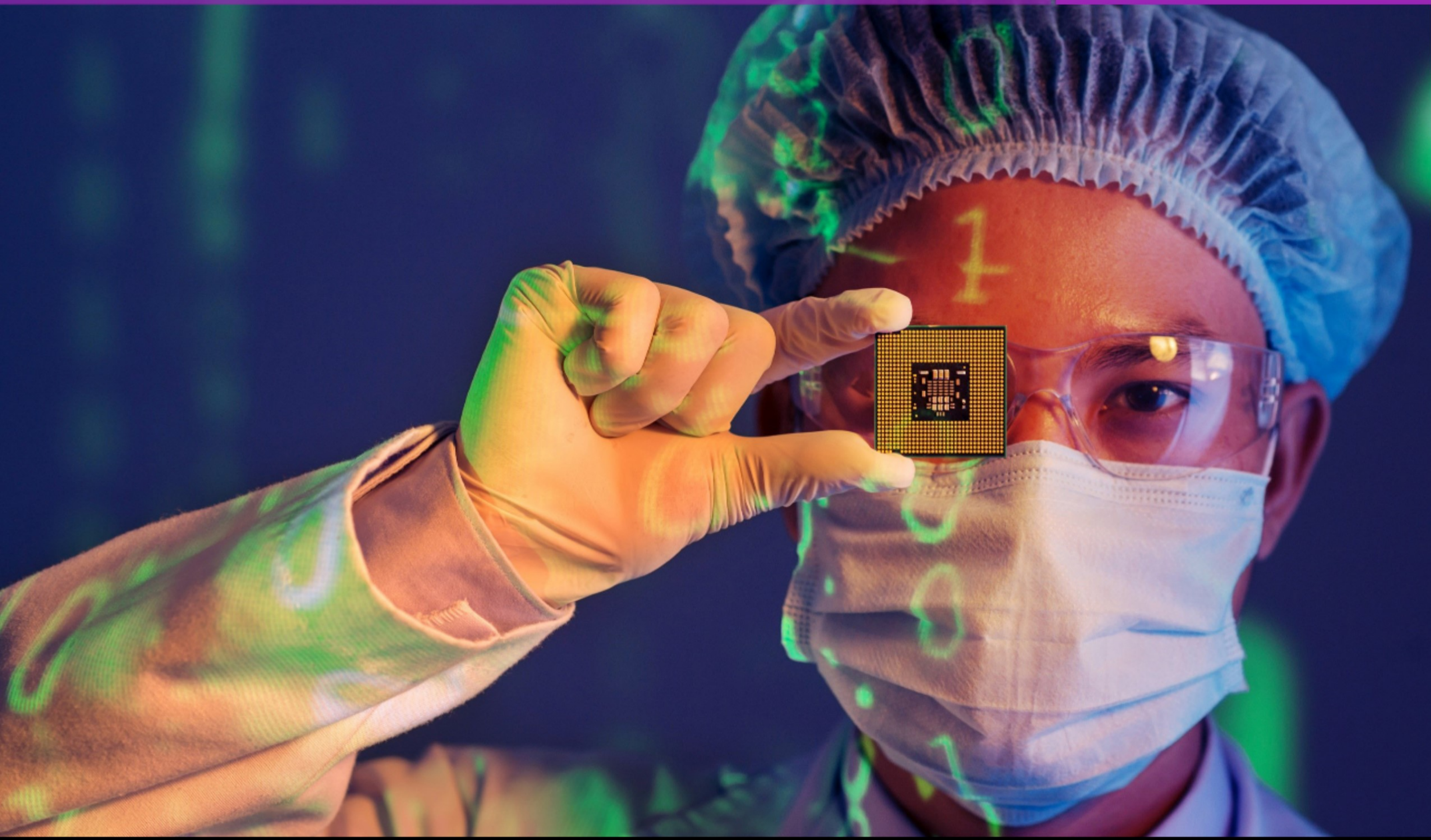

EMI Troubleshooting: The Need for Close Field Probes

KEYSIGHT

Overview

Close field electromagnetic interference (EMI) tests are a valuable tool in electromagnetic compatibility (EMC) radiated emission pre-compliance testing. Close field testing is performed at short distances. Far Field testing is performed at distances between 3 to 10 meters at test facilities using EMI receivers and antennas. 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 port, a LAN port, the seam of a shield, a cable, or even a power cord. Close field testing is the only way to locate the exact source of the emission and is typically performed using a signal analyzer and close field probe. Close field testing is a relative test, meaning a comparison of the radiator's results to the rest of the device's results can help you address where redesign work is required. 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 white paper looks at the role of close field probes for locating, evaluating, and troubleshooting potential emission sources.

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Close Field Probes

An electromagnetic field is a combination of the electro field (E-field) and the magnetic (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 signal 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 signal analyzer from becoming over loaded. However, the attenuation increase will degrade the sensitivity of the signal 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 of 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 testing. So, we'll go ahead and look at H-field probes.

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 signal analyzer, the sensitivity of a close field probe is not an absolute value. Because of this, engineers need to evaluate the sensitivity of the signal 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 area, 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 why having a variety of probe types is typically 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 the same amplitude at 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, making 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.

Keysight N9311X-100 Close Field Probe Set

The Keysight Technologies, Inc. N9311X-100 close field probe set covers a frequency range of 30 MHz to 3 GHz and is part of a cost-effective solution for quickly troubleshooting and solving EMI problems. When used with powerful EMI pre-compliance measurement software and a signal analyzer this four-probe set, as shown in Table 1 below, provides an effective combination of sensitivity, resolution, and diversity.

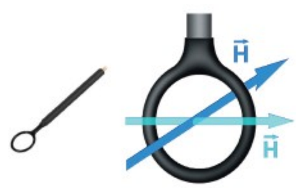
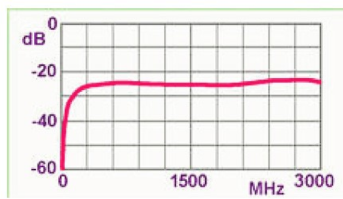
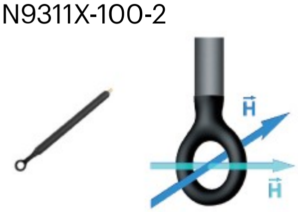
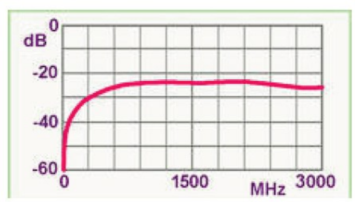
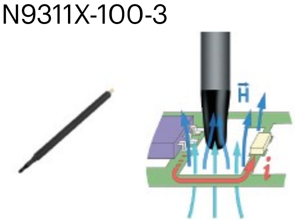
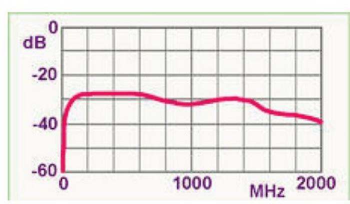
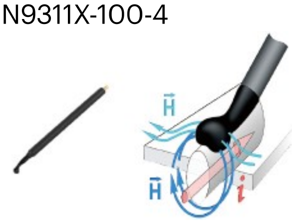
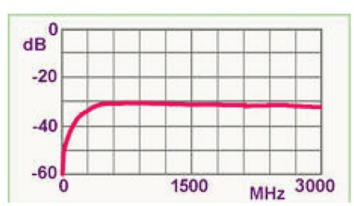
Model number	Frequency range	Descriptions
N9311X-100-1 		This large-diameter close field probe is the most sensitive and therefore has the lowest resolution. It can be used of distances up to 10 cm from units. Frequency: 30 MHz to 3 GHz Diameter: Approx. 25 mm
N9311X-100-2 		With a higher resolution 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 flats units. The probe enables the measurement of obstructed parts of the printed circuit board. Frequency: 30 MHz to 3 GHz Diameter: 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 Diameter: Approx. 5 mm

Figure 1. Technical parameters of N9311X-100 four-probe set

Conclusion

Close field EMI testing is a valuable tool in EMC radiated emissions pre-compliance testing. 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, Keysight 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.keysight.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.keysight.com/find/x-series

N6141A/N6141C EMI measurement application
www.keysight.com/find/n6141a
(for PXA, MXA, and EXA)

www.keysight.com/find/n6141c
(for the multi-touch GUI X-series signal analyzers)

W6141A EMI measurement application
www.keysight.com/find/w6141a
(for CXA N9000A Signal Analyzer)

N9311X-100 close-field probes
www.keysight.com/find/n9311x

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