EMC Testing During Product Development

An in-house pre-compliance test facility can expedite product development.

J. R. BECKETT
WAYNE KERR/FARNELL INSTRUMENTS

INTRODUCTION

Radiated emission testing during the early phases of product development is essential to check enclosure design and the compatibility of subassemblies. This testing will, by its very nature, take place in a location which is conveniently close to the development area, but as a result can suffer from locally generated factory emissions and local broadcast transmissions within the 30 MHz to 1 GHz band of interest. There are a number of tradeoffs which have to be made when attempting to make repeatable radiated emission measurements in a non-ideal environment. This article outlines a cost-effective test strategy which uses a partially screened chamber and minimum size open area test site (OATS) to obtain repeatable device-under-test (DUT) results prior to submission to an independent test house.

STANDARDS

There are a number of product specific EN (European Norm) standards in place, one of the most frequently cited being EN55022 (BS 6527), which covers Information Technology Equipment (ITE). Nevertheless, EN50081-1 will be used for this article since it is more generally applicable and since it references EN55022.[1] The salient features of EN50081-1 are:

- Radiated emission frequency range is 30 MHz to 1 GHz.
- Generic class is "Domestic, Commercial and Light Industry."
- Maximum field strength level is 40 dBμV/m below 230 MHz, rising to 47 dBμV/m above 230 MHz, allowing for testing at 3-meter spacing rather than at 10 meters.

The standard also calls for the following specific test conditions:

- Quasi-peak detection method using 120 kHz pre-detection bandwidth (as specified by CISPR Publication 16).
- An OATS with a major axis of at least twice the DUT-to-antenna spacing, a ground plane and infinite headroom.

MEASUREMENT TOOLS

For pre-compliance and diagnostic work, speed of operation is vital. A measuring receiver will give better absolute level accuracy (typically ±1 dB) than a spectrum analyzer (typically ±3 dB), but the measuring receiver does not give the real-time panoramic overview which is essential before commencing detailed measurements. To speed up the measurement process, the peak detection facility of a spectrum analyzer may be employed initially. It is only necessary to use the much slower quasi-peak detection method when measuring the specific frequencies of interest.

For many years the accepted antennas for the frequency range relevant to this type of test have been biconical (for 30 MHz to 200/300 MHz) and log periodic (for 200/300 MHz to 1 GHz). These give the best achievable antenna accuracy (typically ±2 dB), but for convenience, broadband antennas are now available which cover the entire 30 MHz to 1 GHz band with a typical accuracy of ±4 dB.[2]

ENVIRONMENTAL FACTORS

There are a number of environmental factors which can have a dominant effect on the measured radiated levels from the DUT.

The most serious problem with an OATS is the presence of unwanted background signals, particularly from VHF FM and UHF TV transmitters. These signals cannot be removed from plots and can only be identified as "ambient" signals by first plotting these signals with the DUT switched off. The only method available to improve the DUT-to-ambient ratio on an OATS is to select a 3-meter test distance rather than a 10-meter or 30-meter distance. This is highly desirable since each $\sqrt{10}$ times reduction in test distance increases the DUT measured field strength by nominally 10 dB. A sample ambient plot of a 5.2 meter x 6 meter open field in-factory test site is shown in Figure 1. The plot looks crowded, but there are typically about 80 distinct signals over the limit line out of a possible 8038 channels. This means that only 1% of the channels are obscured.

An easier way to identify DUT frequencies of interest is to make preliminary tests in a shielded enclosure. In order of cost and effectiveness, this can take the form of a wire mesh frame, a steel

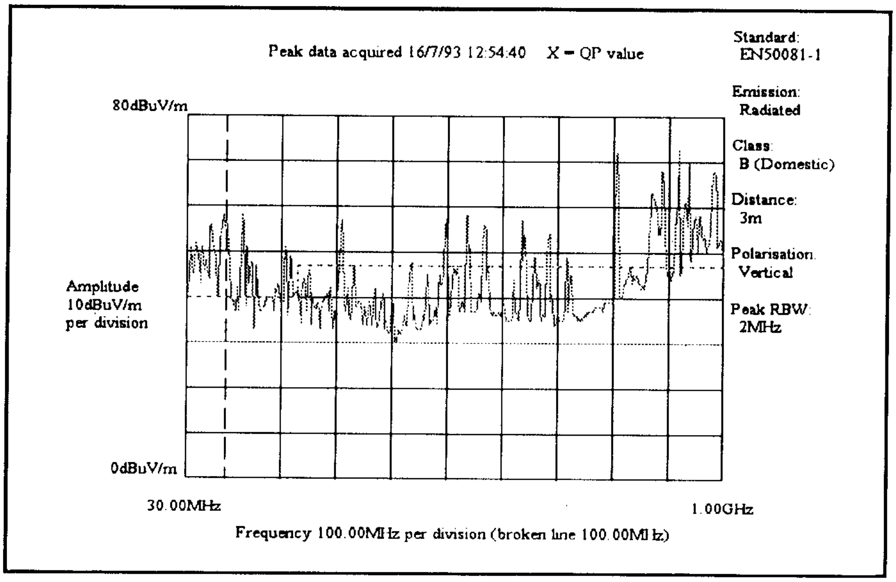

***Figure 1**. Sample Plot of 5.2 x 6 Meter OATS.*

container (as used in road/sea freight) or a custom EMC shielding tent. All of these enclosure tests will suffer severe accuracy degradation due to internal reflections, but will provide an unambiguous short list of DUT frequencies for measuring on the OATS, without having to worry about the possibility of DUT frequencies being obscured by ambients. A sample test plot obtained inside a standard 20 x 8 x 8.5 foot five-sided steel freight container is shown in Figure 2. Note that all the ambients are now below the limit line.

The second problem which can be easily overlooked is the operating condition of the DUT. For example, in the case of a PC, it is necessary to configure the keyboard, disk drives and display in such a way that the radiated energy is maximized. There is no generally accepted method of ensuring that this condition is met. A test report should always make clear under what conditions the DUT was being exercised when the measurements were taken.

The third problem is interconnection cables. These include both power line cables and cables

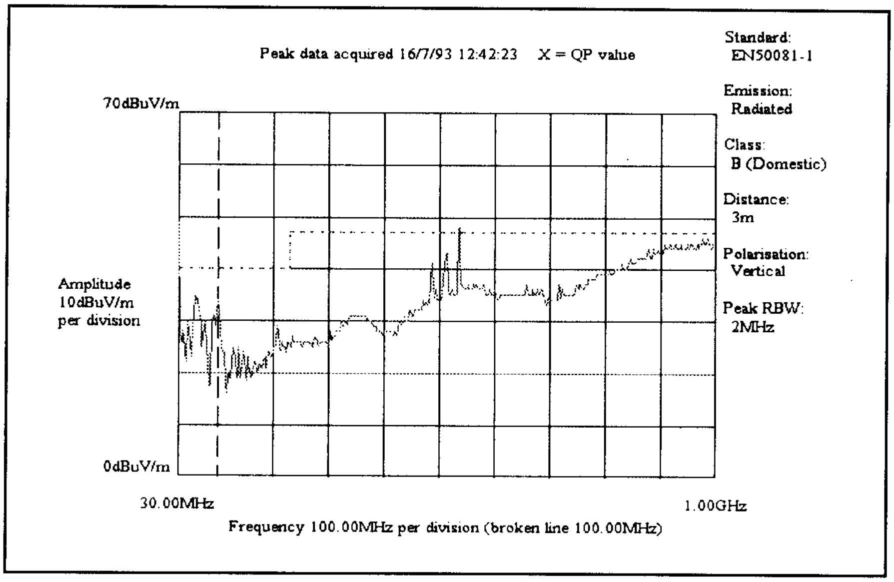

***Figure 2**. Test Plot Obtained Inside Steel Freight Container.*

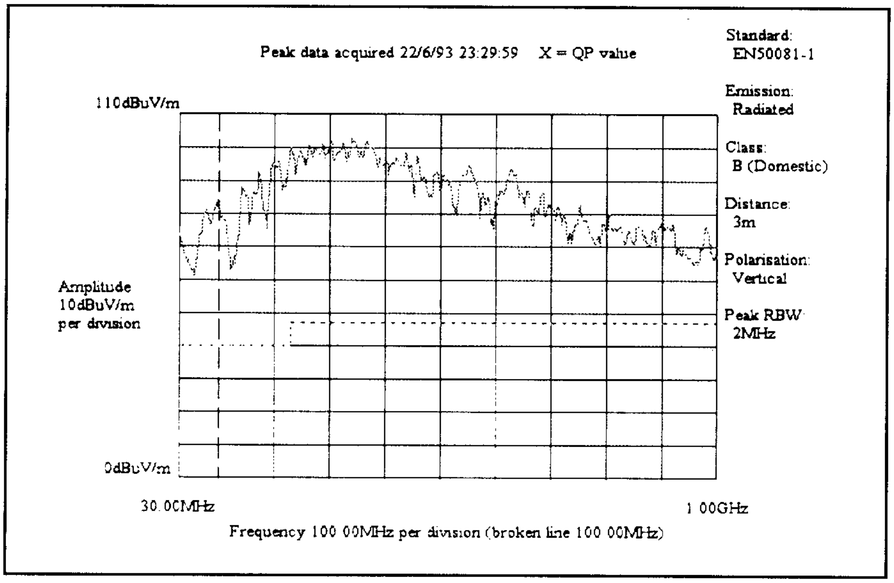

***Figure 3**. Results with Comparison Noise Emitter Inside Freight Container.*

between system components. Any cables supplied by the manufacturer must be used because they may include custom screening or ferrite chokes to reduce radiation. Any excess length of cable should be folded back against itself in 0.4 meter lengths and tied together to avoid uncontrolled variations in signal strength due to cable positioning. If a system is being tested in a 19-inch rack, the test report must state whether the rack is bonded to the ground plane or not.

The fourth problem is how to qualitatively assess the suitability of a proposed OATS. A device developed specifically for this job is the comparison noise emitter (CNE)[3]. This device emits a continuous power spectrum with no resonances or nulls over the 30 MHz to 1 GHz range of interest. It is therefore simple to check for any local site effects by substituting a CNE in place of the DUT. Examples are shown in Figures 3, 4 and 5.

Figure 3 was obtained with the CNE inside the freight container. Note the distinct periodic nodal resonances which are occurring at the lower frequencies consistent with the major axis dimensions of the screened enclosure. This highlights the folly of regarding the levels measured in an undamped enclosure as an indicator of true OATS levels.

Figure 4 shows the performance of the 5.2 x 6 meter in-factory OATS. Although this site meets the requirements of the EN55022 basic standard, with the exception of infinite headroom, regular nulls are visible on the plot due to a metal partition which is outside (but only just!) the defined 5.2 x 6 meter elliptical test area.

Figure 5 shows the performance of an empty parking garage with no walls or other obstructions within 10 meter of the 5.2 x 6 meter elliptical test zone. The response is free of any resonances or nulls and proves that this site is superior to the previous two examples.

Finally, it should be noted that the comparison noise emitter can be used as a transfer standard to calibrate a site used for pre-compliance tests against a National Measurement Accreditation Service (NAMAS)-approved OATS if required.

SUMMARY

To summarize the above points, a recommended step-by-step program for a cost-effective test strategy for radiated emissions testing is outlined below.

One-time setup preparation:

- Identify a person within the test organization who can become the EMC expert. Arrange for hands-on training if necessary.
- Purchase a suitable spectrum analyzer and antenna(s). It is easier to control the large amounts of data produced if

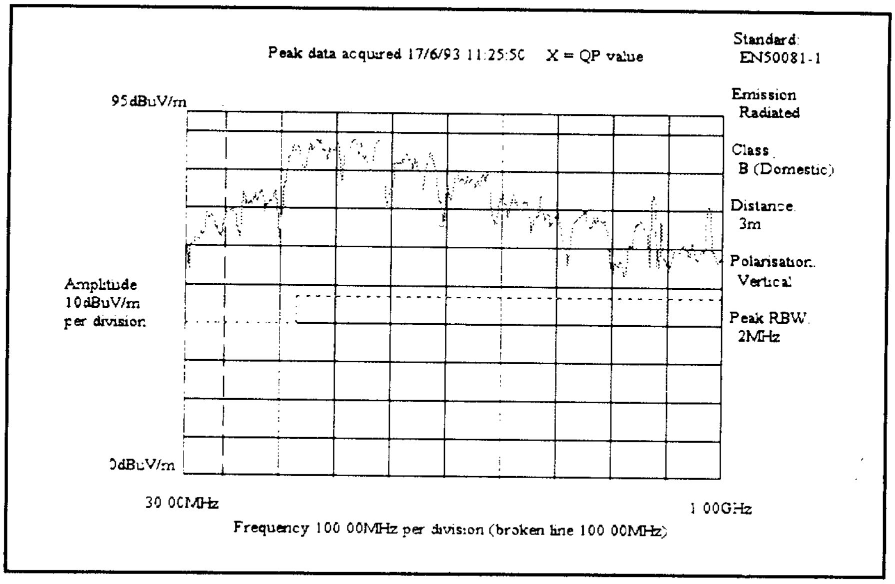

***Figure 4**. Results Obtained for 5.2 x 6 Meter In-factory OATS.*

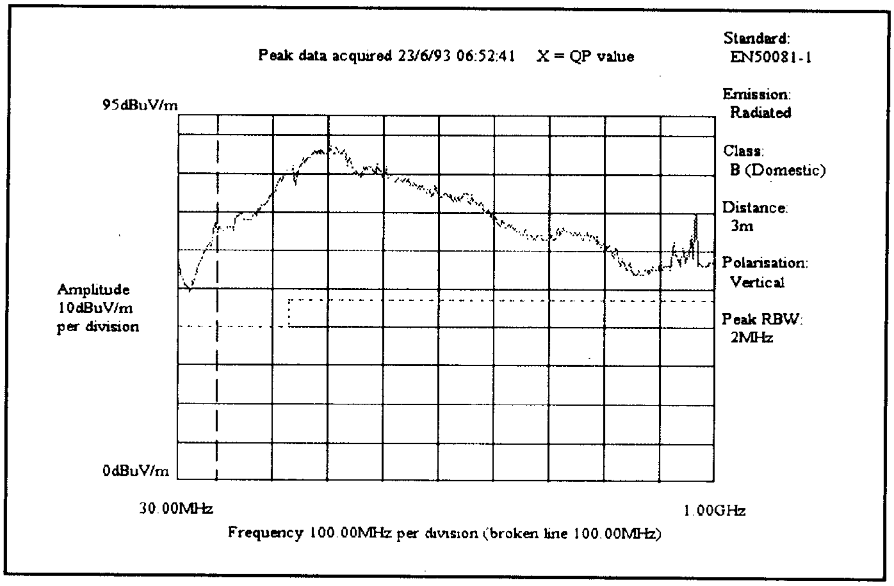

***Figure 5**. Results Obtained within 10-Meter Elliptical Test Zone.*

compatible PC-based general purpose interface bus (GPIB) measurement software is purchased at the same time.

- Identify one or more potential OATS and check for suitability with a comparison noise emitter.
- Unless local ambients prove benign, invest in a screened enclosure which reduces the ambient levels below the appropriate EN radiated emission limit.

For each product to be tested:

- Set the antenna height to the same height as the base of the DUT above the ground (usually 0.75 or 1 meter). When testing a floor-standing rack system, use half-height as a default. Set the DUT to antenna distance equal to 3 meters to maximize the signal-to-ambient ratio. Repeat all the following tests with both horizontal and vertical antenna polarization.
- Using the screened enclosure, identify a short list of frequencies of interest by noting all levels which are within 12 dB of the limit. Look for any known internal DUT clock frequencies and harmonics. Rotate the DUT to check for maximum emission orientation.
- Repeat the measurements for this short list using the OATS. This should be done at each frequency, with the DUT off, to check that the emission level measured is indeed DUT and not ambient. Reduce the short list as appropriate by deleting those frequencies which are more than 6 dB below the limit line.
- For those frequencies which remain, perform quasi-peak measurements to see if any reduction in level is obtained. As a final check, antenna height may be adjusted to check for any unwanted nulling effects.

ACKNOWLEDGEMENT

The author thanks Alan Reynard for supplying the plots used in this article.

REFERENCES

1. C. Marshman, *The Guide to the EMC Directive 89/336/EEC*, EPA Press, 1992.
2. N. Wainwright, *Effective Low Cost Pre-Compliance Emission Measurements*, York Electronics Centre, University of York.
3. *Applications Manual for the Comparison Noise Emitter*, York Electronics Centre, University of York, April 1990.

***JON BECKETT** received a B.A. degree in Electrical Science from Cambridge University in 1975. He has over 15 years experience in the test and measurement industry and is currently Technical Director of Farnell Instruments, Bognor Regis, U.K. Tel: 0243 825811. Fax: 0243 824698.*