ANNEX TO NPL CERTIFICATE FOR BICONICAL AND SHORT DIPOLE ANTENNAS

Antenna Factor

Where the antenna factor has been given for a specific configuration above a ground plane (including free-space), the associated uncertainties only apply when the antenna support structure, including the input cable, does not cause significant reflections which would affect the received signal. If there are any significant sources of reflection then the user should asses the resulting uncertainty and treat it as an additional uncertainty term. For calibration purposes the free-space condition is achieved by mounting the antenna vertically polarised at a height above the ground plane at which mutual coupling is negligible.

Where there is a sharp resonance in the antenna factor the uncertainty given in the certificate does not apply. At the frequency where the resonance causes a deviation of greater than 1 dB from the overall trend of the data, the magnitude of the increased uncertainty can be estimated from the height of the spike on the antenna factor graph. The affected range can be taken as ± 1.5 % of the centre frequency. because the data is sampled at discrete points the maximum error may be much larger than that shown in the antenna factor graph.

The antenna factors are valid at the measurement height for any separation distance from the source exceeding one wavelength. For shorter distances the change in antenna factor with distance becomes significant and additional uncertainty would therefore be introduced. When the antenna is used for emission testing at a distance of 3 m from an equipment under test, whose size does not exceed that of the biconical antenna, there is an estimated increase in uncertainty of ± 0.3 dB in the range 50 MHz to 100 MHz, which is caused by mutual coupling of the antenna to the EUT. Below 100 MHz the antenna is in the near-field of the EUT and though the field magnitude will be correctly measured there will be additional uncertainty if the field strength were extrapolated to a greater distance. For extrapolation to a distance of 10 m, which is effectively in the far-field, this uncertainty is estimated to be ± 0.2 dB at 100 MHz and ± 1 dB at 30 MHz.

In order to measure the absolute E-field at different heights and polarisations above the ground plane it is necessary to know the antenna factor at each height and polarisation. However, a viable alternative is to use the free-space antenna factor for every configuration which minimises the additional uncertainty incurred. The additional uncertainty is caused by coupling of the antenna with its image in the ground plane which results in a change in the input impedance. For vertical polarisation there is no additional uncertainty for heights above 1.5 m, but between 1 m and 1.5 m the additional uncertainty is ± 0.7 dB in the range 50 MHz to 100 MHz. For horizontal polarisation, at heights above 1 m, the antenna factor may differ from the quoted values by up to ± 0.5 dB in the range 20 MHz to 50 MHz, and by ± 1.5 dB in the range 50 MHz to 100 MHz, and by ± 1 dB in the range 100 MHz to 300 MHz. The values for horizontal polarisation can be reduced by 0.5 dB for antenna heights above 2 m. The above variations are representative; the exact variation will vary slightly according to each antenna design.

If the antenna is used in an unlined screened room the use of these antenna factors may not give the absolute value of field strengths, but a calibration provides an essential check that the antenna is working properly. The antenna factors can be used to compare measurements made in an identical setup using a different antenna of the same type.

During height scans there will be an additional uncertainty caused by the directivity of the vertical radiation pattern. In normal use, signal maxima on a 10 m range occur for antenna heights below 2.5 m and the error here will be negligible. However, for a 3 m range the received signal could decrease by more than 1 dB.

Balance Test

The balance of the antenna balun may be tested by mounting the vertically polarised antenna in a uniform vertically polarised electric field, and observing the difference in received signal when the antenna is inverted. The change is caused by common mode current on the cable which is caused by an unbalance of the balun. It is important for this test that the cable hangs vertically behind the antenna in the usual manner. Typically there should be a horizontal distance of between 0.5 m and 2 m from the antenna element to the point at which the cable drops vertically. The cable should not move during the course of the measurements. An antenna is considered to have a good balun balance when the observed difference is less than ± 0.5 dB.

The inversion test is a qualitative measurement which reveals imbalance of the balun which, for some models of biconical antenna, can cause a large uncertainty in the measured field when the output cable is aligned parallel to the antenna elements. It is recommended that the user conducts tests of their own to quantify this effect in each particular measurement configuration. Some reduction of braid current can be achieved by the use of ferrite clamps on the cable. For antenna models with significant balun imbalance it is recommended that ferrites are also placed on the cable near the antenna input when the antenna is used for emission testing. Ferrite clamps on the output cable only provide a partial reduction of the braid current; a better solution is to use a perfectly balanced balun.

Return Loss

The quoted antenna factors apply when the mismatch between the antenna and the receiver is attenuated. A well matched 10 dB attenuator is recommended. If no attenuator is used (and the receiver front-end attenuation is set to zero), then the antenna factor can change by ± 1.4 dB at 30 MHz, assuming a receiver return loss of greater than 14 dB, an antenna return loss of 1 dB and a cable loss of 1 dB.

ARP958 Antenna Factor

Measurements at 1 m distance from an emitter is called for in MIL-STD-461D[1], which stipulates that procedure ARP958[2] is to be used for 1 m calibrations. It is necessary to distinguish between AF_{1m} and conventional AF which enables absolute E-field strength to be obtained from the voltage output of the antenna. ARP958 describes AF_{1m} as "apparent" antenna factor because it is derived from equations which do not take near-field terms into account. When AF_{1m} is used to measure absolute field strength an additional uncertainty term of ± 2 dB must be included. This only applies to the frequencies above 30 MHz, below 30 MHz the additional uncertainty is ± 5 dB.

ANSI Height Scan Method

The ANSI C63.5[3] procedure describes how the antenna factor may be measured over a ground plane by a height scanning three antenna method. For each measurement pair, one antenna is at a fixed height and polarisation, and the other is height scanned. The receiver is set to record the maximum measured signal during the scan. In the three pairings each antenna is measured twice, and if the customer supplies two antennas then one of the antennas is always allocated to the height scanning mount, and the other to the fixed mount. An NPL antenna is used for the third antenna which height scans for one pair and is fixed for the other pair.

References

[1] MIL-STD-461D, Requirements for the control of electromagnetic interference emissions and susceptibility, 1993, Department of Defence, USA.

[2] SAE ARP958:1992, Electromagnetic interference measurement antennas; standard calibration method. Society of Automotive Engineers.

[3] ANSI C63.5-1998, American National Standard: Calibration of antennas used for radiation emission measurements in Electromagnetic Interference (EMI) control.