Tools for highly sensitive electronics

If you believe what certain publications say, electronic modules are only subjected to immunity tests because standards call for them. The quality of the product and thus its reliability are just taken as side effects. There are also diametrically opposed opinions that emphasize the product's usefulness for the customer. To push the latter through it is important for the developer to have effective methods at hand to improve immunity in the run-up instead of being forced to make up for failed tests afterwards.
The following article explains how the electronics developer can methodically search for, determine and remedy weak points in the run-up to an immunity **test.**

The following scenario was quite common in industry after EMC standards were introduced: A failed immunity test that had been carried out in accordance with the respective standards was the starting point for all EMC activities.
The module was then subjected to external disturbances and observed. Any functional faults were registered. The observer was unable to either pinpoint the interference in the equipment under test (EUT) or to discover its operating mechanism. Without these details, however, efficient modification and re-design were almost impossible later on.

Regulations specify how disturbances have to be coupled into the EUT:

- Disturbance currents penetrate the EUT by capacitive coupling with a coupling clamp or coupling/decoupling network simulation via lines in compliance with EN61000-4-4. Strong magnetic fields that interfere with the EUT's electronics are connected with these disturbance currents (Figure 1).
- Strong electric fields develop between the EUT housing, for example, and the electronic components through ESD to metal parts in or near the EUT according to EN61000-4-2. These fields interfere with components and printed conductors and in turn excite disturbance currents that are connected with magnetic fields.

Today the developer knows that the inner EUT structure determines the intensity by which disturbances and/or their magnetic and electric fields can reach the electronics. Filters and GND system layout thus determine the path these current pulses take inside an EUT and their dimension if burst current pulses are injected via a coupling/decoupling network simulation.
Magnetic fields that are connected with these currents induce voltages in the GND system and line network. These voltages superpose the useful signal so that faults occur only in certain locations of the p.c.b. A qualified developer is able to locate and remedy these weak points with the respective tools in company pre-compliance tests nowadays.

In practice, these weak points are located and remedied in three steps:

1. Analysing faults
2. Locating weak points
3. Remedying weak points

Step 1: Analysing faults

A precise analysis of the faults that occurred during the tests is a prerequisite for EUT examinations. The smallest details are often most important and should be given great attention. These are mostly statistic statements such as: Does a fault occur as of a certain disturbance voltage immediately or only after a certain time, or are there a few seconds or many minutes between individual faults.
During subsequent location of the respective weak points, several may be found that generate different faults. The weak points that are critical for compliance testing can only be pinpointed by precisely comparing the faults.

*We found **one example** of a typical disturbance immunity problem during an EMC optimisation at the customer's site* (Figure representing the example: RESET system 03*). A control system with controller, watchdog module, drivers and power supply (see Figure 0) was the object of examination in this example.*
The developer was confronted with the following problem: A reset of the micro-controller was triggered by burst voltages as of 1.7 kV during burst immunity tests in compliance with EN 61000-4-4.

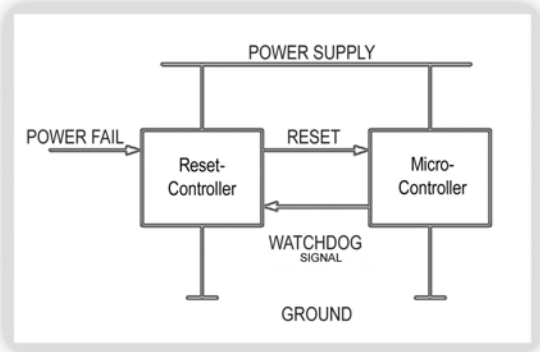

Figure 0: RESET system of the module

The faulty RESET on burst injection may have various causes:
- Direct interference with the micro-controller and internal RESET triggering
- Interference with the controller module and failure of the WATCHDOG pulses
- Interference with the watchdog IC and triggering of the defined RESET of 140 ms
- Coupling of burst pulses into the RESET line.
It was not possible to determine which of the potential causes was responsible for the failure based on the compliance test results. There are two alternatives for the developer at this stage:

- *He either tries to take the appropriate countermeasure for the individual potential causes or*
- *he locates the fault by further measurements.*

*The suppression of disturbance current flowing to the liquid-crystal display is **another example** of EMC optimisation in electronic modules. Our example module comprises a controller and peripherals on a p.c.b. plus an external power supply unit and liquid-crystal display. The display is linked to the processor p.c.b. below it via a ribbon cable. Two screen plates are provided, one below and another above the controller module (Figure 1).*

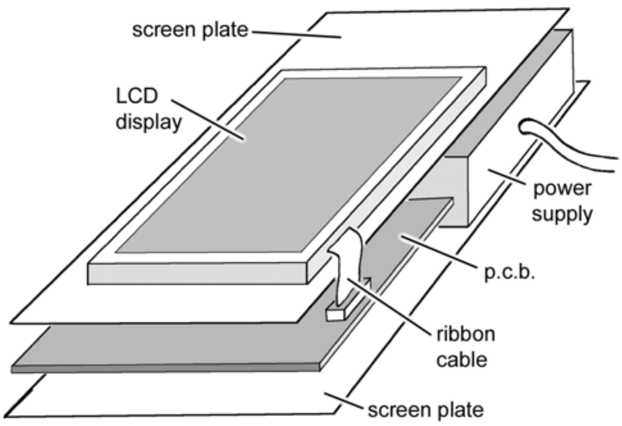

Figure 1: Display

The display driver crashed when the module was subjected to a burst current in a burst immunity test in compliance with EN 61000-4-4.
The developer presumed the following disturbance current path:
The burst current flows to the display via the power-supply unit, the controller p.c.b. and the ribbon cable and causes a crash of the display controller.
The developer needs a more definite statement with regard to the weak point's location on the presumed disturbance current path to confirm this theory and carry out targeted countermeasures in a second step. He can either employ some of the countermeasures that proved useful in earlier trials and leave success to chance or he can check the disturbance current path for actual weak points.

Step 2: Locating weak points

The magnetic and electric fields that are responsible for interference can be simulated with probes that generate small concentrated fields. The objective is to subject only a few square millimetres of the EUT to these fields and trigger those faults that occurred during compliance testing. The developer has located a weak point if he succeeds in triggering a fault at one particular point.

Figure 3: Field sources (Set H3)

Probes for generating magnetic fields and those for generating electric fields are available in various designs. They can be injected by a burst generator in compliance with EN 61000-4-4 (Figure 3).

The BS 04DB probe is passed like a pen over the p.c.b. (Figure 4) and generates a magnetic field beam with a diameter of approximately 5 mm at its tip. When this field beam hits a weak point, the EUT generates faults (Figure 5). By comparing this fault to the fault from the compliance test it is possible to determine whether the located weak point or another one not located so far responds in compliance testing.

Figure 4: Field source probe BS 04DB

Both the voltage set on the burst generator and the distance between probe and p.c.b. can serve as a criteria for a weak point's susceptibility.

This method was also used in our first example. First the developer subjects the POWER FAIL line and then the RESET line to a B magnetic field using the BS 04DB magnetic field probe. The magnetic field pulses encircle the line and induce the desired disturbance current. The same failures as during

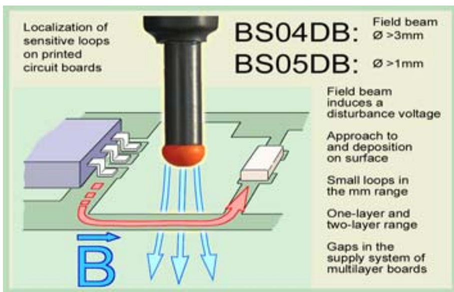

Figure 5: Field chracteristic

compliance testing can be observed when the RESET line is subjected to the field. Only now can the developer be sure that the weak RESET line in connection with the controller is responsible for the failures. He can now take targeted countermeasures.

The ES 05DB probe is used to examine individual sections with an electric field in our second example. One line after the other is subjected to the field on the ribbon cable section (Figure 6). One line produces the failure that was observed before. The line to the controller module itself is the weak point. Knowing this the developer can take a successful countermeasure by installing a filter and/or discharge capacitor within a few minutes. The module then has a much better disturbance immunity than planned. The expenditure in time and cost is that of a routine job.

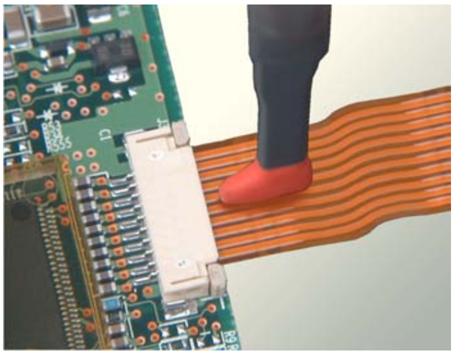

Figure 6: electric field probe ES 05DB

Step 3: Remedying weak points

After locating a weak point the developer can effect selected modifications using the information from his wiring diagram, e.g. he can strengthen the GND system at this point, change the position of the components or add filter capacitors.
A further precise fault analysis is then required. This will show if the EUT's immunity to disturbances now meets the requirements. The modification was insufficient or another weak point that produces the same fault exists if the EUT fails at a higher disturbance voltage.
Injecting an electrical field into one line of a ribbon cable with an ES 05DB probe (Figure 6) and generating a local circular magnetic pulse field that encircles the cable in the plug and generates a current flow by induction with an BS 04DK probe (Figure 7) are two further examples of how probe diagnostics are used to locate a module's weak points. Compared to compliance testing, all described variants benefit from the fact that the disturbance current flows through the EUT on selected current paths and any susceptible lines and components can thus be evaluated.

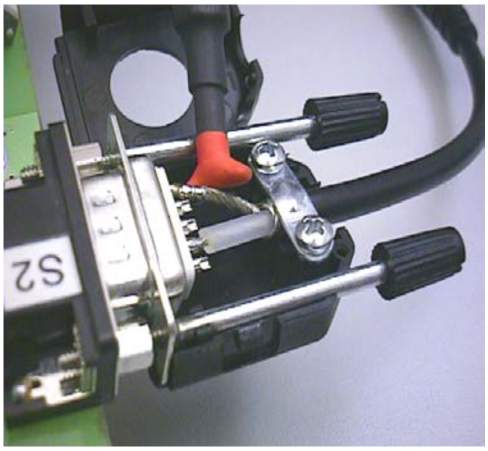

Figure 7: BS 04DK magnetic field probe

All in all, it can be said that the use of field sources (probe) enables a systematic approach to troubleshooting. The time that is needed to solve EMC problems can be calculated because the probability of positive changes to the electronics increases and that of the developer getting lost in fruitless modification decreases thanks to a selective and thus thorough magnetic and electric field analysis. The described strategy effectively supports circuit dimensioning and electronic layout. The developer is in a position to produce electronics that meet the customer's requirements with respect to functionality and reliability.

Contact:

Langer EMV-Technik GmbH; (EMC-technic producer); mail@langer –emv.com
Fax ; 0049-351-43004322 ; Nöthnitzer Hang 31; 01728 Bannewitz; Germany