Electromagnetic field probes (field sensors) have become an indispensable tool for engineers performing EMC measurements and tests. First introduced commercially in the 1980’s, they are now a common item in test labs worldwide.

The subject of this article is the factors involved in selection and use of the electric field (E-field) probes typically found in the feedback loops of immunity test setups, and anywhere else field strength values need to be measured.

Understanding The Difference Between Probes And Antennas
While in a broad sense probes can be thought of as antennas, they are different than most antennas in a number of aspects. Generally speaking, antennas are designed to transmit or receive electromagnetic signals or power with maximum coupling to the electromagnetic field. As a result, antennas typically perturb the electromagnetic field. Probes on the other hand, are designed to measure the electromagnetic field with minimal field perturbation. To accomplish this, they should be as physically and electrically small as practical for the application, so coupling with the field of interest is minimized. E-field probes usually use an electrically small dipole coupled with a diode as a sensor. The diode and conditioning circuitry present a high impedance load to the probe’s dipole, so little power is drawn from the received field. The combination of small size and a high impedance load minimizes the field perturbation.

While not in the scope of this article, it’s also worth mentioning that trying to apply standard antenna calibration methods to field probes can produce inconsistent results. IEEE Standard 1309 [1] should be used as a reference for probe calibration methods.

Isotropic Probes
For most EMC test applications, isotropic (non-directional) probes are the best choice. They provide more accurate measurement and are less critical about their orientation in the field of interest. This results from the geometry of their construction. Three independent broadband sensing elements are placed orthogonally to each another in an X, Y, Z configuration. Each element’s output is measured, the vector sum is determined, and the result is the total field value.

A three-axis probe allows you additional flexibility. Ordinarily, you’ll simply program the probe to calculate and send you RMS values and then use this measurement to control the field inside a test chamber. However, you can program the probe to send you readings from each of the three axes. Using this data, you can then calculate field polarization as well as magnitude.
Isotropic Deviation

Isotropic deviation (isotropy) is the specification that describes how well a probe measures field intensities irrespective of the polarization of the field, or the probe’s orientation. Lower is better. The best probes typically have an isotropic deviation of 0.5 dB (which is a uniformity of 6%) or less.

Manufacturers typically specify isotropic deviation at a particular frequency, but this specification can be misleading, because the value given can be frequency dependent. Usually it increases (i.e., gets worse) as the frequency increases.

You can minimize the effect of isotropic deviation on your test if you know the specifics of your test setup and take measurements separately from each of the probe’s sensing elements. For example, if you know the polarization of the field, you can position the probe so that one of the elements is aligned with the field. Measuring the field strength is then simply a matter of making a measurement from that element. The measurements from the other elements, which will be oriented perpendicular or end-on to the field, will tend to be very small and can usually be ignored.

Dynamic Range And Linearity

Dynamic range is the maximum to minimum power level or field intensity that can be sensed by the probe over its specified frequency range. Measurements are expressed in dB and represent a logarithmic power or voltage ratio. For example, a 10:1 field strength ratio is 20 dB. It’s a good idea to check the manufacturer’s specifications against your requirements and make sure you have some headroom to prevent inaccurate readings due to compression.

Linearity is a measure of how accurately the probe indicates actual values over its dynamic range. Manufacturer’s specifications of ± 0.5 dB are common. However, consider whether the specification is referencing the reading or the full scale. For example at 0.5 dB, if you’re making a 1 V/m reading with a probe that has a 10 V/m range, and the linearity specification is referenced to the reading, then the maximum linearity error is 60 mV/m (6% of 1 V/m). On the other hand, if the specification is referenced to full scale, the linearity error is ten times that, or 600 mV/m.

Frequency Response

A probe’s response will not be perfectly flat across its entire frequency range. To compensate for this, manufacturers provide calibration data for their probes. If the calibration contains many data points across the probe’s frequency range, it will be easier to compensate for frequency variations with greater precision. However, if the calibration data provided is not sufficient for your application, you may have to pay extra to have the manufacturer (or a third party) generate a more detailed frequency response plot for your particular application. The calibration factors can often be entered into the control program and factored into the system measurement calculations.

Response Time

Typical EMC susceptibility tests call for sweeping the test signal across a specified frequency band. Because E-field probes are used in the control loop to regulate the field intensity, their response time is a factor in how quickly you can sweep the test signal. Probes used should be able to sample more than 50 times per second. Faster response time will save time and let you finish the test more quickly. At the highest sample rates (now in excess of 200 readings per second) the limiting factor may be the ability of the readout device or computer to accept and process the data.

Of course, probe response time is not the only factor determining how fast you can sweep the test frequency. Other factors include the settling time of the signal generators and amplifiers you use to generate the field. Take all of these factors into account when writing a test program to ensure that the field is stable before performing tests.

If your application includes mode stirred testing in a reverberation chamber, sampling speeds greater than 50 times per second will be required. The reason is that you are not simply controlling the field, but also collecting data to verify that the field inside the chamber has the appropriate distribution of field strengths and approach angles. The faster you collect this data, the faster you can make this verification, and the shorter your test time will be. Fast probes with sampling speeds exceeding 200 samples per second should be considered for mode stirred testing.

Measurement Range

For some applications, it’s important to use a probe with a single measurement
range. In an environment with a constantly fluctuating field (such as a reverb chamber) changing ranges can be time consuming or impossible. Range changing effectively reduces the probe’s sample rate. If the length of the test is dependent on the sample rate of the probe, and significant range switching is involved, test times will increase.

Readouts

Probe signal conditioning, control and monitoring functions and system interface can be accomplished by connecting with a personal computer or dedicated probe controller. Each method has its advantages.

A dedicated probe controller usually manages the functions of one or more probes, and provides a GPIB (or other) interface port. The advantage of a dedicated controller is that the probes can continue to function even if the test system's computer is down or unavailable. Another advantage is that the probes can be isolated from the rest of the equipment - a help when troubleshooting problems. If you plan on using a dedicated controller, check to see that it can support the number and types of probe you plan to use, that it provides test system I/O using accepted conventions (i.e. GPIB, etc.), and that any software required is documented and supported.

You may also choose to use a desktop PC or laptop computer as your probe controller. Make sure the computer you choose is sufficiently robust to process and store input from one or more of the type of probes you intend to connect. Bus speed will be important and should exceed the data transfer rate of your probes. This applies to the computer’s input ports (i.e. serial, USB) as well. Some probe manufacturers supply PC compatible software for their probes as well as drivers for GPIB, LabVIEW®, etc. Check to be sure documentation and support are provided.

Power Source

Most E-field probes use batteries as their power source. The typical operating life of these batteries (before recharging or replacing) is approximately 8-10 hours. If your test exceeds that time frame, you’ll need to recharge or swap your probe’s batteries. This can become inconvenient for long duration tests, or if there are multiple probes located in out of the way locations such as chamber ceilings, motor bay cavities, etc.

To overcome these disadvantages, probes with external laser-driven power sources have been recently introduced. In laser-powered probes, laser light is piped from a laser source through fiber optic cable to the probe where it is converted to electric power. While this technology is not entirely new, its application as a power source for E-field probes is. The advantage is that measurements can be made continuously without interruption, for a virtually unlimited length of time.

The power sources for some laser-powered probes are physically large and require AC power. However, one manufacturer has introduced a unit that is not much larger than an iPod, and draws its power from the USB port of a PC. This makes remote field measurements using only a laptop PC, a practical possibility.

With current technology, laser powered field probes can be placed up to 100 meters from the power source.

Size Matters

Small probes will perturb fields less than larger ones. A probe will begin to perturb fields when the dimensions of its housing approach a wavelength of the frequency of interest. Some manufacturers have been able to miniaturize their probes by having the signal conditioning performed outside of the probe. If this is done properly, the size of the probe can be reduced without sacrificing accuracy.

Another benefit of miniaturization is the ability to place probes in small confined spaces like the interior of equipment enclosures, small TEM Cells or bench top RF isolation cells.

Conclusion

We’ve addressed a number of the factors involved in the selection, evaluation, comparison, and use of E-Field probes. This survey is not exhaustive, but should provide a good basis on which to select, evaluate, and use E-field probes.

References


About The Author

Steve King is the Technical Manager of Field Sensing Devices for ETS-Lindgren, in Cedar Park, Texas. He can be reached at steve.king@ets-lindgren.com.
Color Isn’t the Only Thing New About These Probes

Change
Until now, when you bought one of our EMC probes they were labeled with another company’s logo. We’re flattered they chose our probes to carry their name and we’re grateful for the success we shared together. But we feel it’s time for a change.

The Source
Starting now, you can buy these probes - the EMC industry standard - direct from the source; ETS-Lindgren. That means you’ll also be able to communicate directly with the engineers, technicians and support people most knowledgeable about the product.

Service
If you have one of our probes that needs repair, service or calibration - no problem. Whether it’s under warranty or not, we’ll be glad to assist. As the manufacturer, we have the right calibration equipment, parts and people to put your probes in service quickly.

Future
We recently released a new laser powered EMC probe, a shaped frequency response probe, and new probe software. In the next several months we’ll be making several more new product announcements. Stay in touch and visit our website for more information.

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www.ets-lindgren.com

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