LANGER
EMV-Technik

User manual

OSE
Optical Signal Acquisition

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The OSE system transmits digital signals
from devices and installations without EUT interaction.

Contents:

1 Mode of operation

The OSE optical systems contain small transducers (sensors) which convert digital electrical signals into light signals. These light signals are transmitted to receivers via optical fibre where they are converted into digital electrical signals.

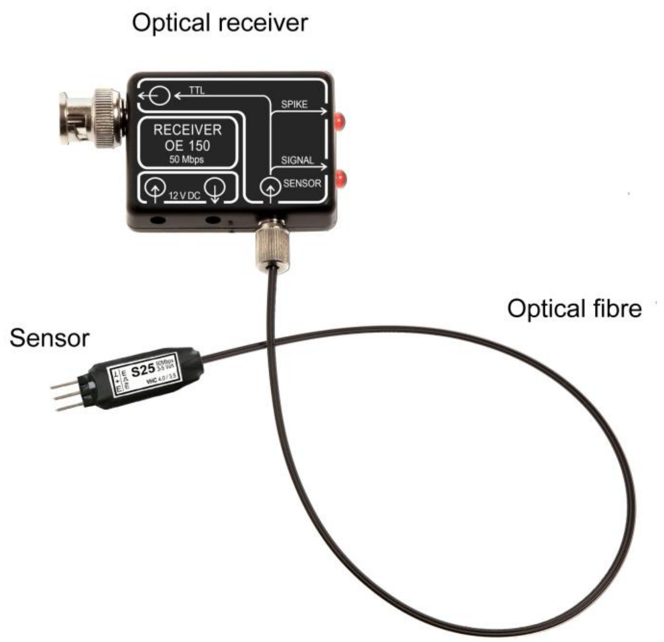


Fig. 1 Sensor, optical fibre and optical receiver are combined in a probe head.

The sensors also contain a pulse stretcher. This stretches short input pulses that cannot be transmitted directly due to the limited band width of the optical fibre to a transmissible pulse width.

This arrangement allows potenial-free signal monitoring without cables. It is thus particularly suitable for measurments during EMC examinations (burst, ESD, RF coupling) and measurements for potential (also high voltage).

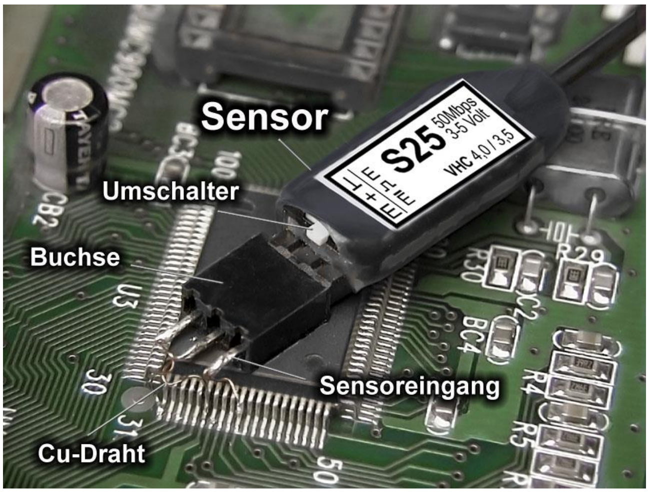
Fig. 2 ***S21*** sensor integrated in the DUT

2 Description of components

2.1 EMC sensors

Design	Sensor types:
	***S21*** Transfer rate: DC-10 Mbps Operating voltage: 3 – 5 volts
	***S25*** Transfer rate: DC-50 Mbps Operating voltage: 3 – 5 volts

2.1.1 Connection of the sensors in the EUT:

	Fig. 3 ***S25*** sensor in the DUT

The sensors must be supplied from the EUT (equipment under test). A battery module (not included in the scope of delivery) can be used if this is impossible.

The sensors are connected to the EUT via sockets (included in the scope of delivery) which have to be fixed to the module in a suitable place with super glue or double-face adhesive tape and connected with enamelled copper wire (also in the scope of delivery). The optical fibre is simply plugged into the sensor.

2.1.2 Level changing:

All sensors have a change-over switch to negate the output signal of the sensor:
Switch position E - High logic level corresponds to "light on"
Switch position E transverse - High logic level corresponds to "light off"
This fuction often facilitates the triggering of external devices such as a burst generator through the DUT.

2.1.3 Pulse stretching:

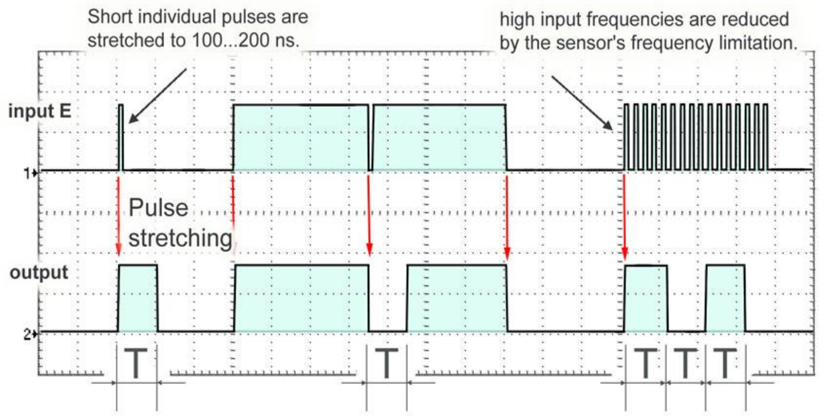


Fig. 4 Pulse stretching

Very narrow input pulses are stretched to a transmissible width (20 ns - 200 ns depending on the sensor) for transmission via synthetic optical fibre. It is thus possible to detect burst or ESD pulses that directly couple in the line connected to the sensor input.
A digital pulse of 20 ns – 200 ns can always be detected at the output of the connected optical receiver if the sensor detects a narrow disturbance pulse.

2.1.4 Frequency limitation:

Since pulse stretching operates with both positive (rest position "low") and negative (rest position "high") pulses, this results in a frequency limitation: individual input pulses are omitted if the input signal exceeds the system's threshold frequency – a pulse number near the maximum transfer rate is output. This ensures that pulses are indicated at the output whenever pulses occur at the input.

2.1.5 Susceptibility:

Due to the different behaviour of their dynamic input switching threshold, ICs have a different susceptibility to fast transient disturbances. Two IC susceptibility characteristics have been defined in order to be able to handle these properties:

E (20) susceptibility:
The E(20) susceptibility definition is based on the 20 volts point of an IC input's dynamic input characteristic. The reciprocal of the pulse width at the 20 volts point (tail time constant of a test pulse) is defined as the E (20) susceptibility: $E(20) = 1/\tau$ (20 Volt). The respective unit of measurement is 1/ns. The susceptibility is between 0.5 and 6 for conventional IC families where ICs with a susceptibility of 0.5 are insensitive and those with a susceptibility of 6 highly sensitive.
The E(20) susceptibility value alone is often unsufficient for wider disturbance pulses (>10 ns).

The *disturbance threshold* (switching threshold) at a pulse width (τ) of 12 ns on the dynamic input characteristic is thus defined as a second parameter: U(12) = u (12 ns).
The respective unit of measurement is volt. The threshold is between 1.5 and 8 volts for conventional IC families where ICs with a threshold of 1.5 volts are sensitive and those with a threshold of 8 volts insensitive.

All parameters are printed on the sensors.

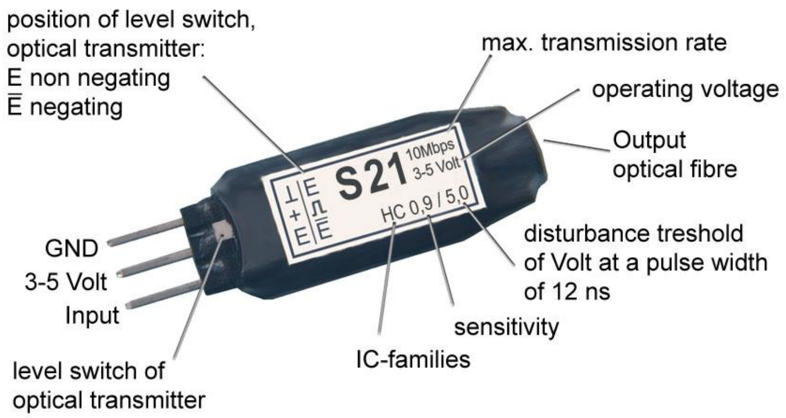
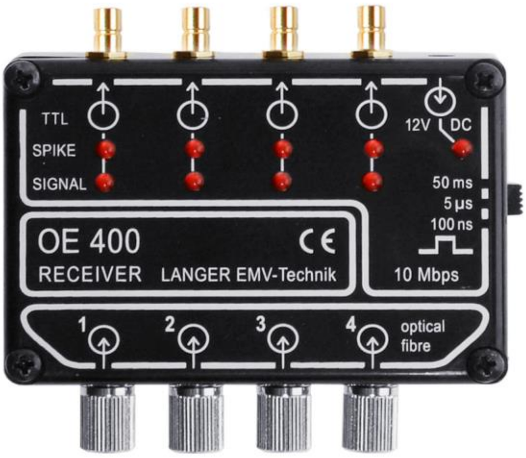


Fig. 5 ***S21*** / ***S25*** sensor

2.2 Optical receivers

	Sensortypen:
	***OE 150*** Transfer rate: DC-50 Mbps Pulse stretching to approx. 100 ms can be activated Suitable for S25 and S21 sensors
	***OE 400*** Transfer rate: DC-10 Mbps Pulse stretching to approx. 5 µs or 50 ms can be activated Suitable for S21 sensors

The optical receivers have one or four inputs for optical fibres with a diameter of 2.2 mm: To connect the optical fibre, loosen the knurled nut, push the optical fibre into the receiver UPTO THE LIMIT STOP and slightly tighten the knurled nut.

Supply:

The receiver is supplied with 12V DC via the enclosed plug-in power supply unit. The OE 110 and OE 150 optical receivers have two sockets marked with 12V DC. These are directly connected with each other. A second receiver, for example, can thus be supplied via a connecting cable (included in the OSE 100's scope of delivery).

Displays:

All optical receivers have two LEDs for each optical fibre input which can be used for viewing the respective signal. These are:

"SIGNAL" LED: The signal is displayed directly. The pulse control factor can be roughly inferred from the LED's brightness with cyclic signals.

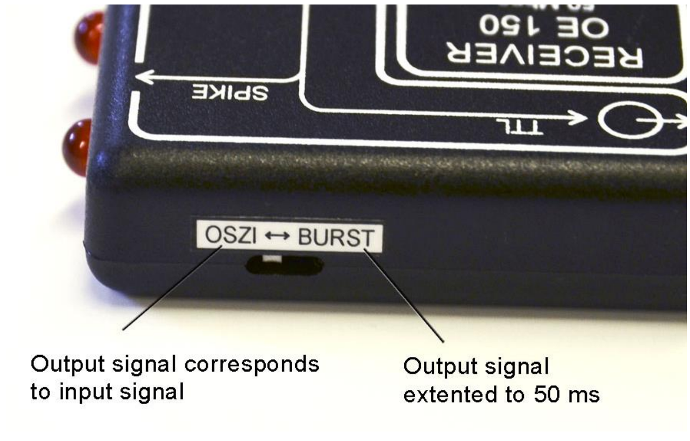
"SPIKE" LED: The signal is displayed. In addition, pulse stretching is integrated which stretches short pulses not visible for the eye to approximately 50 ms. Thus even the shortest pulses (depending on the connected sensor) are clearly recognizable.

Outputs:

All optical receivers have outputs (BNC plugs) to connect an oscilloscope or counter etc. The signal of the connected sensor is output at TTL level.

A pulse stretcher can be connected to each output to facilitate signal evaluation or triggering of external devices.

OE 150:



Switch position "Burst": The >100 ns wide signals of the sensor are stretched to approximately 100 ms (for controlling devices with slow inputs such as burst generators, writers).

Switch position "Oszi": The optical input signals are directly switched to the TTL output. Signals can be evaluated with an oscilloscope, for example, in this switch position.

Fig. 6 Connectable pulse stretcher on the ***OE 150***

OE 400:
A sliding switch is located on the right-hand side of the device to switch the pulse stretcher over to the following switch positions: 100 ns, 5 µs and 50 ms. It has the same effect on all four outputs.

With pulse stretching connected, the individual pulses of a burst event are combined in one 100 ms signal and output on the BNC socket. This pulse stretching prevents devices with high dynamics (counter) from detecting individual pulses of the burst event (a pulse package of a duration of 15 ms is counted as one burst).
Evaluation instruments that have inputs with low dynamics are unable to detect any 20 - 200 ns signals of the sensor. Pulse lengthening is necessary und is carried out in the OE 150 receiver at the "burst" switch position.

3 Measuring methods

3.1 Signal monitoring during EMC tests

The sensor detects logic signals in the EUT's electronic circuit.

Recording signals: The output of the optical receiver is connected to the input of an oscilloscope or a logic analyser to record the signals. Both the frequency limitation of the sensors and the pulse stretching set on the optical receivers has to be observed.

Status display of constant signals: Under certain circumstances it is sufficient to observe the "Spike" LED of the optical receiver with constant signals (e.g. RESET). Disturbance pulses – even very short ones – are stretched to 100 ms and are clearly recognizable.

Counting cyclic signals: The useful signal detected by the sensor must have a constant frequency. Disturbance signals cause an increase in frequency. The signals are counted using a frequency counter.

3.2 Disturbance immunity measurement with sensors

Different device and housing variants as well as the effect of EMC measures can be evaluated through disturbance immunity measurements with sensors. This method is ideal for EUTs where interferences are not immediately recognizable because, for example,

- there is no display,
- values that are not displayed are changed in the memory,
- EUT parameters are changed.

Procedure:
The disturbance threshold of the device to be tested is replaced by an artificial disturbance threshold for the measurement. This disturbance threshold is formed by a conducting track (reference conducting track located in the EUT) and a reference IC with a known IC susceptibility (EMC sensor). The advantage: a sensor has a time constant disturbance threshold – i.e. each ESD pulse or each individual burst spike which exceeds this threshold is displayed. Delays or static effects caused by the software are excluded.

Disturbance voltage is applied or disturbance current is fed to the EUT through a disturbance generator. Both the sensor and the EUT's electronic circuit are subjected to disturbances. The disturbance voltage is increased according to a ramp function. If the disturbance voltage coupled into the reference conducting track exceeds the sensor's disturbance threshold, the sensor emits a light signal on the optical output which is used for evaluation or for switching the generator off. The disturbance current value associated with the resprective arrangement can be read at the generator.

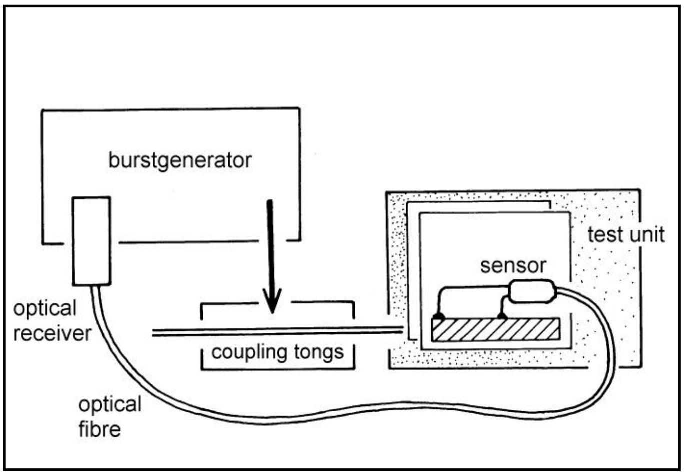


Fig. 7 Connectable pulse stretcher on the ***OE 150***

Changes to the EUT design and modifications to EMC measures can be evaluated by measurements and comparison (Fig. 8).

Attention: The sliding switch of the optical receiver has to be set to "Burst" if the optical receiver is plugged into the "Stop" input of the disturbance generator.

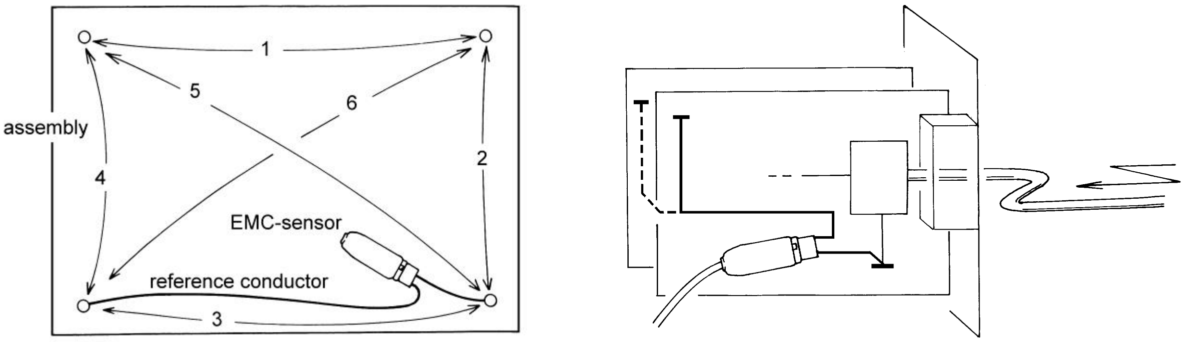


Fig. 8 Routing examples of the reference conducting track

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Dimensioning the reference conductor

Low-resistance reference conducting track: This reference conducting track simulates a disturbance voltage pick-off for the arrangement: "push–pull output – conducting track – IC input". Disturbance voltage is picked off via GND in modules with this arrangement.
Instead of the push-pull output the reference conducting track is connected directly to GND. The EMC sensor's GND connector is the second reference point of the disturbance current pick-off (the reference conducting track can also be connected to the supply voltage).

High-resistance reference conducting track: This variant simulates the disturbance behaviour of the "open collector output - pull-up resistor – conducting track – IC input" arrangement.
The reference conducting track remains open on one side, or it is connected to a pull-up resistor. This arrangement is particularly suitable for detecting disturbance-relevant electrical fields. The effect of pull-up resistors can be simulated with an adjusting controller (e.g. 10 k).

<u>Attention!</u> **Touching the sensor input with the generator switched-on and high-resistance arrangements can destroy the sensor.**

Routing the reference conducting track
Two strategies are possible.
Worst-case arrangement: The reference conducting track (low-resistance) is routed across the diagonals or along the edges of the electronic system to pick off a maximum disturbance voltage (Fig. 9). Routing can be implemented on one module or across several modules. The disturbance voltage is generally picked off via the GND system. The reference disturbance threshold need not correspond with the EUT's disturbance threshold for relative evaluations of EMC measures. The procedure is more convenient if the reference disturbance threshold is lower than the EUT's disturbance threshold. This can be realised by a relatively long pick-off distance.

Arrangement in agreement with the device: The reference conducting track is routed along critical signal connections. Routing can be along the bus system of a micro-computer, for example. The position of the reference conducting track can be corrected based on comparative measurements.

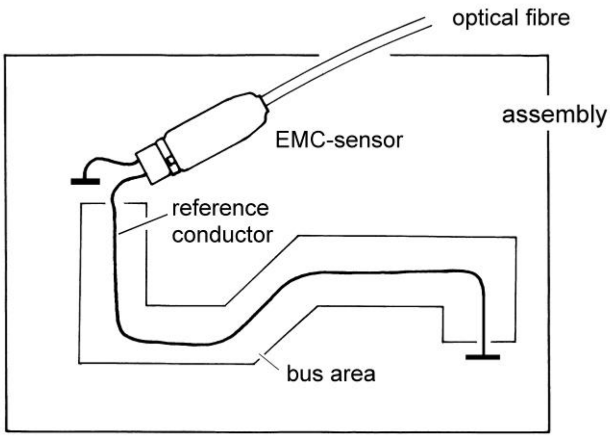

Fig. 9 Routing the reference conducting track with bus systems

4 Practical tips and examples

4.1 Avoiding measuring errors

The sensor is connected via a three-pole adapter socket. The connections from the adapter socket to the monitoring line or GND and voltage (e.g. with the enclosed enamelled copper wire, approximately 0.2 mm) must be as short as possible to avoid faulty measurements.

Requirements are not so high on modules with a sturdy GND system (mainly multilayer GND planes with few apertures). Slightly longer lines (a few centimeters) are permissible here if the lines are routed close to the module and are thus protected by the GND plane.

4.2 Example: disturbance immunity measurements on interfaces

Design and EMC measures which should prevent interference to interface signals are evaluated. An EMC sensor is connected in parallel to the input of the interface IC for this purpose. The EMC sensor and the interface IC presumably have a different susceptibility to the disturbance. As both susceptibilities are constant, however, it can be assumed that an improvement which was proven with the sensor is also applicable to the interface IC. It is possible to evaluate, for example:

- Cable shielding type: aluminum foil, copper braiding, lead wire, density of the braided screen
- Screen connection to GND, PE
- Type of screen connection: stranded wire, sheet-metal segments, clamps, "water-tight" connection
- Design of shielding discharge paths in the housing area: bolts, spacers, metal sheets
- Plug-and-socket connectors: structural design, assignment
- Shielding plates, foils, lacquer
- Suppressor circuits: component selection, layout design, discharge paths

The line should be operated without a useful signal if the signal level of the interface deviates from the TTL level. It is possible, for example, to take measurements with the EUT switched off. (The sensor is supplied from a battery, for example, in this case.)

4.3 Example: monitoring watchdog and RESET signals

An EUT reacts to a burst test with a fault pattern which gives rise to the assumption that a RESET was triggered on the controller. A sensor is connected directly to the RESET line from the monitoring IC to the controller at the output of the monitoring IC to determine the cause. Observe the "Spike" LED and the "Signal" LED of the OE 110 optical receiver whilst performing the test.

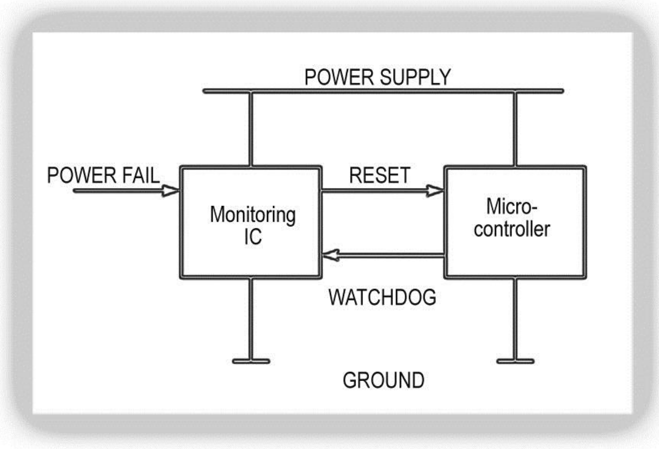

Fig. 10 Monitoring IC and microcontroller can cause a RESET

If signals are clearly recognizable on both the "Signal" *and* the "Spike" LED, the monitoring IC is triggered by the disturbance events and it generates a RESET pulse of approximately 100 ms which is clearly visible on the LEDs. There has been a direct interference of the RESET line if 100 ms pulses are *only* recognizable on the "Spike" LED since it is not possible to recognize the pulses, which are very short in this case, with the naked eye.

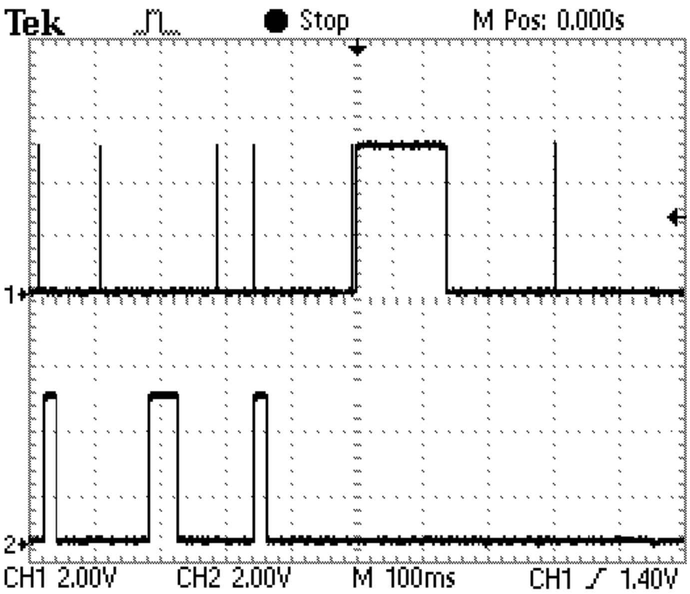

Fig. 11 RESET and watchdog signal

A signal pattern as in Fig. 11 results if two sensors and an oscilloscope are used.
The cyclic watchdog pulses are clearly recognizable on channel 2. Channel 1 shows the RESET signal: the narrow pulses are caused by direct coupling into the RESET line but do not trigger a RESET. The watchdog signal shows that the controller is still running.
Only the pulse with a width of approximately 160 ms triggers a RESET. Since such a wide pulse cannot be caused directly by the disturbance, an interference must have occurred on the monitoring IC.

4.4 Example: locating EMC weak points on an I/O module / micro-processor

Serial data transfer between a micro-processor and a remote I/O module can be disturbed by burst, ESD or radiated or conducted RF emissions. Appropriate test generators can be connected to the EUT for simulation purposes.

The relevant signals such as RDY, DAT, CLOCK etc. are detected by a sensor and transmitted to a memory oscilloscope for evaluation. The sensor can be connected to different points along the signal path such as the micro-processor pin, plug-and-socket connector, beginning of the cable, end of the cable, opto-coupler input, opto-coupler output, driver input, driver output or I/O circuit pin. The location of the disturbance attack can determined by scanning the signal path step-by-step and evaluating the signals.
Correlations between signals can be established if several sensors are used (e.g. handshake signals).

5 Safety instructions

- **Do not use damaged or defective devices.**
- Only personnel who are qualified in the field of EMC and fit to work under the influence of magnetic as well as electric fields may use the device.
- **Follow the operating and safety instructions for the respective disturbance source used in the tests (burst generator, RF power amplifier, transmitting aerials etc.).**
- EMC sensors may only be plugged in and disconnected in an interference-free state.
- Exceeding the disturbance threshold may result in the sensor's destruction. Do not touch the sensor input under the influence of disturbances.
- Before starting, check the function of the optical transmission path and stop function of the burst generator when using a measuring set-up where sensors control the burst generator. Carry out this test by changing over the sliding switch on the sensor, checking the light and checking the stop function of the generator.

6 Technical data

6.1 EMC sensors

Sensor type	***S21***	***S25***
Transfer rate	DC-10 Mbps	DC-50 Mbps
Voltage supply	3 - 5 volts	3 - 5 volts
Current input	10 mA	30 mA
Dimensions	34x10x6 mm	34x10x6 mm
Optical fibre connection	∅ 2.2 mm	∅ 2.2 mm

6.2 Optical receivers

Receiver type	***OE 400***	***OE 150***
Transfer rate	DC-10 Mbps	DC-50 Mbps
Current input	< 100 mA	< 80 mA
Voltage supply	12 V via external , power supply unit	12 V via external , power supply unit
Pulse stretching	5 µs / 50 ms connectable	100 ms connectable
Optical input	4x optical fibre ∅ 2.2 mm	Optical fibre ∅ 2.2 mm
Output	4x BNC plug, 5 V HCMOS	BNC plug, 5 V HCMOS

7 Scope of delivery

7.1 OSE 400 (4 cannels) DC-10 Mbps

	Designation	Type	Quantity
01	Optical receiver	***OE 400***	1
02	Sensors	***S21***	4
03	Plug-in power supply unit	12 V / 300 mA	1
04	Optical fibre	6 m	4
05	Adapter socket	3-pole	8
06	Enamelled Cu wire 0.15 mm	reel	1
07	Transport case with foam insert	(338x260x57) mm	1
08	Short description	Laminate	1
09	Operating instructions		1

* Further sensors are available on request and can be added to the set.

7.2 OSE 150-1 (1 cannel) DC-50 Mbps

	Designation	Type	Quantity
01	Optical receiver	***OE 150***	1
02	Sensor	***S25***	1
03	Plug-in power supply unit	12 V / 300 mA	1
04	Optical fibre	1.5 m	1
05	Adapter socket	3-pole	3
06	Enamelled Cu wire 0.15 mm	reel	1
07	Transport case with foam insert	(240x185x50) mm	1
08	Short description	Laminate	1
09	Operating instructions		1

* Further sensors are available on request and can be added to the set.

7.3 OSE 150-2 (2 cannels) DC-50 Mbps

	Designation	Type	Quantity
01	Optical receivers	***OE 150***	2
02	Sensors	***S25***	2
03	Power split cable	20 cm	1
04	Plug-in power supply unit	12 V / 300 mA	1
05	Optical fibre	6 m	2
06	Adapter socket	3-pole	6
07	Enamelled Cu wire 0.15 mm	reel	1
08	Transport case with foam insert	(338x260x57) mm	1
09	Short description	Laminate	1
10	Operating instructions		1

* Further sensors are available on request and can be added to the set.