User Manual

E2 set

TS 23 Immunity Development System

2026.07.30 E2 set user manual

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1 Declaration of Conformity

Manufacturer:

Langer EMV-Technik GmbH
Nöthnitzer Hang 31
01728 Bannewitz
Germany

Langer EMV-Technik GmbH herewith declares that the

E2 set, Immunity Development System including
TS 23 Pulse Generator and S25 optical sensor

conforms with the following relevant regulations:

- Low-Voltage Equipment Directive 2014/35/EU
- EMC Directive 2014/30/EU
- Restriction of certain Hazardous Substances 2011/65/EU

The following applicable standards were used to implement the requirements specified by the aforementioned directives:

- DIN EN IEC 61000-6-1:2019-11 (EMC immunity)
- DIN EN IEC 61000-6-3:2022-06 (EMC emission)
- DIN EN 61010-1:2020-03 (Safety)
- DIN EN IEC 63000:2019-05 (Restriction of hazardous substances)

Name of the person authorized to compile the technical documentation:

Katja Langer

Bannewitz, 2026-03-01

Signature:

K. Langer, CEO

2 General Information

2.1 Storage of the User Manual

This user manual enables the safe and efficient use of the E2 set. It must be kept close at hand and accessible to the use.

2.2 Reading and Understanding the User Manual

Read the user manual carefully, observe the safety information (Chapter 3) and follow the instructions given in this manual before putting the device into service.

2.3 Local Safety and Accident Prevention Regulations

The local accident prevention and general safety regulations also apply to ensure that the E2 set is used for its intended purpose.

2.4 Images

Figures and images have been included in this user manual to assist the reader's understanding but may differ from the device's actual version.

2.5 Limitations of Liability

In the following cases, Langer EMV-Technik GmbH can assume no liability for damage to property and personal injury if:

- The information given in this user manual has not been observed.
- The E2 set was operated by staff not qualified in the field of EMC.
- The E2 set was subjected to unauthorized modifications or technical changes.
- The E2 set was not used according to its intended purpose.
- Spare parts or accessories were used that had not been approved by Langer EMV-Technik GmbH.

The actual scope of delivery may deviate from the illustrations and texts in this user manual due to the customization of orders or due to technical changes and innovations.

2.6 Errors and Omissions

The information in this manual has been carefully checked and is believed to be accurate; however, the Langer EMV-Technik GmbH assumes no responsibility for any clerical, typographical, or proofreading errors, or omissions.

2.7 Copyright

The content of this user manual is protected by copyright law and may only be used in connection with the E2 set. This user manual may not be used for any other purpose without the prior written approval of Langer EMV-Technik GmbH.

3 Safety

3.1 Labels and Signs

 General warning sign	 Warning; Electricity	 Prohibition sign; No access for people with active implanted cardiac devices.

Safety instructions in this user manual are marked by symbols (**Fehler! Verweisquelle konnte nicht gefunden werden.**). Follow these instructions carefully and act with caution to prevent accidents, personal injury, and damage to property.

3.2 Intended Use

The E2 set is a system of EMC tools for pre-compliance immunity testing and troubleshooting of electronics across all system levels. The E2 set is made for reproduction of typical failure patterns observed in immunity tests with pulsed disturbances, including EFT (IEC 61000-4-4) and ESD pulses (IEC 61000-4-2). This can be done by injecting pulsed disturbance currents directly into the electronics or by applying disturbance fields (electric and magnetic) to the electronic under test.
The test set-up is compact and designed for use directly at the engineer's workbench.

Intended use cases:

- Pre-compliance testing for pulsed immunity tests.
- Troubleshooting and evaluation of countermeasures.
- Observation of failures during all kinds of immunity tests.

The E2 set is intended to be operated under the following environmental conditions:

- Ambient temperature: 5 °C to 40 °C
- Relative humidity: max. 80 % up to 31 °C, linearly decreasing to 50 % at 40 °C
- Altitude: up to 2000 m
- Indoor use only

3.3 Reasonably foreseeable Misuse

 Warning!	**Danger resulting from misuse!** **Misuse of the E2 set can lead to dangerous situations!**

Langer EMV-Technik GmbH shall not be liable for any damage resulting from use of the E2 set other than as intended and described, or from unauthorized modifications to device components.

Incorrect applications of the sets include:

- Use of the product outside of the given specifications.
- Modification or changes to the product without the consent of Langer EMV Technik GmbH.
- Operation of the product with a technical defect.
- Disabling or bypassing safety devices.
- In addition, local safety and accident prevention regulations must be observed to ensure proper use of the device.

3.4 Staff Requisition

Only qualified staff with training, knowledge, and experience in the field of EMC are allowed to operate the E2 set. Persons whose ability to perform is influenced or impaired by alcohol, drugs, or pharmaceuticals are not allowed to operate the E2 set.

3.5 Safety Instructions

3.5.1 Hazards causing injury to persons

 Warning; Electricity!	**Warning due to high voltage!**

Hazards due to high-voltage and electromagnetic fields generated by the TS 23:

The TS 23 generator produces high-voltage pulses at its outputs.

Although the energy of the pulses is low, improper handling may cause:

- unpleasant electric shock
- involuntary reactions (e.g. reflex movements)

Do not touch any metal parts that are connected to the outputs of the TS 23 during operation.
Only make changes to the setup when the TS 23 is turned off.

 Prohibition; No access for people with active implanted cardiac devices	**Danger resulting from electromagnetic fields!** **Risk of affecting a cardiac device!**

Electromagnetic near fields and interference emissions are generated during operation of E2 set due to its functional principle. These fields can pose a risk to persons with implanted electronic devices.

Persons with pacemakers, defibrillators, or other implanted electronic medical devices are not permitted to operate or approach the E2 set during operation, nor to remain in the same room.

The user is responsible for taking appropriate measures to ensure that no hazards to persons arise from the generated electromagnetic fields. This can be achieved by maintaining a sufficient safety distance and by using shielded environments or enclosures (e.g. shielded rooms or tents).

Electrical hazards caused by damaged equipment of the E2 set:

RF currents can cause irreversible damage to the body, therefore the following safety instructions must be observed.

- If any insulation is damaged, the power supply must be disconnected immediately.
- Switch off the device immediately and disconnect the power supply if malfunctions occur.
- Damaged parts must be replaced before operation. Contact Langer EMV-Technik GmbH to obtain replacement parts.
- Protect live parts from moisture to prevent short circuits.
- Never leave a Langer EMV-Technik GmbH product unattended while it is in operation.
- Only qualified personnel of Langer EMV-Technik GmbH are permitted to open the TS 23 and field sources or work on electrical components and wiring.

Electrical hazards caused by the DUT:

Since the TS 23 can be directly connected to the equipment under test (DUT), contact with hazardous voltages cannot be ruled out even when the TS 23 is switched off.

Therefore, the DUT must not be tested without precaution with the TS 23 if the DUT contains voltages exceeding:

- 60 V DC
- 30 V AC (rms)

If higher voltages are present on the DUT, appropriate safety precautions must be taken:

- During test setup and when making changes to the setup, the DUT must always be verified to be in a voltage-free state.
- During operation, appropriate protection against accidental contact (e.g. by using insulating covers such as Plexiglas) must be ensured.
- The use of the handheld field sources is strictly prohibited if the DUT contains voltages exceeding 60 V DC or 30 V AC (rms), as sharp edges may damage insulation, which may result in direct exposure to hazardous voltages during operation.

3.5.2 Hazards causing damage to equipment and surrounding electronics

Direct damage caused by pulses from the TS 23 pulse generator:

The TS 23 pulse generator produces high voltages that may damage or destroy electronic components if pulses are applied to the DUT in an improper manner.

To minimize the risk of damage, the disturbance level of the TS 23 should be increased gradually, and testing must be stopped immediately when a functional fault occurs.

Damage may occur to:

- The DUT itself and components assembled on it (e.g. integrated circuits, sensors, …).
- measurement and monitoring equipment connected to the DUT, including but not limited to oscilloscopes, spectrum analyzers, and their accessories (e.g. active probes), as well as similar or comparable equipment.
- Power supply units, including SMUs, SMPS, and other types of power supply units or comparable power sources.
- Any additional electronic devices connected to the DUT via cables, such as computers, programming adapters used for debugging (e.g. J-Link adapter), communication interfaces (e.g. CAN-to-USB converters), and other similar or comparable devices.

Indirect damage caused by electromagnetic fields:

Electronic devices that are not required for testing (e.g. smartphones, tablets, watches, laptops, …) must be kept at a safe distance to prevent damage caused by the electric and magnetic fields generated by the TS 23 pulse generator.

Performing tests with the E2 set in a fully or partially shielded environment or enclosure (e.g. shielded rooms or tents) is recommended to protect electronic equipment from near-field and far-field electromagnetic interference.

Damage caused by overcurrent:

The pulses generated by the TS 23 can cause temporary short circuits in the DUT. The resulting increased current draw may lead to destruction of the DUT or damage to the power supply unit.

The user must therefore ensure that:

- Benchtop power supplies are operated with appropriate current limiting
- Other power sources, especially batteries and accumulators, are equipped with fuses in the supply lines

4 Scope of delivery

Item	Designation	Type	Parameter	Quantity
01	TS 23 Pulse Generator	TS 23		1
02	Power Supply Unit	NT FRI xx	24 V / 1.25 A	1
03	Ground Plate	GP10		1
04	Magnetic Base Adapter	MA 33-L/R		2
05	Diff-to-single-ended Adapter	DEA		1
06	Differential Injector	DE2 / DE6		6
07	Generator Cable	GK 0.7m SMB-SMB		2
08	Magnetic Field Source	BS 02-h		1
09	Magnetic Field Source	BS 03-d		1
10	Magnetic Field Source	BS 04DB-d		1
11	Magnetic Field Source	BS 04DB-h2		1
12	Magnetic Field Source	BS 05DU-h2		1
13	Electric Field Source	ES 01		1
14	Electric Field Source	ES 02		1
15	Electric Field Source	ES 05D-h		1
16	Electric Field Source	ES 08D-h		1
17	Electric Field Source	ES 10D-h		1
18	Magnetic Field Probe	MS 101		1
19	Optical Sensor	S25		1
20	Optical Fiber	LWL ∅ 2.2 mm 1.5 m		1
21	Measurement Lines	Red / Yellow / Black	7 / 12 / 25 cm	6
22	Alligator Clip			2
23	Micro Kleps			2
24	Adapter Socket, 3-Pole			6
25	Enamelled Copper Wire	Ø=0.2 mm	Reel	1
26	User Manual			1
27	Quick Guide			1
28	System Case			1

Important: The scope of delivery may deviate depending on the respective order.

Figure 1: E2 set system case

5 E2 set

5.1 General Description

The E2 Immunity Development System is a toolkit that allows electronic engineers to examine the immunity of electronic devices, modules, and PCBs to pulsed disturbances. It helps engineers identify weak spots causing immunity problems and determine the root cause of failures in pulsed immunity tests, such as ESD and EFT/Burst. Using the E2 set, engineers can directly verify countermeasures for improving the immunity of electronics, which significantly reduces development time and costs. Disturbance pulses can be fed directly into individual sections of the device under test (DUT) or applied through fields (E and H fields) to specific areas. While pulsed disturbances are applied to the (DUT), signals can be simultaneously monitored via optical fiber without influencing the test itself. An optical sensor soldered to the DUT or an optical magnetic field probe transmits light pulses to the TS 23s internal pulse counter via the optical fiber.

5.2 Design and Function TS 23

The following figure illustrates the user interface of the TS 23 pulse generator. The controls and indicators can be divided into three functional groups. The polarity switch at the top of the device and the two knobs on the left adjust the pulse parameters. The optical fiber input and the two LEDs, "Spike" and "Signal," are related to the internal light pulse counter of the TS 23. The SMB output connectors and output switch belong to the output functional group.

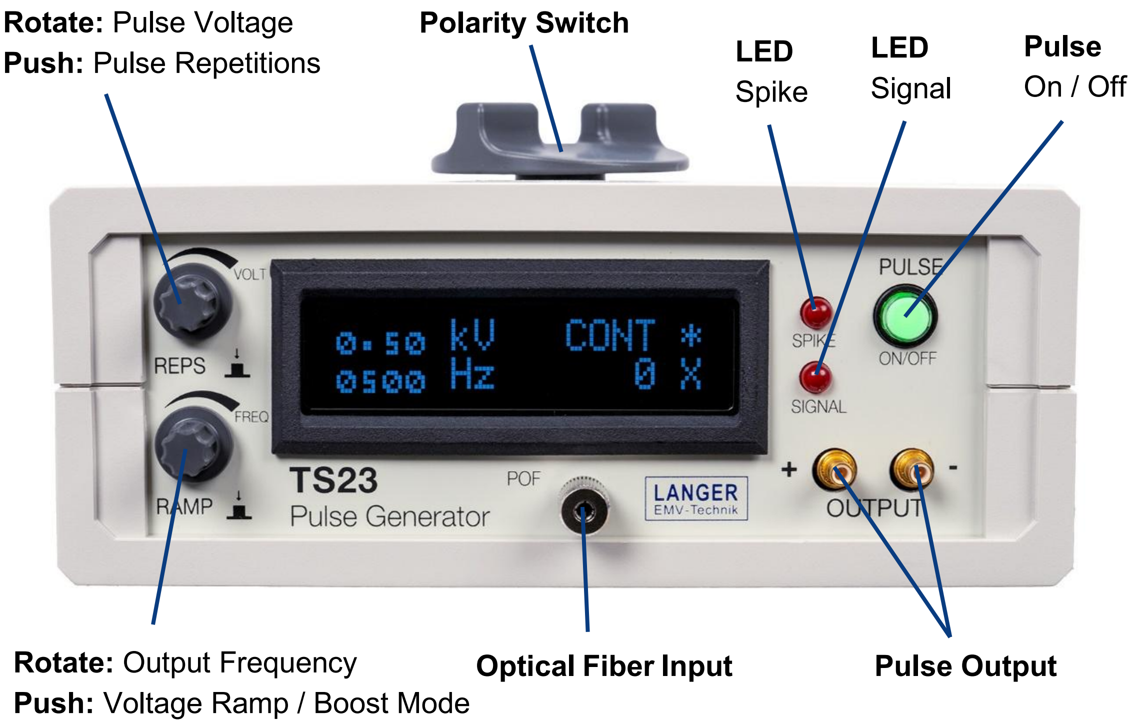


Figure 2: Front Panel – Interface Description

On the rear panel of the device, the connector for the DC power supply is located. Next to it are the external trigger selector switch and the connector for the external trigger input. For detailed information on the external trigger function, refer to Chapter 8.

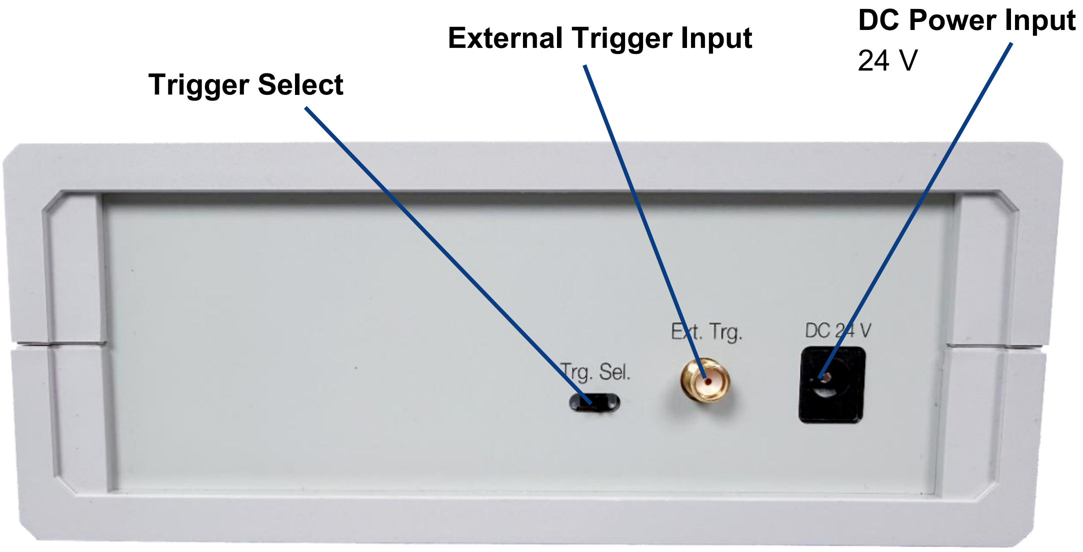


Figure 3: Rear Panel – Interface Description

The display provides information about the pulse parameters, the pulse mode, and the input counter. Detailed information about the displayed values and symbols is provided in Table 2.

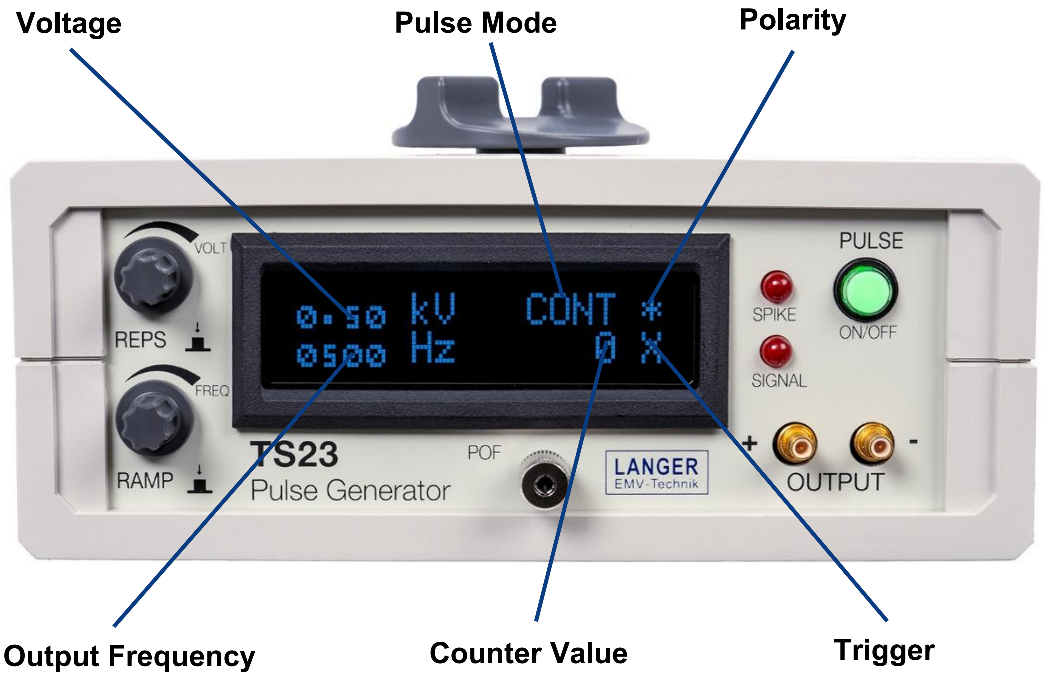


Figure 4: Front Panel - Display Description

Feature Group	Display Symbol	Explanation of the Symbol
Pulse Mode	*CONT*	Continuous Pulsing
	1	Single Pulse
	2	2 Pulse Repetitions
	5	5 Pulse Repetitions
	10	10 Pulse Repetitions
	20	10 Pulse Repetitions
	50	50 Pulse Repetitions
	RAMP	Continuous Pulsing Voltage Ramp
	BOOST	Group of Pulses with Increased Output Frequency
Polarity	*P*	Positive
	*	Invalid polarity switch position
	N	Negative
Trigger	*I*	Internal
	X	External

Table 1: Full Description of the Display Symbols and Abbreviations

5.3 Description of the E2 set Equipment

5.3.1 Field sources

The field sources are supplied with disturbance current by the TS 23 pulse generator and generate either pulsed magnetic or electric fields, depending on the type of field source used. The resulting field strength is determined by the pulse voltage set on the TS 23. The field sources are used to apply defined disturbances to localized areas of the DUT or to individual conductors and traces. Different field source designs are available, optimized for either magnetic-field or electric-field coupling. Various sizes allow disturbances to be applied to areas of different dimensions. In addition, specialized field sources are available for specific applications, such as advanced ESD troubleshooting.
The field sources enable the developer to identify susceptibility hotspots and locate critical components, traces, connectors, or IC pins along the disturbance path. The sensitivity of individual circuits and interfaces can be evaluated, allowing corrective measures to be implemented and verified in a targeted manner.

Field sources for magnetic fields

The E2 set contains five magnetic field sources that are designed to generate magnetic fields. Due to their different geometries, they support two main applications.

a) Localization of layout-related weak points

During standard immunity tests, disturbance currents can generate unwanted magnetic fields at weak points in the layout, such as cutouts, gaps, or discontinuities in the PCB ground plane. These fields can couple into sensitive structures either inductively or capacitively and propagate through PCB traces to the ICs. The E2 field sources are specifically designed to reproduce these coupling mechanisms and locate the corresponding susceptibility hotspots.

b) Evaluation of the susceptibility of IC pins and PCB traces.

The field sources can also be used to evaluate the susceptibility of individual IC pins, PCB traces, and other circuit nodes regardless of the presence of a layout-related disturbance field at that specific location during a standard immunity test. This allows developers to identify sensitive structures and implement targeted corrective measures.

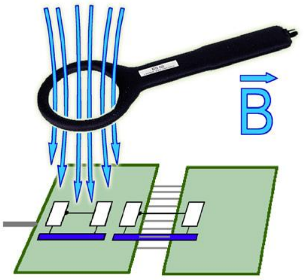
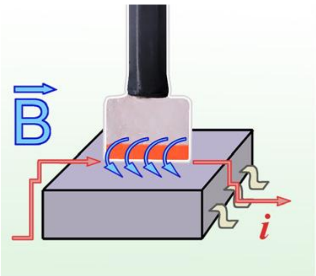
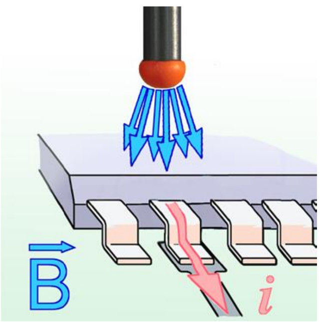
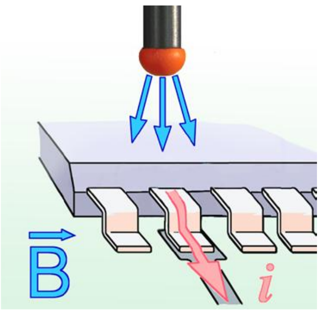
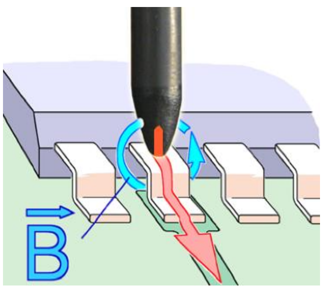
Field pattern	Intended Use
	**BS 02-h** is a magnetic field source designed for the localization of layout-related weak points. It generates a magnetic field with a diameter of more than 5 cm and is suitable for investigations on both complete devices and individual modules. Due to its large diameter, the probe can be used to expose extended areas of enclosures, internal assemblies, interconnections, conductive structures, and integrated circuits to pulsed magnetic fields. This allows the developer to identify areas that are susceptible to magnetic-field coupling. Type: a) Connector: SMB
	**BS 03-d** is a magnetic field source designed to localize sensitive current loops within integrated circuits. It simulates the direct influence of radiated magnetic fields on the IC. By rotating the probe above the IC, the orientation of sensitive internal current loops can be determined. This makes the BS 03-d a powerful tool for evaluating ICs located near PCB edges, cables, or other areas where increased magnetic field exposure is expected. Type: b) Connector: double SMB
	**BS 04DB-d** is a magnetic field source designed for the localization of layout-related weak points. It generates a highly focused magnetic field with an effective diameter of approximately 3 mm. The magnetic field emerging from the probe tip can be used to scan PCB surfaces, ribbon cables, and integrated circuits for susceptibility to magnetic-field coupling. The BS 04DB-d differs from the BS 04DB-h2 primarily in the number of coil windings. Its design is optimized for the generation of fast transient pulses, making it particularly suitable for ESD-related troubleshooting. Type: a) Connector: double SMB
	**BS 04DB-h2** BS 04DB-h2 is a magnetic field source designed for the localization of layout-related weak points. It generates a magnetic field with an effective diameter of approximately 3 mm. The field source is intended for scanning PCB surfaces from both the top and bottom sides. Furthermore, cables and connectors can be investigated at their interfaces. Type: a) Connector: SMB
	**BS 05DU-h2** is a magnetic field source designed to determine the susceptibility of individual IC pins and PCB traces. The probe generates a circular magnetic field in the millimeter range.2 3It can also be used as a miniature coupling clamp to couple disturbance currents into selected PCB traces, IC pins, SMD components, and thin wires such as ribbon-cable conductors. Type: b) Connector: SMB

Table 3: Overview of the magnetic field sources included in the E2 set

Field sources for electric fields

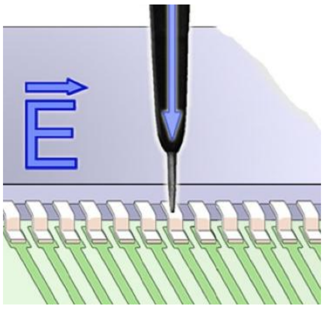
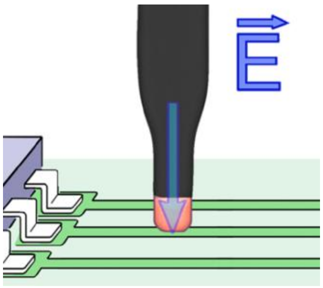
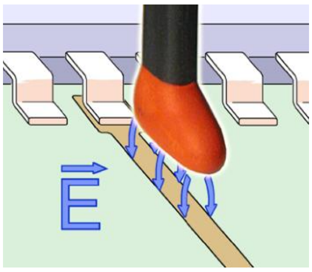
The E2 set contains five electric field sources that are designed to generate electric fields. Due to their different geometries, they support two main applications.

a) Localization of layout-related weak points

These field sources generate a widely distributed electric field across their active surface. They are intended to simulate nearby conductive structures at a different electrical potential, such as enclosures, heat sinks, neighbouring PCBs, or other metal parts. This allows the developer to reproduce electric-field coupling effects that may occur during standard immunity tests and to identify layout-related weak points.

b) Evaluation of component susceptibility

These field sources concentrate the electric field in a small area around the probe head, minimizing the influence on neighboring traces, pins, and components. They are used to identify components, PCB traces, pins or circuit nodes that are generally susceptible to electric-field disturbances, regardless of whether such coupling occurs at that location during a standard immunity test.

	**ES 08D-h** is a probe tip designed to determine the susceptibility of individual IC pins and PCB traces. The pin or trace is contacted directly with the probe tip. Disturbance pulses from the TS 23 are coupled capacitively through an integrated galvanically isolated coupling point with a capacitance of approximately 1 pF. This design is particularly suitable for very small structures and allows the susceptibility of individual pins and traces to be evaluated without significantly affecting signal integrity. Type: b) Connector: SMB
	**ES 10D-h** is an electric field source designed to determine the susceptibility of individual IC pins and fine PCB traces. The probe head features a coupling electrode with a width of approximately 0.2 mm, enabling highly localized capacitive coupling of disturbance pulses from the TS 23 into the DUT. This makes the probe particularly suitable for investigating individual IC pins, high-pin-count ICs, and very fine PCB traces. Type: b) Connector: SMB
	**ES 05D-h** is an electric field source designed to determine the susceptibility of individual IC pins, PCB traces, and electronic components. The probe head contains a narrow, line-shaped coupling electrode, making it particularly suitable for investigating PCB traces, small components and their interconnections, wires, and individual SMD components such as resistors and capacitors. During testing, the probe is placed directly on the component or PCB trace to inject the electric field. Type: b) Connector: SMB

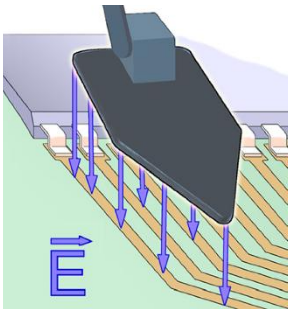
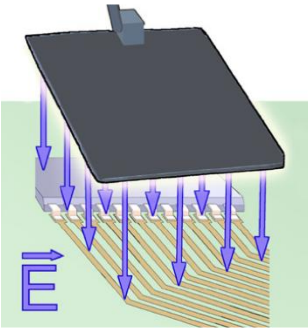
	**ES 02** is an electric field source designed for the localization of layout-related weak points. Its size allows the developer to apply the electric field to large areas of enclosures, internal assemblies, interconnections, and conductive structures such as bus systems, LCD displays, and ICs. When the field source is positioned with its flat surface facing the DUT, large areas can be exposed to the electric field. When the probe tip is placed directly onto the PCB, the coupling is concentrated to a much smaller area, allowing localized investigation of structures that are susceptible to electric-field coupling, such as PCB traces, crystal oscillators, pull-up resistors, and ICs. Type: a) Connector: Pin Header
	**ES 01** is an electric field source designed for the localization of layout-related weak points. It is intended for applying electric fields to extended or line-shaped structures with dimensions of approximately 5 to 10 cm. The ES 01 can be used to capacitively couple disturbance currents into a DUT. The coupling intensity can be adjusted by varying the distance between the field source and the DUT. Type: a) Connection: Pin Header

Table 4: Overview of the electric field sources included in the E2 set

5.3.2 Optical Sensor

The S25 sensor (Figure 5) is a digital probe for the non-intrusive transmission of binary signals from the device under test (DUT) during immunity testing with the E2 set. The sensor is mounted directly on the DUT and powered by the DUT itself. The monitored digital signal is converted into an optical signal inside the sensor and transmitted via a plastic optical fiber to the optical input of the TS 23 pulse generator. The TS 23 can use the received signal for event counting and monitoring of DUT reactions during testing.
The sensor is equipped with a three-pin connector. One pin is connected to the DUT supply voltage (3 V to 5 V), one pin to ground, and the third pin serves as the signal input. The sensor supports signal transmission rates from DC up to 50 Mbps.

The level inversion switch allows the logic state of the transmitted signal to be inverted.

The S25 sensor can be used in two different ways:

a) Monitoring digital signals in the DUT

Important signals such as reset, chip-enable, clock, communication, or status signals can be monitored during immunity testing. Since the signal is transmitted optically, no conductive connection exists between the DUT and the TS 23. As a result, the test setup and disturbance current paths are not affected by the monitoring system, allowing functional disturbances to be detected without influencing the test conditions.

b) Detecting disturbances in the DUT

The digital input of the S25 can also be used as a disturbance detector. If interference pulses induce unwanted logic level transitions at the monitored node, these events are transmitted to the TS 23 and can be counted or observed during testing. This allows the developer to identify susceptibility hotspots and evaluate the effectiveness of corrective measures.

Figure 5: S25 Optical Sensor.

Pulse stretching

The S25 sensor of the E2 set can detect fast transient disturbances. The pulse widths of these disturbances may be in the nanosecond range. Due to the limited response time of the optical transmission system, such short disturbances cannot be transmitted directly. Therefore, the sensor incorporates a pulse-stretching circuit that extends short pulses to 20 ns. The optical fiber is then able to transmit these pulses. The optical system of the sensor is also unable to transmit frequencies above 25 MHz. The same circuit reduces frequencies greater than 25 MHz to 25 MHz. Since a 25 MHz signal consists of one high and one low state per period, an effective transmission rate of 50 Mbps is achieved.
Without this circuit, the optical system would not be able to transmit these short disturbance events reliably and would merely assume a constant high or low state. The circuit ensures that disturbance-induced fault states are transmitted from the device under test.

Principle of operation and installation of the sensor

The S25 sensor is installed directly on the DUT and connected to the signal of interest. A three-pin socket supplied with the E2 set should be glued to the PCB close to the measurement point and connected using short wires. The wiring for supply voltage, ground, and signal should be kept as short as possible and routed directly along the PCB surface to minimize loop areas that could be affected by electric or magnetic field coupling.
The adapter socket can be fixed to the PCB using adhesive. The supply voltage, ground, and signal connections are then soldered according to the pin assignment of the S25 sensor (Figure 6). If no suitable supply voltage is available on the DUT, an external battery module may be used.
For applications involving particularly sensitive signals, additional shielding of the sensor may be required.

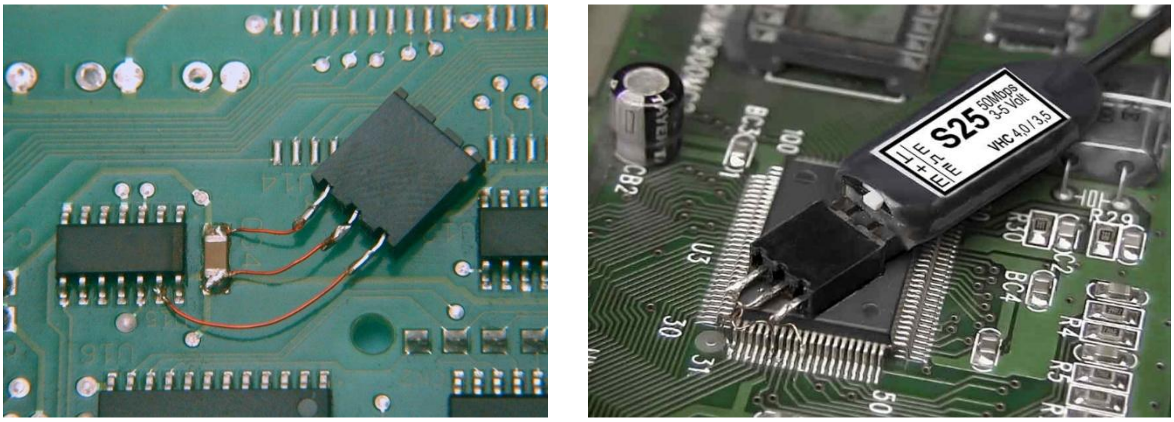


Figure 6: A socket where the S25 sensor can be connected is placed on a PCB

The optical fiber must be inserted fully into the optical fiber connector of the TS 23 pulse generator and secured using the knurled nut.

The received optical pulses are indicated by the "Signal" LED. Since the optical pulses transmitted by the S25 sensor may be as short as 20 ns, they would not be visible to the human eye. Therefore, the TS 23 generates a pulse-stretched indication of each received pulse, which is shown by the "Spike" LED.

The received pulses are counted by the integrated counter of the TS 23. The counter operates with a gate time of 1 s and displays the number of pulses received during this time interval as “Counter Value” on the display. In combination with the Pulse Density Method (Appendix A), the sensor and counter provide a fast and efficient means of evaluating the susceptibility of the DUT.

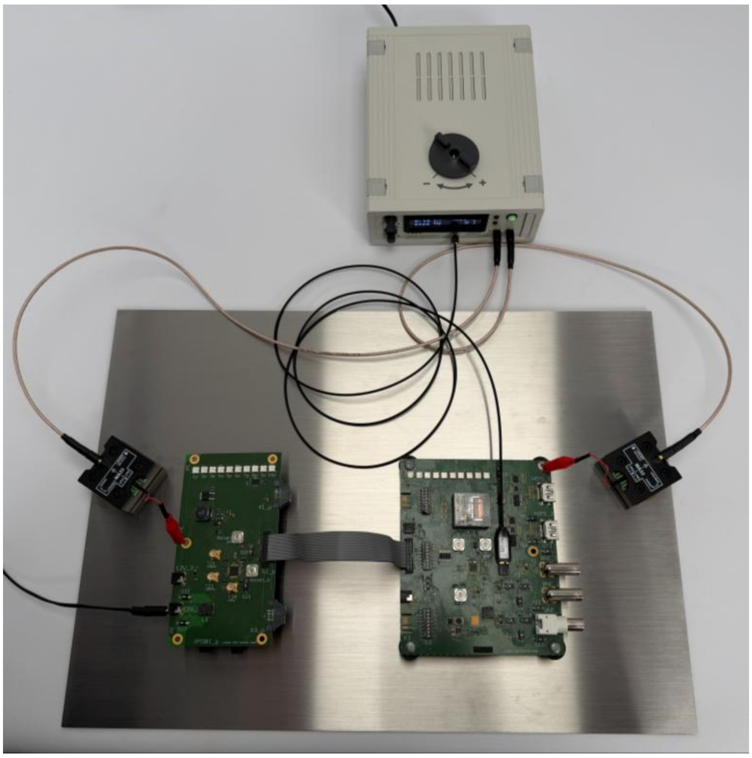


Figure 7: Setup with the S25 Sensor connected to the TS 23 using the optical fiber

5.3.3 Magnetic field probe

The MS 101 magnetic field probe is used to determine the spatial distribution of magnetic fields within and around the DUT. It is particularly suitable for investigating cables, shield connections, instrument housings, and other conductive structures through which disturbance currents may flow. The measured magnetic field distribution provides valuable information about the corresponding disturbance current paths and helps the developer understand the interference mechanisms within the DUT.

The probe detects magnetic field pulses by means of an induction coil integrated into the probe head. Magnetic fields penetrating the coil induce a voltage that drives an optical transmitter inside the probe. Each detected magnetic field pulse generates a corresponding optical pulse, which is transmitted via an optical fiber to the optical fiber input of the TS 23 pulse generator.

Only magnetic field components penetrating the probe coil orthogonally generate a signal. Magnetic fields parallel to the coil plane are largely suppressed. By rotating the probe, the orientation of the magnetic field can be determined. The maximum signal is obtained when the magnetic field penetrates the coil orthogonally, whereas a minimum or null point is obtained when the field direction lies in the plane of the coil. By scanning the DUT with the probe, the spatial distribution of magnetic fields and therefore the disturbance current distribution can be determined. This allows the developer to identify where disturbance currents flow through the DUT, whether they are coupled into critical circuits or ICs, and which structures are most exposed to magnetic-field-related disturbances. The probe is particularly useful for locating critical magnetic field concentrations in the vicinity of ICs, cables, shield connections, and conductive structures. It can also be used to identify magnetic field concentrations caused by gaps, cutouts, and other discontinuities in ground structures, which often indicate unfavourable disturbance current paths and may increase the susceptibility of nearby traces and components.

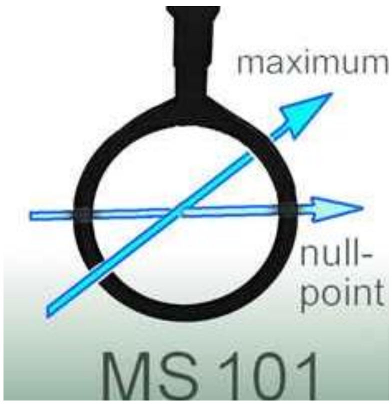


Figure 8: The MS 101 magnetic field probe can detect a magnetic field which is orthogonal to the probe opening

The received optical pulses are indicated by the "Signal" and "Spike" LEDs of the TS 23 and counted by the integrated counter. The displayed counter value is proportional to the detected magnetic field activity and can be used to compare different locations on the DUT using the Pulse Density Method (Appendix A). The measurement is intended as a relative comparison of magnetic field activity and disturbance current paths rather than an absolute magnetic field strength measurement. This information can be used to assess the effectiveness of shielding measures, shield connections, discharge paths, and decoupling concepts.

The MS 101 is a passive probe and does not require an auxiliary power supply. The energy required for optical pulse generation is extracted directly from the detected magnetic field. The optical fiber must be inserted fully into the opening at the rear of the probe.

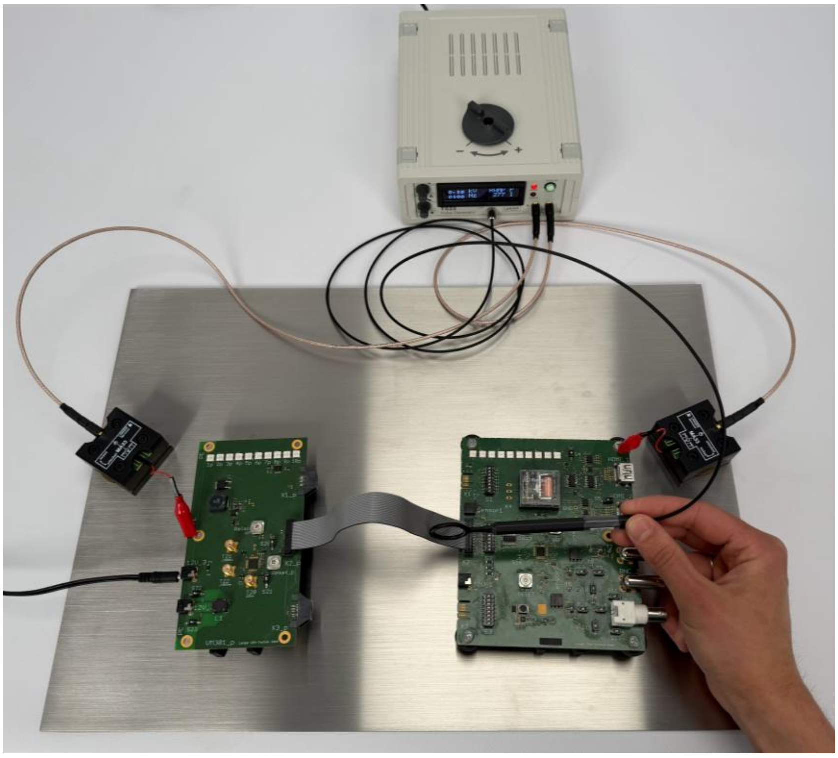


Figure 9: Setup with the MS 101 magnetic field probe connected to the TS 23 using the optical fiber

6 Operational Notes

6.1 Pulse Modes

The operating mode of the TS 23 is defined by the Pulse Mode setting displayed in the upper center area of the display. Depending on the selected mode, the pulse generator can generate continuous pulses, predefined pulse sequences, automatic voltage ramps, or pulse groups with increased pulse repetition frequency.

6.1.1 Continuous Pulse Mode

In Continuous Pulse Mode (CONT), the TS 23 generates disturbance pulses continuously.
This is the default operating mode and usually the recommended starting point for immunity investigations. Continuous pulse injection increases the probability of triggering intermittent faults and allows the developer to localize weak points efficiently before moving on to more specialized operating modes and measurement techniques.
The pulse voltage can be adjusted from 10 V to 2.2 kV. The currently selected value is displayed in the upper left corner of the display. The pulse repetition frequency can be set between 1 Hz and 1500 Hz and is indicated in the lower left corner.

6.1.2 Pulse Repetitions

The pulse repetition mode generates a predefined number of consecutive pulses each time the Pulse ON/OFF button is pressed. The desired number of pulses is selected by pushing the upper rotary knob labeled REPS and can be set to 1, 2, 5, 10, 20, or 50 pulses.
These modes are useful when a malfunction can already be triggered by a small number of pulses or when a defined pulse sequence is required to reproduce a specific fault condition. They are particularly useful when the DUT requires a recovery period after a disturbance event and continuous pulse injection would trigger secondary faults that are not representative of the original immunity problem. The pulse repetition frequency between individual pulses is determined by the selected output frequency.
Pulse repetition modes can only be used with the internal trigger and can’t be triggered by the external trigger.

6.1.3 Voltage Ramp

In Voltage Ramp Mode (RAMP), the TS 23 automatically increases the pulse voltage from a minimum value to the voltage displayed as the pulse voltage. The voltage rise is linear, and the ramp is repeated continuously. The output pulse sequence generated in RAMP mode is shown in Figure 10. The number of pulses contained in a single ramp, and thus the voltage step size between consecutive pulses, is determined by the pulse repetition frequency set using the “Output Frequency” control.
The RAMP mode was specifically developed for the Pulse Density Method. Together with the S25 optical sensor or the MS 101 magnetic field probe, it enables a rapid assessment of the immunity level of a DUT and the comparison of different layouts, design revisions, and EMC countermeasures. The method can be used to verify whether implemented corrective measures actually improve the immunity of the DUT.
A detailed description of the Pulse Density Method is provided in Appendix A.
The voltage ramp mode can only be used with the internal trigger.

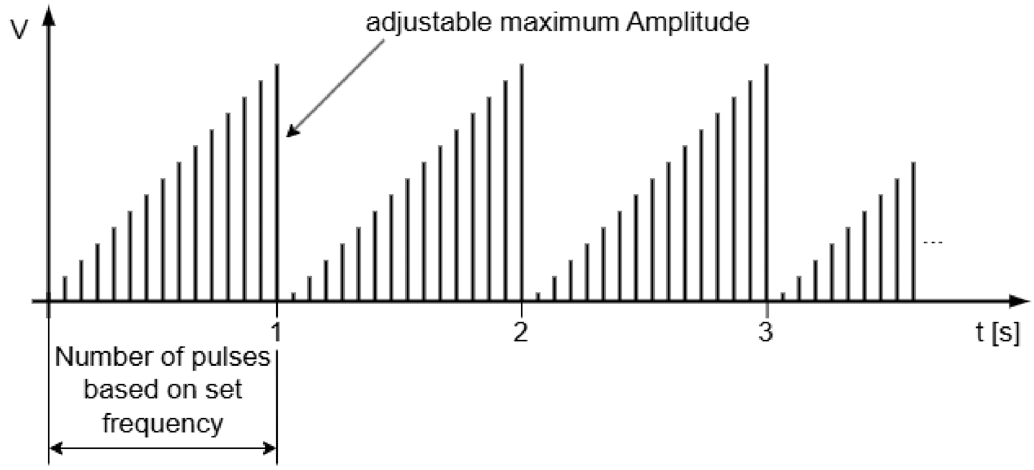


Figure 10: Voltage ramp generated in RAMP mode. The pulse amplitude increases linearly during a 1 s interval.

6.1.4 Boost Mode

Boost Mode generates groups of 50 pulses with an increased pulse repetition frequency (3.5 kHz), followed by a break of approximately 300 ms. This operating mode can be used to simulate brief periods of intensified disturbance activity and to reproduce faults that cannot be triggered by isolated pulses.
Boost Mode is particularly useful when the susceptibility of the DUT depends on several disturbance pulses occurring within a short period of time. Typical examples include communication interfaces, data transfers, and other time-critical processes where repeated disturbances can affect consecutive transactions before the system has time to recover. As a result, Boost Mode can reveal susceptibility mechanisms that may not be observable with individual pulses or lower pulse repetition rates.
The pulse sequence generated in Boost Mode is illustrated in Figure 11.

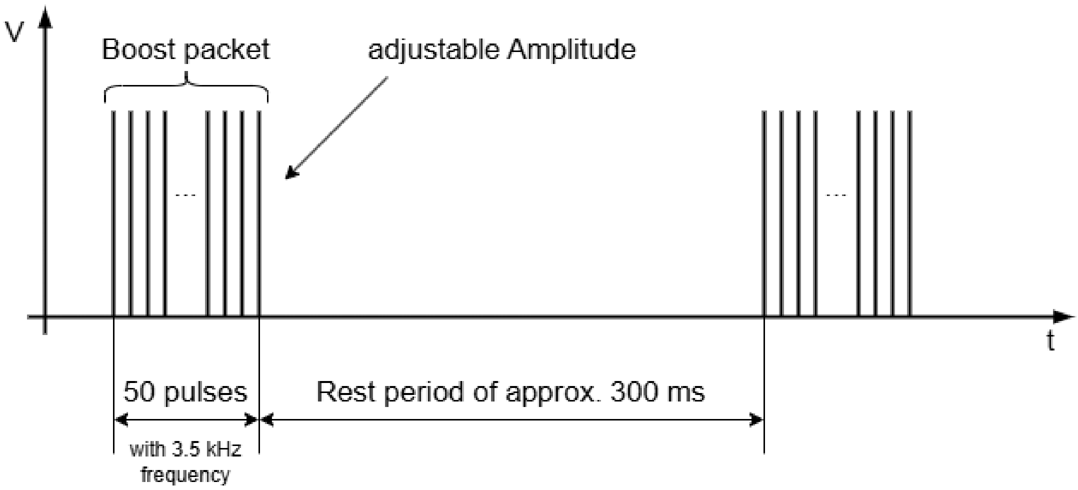


Figure 11: Output pulse sequence generated in BOOST mode. The TS 23 periodically generates bursts consisting of 50 disturbance pulses with higher output rate (3.5 kHz). The time between two bursts is 300 ms

6.2 Trigger Specification

The TS 23 can be operated using either the internal trigger generator or an external trigger source.
When the trigger mode is set to Internal (I), pulse generation is controlled by the TS 23 itself. The pulse output rate is determined by the output frequency setting.
When the trigger mode is set to External (X), pulse generation is controlled via the external trigger input on the rear panel of the device. The pulse voltage is not affected by the trigger source and remains at the value selected by the voltage setting at the TS 23.
The currently selected trigger source is indicated on the display. Detailed specifications of the trigger input and all associated trigger parameters are provided in the Technical Parameters section (Chapter 8).

6.3 Optical Input counter

The optical input counter is used together with the S25 optical sensor and the MS 101 magnetic field probe. It allows the TS 23 to count optical pulses generated by these accessories and to display the result directly on the front panel.
The received optical signal is indicated by the "Signal" LED. Since the optical pulses generated by the connected accessories may be too short to be visible to the human eye, the TS 23 generates a pulse-stretched indication which is shown by the "Spike" LED.
The integrated counter operates with a gate time of 1 s. The displayed counter value corresponds to the number of optical pulses received during this period.
In combination with the S25 optical sensor, the counter can be used to monitor fault events and logic state changes in the DUT. It is also used for Pulse Density Method measurements to assess and compare the immunity level of the DUT.
In combination with the MS 101 magnetic field probe, the counter is used for Pulse Density Method measurements and for the relative comparison of magnetic field activity at different locations on the DUT. This helps identify disturbance current paths and magnetic-field-sensitive areas.

7 Measurement Setup

7.1 Current injection

This measurement setup enables the injection of disturbance current into individually defined disturbance current paths. This allows the developer to deliberately define the disturbance current path and to narrow down the search for the root cause of a fault to specific areas of the DUT. Fault localization begins as soon as a malfunction can be reproduced reliably. Individual modules, cable connections, interfaces, or localized areas of a larger PCB can then be investigated separately.

This measurement setup always requires the metallic base plate supplied with the E2 set. The base plate serves as the reference potential for the injected disturbance pulses, as the outer conductor of the coaxial generator cables is referenced to the base plate potential. In addition, the magnetic base adapters can be positioned and fixed easily on the plate. To electrically isolate the DUT from the base plate, two foam strips supplied with the E2 set can be placed between the DUT and the base plate.

The SMB outputs of the TS 23 are connected to the two MA 33 magnetic base adapters using the generator cables. The disturbance current path is then defined by the measurement cables (7 cm, 12 cm, or 25 cm) connected to the center pin of each MA 33. The measurement cables can be equipped with either alligator clips or micro-kleps. This allows them to be attached quickly to ground points, shield connections, and other conductive structures on the DUT without the need for soldering.

Figure 12: Alligator clips on the left and micro-kleps on the right.

For maximum current flow through the DUT ground system, the measurement cables of both MA 33 are connected to separate ground points on the DUT. The resulting disturbance current flows through the DUT ground structure between the two connection points and generates a strong magnetic field to which the DUT is exposed.

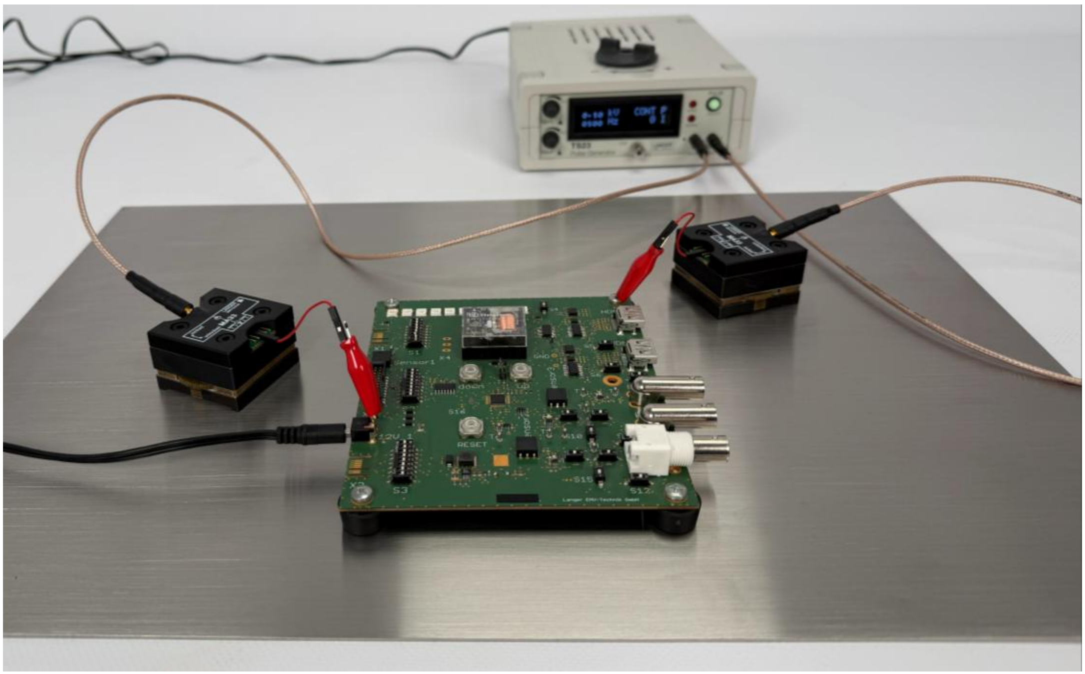


Figure 13: Both Generator outputs connected to the GND of the PCB

As an alternative, the measurement cable of one MA 33 can be connected to the DUT ground while the measurement cable of the second MA 33 is connected to an E-field source (ES 01 or ES 02). The E-field source can be connected to the MA 33 using mounting pins. These mounting pins are located on the handle of the field source and directly on the coupling plate. Select the mounting position that allows the field source to reach the area of interest most easily. In this configuration, disturbance current flows as a displacement current from the E-field source into the DUT ground system. This generates a strong electric field in the nearby area of the DUT and the field source.
The E-field source thereby simulates nearby conductive structures that may have been removed or disconnected during troubleshooting, such as neighboring PCBs, heatsinks, shielding parts, or other metal structures. This allows the influence of electric-field coupling from the DUT environment to be reproduced under controlled conditions.

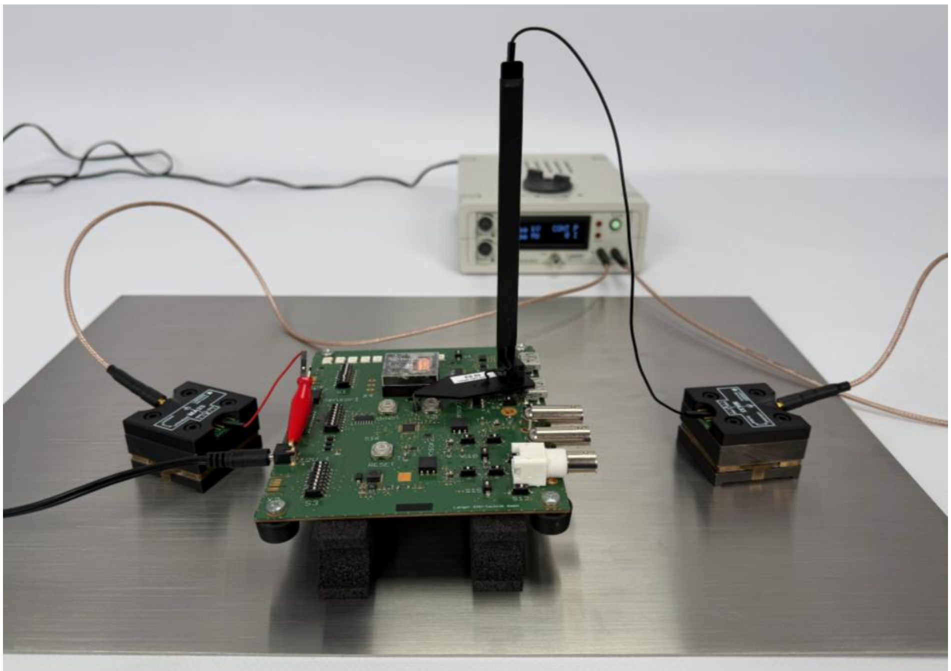


Figure 14: One Generator output connected to the GND of the PCB, the second one connected to a field source (ES 01 and ES 02)

A third configuration can be used to capacitively couple disturbance current between the DUT ground and the base plate. In this case, the measurement cable of one MA 33 is connected to the DUT ground, while the measurement cable of the second MA 33 shorts the center pin directly to the adjacent ground pins of the same adapter. This creates a defined coupling path from the generator output to the base plate.

In this configuration, the base plate simulates a conductive enclosure, machine frame, mounting plate, or other ground-referenced metal structure from which the PCB may have been removed for troubleshooting. This allows the influence of displacement currents and electric-field coupling between the DUT and its surrounding mechanical environment to be reproduced under controlled conditions.

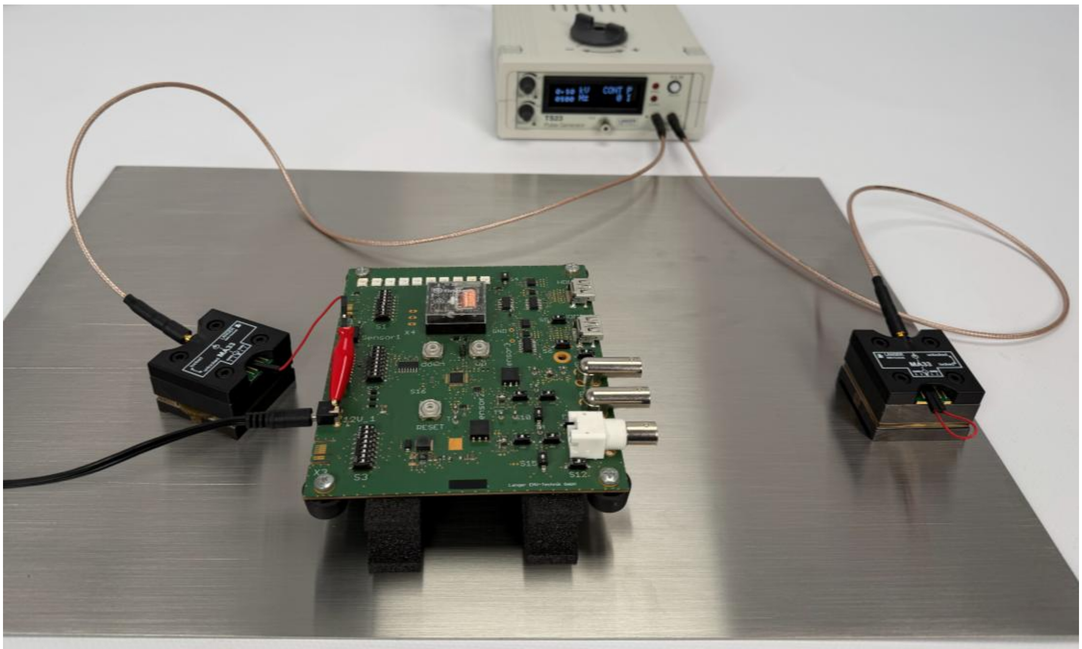


Figure 15: One Generator output connected to the GND of the PCB, the second one shortened to the base plate

These three configurations allow disturbances to be applied selectively to different sections of the DUT. As a result, immunity-related failures can be reproduced, and weak points can be localized systematically.

7.2 Differential Injector (preferred for ESD problems)

Similar to the measurement setup described in the previous chapter, this configuration enables the injection of disturbance currents into individually defined disturbance current paths. In contrast to the MA 33-based setup, the generator cables are connected directly to the DE2 or DE6 differential injectors. As a result, the coaxial transmission path extends up to the DUT, minimizing impedance discontinuities and preserving the fast rise times of the TS 23 pulses. Reflections and pulse distortions caused by longer non-controlled interconnections are reduced significantly. This makes the setup particularly suitable for investigating susceptibility to fast transient disturbances and ESD-like events.

Since the MA 33 magnetic base adapters are not used, no base plate is required for this measurement setup. Disturbance currents are injected directly into the DUT, allowing investigations under conditions that closely resemble realistic ESD current paths.

The differential injectors must be soldered directly to the corresponding points on the DUT. Disturbance currents are then injected into a precisely defined structure, allowing the developer to reproduce failures and localize immunity-related weak points.

This setup is particularly suitable for investigating board-to-board connectors, stacked PCB assemblies, ribbon cables, shield connections, and other conductive structures that frequently form critical disturbance current paths during ESD events. The resulting current flow generates magnetic fields and transient voltage drops similar to those occurring in real ESD test scenarios.

In addition, the DE2 can be used for direct coupling into IC packages and other localized structures. For this purpose, one side of the differential injector is connected to the DUT ground, while the second side is connected to a small metal plate or metal foil approximately matching the size of the IC package. The metal plate is positioned above the IC with a thin insulating layer in between. Disturbance pulses are capacitively coupled into the IC package, allowing the developer to investigate the susceptibility of individual integrated circuits under controlled conditions.

Depending on the size of the structure under investigation, either the short (DE2) or the long (DE6) version of the differential injector can be used.

The differential injection method allows the developer to investigate individual current paths with maximum pulse integrity and supports the localization of weak points related to fast transient and ESD-like disturbances.

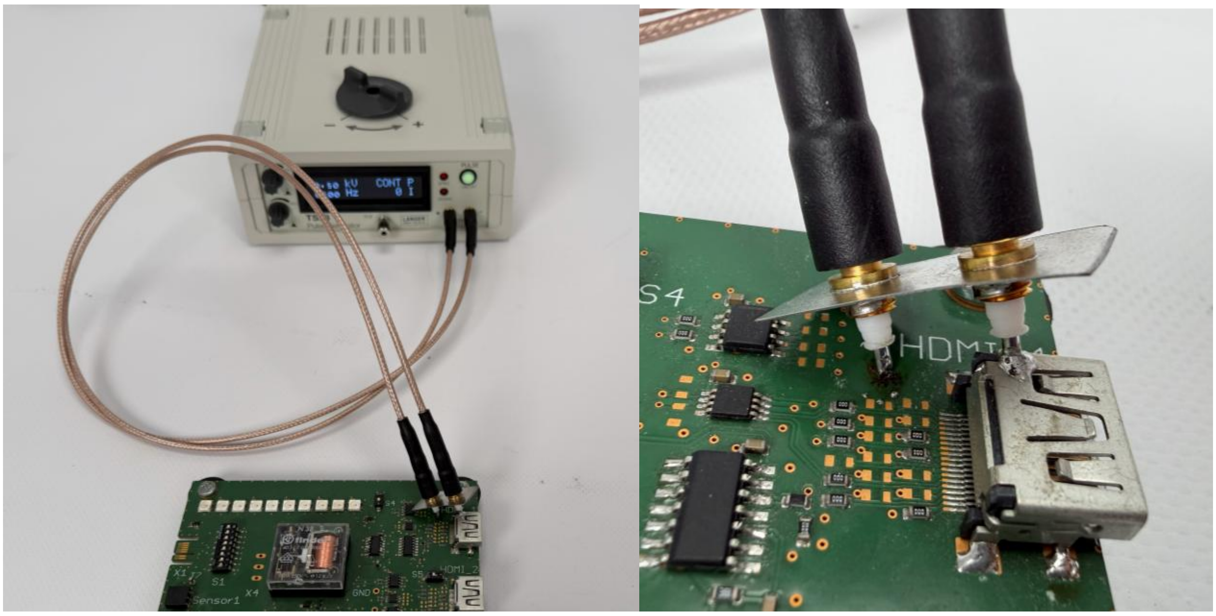


Figure 16: The DE2 connected to the shield of a connector and the GND of the PCB

7.3 Field sources

Disturbance currents and voltages generate electric and magnetic fields that can couple into sensitive structures of the DUT and cause immunity-related malfunctions.

The field sources of the E2 set are designed to reproduce these coupling mechanisms locally and under controlled conditions. By applying defined electric or magnetic fields to specific areas of the DUT, weak points can be identified and fault mechanisms can be analyzed efficiently. Refer to Chapter 5.3.1 for details on the available field sources and their intended applications.

The choice of the most suitable field source depends on the coupling mechanism to be investigated. Important selection criteria include the electrical characteristics of the structure under test (e.g. high-impedance or low-impedance nodes, signal lines or power distribution networks), the geometry of the structure, and its orientation relative to the field source. Depending on the application, either electric-field or magnetic-field sources may be used.

The differential field sources (BS 03-d and BS 04DB-d) are optimized for the generation of particularly fast disturbance pulses and are therefore especially suitable for ESD-related investigations. They can be connected directly to the differential outputs of the TS 23 using the two generator cables.

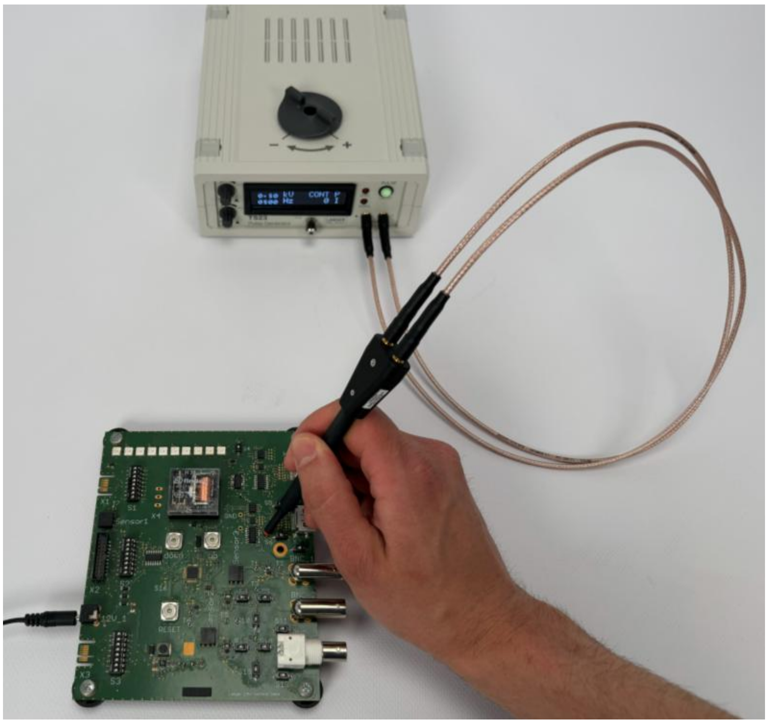


Figure 17: Differential field source (BS 04DB-d) connected directly to the TS 23 using the two generator cables.

The single-ended field sources are equipped with a single SMB connector and therefore require the Diff-to-Single-Ended Adapter (DEA) for operation with the TS 23.
The DEA is connected directly to the two differential outputs of the TS 23 via its permanently attached cables. The selected field source is then connected to the DEA using a single generator cable. The DEA converts the differential output signal of the TS 23 into a single-ended signal that can be used with all field sources equipped with a single SMB connector.

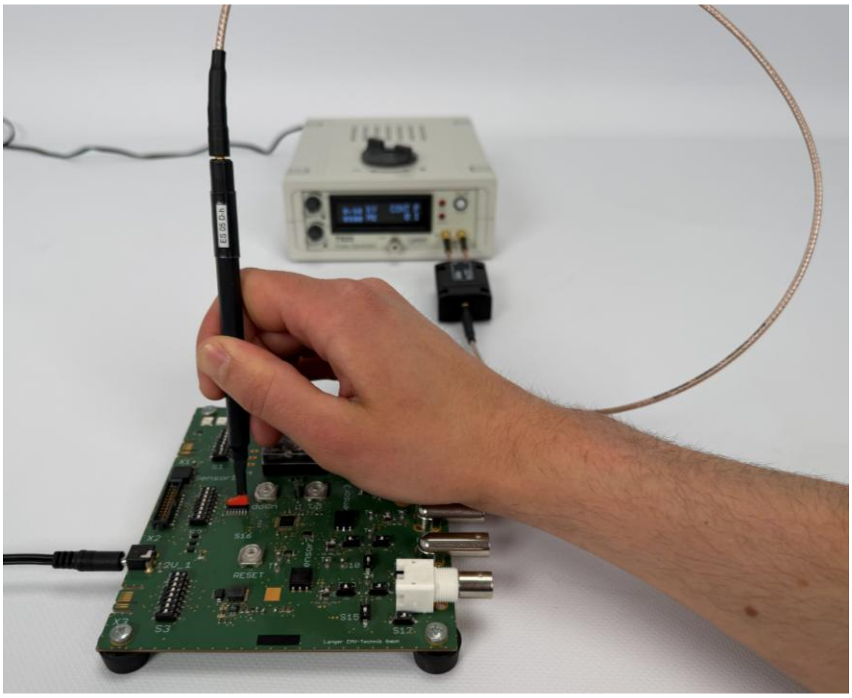


Figure 18: Connection of a single-ended field source (ES 05D-h) to the TS 23 using the DEA

During testing with field sources, care must be taken to avoid damage to the DUT. The field sources of the E2 set are designed to generate highly localized electric and magnetic fields. These fields can exceed the field strengths occurring naturally on the DUT during immunity tests and may therefore cause malfunction or damage if applied with excessive pulse amplitudes.
To minimize the risk of damage to the DUT during testing with field sources, the disturbance level should always be increased gradually, starting with the lowest pulse voltage setting of the TS 23.

8 Technical Parameters

8.1 TS 23 Pulse Generator

Device Parameters	
Output Connector	2 x SMB
Output Isolation	500 V DC
Output Configuration	Differential
External Trigger	
Connector	SMA
Voltage threshold	3.3 V
Maximum Voltage	5 V
Input Impedance	50 Ω
Trigger Type	Edge
Trigger-to-Pulse Delay	45 ns (± 150 ps)
Optical Input	
Max. Frequency	5 MHz
Min. Pulse Width	100 ns
Optical Fiber	Ø 2,2 mm
Power Supply	24 V / 1.25 A / DC
Current consumption	200 mA
Weight	850 g
Dimensions (L x B x H)	200 x 160 x 75 mm

Table 5: Technical Parameters TS 23

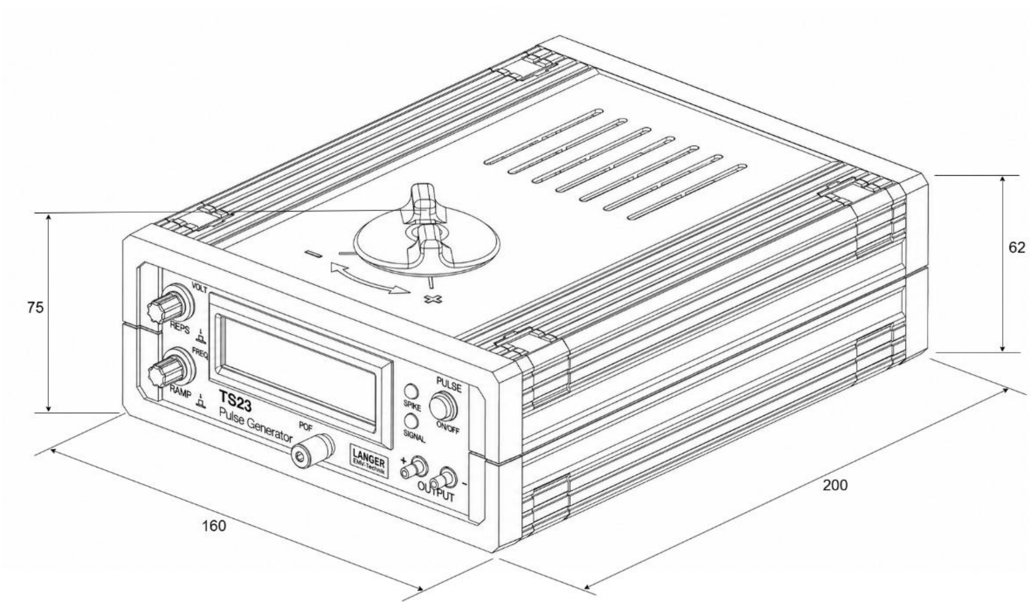


Figure 19: Overall dimensions of the TS 23 pulse generator.

Pulse Parameters	
Pulse Voltage (on a 50 Ω load)	± 5 … 1100 V
Pulse Voltage (on a 2.5 kΩ load)	± 10 … 2200 V
Pulse voltage deviation (for U ≥ 100 V)	± 5%
Pulse voltage deviation (for U < 100 V)	± 10V @ 50 Ω
Polarity	Switchable + / -
Pulse Rise Time (50 Ω)	1.5 ns (± 100 ps)
Pulse Shape (50 Ω)	1.5 / 12 ns
Repetition Frequency (continuous)	Single – 1500 Hz
Number of Pulses per Ramp	Variable (Output Frequency)
Voltage steps in Ramp	linear
Number of Ramps per Second	1

Table 6: Pulse Parameters TS 23

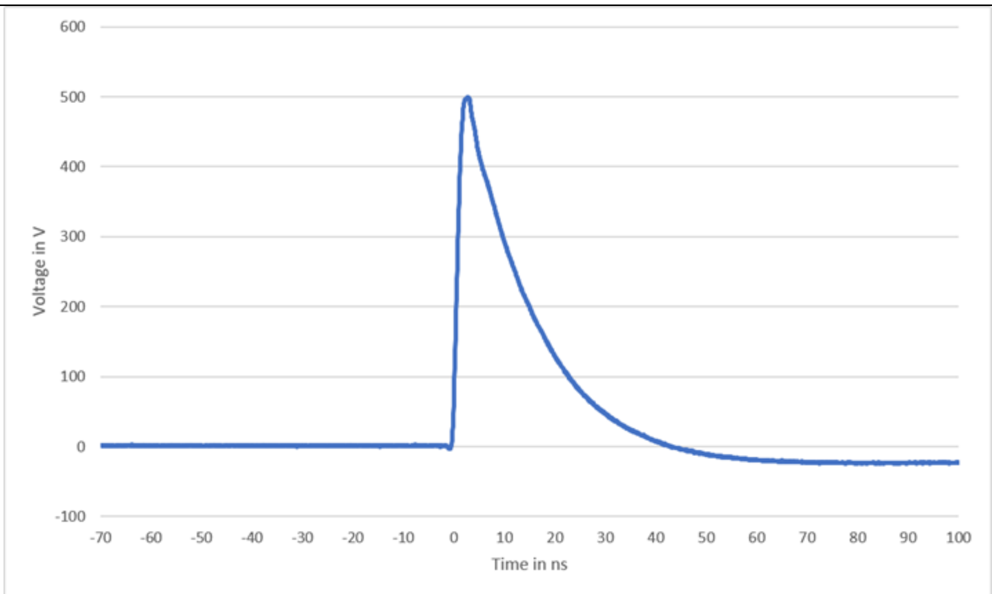


Figure 20: Pulse shape of a single TS 23 pulse measured with a 50 Ω termination

8.2 Optical Sensor S25

Transmission Range	DC – 50 Mbps
Optical Fiber	Ø 2,2 mm
Supply Voltage	3 – 5 V
Current Input	30 mA

Table 7: Technical Parameters S25

9 Information on Recycling and Disposal

In accordance with the WEEE Directive 2012/19/EU (Waste of Electrical and Electronic Equipment), the following must be observed:

At the end of its service life, this product should be taken to a suitable disposal facility for recycling and disposal. Do not dispose of with household waste.

10 Customer service

Please contact us if you have any questions, comments or suggestions.

You can contact us:

Monday – Friday
8:00 a.m. – 3:00 p.m.

Contact us at:

Address: Langer EMV-Technik GmbH
Nöthnitzer Hang 31
01728 Bannewitz
Germany

Internet: https://www.langer-emv.com/
E-mail: sales@langer-emv.de
Phone: +49 (0) 351-430093-0
Fax: +49 (0) 351-430093-22

Calibration
We recommend having the product calibrated every two years by the manufacturer Langer EMV-Technik GmbH or by a certified service partner
.

11 Warranty

Langer EMV-Technik GmbH shall remedy all defects attributable to material or manufacturing faults within the statutory warranty period by repairing the product or supplying replacement parts.

This guarantee is only granted on condition that:

- the information and instructions in the operating instructions are observed.

The guarantee expires if:

- an unauthorized repair is carried out on the product
- the product is modified
- the product is not used as intended

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Appendix A: The Pulse Density Method

The Pulse Density Method enables a quantitative assessment of the susceptibility of electronic assemblies to disturbance pulses generated by the TS 23. For this purpose, the TS 23 is operated in RAMP mode, causing the peak voltage of the disturbance pulses to follow a linear ramp function. The ramp is repeated cyclically every second.

An optical sensor (S25) or a magnetic field probe (MS 101) is connected to the optical input of the TS 23. Whenever a disturbance pulse exceeds the selected threshold level represented by the sensor or probe, an optical pulse is transmitted to the TS 23 and counted. Consequently, the number of counted pulses depends on how many disturbance pulses exceed the threshold during a ramp cycle.
The principle of the Pulse Density Method is illustrated schematically in Figure 21.

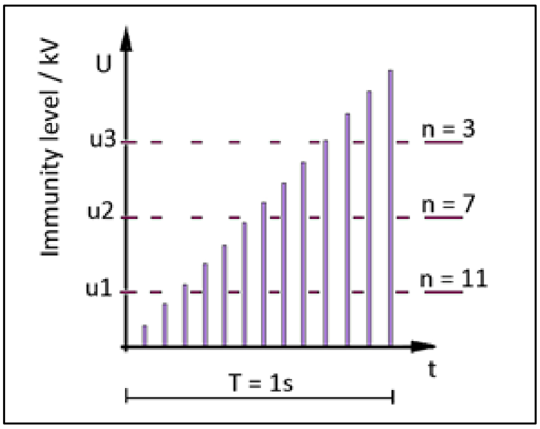

Figure 21: Principle of the Pulse Density Method. The number of disturbance pulses exceeding the immunity threshold of the DUT during a voltage ramp is counted and used as a relative measure of immunity.

The pulse voltage u increases continuously from a minimum value to a maximum value during the ramp period T = 1 s. If the DUT exhibits an immunity level u1, all disturbance pulses with amplitudes greater than u1 will trigger a response and be counted. In the example shown, this results in n = 11 counted pulses. If the DUT has a higher immunity level u3, only the highest-amplitude pulses exceed the threshold, resulting in n = 3 counted pulses.

The number of counted pulses is therefore inversely proportional to the immunity level of the DUT. A low count value indicates high immunity, whereas a high count value indicates low immunity.

This principle can be implemented using the components of the E2 system. The TS 23 generates the disturbance pulse ramp, which is injected into the DUT. The S25 sensor can be connected to a representative signal within the DUT and acts as a defined threshold detector. Whenever its threshold is exceeded, an optical pulse is transmitted to the TS 23 counter via optical fiber. The same principle can be applied using the MS 101 magnetic field probe.

The resulting counter value provides a rapid and reproducible means of comparing layouts, design revisions, shielding concepts, grounding schemes, and other EMC countermeasures. Improved immunity results in lower count values, while reduced immunity results in higher count values. In a troubleshooting process, the ideal goal is to reduce the counter value to zero through suitable corrective measures.

When the S25 sensor is connected to a digital signal that already contains regular logic transitions, such as a clock signal, data signal, or other periodically changing digital signal, these transitions are counted as well and are displayed on the counter. The disturbance-related count value generated by the Pulse Density Method is superimposed on this base count rate. Consequently, the displayed value consists of both the normal signal activity and the disturbance-induced events. If the monitored signal frequency is so high that the counter approaches its maximum display value of 999999, the additional disturbance-related counts can no longer be evaluated reliably. In such cases, the Pulse Density Method is not suitable for use with that particular signal.

The measured count value can range from 0 to the pulse repetition frequency selected on the TS 23. The pulse generator and counter do not require synchronization. The measurement result is independent of the start time of the ramp cycle and depends only on the immunity characteristics of the DUT and the selected pulse voltage setting.

Appendix B: Recommended procedures for advanced ESD Troubleshooting

In some cases, ESD-related failures cannot be reproduced immediately using the E2 set. The following troubleshooting procedures are based on practical experience gained during ESD investigations and can help identify sensitive structures, coupling mechanisms, and root causes of difficult-to-reproduce failures.

Combination of the BS 03-d with the MS101 (Pulse Density Method)

In some ESD investigations, the primary coupling mechanism does not involve PCB traces or other conductive structures acting as coupling electrodes or coupling loops that subsequently transfer the disturbance into an IC. Instead, the electric or magnetic fields generated by the ESD event may couple directly into sensitive structures within the integrated circuit itself. This effect is frequently observed for ICs located close to the edges of a PCB, where considerably higher field strengths may occur during an ESD discharge.
In such situations, the disturbance current injection methods using the MA 33, DE2, or DE6 may not always generate field strengths high enough to reproduce failures that occur during ESD tests at 8 kV, 12 kV, or higher test levels. Consequently, the failure may not be reproducible directly with the TS 23, even though the relevant coupling mechanism has been identified.
The BS 03-d differential magnetic field source can then be used to investigate the susceptibility of the IC directly. Position the field source above the IC and gradually increase the pulse voltage while rotating the probe. The orientation producing the malfunction at the lowest pulse voltage usually corresponds to the most sensitive internal current loop of the IC. This procedure allows the developer to identify the dominant field coupling direction.
After the most susceptible orientation has been determined, place the MS 101 magnetic field probe above the IC using approximately the same position and orientation. Now, inject disturbance pulses using the MA 33, DE2, or DE6 in combination with the RAMP mode of the TS 23. The resulting magnetic field activity is evaluated using the Pulse Density Method.
The objective is not to trigger the failure from the standard test continuously but to generate measurable counter values with the MS 101 that are related to the field activity at the sensitive location. Design modifications can then be implemented and evaluated by comparing the resulting counter values. A reduction in the counter value generally indicates a reduction in the magnetic field coupling into the IC and therefore an improvement of the immunity margin.
For this type of investigation, the DUT may even be powered off, since the MS 101 is only used to evaluate the local magnetic field activity generated by the injected disturbance pulses. Once the counter value has been minimized, the effectiveness of the implemented modification should be verified by repeating the original ESD test using a standard ESD generator.
This method is particularly useful when the failure mechanism is suspected to be caused by direct field coupling into an IC and when the ESD failure cannot be reproduced directly using the maximum pulse voltage available from the TS 23.

Differential injector and ES08-d

The DE2 differential injector is a powerful tool for reproducing ESD-related failures in systems consisting of multiple stacked PCBs interconnected through board-to-board connectors. Such connector structures often form critical disturbance current paths during ESD events and can therefore be the root cause of immunity-related malfunctions.
The recommended procedure is to first reproduce the malfunction using the DE2 differential injector.

By injecting disturbance currents into the board-to-board connection, the developer can identify whether the connector is involved in the failure mechanism.

Once a susceptible board-to-board connector has been identified, the ES 08D-h can be used to localize the sensitive pins within the connector. During normal operation of the DUT, the ES 08D-h is applied successively to the individual connector pins while disturbance pulses are injected. The pins that trigger the malfunction at the lowest disturbance level should be regarded as the most critical coupling locations.

Corrective measures can then be focused on these specific pins or signals. After implementing a modification, the measurement should be repeated to verify the effectiveness of the corrective action.