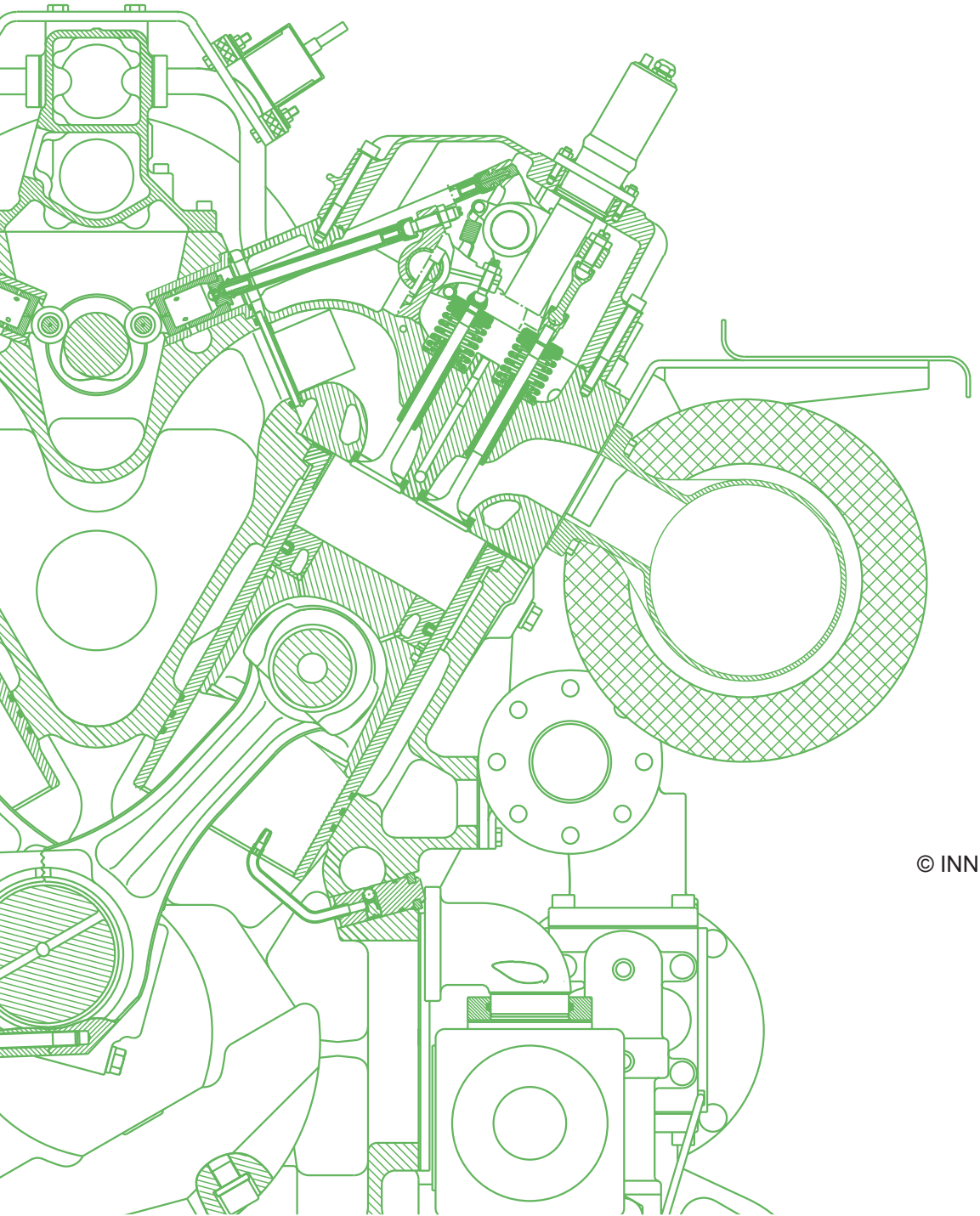
JENBACHER

TA 1502-0072

Technical Instruction

SPA24 (SAFI pick-up amplifier)



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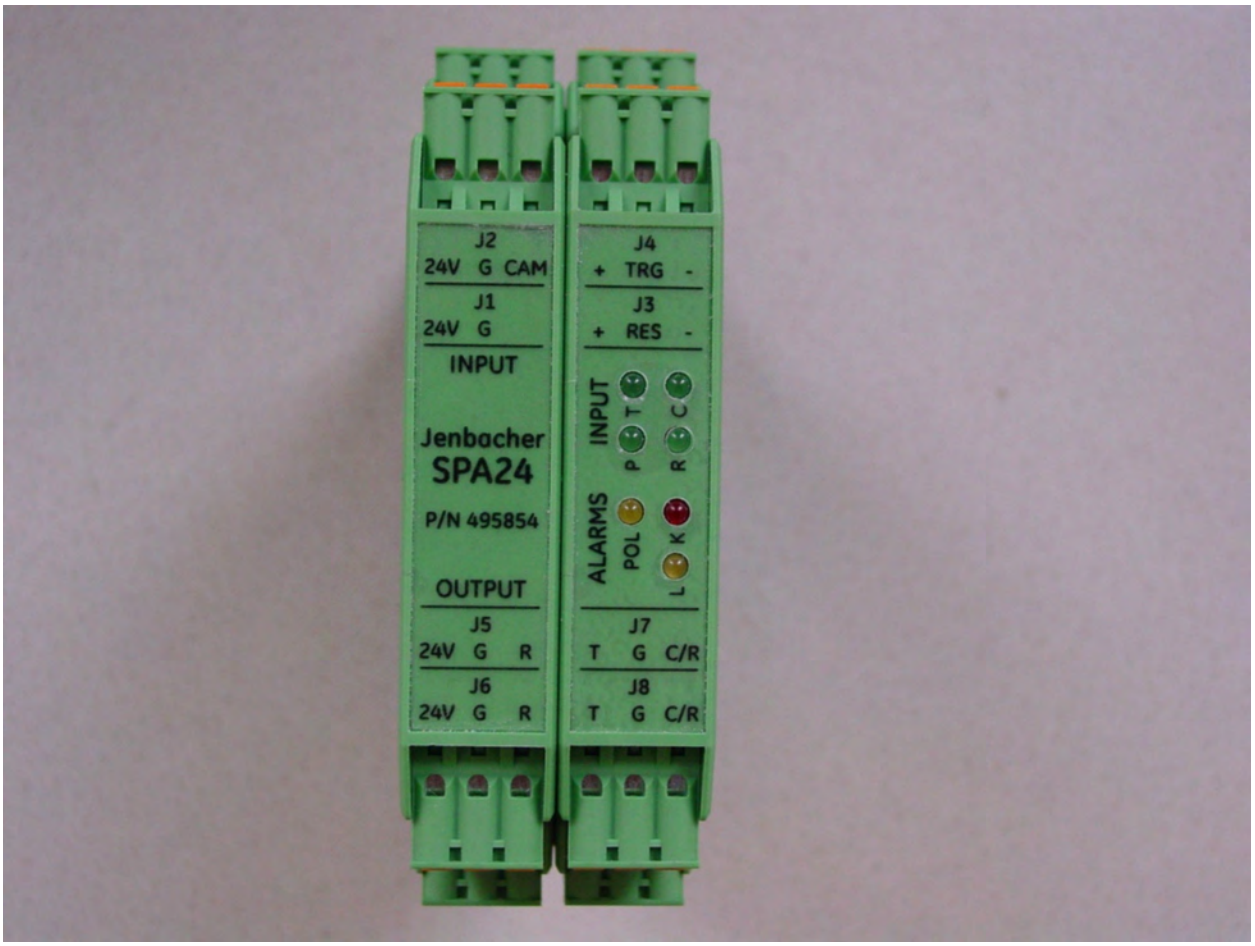
1 Description



1.1 General

SPA24 stands for **S**AFI-**P**ickup-**A**mplifier with **24** V DC supply voltage.

INNIO Jenbacher GmbH & Co OG Part number: **495854**

SPA24 is a pickup amplifier with internal logic which generates all three engine pickup signals - camshaft signal (CAM), reset signal (RESET) and ring-gear signal (TRIGGER) - in the digital form required for **SAFI**.

The **SPA24** is supplied with power via the +24 V DC circuit.

The following Technical Instructions are referred to in this document:

- TA 1502-0071 - SAFI (Sensor Actor Functional Interface)

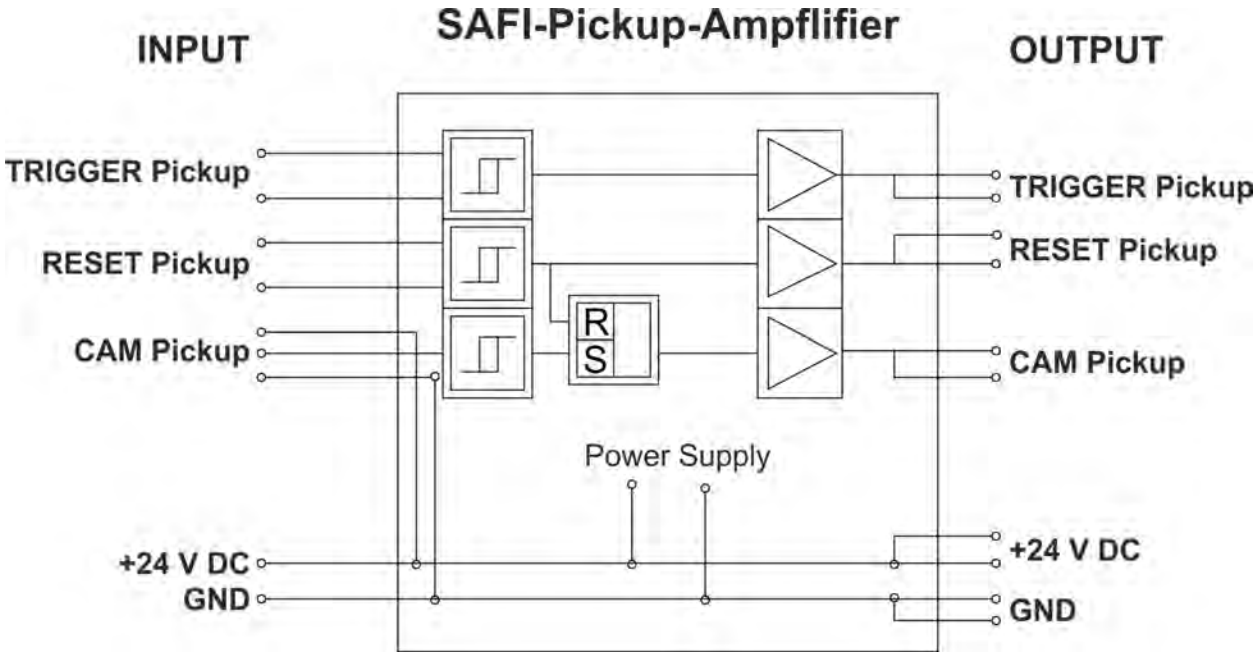
- TA 1502-0068 - MORIS (Modular Rail Ignition System)

The following functionalities are included in **SPA24**:

- internal logical linking of all three analogue engine pickup signals
- providing suitable, accurately timed, amplified, digital output signals for **SAFI** which are accurate to 0.1 crankshaft angle degree
- providing the digital generated **TRIGGER** pickup signal for **SAFI**
- (cylinder banks A and B)
- providing the digital, logically linked **CAM**shaft / RESET pickup signal for **SAFI** (cylinder banks A and B)
- providing the generated **RESET** pickup signal (cylinder banks A and B)
- monitoring the correct polarity of the analogue RESET and TRIGGER pickup input signals
- control voltage output +24V DC (twice).

1.2 Basic information

1.2.1 SPA24 block diagram



1.2.2 Input signals

The input values are all three engine pickup signals, i.e. **TRIGGER** (ring-gear signal), **RESET** (ring-gear reset signal), **CAM** (camshaft signal), and the +24V DC supply voltage. TRIGGER and RESET are passive pickups without their own + 24V DC voltage supply. CAM is generated by an active pickup which is supplied with + 24V DC by the **SPA24**. The TRIGGER ring-gear signal has a repetition rate which is equal to the flywheels number of teeth (in the range of 50 to 500 teeth), the RESET signal repeats itself once every crankshaft rotation and the CAM signal every two crankshaft rotations (flywheel). The CAM signal is generated once every engine cycle, i.e. once every camshaft rotation.

1.2.3 Output signals

The **SPA24** provides accurately timed signal outputs for an engine speed range between 0 and 2500 rpm. The output signal level values are either „0V“ or „+14V“ DC, depending on the operational condition. The **SPA24** amplifies the pickup input signals and produces suitable digital output signals. The output consists of a **logically linked digital CAM/RESET output signal** - which is generated from CAM and RESET input - and the generated **digital TRIGGER output signal**. The digital RESET output signal is provided for monitoring purposes. The generation of the digital output signals will be explained in more detail in sections 1.4 to 1.6. The duplicated +24V DC voltage outputs can be used to supply the electronics to be controlled (e.g. SAFI). The output signals are duplicated.

The release of the digital **SPA24** output signals is defined with an engine speed of ≥50 rpm^{-1} and a pickup input signal of ≥ +/-3 V. The engine speed of 50 rpm is detected by the **SPA24** by independently and internally measuring the input frequencies of the RESET and TRIGGER signal. If two input signal pulses are chronologically too far apart, the output signals are not released if the 50 rpm limit value is underrun. This results in a more accurate signal analysis. If both conditions for the RESET or TRIGGER signal have not been met, the output concerned is set to a 0V DC output level and optically indicated using orange LED „L“ (e.g. when engine is idling out or at standstill). The LED indication „L“ refers to „Low Speed“, i.e. the engine speed is too low and underruns the defined digital output signal’s release speed of 50 rpm. If the above conditions are met, the output signals generated for engine start and engine operation are available. During engine operation (≥50 rpm) LED "L" is dectivated and it is checked that the pickup distances are set correctly. The +/- 3 V switch threshold of the pickup input signals is reached at a pre-defined pickup default setting of ¾ to 1 ¼ turns at 50 to 90 rpm.

During engine standstill, all **SPA24** digital signal outputs have a 0V DC signal value. The double +24V DC outputs are continuously active, independently of the digital signal outputs release speed monitoring.

1.3 Displays/indications on the device

On the **SPA24**, the operating conditions of the input signals and various controls are indicated using light-emitting diodes (LEDs).

The three green LEDs "T", "C" and "R" indicate that the relevant pickup input signals TRIGGER, CAM and RESET are available. The LEDs always blink at the rising edge of the positive edge of the pickup signal concerned.

The presence of the supply voltage is indicated by a green LED „P“.

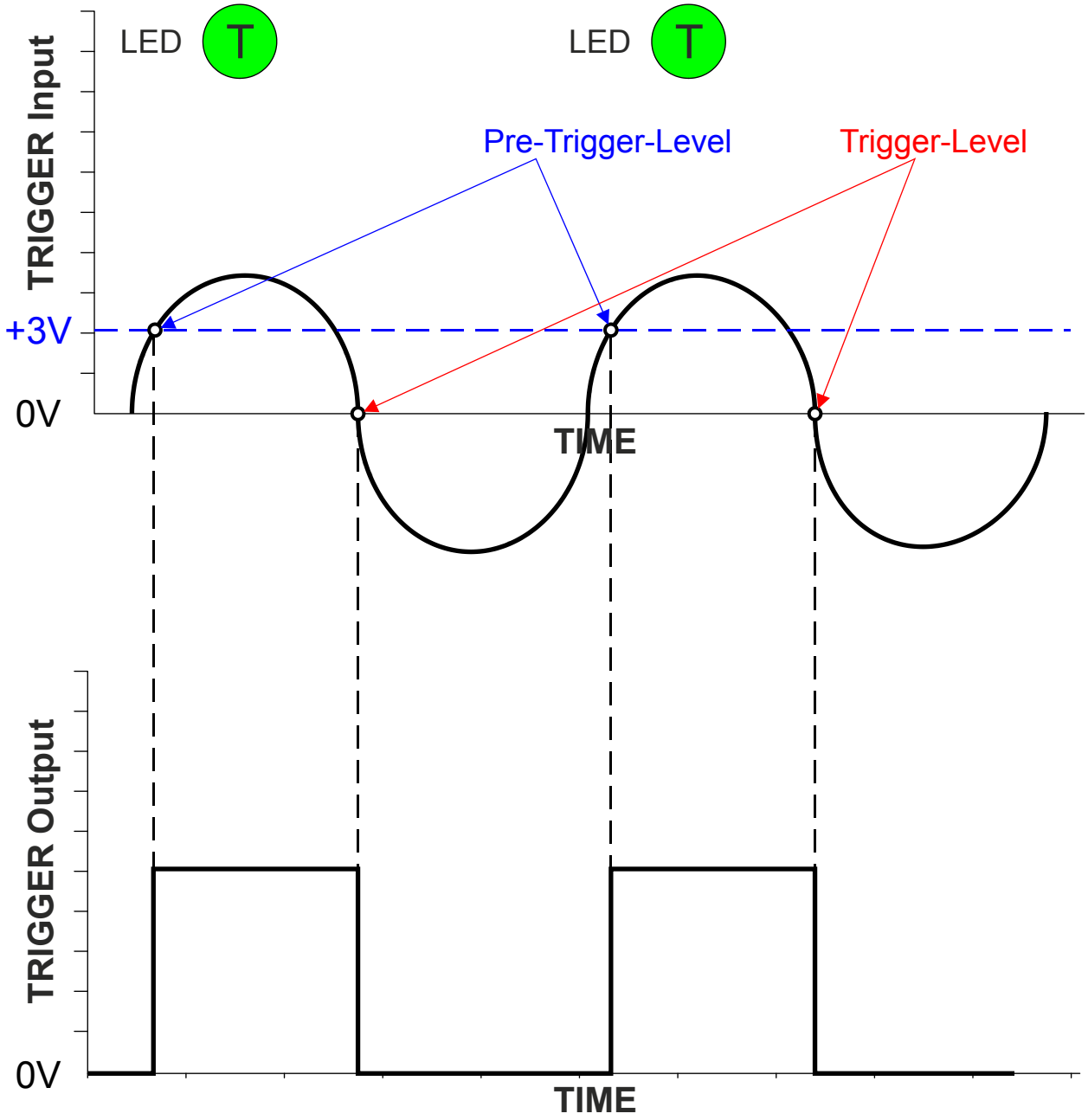
The red alarm LED „K“ lights up when the zero-voltage level crossover of the falling edges of the RESET and TRIGGER input signal are within 20 microseconds of each other (see 1.7.2 – Chronological overlap of TRIGGER and RESET input signals).

The orange „POL“ LED indicates the incorrect polarity of the RESET input signal (see 1.7.1 – Polarity RESET input signal).

The orange „L“ LED indicates that the **SPA24** output signals are blocked due to an engine speed which is too low (see 1.2.3 – Output signals). Therefore, LED „L“ lights up at engine standstill and extinguishes at engine start-up.

1.4 TRIGGER signal

1.4.1 Signal generation

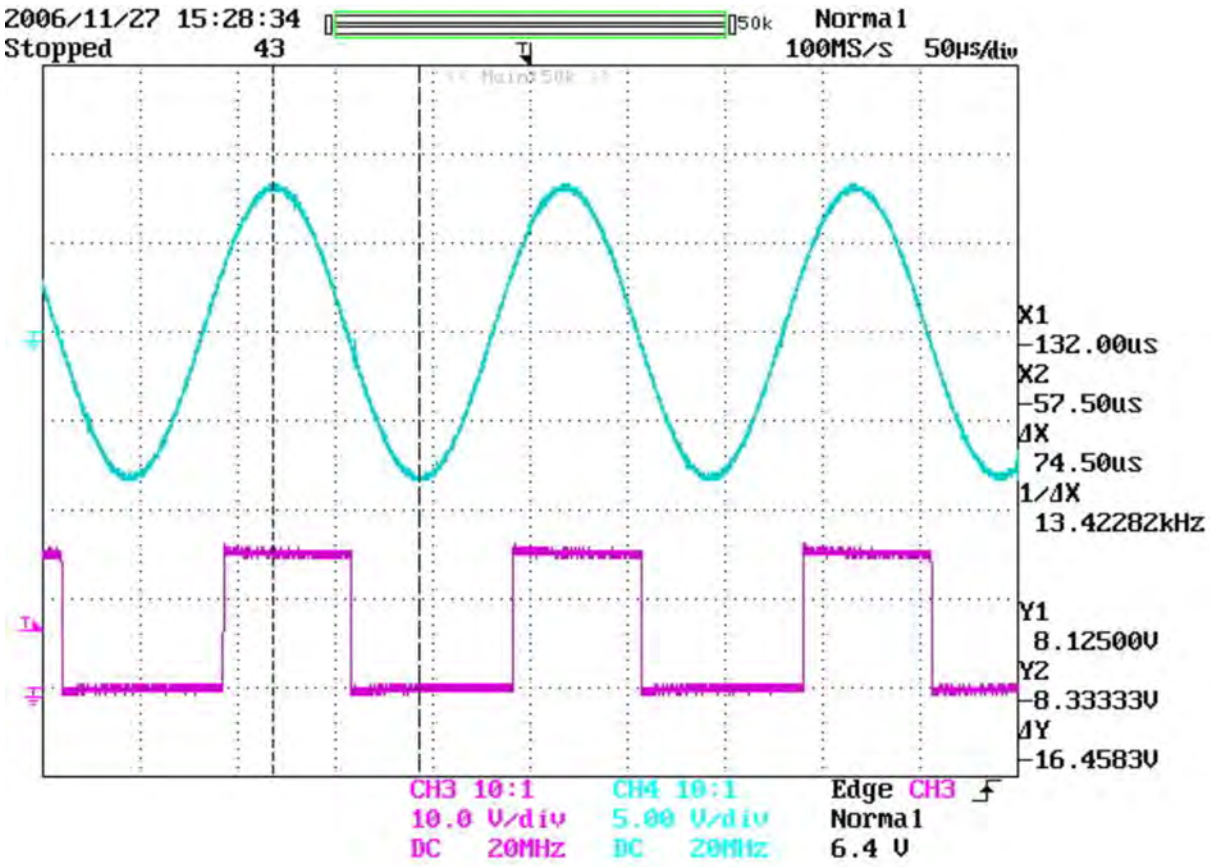


The TRIGGER input signal (ring-gear signal) is generated by a passive pickup.

The TRIGGER input signal is pre-triggered at a +3V signal level to detect the positive, rising edge of the analogue sinus-shaped pickup signal, while at the same time the TRIGGER output signal is activated at the digital +14V High level. The chronologically later 0V Low signal level (= zero-voltage level crossover) of the same TRIGGER input signal pulse is the trigger point which resets the TRIGGER output signal to the 0V Low signal level.

The „T“ LED (= TRIGGER input signal) lights up when the input signal level exceeds the +3V pre-trigger level, and extinguishes when the +3V pre-trigger level is underrun.

1.4.2 Engine signal shape

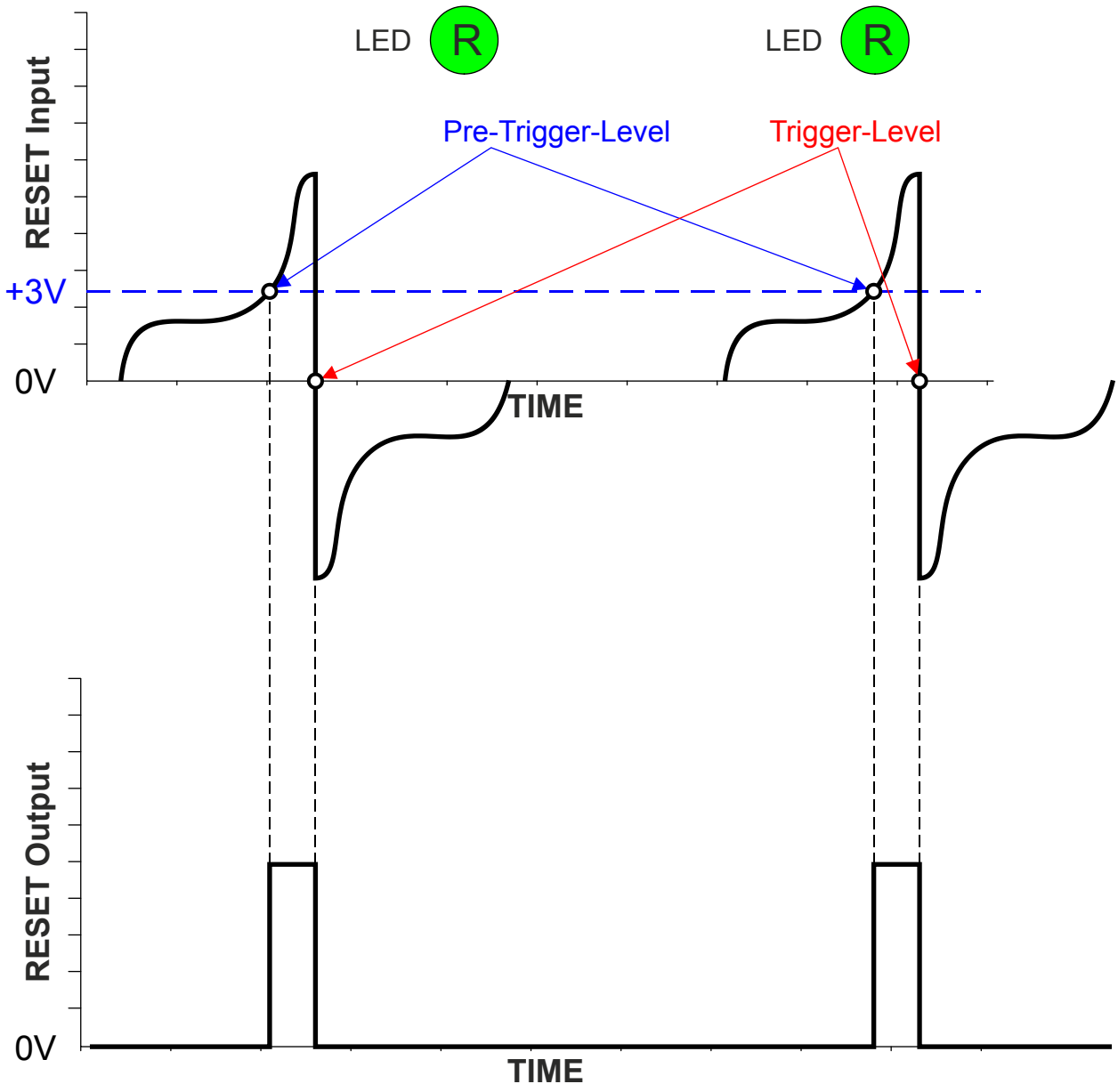


CH4: **SPA24** TRIGGER input signal

CH3: **SPA24** digital TRIGGER output signal for **SAFI**

1.5 RESET signal

1.5.1 Signal generation



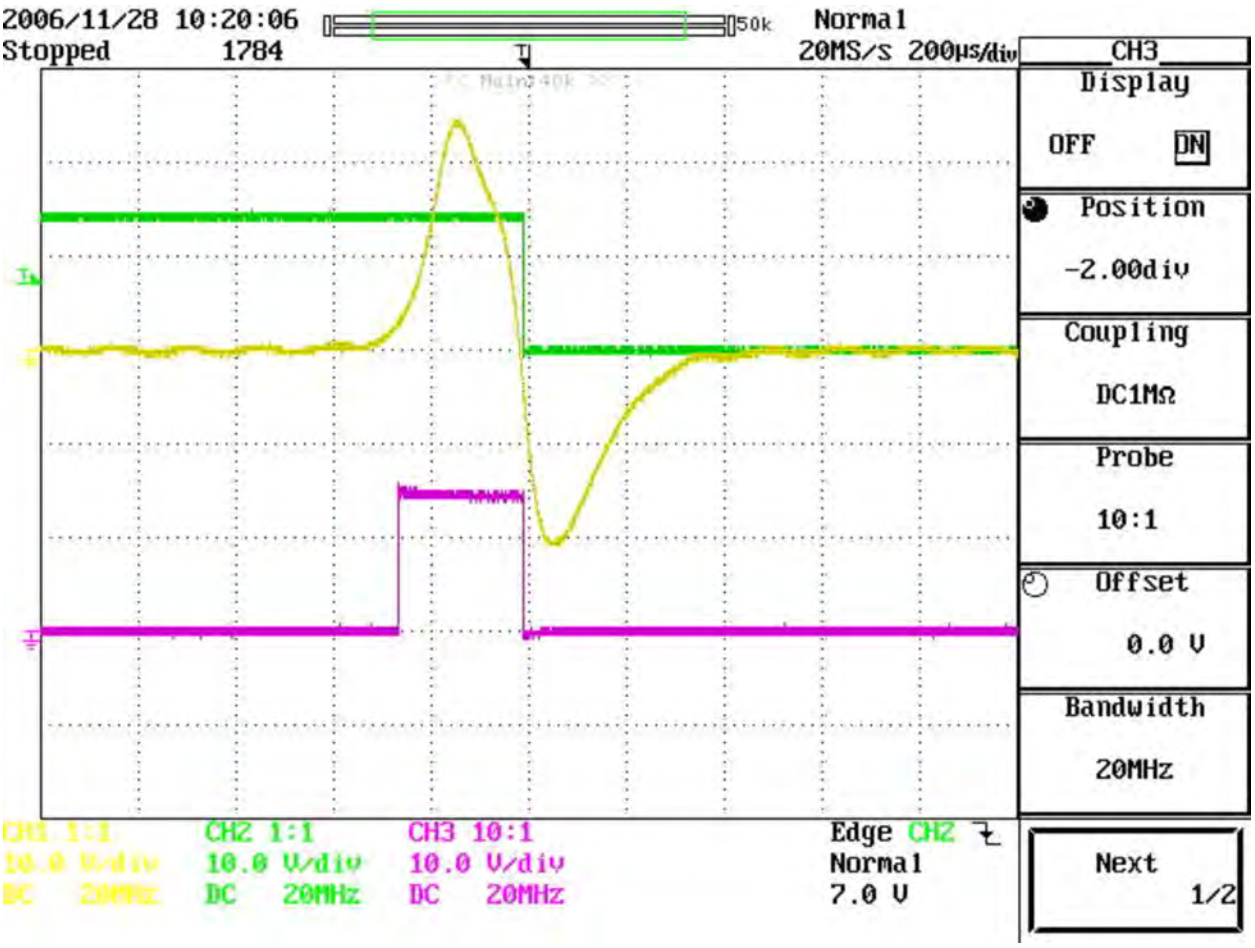
The RESET input signal (= ring-gear reset signal) is generated by a passive pickup.

The RESET input signal is pre-triggered at a +3V signal level to detect the positive, rising edge of the analogue pickup signal, while at the same time the RESET output signal is activated at the digital +14V High level. The chronologically later 0V Low signal level (= zero-voltage level crossover) of the same RESET input signal pulse is the trigger point which resets the RESET output signal to the 0V Low signal level.

At every engine rotation, the RESET output signal is set to High and subsequently reset to Low.

The "R" LED (= RESET input signal) lights up every engine rotation by a short 25 ms impulse when the input signal level reaches the +3V pre-trigger level.

1.5.2 Engine signal shape



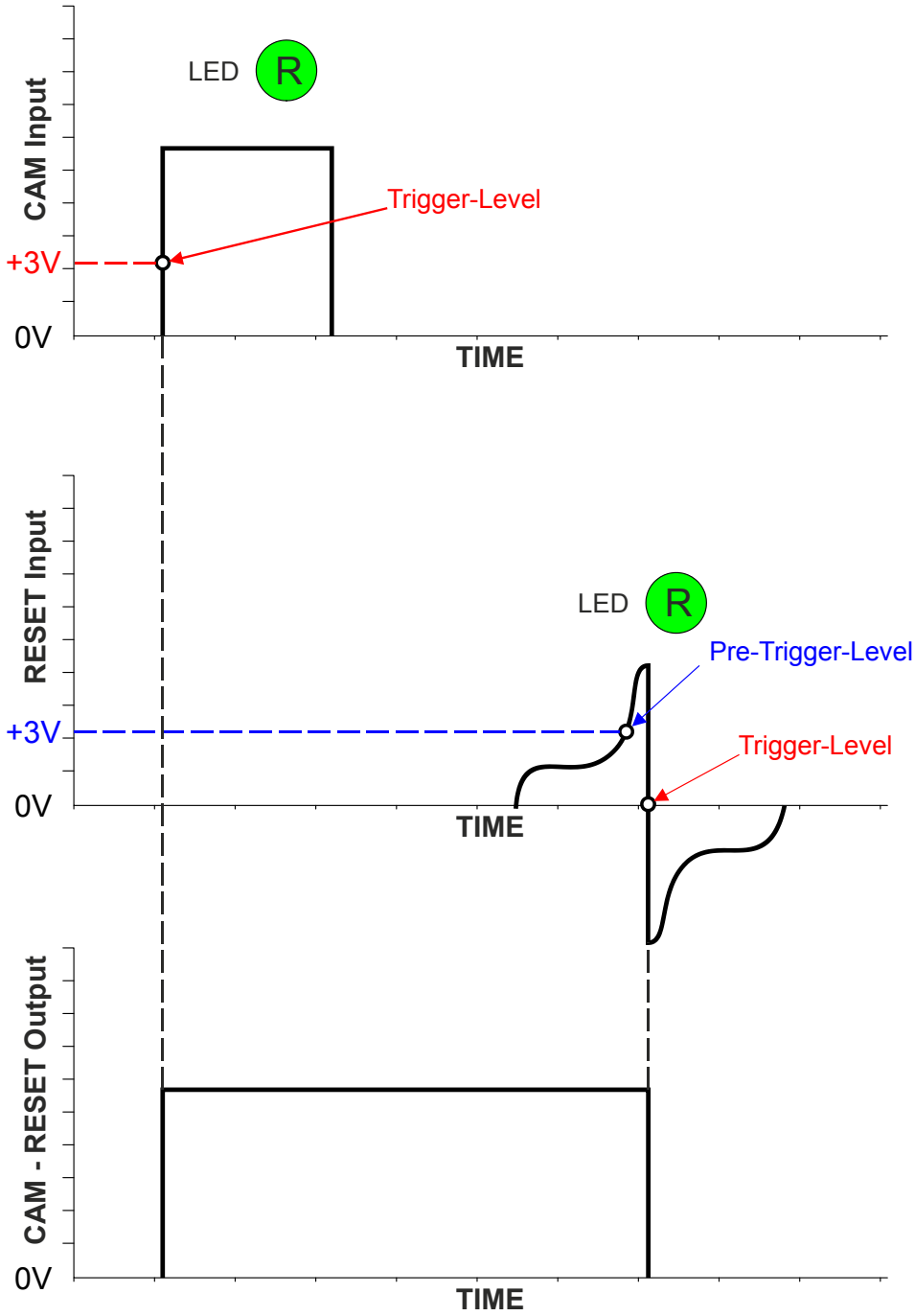
CH1: **SPA24** RESET input signal

CH2: digitally linked **SPA24** CAM/RESET output signal for **SAFI**

CH3: digital **SPA24** RESET output signal

1.6 CAM/RESET signal

1.6.1 Signal generation



The CAM input signal (= camshaft signal) is generated by an active pickup with a + 24V DC voltage supply.

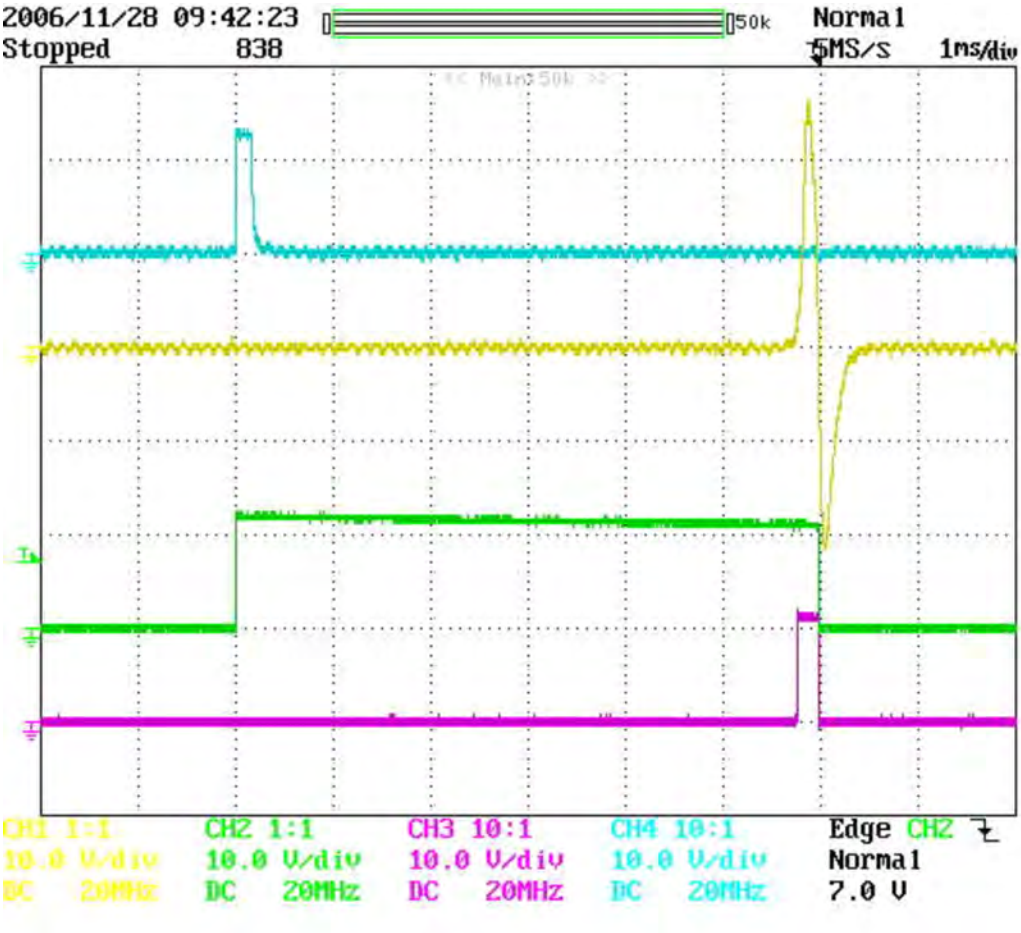
The RESET input signal (= ring-gear reset signal) is generated by a passive pickup.

The CAM input signal is pre-triggered at a +3V signal level to detect the positive, rising edge of the digital rectangular pickup signal, while at the same time the logically linked CAM/RESET output signal is activated at the digital +14V High level. The next RESET input signal - which is chronologically in the same engine cycle - is also pre-triggered at a +3V signal level to detect the positive, rising edge. The chronologically later zero-voltage level crossover of the RESET input signal pulse is the trigger point which resets the logically linked CAM/RESET output signal to the 0V Low signal level. At every second engine rotation, the logically linked CAM/RESET output signal is therefore set to High and subsequently reset to Low (see 1.2.3 – Output signals / 1.7.1 – Polarity of the RESET input signal).

LED „C“ (= CAM input signal) lights up every two engine rotations when the input signal level exceeds the +3V pre-trigger level, and extinguishes when the +3V pre-trigger level is underrun.

LED "R" (= RESET input signal) lights up every engine rotation by a short 25 ms impulse when the input signal level exceeds the +3V pre-trigger level.

1.6.2 Engine signal shape



CH4: **SPA24** CAM input signal

CH1: **SPA24** RESET input signal

CH2: digital logically linked **SPA24** CAM-RESET output signal for **SAFI**

CH3: digital **SPA24** RESET output signal (for control measuring purposes)

1.7 Monitoring systems

1.7.1 Polarity RESET input signal

The RESET input signal (= ring-gear reset signal) is generated by a passive pickup.

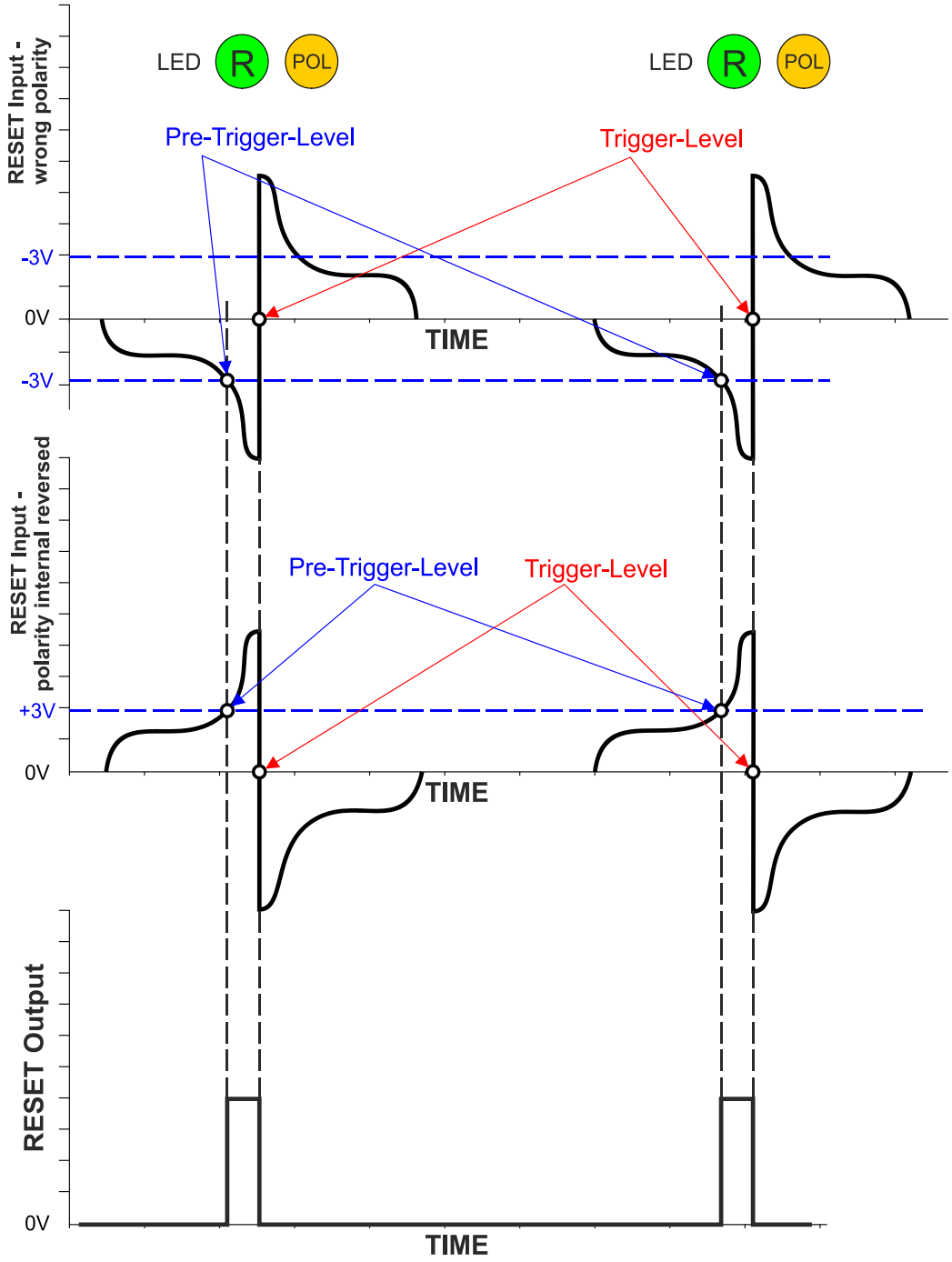
An incorrect polarity of the RESET input signal is automatically corrected by the **SPA24**.

The polarity is detected by the **SPA24** by pre-triggering the positive and negative signals. If the polarity is incorrect, the input signal is inverted by the **SPA24** software for further internal processing resulting in a functional correct signal transmission of the logically linked CAM/RESET and RESET output signals. The diagram below shows the internal inversion by the **SPA24** in the case of an incorrectly polarized RESET input signal.

Pole reversal of the RESET input signal at the **SPA24** terminals results in the correct polarity therefore preventing the „POL“ LED from lighting up. This condition should be reached after the engine is started up!

⚠ The polarity of the RESET pickup signal should be corrected only at engine standstill.

Internal polarity reversal of the RESET signal



1.7.2 Chronological overlap of TRIGGER and RESET input signals

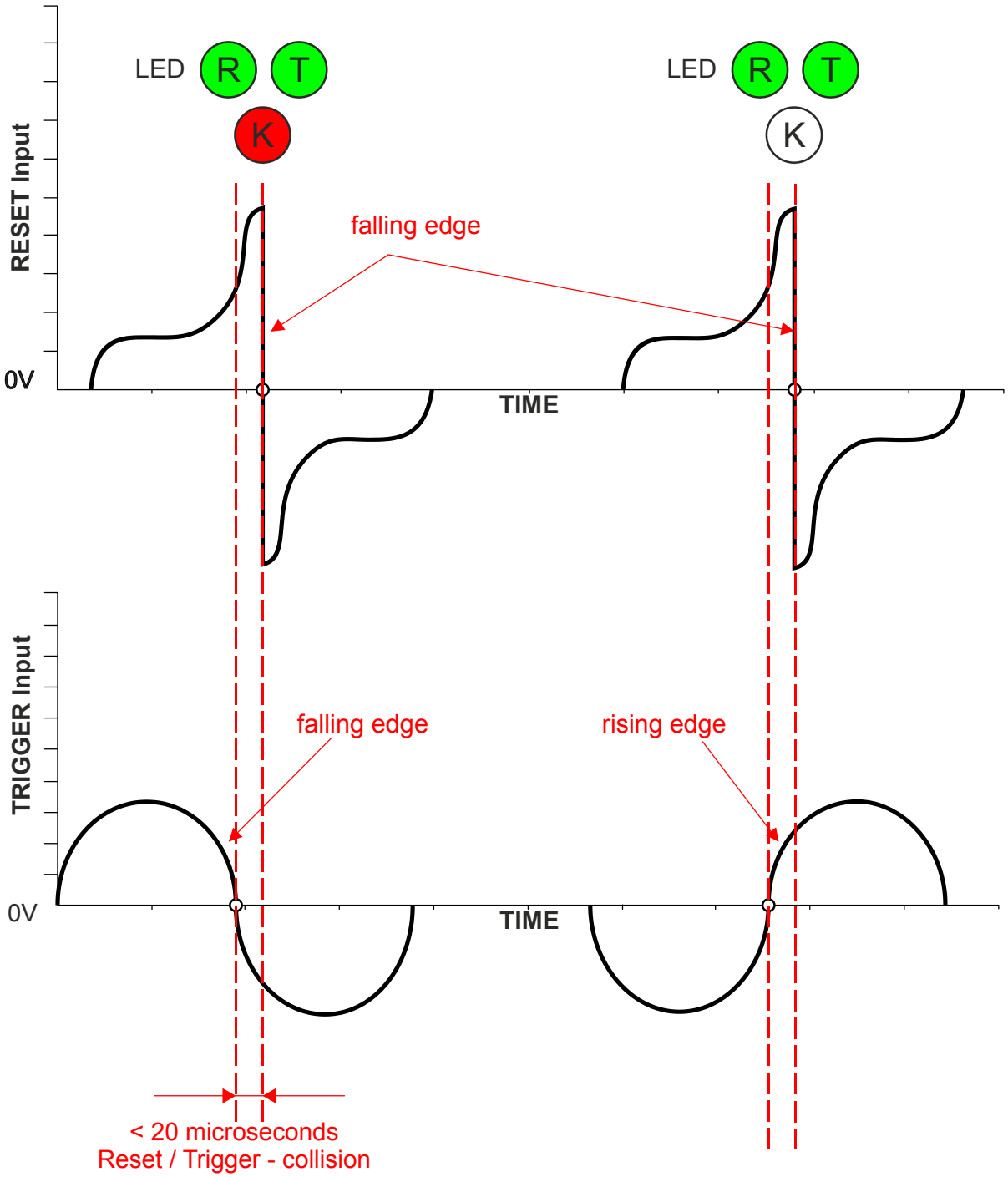
The TRIGGER input signal (ring-gear signal) and the RESET input signal (= ring-gear reset signal) are generated by a passive pickup.

Under certain unfavourable conditions, the RESET and TRIGGER pickup signals may chronologically overlap at the zero-voltage level crossover. As a consequence, a trouble-free operation of the ignition cannot be guaranteed.

The RESET and TRIGGER input signals are triggered by the chronologically later zero-voltage level crossover “0V signal level” at the positive falling flank of the relevant signal. If the zero-voltage level crossovers of the RESET and TRIGGER input signals overlap, there is a common trigger time and the RESET and TRIGGER input signals coincide. According to the definition, a trigger point chronologically overlaps whenever the trigger times of both signal and zero-voltage level crossovers fall within a 20 ms timeframe.

The red alarm LED „K“ lights up at every ‘trigger point collision’ for 2 seconds and then extinguishes automatically. Red alarm LED "K" does not light up if the trigger times of both signal and zero-voltage level crossovers fall outside the 20 ms timeframe.

⚠ If this situation arises, the polarity of the TRIGGER signal at the equipment input terminals must be reversed during engine standstill.



The diagram below illustrates the definition of a ‘chronological trigger point overlap’ at different TRIGGER input signal polarities.

2 Safety information

Please observe the safety and hazard signs in the safety instructions (TA 2300-0005) and wear the appropriate personal protective equipment.

3 Technical data

3.1 Protection class

When fitted, **SPA24** has protection class IP20.

3.2 Ambient conditions

Temperature limits	Storage	-40 ... + 70 °C
	Operation	-25 ... + 70 °C
Relative humidity	Storage	90 %, no dew
	Operation	85 %, no dew

3.3 Mechanical data

3.3.1 vibrations

SPA24 is installed in the module interface cabinet and assembled vibration-free onto the engine frame using rubber buffers.

3.3.2 Physical Dimensions

Housing: width x height x depth = 35 mm x 100 mm x 115 mm.

3.3.3 Fitting

For reasons of easy access, the **SPA24** housing is assembled into the module interface cabinet using a top-hat rail, type TS 35/15 mm.

3.4 Electrical data

3.4.1 Power supply

SPA24 is powered by a battery with a nominal voltage of 24 V DC. The battery voltage may fluctuate in a range from 15 V to 32 V ± 10% residual ripple.

3.4.2 Power consumption

The maximum power consumption of the **SPA24** is approx. 170 mA with maximum 12 **SAFI**s without additional load at both voltage outputs (output connectors J5 and J6) at a +24V DC supply voltage.

3.5 Connections and displays

3.5.1 Terminal designation

All four 3-fold **input junctions** of the **SPA24** are located on top of the housing and are coded. An incorrect plug connection is therefore not possible.

Input junction	Pin	Description
J1	24V	+ 24V DC supply voltage for **SPA24**
J1	G	supply voltage, earth

Input junction	Pin	Description
J1		
J2	24V	+ 24V DC supply voltage, camshaft pickup
J2	G	camshaft pickup, earth
J2	CAM	camshaft pickup signal
J3	+ RES	RESET pickup signal
J3		
J3	- RES	RESET pickup signal
J4	+ TRG	TRIGGER pickup signal
J4		
J4	- TRG	TRIGGER pickup signal

All four 3-fold **output junctions** of the **SPA24** are located on the bottom of the housing and are coded to prevent using incorrect plug connections.
The output signals are always double. Plug connections serving functionally equal signals both have a similar coding to facilitate faultfinding when on-site.

Output junction	Pin	Description
J5	24V	+24V DC control voltage output
J5	G	control voltage, earth
J5	R	RESET output signal - cylinder bank A
J6	24V	+24V DC control voltage output
J6	G	control voltage, earth
J6	R	RESET output signal - cylinder bank B
J7	T	TRIGGER output signal - cylinder bank A
J7	G	Earth
J7	C/R	combined CAM/RESET output signal - cylinder bank A
J8	T	TRIGGER output signal - cylinder bank B
J8	G	Earth
J8	C/R	combined CAM/RESET output signal - cylinder bank B

Coding of the connector plugs

Inputs

Input junction	Pin	SPA24 socket coding	Plug coding
J1	24V	No	Yes
J1	G	Yes	No
J1		No	Yes
J2	24V	Yes	No
J2	G	Yes	No
J2	CAM	No	Yes
J3	+ RES	Yes	No
J3		No	Yes

Input junction	Pin	SPA24 socket coding	Plug coding
J3	- RES	Yes	No
J4	+ TRG	No	Yes
J4		Yes	No
J4	- TRG	Yes	No

Inputs

Output junction	Pin	SPA24 socket coding	Plug coding
J5	24V	Yes	No
J5	G	No	Yes
J5	R	No	Yes
J6	24V	Yes	No
J6	G	No	Yes
J6	R	No	Yes
J7	T	No	Yes
J7	G	No	Yes
J7	C/R	Yes	No
J8	T	No	Yes
J8	G	No	Yes
J8	C/R	Yes	No

3.5.2 Displays on the device

The device has seven LED to indicate the operating conditions and various monitoring activities.

Designation	Colour	Meaning
P	Green	Supply voltage **SPA24**
T	Green	Signal from ring-gear TRIGGER pickup
C	Green	Signal from CAM pickup
R	Green	Signal from crankshaft RESET pickup
POL	Yellow	Incorrect polarity of RESET pickup signal → The RESET signal is automatically inverted internally.
K	Red	If the zero point of the falling edge of the RESET and TRIGGER signal falls within a 20 µs timeframe pole reversal of the TRIGGER signal!
L	Yellow	The **SPA24** does not transmit any signals because the speed has fallen below 50 rpm or the pickup input signal voltage is below 3V. The LED lights up at engine standstill and extinguishes at engine start-up! (L stands for Low Speed)

4 Installation

4.1 SPA24 assembly

The **SPA24** is assembled into the module interface cabinet using a TS35/15mm top-hat rail.

4.2 Pickup adjustment at the engine

4.2.1 CAM camshaft signal

Four-stroke engines require information about the angle of rotation of the camshaft in order to distinguish between the compression stroke and the gas-exchange stroke. As the signal equals the camshaft speed and has a smaller angle speed, an active pickup must be used.

4.2.2 Crankshaft RESET signal

To be able to accurately determine the crankshaft position during the working cycle, a crankshaft reset signal in connection with the camshaft signal is required.

The RESET position is approximated by mechanically measuring the crankshaft angle (CA) position before the top dead centre (BTDC) of the first cylinder.

The exact reset position must be checked following every engine adjustment which may influence the reset position using a strobe light and adjusted in the ignition using the RESET POSITION parameter (see the technical instructions for **SAFI** - TA 1502-0071).

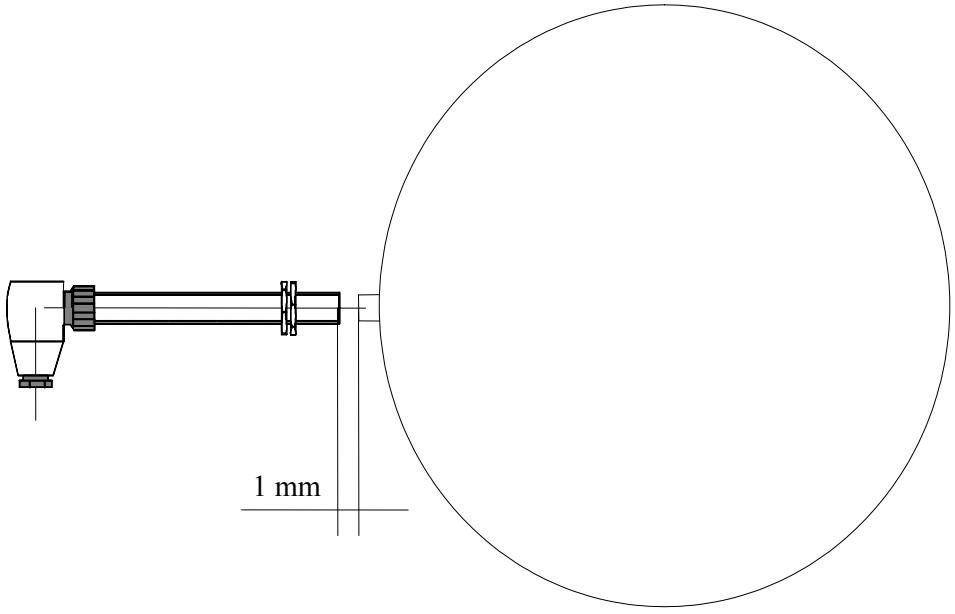
4.2.3 TRIGGER pickup signal (flywheel)

The flywheel requires at least 50 (at most 500) impulses per revolution (TRIGGER signal).

4.2.4 Assembly of the active camshaft pickup

The gap between signal transmitter and pickup must be between 0.75 and 1.25 mm. The M12x1 pickup originally supplied by INNIO Jenbacher GmbH & Co OG must therefore be adjusted to ¾ to 1¼ turns. Despite reduced accuracy, the gap is set at ¾ to 1¼ turns for 5/8“ UNF thread pickups.

Default setting: 1 turn = 1 mm gap



The camshaft signal must appear before the crankshaft reset signal and must be between 110° and 205° CA BTDC in the ignition cycle.

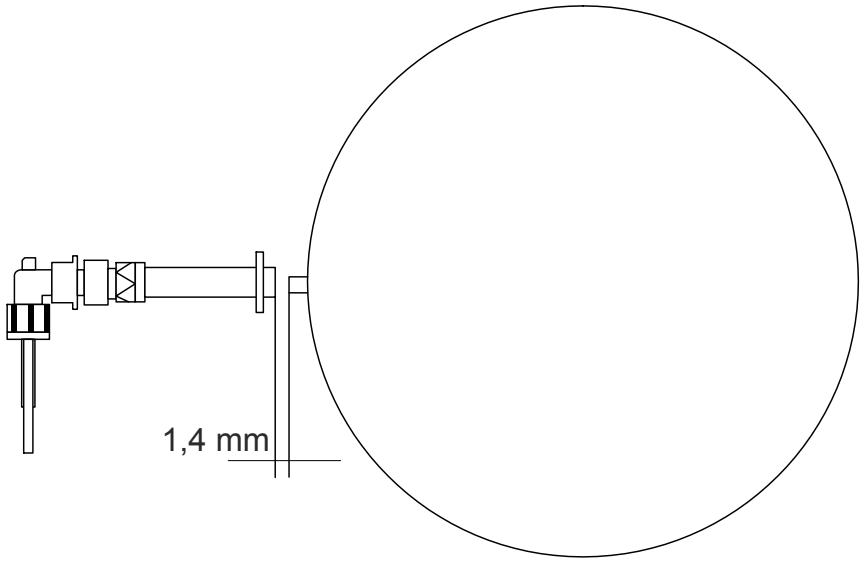
When adjusting, make sure that the pickup is reset to the maximum distance. Especially when using a screw, an incorrect adjustment can lead to mechanical destruction of the pickup.

4.2.5 Assembly of passive RESET and TRIGGER pickups for the flywheel and reset signals

Magnetic (passive) pickups should be carefully adjusted to a distance between 1.0 and 1.8 mm between the pickup and the tooth or trigger source. A 5/8“ UNF thread pickup as originally supplied by INNIO Jenbacher must therefore be adjusted to ¾ to 1¼ turns.

When adjusting, make sure that the pick-up is set to the maximum gap. Especially when using a screw head as trigger source, for example, in type 6 engines, an incorrect adjustment can lead to mechanical triggering and destruction of the pickup.

Default setting: 1 turn = 1.4 mm gap



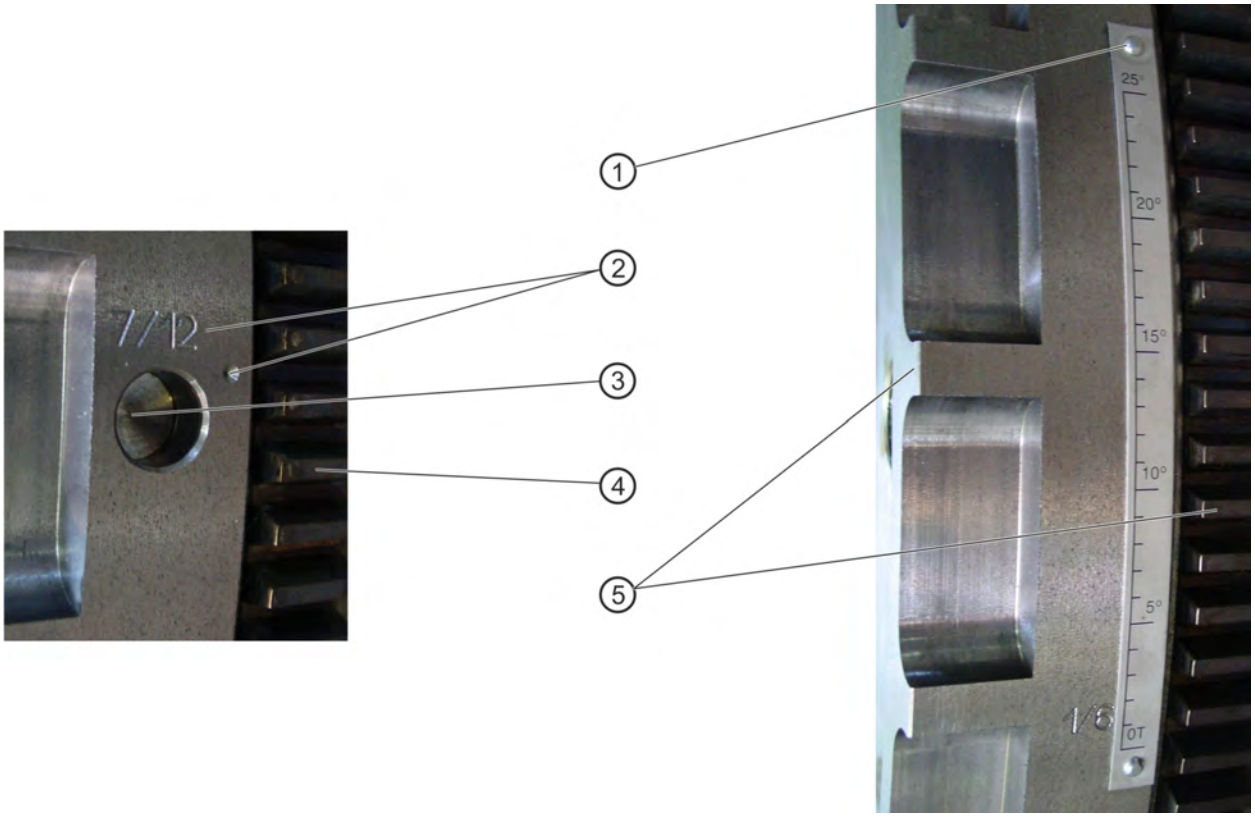
Make sure that the pickup cannot receive any other signals besides the reset or ring-gear signals (e.g. holes, markings or protrusions). This danger exists, for example, when the head of the hexagonal bolt is too close to the ring gear or other failure sources are nearby. The amplitude of the interference signals increases with the speed.

If the failure source cannot be eliminated, increase the distance between the pickup and the trigger source to such an extent that any interference signal peak voltages remain below 1.5 V and therefore below the **SPA24** trigger limit value. The **SPA24** requires a peak voltage from the pickup of at least +/- 3 V, which is reached at an engine speed of 50 to 90 rpm depending on the pickup distance set (¾ to 1 ¼ turns). If the voltage is lower than Â± 3V, the **SPA24** does not emit any output signals as a result of which no ignition signals are emitted by the **SAFI**.

The distance should therefore be selected in such a way that a sufficient amplitude is available for the regular reset signal or ring-gear signal during the starting procedure and at the same time sufficient protection is guaranteed against any interference signals while at nominal engine speed. In general, a gap of 1 to 1¼ turns will prove to be optimal.

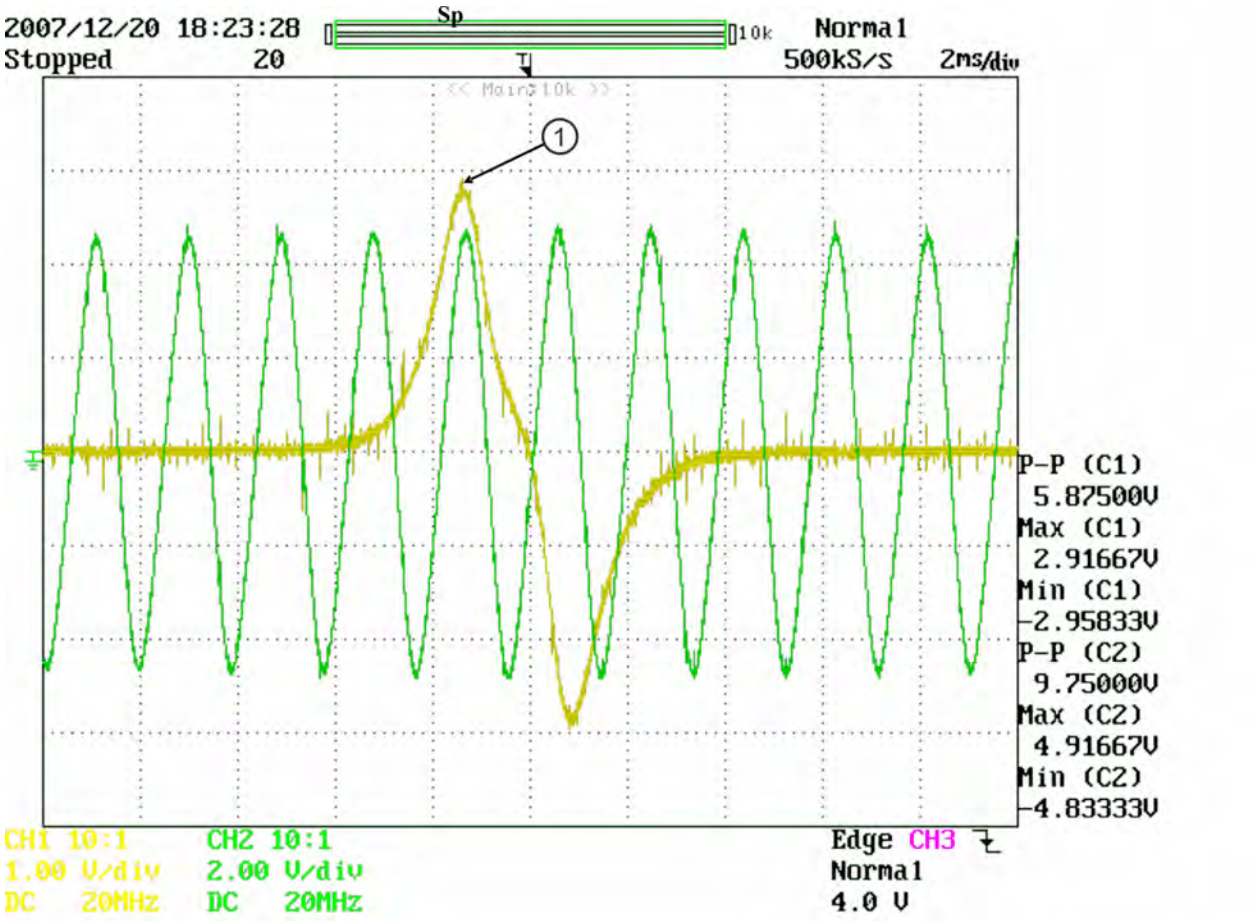
In the following two photographs, examples of possible failure sources are shown.

Examples of an interference source based on a type 4 engine flywheel disk



①	Error: Protruding rivets on the marking plate for determining TDC.
②	Error: Excessively-deep punch marks to mark the cylinders can also cause interference signals.
③	Drilled hole as reset trigger source
④	Flywheel ring gear
⑤	Error: Reset pick-up position too near to the teeth for the torsion measurement or ring gear.

In the illustration below, the reset pickup has been adjusted to an excessive gap (1½ turns) while the trigger pickup has been adjusted to the default setting of 1 turn. A reset signal level of only +/2.95 V is achieved at start-up, which is too low for a functional correctly generated digital CAM/RESET output.



①	Voltage below 3 V trigger level!

CH1: RESET input signal +/- 2.9V (1V/div) / pickup gap 1½ turns

CH2: TRIGGER input signal (attention 2V/div) / pickup gap 1 turn

5 Diagnosis and troubleshooting

Only **SPA24**-related messages are dealt with below.

Detailed information and descriptions of monitoring functions, operational, warning and error messages and setting parameters for the **SAFI** and **DIA.NE XT** can be found in Technical Instruction TA 1502-0071 – **SAFI**.

5.1 Operational messages

Message number	Message	Description
B3276	**SAFI** trigger pickup cylinder failure	Display of cylinder position of **SAFI** with trigger pickup failure
B3277	**SAFI** camshaft/reset pickup cylinder failure	Display of cylinder position of **SAFI** with camshaft/reset pickup failure

5.2 Error messages

Message number	Message	Description/Solution
A3336	**SAFI** trigger pickup failure	A problem with the trigger signal has been detected, i.e. = **SPA24** TRIGGER output signal.
		Check **SPA24** and **SAFI** supply voltage! Every **SPA24** and **SAFI** is provided with a POWER LED! Check **SPA24** TRIGGER input signal and **SPA24** TRIGGER-output signal (= **SAFI** input signal). A TRIGGER LED on **SPA24** and each **SAFI** flashes when a pickup input signal is detected. These displays are helpful for checking whether a signal has failed in the event of an error. → Check pickup for contamination (e.g. metal chippings) → The error message during engine start-up can be caused by an incorrect pickup setting. Check the pickup setting acc. to **SPA24** TA 1502-0072 (section 4).
A3337	**SAFI** camshaft/reset pickup failure	A problem with the logical camshaft/reset signal has been detected, i.e. linked **SPA24** CAM/RESET output signal.
		Check **SPA24** and **SAFI** supply voltage! Every **SPA24** and **SAFI** is provided with a POWER LED! Check **SPA24** CAM and RESET input signal and **SPA24** logic output signal (= **SAFI** input signal). On **SPA24** the CAM and RESET LEDs flash when a pickup input signal is detected, and on **SAFI** a CAM LED. These displays are helpful for checking whether a signal has failed in the event of an error. → Check pickup for contamination (e.g. metal chippings) → The error message during engine start-up can be caused by an incorrect pickup setting. Check the pickup setting acc. to **SPA24** TA 1502-0072 (section 4).

6 Revision code

Revision history

Index	Date	Description / Revision summary	Expert *Auditor*
3	30.04.2019	GE durch INNIO ersetzt / GE replaced by INNIO	**Stojiljkovic T.** *Pichler R.*
2	08.11.2010	Version irrtümlich angelegt / Version created in error	**Provin** *Provin*
1	27.05.2010	Umstellung auf CMS / Change to **C**ontent **M**anagement **S**ystem ersetzt / replaced Index: **-**	**Schartner** *Pichler*