The Field Site Source: A Hands-on Report

The integrity of radiated emissions measurements can be verified with a stable reference source.

MARK J. NAVE
EMC SERVICES
HUNTSVILLE, AL

THE FIELD SITE SOURCE

Most engineers and test technicians have, at one time or another, completed a radiated emissions measurement of a product and then questioned whether everything was really working correctly. Even worse, customers (in-house or outside) have questioned whether systems were functioning correctly. With a professional reputation at stake, how does one prove everything is operating normally, and equipment is still calibrated? Long-winded explanations and colored calibration stickers may relieve some doubt, but they are not conclusive.

A reliable method to determine the proper operation of a test setup is to measure a stable, standard reference source, and compare the immediate results to the known accurate results. The field site source shown in Figure 1 is a stable reference source suitable for ensuring proper site performance.

A BRIEF HISTORY

During compliance measurements at a major equipment manufacturer's in-house facility, even experienced EMI design engineers constantly questioned the test setup and the test results when their prototypes failed. Time was spent repeatedly justifying and verifying the performance of the test setup instead of solving the problems of the prototype.[1] To circumvent this time-consuming effort, a radiated emissions source was developed to verify the performance of the test setup.[2] To be optimally useful, the source had to be repeatable, small, and localized. The designer of the field site source used a low-power, current-controlled ECL chip as the basis of the design for stability.[3] Typical radiated emissions are shown in Figure 2. Data taken from the field site source given in Reference 2 shows its short-term stability (< six months) to be 0.015 dB, and its long-term stability to be 0.14 dB. This is certainly within the stability of the spectrum analyzer.

Clearly, the source is well within the repeatability requirements necessary to demonstrate the proper operation of the test setup. In this way, the field site source can function as the cornerstone of a statistical quality control program as detailed in Reference 2.

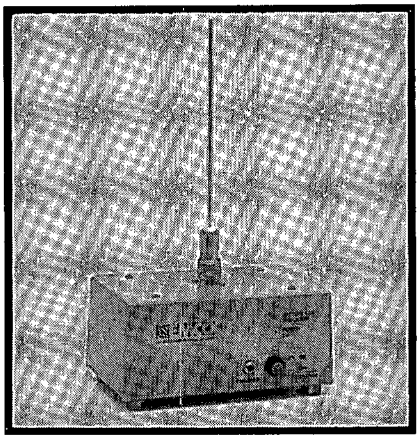

FIGURE 1. Field Site Source.

ANOTHER APPLICATION

EMC engineers at every large company have had tests conducted at an outside facility at one time or another. Inconsistency of results is a constant complaint. Inconsistency is an issue even at different facilities within the same company. The field site source has been used to isolate problems at different sites and develop the repeatability required for a solid EMC program. Because of its electrically small construction, the field generated by the field site source at 3 meters has characteristics closer to a far-field wave than an actual EUT. Two labs which measure the same result from a field site source can be said to "not be wrong," but cannot be asserted to "be right."

As an example, a PC with a monitor and peripherals would have many clocks which, at some frequency, would have coincident harmonics. At least at one frequency, the source consists of the PCB, the cable, and the peripheral. Clearly, the spacing of the three different sources would not be small with respect to the measurement distance, one criteria for far field conditions.

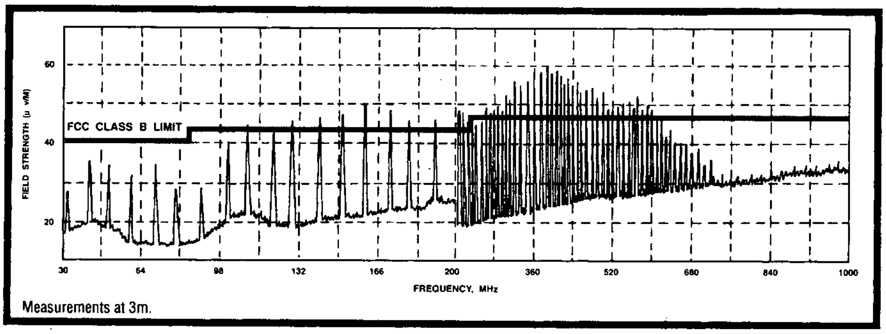

FIGURE 2. *Typical Field-Site Source Emissions (versus FCC Class B Limit).*

Alternatively, assume an EUT radiating at 150 MHz which occupies the width of the 1 m by 1.5 m table specified in ANSI C63.4. For the dipole antenna, the wire antenna far-field condition of $2D^2/\lambda$ would be satisfied at 1 m. Clearly the site source generates a plane wave at 3 m. However, the EUT has a physical size of 1.5 m, resulting in a wire antenna far-field condition of 9 m. Hence, in the *best* case the measurement antenna is still in the near field of

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FREQUENCY	3 kHz	10 kHz	30 kHz	100 kHz
Z_{air}	j0.83	j2.8	j8.3	j28
R_{42}	4.9	9.0	15.6	28
R_{Cu}	0.015	0.027	0.047	0.085

TABLE 1. *Wave Impedances in Different Media (milliohms; in metals, $Z = (1 + j)R$).*

all frequencies, the 42% nickel alloy has an impedance approximately 300 times larger than that of copper. On the other hand, the alloy's impedance can be fairly comparable to that of the arriving magnetic wave. The fact that the impedances of all metals are very low compared to 377 ohms explains the excellent shielding against plane waves afforded by relatively thin sheets of metal.

We now see the advantage of a composite shield: it provides a large change of impedance at each of the four interfaces, and hence, maximum reflection. When the components are tested separately, reflection takes place at the two surfaces of the copper sheet, but little reflection occurs at the surfaces of the alloy. The three-layer composite then provides the same shielding due to energy loss as does its component parts, but greatly increases attenuation at the two surfaces of the ferromagnetic layer. (This explanation is also in agreement with the observed fact that an alloy-copper-alloy shield is usually less effective than copper-alloy-copper.)

CONCLUSION

Although the exact analysis is very complex and the best equations for predicting shielding effectiveness are not agreed upon by all researchers, it seems reasonable to conclude that the observed

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the radiation from the EUT. In the near field the radiation is very sensitive to the physical configuration of the cables and peripherals of the EUT. What are the chances of two independent labs having *exactly* the same physical set-up?

Another factor affecting comparison of measurements between sites is randomness. One example concerns a power supply. A master clock (250 kHz) internally synchronized two board-level clocks (125 kHz). Due to the method by which the circuit was implemented, either board-level clock would sync to the first or second pulse of the master clock at start-up. There was a 50-percent chance of the board level clocks starting up out of phase. After many re-starts, a consistent 4 dB variation was observed due to phasing of the clocks. Essentially, the measured conducted emissions were binary random variables. In asynchronous digital systems with no synchronizing, emissions can vary more dramatically.

SUMMARY

A standard field site source is the hardware equivalent of a test specification: a standard to ensure repeatability. A highly stable and repeatable field source is ideal for performance verification of radiated emissions measurements at one site or between sites. For laboratories serious about quality control, a standard field site source is an essential tool.

REFERENCES

1. Private conversation with Scott Roleson.
2. Scott Roleson, "Monitoring Measuring Repeatability at Radiated Emissions Testing Facilities," *Proceedings of the 1987 IEEE International Symposium on EMC*, August 25-27, 1987, Atlanta, GA pp. 231-235.
3. Private conversation with Bill Royce.

MARK NAVE *is the president of EMC Services, a consulting and training company. Mark's interests lie in the areas of modeling, diagnostics, and suppression techniques. EMC Services seminars include Diagnostics and Retrofits, and Filter Design for Switched-Mode Power Supplies. (205) 461-0241.*