Predicting EMI Emission Levels Using EMSCAN[1]

Author:

Bruce Archambeault
EMI Consultant Engineer
Digital Equipment Corporation

Introduction

Today, prediction of the emission levels for new products is more important than ever. Reducing the time-to-market requires the design cycle to be shortened, and allows no extra time for trial-and-error approaches to EMI design.

Various EMI modeling tools exist to help product designers predict the EMI emissions from their products. However, all these modeling tools must simplify the actual product to allow the tool to perform the rigorous modeling of the emissions. Often the designers are faced with a developed printed circuit board where minor changes are needed, and for which the emissions must be predicted without the lengthy development of a numerical tool. In this case a simplified prediction tool was needed, even at the expense of reduced accuracy.

The EMSCAN is a device that measures the RF currents existing on a functioning PC board. This measurement provides a spatial representation of the RF current levels across the entire PC board by measuring the near-field magnetic fields using an array of loop probes. Once these currents are known, the radiated electric fields can be calculated for small devices using straightforward Green's functions since the PC board is assumed to be small compared to the wavelength of the frequency of interest. Naturally, the presence of the measurement probes changes the RF current. However, it has been found that the measurement probes do not affect the accuracy of the measurements beyond the typical measurement accuracy of these types of tests when a scaling factor is used.

Therefore, the EMSCAN data is useful to predict the approximate radiated electric field levels from the (unshielded) PC board itself. This information can help product designers to decide between design trade-off options without more expensive and time consuming Open Area Test Site (OATS) testing.

EMSCAN

The EMSCAN is a tool which measures the near-filed magnetic fields under an active PC board. The measurement panel consists of an array of 39 x 31 loop probes built into a 22 layer circuit board. Each loop probe is individually addressable via the IEEE488 bus, and the received signals are measured using a spectrum analyzer. The switching of the probes and the spectrum analyzer are controlled by a personal computer.

The probes are centered with a .3" spacing in the array described above. Since the near-field magnetic fields are measured, the EMSCAN provides a spatial representation of the RF current flowing on the pc board under test (at a particular frequency. Once the RF current is known, the Electric field in the far-field could be predicted.

EMSCAN Calibration

The computer program that controls the EMSCAN provides the measured voltage on each

[1] EMSCAN is a registered Trademark of EMSCAN Corporation

CH3310-0/93/0000-0010 $3.00 © 1993 IEEE

of the active loop probes. The EMSCAN manual reports that 1 uAmp of current will measure .5 uvolts @ 100MHz. Since this is height sensitive and frequency sensitive, additional calibrations were performed during this effort. These calibrations were performed by building a 3" loop with a 50 ohm termination resistor. A know RF voltage was applied (therefore the RF current was known in the loop since the loop was kept small relative to the wavelength) and the EMSCAN voltage under the test loop determined.

As shown in Figure 1, the voltage response to a particular current on the EMSCAN probe array was dependent on the height above the array. The calibration is shown for two example frequencies in Figure 1. Before any predictions of the Electric field strength could be made a complete calibration of the EMSCAN probes was required for each frequency of interest.

Prediction Technique

Once the RF current was known, the EMSCAN representation shows a current flowing along a portion of the circuit board. Throughout this effort the RF current was flowing along a path that was short compared to the wavelengths involved. Although EMSCAN reports some amount of current along the entire board, only the highest levels of current flow was used.

Since the current path was electrically short, a Hertzian dipole was used to replace the pc board under test with the same current. The straightforward equation (1) was used to determine the predicted Electric field of the Hertzian dipole. (1)

$$E = (60I / R)(-\cos(\beta(L / 2)))$$

Results

The results from using the RF currents and the Hertzian dipole equation provided results that were consistently too high when compared to measured data. A factor of -45 dB was determined experimentally to provide fairly good and repeatable results.

Figure 2 shows the spectral scan results for a particular product's printed circuit board. The frequency of the peaks shown here were repeated during open field site measurements. Thus the EMSCAN did predict the frequencies of interest on the open field site.

Figure 3 shows the final measured and predicted Electric field strength for frequencies between 100 and 250 MHz. There was fairly good agreement overall with the greatest error about 7 dB. This amount of deviation between measurement and prediction was considered low enough to allow this technique to be useful. Care should be used whenever using this technique to use the predictions as approximate, and not absolute. Some amount of deviation should be expected, and if any levels are predicted close to the appropriate limits, extra care should be taken.

Technique Limitations

EMSCAN measures the current over the probe array but provides no information on current direction or phase. The user must determine the horizontal or vertical direction of the current in order to predict the polarization of the final electric field. A computer program could be created to recognize this current direction, but this was considered too much trouble for this effort.

Also, as described above, the predicted levels from the EMSCAN measurements provide a rough prediction only. Any predicted levels that are close to the regulatory limits should be considered suspect even if slightly below the limits.

Summary

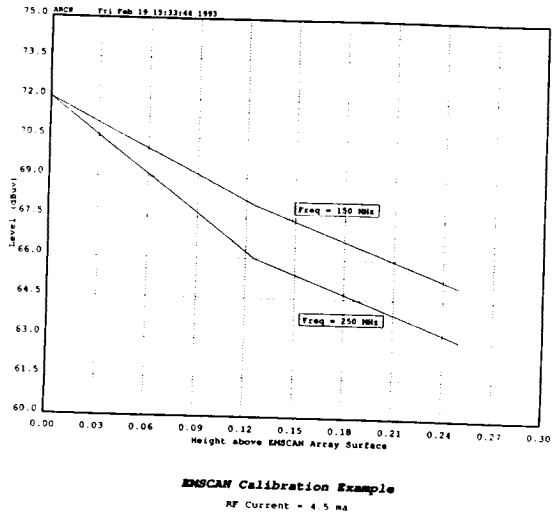
The EMSCAN measures the near-field magnetic fields from a printed circuit board. This can be calibrated to the RF current at the frequency of interest. Using the Hertzian dipole approach and a scaling factor, it was shown that the data from the EMSCAN can be used to predict the electric field strength from that pc board. Differences between the measured and predicted data vary from less

than a dB to about 7 dB. This is quite reasonable agreement for this application as long as care is used if the levels are close to the regulatory limits.

References

[1] Kraus, John D., "Antennas", 2nd Edition, 1988, p221

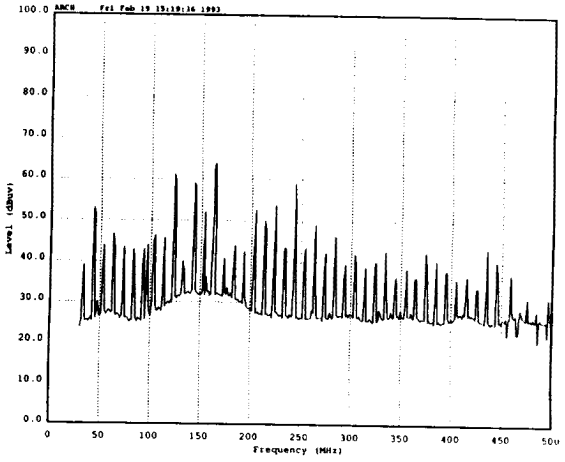
Figure 1



EMSCAN Calibration Example

RF Current = 4.5 ma

Figure 2



Example EMSCAN Spectral Response

Figure 3