Pre-test checks how and why?

It is usual for the equipment used in an EMC test laboratory to be fully calibrated at periodic intervals. Such calibrations are typically undertaken annually, a trade-off between confidence in the accuracy of the equipment against the cost and downtime associated with the calibration process.

In the period between calibrations it is just as important to perform regular verification and monitoring of the particular test setups for the following reasons:

- The need for confidence in the operation of the test setup
- The need for confidence in the measurement equipment performance
- To provide continued monitoring of trends in system performance
- To provide repeatability data for uncertainty analysis
- To demonstrate compliance with the requirements of quality systems (e.g. ISO 17025)

This is especially important when equipment and facilities are used for performing several different tests, with equipment being assembled and disassembled frequently. When testing a novel piece of equipment with unknown characteristics, as is usually the case in commercial EMC testing, it is vital that the characteristics measured are of the equipment under test and not the unwitting result of, say, a loose connector somewhere in the measurement system. Pre-test checks have two requirements in addition to accuracy and repeatability:

- To be worthwhile, a pre-test check needs to allow as much of the complete test setup to be examined as possible.
- The test needs to be performed quickly so as to minimise the effective downtime.

Placing a single known reference signal or disturbance in place of the test subject addresses the first requirement. By placing the known source in-situ prior to the Equipment Under Test (EUT), any deviations from the expected performance can be identified. This also has the benefit of not requiring any extra setup time. In the case of emissions measurements, a simple verification might involve a single frequency spot check. This is certainly quick, however it might easily miss problems elsewhere across the frequency range. Multiple spot frequency measurements, such as those afforded by using the signals produced by a comb or harmonic generator are a significant improvement, but may still miss some of the finer detail. However, a wideband noise source allows such detail to be examined.

For thoroughness a pre-test check should ideally comprise the actual test to be performed on the EUT. However the second requirement, to minimise downtime, may make this impractical, so a stripped down version is usually more appropriate. Again taking the example of emissions testing, this could be a version of the test to be carried out on the EUT which uses a greater frequency step size, so introducing a sampling element but significantly reducing the time taken to perform a measurement sweep. A pre-test check that only takes a few minutes to perform and produces worthwhile levels of confidence is more likely to be used than one that is long winded or prone to error.

The data taken from regular verification measurements should be recorded over time. Examination of these results will give valuable information on the following:

- Variations in day-to-day test setups
- Long term trends in measurement results
- Periodic trends in measurement results

Variation in day to day test setups are inevitable and are influenced by such factors as:

- Specific measurement equipment used, particularly if equipment is shared between different environments (e.g. a receiver used for an OATS and chamber tests) or reconfigured (e.g. if correction factors are loaded into the test equipment for direct application to the measurements)
- Ambient measurement conditions, such as temperature, humidity and/or cable positions.
- Measurement personnel, the “human factor”.
- Small variations in test distances, especially important at >1 GHz frequencies, but also important if the test environment exhibits irregularities, nulls or undamped resonances.

When these variations are examined then a random element can be extracted and fed into the measurement uncertainty budget for the given test.

Stable reference sources such as the York EMC Services’ range of noise, comb and harmonics/flicker generators provide a flexible tool to aid in the verification of test systems. As an example a CNE, comparison noise emitter, can be used to monitor a radiated emissions test setup on a weekly basis over a year.

Procedure

This example shows the use of a CNE VI to validate a radiated emissions test setup in a fully anechoic room (FAR). The procedure involves simply placing the CNE VI in a prespecified position and running the standard emissions test (see Figures 1 and 2).

An ideal position for the reference source is the typical location of the EUT. In this example, the standard emissions test is carried out at a distance between the antenna and the EUT of 3 m, with the EUT elevated by 0.86 m on a non-conducting surface. To speed up the pre-test time, a modified version of the usual measurement test script can be used, with an increased step size of, say, between 1 and 5 MHz. This can reduce the pre-test time compared to a full EUT test, which may be significant when using older test equipment. In a commercial operation, a pre-test taking only a few minutes could be run whilst booking in the customer’s equipment.

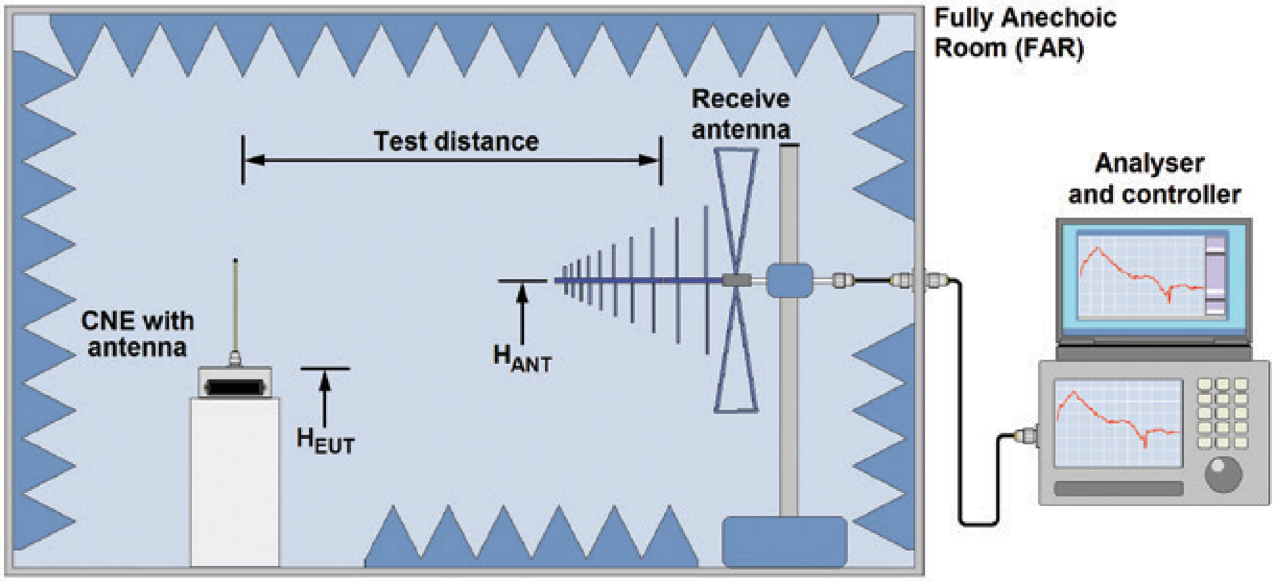

Figure 1. Radiated emissions pre-test check setup

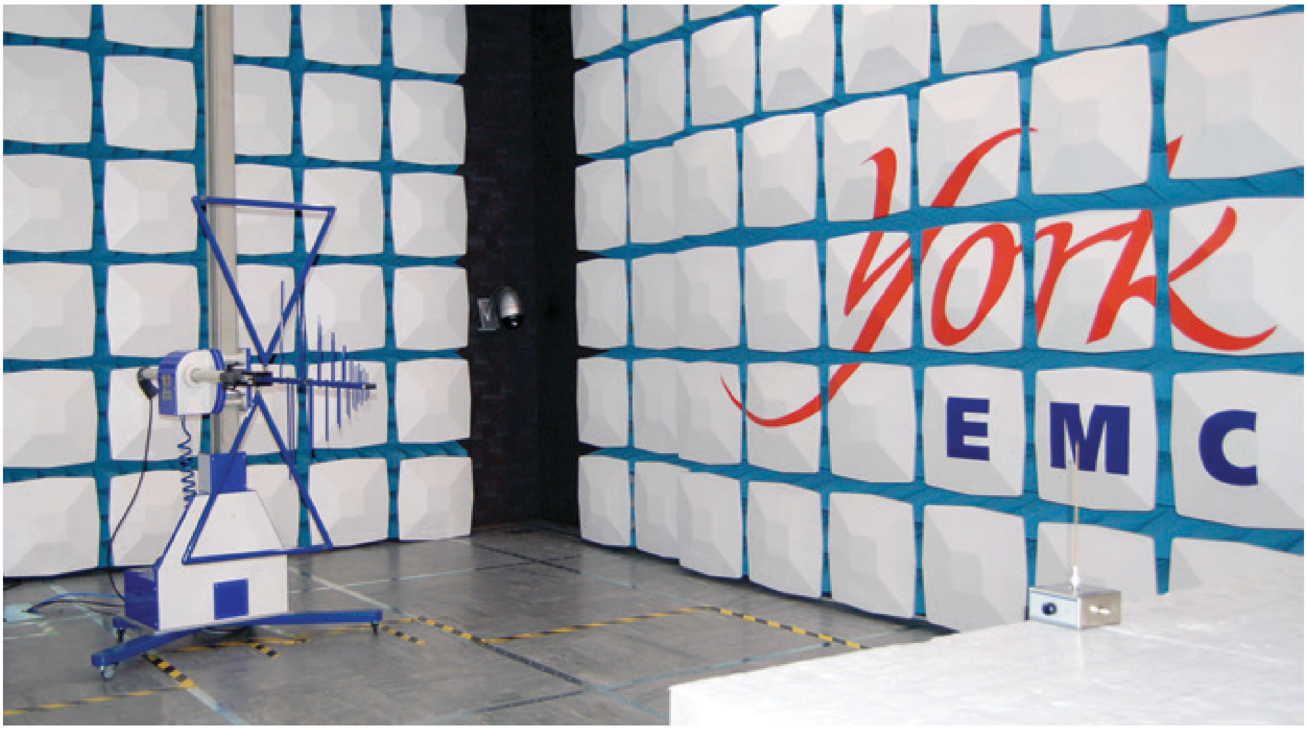

Figure 2. Radiated emissions pre-test check in operation

Figure 3 shows a possible result of a regular weekly verification for a single frequency of a radiated emissions test. Here a noticeable long term drift in the measurement result can be seen superimposed on the random error. This long term trend could be due to, for example, the receiver ageing or to a gradual deterioration in the performance of the test site. In this case the information might also trigger an investigation into the cause of the drift and inform the planning process on replacement and refurbishment of equipment.

Figure 4 shows another example of a verification result plotted over time. In this case there can be seen both a periodic trend and random element in the result. The periodic trend could be owing to seasonal temperature fluctuations for example. If the source of the drift can be identified and quantified then it may be possible to add a correction factor into the measurement. If the source cannot be quantified then it will be necessary to include the drift magnitude as a source of uncertainty in the stated measurement result.

It must be stressed that results such as these can only be meaningful if the source used for verification purposes is stable over all expected operating conditions and over time, characteristics inherent in the design of the York EMC Services' reference sources.

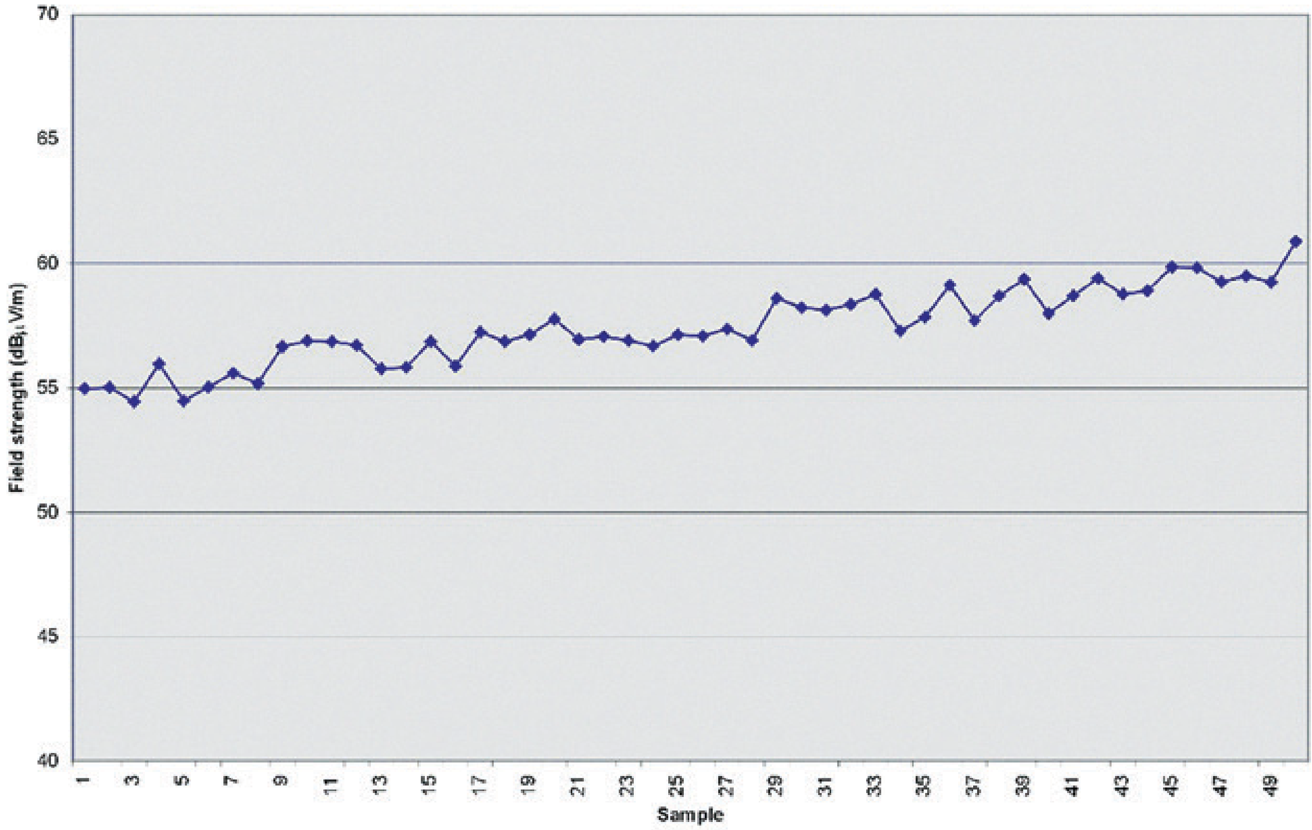

Figure 3. Sample measurements taken weekly

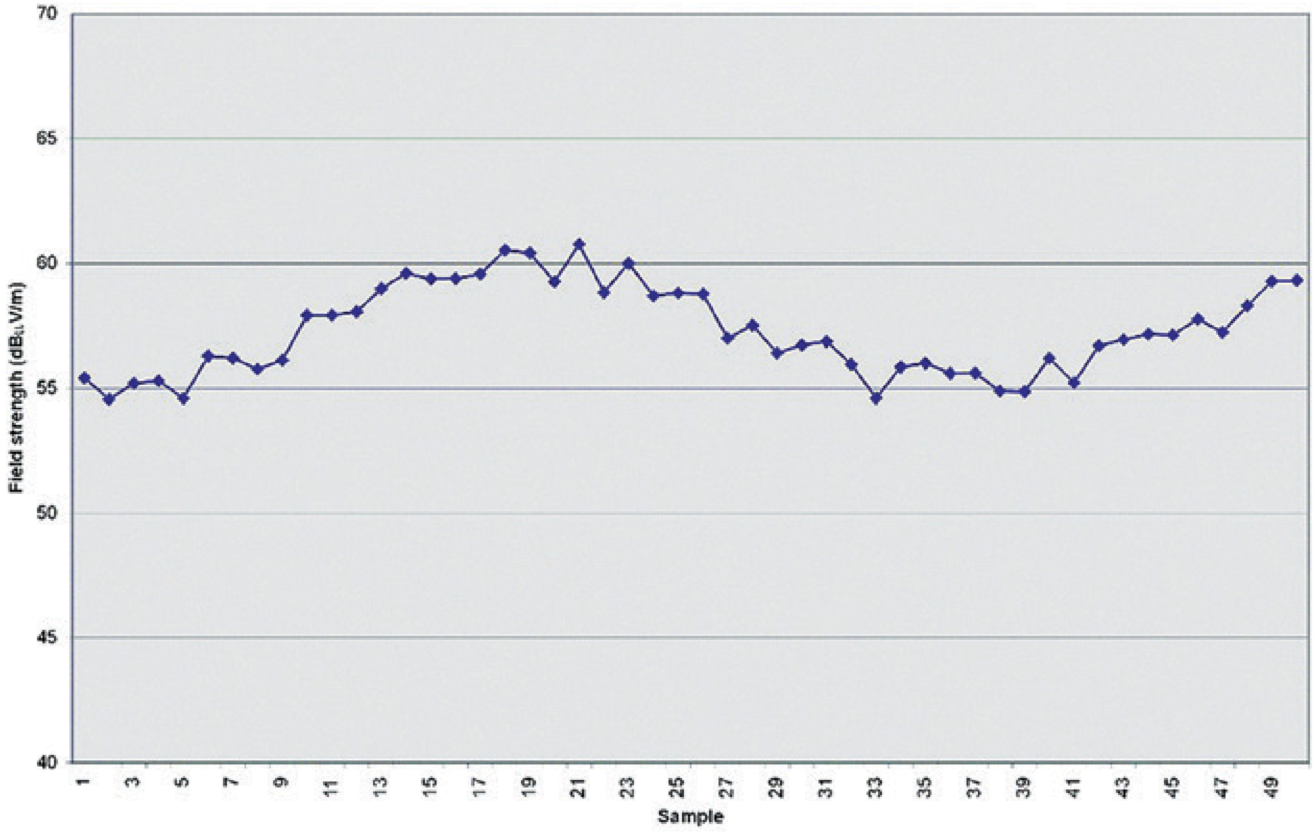

Figure 4. Sample measurements taken weekly

Examples of test setup problems identified using verification methods

The following three examples show the kind of problems with measurement setups that can be encountered in a working laboratory, which were identified by performing the kind of quick pre-test checks described (see “Pre-test Checks How and Why?” and “How to use an HFG to check harmonics and flicker test setups”).

Damaged measurement antenna in a fully anechoic room

Figure 1 shows the result of a radiated emissions verification made in a fully anechoic room. The verification measurement (grey line) differs significantly from the expected reference result (black line) over part of the frequency range. In this case damage to low-frequency elements of the measurement antenna was found to be responsible for the loss in performance.

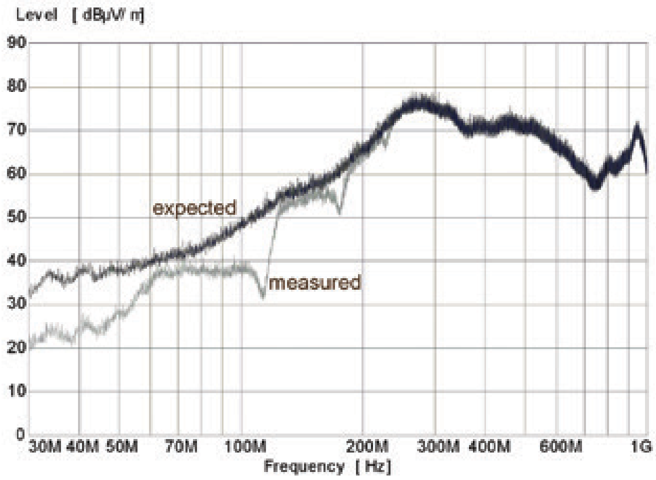

Figure 1. Damaged receive antenna used in an emissions setup

Water ingress into connectors on an OATS

The expected (based on previous measurements: grey line) and actual result of a verification on an OATS is shown in Figure 2. The unexpected readings (black line) and periodic variations in levels were traced to water ingress into an RF connector adaptor used for joining two cables together, introducing both transmission effects and mismatch errors. The resultant corrective actions included the withdrawing of the particular connector from service and the redesign of the weather protection for cable joints for this site.

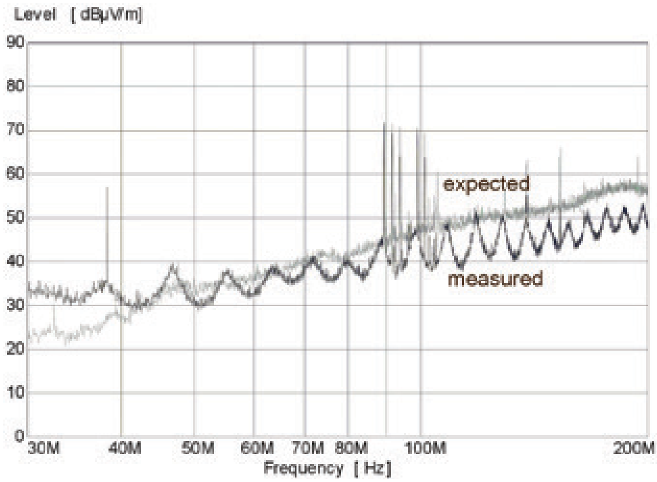

Figure 2. Effect of water ingress into a connector used on an OATS

Source impedance error in harmonics/flicker equipment

A comparison made using an HFG01 between a number of harmonics and flicker measurement setups used in different test facilities indicated a problem with several of them when measuring short term flicker (Pst). Figure 3 show the variance in the results obtained, with test setup 3 taken as the reference norm. The accuracy limit required by EN 61000-3-3 is +/– 8%. One result (not shown) yielded an error of over 300%, well outside the range of values given by the other setups.

Each test setup was built around separate items of equipment of various lineage, generally a “clean” supply source, an external reference source impedance and a harmonics/flicker analyser, all under the control of standard test software. In the case of the “rogue” measurement each item of equipment was fully within calibration and, when taken out of the setup and examined individually, appeared to be working satisfactorily.

The problem was traced to an incorrect source impedance being selected by the control software, which was not made clear to the operator. This problem was easily remedied by resetting the test software parameters, however a point noted was the spread in results achieved over all the test setups used. Apparently minor details, such as the quality/tightness of the connections to the reference

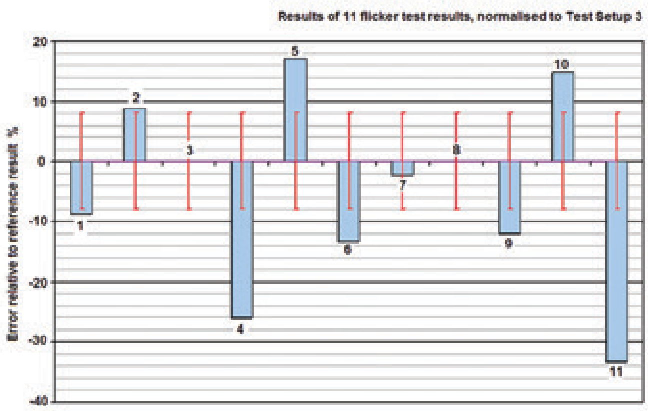

Figure 3. Variance in measurement across flicker tests

source impedance across which the voltage deviations are measured, conspire to increase the measurement uncertainty beyond what might be expected. In this case, the uncertainty of the whole is clearly greater than the apparent sum of the parts, and would only be noticed by exercising the system as a whole.

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