Near-field probes sniff circuits

Martin Rowe - August 01, 2003

Before sending an electronic product to a lab for compliance testing for EMI emissions, you can perform a precompliance (far-field) EMI scan on the product with a spectrum analyzer and an antenna. If the product's emissions occur at amplitude levels that exceed limits set by national and international standards, you'll need to hunt down emissions sources and mitigate the problem.

You can often uncover the source of EMI emissions with near-field probes. Near-field magnetic (H-field) and electric (E-field) probes let you "sniff" where EMI lurks—around circuits, cables, and enclosures. H-field probes use a conductive loop to detect magnetic fields produced by clock signals, serial data streams, control signals, and switching power supplies. The probes produce a voltage proportional to the magnetic field that's perpendicular to the loop. The larger the loop, the more energy it will capture and the higher the voltage output. To find emissions on individual pins or PCB traces, use E-field probes that make direct contact with your circuit.

![Figure 1. Near-field probe sets may include three sizes of H-field loop probes and one E-field contact probe. Courtesy of EMC Test Systems.](image)

You'll often need more than one size of H-field probe to help you zero in on an emission. Commercial probe kits provide up to three H-field probes with different loop diameters (6 cm, 3 cm, and 1 cm) and either one or two E-field probes (Figure 1). Many EMC engineers build their own near-field probes because they're easy to make. "Bend your own probe," p. 34, shows how to construct both H-field and E-field probes.

Before you reach for near-field probes to track down emissions, though, you should learn as much as
possible about the offending signals. Reduce the spectrum analyzer's resolution bandwidth from the typical 120 kHz required by standards. As you reduce the bandwidth, you may find modulation around a peak. Modulation will tell you if more than one emission contributes to the excessive level.

Mike Murphy, EMC engineer at ETL Semko (Boxborough, MA; www.etlsemko.com) suggests that you also use a spectrum analyzer's demodulation feature, which lets you listen to the modulation's sound. You can then listen for the offending emissions as you "sniff" around your product.

After you identify and understand the nature of the offending signals, you can take your EUT back to your engineering bench to tweak your product. But be sure to make some far-field baseline measurements first. By making these measurements, you'll be able to determine whether the emissions drop sufficiently after you make design changes.

**Not quite Sherlock Holmes**

Once you've made your baseline measurements, you can use H-field and E-field probes to try to find the source of the emissions. You may need to experiment with design modifications and repeated near-field measurements to get to the heart of the problem. Tim Dwyer, EMC program manager at TUV Rheinland (Newtown, CT; www.us.tuv.com), points out that RF emissions from a PCB can couple into cables or metal enclosures, which then radiate the emissions. "With near-field probes," says Dwyer, "you have about a fifty-fifty chance of finding the source of the offending emissions."

![Figure 2: EMI will find the best radiator in the system, even an opening on the other side of the enclosure.](image)

Openings in enclosures let emissions escape, but they can also cause current to flow in the metal enclosures. **Figure 2** shows how an emission that originates on a PCB can cause current to flow in an enclosure. Coupling, caused by an opening in the enclosure's rear, produces the current. Another opening, perhaps on the opposite side of the enclosure, may turn the current back into a magnetic field that radiates outward. Your H-field probe may find the offending emission there. You then must either try to close the gap with EMI gaskets or go inside the enclosure to find the emission's source.

You can also use an H-field probe to measure the relative current in an enclosure. Place your loop parallel to and as close to the enclosure as possible. Using an oscilloscope, measure the peak voltage output of a magnetic field probe before and after you make design changes to a circuit. You can also estimate the current in the enclosure. The transfer impedance of a 2.5-cm square loop is about 6 Ω from 100 MHz to 1 GHz (Ref. 1). Knowing that impedance, you can calculate current from a voltage measurement.

H-field probes can lead you to a cable that's emitting RF energy, which often couples from the signal's source because of a poor or incomplete shield surrounding the cable's connector. A near-
field probe will help you identify a cable that's acting as a radiating antenna. Once you find that cable, you should use current probes around the cable to measure common-mode current that causes emissions.

If you can isolate the source of the excessive emissions with an H-field probe, you should measure the distance and note the location of the probe relative to the source, recommends Mark Briggs, director of engineering at Elliott Labs (Sunnyvale, CA; www.elliottlabs.com). Measure the amplitude of the offending frequency at that distance. After you make design changes, measure the emission at the same distance. Then, try using your dipole antenna to see if you get a drop in far-field emissions. If you see an acceptable drop in emissions, you're ready to perform another round of precompliance tests.

While using near-field probes, keep a circuit schematic and board layout nearby to help you navigate the EUT. You may find, for example, a bypass capacitor that's too far away from an IC to adequately suppress emissions, says ETL Semko's Murphy. Look at the power and ground pins on the IC in question. If either or both show ringing, then the bypass capacitor is either too small or too far away from its IC. The result: excessive emissions. You've correctly located your EMI problem.

Reference