Project: MSS54

Module: KAT conversion

	Department	Date	name	Filename
editor	EE-32	01.04.2013 12:51:00		5.05

1st General

This function checks the oxygen storage capacity of the catalyst. If this storage capacity is significantly reduced due to aging of the catalyst, the conversion of the catalyst is also reduced.

The lambda sensor amplitude ratio of the NKAT and VKAT sensors is used as a quality measure for the storage capacity. Significant lambda sensor amplitudes of the NKAT signal occur when the catalytic converter ages, but also when there are momentary loads within certain load and speed ranges - therefore a load and speed-dependent evaluation must be carried out.

The determination of the quality measure and the associated filtering etc. are carried out in 100ms intervals.

2nd diagnostic conditions

2.1. Description of the switching conditions

The function is released when

• BIT6 is set **in** the application constant **K_LA_OBD_FREIGABE**

• the **lambda control VKAT** is active and no dynamic behavior is present
=> B_LA1/2
=> !B_LA1/2_DYNAMIK

• the **lambda control NKAT** is operational
=> B_LANK1/2_SONDE_BEREIT

• the **n-/rf range detection** is within the evaluation range and no dynamic behavior present
=> !B_N_DYNAMIK
=> !B_RF_DYNAMIK_KAT

• **no general switch-off condition** exists and the waiting time has expired.
=> B_LA_KONV_AKTIV_T1/2

• the waiting time **K_LA_KONV_AKTIV_T** has expired

If all these switch-on conditions are met, the condition **B_LA_KONV_AMPL1/2** set and the calculation of the amplitude ratios and the limit filtering is released.

2.2. Description of the STOP criteria

The function will stop if

• the **speed** becomes greater than a threshold
=> n > K_LA_KONV_N_MAX

• the **catalytic converter temperature** is below a certain threshold
=> tkatm < K_LA_KONV_TKAT

• the **temperature of the intake air** is below a threshold value => tan < K_LA_KONV_T_UMG

• the **engine has not** been running for a certain time
=> (t_start_exit < K_LA_KONV_T_MOT) && B_ML

• the **KAT - Clearing** function is active
=> B_LA_KA1/2

• **after the KAT was cleared,** a certain **amount of air** flowed through the **KAT** => la_ausr_ml_kat > K_LANK_ML_SCHW => la_ka_ausr_st, BIT4

• there is a **tank ventilation with a high load** => tea1/2_f < K_LA_KONV_TEA_SCHW

• a **throttle potentiometer error** => ! B_WDK_FEHLERFREI_DPR

• a **probe heating error VKAT or NKAT**
=> B_LSHV1/2_ERROR
=> B_LSHN1/2_ERROR

• a **dropout detection error**
=> B_AUSS_FEHLER

• a **fault in the tank ventilation system or in the diagnosis**
=> B_TEV_FEHLER
=> B_TE_FEHLER (not yet implemented)

• a **UBATT error**
=> B_UB_FAILURE

• an **air mass error**
=> B_HFM_FAILURE

• an **error in the intake air temperature**
=> B_TAN_FEHLER

• an **error in the engine temperature**
=> B_TMOT_FEHLER

• a **fault in the fuel system**

=> B_KSD1/2_ERROR

• the **catalytic converter protection function** is active when the tank is empty
=> B_KATS_MD_RED

• an **error for the VKAT or NKAT sensors regarding exceeded adaptation error thresholds**
=> LAA1/2_SCHW

• an **error due to the lambda aging monitoring for the VKAT or NKAT probes**
=> B_LA_ALT1/2_ERROR
=> B_LA_VKAT1/2_HUB_FEHLER

is present.

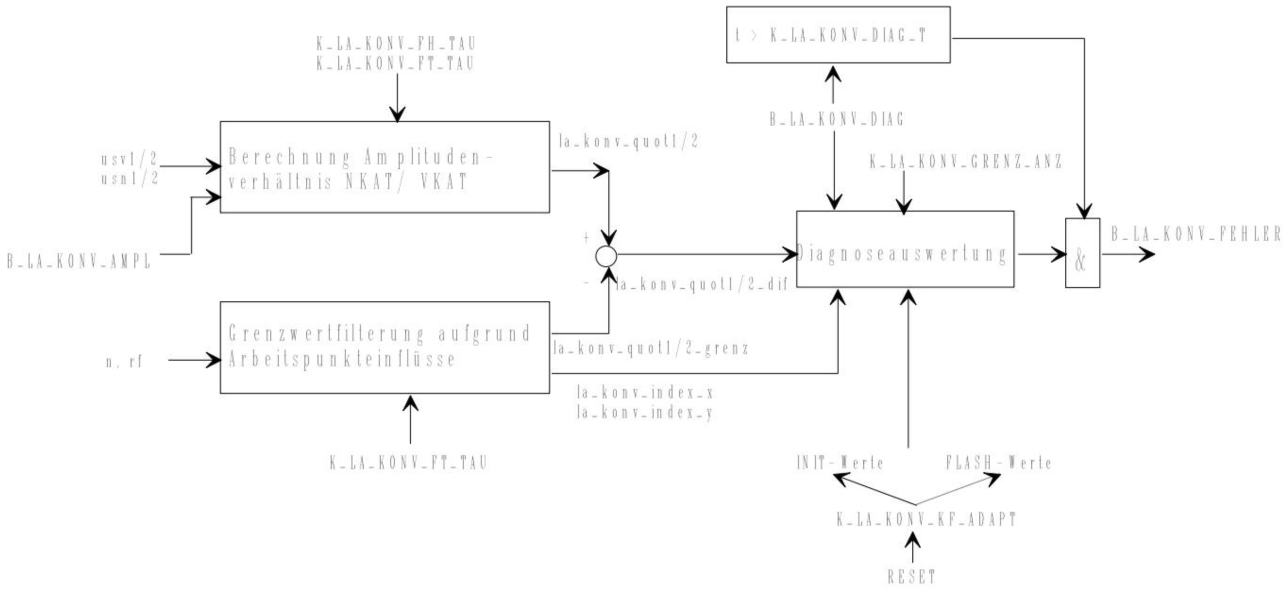
All these general switch-off conditions are summarized in one condition **B_LA_KONV_AUS1/2** (BIT0/1 in la_konv_st).

As soon as a STOP criterion is present for this function, all important working variables (described below) are frozen. Untypical signal changes at the lambda sensors therefore do not affect the quality measure.

However, the actual diagnosis only becomes **active** when, in addition to the **elapsed waiting time,** the average amplitude value of the VKAT probe **usv1/2_wb_ft** has also exceeded a certain threshold **K_LA_KONV_WB_VKAT** => **B_LA_KONV_DIAG.**

As soon as the state B_LA_KONV_DIAG is established, the **diagnostic time (la_konv_diag_time) K_LA_KONV_DIAG_T** also expires .

3. Graphical representation of the KAT conversion



4. Evaluation description - Quality measure of aging

4.1. Determination of the amplitude ratio

Here, the quotient of the rectified mean values of the alternating voltage components of the VKAT and NKAT probes is first formed.

The separation of the alternating voltage component of a probe signal is carried out with a high-pass filter (1 - PT1 filter); then the signal is calculated and filtered. This way, a rectified average value of the alternating voltage components is obtained. This function is applied to both the VKAT and the NKAT signal and forms
then the amplitude ratio NKAT / VKAT. This ratio is now a measure of the aging of the catalyst.

Function:

• VKAT voltages

The direct voltage component is separated from the probe voltage **usv1/2** using a high-pass filter (time constant K_LA_KONV_FH_TAU). The value usv1/2_wb is then calculated from this alternating voltage component usv1/2_w. After averaging with a low-pass filter **(time constant K_LA_KONV_FT_TAU), the** value usv1/2_wb_ft is obtained .

- NKAT voltages

With the help of a high-pass filter (time constant **K_LA_KONV_FH_TAU)** the probe voltage **usn1/2** the DC voltage component is separated. The amount **usn1/2_wb** is then formed from this AC voltage component **usn1/2_w .** After averaging with a low-pass filter (time constant **K_LA_KONV_FT_TAU)** the value usn1/2_wb_ft is obtained .

- Quality measure of the KAT conversion (if condition B_LA_KONV_AMPL1/2 applies)

la_konv_quot1/2 = usn1/2_wb_ft / usv1/2_wb_ft

4.2. Limit filtering

For a valid diagnosis, operating point influences must be taken into account, since the catalytic converter conversion quotient also increases under high load.

In order to take this load into account in different load ranges, the quality measure **la_konv_quot1/2** is compared with a limit value from a load and speed-dependent characteristic map **KF_LA_KONV_QUOT_GRENZ .**

In order to take into account the influence of operating point changes, the limit value **KF_LA_KONV_QUOT_GRENZ** is filtered with the same time constant **K_LA_KONF_FT_TAU** as the amplitude values before the difference is formed.

la_konv_quot1/2_dif = la_konv_quot1/2 - la_konv_quot_limit

This characteristic map KF_LA_KONV_QUOT_GRENZ is a 3 x 3 characteristic map that describes load influences within a certain rf/n range. The entire diagnostic range is spanned by constants. These MIN and MAX values must be applied in such a way that they enclose the characteristic map KF_LA_KONV_QOUT_GRENZ.

The entire diagnostic range spans over (flows into B_LA_KONV_AMPL):

K_LA_KONV_GR_N_MIN <= n <= K_LA_KONV_GR_N_MAX

K_LA_KONV_GR_RF_MIN <= rf <= K_LA_KONV_GR_RF_MAX

The current map area is required for the subsequent diagnosis. Therefore, the support points are passed on to the outside via table interpolation => **la_konv_index_x, la_konv_index_y.**

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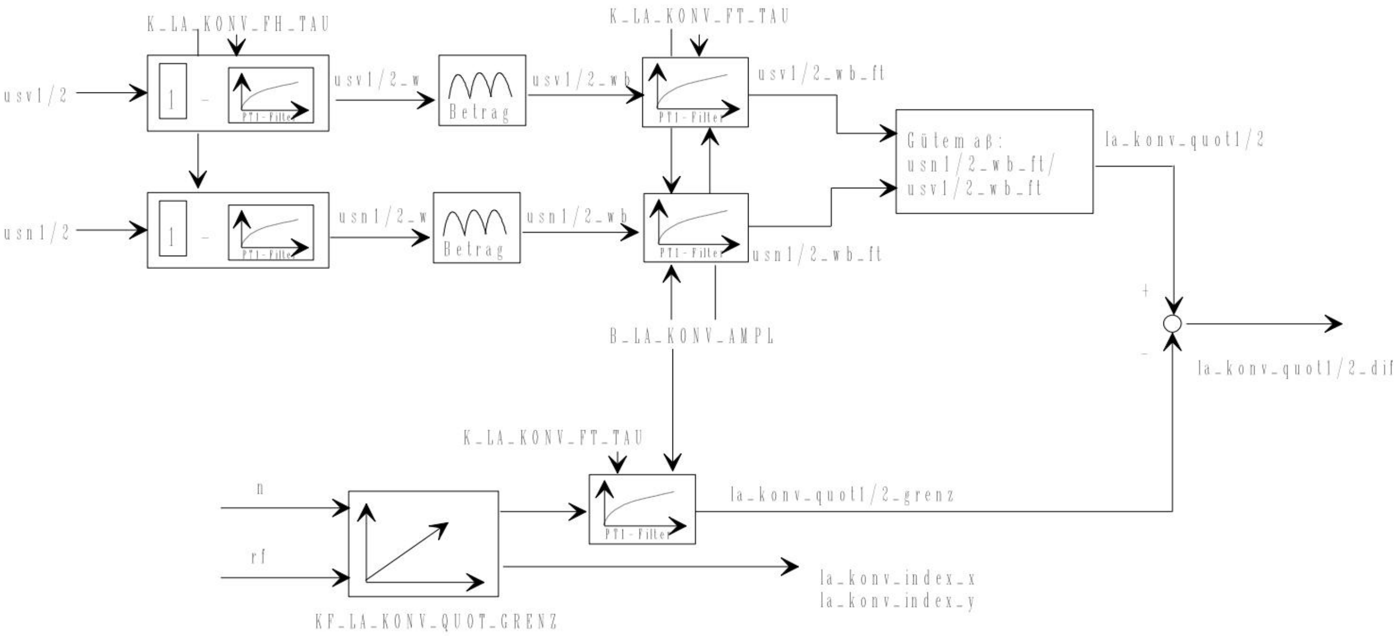
4.3. Graphical representation - amplitude ratio and limit filtering



5th Diagnosis KAT conversion

5.1. Adaptation of the difference value ((ACTUAL - TARGET) quotient)

The diagnosis is also carried out according to load and speed ranges. For this purpose, the difference **la_konv_quot1/2_dif** is filtered **separately into 9 areas** using the previously determined support points (la_konv_index_x/y) (3 x 3 matrix).

With the time constant **K_LA_KONV_APPL_TAU** of this filter, an averaging over a longer residence time within a range is achieved => this results in an adaptation matrix **la_konv1/2_ad[3][3].**

5.2. Diagnostic evaluation

To avoid misdiagnosis, a limit violation must be detected within a driving cycle present in several work areas at the same time.

After the diagnosis time has elapsed (catalytic converter healing must also be taken into account), the adaptation matrix is checked for limit value violations. All **positive** areas of the matrix **la_konv1/2_ad** are counted => **la_konv_anz_grenz1/2 .**

Is the condition

la_konv_anz_limit1/2 > K_LA_KONV_GRENZ_ANZ

fulfilled, the catalyst is **detected as defective.**

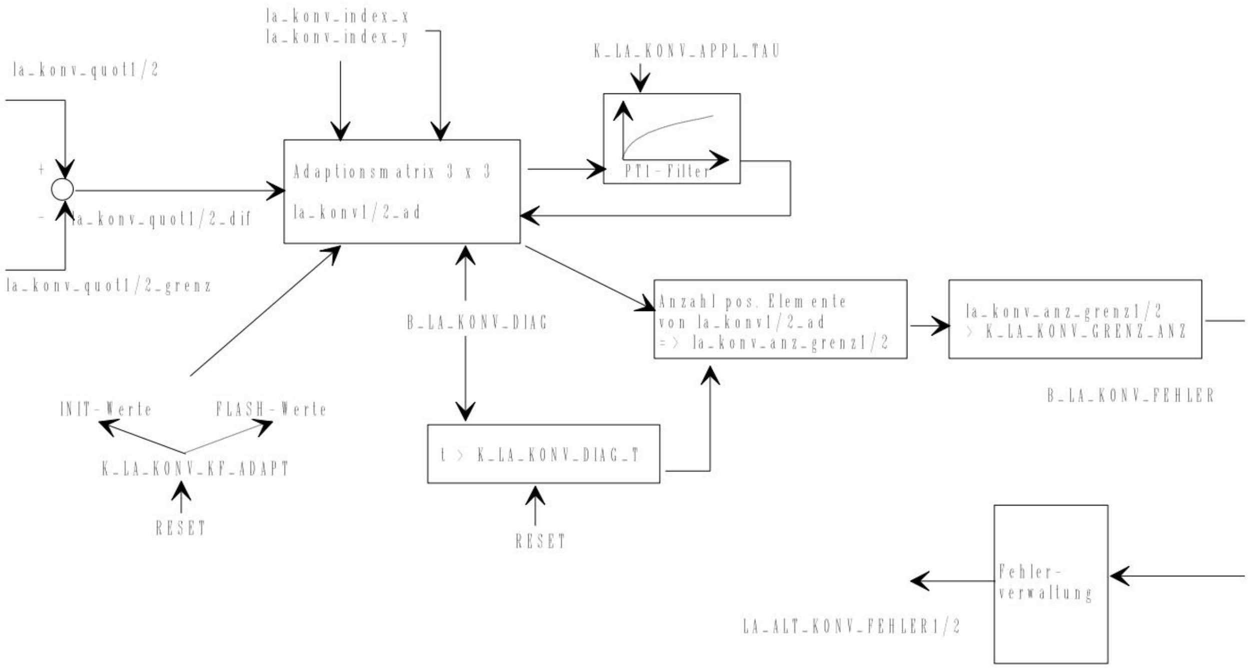
Furthermore, after this minimum diagnostic time has elapsed, the **ed_report** function is used to enter either the error type **“limit value exceeded due to aging”** (SH_TO_UB) or **“no error present”** (NO_FEHLER) into the error memory.

This error entry only occurs once during an engine run (debounce counter etc. = 1). The MIL lamp is activated when the diagnosis detects a limit violation on two consecutive driving cycles (DrCy).

During **initialization,** all filters/areas of the adaptation matrix la_konv1/2_ad are set to an **initialization value** that corresponds to a **good catalyst .** In each driving cycle, the catalyst is thus checked for aging without being influenced by its previous history.

However, it is possible to switch off this initialization using the constant **K_LA_KONV_KF_ADAPT** and instead read the non-volatile values **from the FLASH .**

5.3. Graphical representation of the diagnostic evaluation



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6th application instructions

The application of the "KAT conversion" function only makes sense when the application of the lambda controllers VKAT / NKAT is completed and the FTP results of the vehicle are close to the target value; only then is it possible to select a limit catalyst, which must be recognized as bad.
During the application, a nominal control probe should first be used.

Application of the characteristic map KF_LA_KONV_QUOT_GRENZ

The n-/rf limits must be selected so that during an FTP72 the total time spent in several areas is at least 50-60s each. In any case, LL or near-LL areas and load peaks during start-up processes must be excluded.

Attention: If the lower limit of the evaluation is set to a frequently occurring value,
The evaluation time can be extended considerably, since a waiting period must elapse each time the evaluation limit is exceeded.

The initialization value must not be too far negative (too good CAT), otherwise the available evaluation time for the filters to settle is not sufficient.

7th variables and constants

bit position	la_konv_st
Bit0	Switch-off condition Bank1 is present
Bit1	Switch-off condition Bank2 is present
Bit2	Diagnostic time Bank1 has expired
Bit3	Diagnostic time Bank2 has expired
Bit4	Diagnostic conditions are met (Bank1)
Bit5	Diagnostic conditions are met (Bank2)
Bit6	n-/rf range detection Bank1 is active
Bit7	n-/rf range detection Bank2 is active

Variables:

name	Meaning	Type	Resolution
la_konv_st Status variable	for KAT conversion la_konv_quot_grenz_of	uc	--
Limit value for the quality	measure, unfiltered la_konv_quot_grenz	uc	--
Limit value for the quality	measure, filtered usv/n_w[2]	uw	--
	AC voltage component of the probe voltage usv/	sw	mV
n_wb_ft[2] filtered value of	the AC voltage component la_kon_quot[2]	uw	mV
	quality measure of the KAT conversion	uw	--

la_konv_quot_dif[2]	Difference between actual quality measure and theoretical quality measure	sw --	
la_konv_diag_time[2]	current diagnostic time	uw s	
la_konv_index_x/y	indices of the matrix or KF_LA_KONV_DIAG_TIME		
la_konv_anz_limit[2]	Number of faulty areas in the adaptation matrix error status variable	uc --	
la_konv1/2_ed		uc --	

Application data:

name	type	Meaning
K_LA_KONV_T_MOT	constant	current engine running time
K_LA_KONV_AKTIV_T	constant	Waiting time after STOP condition
K_LA_KONV_N_MAX	constant	speed threshold for STOP criterion
K_LA_KONV_TKAT	constant	catalytic converter temperature for STOP criterion
K_LA_KONV_DIAG_T	constant	diagnostic time of the KAT conversion
K_LA_KONV_FH_TAU	constant	filter constant high-pass filter
K_LA_KONV_FT_TAU	constant	filter constant low-pass filter
K_LA_KONV_WB_VKA	constant	VKAT threshold for diagnostic release
K_LA_KONV_GR_N_MIN	constant	lower N-threshold for release
K_LA_KONV_GR_N_MAX	constant	upper N threshold for release
K_LA_KONV_GR_RF_MIN	constant	lower RF threshold for release
K_LA_KONV_GR_RF_MAX	constant	upper RF threshold for release
K_LA_KONV_T_UMG	constant	threshold, depending on the ambient temperature
K_LA_KONV_ANZ_BORDER	constant	threshold for error entry
K_LA_KONV_KF_ADAPT	constant	Constant for switching between INIT and flash values of the application matrix
K_LA_KONV_APPL_TAU	constant	filter constant for matrix
KF_LA_KONV_QUOT_BORDER	map	Threshold for diagnosis of good/bad CAT
K_LA_KONV_KF_INIT	constant	Init value for adaptation matrix