SOME OBSERVATIONS ON RFI/EMI MEASUREMENTS

A great deal of uncertainty exists with respect to RFI, EMI and TEMPEST type measurements, whether the problem is to determine the radiation emission (RE) characteristics of a given piece of electrical or electronic equipment operating in its normal capacity, or to determine the radiation susceptibility (RS) of the equipment. The uncertainty is more in the understanding and interpretation of what has been learned as the result of a measurement than in the measured results themselves. The MIL-STD-461 and SAE ARP-958 specifications are not much help in this respect. They only specify the antennas which are to be used in various frequency ranges for certain tests. Unfortunately, much of the testing is strictly empirical.

Antennas for RE testing may be either passive or active, since they are not required to radiate signals. Some tests for RE involve such weak fields that only an active antenna is capable of satisfying the needs, which almost invariably include a more-or-less flat response without tuning. In either case, the antenna is calibrated by the manufacturer as to its far-field (plane traveling-wave) antenna factor, which has a well-known relationship[1] to the absolute gain of the antenna. Uncertainty about measurement results begins to develop when the far-field calibration curves are used blindly to determine the field intensity at relatively short distances from an emanator, where the field contours are curved.

Now there is nothing special about near fields, except that the field strength in a given direction at a given point is the phasor sum of the static, induction and radiation field components in that direction. When placed in a near-field environment, the antenna develops a voltage at its output terminals which represents the line integral of the incident field intensity projected along its length. The field may be far from uniform or constant in phase. Whatever the nature of the field, the far-field antenna factor calibration renders the read-out as the equivalent plane traveling-wave field. Obviously, this is not the desired answer because the static and induction components of the near field attenuate rapidly as the distance begins to exceed one electrical radian length. Thus the measured field does not represent the situation at any other distance than that at which it was measured. That is, the field at any other point is not readily calculable from the measured result. To complicate things further, the location of the point at which the field was measured is indeterminate. In fact, the field was not measured at a point, but averaged over a finite line segment or even over a surface. These aspects of the measurement are with us whether we are measuring electric-field intensities or magnetic-field intensities.

Another factor that enters the near-field measurement problem is that the near field of the emanator, at least at lower frequencies, will be predominantly either electric or magnetic. That is, the near electric and magnetic fields will not be in the same ratio that they are at large distance. In order to make a proper RE analysis, it is generally necessary to use both electric and magnetic sensors. Here, again, certain frustrations are felt, especially at frequencies below about 20 MHz. At these frequencies, and in the usual closed-space environment where such measurements are usually performed, it is difficult to place a sensor anywhere but in the near field of the emanator because of the long wavelength. It is customary to use a whip-monopole type of electric-field sensor worked against a ground plane for the electric-field evaluation, and a balanced loop sensor for the magnetic-field measurement. The requirement of a conducting floor for the electric-field sensor introduces an environmental complication that may not exist where the equipment under test is eventually to be used. Such a floor is certain also to affect the magnetic field characteristics exhibited by the emanator.

At higher frequencies, where wavelengths are comparatively short, the measurement problem is not so difficult. Directive, passive sensors of relatively small size are available which serve equally well as emanators to illuminate equipments for RS testing. The difficulty with short wavelengths is that the tests must be made from several directions, compared to one or two for the long wavelengths.

With all of the above negativism about RFI/EMI measurements the job nevertheless has to be done, and one rightly asks what can be done to make good sense out of the testing. The answer is very simple in principle. What we really wish to know is the field intensity surrounding an emanator as a function of position. One should therefore use a balanced sensor that is short compared to a wavelength and to the distance from the emanator, and have it with as much amplification and sensitivity as practically feasible or possible. Of course, the smaller the sensor becomes, the lower the noise figure of the associated active circuitry must be and the greater the amplification must be in order to observe the field. The challenge to antenna designers is to design such a broadband antenna. The performance rating criterion[2] proposed in a previous article is recommended for consideration in a new design. The article combined the concepts of antenna factor and the ratio of available noise power to actual noise power to obtain a performance rating formula for active antennas.

The measurement problem for RS is perhaps easier than that for RE. In RS testing, one only needs to observe the performance of the equipment under test when illuminated by a prescribed antenna at a prescribed location and operated at various excitation levels. Some judgement is involved in deciding at what level of excitation the equipment under test is affected, but quantitative knowledge of signal level incident on the equipment is not generally required. One might say the same in reverse for RE testing, because of the principle of reciprocity, but one usually needs to know a little more in RE testing than in RS testing. Given two receiving sensors with identical far-field antenna factor calibration, but substantially different size and construction, one will obtain different results in a short-distance RE test. It is just this kind of thing that points up the need for a quasi-infinitesimal sized sensor, with an accurate calibration. Such a sensor will indicate the field intensity accurately at almost any location relative to the emanator. That is, its antenna factor applies at virtually all ranges for which the field can be considered uniform in phase and amplitude over its length or surface.

One final comment is in order concerning the use of traveling wave directive structures for receiving antennas, such as log-periodic dipole arrays, in the near-field region of an emanator. Such antennas are wave couplers, and are like directional couplers in the sense that they are substantially blind to the static and induction near-field components. The results obtained at distances that can be construed as near-field will be in error at least to the extent of the so-called near-field components, plus whatever additional error may arise due to the averaging effects mentioned earlier. The traveling wave directional sensor is excellent at larger distances where the field being measured is substantially plane-wave in nature.

REFERENCES

1. R.W. Masters, "Antenna Factor", Interference Technology Engineers Master, ITEM 1978, pp. 168-172.
2. R.W. Masters, "A Performance Rating Formula for Active Antennas", Interference Technology Engineers Master, ITEM 1979, pp. 88-90.

This article was prepared for ITEM by Dr. R.W. Masters, President and chairman, Antenna Research Associates, Inc., Beltsville, MD 20705.