MSS54

module description
ignition

	Department	Date	name	Filename
editor				TZ.DOC

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CHANGE DOCUMENTATION FROM V3.18 (SERIES STANDARD E91/M3 ECE)

V:4.02 Conversion of the characteristic curve KL_TZ_LL = f(n) into a characteristic field KF_TZ_LL = f (n, rf)

V:4.03 Introduction of a third range in the ignition angle change limitation Range 1: n > threshold and rf < threshold Range 2: n > threshold and rf > threshold
Range 3: n < threshold

V:5.02 Switching off the ignition with terminal 15 off
From now on, the ignition coils will not be switched off directly with Kl.15, but will remain active for a total of K_TZ_KL15_NACHLAUF segments (provided that the switch-off speed of the ignition coils has not yet been reached)

Intermittent generator for the ignition Due
to popular demand, an intermittent generator similar to the injection has now been implemented for the ignition.

V:5.06 Extension of the misfire generator to include the operating mode “sporadic”

evt 301 Basic ignition angle now from basic maps, depending on operating mode

1. IGNITION

This chapter describes the calculation of the ignition angle and the closing time as well as the ignition signal generation.

The ignition software is based on a static ignition distribution with six/eight independent individual ignition coils.

The ignition angle is calculated with a calculation width of 16 bits. The resolution is 0.1° KW. All ignition angle values are relative to the ignition TDC of the respective cylinder, whereby a positive value means an ignition point before TDC, a negative value after TDC.

The ignition angle calculation is carried out in every operating state of the MSS54. However, the ignition output stages are only activated when the following condition is met:

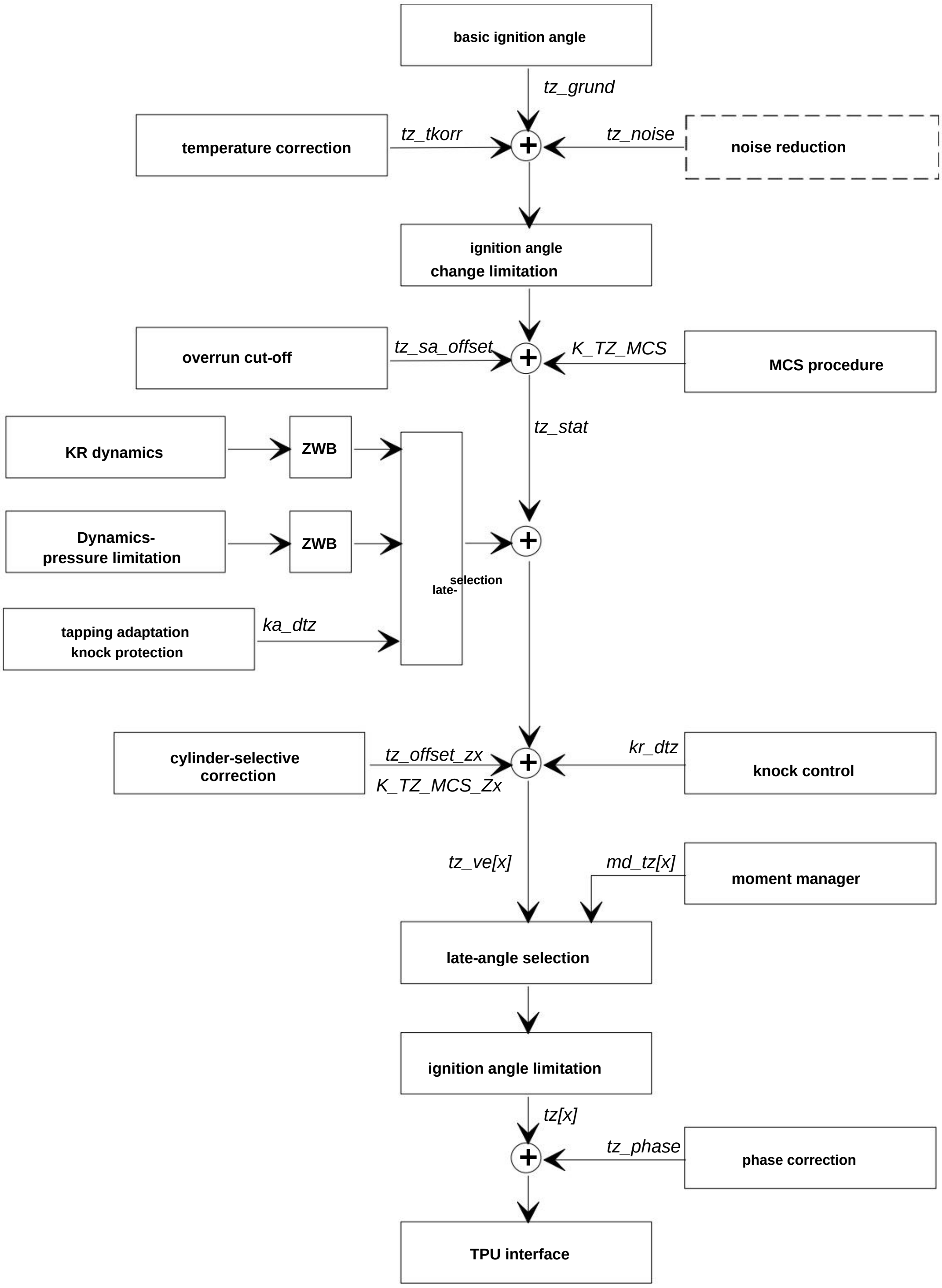
Terminal 15 active
and TPU synchronized
and (n > K_TZ_NMIN_KL50 ON at S_KL50 active
or n > K_TZ_NMIN_KL50 OFF if S_KL50 inactive)

As of program status 5.02, the ignition is not switched off immediately with KL15, but remains active for K_TZ_KL15_NACHLAUF segments, provided that the other conditions are still met.

The same speed thresholds (without hysteresis) apply to switching off the ignition output stages.

1.1. OVERVIEW OF IGNITION ANGLE CALCULATION

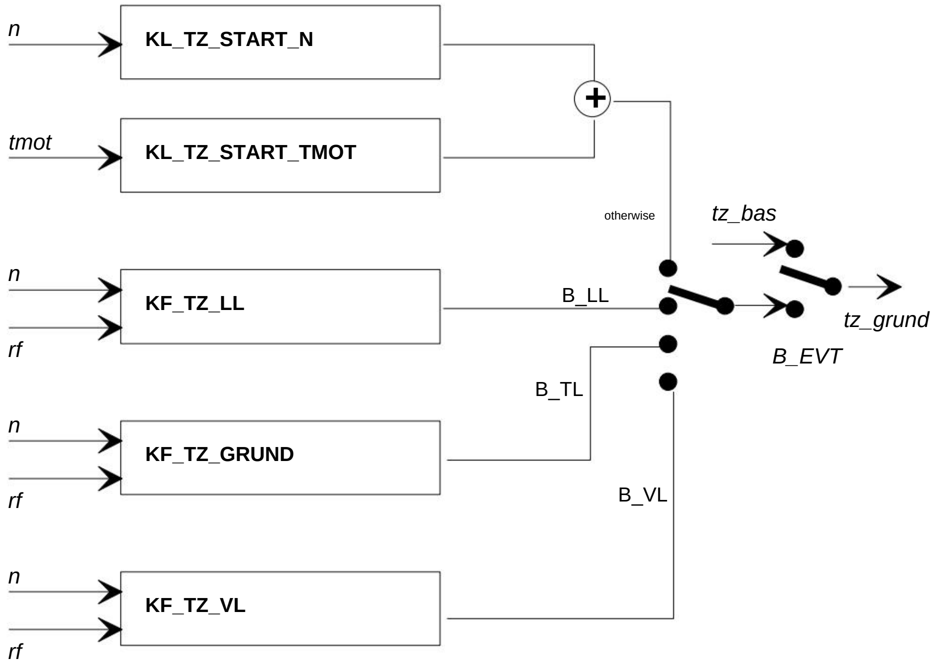
Picture : Overview of the ignition angle calculation



1.1.1. Basic ignition function

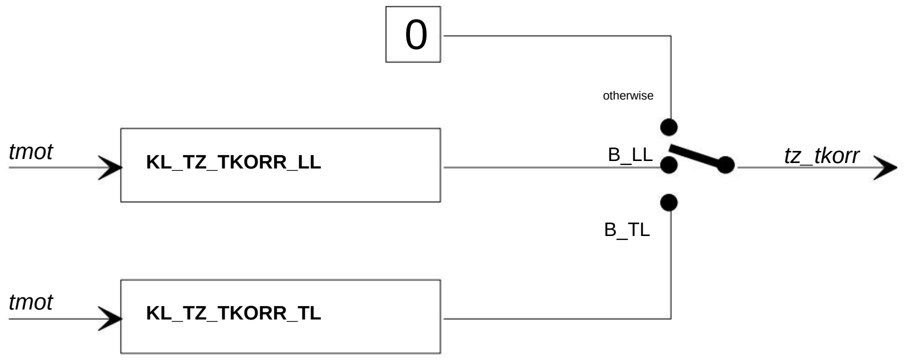
The basic function of the ignition angle calculation is active in every operating state and cannot be switched off. Depending on the current operating state, it provides a basic ignition angle that is modified by the downstream calculation modules.

For EVT engines (B_EVT = 1), the base ignition angle tz_bas is read from maps (see evt_momentenrealisierung.doc) and saved in tz_grund.



1.2. TEMPERATURE CORRECTION OF THE STATIONARY IGNITION ANGLE

Additive correction offset depending on engine temperature and operating condition.



1.3. NOISE REDUCTION

not yet implemented at the moment.

1.4. IGNITION ANGLE CHANGE LIMITATION ZWB

The ignition angle change limit is set via the basic ignition angle, the temperature correction, the noise reduction and the cylinder-wide intervention of the catalytic converter heating function, which only allows a fixed change in the ignition angle output per segment. The ignition angle increments are specified in °KW/segment.

The ZWB is divided internally into three areas.

Definition of the three AEOI areas:

B_ZWB1 : n > llr.nsoll + K_TZ_DNSOLL_ZWB
; Target speed of the LLR + offset
and rf < K_TZ_RF_ZWB ; load threshold for ZWB transition

B_ZWB2 : n > llr.nsoll + K_TZ_DNSOLL_ZWB
and rf > K_TZ_RF_ZWB

B_ZWB3 : n < llr.nsoll + K_TZ_DNSOLL_ZWB

In the "Start" operating state, the ZWB is bypassed; in the "Engine stopped" and "Coasting on" operating states, the ZWB is no longer activated because it requires a rotating engine (change per crankshaft angle segment).

1.5. INTERMEDIATE INTERVENTION FOR OVERHEAT CUT-OFF

In parallel to the torque reduction for the transition into or out of overrun cut-off in the torque manager, a second mechanism was implemented in the ignition module, which is intended to realize the torque reduction for overrun cut-off or the torque build-up for resumption via a controlled ignition angle retardation.

The advantage of the controlled ZW intervention is its simplicity and reproducibility. Unlike the ignition angle intervention of the torque manager, it works independently of the operating point and without cross-influences from other modules and is therefore easier to adjust. The disadvantage is that it actually only carries out a ZW intervention and not a controlled torque intervention and does not take into account the operating point-dependent influences or interventions of other modules in the torque generation.

The choice between the two types of ZW intervention for SA/WE is made via the configuration parameters
K_TZ_SA_CONTROL (SA/WE directly enabled).
and K_MD_TZ_CONTROL (MD_TZ SA-2stage).

Transition in SA:

Requirement: Condition SA readiness fulfilled (Bit0 set in sa_we_st)
filling reduced to a minimum

Starting from the value = 0, the ZW offset tz_sa_offset is reduced in a ramp-like manner until the resulting ZW angle tz_grund + tz_tkorr + tz_sa_offset reaches the minimum value tz_min.
The steepness of the reduction ramp depends on the speed and is stored in the characteristic curve KL_TZ_ZWB_SA.

Transition from SA:

Requirement: Condition SA no longer fulfilled

After removing the overrun cut-off condition, the ZW offset remains at its last value for K_TZ_WE_SEGM KW segments. The offset is then ramped up again to the neutral value of zero. The ramp-up is different for hard and soft restarts. For hard WE, a constant value K_TZ_ZWB_WE_HARD is used; for soft WE, a speed-dependent characteristic curve KL_TZ_ZWB_WE_SOFT is used.

1.6. IGNITION ANGLE INTERVENTIONS FOR DYNAMIC ADVANCE

Depending on the load step and the current operating point, two different transient interventions in the ignition exist.

- ÿ Knock protection dynamic lead
- ÿ Dynamic reserve for cylinder pressure limitation

The basis for triggering a dynamic lead is the detection of a load jump within the last 20 ms. The load jump is calculated using a Delta_rf, which is converted into a Delta_tl for the dynamic module.

Calculation of the load step:

delta_rf	=	KF_RF_N_DK(wdkt , nt) - KF_RF_N_DK(wdkt-20ms , nt)
dyn_trigger	=	Conversion_rf_tl(delta_rf , n)

If the trigger condition is met, the dynamic lead pulls the ignition angle by a defined offset in the retard direction. This occurs directly and without a change limit. This offset then remains at this amount for an applicable number of angle segments. The ignition angle intervention is then regulated synchronously with the angle via a change limit ZWB.

If several dynamic interventions are active at the same time, all measures are calculated including their change limitation and the intervention that retards the most is included in the ignition angle path.

Retriggering of a dynamic lead is only taken into account if the resulting ignition angle offset is adjusted further in the retard direction than the current value of the ignition angle.

The detection of the KR dynamics and the pressure limitation are documented in detail in the dynamic lead module description.

1.6.1. KR DYNAMIK

Trigger condition:

B_TL or B_VL
and d_wdk > K_DYN_DWDK_MIN and dyn_trigger // minimum positive DK gradient
> KL_DYN_TRIGGER_KR(n)
// Load step greater than trigger threshold

Calculation of the ignition angle offset:
dyn_comf_tz = KL_DYN_TZ_KR(tan)

Duration of intervention: K_TZ_SEGM_DYN_KR
Adjustment ramp: K_TZ_ZWB_DYN_KR

1.6.2. PRESSURE LIMITATION IN DYNAMICS

Trigger condition:

B_TL or B_VL
and d_wdk > K_DYN_DWDK_MIN and dyn_trigger // minimum positive DK gradient
> K_DYN_TRIGGER_DBGR
// Load step greater than trigger threshold
and n > K_DYN_DBGR_N_MIN and wdk > // speed threshold
K_DYN_DBGR_WDK_MIN and tmot > // DK threshold
K_DYN_DBGR_TMOT_MIN // Motor temperature threshold

Calculation of the ignition angle offset:
dyn_dbgr = KL_DYN_TZ_DBGR(n)

Intervention duration: K_TZ_SEGM_DYN_DBGR
Adjustment ramp: K_TZ_ZWB_DYN_DBGR

July 1st INTERVENTION APPLICATION SYSTEM

Using the application system, a correction offset can be applied either to the ignition angle for all cylinders or to a cylinder-selective adjustment.

K_TZ_MCS : correction offset that affects all cylinders
K_TZ_MCS_Z[x] : Correction offset that acts cylinder-selectively
x stands for the cylinder number

The resolution of the correction offset is 0.1 °CA. The adjustment range is defined in the MCS system.

August 1st **INTERVENTION KNOCK CONTROL / KNOCK PROTECTION**

The knock control intervenes via two cylinder-specific global variables, which are provided by the knock control/knock adaptation module.

kr_dtz[x] :	ignition angle offset of the knock control
ka_dtz[x] :	Ignition angle offset of the knock adaptation (including knock protection)

The ignition angle offset of the knock path adaptation is included in the ignition path using a retardation angle selection with the offset of the dynamic lead tz_dyn_offset. The ignition angle offset of the knock control is included additively in each segment and is not tied to any further conditions. The calculation of the ignition angle offsets is described in detail in the knock control module.

September 1st **INTERVENTION MOMENT MANAGER**

The ignition angle intervention of the torque manager is carried out cylinder-selectively via a cylinder-specific global variable md_tz[x]. This variable contains an absolute angle related to the respective ignition TDC.

The ignition angle is calculated in the torque manager once per 720° KW approximately 360° KW before the ignition TDC of the cylinder in question. If there is no intervention request in the torque manager, it returns the ignition angle calculated by the ignition module before intervention "tz_ve[x]". If the intervention request is active, an absolute angle is calculated based on the ignition angle before intervention, the torque request for the ignition angle path and the current indicated engine torque via the operating point-dependent ignition hooks and the optimal ignition angle. (Detailed documentation in the torque manager module description)

The ignition angle path is included in the calculation via a retard angle selection with the ignition angle before intervention, so that it is ensured that the torque manager can only adjust in the retard direction.

The torque intervention in the ignition can be blocked via the constant K_TZ_MD_CONTROL.

1.10. IGNITION ANGLE LIMITATION

The resulting cylinder-selective ignition angles tz[x] are first determined by the Ignition angle limitation to the value range

tz_min <= tzx <= K_TZ_MAX

limited.

This is followed by an additional limitation to

tzx <= tz_max

The latest possible ignition timing is calculated in the 10ms task and is made up of a speed/load dependent characteristic map KF_TZ_MIN and an offset characteristic KL_TZ_MIN_TMOT = f(tmot). The current value is visible in the variable "tz_min".

The additional limitation tz_max ensures that no ignition occurs before the intake closes.

In addition, a difference of K_ZWD is added, ie the earliest possible ignition timing tz_max is calculated from the control edge inlet closes es_aw plus the ignition angle difference K_ZWD.

1.11. PHASE CORRECTION

Due to the phase offset of the inductive crank angle sensor, all ignition angles are corrected using a speed-dependent phase angle, which is stored in the characteristic curve KL_TZ_PHASE. The phase angle is calculated in the background task and stored in the variable "tz.phase". The phase correction is only included in the ignition angle path after the ignition angle tz[x] has been calculated and is therefore not visible in these variables.

1.12. CLOSING TIME CALCULATION

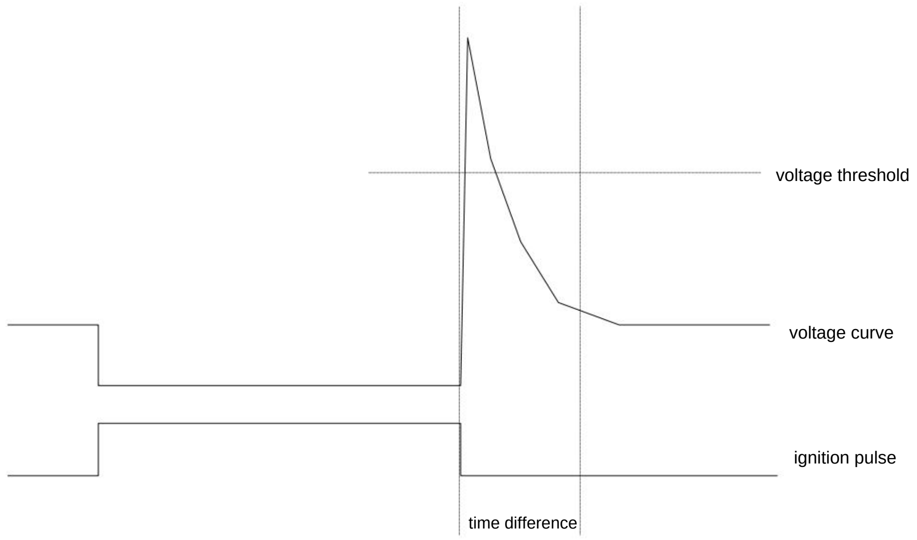
The closing time of the ignition channels is stored in the MSS54 in the map "KF_TZ_SZ" via engine speed and on-board voltage.

The closing time is calculated in the background task. The current closing time is stored in the variable "tz_sz" and the resolution is 3.21µs.

1.13. IGNITION CIRCUIT MONITORING

The ignition circuit (ignition output stage, cable, ignition coil, spark plug) is monitored by evaluating the flyback voltage of the ignition coil.

Image: basic course of the flyback voltage



After the ignition pulse, the flyback voltage must exceed a defined threshold value set by the hardware circuit. If this is not the case, it is concluded that the ignition coil could not be charged sufficiently and therefore a primary circuit fault has been detected. If the

If the threshold is exceeded, an ignition spark must fly at the spark plug within a defined time (also set via resistance values), which leads to a breakdown of the flyback voltage. If the voltage is still above the voltage threshold after the time has elapsed, no spark has flown and a secondary circuit fault is detected.

However, the secondary circuit monitoring can only determine whether a spark has occurred, but not whether it occurred at the spark plug or in the connector on the ignition coil.

The ignition circuit monitoring operates synchronously with the work cycle in the operating states start and engine running.
It becomes inactive when injection is suppressed or for K_TZ_ZKUE_SPERR work cycles afterwards. The primary and secondary circuit monitoring can be activated/deactivated individually using the K_TZ_ZKUE_CONTROL parameter.

If an error is detected in an ignition circuit, an error filter is started. After this has expired, an error log entry is made and the injection of the affected cylinder is switched off. If more than K_TZ_ZKUE_MAXERROR ignition circuit errors occur at the same time, it is assumed that there is a problem with the monitoring module and the injection of all cylinders is enabled again. (Caution: a blown fuse in the ignition circuit supply can lead to the failure of all ignition channels)

Variables of the ZKUE:

tz_ed_status Status ZKUE after error filtering, 1 bit per cylinder, bit set ÿ error
tz_zkue_diag current status ZKUE before error filtering, 1 bit per cylinder
Bit set ÿ last work cycle not OK
tz_edx Diagnostic status of the ignition channels, 1 variable per cylinder
tz_zkue_sperr ZKUE still x work cycles inactive
tz_zkue_info Raw information of the driver diagnosis
tz_zkue_error Endless counter of ignition circuit errors detected during engine operation

1.14. IGNITION COIL CONTROL VIA DS2

For testing purposes and troubleshooting in the workshop, a single ignition channel can also be controlled via the diagnostic interface. The prerequisite for this is that terminal 15 is active and the engine is stopped.

Control frequency: 10 Hz
Closing time: as calculated (tz_sz)

Only one cylinder can be clocked at a time. If the engine attempts to start, the control is immediately aborted and the ignition channels are reconfigured to the normal operating mode.

1.15. INTERMITTENT GENERATOR

To support misfire detection, a misfire generator for the ignition channels is available from version 5.02 implemented, which can either permanently or sequentially hide all cylinders. In version 5.06, the misfire generator was expanded to include the "sporadic" operating mode, in which the cylinders are hidden with a conditionally adjustable frequency, with a random misfire pattern.

The implementation of the skip generator was realized analogously to the skip generator of the injection.

The following parameters are available for configuration:

K_TZ_AUSS_CFG configuration
inactive
static - fixed blanking pattern of individual cylinders
sequential - rolling, sequential fade pattern
sporadic – random fade-out pattern

K_TZ_AUSS_ZYL fade-out pattern
Bit x == cylinder x+1 (e.g. Bit1 == cylinder 2)
Bit set: Cylinder in normal operation
Bit deleted: Cylinder in intermittent operation
in sequential intermittent operation: don´t care

K_TZ_AUSS_BEREICH: Number of work cycles for a blanking cycle

In sporadic mode, this value determines the static Frequency of cylinder suppression, which is approximately calculated from K_TZ_AUSS_BEREICH / number of cylinders

K_TZ_AUSS_ANZ: Number of immediately consecutive cylinder blankings per blanking cycle.

For the “sporadic” operating mode, the parameter must be set to the same value as the parameter K_TZ_AUSS_BEREICH for reasons of process control

Example:

K_TZ_AUSS_CFG = static
K_TZ_AUSS_ZYL = 0xF6
K_TZ_AUSS_BEREICH = 100
K_TZ_AUSS_ANZ = 2

With this setting, cylinders 1 and 4 would be switched off for 2 cycles every 100 cycles.

The prerequisite for the operation of the intermittent generator is that the crankshaft and camshaft synchronization was successful.