

Improving the immunity of electronic modules to pulse disturbances



Complex modules with sophisticated integrated circuits which operate at low supply voltages are becoming increasingly conspicuous in disturbance immunity tests. The developer thus realises a variety of counter-measures in the electronic system that are aimed at guaranteeing a high disturbance immunity. But EMC measures to this end will only be successful if they are derived from a knowledge of assumed disturbance coupling paths. It is useful to verify all options in experiments since every newly developed electronic module may include risks based on misconceptions.

If a modern electronic module is to be developed to include such characteristics as

- a high disturbance immunity,
- no shielded enclosure and
 - a low current input,

its electromagnetic stability will depend on the characteristics of the electronic circuits used and their environment (layout).

The engineer will find it difficult to evaluate any EMC measures taken in the planning phase of a new development. Any new development is governed by assumptions rather than facts since little information is available on the EMC characteristics of the circuits chosen. The more precise the EMC parameters of the circuits to be used are, the more accurate the developer's EMC decisions will be. These parameters are easy to determine nowadays thanks to special IC measuring technology. Tests to localise potentially susceptible devices in the sample module in the course of development are the classical method if the planned series size does not justify the costs of an IC test.

The use of a burst generator in combination with field sources, sensors and probes has proven successful for effective burst and ESD tests in electronic modules during development. The following describes the strategy for testing modules during development to identify disturbance phenomena which up to now were difficult to analyse.

1) Steps towards higher disturbance immunity

Disturbance immunity testing of a module according to the standard IEC 61000-4-4 is the **starting point** of our examination. The disturbances generated by the standard burst generator in compliance with this standard are coupled to the enclosure or into the supply lines. The paths on which the pulse-shaped disturbances flow through the device module are unknown.

An unknown share of these disturbances meets unknown susceptible equipment in the device and generates a functional fault. This weak point can generally be pinpointed to a few square centimetres of a module but cannot be localised by a compliance test. Even if the developer succeeds in measuring the disturbance current on the circuits without further interfering with the module, it is still unclear as to how much disturbance current the circuit can tolerate on the respective pins. The developer does not yet know if and where the disturbance current with its connected magnetic field induces a voltage pulse in a conductor loop or couples electric field capacitively into susceptible lines. Precise information about the fault pattern that occurred is the decisive result of a failed compliance test. This allows the developer to draw conclusions on how to continue the tests on the module during further development.

Any success will be largely a matter of chance if EMC measures are taken in this phase without isolating the weak point more precisely in the layout. Indirect remedial action (shielding plates, filters, changing the star ground system, electrical isolation etc.) is often taken to solve the problem at the fault location.

A **second step** is necessary. This includes a more precise localisation of the weak points. It should be noted that all information about the fault pattern from the first step is taken as a basis for assessing the localised weak point. A defined disturbance current path will help localise the module's layout structures responsible for the fault pattern. But the disturbance current of the burst generator in compliance with EN 61000-4-4 refers to the potential of its enclosure. The engineer thus cannot define a given disturbance current path in the electronics so that the standard test setup cannot be used automatically to localise faults in modules. A disturbance generator with potential-free pulse output is an ideal solution.

Once a weak point has been located it can generally be eliminated with a minimum of effort. Screening and filtering can even be reduced if a layout change becomes necessary and the costs are justifiable.

It goes without saying that the modification is **finally** tested in an experiment by repeating the first step before the layout is then changed.

2) The quick way to higher disturbance immunity

The E1 disturbance immunity development system is an advanced tool for the electronics developer to examine the immunity of modules to pulse disturbances in experiments. It specifically allows him to analyse the disturbance immunity in the confined space of a module as described in the second step. The selective injection of disturbance current into individual sections (disturbance current paths) and application of pulse electric (E fields) or magnetic (H fields) fields to selected areas of the module's surface are decisive for the localisation of weak points. Signals can also be monitored without interactions while the module is subjected to pulse disturbances.

The SGZ 21 pulse generator is the key element of a large number of tests. It generates potential-free, pulse-shaped disturbances whose edges have a rise time of approx. 2 ns and a fall time of 10 ns. In contrast, functional faults are triggered by higher disturbance currents in normalised 5/50 ns pulse shapes. Tests carried out with the SGZ 21 will thus ensure more safety for the engineer and less destruction of electronic components. Furthermore, the current can be partially injected into structural parts, cables, screens, earth connections and primarily directly into the modules. The disturbance current path to be examined can be defined within the device since the generated pulse current does not refer to the potential of the generator's enclosure. Disturbance current can thus be injected into the module via certain sections without significantly influencing the environment (**Figure 1**). Digital EMC sensors determine the effect of the disturbance either directly as functional faults or indirectly by signal monitoring during the test.

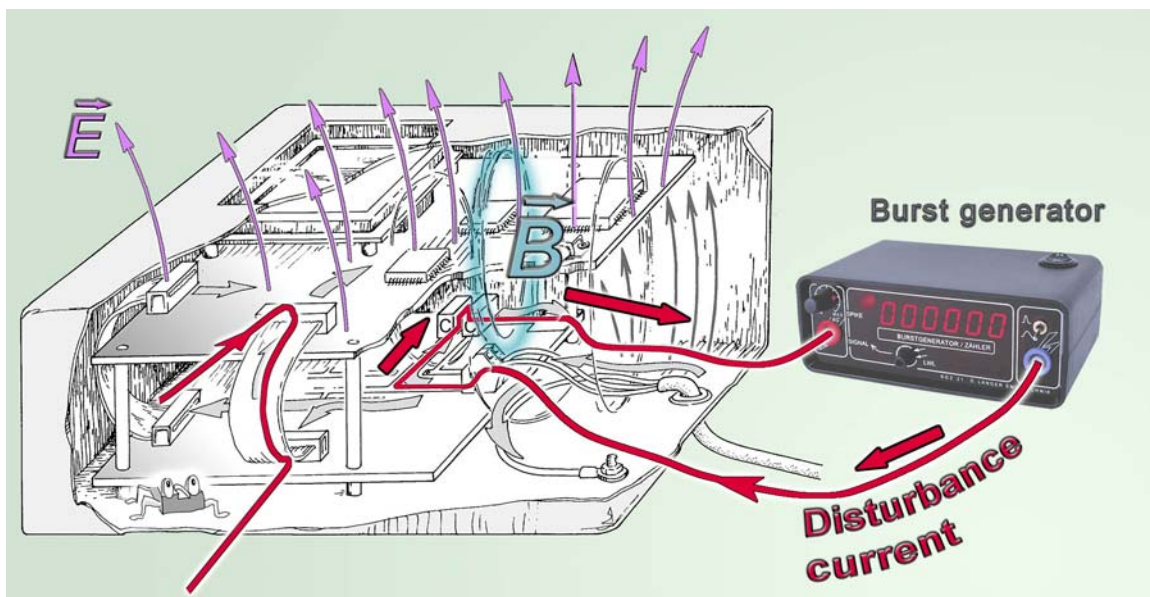


Figure 1: A selected disturbance current path of an electronic module subjected to disturbances using the SGZ 21 pulse-rate generator

3) Weak point localisation with field sources

The disturbance current passes through differently arranged conductor loops and IC connections in the electronic module. Whether these actually cause EMC faults depends on the specific layout. A device's susceptibility to pulse-shaped disturbances is due to the arrangement of the open layout structures, the signal connections and loop-shaped conductors. Only a few confined areas on the entire surface of all modules included in the device are in general susceptible to disturbances. A module which has been developed taking EMC aspects into account often has only one or two weak points of just a few millimetres in size. These weak points are hidden in the layout. Usually they have not been taken into account in the overall conception. Even these hidden weak points can be easily and quickly detected with special handheld miniature field sources.

The field sources are supplied with disturbance current by the burst generator and generate either pulse magnetic or electric fields depending on the type of field source. The field strengths of these pulse fields are comparable to those generated by burst currents on the surface of modules during compliance tests.

The pulse magnetic fields can induce a voltage in conductor loops which causes functional faults in the module. The weak point being sought has been found if this functional fault and the fault from the compliance test are identical. The identified conductor loop must be reduced to lower the undesired voltage induction. It should be noted that large conductor loops cannot be detected with small field sources. The pulse fields enter and exit within the conductor loop. No voltage can thus be induced. Consequently, different types of probe heads are available which are designed for specific measuring tasks. They allow the developer to pinpoint weak points to the millimetre or explore critical links and connections such as components, conductor runs or IC pins on the defined disturbance path. The susceptibility of different IC pins can be assessed (**Figure 2**). Following localisation, the lines which have been identified as susceptible can be treated in a selected way.

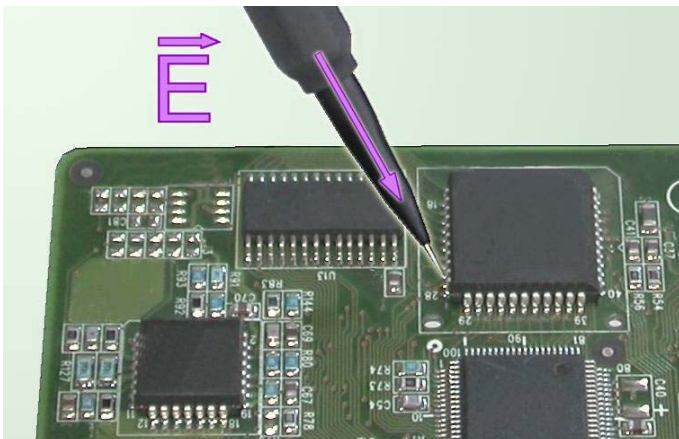


Figure 2: Field source during the search for weak points in an electronic device

E-field-susceptible weak points cannot be identified with the H-field sources. Special E-field probes have to be used to localise these fault points. Apart from conductor run sections, high-resistance components such as pull-up resistors or quartz generators may also prove critical in this respect.

4) EMC sensors / system for monitoring the device under test (DUT)

EMC measures are usually assessed on the basis of functional device faults with a compliance test setup. The results obtained in a time-consuming procedure are, however, inaccurate due to statistical effects and subjective influences. The sole monitoring of functional faults is circumvented by introducing an artificial disturbance threshold into the device under test (reference disturbance level, EMC sensor). Every time the disturbance threshold is exceeded, this is transmitted without delay, randomizing effects and subjective assessment very precisely from the device under test via an optical fibre (Figure 3). Different types of EMC sensors are available for practical implementation.

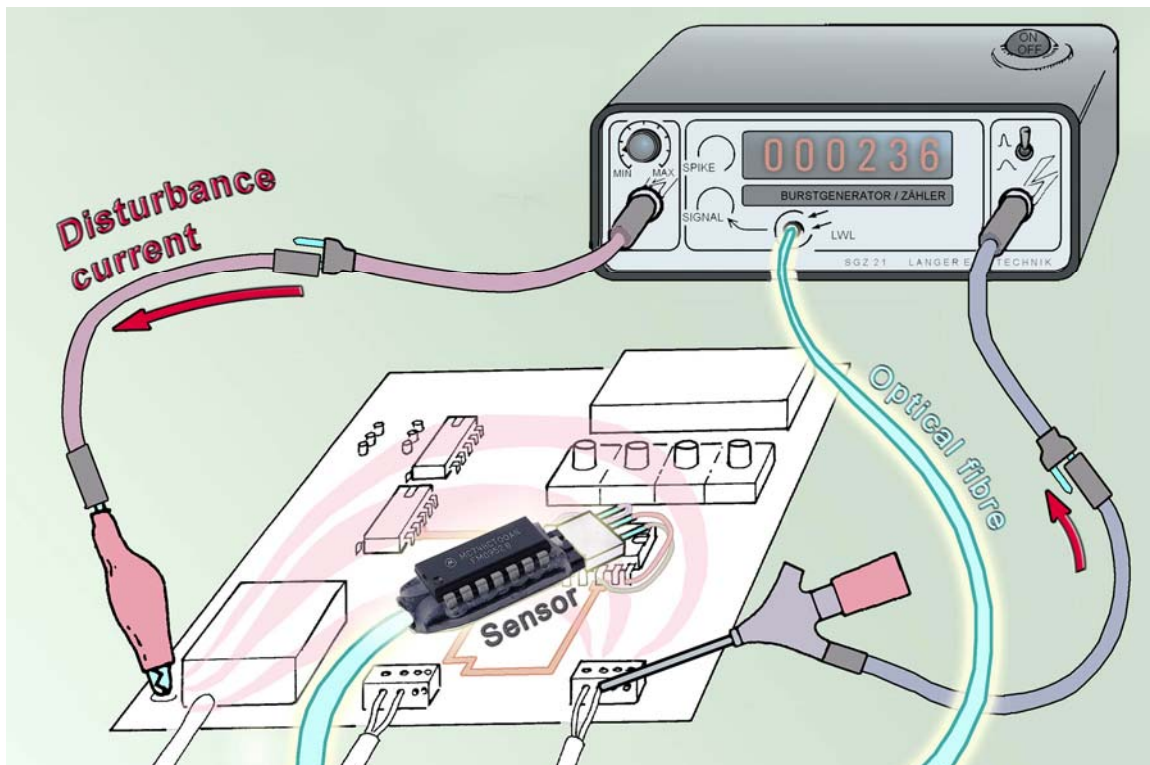


Figure 3: Use of an EMC sensor

Monitoring a signal line with an EMC sensor while the module is subjected to pulse disturbances provides information on how the disturbances advance. The quantitative factor by which an EMC measure inhibits disturbances is measured with great precision. Even small differences in disturbance immunity are measurable. The optical fibre is also used to transmit the signals from the EMC sensor to the receiver.

The signal to be monitored is led directly to the sensor's input and stretched to a 10 ns light pulse. The receiver converts the light signal back into a TTL signal and a counter in the generator displays the number of times the disturbance threshold of the EMC sensor has been exceeded. This ensures signal monitoring without interactions in the course of development. Disturbance immunity is inversely proportional to the number displayed by the counter. This allows a measurement of the effect of a change in layout on the disturbance immunity.

Summary and results

The use of EMC measuring technology in the course of developments is generally accepted as an effective procedure to help improve the disturbance immunity of modern digital technology. The high pressure of costs and inadequately solved EMC problems when using sophisticated electronic components are the reasons for this development. It also encourages the search for generally accepted approaches to solving problems. From a technical point of view, EMC problems can only be solved via the devices' inherent mechanisms of action. The generators, probes and sensors presented here are designed to describe these mechanisms in terms of measurement technology. They allow the developer and EMC engineer to measure, trace and understand disturbance immunity phenomena. EMC measures can be integrated and assessed economically and accurately thanks to this methodology.