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E2 set

TS 23 Immunity Development System

The TS 23 Immunity Development System (E2 set) is a comprehensive system of EMC tools designed for pre-compliance immunity testing. It enables efficient troubleshooting and precise weak-point analysis of electronic systems at all integration levels — from component to full system.

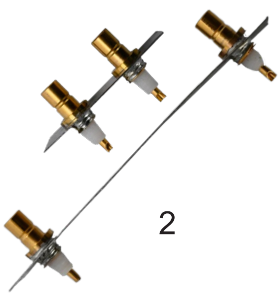
With the E2 set, failure patterns caused by electrostatic discharge (ESD) (IEC 61000-4-2) can be reproduced under controlled conditions. This allows engineers to identify vulnerabilities early in the development process and implement corrective measures before formal compliance testing.

Technical Parameters:

- Rise time 1,5 ns
- Pulse voltage adjustable from 0,01 kV – 2,2 kV
- Polarity adjustable +/-
- Pulse repetition frequency from 1 Hz – 1,5 kHz
- Operating modes: Continuous, Ramp, Pulse groups, externally triggered
- Supply Voltage 24 V / 1A DC
- Size: 157 x 208 x 76 mm

Scope of delivery:

Description	Type	Qty.
Pulse Generator	TS 23	1
Ground Plate	GP 10	1
Magnetic Base Adapter	MA 33	2
Differential Injector	DE2; DE6	6
Diff-to-Single-Ended Adapter	DEA	1
Magnetic Field Sources	BS 02H; BS 03-d; BS 04DB-d; BS 04DB-h2; BS 05DU-h2	5
E-Field Sources	ES 01; ES 02, ES 05D-h; ES 08D-h, ES 10D-h	5
Magnetic Field Probe	MS 101	1
Optical Sensor	S21	1
Optical Fiber Cable	Ø 2,2 mm	1
Accessories	Power Supply, Generator cables etc.	



TS 23
Pulse Generator

The core element of the E2 set is the TS 23 Pulse Generator. This generator produces ESD-like interference pulses that differ significantly from a EFT/Burst generator, particularly in terms of the rise time. The interference pulse of the TS 23 Puls Generator with 1.5 ns can penetrate DUT (devices under test) approx. four times more efficiently than the 5 ns burst interference pulse.

The newly developed magnetic adapters (MA 33), differential probes (BS 03-d, BS 04DB-d) and differential injectors (DE2, DE6) allow for accurate coupling of disturbance signals and support realistic simulation of immunity stress conditions.

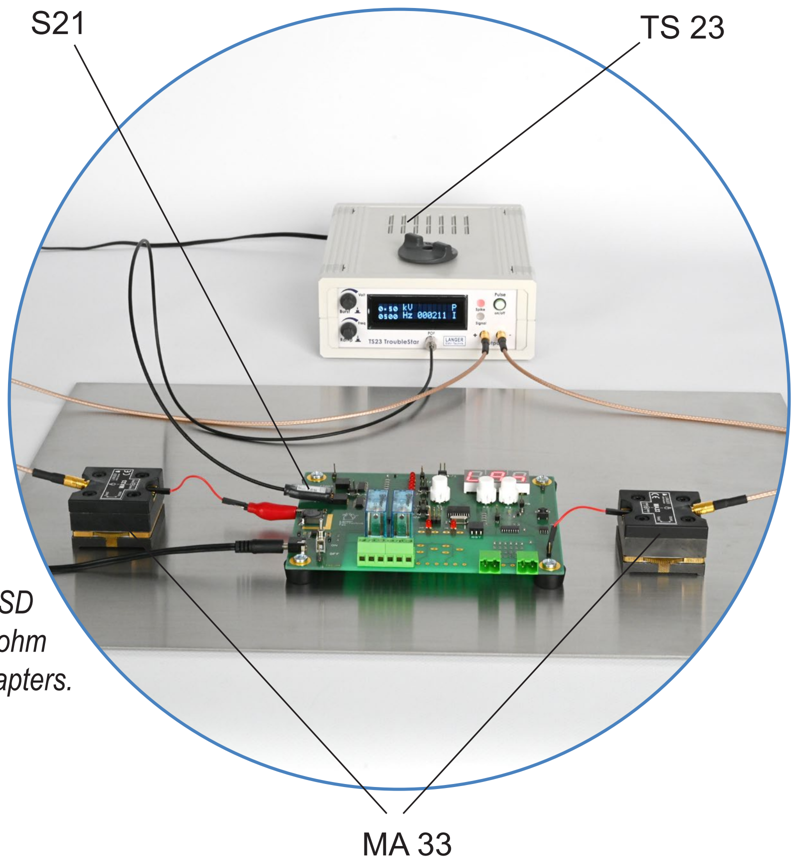
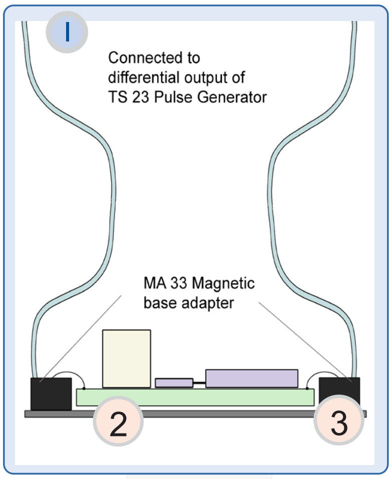
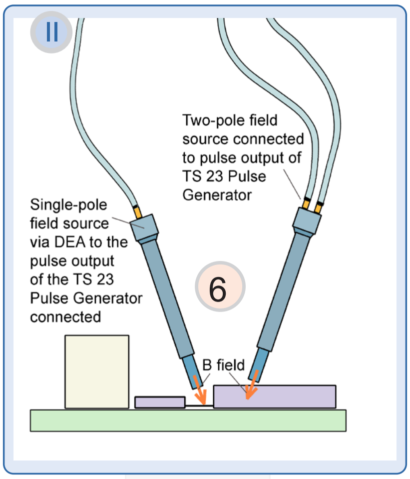
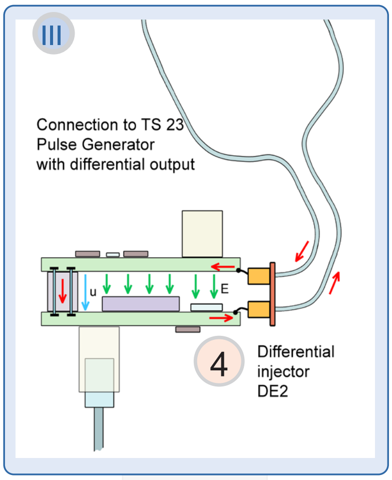


Figure 1: New coupling system for PCB´s. ESD disturbances are coupled into the DUT over 50-ohm lines and magnetic base adapters.

The troubleshooting can be done with following three set-ups:







Measurement setup I
Current injection

This measurement setup enables the injection of disturbance current into individually defined disturbance current paths. This means that the search for the cause of a fault on a module can be limited locally.
In the measurement setup, the middle pins of the MA 33 magnetic base adapter are connected to the ground of the circuit board with one of the measurement cables (7 cm, 12 cm or 25 cm). By connecting both generator cables directly to the module GND, the maximum current through the ground of the module is obtained between the two connections. This leads to a strong magnetic field to which the module is then exposed. Alternatively, the test lead can be connected to the ground on one side only and to one of the E-field sources (ES 01, ES 02) on the other side. The current now flows as a displacement current from the E field source into the ground system, which is accompanied by a strong E field to which the module is exposed.

Measurement setup II
Field sources

The measurement setup using field sources enables the direct coupling of electric or magnetic fields into the assembly and its elements. The most suitable field source for inducing relevant fault patterns is selected according to several criteria. The type of structures (high impedance/low impedance, signal/supply, ...) into which fields are to be coupled is decisive. The geometry and orientation of the elements on the board are also decisive. The two differential probes (BS 03-d, BS 04DB-d) are suitable for generating particularly fast disturbance processes. The simple H field sources can be used together with the Diff-to-single-ended Adapter. When coupling, care must be taken to ensure that the device under test is not destroyed. To minimize the risk of destruction, the test should be started with the lowest voltage setting on the generator.

Measurement setup III
Differential injector

Similar to measurement setup I, this measurement setup also enables the injection of disturbance current into individually defined disturbance current paths. However, in order to further increase the intensity of the interference, the generator cables are now connected directly to the DE2. The differential injector must be soldered to the corresponding points on the module. This setup is particularly suitable for the flow of current through connectors, ribbon cables and shield connections, whereby field strengths occur within these structures.
Field strengths occur within these structures, which are also prevalent in ESD tests. In addition to use at connection points, the DE2 can also be used for direct coupling into IC housings.
Depending on the size of the test structure, the long or the short differential Injector can be used.

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Operating modes of the TS 23 Pulse Generator

The TS 23 Pulse Generator stands out additionally due to the various operating modes, that have been developed to maximize flexibility and repeatability during debugging and validation.

Continuous Operation

The TS 23 Pulse Generator produces continuously disturbance pulses with the peak value and pulse repetition frequency set by the user. Both parameters can be adjusted during operation.

Pulse Groups

In this mode, the TS 23 generates a predefined number of disturbance pulses (1, 2, 5, 10, 20 or 50) at the selected pulse repetition frequency. This allows the DUT to be monitored after individual pulses or to be stressed with fast, defined pulse groups.

Ramp Mode

The TS 23 enables measuring of the penetration capability of the interference pulses using the pulse density method. When the pulse sequence is set to “RAMP,” the peak values of the disturbance pulses follow a ramp function. The ramp is repeated cyclically every second. If one of the signal detectors (Sensor S21 or Probe MS 101) is held to a PCB trace, it transmits an optical signal via fiber optic cable for each pulse on the trace that exceeds the detector’s switching threshold. A counter inside the TS 23 counts these optical signals for the duration of one ramp cycle.

A high count indicates that the DUT was already affected by low peak values of the ramp. Conversely, a low count indicates that the trace is well protected and that only higher voltages resulted in a disturbance.

Externally Triggered Operation

An SMA connector on the rear panel of the TS 23 allows synchronization with external measurement instruments and function generators. The peak value and polarity of the disturbance pulses can still be flexibly set by the user on the TS 23 in this mode.

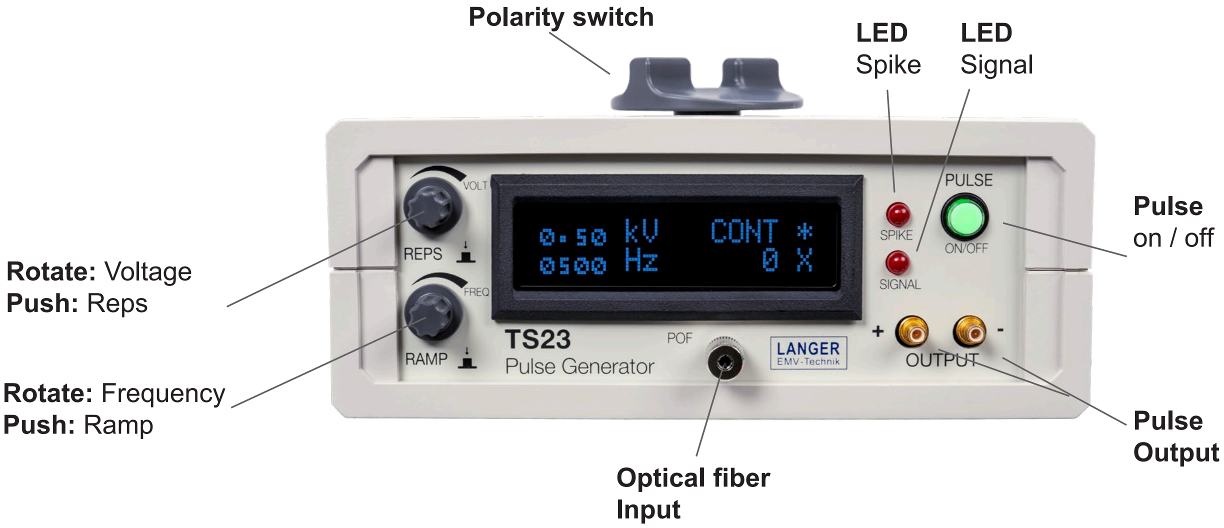

Figure 2: TS 23 Pulse Generator

Use Case of ESD Interference Suppression

The development of IC technology has significantly reduced the structural widths of silicon, which has increased the potential risk of interference.

The higher sensitivity to interference is caused by the lower supply voltages, higher switching speeds and lower switching thresholds of the ICs.

This also increases the sensitivity to ESD interference in particular. Interference suppression and fault isolation are usually carried out with an ESD generator (ESD gun).

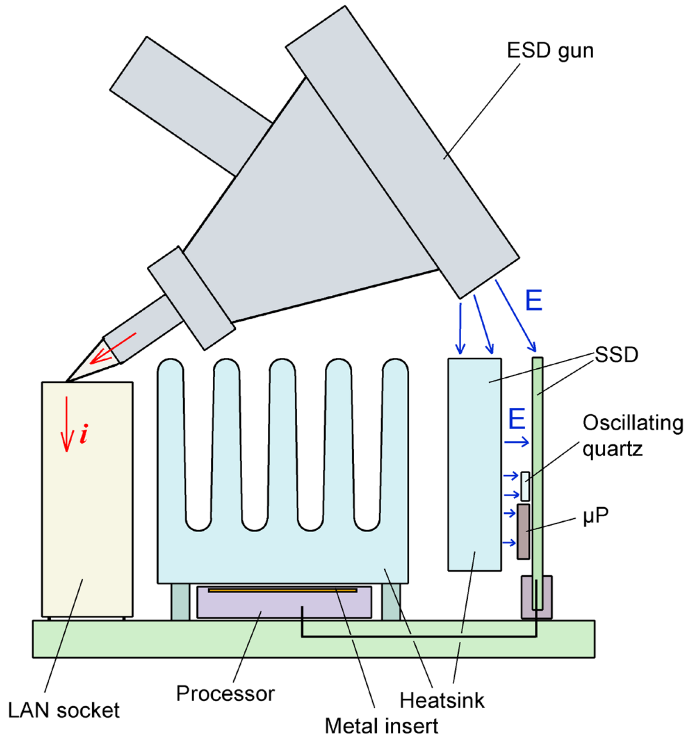

Figure 3: Interference effects of an ESD gun

The ESD gun is a very coarse tool that exposes the assembly in a large area and does not allow the weak points to be located. The tip of the ESD gun injects the disturbance pulse into a metallic structural element of the DUT (network connector). As a side effect, the ESD gun also produces a very fast electric-field emission at the gun head with a rise time of approximately 200 ps, which also affects the DUT.

It is unclear whether the DUT is disturbed by the ESD pulse injected through the tip (network connector) or by the parasitic effect of the electric-field coupling from the gun head.

Figure 3 shows that an SSD card is located in close proximity to the head of the ESD gun. The electric field generated by the ESD gun head produces a current pulse that couples through the heat sink of the SSD card and capacitively into the PCB of the SSD card, which may cause the SSD card to fail.

Troubleshooting with the TS 23 Pulse Generator

The first step is to verify whether the microprocessor is sufficiently resistant to interference. Using the differential output of the TS 23, a pulse current is injected through the metal layer (in Figure 4: A, B) of the microprocessor. This generates an ESD-like magnetic field in the underlying processor.

Next, the disturbance voltage of the TS 23 is applied between the metal layer and ground (in Figure 4: B, C). No influence on the processor was observed. Therefore, a direct disturbance of the processor via its own heat sink can largely be ruled out.

It is therefore suspected that the SSD card contains a corresponding weak point.

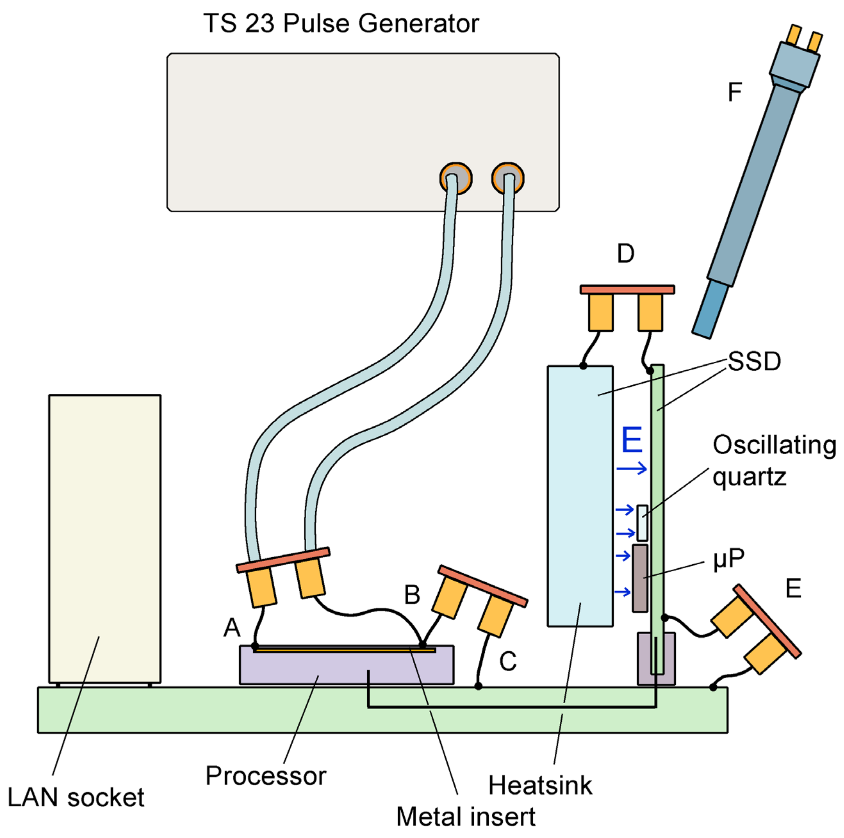

Figure 4: Injection locations for troubleshooting

A microprocessor with an oscillating quartz crystal is located on the SSD PCB directly under the SSD card heat sink. The SSD card is electrically insulated from its heat sink. This allows an electric field to build up between the heat sink and the mounted components (microprocessor and crystal oscillator).

A capacitive displacement current of the electric field couples into the routing of the crystal oscillator. This current flows through the protective diode of the input of the oscillator circuit and raises the output voltage of the quartz crystal above the switching threshold of the oscillator input. As a result, the input no longer receives a valid crystal signal, and the oscillator circuit stops generating a clock signal for several microseconds.

During this time, the microcontroller is no longer clocked and stops operating. Communication with the processor is interrupted, and the processor enters a fault state (display failure).

To verify this hypothesis, the differential injector (DE2) was soldered between the SSD heat sink and the ground of the SSD PCB and connected to the differential output of the TS 23 Pulse Generator. An ESD-like disturbance pulse generated by the TS 23 reproduced the observed DUT failure.

The fault is caused by a disturbance voltage difference between the SSD heat sink and the SSD PCB.

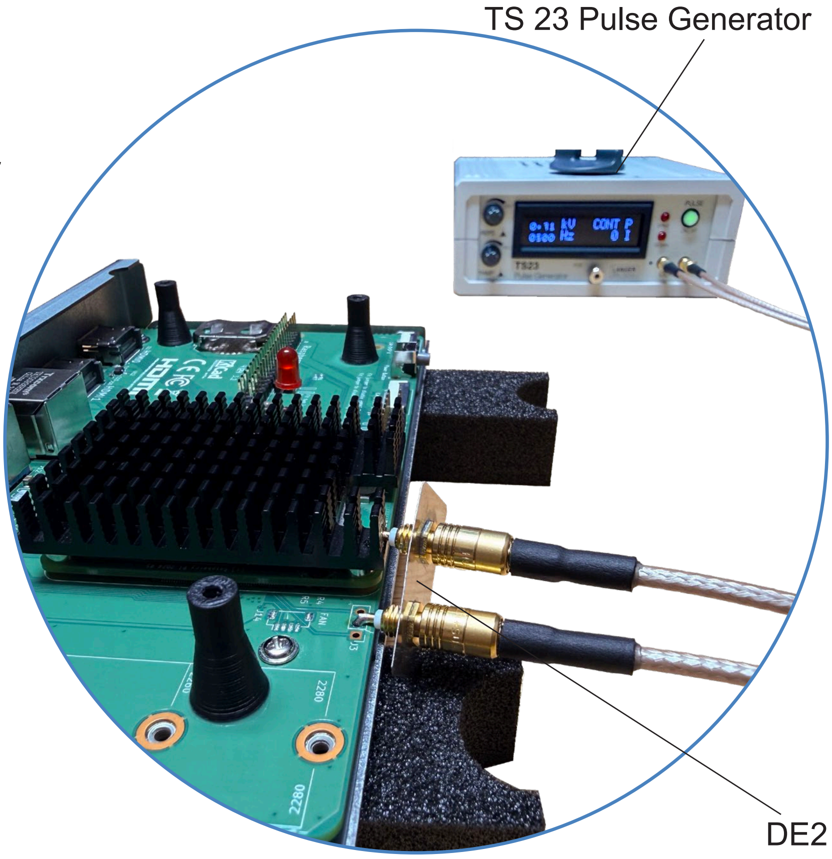

Figure 5: Coupling of the disturbance pulse using a differential injector (DE2)

Countermeasures

In order to short-circuit the electrical field between the heat sink and the SSD circuit board, both metal systems must be electrically connected at least twice, e.g. at points M2 and M3 (Figure 6).

The official product launch of the E2 set will take place on Tuesday, March 24, 2026, at EMV Cologne 2026, featuring a live product demonstration at 12:00 p.m.

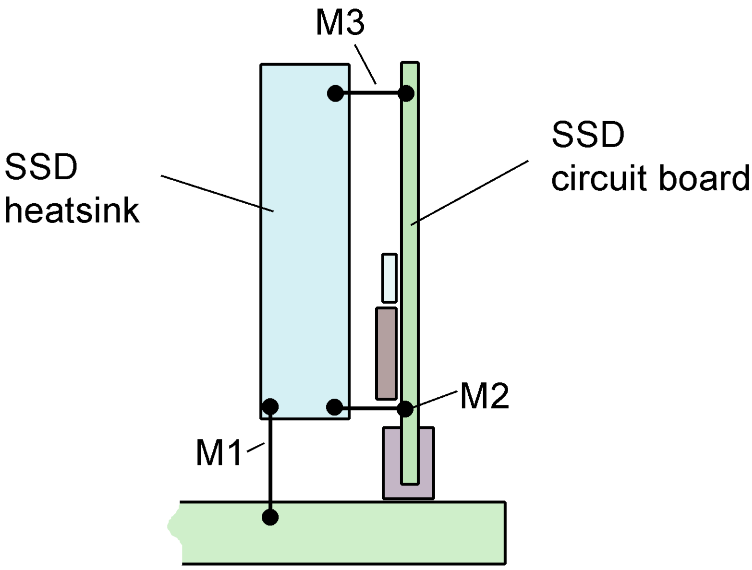

Figure 6: Countermeasures