Modeling Open Area Test Sites (OATS) for Preconstruction Evaluation

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The number of newly-constructed OATS facilities is rising to meet the current demand for tests.

INTRODUCTION

The demand for test facilities to meet the amount of testing required for computer, consumer, medical, and other products has forced many test laboratories to turn away business due to a lack of test capacity. Semi-anechoic rooms are sometimes used to perform radiated emissions testing, but these sites are very expensive and usually limited to large companies doing internal product testing. As a result, construction levels of Open Area Test Sites (OATS) for commercial EMI testing according to FCC and CE radiated emission requirements is at an all-time high.

The preferred location for an OATS is close to the product development areas, but in a wide open, RF-quiet environment. These requirements are usually in conflict with each other, since a geographical location with a high concentration of product development activity tends to be located in close proximity to a highly developed area. Land prices are high, and the ability to have large open spaces around the OATS often requires excessive property purchases. As new OATS facilities are planned, the use of existing land is preferred, even if the space and ground plane sizes recommended by CISPR are impossible.

Once a desired location, ground plane size and nearby metal structures are identified, whether the proposed test site will meet the CISPR site attenuation requirements must be determined.

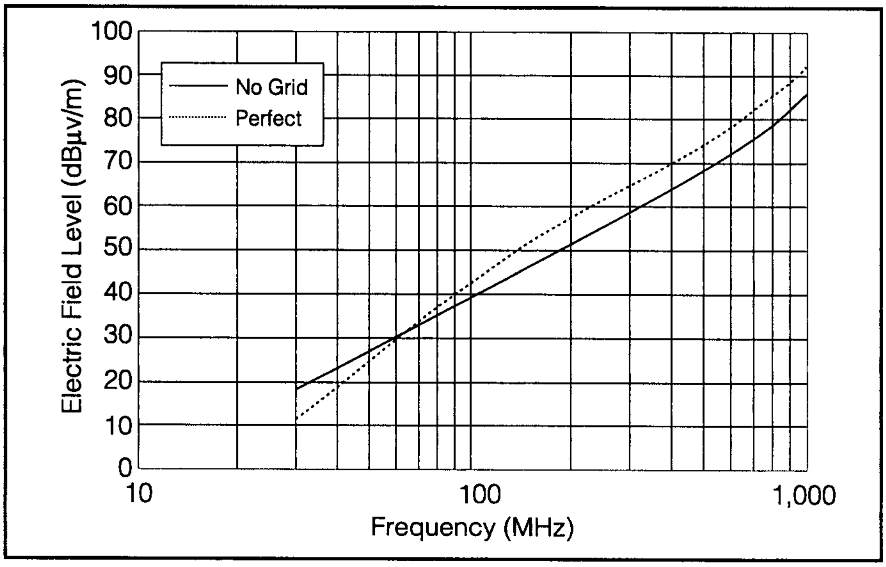

Figure 1. *Maximum Horizontal Electric Field for Perfect and No Ground Plane Cases.*

Since it is often desirable (or necessary) to violate the CISPR ground plane and open space recommendations, a method is needed to achieve a high degree of confidence that the OATS will be acceptable without extra expense after construction. This article discusses some OATS analysis using a numerical modeling techniques, the Method of Moments. Comparison between various ground plane sizes and shapes and nearby metal objects are made to a perfect site.

THE PERFECT OATS

The definition of a perfect OATS includes an infinite ground plane with no other metal structures (fences, posts, power lines, etc.). Of course, it is impossible to achieve such a perfect OATS in real life, but a perfect OATS can be easily simulated using numerical modeling techniques. For this work, the Method of Moments (MoM) was used. A small dipole antenna was created (the length of the antenna was very short compared to the frequencies of interest, 30 MHz to 1 GHz), and the receive location was scanned from a height of 1 to 4 meters, at a distance of 10 meters from the transmit antenna.

Figure 1 shows the maximum received electric field (scanned over the 1 to 4 meter receive height) across the frequency range. The cases of no ground plane (free space condition) and a perfect, infinite ground plane are both shown. The effect of the ground plane reflections can easily be seen.

The perfect, infinite ground plane case becomes the normalized case. That is, all further results are shown as deviations from this perfect OATS case. Although most of the results are shown for the horizontal polarization, the vertical polarization can be analyzed just as easily (and is used for the nearby metal conductor examples).

GROUND PLANE MESH

The size of the CISPR recommended ground plane for a 10-meter site is 20 meters long by 17.3 meters wide. If the entire ground plane is to be enclosed in a weatherproof enclosure, the size of the enclosure will be large, and therefore expensive. Space limitations may require smaller ground planes.

The recommended ground plane size was analyzed using a wire mesh ground plane, as shown in Figure 2. Typically, a mesh size of about 1/10 wavelength (at the highest frequency) is used in wire mesh applications. In this case, at 1 GHz, the wavelength is .333 meters, resulting in a recommended mesh size of .033 meters. Such a mesh size over the full ground plane would result in approximately 650,000 wire segments; clearly too much for a typical MoM model to complete in a reasonable amount of time, even on a fast workstation. Therefore, the initial analysis was performed with much larger mesh sizes, and the size was reduced until the results agreed reasonably well with the perfect OATS case. The final selected size was 0.5- meter meshes. This size is slightly larger than ten times the MoM recommendations, but it was expected that any negative effects would only exist at high frequencies.

Figure 3 shows the electric field results for a perfect OATS and the various wire mesh spacing on the modeled ground plane. Figure 4 shows the deviation between the perfect ground plane and the various wire mesh ground planes. The case involving mesh #6 shows results that are easily within the +/- 4 dB allowed by the normalized site attenuation requirements.

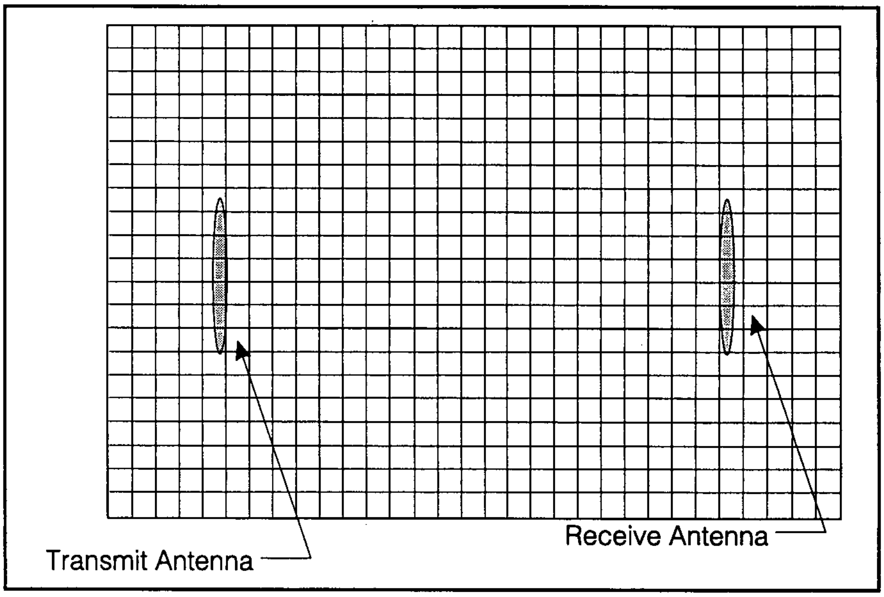

Figure 2. Wire Mesh Ground Plane Example.

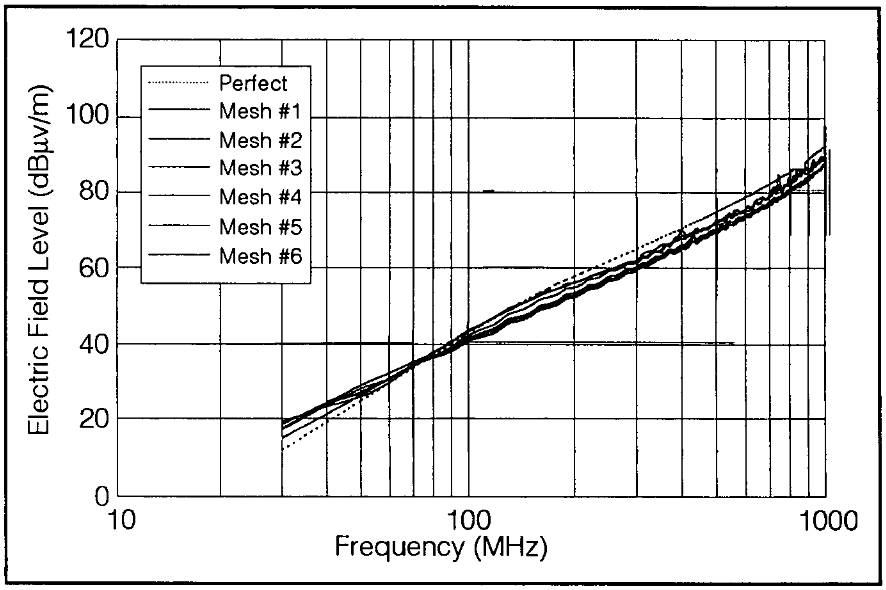

Figure 3. Peak Electric Field from Different Mesh Designs, Horizontal Polarization.

Reduced ground plane sizes were analyzed and the results are shown in Figures 5 and 6. As can be seen, the smaller ground plane sizes clearly introduce additional errors, although one sized ground plane came close to the +/- 4 dB requirement (except at low frequencies). Some current OATS facilities have enabled good results using smaller ground planes when the shape of the ground plane is non-rectangular.

GROUND PLANE SHAPE

A small ground plane has been successfully used in some cases when the ground plane shape is made non-rectangular by adding triangle-shaped portions along the edge of a small ground plane. Figure 7 shows an example of such a non-rectangular ground plane. This shape was analyzed and the results are shown in Figure 8. As can be seen in the figure, the results show a definite improvement with the non-rectangular shape.

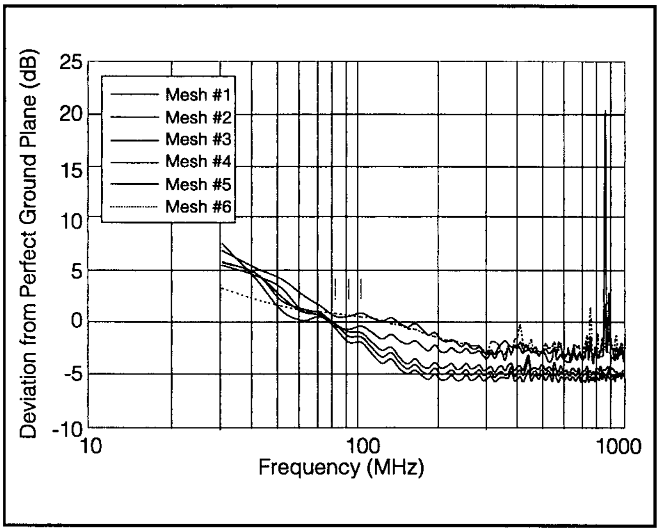

Figure 4. *Electric Field from Perfect Ground Plane Case, Horizontal Polarization.*

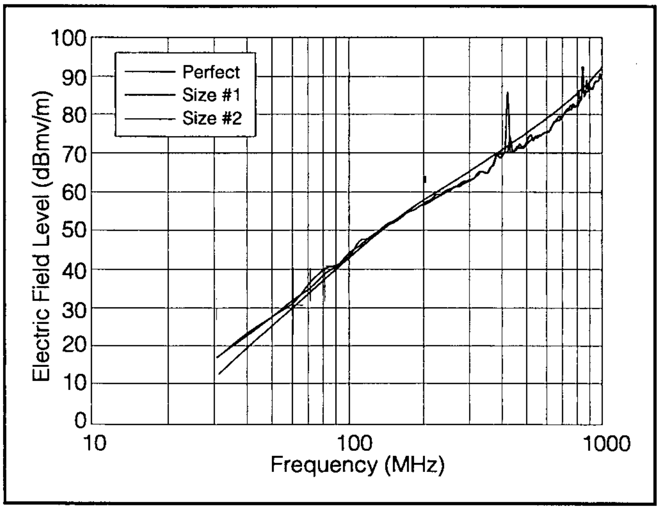

Figure 5. *Peak Electric Field from Different Ground Plane Sizes, Horizontal Polarization.*

NEARBY CONDUCTORS

The presence on metal conductors in the nearby vicinity of an OATS is sometimes an unavoidable fact of life. For example, a number of cases could be used to determine the effect of allowing a metal fence either alongside the OATS or behind the receive antenna at various distances. Figure 9 shows a simulation of a metal light/utility post at two different distances from the EUT side of the OATS ground plane. The effects of the different set-back distances are clear.

SUMMARY

The design of OATS facilities sometimes require a deviation from the recommended ground plane sizes or nearby conductor spacing. Since such deviations can result in

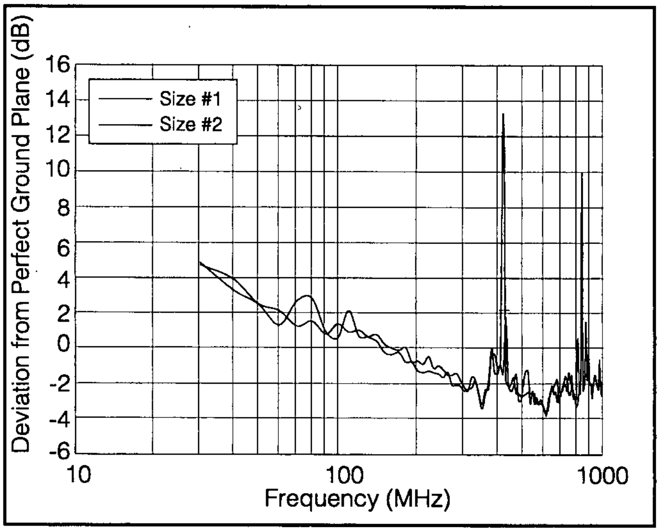

Figure 6. *Electric Field Deviation from Perfect Ground Plane Case, Smaller Ground Planes.*

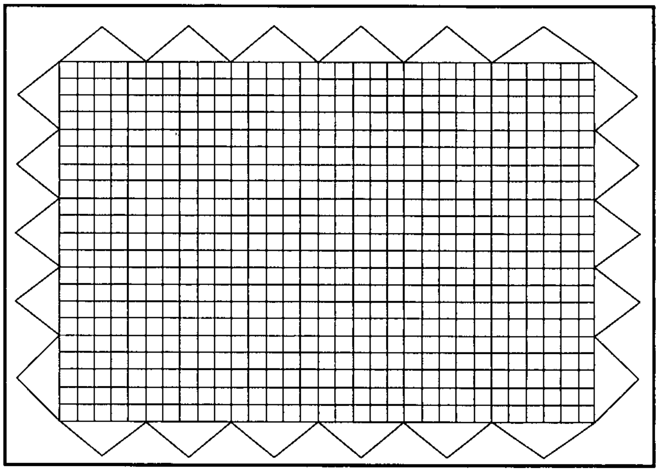

Figure 7. *Non-rectangular Ground Plane Example.*

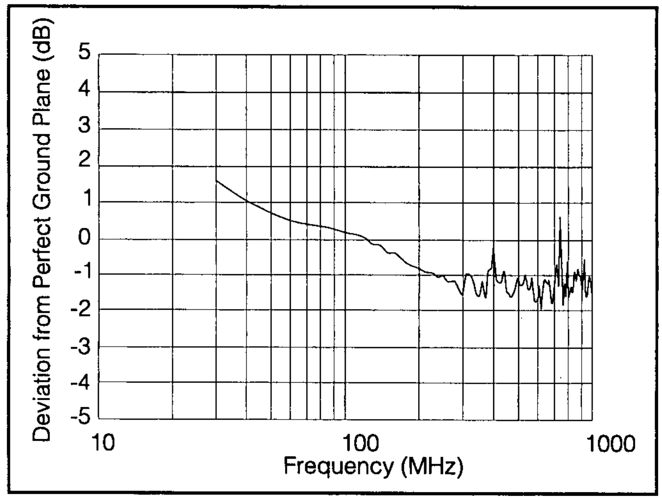

Figure 8. *Electric Field Deviation from Perfect Ground Plane Case, Horizontal Polarization – Non-rectangular Shape Ground Plane.*

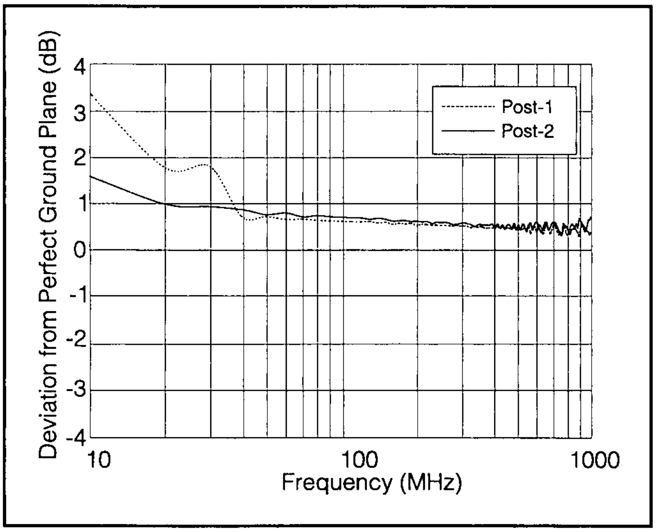

Figure 9. Electric Field Deviation from Perfect Ground Plane Case Due to Nearby Metal Post Vertical Polarization.

serious cost penalties if the OATS cannot pass the normalized site attenuation certification tests after construction, normal practice is to avoid any deviation even though it will result in extra cost to the facility during construction.

However, numerical modeling techniques have been proven helpful to analyze these nonstandard OATS designs and provide engineers with a risk assessment in terms of expected normalized site attenuation error vs. cost of design options. The various design parameters which can be analyzed include ground plane size, ground plane shape, and distance to nearby conductors, such as fences and metal poles.

***BRUCE ARCHAMBEAULT** currently works for SETH Corporation developing new EMI modeling tools and advanced EMI/EMC techniques for industry. Bruce has been working in EMI modeling for over eight years and has been in the EMI/EMC/TEMPEST business as an advanced development, test and design engineer for over 15 years. Bruce is currently completing his Ph.D. in electromagnetics, specializing in E/M modeling. (814) 255-4417.*