with Nernst probe (word), Bank 2
LAMSONS_W	Lambda target value based on location of lambda sensor
LAMSONS2_W	Lambda nominal value based on location lambda sensor Bank2
ML	Air mass flow
MLNKA_W	Catalyst air mass after clear out, Bank 1
MLNKA2_W	Catalyst air mass after clear out, Bank 2
ML_W	Filtered air mass (Word)
NMOT	Engine speed
PERCNT_W	Number of 10 ms steps for fr-synchronous lamsolh averaging, Bank 1
PERCNT2_W	Number of 10 ms steps for fr-synchronous lamsolh averaging, Bank 2
RL	Relative air charge
R_T10	10 ms time frame
R_T100	100 ms time frame
SY_STERHK	System constant condition: stereo post-catalyst system
SY_STERVK	System constant condition: stereo pre-catalyst system
TKATM	Catalyst temperature from model Bank 1
TKATM2	Catalyst temperature from model Bank 2

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USHK_W	Lambda probe voltage (4.88 mV/LSB) post-catalyst, Bank 1
USHK2_W	Lambda probe voltage (4.88 mV/LSB) post-catalyst, Bank 2
USRHK	Actual post-catalyst lambda signal control threshold, Bank 1
USRHK2	Actual post-catalyst lambda signal control threshold, Bank 2
Z_LASH	Cycle flag: post-catalyst lambda probe ageing, Bank 1
Z_LASH2	Cycle flag: post-catalyst lambda probe ageing, Bank 2

FB MDBAS 8.30 (Calculation of the Basic Parameters for the Torque Interface)

MDBAS 8.30 Function Description

See the *funktionsrahmen* for the following diagrams:

MDBAS MDBAS (included in this translation)
MDBAS ZW NWS

The optimum torque values mioptl1_w at lambda = 1 are calculated with the help of the map KFMIOP. This torque is corrected for the influence of lambda by multiplying by the lambda efficiency (etalab). The lambda efficiency is obtained from the characteristic line ETALAM. Multiplying by the ignition angle efficiency gives the basic torque mibas. This corresponds to the indicated torque that is set when the combustion takes place with the basic lambda (lambas) and the base ignition angle (zwbas).

The optimum ignition angle at lambda = 1 is determined from the map KFZWOP. The sub-function ZW_NWS describes the influence on the optimum ignition angle of an existing camshaft timing adjustment. The equipment options are none, binary (on or off), or continuously variable camshaft timing adjustment. In the case of binary adjustment, the factor fnwue governs continuous switching between the maps KFZWOP and KFZWOP2. In the case of continuous camshaft timing adjustment which depends on the camshaft overlap angle (wnwue) an ignition angle correction is added to KFZWOP. The determined optimum ignition angle (zwoptl1) again applies for lambda = 1. The currently applicable camshaft timing adjustment type is defined by the system constant SY_NWS in SW generation:

SY_NWS = 0: no camshaft timing adjustment
SY_NWS = 1: binary camshaft timing adjustment
SY_NWS = 2: continuously variable camshaft timing adjustment
SY_NWS > 2: not defined.

The software is translated conditionally, i.e. there is only one variant in the EPROM. SY_NWS is not in the EPROM and can not be applied.

Additive corrections depending on lambda, the exhaust gas recirculation rate and engine temperature are included. The resulting ignition angle (zwopt) now forms the basis for the ignition angle efficiency calculation. The basic ignition angle efficiency is calculated using the characteristic ETADZW, the input value is obtained from the difference between zwopt and zwbas. This is followed by an averaging of the basic efficiencies across all cylinders and the result is the base efficiency etazwbm.

The ignition angle correction for exhaust gas recirculation operation can through the code word CWMDBAS either always be included or only included if B_agr = true. In the case of permanent inclusion, ignition angle jumps are avoided by switching off B_agr.

MDBAS 8.30 Application Notes

Exhaust gas recirculation should be inactive throughout all these measurements! Data input requires the following measurements to be made:

1. Operation at Lambda = 1:
Ignition angle fine tuning on an engine dynamometer at lambda = 1 with the engine at normal operating temperature at the following operating points:

Engine speed = 500, 750, 1000, 1250, 1500, 2000, 2500, 3000, 3500, 4000, 4500, 5000, 5500, 6000 & 6500 rpm (if possible)
Relative cylinder charge = 10, 20, 30, 40, 50, 60, 70, 80, 90 and 100%

Ignition angle fine turning begins at the ignition angle at which maximum torque is achieved (i.e. maximum brake torque, MBT) if not to drive at the knock limit. The ignition angle should now be retarded in steps of 4.5° crank angle until the latest mobile firing angle is achieved. The following data must be recorded at each point: engine speed (nmot), relative cylinder charge (rl), lambda, clutch torque and ignition angle.

2. Lambda Dependence
Ignition angle fine tuning through lambda at the following measuring points:

Engine speed = 1000, 2000, & 3000 rpm
Relative cylinder charge = 30, 50 & 70 %

Lambda = 0.80, 0.85, 0.90, 0.95, 1.00, 1.05, 1.10, 1.15 & 1.20

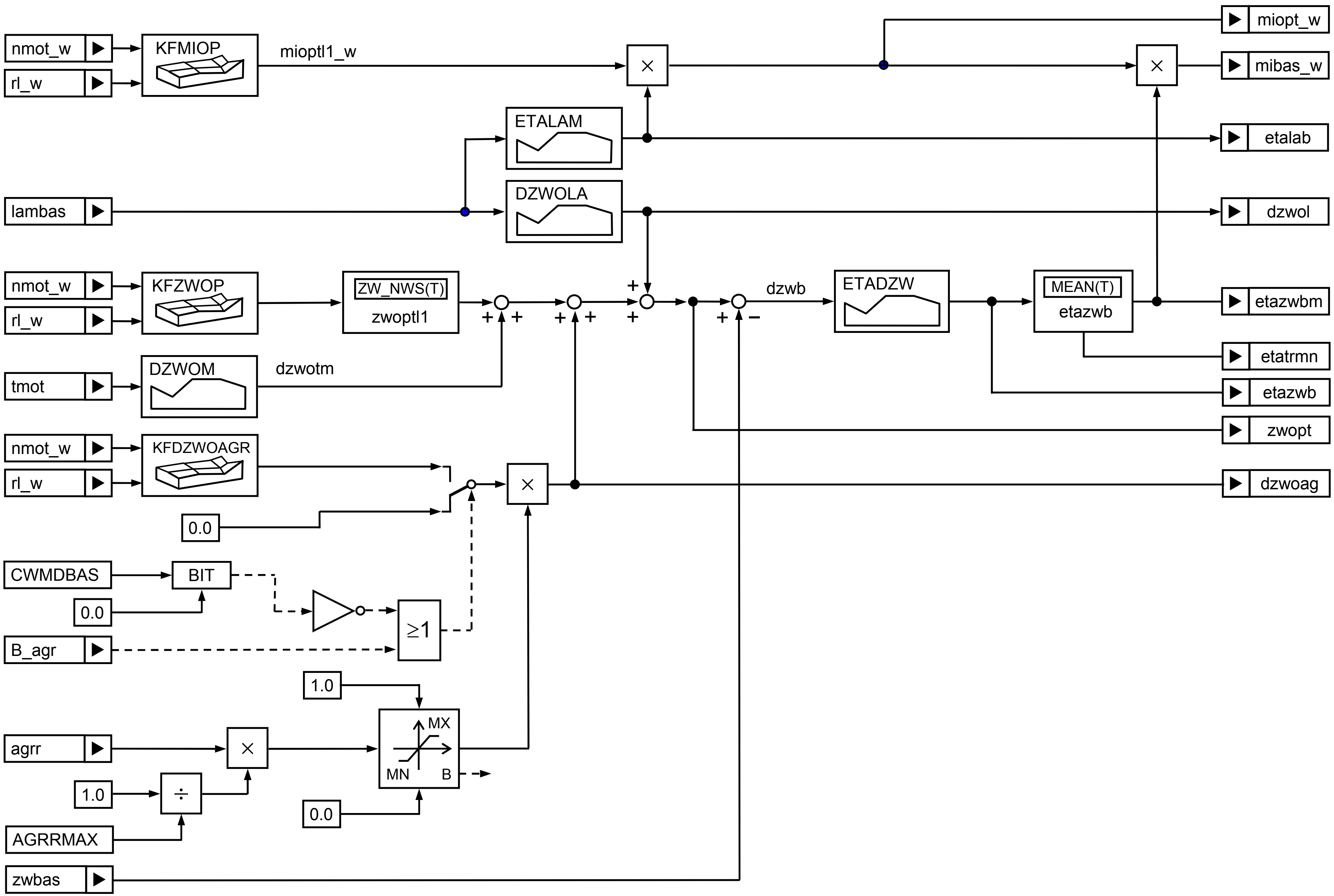
Measurements as above.

3. Drag Torque
The drag torque (engine braking) must be obtained at all the measuring points specified in 1. Measure on an engine dynamometer with no ignition and with the engine at its normal operating temperature.

4. Evaluation
Evaluation of the results takes place at K3/ESY4-Hes.

Parameter	**Description**
AGRRMAX	Maximum possible exhaust gas recirculation rate
CWMDBAS	Codeword to take account of the ignition angle correction for exhaust gas recirculation operation
DZWNWSUE	Delta ignition angle depending on camshaft angle
DZWOLA	Lambda dependence of the optimum ignition angle relative to lambda = 1
DZWOM	Temperature dependent offset of the optimum ignition angle
ETADZW	Ignition angle efficiency dependence on delta ignition angle
ETALAM	Lambda efficiency
KFDZWOAGR	Offset of the optimum ignition angle with exhaust gas recirculation operation
KFMIOP	Optimum engine torque map
KFZWOP	Optimum ignition angle
KFZWOP2	Optimum ignition angle variant 2
Variable	**Description**
AGRR	Exhaust gas recirculation rate
B_AGR	Exhaust gas recirculation one condition
DZWOAG	Exhaust gas recirculation rate dependent ignition angle correction of the optimum ignition angle
DZWOL	Lambda dependent ignition angle correction of the optimum ignition angle
DZWOTM	Temperature dependent ignition angle correction of the optimum ignition angle
ETALAB	Lambda efficiency without intervention based on optimum torque at lambda
ETATRMN	Minimum value of the cylinder barrel efficiency
ETAZWB	Ignition angle efficiency of the basic ignition angles
ETAZWBM	Mean ignition angle efficiency of the basic ignition angles
FNWUE	Weighting factor for inlet camshaft overlap
LAMBAS	Basic lambda
MIBAS_W	Indicated basic torque
MIOPTL1_W	Optimum indicated torque at lambda = 1
MIOPT_W	Optimum indicated torque
NMOT W	Engine speed
RL_W	Relative cylinder charge (word)
R_SYN	Synchro-raster
SY_NWS	System constant for camshaft control: none, binary (on/off) or continuous
TMOT	Engine (coolant) temperature
WNWUE	Camshaft overlap angle
ZWBAS	Basic ignition angle
ZWOPT	Optimum ignition angle

FB MDBAS 8.30 (Calculation of the Basic Parameters for the Torque Interface)



MDFAW 12.260 Driver's Requested Torque

See the *funktionsrahmen* for the following diagrams:

mdfaw-mdfaw	MDFAW overview
mdfaw-pedchar	Sub-function PEDCHAR: throttle pedal characteristic
mdfaw-mrfmx	Sub-function MRFMX: maximum relative driver requested torque
mdfaw-dmlwhs	Sub-function DMLWHS: indicated driver requested torque for change limitation in the homogenous charge mode
mdfaw-dmfabeg	Sub-function DMFABEG: change limitation for the driver's requests
mdfaw-sawe	Sub-function SAWE: change limitation during overrun fuel cut-off & reinstatement
mdfaw-filsawe	Sub-function FILSAWE: filter for change limitation during overrun fuel cut-off & reinstatement
mdfaw-dashpot	Sub-function DASHPOT: change limitation during negative load change (dashpot)
mdfaw-fildash	Sub-function FILDASH: filter for dashpot
mdfaw-zdash	Sub-function ZDASH: filter time constant for dashpot
mdfaw-ebdash	Sub-function EBDASH: switching conditions for dashpot
mdfaw-mismeus	Sub-function MISMEUS: change limitation during fast torque intervention for operating mode changeover
mdfaw-lsd	Sub-function LSD: Change limitation during positive load changes (load change damping)
mdfaw-fillsd	Sub-function FILLSD: filter for load change damping
mdfaw-zlsd	Sub-function ZLSD: filter time constant for load change damping
mdfaw-pt2fil	Sub-function PT2FIL: PT2-filter
mdfaw-eblsd	Sub-function EBLSD: switching conditions for load change damping
mdfaw-mdbg	Sub-function MDBG: torque change limitation
mdfaw-mifal	Sub-function MIFAL: driver requested torque for the cylinder charge path
mdfaw-fwmifal	Sub-function FWMIFAL: excessive increase factor for driver requested torque for the cylinder charge path during positive load changes
mdfaw-bits	Sub-function BITS: Saving of the significant bits in the flag byte mdfaw_bits

MDFAW 12.260 Function Description

The duty of this function is to calculate the driver's requested torque as a function of accelerator pedal position (wped_w) and cruise control output (mrfgr_w). Separate values are provided for cylinder charge and ignition influences (mifal_w, mifa_w).
The throttle pedal characteristic is defined by maps, where through pedal position and engine speed, a factor (relative torque) is stored to help scale indicated torque between the minimum and maximum. The relative driver's requested torque can have values greater than 100% (pedal crossover). For reverse gear, a separate map is available that can be used on vehicles with automatic transmission. To enhance driving comfort, a change in the driver's requested torque limit can take place under certain conditions (load changes, overrun fuel cut-off and reinstatement, transition from part load to idle and vice versa. See sub-function DMFABEG).

The idle condition (B_ll) is set when the relative driver's requested torque drops below the threshold MRFALLU and is reset when the threshold MRFALLO is exceeded. The cruise control condition (B_fgr) is set when the cruise controller output is greater than the output of the pedal characteristic. The integral component of the idle control (dmllri_w) is included in the driver's request.

The change limitation for the driver's requested torque (sub-function DMFABEG) is used to improve ride comfort and overrun fuel cut-off and smooth resumption of positive and negative load changes. With that, a DT1-element filtered torque loss (dmverl_w) is added behind the change limitation around jumps in the clutch torque to damp the connection or disconnection of load.

Overrun fuel cut-off/reinstatement

Via a PT1-filter, down-regulation of the target torques starting from the actual torque at zero takes place by overrun fuel cut-off; smooth resumption by up-regulation of the target torques starting from mizwmn_w to mimin_w. The filter time constants for up-regulation and down-regulation can be chosen independently of each other. One more time constant is made available for hard resumption and leaving idle (under light throttle). The initialization of the filters on the overrun fuel cut-off to the actual torque is needed to avoid a jump in torque on enabling of the ignition angle interventions. The filtering is, or is not cancelled:

- During active dashpot,
- For active load shock absorption,
- In the test laboratory
- On a steep negative speed gradient (uncoupling of thrust or throttle),
- When the clutch is actuated (configurable via CWDMFAB)
- mrfa gradient at higher threshold (important during hard resumption and when leaving the idle),
- Upon reaching the basic ignition angles.

Dashpot

The change limitation for negative load changes (dashpot) is implemented using a PT1-filter with gear and speed-dependent time constant. The PT1-filter runs at a negative gradient of the unfiltered driver's requested torque. The dashpot is triggered when the difference between the filtered and unfiltered output value exceeds a clutch-dependent and torque-dependent threshold, and cruise control is not engaged. The trigger also always occurs at the transition to idle. The PT1-filter triggered by the dashpot is initialized with the actual torque in order to avoid a jump in torque during ignition angle interventions. The dashpot is terminated when the difference between filtered and unfiltered value falls below a gear-dependent threshold. As long as the dashpot is active, there will not be any overrun fuel cut-off (see function %BBSAWE).

The driver's desired torque for the cylinder charge influence mifal_w is calculated by a dashpot with its own PT1-filter that is initialized when the unfiltered driver's desired torque drops below the trigger level. In this way, a steep initial drop is reached, which leads to the rapid closing of the throttle. Then a soft change is made to the target value. The dashpot can be active only when:

- The general dashpot-enable is done via CWDMFAB Bit1,
- There is no commitment to overrun fuel cut-off,
- Load shock absorption is not active,
- There is the speed signal,
- The minimum speed is exceeded for dashpot,
- The clutch is not pressed,
- Start end is reached,
- The response is greater than zero,
- ASR intervention is not active,
- The cylinder charge is greater than the minimum charge.

Load Shock Absorption

The change limitation during positive load changes is realized with the help of a PT2 filter whose damping and time constant are gear- and speed-dependent. The PT2 filter runs with a positive gradient of the unfiltered driver's requested torque. Load shock damping is triggered when the difference between unfiltered and filtered output value exceeds a gear- and clutch torque-dependent threshold. The PT2 filter is triggered when the load shock absorption is initialized with the actual torque or a speed-and gear-dependent initial value, to avoid a jump in torque upon enabling of the ignition angle interventions and to influence the response behavior. The load shock damping is terminated when the difference between the filtered and unfiltered value drops below a gear-dependent threshold.

The driver's desired torque for the cylinder charge influence mifal_w with active load shock damping is calculated from a map which depends on the desired torque for the ignition influence (mifa_w) and on the gear, which is a limitation on the unfiltered target. Thus, the cylinder charge can be controlled so that there is no significant ignition angle intervention in order to set the desired torque curve.

The load shock damping can be active only when
- Load shock damping is generally enabled via CWDMFAB Bit 0,
- There is no idle
- For vehicles with CVT transmission, the torque gradient limitation is not active and the torque converter clutch is not open,
- The speed signal is present
- The minimum speed for load shock absorption is exceeded,
- The clutch is not actuated
- Cruise control is not engaged,
- Speed and speed limits are not active,
- End of start conditions is reached,
- The gear is greater than zero,
- No traction control intervention is active.

The PT2 filter is implemented with two integrators and feedback. There is also the possibility that the filter is initialized with a given value (iwflsd_w) if the condition B_iflsd is set.

MDFAW 12.260 Application Notes

CWDMFAB

Bit 0   0: Load shock damping deactivated

1: Load shock damping enabled
Bit 1 0: Dashpot deactivated
1: Dashpot enabled
Bit 2 0: Load shock damping with B_gwhs inactive
1: Load shock damping with B_kupplv inactive
Bit 3 0: Dashpot with B_gwhs inactive
1: Dashpot with B_kupplv inactive
Bit 4 0: Overrun fuel cut-off/reinstatement filter with B_kuppl active
1: Overrun fuel cut-off/reinstatement filter with B_kuppl inactive
Bit 5 0: Dashpot and load shock damping even with traction control intervention enabled
1: Dashpot and load shock damping with traction control intervention inactive
Bit 6 0: Dashpot triggering independently of B_ll
1: Dashpot triggering on positive edge of B_ll
Bit 7 0: Load shock damping and dashpot triggering via threshold inactive, until cruise control intervention
1: Load shock damping and dashpot triggering via threshold also possible during cruise control intervention

CWMDFAW

Bit 0 0: Initialization of migef_w when reinstating with miistoar_w
1: Initialization of migef_w when reinstating with 0 (for sequential reinstatement)
Bit 1 0: Initialization of mifal_w with dashpot with mivbeb_w
1: Initialization of mifal_w with dashpot with mibdp_w - dmdpo_w
Bit 2 0: Load shock damping with B_kupplv or B_gwhs inactive
1: Enable the load and shock damping independent of B_kupplv and B_gwhs

KFPEDL and KFPEDR must contain smaller values than KFPED at the same pedal value and the same speed so that the torque monitoring only depends on KFPED.

Parameter	**Description**
CWDMFAB	Codeword ECU switch for change limitation
CWMDFAW	Codeword for %MDFAW
DMDPOSCH	Delta torque dashpot triggering in the shift operation
DMDPUG	Delta torque dashpot end
DMIFLSD	Delta torque for initialising filter load shock damping
DMISMEUS	Delta indicated torque for change limitation by B_mismeus
DMLSDUG	Delta torque end load shock damping
DMRFAWEN	Threshold mrfa-gradient for deactivating PT1-filter during reinstatement
DRLMINDP	Offset on rlmin for switching off dashpot
FGMIFAL	Weighting factor for elevation via KFWMIFAL
FGZLSD	Weighting for reduction via KFZLSD
FKFPEDV	Factor for interpolation between the two pedal maps
FKZDPTM	Correction factor time constant dashpot
FLRMIFAL	Factor for driver requested torque cylinder charge path in low range
FLRZDASH	Factor for dashpot time constant im low range
FLRZLSD	Factor for load shock damping-time constant in low range
FZDA1SCH	Dashpot time constant correction factor in shift operation
FZDA2SCH	Dashpot time constant correction factor at small clutch torque in shifting operation
KFDLSD	Damping PT2-filter load shock damping
KFDMDPO	Delta torque dashpot triggering
KFDMLSDO	Delta torque triggering load shock damping
KFDMLSDS	Delta torque triggering load shock damping after shifting operation
KFMIFABG	Delta torque for gradient limitation
KFMIFALS	Indicated driver requested torque for cylinder charge path during load shock damping
KFMILSD	Indicated torque initial value for load shock damping
KFPED	Relative driver requested torque from throttle pedal
KFPEDL	Relative driver requested torque at low speeds
KFPEDR	Relative driver requested torque from throttle pedal for reverse gear
KFWMIFAL	Excessive increase factor for cylinder charge path during load shock damping
KFWZLSD	Reduction factor for time constant load shock damping
KFZDASH	Time constant PT1-filter dashpot
KFZDASH2	Time constant PT1-filter dashpot at small clutch torque
KFZLSD	Time constant PT2-filter load shock damping
MDIMX	Maximum indicated engine torque
MIFABGMX	Maximum value mifa_w for torque change limitation
MIFALMF	Indicated driver requested torque for cylinder charge path with active gradient limitation

MKFADPN	Clutch torque for changeover of dashpot-filter time
MKFADPN1	Clutch torque for changeover of dashpot-filter time for air conditioning
MKMIFABG	Clutch torque for activating the torque change limitation
MRFALLO	Upper idle threshold of the relative driver requested torques
MRFALLU	Lower idle threshold of the relative driver requested torques
MRFAVLN	Full load detection threshold for the relative driver requests
NGFSAWE	Threshold speed gradient for overrun fuel cut-off/reinstatement filter
SNM12MDUW	Sample point distribution for engine speed
SWP16MDUW	Sample point distribution for throttle pedal angle
SY_ASG	System constant: automated manual transmission present
SY_BDE	System constant: petrol direct injection
SY_CVT	System constant: continuously variably transmission present
TDMFBSA	Time constant PT1-filter during overrun fuel cut-off
TDMFBWE	Time constant PT1-filter during smooth reinstatement
TDMFNSG	Filter time constant during target speed increase (continuously variably transmission)
TDMFWEMI	Filter time constant during hard reinstatement
TDMLSDS	Time after clutch actuation with modified load shock damping trigger
TVFSAWE	Delay time for resetting B_fil
VDASH	Minimum speed for dashpot
VLSD	Minimum speed for load shock damping
Variable	**Description**
B_CVT	Condition: continuously variable transmission
B_DASH	Condition: dashpot change limitation active
B_DASHV	Condition: dashpot delay
B_DP	Condition: dashpot value greater than driver request (= 1)
B_EDP	Condition: dashpot permission
B_ELSD	Condition: load shock damping permission
B_FAAN	Condition: functional requirement: general speed increase
B_FGR	Condition: cruise control (Tempomat) active
B_FIL	Condition: PT1-filter for overrun fuel cut-off/reinstatement active
B_GWHS	Condition: gear change by manual switch
B_IFLSD	Condition: initialising filter load shock damping
B_KO	Condition: compressor enabled
B KUPPL	Condition: clutch actuated
B_KUPPLV	Condition: delayed clutch actuation
B_LL	Condition: idle
B_LLVFGR	Condition: idle forbidden by vehicle speed limiter
B_LOWRA	Condition: Intermediate clutch for low range switch-off
B_LS	Condition: load shock limitation without driver request (=1)
B_LSD	Condition: positive load shock damping active
B_MGBGAKT	Condition: torque gradient limitation active
B_MGBGET	Condition: torque gradient limitation active
B_MIFABG	Condition: mifa limitation
B_MISMEUS	Condition: torque change limitation by B_smeus
B MRPEDASG	Condition: changeover driver requested torque from AMS
B_MRPFA	Condition: zeroing of mrped_w because of general speed increase
B_NMAX	Condition: speed limiter active
B_NMOT	Condition: engine speed: n > NMIN
B_NSGET	Condition: torque requirement for CVT: position the pulley cone
B_SA	Condition: overrun fuel cut-off
B_SAB	Condition: overrun fuel cut-off standby
B_SABFG	Condition: overrun fuel cut-off standby or enable
B_STEND	Condition: end of start conditions reached
B_TDMLSDS	Condition: time after clutch actuation with modified load shock damping trigger
B_TMISMEUS	Condition: trigger for torque filtering B_mismeus
B VL	Condition: full load
B_VMAX	Condition: speed limiter active
B_VNULL	Condition: vehicle stopped
B_WKAUF	Condition: torque converter open
B_ZWSCH	Condition: ignition angle for stratified charge mode active
DLSD_W	Damping PT2-filter in load shock damping
DMBEBL_W	Delta torque for triggering load shock damping
DMDPO_W	Delta torque dashpot triggering
DMDPU_W	Delta torque dashpot end
DMGBEG_W	Delta torque for gradient limitation
DMLLRI_W	Required torque change from idle control (integral component)
DMLSDO_W	Delta torque on triggering load shock damping
DMLSDU_W	Delta torque at end of load shock damping
DMLWHS_W	Delta torque during load alternation between homogeneous and stratified charge modes
DMRFAWE_W	Threshold mrfa-gradient for deactivating PT1-Filter during reinstatement

MDFAW 12.260 Driver's Requested Torque

DMVERL_W	Torque loss after DT1-Filter
FKFPED	Factor for interpolation between the two pedal maps
FWMIFAL	Excessive increase factor in cylinder charge path load shock damping
FWZLSD	Reduction factor time constant load shock damping
FZDASH	Factor time constant dashpot
GANGI	Actual gear
IWFLSD_W	Initialising value for filter load shock damping
MDFAW_BITS	Flag byte for %MDFAW
MDGRAD_W	Torque gradient limiting through the transmission
MDSLWHOM_W	Load alternation torque loss in the homogeneous mode
MDSLW_W	Torque loss: load alternation
MDVERL W	Engine torque loss
MIASRS_W	Indicated target engine torque traction control for fast intervention
MIBAS_W	Indicated basic torque
MIBDP_W	Indicated target engine torque dashpot
MIBLSD_W	Limited indicated torque for load shock damping
MIFA	Indicated driver requested engine torque
MIFABG_W	Gradient-limited driver requested torque
MIFAL_W	Indicated driver requested torque for torque coordination on the charge path
MIFA_W	Indicated driver requested engine torque
MIGEF_W	Filtered indicated driver requested torque
MIISTOAR_W	Actual torque without anti-judder component
MIMAX_W	Maximum permissible indicated torque
MIMINHOM_W	Minimum torque for the homogeneous charge mode
MIMIN_W	Minimum engine torque
MINBEG_W	Indicated driver requested torque after / change limitation
MISMEUS_W	Indicated torque during change limitation B_mismeus
MIVBEB_W	Indicated torque before change limitation, upper limit of mimax_w
MIVBEGVH_W	Indicated driver requested torque before maximum limit for homogeneous charge mode
MIVBEGV_W	Indicated driver requested torque before maximum limit
MIVBEG_W	Indicated driver requested torque before change limitation
MIZWMN_W	Indicated engine torque at the latest igniton angle
MKFADPN_W	Clutch torque for changeover dashpot-filter time
MKFANB_W	Clutch torque from limited driver's request
MKFA_W	Driver requested torque (clutch) after change limitation
MRFAMXAS W	Relative driver requested torque maximum value from automated manual transmission
MRFAMX_W	Relative driver requested torque maximum value
MRFA_W	Relative driver requested torque from cruise control and throttle pedal
MRFGR_W	Relative torque requirement from cruise control
MRPEDASG W	Relative driver requested torque from automated manual transmission
MRPEDL_W	Relative driver requested torque from the throttle pedal for less speed
MRPEDS W	Relative driver requested torque from the throttle pedal for greater speed
MRPED_W	Relative driver requested torque from the throttle pedal
NGFIL_W	Filtered speed gradient
NMOT W	Engine speed
RLMINDP_W	Minimum relative cylinder charge for dashpot switch off
RLMIN_W	Minimum permitted relative load
RL_W	Relative air charge (word)
TMOT	Engine coolant temperature
VFZG	Vehicle speed
WPED_W	Normalised throttle pedal angle
ZDASH1_W	Time constant PT1-filter dashpot
ZDASH2_W	Time constant PT1-filter dashpot at small clutch torque
ZDASH_W	Time constant dashpot
ZLSDV_W	Time constant PT2-filter load shock damping before reduction
ZLSD_W	Time constant PT2-filter load shock damping

MDFUE 8.50 (Setpoint for Air Mass from Load Torque)

MDFUE 8.50 Function Description

See the *funktionsrahmen* for diagram mdfue:

The torque variable milsol_w, which is set on the charge path at the basic ignition angle and basic efficiency is converted into torque variable misopl1_w, which corresponds to the optimum torque at lambda = 1. The map KFMIRL provides the cylinder charge which corresponds to this operating point.
This cylinder charge is limited to a minimum permitted value rlmin_w at which the condition B_mdmin is set for idle control which then stops the integrator. In the case of a turbocharger, there is a limit on the maximum permitted cylinder charge rlmax_w. This variable does not exist for naturally-aspirated engines!
The result is the desired cylinder charge rlsol_w.

Supplement to the application interface:

CWRLAPPL = 0: Function as before: rlsol generated from the limited KFMIRL.
CWRLAPPL bit 1 =1: rlsol_w = RLSOLAP
CWRLAPPL bit 2 =1: rlsol_w = wped_w × FWPEDRLS

Application Notes
The map KFMIRL is the inverse of map KFMIOP in the function MDBAS *(it is understood that this is not a direct arithmetic inverse, but is intended to mean that the functions on the x, y & z axes are complementary)*. See MDBAS for application notes.

Parameter	**Description**
CWRLAPPL	Code word: default rlsol_w during applications phase
FRLMNHO	Correction factor for rlmin via altitude
FWPEDRLS	Factor for direct entry to the default rlsol from wped (application)
KFMIRL	Map for calculating target cylinder charge
KFRLMN	Minimum cylinder charge in firing mode
KFRLMNSA	Minimum rl during overrun fuel cut-off
RLSOLAP	Target cylinder charge for application calibration purposes
ZKDRLSOL	Time constant for drlsol-integrator

Variable	**Description**
B_MDMIN	Condition flag: minimum achievable indicated torque reached
B_SA	Condition flag: overrun fuel cut-off active
C_INI	ECU initialisation condition
DRLSOLF_W	Filtered change in target cylinder charge
DRLSOL_W	Change in target cylinder charge
ETALAB	Lambda efficiency without intervention with respect to the optimum torque at lambda = 1
ETAZWBM	Average ignition angle efficiency at the basic ignition angles
FHO	Altitude correction factor
MILSOL_W	Driver's requested torque for cylinder charge path
MISOPL1_W	Target air torque, back-calculated from lambda = 1 and zwopt
NMOT	Engine speed
NMOT_W	Engine speed (word)
RLMAX_W	Maximum achievable cylinder charge from the turbo
RLMIN_W	Minimum permitted rl
RLSOL_W	Target cylinder charger
RLTEDTE_W	Relative cylinder charge from the fuel tank breather valve determined from DTEV
R_T10	Time graticule of 10 ms
SY_TURBO	System constant: turbocharger
TMOT	Engine temperature
WPED W	Normalised throttle pedal angle

14.70 MDKOG (Torque Coordination for Overall Interventions)

See the *funktionsrahmen* for the following diagrams:

mdkog-main	Main function overview
mdkog-bbmdein	Sub-function BBMDEIN: active torque intervention conditions
mdkog-bbzwein	Sub-function BBZWEIN: active ignition angle intervention conditions
mdkog-mdbeg	Sub-function MDBEG: limit of the indicated torque
mdkog-mdbeg-diag	Sub-function MDBEG_DIAG: connection of the torque limit to the diagnosis
mdkog-mdabws	Sub-function MDABWS: stalling

MDKOG 14.70 Function Description

Coordination of the Requested Engine Torques

Through the torque coordination calculation, the indicated desired engine torque (misol_w) is used to calculate the fade out stage and/or the ignition angle adjustment. The externally-requested indicated torques from the cruise control (miasrs_w) and transmission protection (migs_w) and the internal torque requirements (e.g. driver requested torque, maximum engine speed or maximum load) will be converted into an indicated desired engine torque (misolv_w) via either a minimum or maximum range.

The desired torque for the ignition path is dependent on the enable condition B_zwvz (cf. BBMDEIN):

- When ignition angle interventions are enabled, mizsolv_w is calculated as follows:
The upper limit of the desired torque, misolv_w, is given by the product of optimal internal torque (including lambda influence) and ignition angle (miopt_w × etazwb), then the torque requirements of the idle control dmllr_w (only proportional and differential components) and the anti-judder feature, dmar_w are added.

- When ignition angle interventions are not required, the basic torque mibas_w is used as the desired torque which depends only on the stipulated ignition and mixture-application efficiencies. The anti-judder feature intervention is also considered in this case.

Sub-function BBMDEIN: Active Torque Intervention Conditions

In addition, via the traction control torque intervention, the condition flag B_msr is set so that overrun fuel cut-off is prohibited (see %MDRED). During cruise control intervention, the condition flag B_asr to cylinder suppression is possible (see %MDRED). The condition flag B_mdein is used to disable the misfire detection (see %DASE) and enable the anti-judder feature or idle speed control (for B_mdein = 0). The condition flags B_zwvz and B_zwvs are responsible for enabling the torque adjustment through ignition.

- B_zwvz is set when the time frame level detects the need for an intervention. This is the case at all operating points which require a torque reserve, i.e. idle, catalyst heating, short journeys and for the dashpot driveability functions, load shock attenuation, filtering for overrun fuel cut-off and short journeys. When the clutch is also immediately released to avoid revving the engine. All external intervention is detected by comparing mifa_w and misol_w.

An ignition angle enable can also be made via the code word CWMDKOG, when the desired the cylinder charge corresponds to the minimum cylinder charge. In addition, if the difference between the actual cylinder charge and the minimum cylinder charge is less than the delta value to be applied, data input to the code word for the ignition angle can be enabled.

- B_zwvs is set when either a timeframe intervention is submitted or a torque influence from the anti-judder feature is required. The desired value is not then switched to misol_w in the function %MDZW (torque influence on ignition), however, the influence is activated.

Sub-function MDABWS: Stalling

Should the engine speed during torque reduction through cruise control or transmission protection fall under NASNOTTM, miext is immediately set equal to MDIMX so that the two operations are prohibited. NASNOTKL is a function of engine temperature, tmot.

Sub-function BBZWEIN: Active Ignition Angle Intervention Conditions

see BBMDEIN

14.70 MDKOG (Torque Coordination for Overall Interventions)

Sub-function MDBEG: limit of the indicated torque

The two torque variables misolv_w and mizsolv_w are limited to the maximum indicated torque miszul_w (from module MDZUL). This is to ensure that monitoring in level 2 only becomes active when the desired (and possibly limited) torque is not converted correctly into an actual torque. The data input to KFMIZU will be aligned to the level 2 permitted torque. Particularly in the application phase this can prevent an unwanted torque monitoring response. By noting the value of B_mibeg it is possible to detect whether a limitation of the desired torque has been made.

To test the data monitoring, there is a counter cmibeg_w that counts the number of active limitations. The counter cmibeg_w is incremented with each rising edge of B_mibeg. The counter is not active when the driver releases the throttle pedal or the maximum value is reached (MAXWORD = 65,535). The value is cached and only an error path enable or a power failure resets it.

Sub-function MDBEG_DIAG: Connection of the Torque Limit to the Diagnosis

This function MDBEG_DIAG is part of the EGAS monitoring concept (level 1). The desired torque MDBEG is limited to a maximum permissible torque, miszul_w. If this limit is active, the bit B_mibeg is set. In certain operating conditions (e.g. very cold engine and idle), this level-1-limit will be active, but only for a short time. If the limit B_mibeg is active for a longer time (e.g. 10 minutes), there might be a fault in the system and a diagnostic entry is made.

MDKOG 14.70 Application Notes

Typical values:

MDIMX = 99.6%;

NASNOTKL

Engine temperature/°C	–30	0	30	60
NASNOT	1500	900	600	600

The engine speed threshold NASNOT must not be larger than 2550 rpm.

DELRL < 2%
THDMB = 1 sec
CWMDKOG = 2

Bit	7	6	5	4	3	2	1	0
CWMDKOG	*	*	*	*	Note 4	Note 3	Note 2	Note 1

Note 1. Ignition angle enable with rlsol = rlmin
Note 2. Ignition angle enable with B_mibeg
Note 3. Ignition angle enable with rl – rlmin_w ≤ DELRL
Note 4. !B_mibegl kill data input

Parameter	**Description**
CDCMDB	Codeword CARB: torque limitation desired torque
CDKMDB	Codeword Client: torque limitation desired torque
CDTMDB	Codeword Tester: torque limitation desired torque
CLAMDB	Codeword Error Class: torque limitation desired torque
CWMDKOG	Codeword: MDKOG: ignition angle retardation via vacuum limitation
CWTEZW	Codeword: ignition angle intervention via fuel tank breather valve check
CWZWVMX	Codeword: ignition angle intervention via speed limitation
DELRL	Delta relative cylinder charge for enabling ignition angle intervention
FFTMDB	Freeze frame table: torque limitation desired torque
MDIMX	Maximum indicated engine torque
NASNOTKL	Characteristic curve for stall protection speed threshold
THDMB	Healing debounce time of the entry error in long-term torque limitation
TMVER	Debounce time detection of a long-term torque limitation
TSFMDB	Error summation period: torque limitation desired torque
TVLDSZW	Duty cycle ignition angle enable via recharge effect

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TVMIBEG	Debounce time for ignition angle enable via torque limitation
BLOKNR	DAMOS source for block number
B_ASR	Condition flag: cruise control active
B_BEMDB	Condition flag: tape end functions requirement torque limitation
B_BKMDB	Condition flag: torque monitoring (long-term limitation) active
B_CLMDB	Condition flag: cancellation of long-term torque limitation
B_DASH	Condition flag: dashpot-adjustment limit active
B_FIL	Condition flag: PT1-filter for overrun fuel cut-off/reinstatement active
B_FTMDB	Condition flag: error input from tester for torque limitation
B_KH	Condition flag: catalyst heating
B_KUPPLV	Condition flag: delayed clutch actuation
B_KW	Condition flag: catalyst keep warm
B_LDSUA	Condition flag: charge air recirculation valve active (open)
B_LL	Condition flag: idle
B_LLREIN	Condition flag: idle control active
B_LSD	Condition flag: positive load change damping active
B_MDEIN	Condition flag: torque intervention active
B_MDMIN	Condition flag: minimum achievable indicated torque achieved
B_MGBGET	Condition flag: torque gradient limitation active
B_MIBEG	Condition flag: torque limitation active
B_MIBEGL	Condition flag: torque limitation cylinder charge path active
B_MNMDB	Fehlertyp min.: torque monitoring long-term limitation
B MSR	Condition flag for torque slip control
B_MXMDB	Error type: maximum permissible desired torque is exceeded permanently
B_NPMDB	Implausible error: torque monitoring long-term limitation
B_PWF	Condition flag: power fail
B_SA	Condition flag: overrun fuel cut-off
B_SIMDB	Error type: torque monitoring long-term limitation
B_STEND	Condition flag: end of start conditions achieved
B_ZWGET	Ignition angle intervention through transmission intervention
B_ZWNGET	Ignition angle intervention not through transmission intervention
B_ZWVS	Condition flag: for quick exit of ignition angle intervention in the torque interface
B_ZWVZ	Condition flag: for ignition angle intervention in the torque interface
B_ZWVZVB	Condition flag: for ignition angle intervention in the torque interface for limitation
CMIBEG_W	Counter for active limitations of the internal torques
DFP_MDB	ECU internal error path number: torque monitoring long-term limitation
DMAR_W	Delta engine speed (anti judder)
DMLLR_W	Demanded torque change for idle control (P & D components)
DMRKH	Torque reserve for catalyst heating
DMRKT_W	Torque reserve for short journeys
DMRLLR_W	Torque reserve for idle control
DMZMS_W	Difference between the indicated desired torque and the allowed desired torque
ETAZWB	Ignition angle efficiency of the basic ignition angles
E_MDB	Error flag: torque monitoring long-term limitation
MIASRL_W	Indicated desired engine torque (cruise control), slow intervention
MIASRS_W	Indicated desired engine torque (cruise control), fast intervention
MIBAS W	Indicated basic torque
MIBEG_W	Torque limit
MIBGR_W	Indicated desired torque for input-dependent clutch torque limitation
MIEXTV_W	For external demanded torque for stall protection
MIEXT_W	For external (cruise control, transmission protection, etc.) demanded indicated engine torque
MIFAB_W	Limited indicated driver's desired torque
MIFA_W	Indicated driver's desired torque
MIGS_W	Indicated desired engine torque for transmission protection, fast intervention
MILRES_W	Torque requirement for air path with all reserves
MIMAX_W	Maximum achievable indicated torque
MIMSR W	Indicated desired engine torque, traction control
MINMX_W	Torque requirement of the speed limiter
MIOPT W	Optimum indicated torque
MISOLP_W	Indicated desired torque for torque limitation, local variable
MISOLV_W	Indicated resulting torque for torque limitation
MISOL_W	Indicated resulting desired torque

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MISZUL_W	Maximum possible indicated torque
MITEBG_W	Torque target for minimum filling fuel tank breather
MIVMX_W	Indicated desired torque for speed control
MIZSOLV_W	Indicated resulting desired torque for ignition angle intervention for torque limitation
MIZSOL_W	Indicated resulting desired torque for ignition angle intervention
NASNOTTM	Speed threshold for stall protection as a function of engine speed
NMOT	Engine speed
RLMIN_W	Minimum possible relative cylinder charge
RLSOL_W	Desired cylinder charge
RL_W	Relative cylinder charge (word)
SFPMDB	Error path status: torque monitoring, long-term limitation
TMOT	Engine temperature
WPED_W	Normalised throttle pedal angle
Z_MDB	Cycle flag: torque limitation, long-term limitation

MDZW 1.120 Calculating Torque at the Desired Ignition Angle

MDZW 1.120 Function Description

When calculating the desired ignition angle there are three different cases:
1. Torque influence on the ignition angle active (B_zwvs = 1)
2. Switching off torque influence on the ignition angle (B_zwvs = 0, dmaufr_w> 0)
3. Torque influences inactive (B_nozwe = 1)

1. Active Torque Intervention

The enable condition (B_zwvs) condition is set and the switch-off condition for the ignition angle intervention (B_nozwe) is false. The desired ignition angle is calculated from the torque requirement for the ignition path mizsol_w. The perturbation ramp (dmaufr_w) is zero. The requested torque mizsol_w is converted into the desired efficiency etazws. This is done by dividing by the optimum torque, which is calculated by multiplying miopt_w with the efficiency etazaist. The desired efficiency (etazws) is converted via the inverse ignition angle efficiency characteristic DZWETA into a delta-ignition angle (dzws). The difference between the optimum ignition angle zwopt and dzws gives the desired ignition angle zwsol.

2. Switching off the Torque Influence

When switching off the torque intervention (B_zwvz = 1→0, see %MDKOG), the desired torque mizsol_w can jump to a higher value. This positive torque perturbation must be prevented for driveability reasons. This is done by eliminating the requirement B_zwvz. A perturbation ramp dmaufr_w is reset, which initialises the amplitude of the jump and runs down to zero with a speed-dependent rate. This ramp is subtracted from the input mizsol_w and ensures a smooth transition into a state without any intervention within the timeframe. In this state B_zwvs = false, the switch-off condition for the ignition angle intervention B_nozwe is set but only after the ramp.

A special case is the anti-judder feature intervention, in which B_zwvs, but not B_zwvz is set. When the anti-judder torque requirement is eliminated from input mizsol_w, there is no jump, so that the switch-off ramp in this case is not necessary.

3. Torque Influences Inactive

In this state, no requirement is active (B_zwvs = 0) and the ramp dmaufr_w is screened. The switch-off condition for the ignition angle intervention B_nozwe is set. In this case, the desired ignition angle zwsol for the ignition is not taken into account (c.f. %ZUE) so the calculation can be omitted.

MDZW 1.120 Application Notes

The values are in DMAUFN are preset to give a slope of approximately 5%/sec for all engine speeds.

Parameter	**Description**
DMAUFN	Delta torque control after engine torque intervention
DZWETA	Inverse delta ignition angle efficiency
Variable	**Description**
B_NOZWE	Condition flag: no ignition angle intervention on the engine torque structure
B_ZWVS	Condition flag for fast external ignition angle intervention on the torque interface
B_ZWVZ	Condition flag for ignition angle intervention on the torque interface
DMAUFR_W	Delta “up regulation” torque
DZWS	Delta ignition angle between zwopt and zwsol
ETAZAIST	Actual cylinder suppression efficiency
ETAZWS	Desired ignition angle efficiency
MIBAS_W	Indicated basic torque
MIOPT_W	Optimum indicated torque
MISOL_W	Indicated resulting desired torque
MIZSOL_W	Indicated resulting desired torque for ignition angle intervention
MIZWMN_W	Indicated engine torque at the latest ignition angle
NMOT W	Engine speed
REDIST	Actual reduction stage
R_SYN	Timeframe
ZWOPT	Optimum ignition angle
ZWSOL	Desired ignition angle for torque intervention

RKTI 11.40 (Calculation of Injection Time ti from Relative Fuel Mass rk)

RKTI 11.40 Function Description

ti_w represents a physical value of injection time which is correct also during start conditions. During start the physical value of ti_b1, ti_b2 and ti_tvu_w has to be corrected by the user by a factor of 8, because start quantisation of ti_b1 is internally corrected by dividing by 8 to store large ti-values into a 'word' variable instead of a 'long' variable.

Please see the *funktionsrahmen* for the following diagrams:

1. Battery correction of injection time for injection valves, calculation frkte (fuel mass into injection time)
2. Calculation of ubatt correction of injector time for injectors
3. Correction for injected fuel mass if the reference pressure of the fuel rail pressure controller is not manifold pressure (i.e. with a returnless fuel rail).
4. Calculation of the injection time during start conditions
5. Calculation of the injection time after end of start conditions

This function calculates the effective injection time before fine tuning (tevfa_w, tevfa2_w) from the relative fuel mass (rk_w, rk2_w) and the factor frkte. With an ideal fuel supply system, tevfa_w + tvu_w, tevfa2_w + tvu_w should result in lambda of 1.0 in the combustion chamber, with pilot control to lambda = 1.0 and neutral values of all mixture adaptations.

In practice, a deviation in lambda may occur due to injector nonlinearities or pulses in the fuel system. This deviation is corrected using the map FKKVS as a function of engine speed (nmot_w) and effective injection time (tevfa_w or tevfa2_w). The corrected effective injection time is te_w or te2_w. By adding the battery voltage correction for the injectors, the actuation time is calculated thus: ti_b1 = te_w + tvu_w. The function ACIFI controls the actuation times ti_b1 and ti_b2 for the associated injectors. In a single bank system (SY_stervk = false) the actuation times for bank 1 (ti_b1 or ti_b2) are forwarded to CIFI. In order to achieve the long injection times required during starting conditions, the quantization times ti_b1, ti_b2 are increased by a factor of 8 which thus expands the range to 1677.696 ms. The same applies for the additive quantity ti_tvu_w.

Therefore, a 16 bit value is required for the interface to the function ACIFI. This is important for runtime reasons for normal operation. During start conditions, VS100 measurements of the physically indicated injection time are multiplied by a factor of 8. The resolution during start conditions for ti_b1, ti_b2 and ti_tvu_w is 25.6 microseconds, whereas in normal operation it is 3.2 microseconds.

The RAM cells ti_w and ti_2_w show the physically correct injection time during both start conditions and also normal operation with a resolution of 16 microseconds. The resolutions are valid for a 20 MHz processor.

The minimum injection time TEMIN or TEMINVA is set when outputs B_va = true, B_temin = true or B_temin2 = true. This serves to lock out the lambda control. The threshold value TEMINVA is differentiated from TEMIN with a cold engine when the wall film degradation is not properly emulated by the thinning-delay because te_w limits TEMIN. At higher speeds it is possible that the available theoretical maximum injection time is not sufficient to obtain the required target torque. Therefore, an injection time timx_w that is larger than the maximum possible injection time timxth_w is deployed until the desired torque is withdrawn and timx_w is not larger than timxth_w. For this purpose, the control error dtimx_w is assigned to a PI controller. When the controller is active, the output controlled variable mitibgr_w represents the desired torque. When the controller is inactive, mitibgr_w receives the value 100%. The desired torque in %MDBGRG is obtained by initializing with mifab_w and mitibgr_w. In order to avoid jumps in the nominal torque, the integrator of the integral component is initialized with mifab_w.

The controller is activated as soon as timx_w exceeds the speed-dependent threshold timxth_w. The controller remains in operation until timx_w < timxth_w AND mitibgr_w > mifab_w. See Applications Information.

RKTI 11.40 Application Notes

Calculation of the constant KRKTE:

$$\begin{aligned} KRKTE &= (\rho_{air} \times V_{hcyl}) \div (100 \times 14.7 \times 1.67\times10^{-5} \times 1.05 \times Q_{stat}) \\ &= (50.2624 \times V_{hcyl}) \div Q_{stat} \end{aligned}$$

Where:

ρ_{air} = air density (1.293 g/dm^3 at 0°C and 1013 mbar)
V_{hcyl} = Volume of a cylinder hub in dm^3
Q_{stat} = injector constant with *n*-heptane
1.05 = injector correction factor for petrol
14.7 = Stoichiometric air quantity at lambda = 1.0
1.67×10^{-5} = conversion factor minutes to milliseconds.

Calculation of the correction for fuel supply systems where the reference pressure of the fuel pressure regulator is ambient pressure:

FRLFSDP = √[pdr_evmes/(pdr_akt + (pu – ps))]

Where:

pdr_evmes = absolute pressure in the fuel system before the injectors at the injector constant (Qstat) generally 3 bar
pdr_akt = actual fuel system pressure
pu = ambient pressure
ps = intake manifold pressure

For systems that take their reference pressure from the intake manifold pu – ps = 0 is used in the calculation above.

It then applies to the entire relationship FRLFSDP = √(pdr_evmes/pdr_akt)

For a fuel pressure of 3 bar, the results for FRLFSDP (where dpus = pu – ps) are as follows:

Naturally-aspirated Engine		Turbocharged Engine	
dpus/mbar	FRLFSDP	dpus/mbar	FRLFSDP
0	1.0000	-1200*	1.2990
100	0.9837	-1000	1.2247
200	0.9682	-800	1.1678
300	0.9535	-600	1.1180
400	0.9393	-400	1.0742
500	0.9258	-200	1.0351
600	0.9129	0	1.0000
700	0.9005	200	0.9682
800	0.8885	400	0.9393
		600	0.9129
		800	0.8885

*Boost pressure = 1800 mbar, ambient pressure = 600 mbar

For consistency reasons, 11 sampling points for vacuum and turbo are used with the turbo-values.

In the charge sampling and injection application in returnless fuel systems via the code word for the reference pressure for the fuel pressure regulator (CWPKAPP), the constant PSAPES (intake manifold pressure for injection application) is used as a substitute value where the modelled intake manifold pressure ps_w has not been applied. Thus the manifold pressure can be set directly with a VS100 processor. With the VS20 processor, the pressure PSAPES can be changed with an adjustment factor between 0 and 2 via the RAM cell vsfpses (pses_w = PSAPES × vsfpses).

The initial value for PSAPES is 1013 mbar. If this value (in conjunction with a factor of 2 from vsfpses) does not define the maximum manifold pressure for turbocharged engines with VS20, the one-off value of PSAPES must be increased with VS100.

Initialization:
Map size in program development nmot × tevfa_w = 10 × 10

FKKVS: Sample points

Speed	800	1400	2000	2600	3200	3800	4400	5000	5600	6200	RPM
Tevfa_w	1.5	2.5	3.5	4.5	5.5	6.5	7.5	8.5	9.5	10.5	ms
Value	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	

The characteristic field FKKVS corrects errors in the fuel system (pulses in returnless fuel systems)
The map size of FKKVS can be extended to about nmot $\times$ tevfa_w = 10 $\times$ 10 auf 16 $\times$ 10.
This is especially important to simplify the application for proportional systems. The speed sample points should match the number and values of the map KFPRG in the function BGSRM.

TEMIN: 1 milliseconds
TEMINVA: 1 milliseconds so that overall, the same TEMIN is active
TEMINVA: 0 milliseconds so that it is inactive when the engine is cold and thinning delay B_va = true, te to TEMIN seated and so that the wall film is not broken down properly.
ti-resolution values are valid for a 20 MHz processor frequency. Otherwise thery must be converted thus: 20 MHz / (current processor frequency [MHz]).

Start:
ti_b1, ti_b2 25.6 microseconds. Measurements from VS100 must be multiplied by a factor of 8.
ti_tvu_w 25.6 microseconds. Measurements from VS100 must be multiplied by a factor of 8.
ti_w, ti2_w 16 microseconds.
te_w, te2_w not available.

Normal:
ti_b1, ti_b2 3.2 microseconds.
ti_tvu_w 3.2 microseconds.
ti_w, ti2_w 16 microseconds.
te_w, te2_w 3.2 microseconds.

First inputs:
ZTSPEV = 240 seconds

TVTSPEV

Etvmodev [°]	–20	0	100	120
tvsp_w [ms]	0	0	0	0

DMIL
CWDMIL
Bit 0 true: controller activated
Bit 0 false: controller deactivated
Bit 1 true: inputs B_ba and B_bag both active
KMITIBGR = 15 %/ms*s
PVMITIBGR = 0.8 %/ms

Explanation of Variables

Variable	**Description**
CWDMIL	Code word ti-continuous wave control RKTI
CWPKAPP	Application code word for the fuel pressure regulator pressure reference
FKKVS	Correction factor for the fuel supply system
FRLFSDP	Injection correction RLFS
KMITIBGR	On-slope factor for the integration of dtimx_w through torque limitation
KRKTE	Conversion of relative fuel mass rk to effective injection time te
PSAPES	Intake manifold injection for application
PVMITIBGR	Proportional gain factor for torque limitation through continuous wave injection
SY_STERVK	System constant condition: stereo before catalytic converter
TEMIN	minimum TE
TEMINVA	minimum TE at VA
TVTSPEV	Correction of the injection time depending on evtmod
TVUB	Voltage correction
ZTSPEV	Time constant for filtering evtmod taking tvu-control into account

RKTI 11.40 (Calculation of Injection Time ti from Relative Fuel Mass rk)

B_BA	Acceleration enrichment condition (indicator)
B_BAG	Strong acceleration enrichment condition
B_ENIMITI	Integrator release condition for torque limitation through continuous wave injection
B_STEND	End of start condition
B_TEMIN	TEMIN-limiting condition active, Bank 1
B_TEMIN2	TEMIN-limiting condition active, Bank 2
B_VA	Wall-film thinning delay condition (indicator)
DPUS_W	Delta intake manifold pressure environment
DTIMX_W	Difference between theoretical and maximum injection time
EVTMOD	Intake valve temperature models (temperature model)
EVTMODEV	Filtered value of evtmod taking into account the formation of tvu_w
FRKTE_W	Conversion factor relative fuel mass rk to effective injection time te
FTEK2_W	Correction factor for effective injection time, Bank 2
FTEK_W	Correction factor for effective injection time
MIFAB_W	Limited indicated driver-desired torque
MITIBGRI_W	I-component for torque limitation via ti-control during continuous injection
MITIBGRP_W	P-component for torque limitation via ti-control during continuous injection
MITIBGR_W	Torque limitation via ti-control during continuous injection
NMOT	Engine speed
NMOT_W	Engine speed
PS_W	Manifold Absolute Pressure (Word)
PU_W	Ambient pressure
RK2_W	Relative fuel mass, Bank2
RK_W	Relative fuel mass
TE2_W	Effective injection time Bank2 (word)
TEVFA2_W	Effective injection time before trim (word)
TEVFAKGE_W	Addressing map FKKVS with effective injection time before fine-tuning
TEVFA_W	Effective injection time before trim (word)
TE W	Effective injection time (word)
TI2_W	Injection time for cylinder 2 (word)
TIMXTH_W	Theoretical maximum injection time
TIMX_W	Maximum injection time
TI B1	Injection time for injectors in Bank1
TI_B2	Injection time for injectors in Bank2
TI_TVU_W	Battery voltage-dependent injection time correction CPU quantization
TI_W	Injection time
TVSP_W	Injection delay time depending on evtmod
TVU_W	Battery voltage correction
UB	Battery voltage
VSFPSES	Adjustment factor for intake manifold pressure for the injection application

SLS 88.150 (Secondary Air Control)

SLS 88.150 Function Description

See the *funktionsrahmen* for the following diagrams:

sls-sls	Function overview
slson	Conditions for switching on secondary air
slsoff	Conditions for switching off secondary air
sls-slp	Conditions for setting the bits of SLP
sls-bmsl	Calculating the secondary air mass
sls-dichte	Calculating the correction factors for the secondary air mass
sls-bslpdyn	Description of the dynamic of the secondary air pump
sls-bslsoff	Description of the secondary air dynamic in the exhaust system
sls-bfmlssl	Calculation of enrichment due to secondary air
sls-bkt	Secondary air adaption/short journey
sls-e-slpe	E_SLPE: error flag secondary air pump
sls-e-slve	E_SLVE: error flag secondary air valve
sls-e-slpanst	Evaluation of the SLP-output stage
sls-slvanst	Evaluation of the SLV-output stage
sls-z-sls	Cycle flag: secondary air control (cylinder bank 1)
sls-z-sls2	Cycle flag: secondary air control (cylinder bank 2)
sls-init	Initialisation
sls-swoff	ECU delay

Function Description

Secondary air control is coordinated by the sub-function BBKHZ in overview module AK 1.10 and consists of the following sub-functions:

Switching Conditions:

The secondary air system is activated (i.e. B_SLS, B_SLV and B_SLP are all equal to 1) when B_kh = 1 and the imlpr-threshold IMLSLMN is crossed when the engine start temperature TMST lies in the window TMSSLU<tmst<TMSSLO and the intake air temperature tans is in the window TASLU<tans<TASLO. This allows the temperature range for switching on the secondary air system with respect to catalyst heating to be restricted, for example, secondary air pumps overheating or switching on to avoid a frozen secondary air system.

By setting bit 0 of the code word CWSLS, secondary air can already be enabled at start in the restricted temperature window TMSSLSTU<tmst<TMSSLST, for example in designs with thermal reactor, the self-ignition already ensured at engine start. However, the pre-condition is that this is voltage-slope compatible, i.e. the battery voltage is greater than UBSLSTMN.

Alternatively, by setting bit 1, the secondary air system can only be activated if the speed threshold VSLS is exceeded. This is common in secondary air designs in which the exothermic reaction is first ignited in the catalytic converter. Control of the secondary air pump relay is achieved by B_slp = 1 with the minimum holding time TSLPMN to prevent opening of the relay during pump starting current. Opening of the secondary air valve (B_slv = 1) can be delayed with respect to the pump by the time TVSLON. The secondary air valve is opened when B_sls = 1. For diagnostic purposes, the secondary air pump and the secondary air valve can be controlled additionally with the flags B_dspe, B_dslfa and B_dslp4.

In twin ECU designs, the secondary air valves or secondary air pumps are activated when it is detected by one of the two ECUs that conditions B_slp or B_slv are met. The two bits B_slp and B_sls are then fed to each ECU over the CAN bus to ensure that the desired effects are initiated on both sides of the same arrangement.

Switch-off/termination Conditions:

The secondary air is terminated:

- When the threshold IMLSLMX is crossed (B_slpoff = 1)
- Via a debounce time TSLABB after the end of start conditions (B_stend = 1)
- When the maximum air mass threshold MLSLMX is crossed
- When the pressure difference DPSLV is too low to keep the vacuum-actuated secondary air valve open
- When the battery voltage is too low (UBSLMN)
- When there are output stage errors E_slpe, E_slve, or
- When the catalyst-heating termination condition is met (B_khab = 1).

The secondary air is not activated in the first place if:

- the output stage error has already been switched on
- A high electrical system voltage is detected (as UBSLMX) from a boost-start, a twin battery system or battery emergency power.

After switching off the secondary air pump, the secondary air valve can be closed after the time delay TVSLOFF. This is possibly required for engine designs in which the secondary air effects an improvement in fuel atomization in the combustion chamber. Closing the secondary air valve later can dampen the load-diminishing effect due to run-down of the secondary air pump. Caution: For designs with a valve check function for the secondary air diagnosis, a delayed switch-off of the secondary air valve is not acceptable, since the pump must work against the closed secondary air valve. After the power is switched off, the function to reinitialize secondary-air (C_ini) is blocked.

Description of the Secondary Air Mass:

The secondary air mass msl is dependent on the electrical system voltage which is predetermined by the characteristic MSLUB and is corrected depending on the operating point from the map KFFMSML and the ambient air density (characteristic FMSRHOL). When the engine is hot, especially during adaptations-additional diagnostic phase, the secondary air mass can still be corrected depending on tmot by the characteristic FMSTMOT. The pump will run up and down described by the dynamic factor fslpdyn.

In twin cylinder bank designs (SY_STERVK) as well as twin-ECU designs (SY_2SG) with an exhaust bank per ECU (not SY_STERVK) and a single SLP (SY_SLPANZ = 1) and one exhaust bank each, the secondary air system can be split in half and corrected on a bank-specific basis (FMSL, -2).

With bit 6 from the code word CWSLS (= B_slsadap), a secondary air adaptation factor fmsla(2) can be included as determined from the secondary air diagnosis. Finally, the secondary air dilution factor flamsl is calculated for the mixture control from the secondary air mass msl. After opening or closing the secondary air-valve, the dynamics of the secondary air flow into the exhaust are described by factor fmsldyn with the time constants ZKSLON and ZKSLOFF, after the air masses IMLSLSA, IMLSLSE were incorporated. The secondary air wash after closing the valve is indicated by B_slsoff.

Calculation of Enrichment due to Secondary Air:

Bit 3 of the code word CWSLS determines whether there is lambda-engine set point during secondary air injection via map KFLMSKH from function LAKH (flmssl = 0) or whether there is lambda-exhaust set-point, including secondary air via map KFLASKH from function LAKH (flmssl = 1) from an automatic calculation of the required lambda-engine with consideration of the secondary air dilution factor flamsl. Designs with lambda-exhaust set point can also be dependent on bit 4 realized after leaving the debounced idle or inputting the driving phase (bit 5) of the transition to lambda-engine through a filter with time constants ZFLMSSL. Via bit 2 of the codeword CWSLS, one can select whether with transition from B_slsoff or B_sls flmssl from the PT1-filter output is switched hard to 0.

Secondary Air Adaption/Short Journey:

The secondary air adaption via B_dslfa is requested from the secondary air diagnosis and switches on the secondary air for the time TDDSLA (B_sldsl4). It occurs in conjunction with the specification for lambda catalyst-heating then the secondary air mass adaptation or diagnosis in diagnostic phases 4, 5 (see also the description of the secondary air diagnosis in DSLSLR or DLSLRS).

The short journey is requested via B_fa and B_fasls when tmot > TMFASLMN and secondary air is activated for the time TDSLKT (B_slkt) when indicated by B_dslfa from module DSLSLR(S) via the diagnostics readiness. If catalyst heating is active, it remains so for the short test until the time TFALAMN and after that is disabled (since passive diagnostics are already running). Additionally, idle speed and torque reserve can be specified to set a diagnostics-capable engine operating point. This is especially necessary in conjunction with the diagnostic function DSLSLR for the two-point lambda control, by holding the engine under lambda = 1-control while the secondary air is not to operate at the rich limit.

It can be determined via CWFASL bit 2 whether the repeated incentives of short trips in a driving cycle is possible.

Application Notes

Suggested initial programming:

Overview of the coding variants of code word CWSLS:

Bit 0 = 0: secondary air with B_kh	Bit 0 = 1: secondary air at start already in engine temperature window
Bit 1 = 0: secondary air with B_kh	Bit 1 = 1: no secondary air until vehicle speed ≥ VSLS threshold

Bit 2 = 0: select lambda-engine with B_sls TRUE.	Bit 2 = 1: select lambda-engine with B_slsoff TRUE
Bit 3 = 0: select lambda-engine	Bit 3 = 1: select lambda-exhaust (= secondary air enrichment)
Bit 4 = 0: lambda-set point the same as idle/part-load.	Bit 4 = 1: transition to lambda-engine in part load
Bit 5 = 0: lambda-set point the same as o/m drive.	Bit 5 = 1: transition to lambda-engine with driving phase
Bit 6 = 0. without secondary air adaptation	Bit 6 = 1: with secondary air adaptation
Bit 7 = 0: KFLASKH-set point with B_atmtpl (B_atmtpl enable secondary air enrichment)	Bit 7 = 1: KFLASKH-set point without B_atmtpl, B_atmtpl is meaningless. (WARNING: only set for application phase!)

Secondary Air Concept with Thermal Reaction in the Exhaust Manifold:

CWSLS.0 = true. Secondary air already in the start in FTP-tmst region for quick start of post-reaction, Attention: On-board system load!

CWSLS.3 = true. Lambda exhaust set point → automatic calculation of lambda-engine from secondary air dilution flamsl_w

CWSLS.4 = true. Transition to lambda-engine when leaving idle, because post-reaction stops anyway

CWSLS.5 = true. Transition to lambda-engine when loading the driving phase, because post-reaction stops anyway

CWSLS.6 = false. No secondary air adaptation

CWSLS.7 = false. KFLASKH set point only when B_atmtpl = true

Secondary Air Design with Further Reaction in the Catalyst:

CWSLS.0 = false: no secondary air in the false start

CWSLS.1 = true/false depending on the start of partial light-offs in the catalyst (cat-position)

CWSLS.3 = false: lambda engine set point during secondary air injection

CWSLS.6 = false: no secondary air adaptation

Overview of the coding variants of code word CWFASL:

Bit 0: 0: Short test termination if B_fs, vfzg> 0 or B_brems / B_kuppl (see bit 1). 1: no short test termination via B_fs, or vfzg B_brems/B_kuppl possible.

Bit 1: 0: Short test termination if B_brems or B_kuppl. 1: brake and clutch have to be actuated for a short test.

Bit 2: 0: short test can be induced only once in the driving cycle. 1: Short test times can be induced (see bit 3).

Bit 3: 0: Short test only possible after deleting previous fault memory. 1: short test possible without deleting error memory.

WARNING: When bit 3 is set, there is a risk that the catalyst is superheated by repeatedly carrying out short tests.

SLS parameters:

IMLSLMN	0	Secondary air at the same time as B_kh
IMLSLMX	0.9961	Secondary air during entire catalyst heating
TMSSLSTU	15°C	Secondary air from tmst > 15°C is already at the start CWSLS.0 = true
TMSSLSTO	35°C	Secondary air from tmst < 35°C
TMSSLU	15°C	Secondary air with B_kh when tmst > 15°C
TMSSLO	35°C	Secondary air with B_kh when tmst < 35°C
TASLSU	15°C	Secondary air with B_kh when tans > 15°C
TASLSO	35°C	Secondary air with B_kh when tans < 35°C
VSLS	10 km/h	Secondary air only when vehicle speed > 10 km/h when CWSLS.1 = true
MLSLMX	200 kg/h	Termination threshold when ml > 200 kg/h
DPSLV	0 mbar	Termination threshold pressure difference to open the secondary air valve
UBSLMN	9 V	Minimum battery voltage for sufficient secondary air mass
TSLABB	1 sec	Debounce time for secondary air termination after engine start (B_stend)
UBSLMX	16 V	Fan protection during boost start
UBSLSTMN	8 V	B_sls at start when battery voltage > 8 V
TSLUBST	2 sec	Debounce time for battery voltage at start

SLS 88.150 (Secondary Air Control)

Secondary air pump parameters:

TVSLVON	0.1 sec	Secondary air valve opened at the same time as secondary air pump control
TVSLVOFF	0 sec	Secondary air valve closes at the same time as secondary air pump control
TVDSLOFF	2 sec	Secondary air valve closes 2 seconds after short journey/adaptation
TSLPMN	500 ms	Minimum dwell time of the secondary air pump-relay to the relay protection
TVSLP2	2 sec	Delay time for triggering a second secondary air pump

BMSL parameters:

MSLUB =	Function of battery voltage. Obtained from laboratory measurements of the fan at 100 mbar back pressure, check the details required in the vehicle!
KFFMSML =	Function of engine speed and relative load
FMSRHOL	overall factor = 1, approximate without air density correction
FMSTMOT =	Function of engine temperature overall = 1, approximate without correction
FMSL,-2	1 no single bank correction

BSLPDYN parameters:

ZKSLPON	1s	Fan run-up
ZKSLPOFF	1s	Fan run-down

BSLSOFF parameters:

IMLSLA	3.5 g	
IMLSLSE	3.0 g	Implementing air mass to clean out the secondary air system

Dynamic SLP:

Dependent on ml:	20	40	60	100	kg/h
ZKSLSONML 0.5 s	1.5 s	1.0 s	0.5 s	0.2 s	Project specific
ZKSLSOFML 0.5 s	1.5 s	1.0 s	0.5 s	0.2 s	Project specific

BFMLSSL parameters:

TLMSSLMX	60 s	Termination of the thermal reaction (lambda-exhaust set point) after 60 s at idle
TLMSSLAB	1s	Debounce time for detection of exit from idle
ZFLMSSL	1s	Time constant for transition from lambda-exhaust → lambda-engine

BKT parameters:

CWFASL s. o

TMFASLMN: 60°C

TFASLAMN: 60 sec

TDDSLA: 25 s

TDSLKT: 10 s

Abbreviations

Parameter	**Description**
CONT	
CWFASL	Code word: calibrator intervention for secondary air diagnostics
CWSLS	Code word for secondary air system
DPSLV	Minimum pressure difference across the secondary air valve

FMSL	Factor for correcting secondary air mass, cylinder bank 1
FMSL2	Factor for correcting secondary air mass, cylinder bank 2
FMSLOFF	Clearing threshold of the secondary air terminated
FMSRHOL	Air density correction of the secondary air mass
FMSTMOT	Engine speed correction of the secondary air mass
IMLSLMN	Minimum ratio factor psum_w/mlsu for switching on SLS
IMLSLMX	Maximum ratio factor psum_w/mlsu for switching on SLS
IMLSLSA	Air mass integral threshold for initiation of secondary air in exhaust
IMLSLSE	Air mass integral threshold for termination of secondary air in exhaust
KFFMSML	Exhaust back-pressure corrections of the secondary air mass
MLSLMX	Maximum engine-air mass for secondary air injection
MSLUB	Secondary air mass dependent on the battery voltage
SY_BATTSG	System constant: twin battery design
SY_SGANZ	System constant: number of ECUs
SY_SLPANST	System constant: activation of the secondary air pump with twin-ECU, 0 = master, 1 = slave, 2 = master & slave. Seperate
SY SLPANZ	System constant for the number of secondary air pumps
SY_SLVANST	System constant: activation of the secondary air valve with twin-ECU, 0 = master, 1 = slave, 2 = master & slave. Seperate
SY_SLWG	System constant condition flag: secondary air/turbo wastegate present
SY_STERVK	System constant condition flag: stereo lambda control before catalytic converter
TASLSO	Upper air intake temperature threshold for secondary air system
TASLSU	Under air intake temperature threshold for secondary air system
TDDSLA	Continuous secondary air injection for adaptation phase
TDSLKT	Continuous short test secondary air diagnose for mass measurement
TFASLAMN	Minimum catalyst heating time for test requirement in secondary air diagnostics
TLMSSLAB	Debounce time for terminating secondary air enrichment
TLMSSLMX	Maximum time for secondary air enrichment during idle
TMFASLMN	Engine temperature threshold test requirement for secondary air diagnostics
TMSSLO	Upper start temperature threshold for secondary air
TMSSLSTO	Upper temperature threshold for secondary air at start
TMSSLSTU	Lower temperature threshold for secondary air at start
TMSSLU	Lower start temperature threshold for secondary air
TSLABB	Delay time for secondary air – termination condition
TSLPMN	Minimum duty cycle of the secondary air pump
TSLUBST	Debounce time for secondary air on at start by UBSLSTMN
TVDSLOFF	Time delay for closing secondary air valve for adaptation/short journey
TVSLP2	Time delay for control of the no. 2 secondary air pump
TVSLVOFF	Time delay on closing the secondary air valve
TVSLVON	Time delay on opening the secondary air valve
UBSLMN	Minimum voltage for secondary air on
UBSLMX	Maximum voltage for secondary air on
UBSLSTMN	Minimum voltage for secondary air on at start
VSLS	Vehicle speed threshold for secondary air control on
ZFLMSSL	Time constant: mixture part secondary air
ZKSLPOFF	Time constant: secondary air fan off/low flow
ZKSLPON	Time constant: secondary air fan on/run-up
ZKSLSOFML	Time constant: evacuation of the secondary air after valve shut
ZKSLSONML	Time constant: introduction of secondary air after valve open

Variable	**Description**
B_ATMTPL	Condition flag: dew point after catalyst exceeded (last journey)
B_BATNOT	Condition flag: battery emergency start with twin battery design
B_BREMS	Condition flag: brake operated
B_DSLFA	Condition flag: secondary air system requirement for short test
B_DSLRESET	Condition flag: reset secondary air adaptation/short test
B_DSLSET	Condition flag: set secondary air adaption/short test
B_DSLSP4	Condition flag: secondary air system requirement for secondary air adaption/additional diagnostics
B_DSPE	Condition flag: diagnostic secondary air on
B_DWG	Condition flag: wastegate diagnostics
B_ESLPE_C	Condition flag: error secondary air pump (output stage) sent via CAN
B_ESLVE_C	Condition flag: error secondary air valve (output stage) sent via CAN

B_FA	Condition flag: general functional requirement
B_FASLA	Condition flag: external request to activate secondary air system
B_FASLS	Condition flag: function requirement secondary air system
B_FS	Condition flag: driving phase
B_KH	Condition flag: catalyst heating
B_KHA	Condition flag: catalyst-heating requirement
B_KHAB	Condition flag: catalyst-heating terminated
B_KUPPL	Condition flag: clutch actuated
B_LL	Condition flag: idle
B_LMSSLOF	Condition flag: lambda-engine-set point-secondary air part, off
B_MASTERHW	Condition flag: master-ECU in accordance coding pins (plausibility check)
B_MSLMN	Condition flag: insufficient secondary air mass
B_MSLOFF	Condition flag: secondary air mass ausgeräumt after secondary air phase
B_MSLON	Condition flag: steady-state secondary air mass after start of the secondary air
B_NMOT	Condition flag: engine speed > NMIN
B_SLDSL4	Condition flag: enabling secondary air for diagnostics phase 4
B_SLKHOF	Condition flag: switching off the secondary air pump via imlpr-threshold
B_SLKT	Condition flag: enabling secondary air for short test
B_SLP	Condition flag: secondary air pump No. 1
B_SLP2	Condition flag: secondary air pump No. 2
B_SLPANST	Condition flag: for evaluation of the output stage error in secondary air control function
B_SLPENA	Condition flag: switching on the secondary air pump
B_SLPMN	Condition flag: minimum operating time of the secondary air pump
B_SLPOFF	Condition flag: secondary air pump switched off
B_SLPOFST	Condition flag for setting flip-flop B_slpoff
B_SLPT	Condition flag for secondary air pump, temporary intermediate size
B_SLP_C	Condition flag for secondary air pump, sent via CAN
B_SLS	Condition flag: secondary air active
B_SLSADAP	Condition flag: secondary air mass adaptation
B_SLSDIS	Condition flag for switching off the secondary air pump
B_SLSERR	Condition flag for blocking activation of the secondary air pump
B_SLSFZ	Condition flag: secondary air system installed in the vehicle
B_SLSINHI	Condition flag: blocked by setting bit B_sls
B_SLSOAB	Condition flag: secondary air system without implementing the termination criterion
B_SLSOFF	Condition flag: secondary air injection terminated after elimination of the secondary air
B_SLST	Condition flag: secondary air active, temporary intermediate size
B_SLS_C	Condition flag: secondary air active sent via CAN
B_SLV	Condition flag for secondary air valve
B_SLVANST	Condition flag for determining the output stage error in the secondary air control module
B_ST	Condition flag: start
B_STEND	Condition flag: end of start conditions reached
DFP_SLPE	Internal error path number: secondary air pump output stage
DFP_SLS	Internal error path number: secondary air system (cylinder bank 1)
DFP_SLS2	Internal error path number: secondary air system (cylinder bank 2)
DFP SLVE	Internal error path number: secondary air valve output stage
E_SLPE	Error flag: secondary air pump (output stage)
E_SLVE	Error flag: secondary air valve (output stage)
FLAMSL_W	Factor for lambda adjustment through secondary air (cylinder bank 1)
FLAMSL2_W	Factor for lambda adjustment through secondary air, (cylinder bank 2)
FLMSSL	Factor lambda-engine-set point secondary air part
FMSAGD	Exhaust gas back-pressure correction factor for the secondary air mass
FMSLA	Correction factor secondary air mass adaptive (cylinder bank 1)
FMSLA2	Correction factor secondary air mass adaptive (cylinder bank 2)
FMSLDYN	Factor for dynamic specification of secondary air
FMSLKOR	Factor to correct the secondary air mass
FMSLRHO	Air density correction of the secondary air mass
FMSLTM	Engine temperature correction of the secondary air mass
FRHOKOR_W	Factor to address the air density correction of the secondary air
FSLPDYN	Factor for dynamic specification of the secondary air pump
IMLPR	Relative air mass integral during catalyst heating
IMLSLA_W	Air mass integral for introducing the secondary air
IMLSLE_W	Air mass integral for end of secondary air in exhaust
MLBB_W	Air mass flow filtered (word), cylinder bank 1

MLBB2_W	Air mass flow filtered (word), cylinder bank 2
ML_W	Air mass flow filtered (word)
MSL	Secondary air mass flow (cylinder bank 1)
MSL2	Secondary air mass (cylinder bank 2)
MSL2_W	Secondary air mass (cylinder bank 2) 16-Bit value
MSLKORR_W	Corrected secondary air mass flow with consideration of pump dynamics (bank 1)
MSLPUB_W	Secondary air mass flow (battery voltage dependent) 16-Bit
MSLSTAT	Static secondary air mass flow
MSLSTAT_W	Static secondary air mass flow, 16-Bit
MSL_W	Secondary air mass flow 16-Bit value
NMOT	Engine speed
PS_W	Intake absolute pressure (word)
PU	Ambient pressure
RL	Relative air charge
TANS	Ambient air temperature
TMOT	Engine temperature
TMST	Engine start temperature
TNST_W	Time after end of start
UBSQF_W	System voltage, converted into standard quantization and filtered
VERHMSB_W	Number of the cylinder-specific mass flow distribution factor for cylinder bank 1
VERHMSB2_W	Number of the cylinder-specific mass flow distribution factor for cylinder bank 2
VFZG	Vehicle speed
Z_SLS	Cycle flag: secondary air-system (cylinder bank 1)
Z_SLS2	Cycle flag: secondary air-system (cylinder bank 2)

ZUE 282.130 (Fundamental Function – Ignition)

See the *funktionsrahmen* for the following diagrams:
zue zue
zue dzwll

ZUE 282.130 Function Description

The ignition angle (zwgru) from the fundamental ignition angle calculation is corrected by the warm-up angle (dzwwl) and the cylinder-specific knock control angle (dwkrz), and it follows that the basic ignition angle (zwbas) is identical with the earliest possible ignition angle. This ignition angle now forms the route in to the ignition engine torque implementation (MDZW), which provides the output ignition angle (zwsol). This ignition angle is now limited to the earliest or latest possible ignition angle. The resulting ignition angle (zwist) is corrected by the phase error which gives the output ignition angle (zwout).

For back-up protection of the ignition angles, the one's complement (i.e. inverse binary value) of zwout is calculated which forms zwoutcpl. This then becomes the input variable of the function monitor.

The cylinder bank selective ignition angle adjustment is activated via the codeword CWDZWLL = 1.
The delta ignition angle (dzwll) corresponding to B_bankl2 is added to, or subtracted from zwsol.

ZUE 282.130 Application Notes

Three interfaces are provided for the application; the RAM cell vszw and the fixed value ZWAPPL ZW enable adjustment of application tools. Engagement of the torque functions can be disabled using the codeword CWMDAPP (bit 0), so that the applied ignition angle (zwbas) can be driven directly.

Parameter	**Description**
CWZWBANK	Codeword for enabling cylinder-specific ignition angle offsets
FZIZWV	Factor for torque correction via cylinder-specific ignition angle adjustment
KFDZWLL	Map for delta ignition angle during idle
KLZWBSMN	Latest possible basic ignition angle
TMZIZWV	Engine temperature threshold for enabling cylinder-specific ignition angle adjustment
VZIZWV	Vehicle speed threshold for disabling cylinder-specific ignition angle adjustment
WPHN	Phase response
ZWAPPL	Application interface: ignition angle adjustment
Variable	**Description**
B_BANK2	Condition flag for cylinder bank 2
B_LL	Condition flag for idle
B_LLREIN	Condition flag for idle control active
B_NOZWE	Condition flag for no ignition angle intervention in the torque structure
B_SA	Condition flag for overrun fuel cut-off
B_ZWAPPL	Condition flag for ignition angle application without torque intervention
B_ZWKRA	Condition flag for ignition angle output during knock regulation
CWDZWLL	Codeword for delta ignition angle during idle active
DWKR	Cylinder-specific ignition angle retardation during knock control
DZWBANK	Cylinder bank-specific ignition angle offset
DZWOB	Delta ignition angle during overboost
DZWWL	Delta ignition angle during warm-up
DZWZK	Delta ignition angle during knock
MISOLZ_W	Indicated resulting desired torque for ignition angle intervention
MIZSOL_W	Indicated resulting desired torque for ignition angle intervention
NMOT	Engine speed
NSOL	Desired idle speed
REDIST	Actual reduction stage
RL	Relative cylinder charge
SY_REDMX	System constant: maximum reduction stage
SY_TDZW	System constant: additive ignition angle adaptation active
SY TURBO	System constant: turbocharger
SY_WMAX	System constant: earliest outputtable ignition angle
SY_WMIN	System constant: latest outputtable ignition angle
SY_ZIZWV	*Text must be provided by Mrs Sauer*
SZOUT_W	Closing time output
TMOT	Engine temperature
VFZG	Vehicle speed

VSTDZW	Additive ignition angle adaption
VSZW	Ignition angle correction adjusting system
WKRDY	Ignition angle retardation via dynamic knock regulation
WPHG	Ignition angle speed sensor phase correction
ZNACHANZ	Number of ignitions in overrun
ZWBAS	Basic ignition angle
ZWDLLPRT	Ignition angle pointer with delta idle ignition angle
ZWGRU	Fundamental ignition angle
ZWIST	Actual ignition angle
ZWOUT	Ignition angle output
ZWOUTCPL	One’s complement of the ignition angles for function monitoring
ZWOUTPRT	Ignition angle pointer
ZWSOL	Desired ignition angle for torque intervention
ZWSPAE	Latest ignition angle
ZWSTT	Ignition angle during start
ZWZYL1	Ignition angle for cylinder 1
ZZYLZUE	Dwell angle-cylinder counter for calculating ignitions

ZWGRU 23.110 (Fundamental Ignition Angle)

See the *funktionsrahmen* for the following diagrams:

zwgru-zwgru
zwgru-zw-nws Sub-function ZW_NWS: Provision for binary or continously variable camshaft control
zwgru-dzw-nws Sub-function DZW_NWS: Provision for binary or continously variable camshaft control (delta-ignition angle)

ZWGRU 23.110 Function Description

The fundamental ignition angle is provided by the map KFZW. The sub-function ZW_NWS describes the provision for any necessary camshaft timing (NWS). For binary camshaft control, the factor fnwue switches seamlessly between the maps KFZW and KFZW2. In the case of continuously variable camshaft control which depends on the camshaft overlap angle wnwue, an ignition angle correction DZWNWSUE added to KFZW. The currently valid camshaft control version is defined by the system constant SY_NWS in the software generation:

SY_NWS = 0: no camshaft control
SY_NWS = 1: binary camshaft control
SY_NWS = 2: continuously variable NWS
SY_NWS > 2: not defined.

The software is translated conditionally, i.e. only one variant is available in the EPROM. SY_NWS is not in the EPROM and cannot be applied. The same additive ignition angle correction is performed as when calculating the optimum ignition angle (see %MDBAS), i.e. exhaust gas recirculation and lambda dependence are considered. The temperature dependence is considered in a separate module (ZWWL). The result is the ignition angle for cylinder bank 1 (zwref) which is also the reference for cylinder bank 2. For cylinder bank 2, the ignition angle offset dzwb2 is added to the ignition angle.

ZWGRU 23.110 Application Notes

The maps KFZW and KFZW2 are applied when the engine is warm for the respective camshaft control position, exhaust gas recirculation is inactive and lambda = 1. If the engine does not knock, the optimal ignition angle is input. For engine knock, the knock limit is input.

Parameter	**Description**
CNOKT	Codeword for lower octane fuel
CWZWBANK	Codeword for enabling cylinder-specific ignition angle offsets
DZWNWSUE	Delta ignition angle depending on camshaft overlap angle
KFDWSZ	Delta ignition angle for cylinder bank 1-specific ignition advance; through camshaft control
KFDWSZ2	Delta ignition angle for cylinder bank 2-specific ignition advance; through camshaft control
KFDZK	Delta ignition angle during knock
KFDZWKG	Ignition angle correction by moving the knock limit
KFSWKFZK	Ignition angle retardation threshold for switching between ignition angle maps
KFZW	Ignition angle map
KFZW2	Ignition angle map, variant 2
TMZIZWV	Engine temperature threshold for enabling cylinder-specific ignition angle adjustment
TSWKR	Time lag for summing ignition angle retardation queries
VZIZWV	Vehicle speed threshold for disabling cylinder-specific ignition angle adjustment
Variable	**Description**
B_KFZK	Condition flag for anti-knock map
B_KRDWS	Condition flag for knock control safety retardation
B_NOZWE	Condition flag for no ignition angle intervention on the engine torque structure
C_INI	Condition flag for intialising ECU
DZWB2	Ignition angle offset for cylinder bank 2
DZWBANK	Cylinder-bank specific ignition angle offset
DZWKG	Delta ignition angle for moving the knock limit
DZWOAG	Exhaust gas recirculation rate-dependent ignition angle correction of the optimum ignition angle
DZWOL	Lambda-dependent ignition angle correction of the optimum ignition angle
DZWZK	Delta ignition angle during knock
FNWUE	Weighting factor for ignition angle overlap (inlet)
LAMBAS	Basic lambda
NMOT	Engine speed
NMOT W	Engine speed (Word)
RL_W	Relative cylinder charge (Word)
SY_NWS	System constant for camshaft control: none, binary (on/off) or continuously variable

ZWGRU 23.110 (Fundamental Ignition Angle)

SY_ZIZWV	*Text must be provided by Mrs Sauer*
TMOT	Engine temperature
VFZG	Vehicle speed
WKRMA	Average of the ignition angle retardation during knock control, general (in limp mode with safety)
WNWUE	Camshaft overlap angle
ZWGRU	Fundamental ignition angle
ZWNWS	Fundamental ignition angle taking camshaft control into consideration
ZZYLZUE	ECU cylinder counter for ignition calculation