Project: MSS54

Module: Diagnosis of lambda sensor heater

1st General

The lambda sensor heater is checked with two diagnostic functions:

- electrical diagnosis
- Diagnosis of heating performance

The electrical diagnosis is carried out via a driver diagnosis. The driver provides the information as to whether there is a short circuit to ground, to UBATT or whether there is an open circuit.

To diagnose the heating output, the heater current of the VKAT or VKAT-T is measured for each exhaust system. NKAT probe heating is used. The current can be measured via the driver used for the probe heating. The heater current is determined every 10ms, the diagnosis itself is carried out in the background task.

2nd activation condition for the diagnosis

Both diagnostic functions have common activation conditions.

Since the heater resistance is initially low when the probe is cold, no diagnosis is initiated at this point. The probe heater is initially heated to maximum until the probe is ready for operation. It is then heated at reduced heating power until the dew point is exceeded. To ensure that the heater current has fallen to its steady-state value, a certain amount of time is waited after the dew point has been exceeded before diagnosis is started.

Conditions:

- all switch-on conditions for the lambda probe heating are met
  => B_LSHV1/2_ON for the VKAT sensors
  B_LSHN1/2_ON for the NKAT probes

- the dew point for the individual probes is exceeded
  => !B_LSHV1/2_TAUP for the VKAT probes
  !B_LSHN1/2_TAUP for the NKAT probes

- the dew point condition is fulfilled for the time K_LSHV/N_TAUP_T
  (the time is only started when the heating is switched on)

- the battery voltage ubatt > K_ED_UBMIN is

- the LS heater is not controlled via DS2 (!B_LSHxx_DS2)

- Check whether it is a single-flow or double-flow exhaust system.
  (B_CFG_S50 || B_CFG_S62)

3. Heating performance diagnosis based on a resistance test

3.1. Test criteria

The heater resistance of the probes is used as a diagnostic criterion.

Different resistance thresholds are used for the VKAT and NKAT probes

VKAT:	K_LSHV1/2_DIAG_RO	upper diagnostic threshold	(approx. 18.6 ohms)
	K_LSHV1/2_DIAG_RU	lower diagnostic threshold	(approx. 4.5 ohms)
NKAT:	K_LSHN1/2_DIAG_RO	upper diagnostic threshold	(approx. 18.6 ohms)
	K_LSHN1/2_DIAG_RU	lower diagnostic threshold	(approx. 4.5 ohms)

3.2. Error checking

Error - Heating output too low:

If the resistance test shows that the heater resistance

for the VKAT probe:

lshv_diag_r1 or lshv_diag_r2 > K_LSHV1/2_DIAG_RO

for the NKAT probe:

lshn_diag_r1 or lshn_diag_r2 > K_LSHN1/2_DIAG_RO

the heating output of the probe heater is too low and an error is detected.

Error - heating output too high/ no heating output:

If the resistance test shows that the heater resistance

for the VKAT probe:

lshv_diag_r1 or lshv_diag_r2 < K_LSHV1/2_DIAG_RU

for the NKAT probe:

lshn_diag_r1 or lshn_diag_r2 < K_LSHN1/2_DIAG_RU

The heating output of the probe heater is too high or there is no heating output; thus an error is detected.

With the help of the diagnostic function **ed_report,** as soon as one of these errors is detected, the error type ***"IMPLAUSIBLE"*** is entered into the error memory.

no error - resistance value is within the thresholds:

If the determined resistance of the heater is within the upper and lower thresholds, no error can be detected; ie the lambda probe heater is working properly. If an error of the type "IMPLAUSIBLE" is entered in the error log, the **ed_report** function is called with the error type "No error" to correct it.

4th **Determination of the heater resistance**

4.1. Current measurement via the driver module

The *ATM38 driver* used for the lambda sensor heater is used to measure the heater current.

The driver voltage is detected on the slave at ports PQA4 - PQA7 (LHV1, LHV2, LHN1 and LHN2).
These voltage values are converted by the A/D converter into a 10-bit value (0V = 0; 5V = 1024) and stored in the variables AD_KANAL_LSHV1/2 and AD_KANAL_LSHN1/2.

However, care must be taken that the voltage is not exceeded during any LSH control 5V and decreases accordingly when activated. The signal is thus inverted, which is compensated for by software.

Voltage conditioning:

According to the data sheet:

i_lsh = u_lsh * 650 / 681 Ohm

u_lsh = 5V - AD_KANAL value

In the processor:

lshx_iy_ad = 1024 - AD_KANAL_LSHxy

Conversion to current value: HEX / 215 for the ad

4.2. Determining the resistance of the heater

Since the battery voltage is a known system quantity, the determined current to determine the actual heater resistance.

lshx_diag_ry = ub * LSH_OHM_FAK / lshx_iy

lshx_diag_ry: Resistance of the heater of the VKAT- or NKAT probes
lshx_iy: Heater current of the VKAT or NKAT probes
ub: measured battery voltage
LSH_OHM_FAK: Conversion factor of the AD value to the current value (215dec)

This resistance determination is carried out every 10ms.

Since the probe heating is controlled by pulse width modulation with a period of 200msec, the current is averaged in order to obtain the actual resistance value. To do this, a measured value (AD value) is saved and summed up every 10ms over 2 periods. In this way, an average value can be calculated over 40 measured values. However, this averaged current is not yet the actual current value, since the averaging also takes place over LOW times of the PWM signal. The duty cycle used must therefore be included in the calculation.

Current value determination:

lshx_iy = lshx_iy_sum * (100/LSH_I_SUM_FAK) / lshxy_ta

lshxy_ta: Duty cycle for LSH- VKAT or NKAT
lshx_iy_sum: accumulated current values 40 measured values
LSH_I_SUM_FAK:

5th LSH driver diagnostics

The LSH driver ***ATM38*** also diagnoses the following electrical errors:

- openload = interruption
- Short circuit to UB
- Short circuit to ground

When evaluating the driver module, however, it must be ensured that the driver is read out at an angle-synchronous level. To avoid “turbo effects”, the driver diagnosis must not take place more than once within the LSH period (driver-specific). Since the

If the heating output diagnosis takes place every other period, this diagnosis is also carried out in this grid.

The driver diagnosis has priority over the heating performance diagnosis, which means that an error recorded by the electrical diagnosis gets through and the heating performance diagnosis is skipped.

With the help of the diagnostic function **ed_report,** as soon as an error is detected, the corresponding error type is entered into the error memory.

If there is no electrical error and an error of the type “SH_TO_UB, SH_TO_GND or OPENLOAD” is entered in the error memory, the **ed_report** function is called with the error type “No error” to correct it.

The following transfer parameters to the **ed_report** are now possible in total:

0x00: no error (NO_ERROR)
0x01: short to battery (SH_TO_UB)
0x02: short to ground (SH_TO_GND)
0x04: openload
0x08: implausible (heating power)

As soon as an error is entered in the error memory, the state B_LSHV1/2_ERROR for the VKAT or B_LSHN1/2_ERROR for the NKAT sensor is set.

A diagnostic error of the probe heater affects:

- the release of the NKAT controller (laaktiv.c)
- the probe diagnosis of the VKAT and NKAT (ladiag.c)
- Catalyst conversion (la_obd.c)
- Lambda sensor aging monitoring (la_obd.c)

6th constants and variables

6.1. Constants

K_LSH_TAUP_T	Time that must have elapsed after exceeding the dew point
K_LSHV1_DIAG_RU	lower resistance threshold for the diagnosis VKAT1
K_LSHV2_DIAG_RU	lower resistance threshold for the diagnosis VKAT2
K_LSHN1_DIAG_RU	lower resistance threshold for the diagnosis NKAT1
K_LSHN2_DIAG_RU	lower resistance threshold for the diagnosis NKAT2

K_LSHV1_DIAG_RO	upper resistance threshold for the diagnosis VKAT1
K_LSHV2_DIAG_RO	upper resistance threshold for the diagnosis VKAT2
K_LSHN1_DIAG_RO	upper resistance threshold for the diagnosis NKAT1
K_LSHN2_DIAG_RO	upper resistance threshold for the diagnosis NKAT2

6.2. Variables

lshv_i1/2	current value VKAT1/2
lshn_i1/2	current value NKAT1/2
lshv_i1_ad	"inverted" AD value VKAT2 (current)
lshn_i2_ad	"inverted" AD value NKAT2 (current)
lshv_i1/2_counter	counter to sum the current values VKAT1/2
lshn_i1/2_counter	counter to sum the current values NKAT1/2
lshv_i1/2_sum	summed AD values VKAT1/2
lshn_i1/2_sum	summed AD values NKAT1/2
lshv_diag_r1	actual resistance value VKAT1
lshv_diag_r2	actual resistance value VKAT2
lshn_diag_r1	actual resistance value NKAT1
lshn_diag_r2	actual resistance value NKAT2
lshv1/2_ed	Error status variable for VKAT1/2
lshn1/2_ed	Error status variable for NKAT1/2
lshv1/2_tr_ed	Driver status variable for VKAT1/2
lshn1/2_tr_ed	Driver status variable for NKAT1/2