How To Build An EMC Test Kit

All electronic devices have the potential to emit electromagnetic fields. In order to bring your product to market, you need to ensure it clears a set of EMC tests. Let us find out some facts about these tests and how to build a test kit for it.

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Electromagnetic compatibility (EMC) testing, also referred to as EMC immunity testing, has become an important part of product design all over the world. Electronic equipment should meet certain mandatory EMC immunity criteria to be eligible for use in most countries. This ensures that the equipment will operate well when working in its intended application. Satisfying EMI/EMC safety standards, according to correct regulations, at design stage of the product can help pass the tests in one shot.

EMC testing

Let’s start with a quick primer on EMC testing before moving on to selecting equipment for it. There are two types of emissions that are tested: conducted emissions (CE) and radiated emissions (RE).

CE test determines the radiations propagated along connectors and cables, causing noise in the system. A designer needs to check the susceptibility by choosing proper filters in conduction path. Emissions of all equipment need to be arrested, ensuring there are no disturbances to other equipment running on the same connectors and cables.

RE test is conducted to determine the disturbance caused to the device under test (DUT) in the presence of any radiation source. These can be arrested at the design stage. Radiated susceptibility testing is done to safeguard the device’s immunity to strong radio transmitters in its vicinity. Product immunity testing is conducted to ensure human-machine safety.

How standards decide your equipment

Different types of equipment have different needs depending on factors like (a) operating environment (military equipment are used in harsh environments compared to consumer electronics), (b) reliability (medical devices that monitor vital signs should be more reliable than a personal computer), and (c) safety (if the operator has to be near the equipment, the radiation levels should be low). On the basis of these, the designer has to consider which specific industrial or military (MIL) safety standards should be fulfilled. However, simply knowing that you need to test for a specific industrial standard is not good enough.

Manufacturers of electronic equipment, unfortunately, have a big issue to face: These standards do not remain the same. They evolve to keep up with the pace and a requirement of modern technology on a continual basis. Some of these changes might be relatively minor, while others are withdrawn or completely re-written and superseded. It is important to keep up with all these changes and timelines for making sure a product reaches the market.

Why this trouble? The goal of the changing standards is to make the equipment become least intrusive for other devices, and more immune to hostile electromagnetic environment.

One issue is the increase in number of electronic devices that use advanced semiconductors. Electronic products are tending towards becoming more non-linear. The direct effect of this trend is seen as increased corruption of AC mains, which is a shared public utility.

Another problem faced is when previously discrete technologies converge in a single product. One example is the case of multimedia equipment for which a previously separate CISPR 32 standard was introduced. In order to maintain safety and best performance, the standards should be rewritten or replaced accordingly.

Additionally, with the evolution of technology for radio receivers (Bluetooth and its variants, Wi-Fi and its variants, cellular radio, etc) or electronic transmitters (FM transmitters, radars, etc), EMC standards should also change accordingly to cope up with the changing levels of EMI.

Is it EMI or EMC?

Electromagnetic interference (EMI) is the effect of electromagnetic inductions or electromagnetic radiations emitted by an external source on an electrical/electronic circuit.

Electromagnetic compatibility (EMC) deals with how well an electrical/electronic circuit works in an EMI environment—whether it resists generation of electromagnetic disturbances that may affect other products and living beings in the locality.
Keeping up with changing standards

Designers, test labs and test equipment manufacturers should be very well aware of, and up-to-date, with the changing technology and standards.

Test equipment users must be familiar with the equipment provided by the vendors and their limitations. It is best to buy an instrument that offers programmability for test parameters. This helps you adjust the testing process to minor revisions of standards. Programmability also serves some customised, non-standard requirements that the customers would have adopted to make their products more reliable in a typical operating environment.

Test facility vendors may have to strengthen their equipment as per standards for the safety requirements. Most of the required upgrades would be with respect to sensitivity of the antennae, range of antennae, software updates of the test equipment and periodical calibrations.

“Specifically for the changing compliance standards, we proactively reach out to the designated authorities to know about the likely future compliance changes,” says Raghu Rao, manager of application engineering team of Tektronix India. “This helps in being ahead in the market with future ready solutions.”

Building a basic EMC troubleshooting kit

Troubleshooting is the process of isolating a problem and applying appropriate fixes. A test engineer diagnoses an EMI/EMC problem the same way a doctor diagnoses the medical condition of a patient. The diagnosis involves several stages: looking at clues, examining the equipment, gathering additional information (usually through tests) and finding a suitable solution.

An EMC troubleshooting kit is of great help to both independent and in-house EMC consultants. The essential tools for EMC troubleshooting depend on the kind of industry compliance the customer is looking for. But here is a brief guide that would help you assemble the most basic equipments required for basic troubleshooting, depending on your requirements, at minimum possible cost. The kit can be used for limited pre-compliance testing and assessing radiated emissions.

Spectrum analyser. The heart of an EMC troubleshooting kit is a spectrum analyser. Look for an instrument that is not bulky, preferably a handheld analyser, as it would be easier to carry around. It should have good external command support, fast triggering speed and a capability to buffer many triggered measurements (gated sweep). More useful, if you can afford, is real-time spectrum analyser. Conventional EMC testing involves analysing events that are repetitive. The need for today’s equipment is to be able to catch sporadic and rarely occurring events.

Probes. These include near-field probes and current probes. Probes can be constructed in lab with a little expertise in the field. H-field and E-field probes are near-field RF probes, constructed from semi-rigid coaxial cables, that are used to identify the source of electromagnetic interference emissions and potential radiation frequencies around circuits, cables and enclosures.

H-field probes are made basically from a conductive loop, and they detect magnetic fields produced by clock signals, control signals, serial data streams and switchers. A voltage is produced in the loop proportional to the magnetic field perpendicular to it. With larger size of loops you get higher sensitivity, but lower resolution. E-field probes, which make direct contact with the circuit, are used to find emissions on individual pins or PCB traces.

Poorly-bonded cables are said to be the major cause of radiated emission failures. A current probe, one of the most used accessories in troubleshooting, lets you measure the common-mode current flowing in wires or cables and identify a bad termination, which causes current leakage. Probes let you...
### Criteria for selecting EMC test instruments

1. The kind of task the user wants to perform. Requirements vary depending on the industry or application.
2. Working environment. If the equipment is for use in field, it needs to be heavy-duty, waterproof, rugged and portable. A benchtop instrument can perform delicate, precise measurements indoors.
3. Comprehensive coverage of test standard requirements so that the user can perform test to comply several standards using a single instrument.
4. Programmability and user friendliness of the test equipment.
5. Upgradability of the test equipment, in accordance with the changing standards or latest releases of the instrument, and local technical support available.

### ESD simulator

Electrostatic discharge (ESD) simulator or ESD gun generates ESD pulses that help verify the immunity of a particular device to static electricity discharges. While an actual ESD simulator can be expensive, you can create a rather simple ESD generator using a zipper storage bag with several coins inside. Shake this bag near the circuit to get several volts of ESD pulses at rise times of about 100 picoseconds.

### ESD detector

Issues like loss of data and unusual circuit reset can be due to ESD in the circuit. Commercial ESD detectors are available in the market for higher accuracy applications. But an AM broadcast radio tuned off-station can act as a good ESD detector. If it has an FM receiver, you can even tune in product harmonics from radiated emissions.

### Radiated immunity testing

Nothing can replace the test lab equipment for accurate radiated immunity levels. But a variable-RF signal generator would allow the simulation of radiated immunity test to some degree and give you an idea of whether the object is immune or not. Once the susceptible region is identified, you can implement potential fixes. This can save time and money as opposed to performing troubleshooting at test labs.

### Other contents

Some of the other things include digital multimeter, screwdriver kit, pencil soldering iron, solder, SMA (subminiature version A) connector, flash light, magnifier, tweezers, wires of different lengths and sizes, 10dB and 20dB attenuators, aluminium foils, coaxial adaptors, insulation tape, copper tape, measuring tape, EMI gaskets, ferrite chokes, common-mode chokes, and a range of I/O cables, BNC coaxial cable, SMA coaxial cable, resistors, capacitors and inductors.

“At a compliance lab level, the list of test instruments and test infrastructure can be exhaustive,” says Rajneesh Raveendran, the project manager of Tarang Test Lab, Wipro. But to get a product certified in accordance with the appropriate and latest test standards you always need to seek help of an EMC testing lab. “Semi/fully anechoic chamber, EMI receivers, antenna and antenna masts, turntable, signal generators, RF amplifiers, line impedance stabilisation networks, coupling/decoupling networks, RF current probes, various immunity test generators, etc are provided to cater to the various radiated and conducted emissions/immunity,” adds Rajneesh.

### Very-near-field technique of EMC testing

The terms far-field, near-field and very-near-field describe the fields around an antenna. Near-field is less than one wavelength (λ) from the antenna and far field begins at a distance of 2λ and beyond. With the right implementation, any antenna can be successfully measured on either a near-field or far-field range. Ideally, far-field ranges are a better choice for lower frequency antennae and where simple pattern-cut measurements are required, and near-field ranges are better for higher frequency antennae and where complete pattern and polarisation measurements are required. The near-field is generally divided into two areas, the reactive and the radiative. The reactive region is what we call the very-near-field.
Quick, repeatable, real-time data. According to Erkan Ickam of EMSCAN, a leading developer of fast magnetic very-near-field measurement applications, “Traditional EMC far-field techniques measure the emissions levels; they are not useful for small, printed circuit board assembly (PCBA) level diagnosis as they can’t point at the source of emissions on the PCB.” The very-near-field technique is fast and repeatable; interaction with DUT is unavoidable in this area. “It can measure the entire PCB continuously to make sure intermittent events are captured even when they occur in areas of the board that are not expected to radiate,” he adds.

In other words, very-near-field technique is a good method to quickly identify localised hot spots at a PCBA level. It lets you identify frequency content of emissions and make spatial maps of the currents at each frequency as they occur on DUT. These spatial maps give information to test engineers about where the ultimate source of EMC emissions are, at the PCB level. These very-near-field spatial maps cannot be directly compared to any existing EMC standards like IEC and ANSI; they, however, provide insight into troubleshooting or root-cause analysis for any standard.

Complementary to all standards. Very-near-field testing is a pre-compliance tool and there are no standards for EMC pre-compliance. An example is the EMxpert by EMSCAN. Regardless of the standard, when current EMC chamber measurements indicate a failure, the test results do not generally indicate what the cause of the problem is. This is where a quick measurement utilising very-near-field is extremely valuable. It will indicate the source of emissions, coupling paths, resonant points, shielding issues as well as many other potential problems. This can help the engineers track down the problem quicker and make proper changes to the design.

Indoor testing. Another advantage cited for near-field measurement techniques is that testing can be accomplished indoors, eliminating problems due to weather, electromagnetic interference, security concerns, etc.

Drawbacks. Each hotspot seen in very-near-field probing is an independent vector by itself. Unless the magnitude and polarity of these independent vectors are quantified, convergence to real-lab measurements cannot be assured. Another issue is that the DUT must be smaller than the scanner for pre-compliance. The device should be disassembled for testing.

Testing at the component level

P. Chow Reddy suggests that, to test at component level, make a simple loop probe with a coaxial cable that could be connected to the spectrum analyser. One end of the cable can be stripped and centre wire extended to the braid of the shielded wire. This forms a complete loop with respect to the shield. This arrangement picks up radiations in the loop and transfers to spectrum analyser and hence gives a rough picture of the radiation level.

To specifically identify the radiating component, strip a thin-shielded wire with braid, make the centre wire into a small loop and solder it on to the braid. Then drop silicon sealant on the loop. This forms a mini probe. With one end connected to a spectrum analyser, this probe can be brought close to the specific components to analyse the pickup radiations.

Antennae tuned to particular range of frequencies and resonances are readily available in the market. These can be used to get a very brief picture of the radiations in open labs.

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