NEW ANTENNA SYSTEM FOR HIGH-POWER SUSCEPTIBILITY TESTING

Many of the difficulties associated with shielded-room susceptibility testing are made evident in qualifying equipment designed to conduct just such tests. Because of the problems encountered in quantifying what occurs in a shielded room at any given time, the test-equipment manufacturer is faced with the double task of designing his product and gathering meaningful, useful data on its performance to guide testers in its use.

A new radiator has been designed as an antenna intended specifically for use in a shielded room. It is based on a unique design principle that takes advantage of the structure of the room itself, utilizing a wall or ceiling as the ground plane to greatly enhance the antenna's effective electrical length. Most antennas used in susceptibility testing were originally intended for free-space applications, with specifications and design test data provided for a free-space environment. In the confines of a test room, these data become almost totally invalid.

Part of the problem is that the room looks like a cavity to the antenna, and presents many resonant modes which depend on the various room dimensions and the objects the room holds. This difficulty is compounded at lower test frequencies, where the size of the room approaches the wavelength of the fundamental and it becomes hard to even fit an efficient broadband antenna into the test space.

The new radiator is, in contrast, designed to act as a cavity exciter, and is not intended for use as a free-space radiator. By using the wall or ceiling of the room as a ground plane, it makes possible 30-MHz operation in a four-foot package, where a comparable log-periodic antenna would require at least a 16-foot (½-wavelength) span.

Since the new system was designed for operation in the cavity-like environment of a shielded room, it was important that the specifications and test data reflect actual performance, and arrangements were made to use one of the test rooms at R&B Enterprises, Conshohocken, PA. The room contained the usual copper-covered test bench along one wall, and a utility counter in one corner. The radiator was tried in two locations and E-field readings were taken with the isotropic field sensor in three locations as shown in Figure 1.

Difficulties were encountered almost immediately in the first test. The original sweep from 30 MHz to 1000 MHz indicated wide variations in field intensity caused by room resonances typical of shielded-room operation. The field variations were often in excess of 20 dB peak-to-null, and were frequently only a few MHz apart. The high Q of the shielded room made it difficult to pinpoint the field levels, which at some points were greater than 100 volts/meter at one meter, with only one watt input.

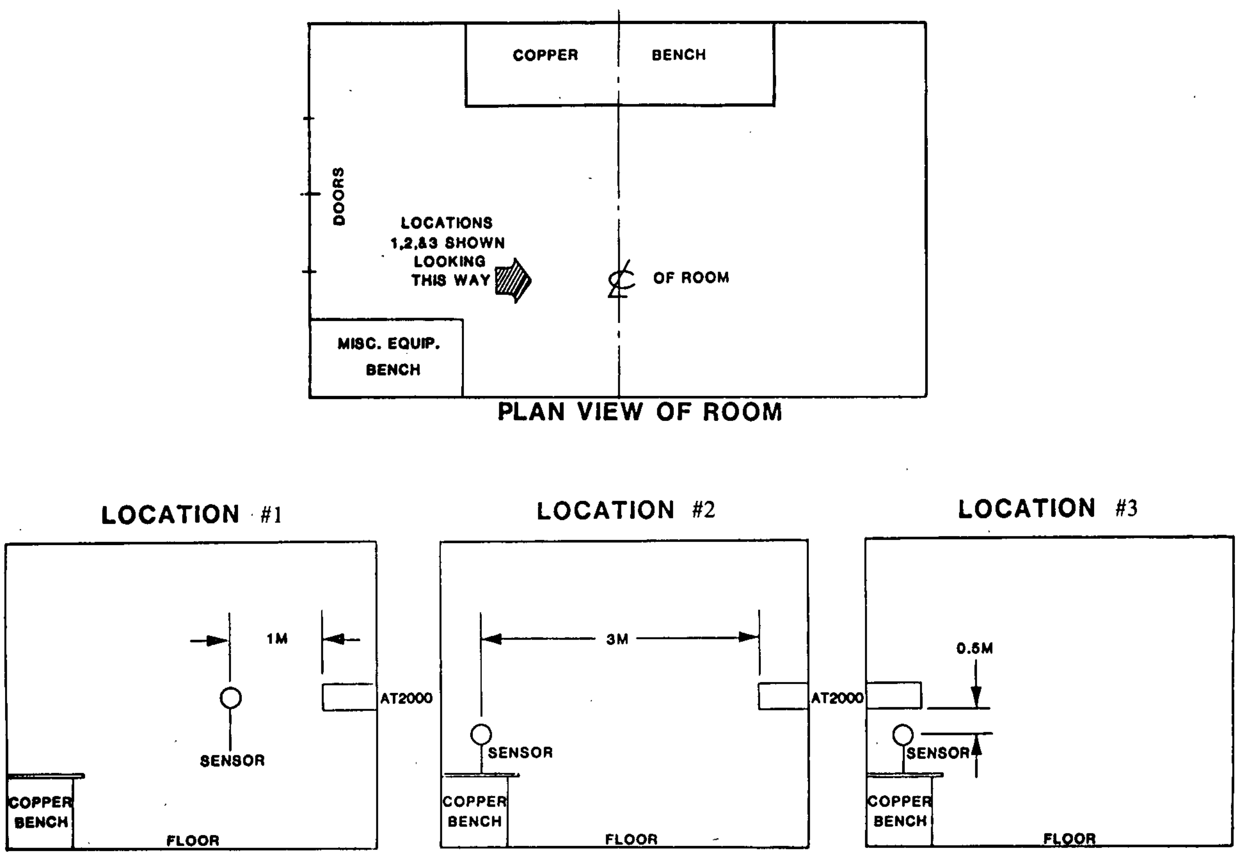

Figure 1. Test Location Diagrams for Room 20′ × 12′ × 10′ (L × W × H)

Rather than attempt a continuous curve of field level-versus-frequency, an extremely difficult undertaking, the test was restructured to use arbitrarily-selected test frequencies. By using the same frequencies in each test setup, it was possible to produce consistent results with the various combinations of antenna and sensor location. After taking field measurements in all locations, calculations were made to adjust to a constant input power of 40 watts, and to compensate for cable losses where cable lengths varied. All data are presented to include losses from 15 feet of RG225/U cable.

In Figure 2, results are shown for Test Location 1. The variations in field intensity as a function of frequency are quite apparent. Because the test frequencies were chosen arbitrarily, some peaks and valleys may have been missed. However, the results are indicative of actual operation, and the average of the measured values—shown as a dashed curve—can be considered as the typical performance of the antenna system.

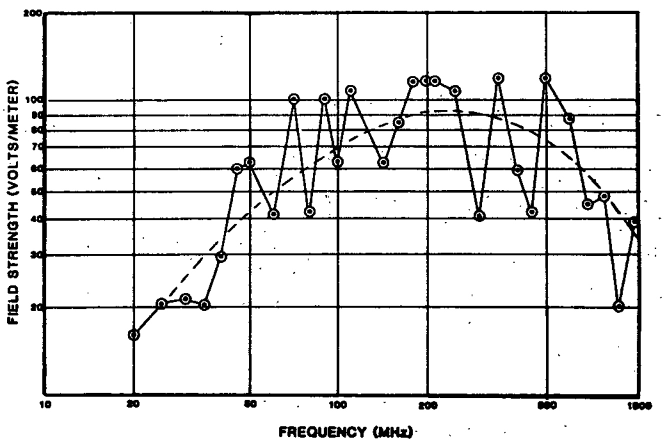

Figure 2. Test Field Strength at 1 Meter with 40W Input

The same methods and test frequencies were used to gather results for Test Locations 2 and 3, with the average curves for all three test setups presented in Figure 3. Comparison of these curves provides considerable insight into both the performance of the radiator and conditions within a typical shielded room.

At close proximity to the antenna, and at lower frequencies, near-field effects are more apparent. The field shown at 0.5 meter and at 20 MHz (Test Location 3) is quite substantial, and is, of course, strictly an E field. Since most measurements at low frequencies are made in the E field alone, it is quite acceptable—and effective—to use the antenna in this mode.

The average field measured from the test bench with the antenna across the room (Test Location 2) is a good indication that a TEM wave is being produced above about 50 MHz. Notice that the field intensity shown in this curve is greater than that at 1 meter (Test Location 1) over a large part of the spectrum, and at one point even exceeds the field level taken from Test Location 3. This is graphic proof that

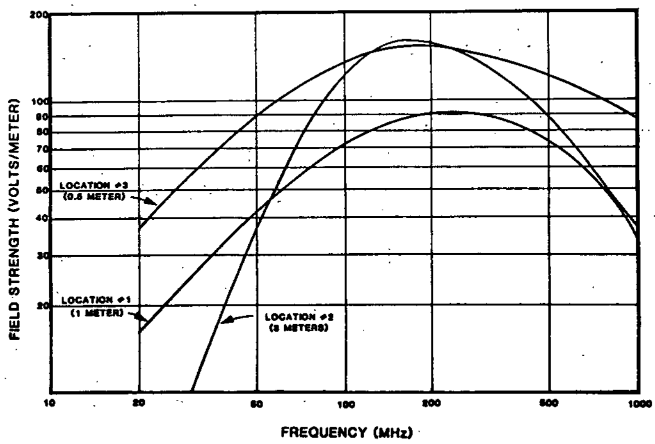

Figure 3. Test (See Figure 1 for Location Diagram)

antenna performance in a shielded room bears little resemblance to performance in free space. If the antenna had been tested in free space (providing a suitable ground plane), the field at 3 meters would have been predictably lower than that at 1 meter. Since the walls of the shielded room confine the energy, normal free-space patterns do not hold, and the field intensity bears no simple relationship to distance.

While the original intent in designing the radiator was to provide efficient operation in the difficult test range from 30 MHz to around 200 MHz, it is evident from the test results that the new design is broadband, and operates efficiently to beyond the 1000 MHz mark. The new antenna will handle 3500 watts from 30-250 MHz, 2000 watts to 500 MHz, and 1250 watts to 1000 MHz, providing field intensities of 200 volts/meter or greater over the full bandwidth of 30-1000 MHz.

The compact size and light weight of the new system make it extremely useful in coping with one other problem that crops up in susceptibility testing as a result of the shielded room. It is possible that a unit under test might not be exposed to certain frequencies during testing if it happens to sit in a null spot in the room. (Conversely, it could sit in a peak, and be drastically overexposed.) The radiator is easy to move from wall to wall during the course of a test, to make sure that the unit being tested sees the proper field level at all frequencies. To make this procedure more practical, optional magnetic clamp mounts are offered.

A second approach to this problem, for automated testing, would be to mount two or more of the new antennas in different locations, and couple them to a coaxial switch to provide completely remote operation during the test. The small size of the radiator makes this method of testing workable.

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