Build a Magnetic Field Immunity Tester

A precompliance test system can help you determine whether your products comply with standards such as the CE Marking.

Jim Ericson, Acme Testing, Acme, WA -- Test & Measurement World, 6/1/1999 2:00:00 AM

The latest versions of European CE-Marking standards include magnetic-immunity requirements for residential, commercial, industrial and audio/visual electrical and electronic equipment. Your product must be immune to magnetic fields from transformers or other sources. These fields can produce character “jitter” on CRT displays, distortion in audio equipment, or false readings in equipment containing Hall-effect devices or other electromagnetic field sensors. You can assemble a precompliance (or even full compliance) magnetic field immunity test system in a few hours using common laboratory instruments, a 100-W audio amplifier, some white PVC “Schedule-40” 3/4-in. water pipe, some wood, and a copper or aluminum sheet.

European Standard EN 61000-4-8:1993 requires a 63 dB test field tolerance.1 That requirement results in a usable test volume of 0.6 x 0.6 x 0.5 m for a square loop 1 m on a side. Larger EUTs would require construction of a larger loop or a double “Helmholtz” coil as shown in the test standard.

The Biot-Savart Law states that a single-turn circular loop with a diameter of 1-m will generate a magnetic field at its geometric center equal to the loop current. So, a round 1-m diameter loop carrying 1 A of current with two turns will produce a field of 2 A/m at its center. For a square loop, the correction factor is 4/(p=2), or 90%. A square 1-m loop with two turns carrying 1 A of current will, therefore, generate a 1.8 A/m field at its center. Magnetic fields, however, are usually expressed in gauss, teslas, and oersteds. See “Handy Conversions,” this page, for help in converting units.

Build the Loop

To construct a 1-m2 multiturn coil, you need straight PVC water pipe, elbows, and tees joined with liquid plastic-pipe cement. **Figure 1** shows a 1-m2 PVC pipe frame that contains a two-turn, insulated 18-gauge solid copper wire loop inside. Solder banana jacks to the loop wires where they exit the pipe. Make a flexible twisted pair cable—not longer than 3 m—and connect it to the audio amplifier or other current source.

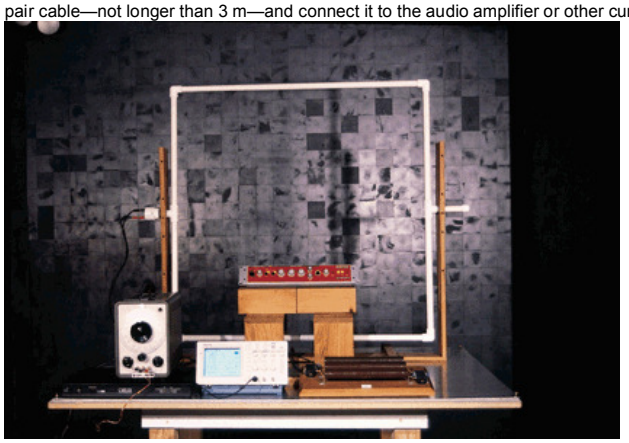

Figure 1. Use PVC pipe to make a loop for magnetic field immunity testing.

Make all connections mechanically strong. Solder them well because the total loop resistance at 50 Hz will be about 200 mV. To complete the test setup, build a wood frame to support the loop. Place the frame and loop above a non-magnetic, aluminum or copper ground plane with minimum dimensions of 1 m x 1 m x 0.25 mm. **Figure 2** shows how to connect the loop to the audio amplifier through an 8-W, 100-W power resistor in series with the loop. The resistor approximates the impedance of a speaker. The amplifier must be capable of having the low side of its output connected to safety earth. Connect the “low” side of the loop coil circuit to the ground plane; connect the ground plane to safety earth.

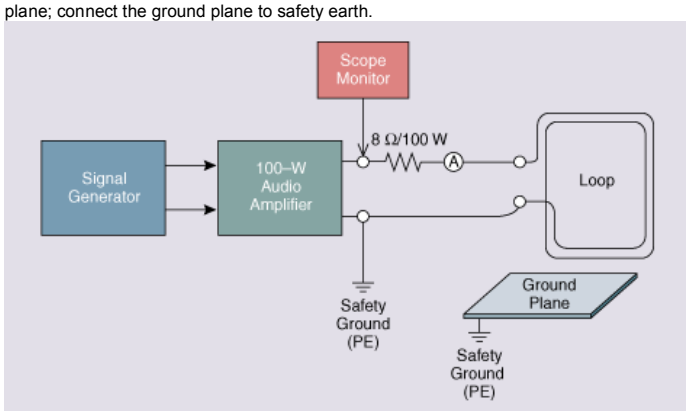

Figure 2. Connect the loop to a 100-W audio amplifier through an 8-W, 100-W resistor. Connect the amplifier to a signal generator and measure current with an AC ammeter.

You can also measure the loop current. Place a current probe or a DMM (set for ACA) in series with the loop. Verify the meter’s accuracy at the frequencies you plan to use. You also need to verify that the loop current sinusoidal distortion is less than 8%. Do that with a distortion analyzer or visually by monitoring the loop voltage waveform with an oscilloscope as you adjust the signal input level. When you begin to overdrive the amplifier and distortion of the sine wave reaches about 5%, the distortion will start to be visible on the scope pattern.

A 100-W audio amplifier will supply about 2.5 A into an 8-W load without appreciable distortion. This corresponds to a maximum magnetic field at the center of the 2-turn 1-m square loop of 2 turns x 2.5 A x 0.9 turns/m, or 4.5 A/m. If you need higher field intensities, either increase the number of loop turns or drive the loop directly from the AC mains through a variac and stepdown transformer.

Test Procedure

To perform the magnetic immunity test, you'll first need to define an appropriate test plan for your EUT.

After verifying the EUT's performance to its technical specifications, expose the EUT (and 1 m of any EUT cables) to the test field at different orientations by rotating the loop and shifting the EUT. Verify that the effects of the magnetic field on the EUT are acceptable and that the equipment is able to recover by itself when you remove the field.

You can use the loop to perform full compliance testing if you calibrate the loop. To perform the calibration, you must measure the field strength with a calibrated instrument. Measure the field generated by the magnetic loop with either a Gaussmeter or a small calibration loop antenna.2 If you use the loop antenna, you must connect it to either an EMI meter or a spectrum analyzer.

Depending upon the EUT's application, the requirements of the generic "light" and "heavy" industrial standards EN 50082-1:1997 and EN 50082-2:1995 for magnetic immunity may range from 3 A/m to 30 A/m at the powerline frequency.[3,4]

The product family standard for EMC immunity of professional audio/video equipment (EN 55103-2:1996) requires magnetic immunity testing from 50 Hz to 10 kHz at levels from 0.008 A/m to 10.0 A/m, depending upon the EUT's classification.5 Requirements for other families (such as medical devices) are under consideration. T&MW

Handy Conversions When measuring the field strength inside the coil, you may have equipment that measures in units that you don't use in everyday EMC testing. These conversion factors will help you convert from the somewhat obscure units to the more familiar units:

H = magnetic field strength (in oersteds). This parameter characterizes the amplitude of alternating magnetic field strength.

B = flux density (in gauss or teslas). A corresponding parameter for the induced magnetic field in an area perpendicular to the magnetic flux path.

Units:

80 A/m = 1 oersted

1 T (tesla) = 10^4 gauss

1 A/m = 1.26×10^{-6} T (in free space)

—Jim Ericson

FOOTNOTES

1. EN 61000-4-8:1993, Electromagnetic compatibility (EMC) - Part 4-8: Testing and measurement techniques—Power frequency magnetic field immunity test. European Committee for Electrotechnical Standardization (CENELEC), Brussels, Belgium, **www.cenelec.be**.
2. Calibrating loop antennas are available from Solar Electronics, Hollywood, CA. 323-462-0806; **www.solar-emc.com**.
3. EN 50082-1:1997, Electromagnetic compatibility - Generic immunity standard—Part 1: Residential, commercial and light industry, European Committee for Electrotechnical Standardization (CENELEC), Brussels, Belgium, **www.cenelec.be**. (This standard is currently active, and although not mandatory until 2001, most equipment manufacturers are applying its requirements to all new product designs.)
4. EN 50082-2:1995, Electromagnetic compatibility - Generic immunity standard—Part 2: Industrial environment, European Committee for Electrotechnical Standardization (CENELEC), Brussels, Belgium, **www.cenelec.be**. (This standard for "heavy industrial" equipment is currently mandatory.)
5. EN 55103-2:1996, Electromagnetic compatibility - Product family standard for audio, video, audio-visual and entertainment lighting control apparatus for professional use—Part 2: Immunity, European Committee for Electrotechnical Standardization (CENELEC), Brussels, Belgium, **www.cenelec.be**. (This product family standard becomes mandatory on September 1, 1999).

Jim Ericson is an EMC engineer at Acme Testing. **acmetest@acmetesting.com**.