Automatic calibration of EMC test sites for radiated emissions measurements

The Problem

It is well known that test site characteristics have a significant effect on the accuracy of radiated EMC measurements. Laplace has now released a new version of their EMCEngineer software which, when used with a Laplace EMC analyser, will provide an automatic calibration of any test site, and apply the necessary corrections to the results.

Apart from issues related to EUT cable configuration, there are two major issues that affect the integrity of radiated EMC measurements. These are related to the test site.

1. On any 'open' site, there is the issue of background (ambient) noise. There are methods available to overcome this by using background cancellation.
2. The effect of reflections. Even on a perfect open area site, the ground plane reflection can cause an error of over 15dB if height scanning is not properly used. Manufacturers who are using the self-test, self certification strategy will typically use a car park, conference room or loading bay (anywhere that a reasonable space can be found). Such sites will inevitably suffer from multiple reflections and additionally, a ground plane is generally not fitted and height scanning will not be performed. On such sites errors of +15dB, -12dB will be typical. Clearly, there is room for improvement. If these errors can be significantly reduced, the integrity of the self certification declarations will be much enhanced.

Laplace has been working on a solution to these difficulties for several years, and has now completed the development of a technique which overcomes this 'site performance' problem. This technique has now been rigorously tested and is available as an update for the EMCEngineer software program included with the Laplace range of EMC analysers.

A solution

The principle of test site correction is simple… take an emission source that has been accurately measured on a perfect test site, place it on your test site at the EUT location and measure it. If the test site was a good as the 'perfect' site, the results would match. In practice, the results would show significant deviations, but the level of that deviation defines the correction that would have to be made to make the site correlate with the reference site.

The source that is used is an ERS, a 2MHz comb generator which has measurements that are traceable to the NPL site at Teddington. It is supplied with a data file that lists the emission levels for every 2MHz harmonic, for both vertical and horizontal polarisation. In effect, it is a transfer standard. The procedure that is used involves several steps… all prompted by the software…

- The ERS is first switched on and the emissions scanned just in the upper frequency range 500-1000MHz. This is purely to identify the precise frequency of each 2MHz harmonic. The process allows for the fact that site conditions may make the ERS emissions difficult to 'spot' at some frequencies due to ambient conditions and site attenuation factors. The software includes an algorithm that is able to extract the precise ERS frequency.
- Now that the ERS frequencies are precisely known, the analyser measures each peak, using a 2MHz (nominal) step size, rather than the normal 50KHz step. This results in a fast scan of 485 points, instead of the 19,400 points obtained on a normal scan. To ensure accuracy and to even out short term ambient effects, the fast scan is repeated 8 times and the results averaged.
- The ERS is now switched off and the same 8 scans repeated again, this time to measure the ambient level at those same points.

- From these two sets of results, the software can cancel out the ambient to arrive at the true level of emissions from the ERS.
- The software can now compare the ERS emissions as measured on site with the calibration data as measured on a 'perfect' site, and thus derive a table of correction factors. For example, if at 456MHz, the ERS measured 61dBuV/m, and the calibration data gave a figure of 68dBuV/m, then the correction factor would be plus 7. This calculation is repeated for all 485 points and the resulting correction table saved. All this processing is automatic.
- The process can then be repeated for the 'other' polarisation.

So we now have the correction data that will adjust measurements of emissions from the location of the ERS so that they match what would have been measured on a perfect OATS.

Note that this correction applies ONLY to emissions originating from a specific location. So when the EUT is to be measured, we need to apply the correction ONLY to the EUT emissions. This means that the ambient should be first measured so that it can be removed from the scan of EUT emissions. The software uses a difference trace technique to achieve this requirement. This difference trace will have only those emissions originating from the EUT. The correction is then applied to this difference trace.

<u>A real test</u>

To obtain a clear indication of the effectiveness, we generated an artificial calibration set for an ERS which sets the emission level at 60dBuV/m across the whole frequency band, 30MHz – 1000MHz.

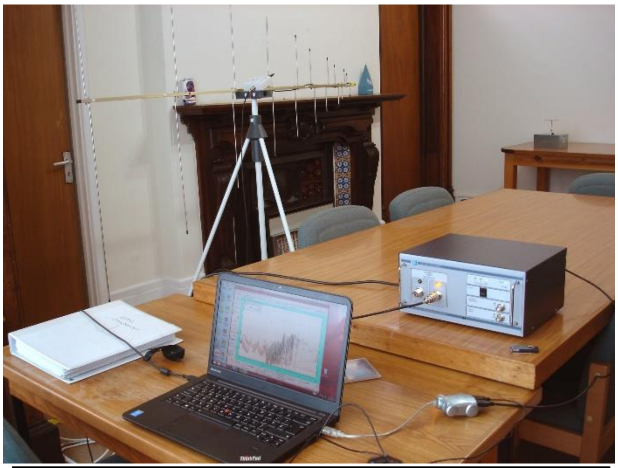

Fig 1. Test site

For a test site we used an indoor site, actually a meeting room in our offices. This is probably typical of the kind of site used by many companies who are adopting the self-test strategy. Outdoor would obviously be better, but it's too cold and wet! The site we are using has the advantage of being relatively free of metal structures (brick building, wooden tables and chairs), but has the inevitable plumbing, central heating pipes and radiators, wiring and electrical panels (just the other side of the adjacent wall).

The ERS can be seen on the table at the far end. An RF200 antenna, the SA1002 analyser and a notebook PC complete the picture.

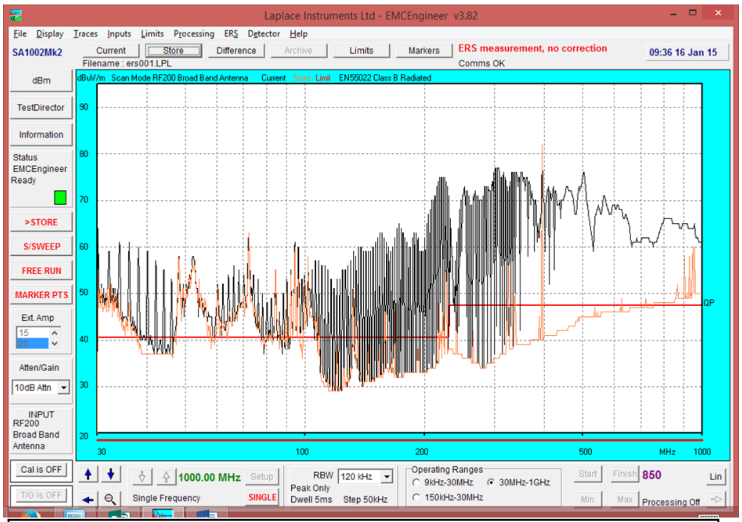

Fig 2. Initial scans

Test distance is 3m. This is the distance used to generate the calibration data at NPL.

The site calibration process was run as described above. Then the ERS was used as the target for a conventional EMC emissions measurement. First the ambient was measured (ERS switched off) then the ERS was measured.

See fig 2.

The ambient scan is shown as an orange trace. This shows that the ambient emission level is fairly typical with general noise below 100MHz, the FM broadcast stations 80 – 106MHz, Tetra showing strongly at 393MHz and some mobile phone activity around 900MHz.

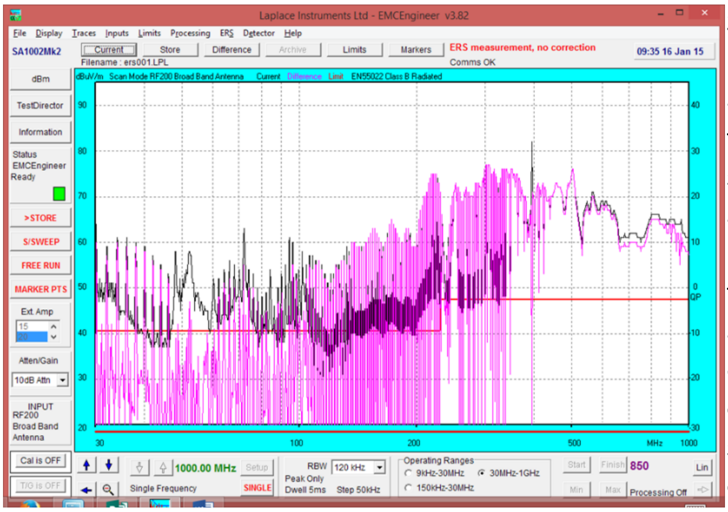

Fig 3. Difference trace, no correction

Switching on the difference trace shows how, in general, the emissions a measured are very largely due to the ERS. Only at frequencies below 100MHz are there significant components due to the ambient. Note how the difference trace is not a ‘simple’ difference. For example, if the EUT + Ambient is 70dBuV/m and the ambient (orange trace) is at 42dBuV/m, the difference is NOT 28dBuV/m, but is very close to 70dBuV/m. This is due to the log scaling of the vertical axis. The difference is calculated by first converting the levels (70 and 42) back to a linear number, subtracting, then converting back to log scaling.

Note also how the ERS emissions vary very significantly across the whole band. They should be a flat line at 60dBuV/m! This effect is typical, and largely due to test site characteristics. There will also be lesser effects due to antenna calibration, cables, pre-amplifier and analyser uncertainties.

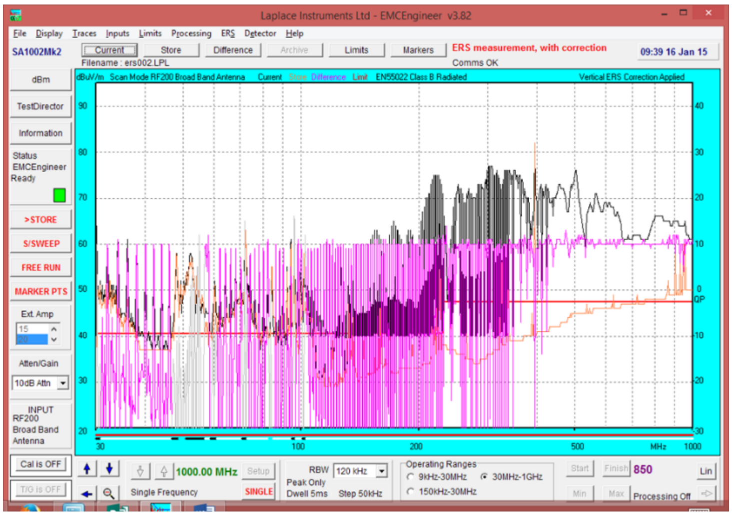

Fig 4. Difference trace, with correction

Fig 4 now shows the effect when we switch ‘ERS Correction’ on.

Fig. 5 is the same result, but with the ‘current’ trace switched off so that the difference trace can be seen more clearly.

It is obvious from the resulting correction that the whole process is very effective. The general level is with 2 or 3dB of the required 60dBuV/m apart from some points below 100MHz. The software automatically marks any results that have reduced integrity. These are shown as a change of trace colour

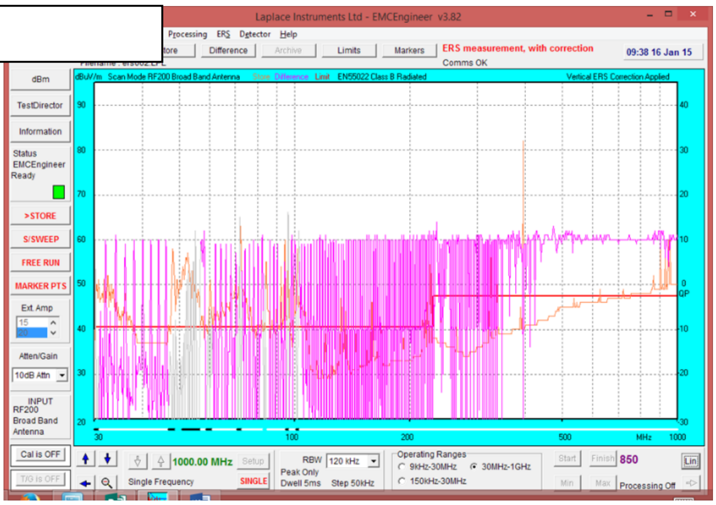

Fig 5. Difference trace, easy viewing!

and have a black indicator in the bar running across just below the horizontal axis.

There are clearly some deviation in the 900 – 960MHz area. These are due to mobile phone activity. These signals are, by their very nature, intermittent, and if (as in this case), they were active when the ERS calibration scans were in progress, but not when the check scan was performed, the results will be as seen. In practice, using averaging techniques not used on this occasion, these rogue peaks would be largely eliminated.

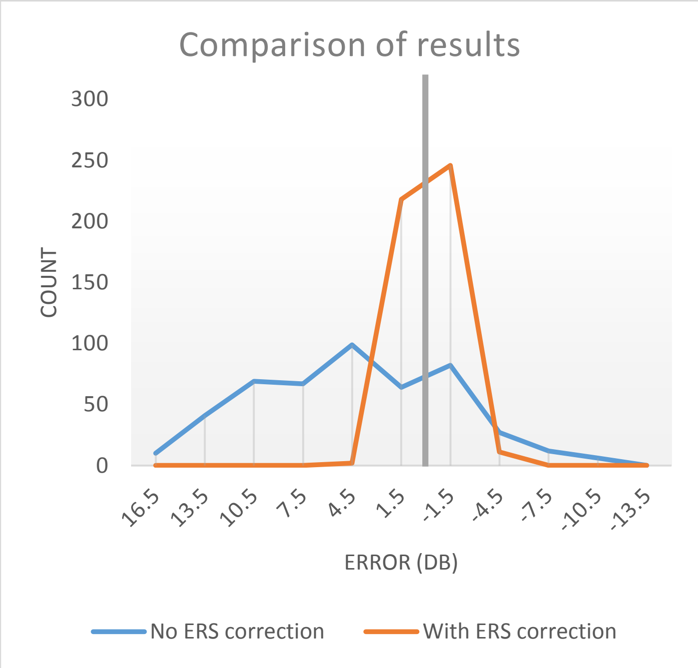

Chart 1.. Comparison of results

Chart 1 shows an analysis of how each 2MHz point compares with the 60dBuV/m 'true' level. This chart shows the number of results (count) in each 3dB block, ie… 18-15dB, 15-12dB, 12-9dB … etc….
Note that the total number of results is the same for both tests, but the test with no correction are clearly spread over a much wider band of error.

The points that have been marked as having poor integrity have been discounted. This shows that the spread of error without ERS is spread across the range +15 to -9dB, whilst the results with ERS are virtually all in the band +/-3dB. Out of a total of 485 measurements, some 450 are within 3dB of the correct value.

<u>Limitations.</u>

The technique relies on the fact that the ERS and the EUT source are located at the same point in space. With a small EUT, this is easy to arrange. However, for larger EUTs and EUTs with cable attached, then this can degrade the effectiveness of the technique. Also, the ERS is a point source whilst EUT emissions may be from a distributed source eg… from a cable. The degree of senistivity to location will be dependent on how 'confined' the test site is. By 'confined' we are relating to the amount of reflecting surfaces in the immediate vicinity. Filing cabinets, radiators, structural steelwork, cabling, plumbing, funiture with metal frames etc… will all make the site more confined. In this case, the location of the source becomes more critical. A strategy that would improve the accuracy of measurement would be to first perform emission measurements on the EUT, then to use near field probe techniques to identify the dominant sources, then to locate the ERS accordingly. Alternatively, the ERS calibration could be performed at a central location using the the '0060' calibration file as the reference, then to measure the ERS when located at the boundaries of the site to check the variation.