

EMC Emissions measurement

Technical paper by David Mawdsley

To Screen or not to Screen?

The ideal site for radiated emissions testing would be one that enables the measurement of a 'free space' emission level, i.e. one that is unaffected by any surrounding artefacts. However thanks to Newton's invention of gravity we are stuck with having to measure the emissions from our EUT in the close proximity of Earth. The best we can do to most nearly match an ideal free space situation is the Open Area Test Site (OATS), and this is the chosen site defined by most common standards. There are two significant problems with this type of site:

(a) the ground, which causes a reflection that interferes with the 'direct path' signal. If the path length difference between these two paths approximates to $\frac{1}{2}$ wavelength, then cancellation will occur, significantly reducing the apparent field strength and introducing large errors. (Up to 15dB). The answer as specified by the standards is to use height scanning of the antenna over the range 1 to 4 metres. Done correctly, this overcomes the 'ground reflection' problem. A little exercise in geometry will clarify this point.

(b) ambient (background) signals. As we all know, the world in general and the UK in particular is immersed in a very crowded RF spectrum. Broadcast FM signals, for instance, can be very strong, up to 90dBuV/m or more and other signals can be infuriatingly intermittent (taxi and other ground mobile services, mobile phones, air traffic control and military communications are typical of signals that tend to broadcast for brief periods only)

So not only is the background strong, it is very unstable. A 90dBuV/m signal is 60dB (that is one thousand times) stronger than a limit of 30dBuV/m! This makes the detection of the relatively feeble emissions from a product tricky, to put it mildly. On top of this, the dynamic range of some of the lower cost spectrum analysers is only 50dB, making the measurement of EMC related signals in noisy locations quite impossible.

The standard answer to all this is to use a screened room.

But is this a good idea?

The answer to this question is, well, yes and no. The issues are not as clear cut as you might expect and the real answer depends on your circumstances.

At first sight, a simple screened room seems like a good idea. It would keep out the ambient noise thus making the detection and measurement of EUT emissions easier, especially for radiated emissions. Indeed many organisations have taken this step for precisely these reasons.

Unfortunately, in many cases, this can represent a retrograde step. A screened room certainly has its uses but must be used with regard for its limitations. Field strength measurements for radiated emissions in particular could be quite meaningless.

As screened room is, by definition, a 'box' made from material which is opaque to RF signals. So inside the box there is a complete absence of radiation from external sources. Any emissions created inside the box can then be 'observed' very easily. Also, when testing for RF immunity, the signals which must be created to meet the test specifications can be contained and nuisance to neighbours avoided. The major problem is that most of the materials that are opaque to RF actually work by reflecting the radiation away, rather than absorbing it. Any conducting surface has this property. Non conducting surfaces or materials are generally transparent to RF. This means that the materials used for screened rooms are metal sheets (aluminium, copper, steel.....) fabricated so that there are no gaps in the conductive surface. This produces an ambient-free environment inside the box. BUT, all these surfaces are reflecting, inside as well as outside. So all the RF 'waves' radiating from the EUT will bounce off the walls/roof/floor of the box producing a very complex pattern of field strength throughout the chamber.

Fig 1 shows the approximate field strength distribution inside an 8 x 10 metre chamber from a centrally located source radiating at 83MHz. The vertical scale shows the deviation in dB from the free space level that should be measured at that point. The calculations for these plots are very simplified, taking into account only the five most significant reflections, but do they do show the extent of the problem.

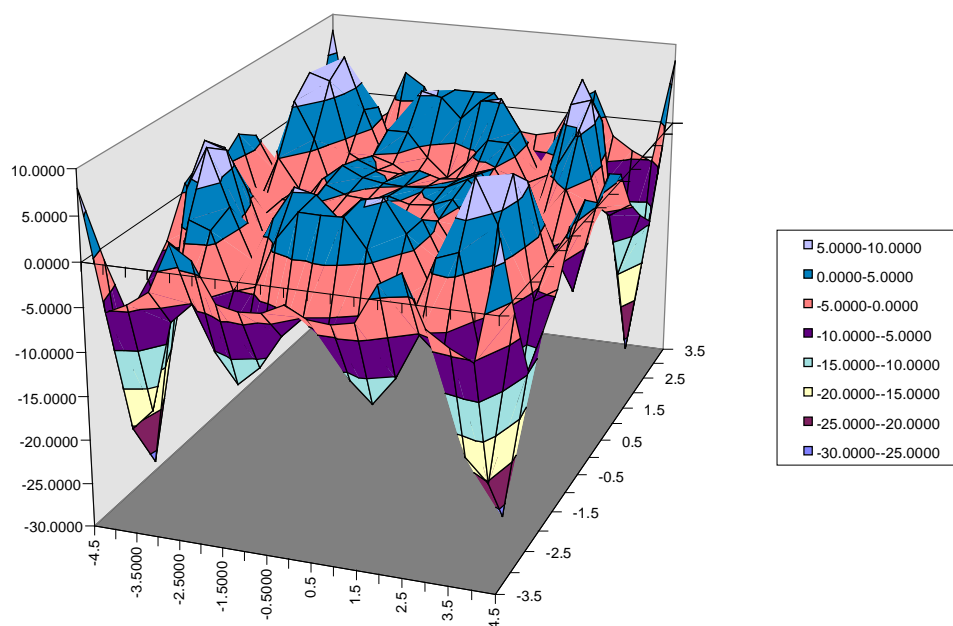
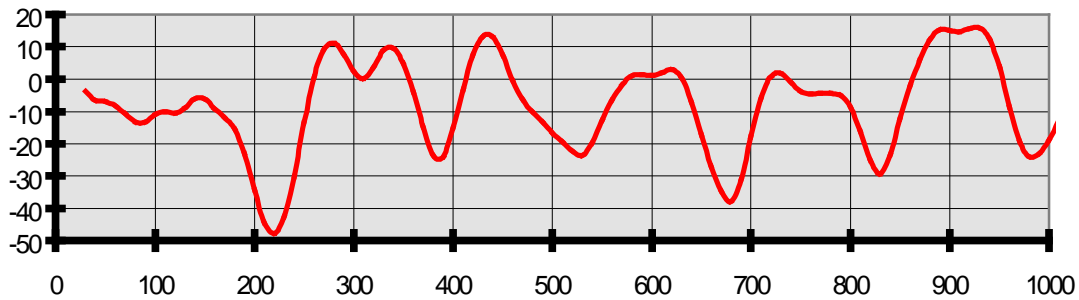


Figure 2 shows the apparent field strength relative to a true free space level, as a function of the frequency of the source. The EUT and antenna locations are on the centre line of the chamber, each one metre in from the end walls giving a 3 metre separation in a 5 metre long chamber. Other dimensions are chamber width, 4 metres and chamber height 3 metres.

Gain/loss of field strength inside screened room



Both the above plots give an idea of the problems associated with screened rooms.

So to summarise the story so far:

- Radiated EMC standards (without exception) specify the use of an Open Area Test Site (OATS), not a screened room.
- To screen out external emissions is not a trivial task. Lining a room with chicken wire or similar has virtually no effect. RF is very searching stuff, and it will pour in at every hole or gap. A 'proper' screened room will be completely metal clad with all gaps and joints either welded or bolted through at close spacing and covered by conductive tape. The door should be fitted with conductive fingers or similar to provide continuity all round the frame when closed.
- Any connections passing in/out of the screened area must be well filtered to prevent external signals coupling into the room and radiating from internal cabling.
- Screened rooms have, by definition, 6 internal faces which are highly reflecting to RF. Opposing surfaces will create resonances at all frequencies for which the distance between the surfaces equals a multiple wavelength. These resonances create a complex pattern of standing waves throughout the room leading to 'hot' spots (peak signal) and 'cold' spots (signal nulls). In these circumstances, completely different results will be obtained by moving the position of the antenna and/or EUT by just a few centimetres. Clearly bad news!

The problem of reflections is the dominant reason why screened rooms should not be used for radiated emissions measurement. However, they can have a role to play even for this test.

Obviously, a screened room of some kind must be used for RF immunity testing. Signals with a strength of 3V/m or 10V/m tend to get noticed by the neighbours! Even for this application, screened rooms have to be designed with care, good screening and some device to ensure a uniform spread of energy over the frequency range to be used. This may involve the use of 'paddle wheels' or similar to mix up the resonances. (So called 'mode stirring')

If the real problem is reflections we could make the surfaces non-reflecting. That is precisely what happens in anechoic chambers. Semi-anechoic chambers cover the walls and ceiling with RF absorbers, full anechoic chambers have all surfaces covered, including the floor. Such chambers provide a near ideal solution, low ambient and absence of reflections. The down side to this approach is the cost and the weight.

Absorber material can be heavy and will cost £300 per sq. metre or more and even a small chamber will have 80 sq. metres of internal surface to cover.

There are two basic types of absorber, carbon filled foam and ferrite tiles.

The foam is supplied in pyramidal form, often seen in photos of chambers. To be effective at low frequencies, they must be relatively tall and will hence reduce the available space inside the chamber by about 1 metre all round. For best performance, a mix of the two types is usually required. For more information on this topic, see Mil Spec 59-41, Part 5, issue 2, section 11, available at www.dstan.mod.uk

However, in spite of their faults, plain screened rooms can provide a useful function if used as a part of a compliance test strategy;

The advantage of the room is that there is no background ambient. Any signals from an EUT can be very quickly detected and the frequencies noted. Having listed these frequencies, the EUT can be taken outdoors to a site which is your best approximation to an OATS, and **JUST THE PREVIOUSLY NOTED FREQUENCIES MEASURED**. No need to blindly trawl through the whole range of 30 to 1000MHz! For better measurement uncertainty, use an Emissions Reference Source to characterise the outdoor site at these same frequencies. If background emissions coincide with the EUT emissions, assume a power summation of the two signals occurs. For instance, assume we have a background of 40dB and a level of 46dB when the EUT is switched on. A 6dB increase is equivalent to a doubling of the field strength. This being the case, the EUT's contribution must also be 40dB. The actual calculation involves anti-logging the two measured figures, one for the background level and the other is EUT + background, subtracting the resultants then re-logging the answer. Analysers such as the Laplace SA1000 will accomplish all this automatically.

If you have no choice and must use a screened room then, if the product is relatively small (12" cube or smaller) you can use an ERS to characterise the site attenuation of the room. The ERS should be located at the precise intended location of the EUT to perform the room calibration over the full frequency range. Then the ERS should be substituted for the EUT and the calculated corrections applied to any emissions. This should give a result which will be a reasonable match to a OATS test. The problems start however when the source becomes relatively large. The classic case is the mains lead. This may be 2 metres long. It therefore does not correlate with a point source such as an ERS. One solution is to 'scan' the volume occupied by the product and its leads; this involves many ERS scans covering a matrix of positions covering the space to be occupied by the EUT. In practice, it is far quicker and easier to obtain the scan of the EUT first, identify the frequencies of interest, then use the ERS to selectively characterise the chamber just at those particular frequencies.
