EMC HIRE Ltd
Ivel Road
Shefford
Bedfordshire. SG17 5JU
Tel: 01462 817111
Fax: 01462 817444

-

The IEEE EMC Society UKRI Chapter, Special Event held at National Space Centre, Leicester. Wednesday 21st June, 2006. Talk No. 4 @ 2pm, by John Wombwell, of EMCH Ltd.

Evaluation of the Reference Site Method (RSM) CISPR 16-1-4 for accurately determining the SA of any Groundplane

1.The Project and Background

An application to apply for consultancy with the Metrology Group at the National Physics Laboratory, Teddington had been successful allowing EMCH Ltd. to undertake a series of experiments on the NPL Open Area Test Site in November 2005. The project was in essence to look at measurement repeatability over the 30m x 60m groundplane using the "Reference Site Method" (RSM). If this repeatability remained within acceptable limits then a feasibility study would be started with a view to performing the Site Attenuation measurement via the RSM (CISPR 16-1-4) instead of the more traditional method. During that period, liaison with the NPL site staff afforded guidance and general help in making the most of their facilities.

2.The Test Site

The NPL Open Area Test Site is a purpose built structure for essentially providing industry with a national standard. It represents a flat uninterrupted metallic ground cover with excellent conducting properties from DC up to UHF. Any other vertical structures, either natural (trees) or man made (huts/posts), are sufficiently distant as to avoid any discernible radio reflection. The surface is made up of continuously welded 8mm galvanised sheet steel plates measuring approx 2.5m x 1.5m forming one large rectangle whose final dimension is 30 metres x 60 metres. The surface is painted white to reduce absorption of the sun's rays whilst the foundations allow for expansion and heavy devices to be placed on its surface. It is in essence the near perfect electrical groundplane from which the majority antenna properties and general electro-magnetic surface propagation phenomena can be observed and measured. It is therefore accepted as a national standard.

3.The Task Environment

Radiated EMC measurements to international standard CISPR 16-2-3 are carried out mainly on either an open area test site (OATS) or within a semi-anechoic room (SAR) with a fully conducting groundplane, the purpose of which is to emulate an OATS but without the RF ambient noise. The conducting groundplanes of both environments should provide an ideal reflective surface but the quality of which may vary and require periodic validation using methods described in CISPR 16-1-5.

In addition to errors pertaining to the groundplane conductivity, the vertical environment in the form of reflective obstacles on an OATS or the inability of the chamber structure above floor level to fully absorb all the RF energy has also to be ascertained as this too can change over time.

4.Current Validation Method

The present method of validation, namely CISPR 16-1-5, relies in the main on transferring the conductive characteristics of either the NPL site or some other considered site into an antenna parameter which can then validate further sites. These sites are then often used to perform (typically, via the three antenna method) an antenna calibration which in turn is again used to validate further sites. This procedure can import as many as three separate limits of uncertainty which, if remaining in phase, could report the source site as being up to ±3dBs in error if the measurement "loop" were to be completed.

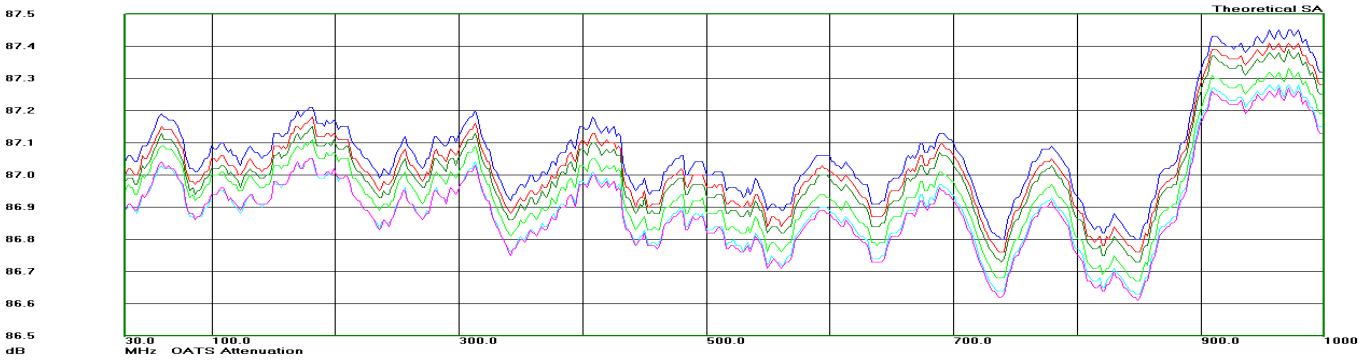
NPL's "Reason for Consultancy" document discusses this procedure and concurs the standard method imports too many uncertainties into the final measurement.

5.Proposed Modus Operandi

EMC Hire who in the past undertook many NSA tests (using the antenna factor method) were also aware of the uncertainties offered to clients and independently in 2001 produced an NSA program controlling a measurement system which in essence treated the NPL site as a "zero error" platform. Once scanned, an algorithm would finely adjust the antenna factor file within the NSA program such that a repeat scan would then measure and confirm a "zero error" (within limits of the system repeatability). The same system could then be transported to a customer's facility, and make a repeat measurement. This would produce a direct comparison with the industry's root standard in both surface conductivity and any unwanted vertical reflectivity. Limits of uncertainty have so far been narrowed down to ±0.3dBs using the RSM. EMC Hire have measured many sites and chambers since 2001 and have confidently issued graphical data which they feel has accurately described the quality of the groundplanes thus measured.

6.Method Investigation

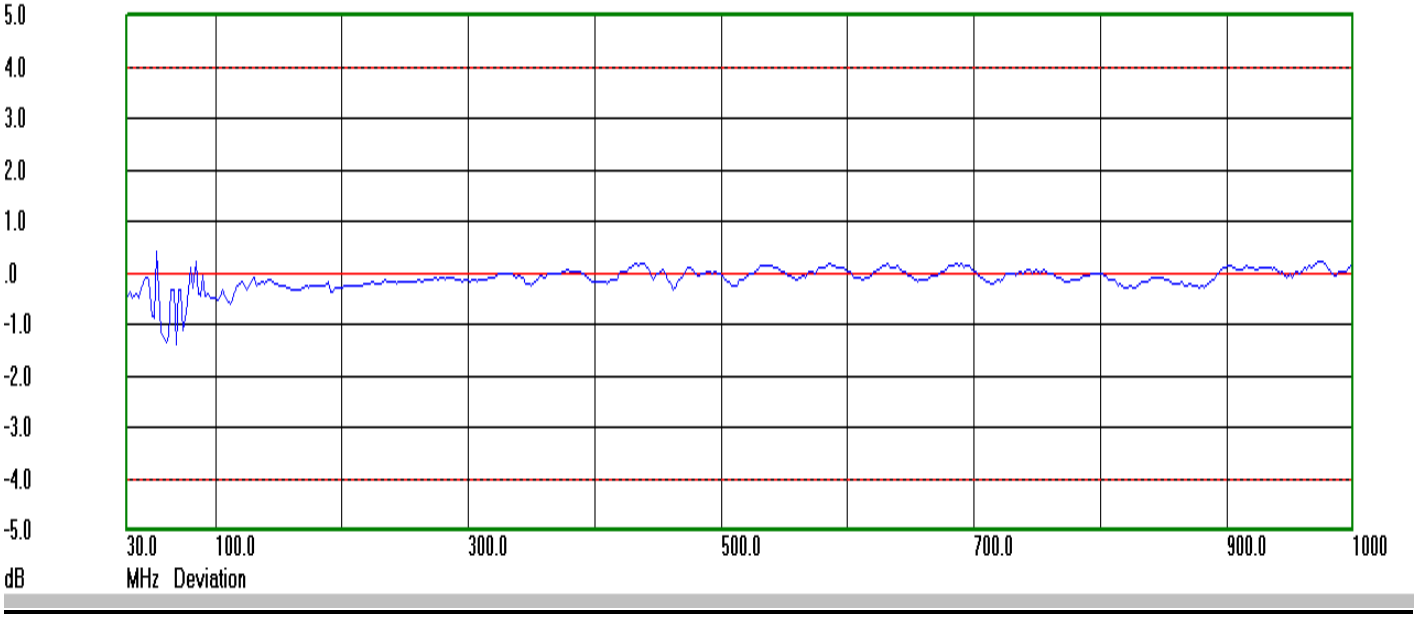
NPL were basically sympathetic to this concept but realised that pivotal to any acceptance was the system's and their site's repeatability. To this end, consultancy was offered on the NPL Site to investigate this and other related parameters. Luckily, the measurement is essentially relative rather than absolute and looks at the difference between coaxial and radiated transmission paths. The measurement system comprises four components, namely: 1. A quality receiver with tracking generator (TG). 2. Amplification of the TG output. 3. Quality coaxial transmission paths to & from the antenna platforms. 4. The two antennas chosen to complete the radiation path. To start this analysis one must first look at the stability of the raw signal source. This was set up away from NPL and recorded over a period of 7 hours. The results can be viewed on the Eml/NSA program as shown below.



The display above is a linear sweep from 30MHZ to 1GHz with the receiver measuring its own fixed TG o/p via a short coaxial link. The full vertical axis amounts to 1dB, hence each vertical division being 0.1dB. After the Rx's 3 hour settlement period a sweep was made at 10:00am (blue); 11:00am (red); 11:30(dark green);14:30 (light blue); 15:40 (cyan) and finally at 17:30 (light green).
There was a downward "creep" in the order of 0.0286dB/hour. When however the amplifier is used to boost the TG output then this "creepage" gathers pace. Several measurements were noted over 5 hours in the method used above and a figure now of 0.72dB /hour was measured which will include the TG drift. The time normally taken to complete the direct coaxial connection, measure, and then re-connect to the antennas and complete a height scan in both directions would be in the order of 5 minutes. So, during this time elapse we could expect a reference measurement drift of approximately 0.05dBs. An acceptable amount for the project in hand.

As both antennas in the operation are passive and handling less than a Watt we would expect no discernible change in factors to occur with temperature.
The next task in the measurement process is that the receive antenna must perform a height scan from 1 to 4 metres. This is to enable the receiver to record the highest signal strength from the direct and reflected wave from the Tx antenna as they arrive with a changing phase relationship.
With a Rx bandwidth of 100kHz the default sweep duration is approximately 375 milliseconds or 2.666r scans/s. These scans are "Peak Held". The mast's has a 3m vertical traverse time of approximately 40 seconds ± 3 secs (or 7.5cm of mast travel per second). The maxima of both direct & reflective rays is confidently achieved by calculating that changes of antenna height of roughly 2.8cm occur every sweep of Rx, which is of course "max holding". It can be reasonably assumed that a true "maxima" would be achieved especially as the Rx "max hold" is maintained for a second downward traverse of the mast.

As an example of this operation, a repeat NSA was performed on the NPL site having just deployed the antenna factor adjustment via the RSM procedure discussed above. (This was a vertical polarisation over a 10 metre site range). The results of this are shown below. This is one of several repeat scans completed, all of which displayed slight variations in the order of ± 0.3dBs. This excludes the erroneous pick-up of the BBC radio channels from 70 thru 103 MHZ. This could be eliminated by using more transmission power to overcome the poor transducer factor of the miniature biconical used as the transmitting source.



Later investigation into the origin of this uncertainty/variation of ± 0.3dBs revealed that the coaxial return loss figure over a total length of some 60 metres was vulnerable to slight changes due to 1. Temperature caused by the sun's rays 2. General movement and stretching as it is hauled up through 4 metres.
This could be reduced by using a still higher quality coaxial transmission without any connector joins.
Fibre optical transmission is now being looked at to reduce the overall variation in the order of ± 0.1dBs

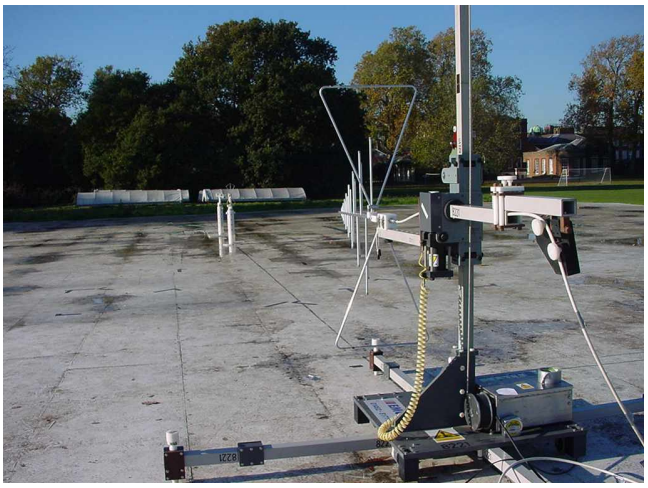
Summary of the RSM (CISPR 16-1-4) for NSA measurement

As mentioned in paragraph 4. errors using the traditional method could possibly amount to ± 3dBs in the assessment of a third party OATS or SAR. And as the pass/fail limit is set at ± 4.0dBs, it does not give any site under investigation much leeway for natural error. The present CISPR 16-1-5 can also call for a volumetric measurement made at the EUT end with some ten points of transmission in just one polarisation. This in itself would involve re-calculating the AFs for each position based on an original single calibration with its incumbent uncertainty. Alternatively, one is paying to have separate figures produced for each position. The RSM procedure allows for easy repetitive scans to be made from each position & polarisation with the subsequent naming of each antenna file appropriate to that position. The cost & time saving here is considerable. And finally, at the present moment in time, there is the opportunity to report out within the order of ± 0.5dBs how any site or SAR directly compares with the country's national standard OATS.

Although the Author has pioneered this method over several years along with the software package, any EMC accreditation group or individual test house is free to book up the NPL site for a day or so and carry out this procedure and obtain the necessary data or factors using their own hardware. They would then be able to assess their own facility and that of others with the same ease and similar limits of uncertainty.

International Acceptance of this method

At the time of presenting this talk at the IEEE EMC Soc. UKRI Chapter, discussion is underway in the various European "Working Groups" formed within CISPR to present this method at least as an alternative to the traditional "Antenna Calibration" Method. It would appear that Germany is favourably disposed toward to the Reference Site Method outlined above.



Concluded