EMI Troubleshooting: The Need for Close Field Probes

Application Note

Figure 1 The Agilent N9000A CXA X-Series signal analyzer and N9311X-100 close field probes

Overview

Close field electromagnetic interference (EMI) test is a valuable tool in electromagnetic compatibility (EMC) radiated emission pre-compliance test. At EMI agencies, EMI receivers and well-calibrated antennas are used to test devices over a distance of 3 or 10 meters. This is called far field measurement. The nature of the electromagnetic field is determined by the device under test (DUT) and the distance of the receivers and antennas from the DUT. A far field radiated emission measurement accurately determines if the DUT is compliant to related EMC/EMI standards.

However, far field testing has limitations. It cannot identify the source of emissions. Radiated emissions may come from a USB, a LAN port, the seam of a shield, a cable, or even a power cord. Close field test is the only way to locate such emission sources and is typically performed using a spectrum analyzer and close field probe. Close field testing is a relative test, meaning a comparison of the DUT results to the results of a reference device can be used to estimate the probability of a device passing compliance testing. It should be noted that comparing close field test results with EMI standard test limits is meaningless because a number of factors can affect the test readout, like the probe position and DUT shape.

This application note looks at the roll of close field probes and explains how specific probes offer distinct advantages for locating, evaluating, and troubleshooting potential emission sources.

Close Field Probes Primer

An electromagnetic field is a combination of the electro field (E-field) and the magnetic field (H-field). Various probes are used to detect emissions in each field type.

H-field probes

Typically the H-field emission source stems from chipset pins, PCB traces, power or signal cables, or metal closures that are not well grounded. Appropriately, the sensing element of an H-field probe is a simple coil that is inductively coupled to the emitting trace or wire. The H-field probe provides the maximum output voltage of the spectrum analyzer when its loop is aligned with the current-carrying wire. When troubleshooting EMI, engineers need to rotate and move the probe over the DUT's surface to locate the maximum power readout and ensure an important emission source is not overlooked.

E-field probes

E-fields can be generated by un-terminated cables and wires, and printed circuit board traces leading to high-impedance logic, which can be high-impedance inputs or tri-state outputs of logic-integrated circuits. The simplest E-field probe is essentially a small antenna. The E-field probe easily detects over-the-air signals, like cellular downlink signals. These higher level over-the-air signals may require an increase in attenuation to prevent the spectrum analyzer from becoming over loaded. However, the attenuation increase will degrade the sensitivity of the spectrum analyzer.

Selecting a probe type

In far field testing, field strength is a function of the distance between the DUT and antenna. As a probe gets closer to the emission source, field strength is primarily a function several properties such as current, voltage, shape, and material. If radiation is generated by a high voltage, low current circuit, or component, the E-field will dominate the EMI close field. If part of the DUT has a high current and low voltage, the H-field will dominate. In close field testing, the H-field fades faster than the E-field as the distance increases. This is why H-field probes are more commonly used to locate emission objects in close field test.

Choosing an H-Field Probe

Probe sensitivity, resolution, and frequency response are important factors to consider when selecting a probe for close field testing.

Sensitivity

Unlike a spectrum analyzer, the sensitivity of close field probe is not an absolute value. Because of this, engineers need to evaluate the sensitivity of the spectrum analyzer and probe together as a system. The whole system should be able to detect small emissions easily and have enough margin to observe the change of emissions before and after hardware modification.

Resolution

A probe's resolution is key to locating emission sources. Generally there is a trade-off between the sensitivity and resolution of a single probe. For example, a larger size H-field probe offers better sensitivity and detects emissions from a larger are, however its resolution degrades making it difficult to isolate the precise emission source. For this reason, it is best to start EMI evaluations using a bigger probe with better sensitivity to capture and determine the rough area of emissions, and then use smaller probes with higher resolution to determine the precise location of the emission source. That is a reason having a set of probes is recommended.

Frequency response

Frequency response is an important factor, but commonly overlooked. Frequency response is the amplitude difference a given probe obtains when measuring signals with same amplitude but different frequencies. When testing the H-field with an antenna, frequency response is of lesser importance than obtaining accurate field strength.

During close field testing, the probe's angle and distance from the DUT changes make the absolute field strength result irrelevant. It is the comparison of data results that is significant in identifying which frequency point has the highest emission. For example, if the frequency response shows high attenuation at a specific frequency, the high emission at this frequency may be comparatively much lower on the signal analyzer and will be ignored.

Other attributes

Shape and diversity are other considerations when choosing a probe set. Other than the normal E-field and H-field probes mentioned, engineers may need special probes for advanced EMI troubleshooting. A common use for specialty probes is to find and shield suspected emission sources. For example, a specialty probe may be needed to identify an emission coupled into cables or a wire and radiated to another part of the DUT. Normal H-field and E-field probes are not effective for detecting interference transmitted through a cable.

Agilent N9311X-100 Close Field Probe Set

The Agilent N9311X-100 close field probe set covers a frequency range of 30 MHz to 3 GHz and is part of Agilent's cost-effective solution for quickly troubleshoot and solving EMI problems. Used with the powerful EMI pre-compliance measurement software and an Agilent X-Series signal analyzer this four-probe set, as shown in Table 1, provides an effective combination of sensitivity, resolution, and diversity.

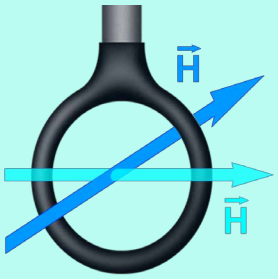
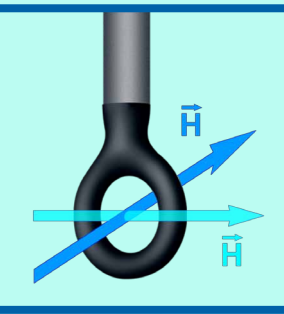
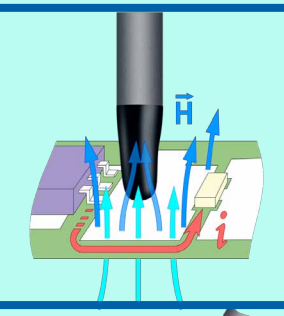
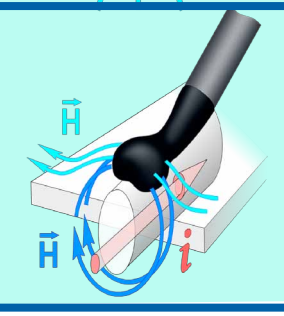
Model Number	Frequency Range	Descriptions
N9311X-100-1  		This large-diameter close field probe is the most sensitive and therefore has the lowest resolution. It can be used at distances up to 10 cm from units. Frequency: 30 MHz to 3 GHz Diameter: Approx. 25 mm
N9311X-100-2  		With a higher resolution and a lower sensitivity than the N9311X-100-1, this probe is suitable for measurements up to 3 cm from units. Frequency: 30 MHz to 2 GHz Diameter: Approx. 10 mm
N9311X-100-3  		Designed for detecting magnetic fields emitting vertically from the surface area of flat units. The probe enables the measurement of obstructed parts of the printed circuit board. Frequency: 30 MHz to 3 GHz Resolution Approx. 2 mm
N9311X-100-4  		Designed for detecting surface and circular magnetic fields on conducting paths, metalized surfaces, plug and socket connectors, cables and component connections. Frequency: 30 MHz to 2 GHz Resolution approx. 5 mm

Table 1 Technical parameters of N9311X-100 four-probe set

Conclusion

Close field EMI test is a valuable tool in EMC radiated emission pre-compliance test. To perform this testing, a variety of close field probes are used based on their distinct advantages for locating, evaluating, and troubleshooting potential emission sources.

For a complete EMI test solution, Agilent offers the N9311X-100 close field probe set and X-Series signal analyzers, combined with the EMI measurement application software. It is a valuable EMI pre-compliance measurement solution, while offering a range of signal analyzer models to meet your performance and budget requirements: from the high-performance PXA, through the mid-performance MXA and EXA, to the very cost-effective CXA.

Additional Resources

Literature

For a more details on radiated and conducted emissions measurements and information about the EMI measurement application, visit www.agilent.com and download the following documents:

Making Conducted and Radiated Emissions Measurements, application note, literature number 5990-6152EN
N6141A and W6141A X-Series EMI measurement application, technical overview, literature number 5990-6035EN

Web

X-Series signal analyzers
www.agilent.com/find/x-series
N6141A EMI measurement application (for PXA, MXA, and EXA)
www.agilent.com/find/n6141a
W6141A EMI measurement application (for CXA)
www.agilent.com/find/w6141a
N9311X-100 close-field probes
www.agilent.com/find/n9311x

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