Keysight Technologies

Enhancing Efficiency of EMI Pre-Compliance Testing with Advanced Software Capabilities

Application Note

KEYSIGHT TECHNOLOGIES

Unlocking Measurement Insights

Introduction

The concept of getting a product to market on time and within budget is not new. Recently, companies have realized that electromagnetic interference (EMI) compliance testing can be a bottleneck in the product development process. To ensure successful EMI compliance testing, pre-compliance testing is being implemented earlier in the product development cycle. In pre-compliance testing, the electromagnetic compatibility EMC performance is evaluated at multiple stages, starting with lab prototypes. Figure 1 illustrates a typical product development cycle.

Many manufacturers use (EMI) measurement systems to perform conducted and radiated EMI emissions evaluation prior to sending their product to a test facility for full compliance testing. Conducted emissions testing focuses on unwanted signals that are on the AC mains generated by the equipment under test (EUT). The frequency range for these commercial measurements is from 9 kHz to 30 MHz, depending on the regulation. Radiated emissions testing looks for signals broadcast for the EUT through space. The frequency range for these measurements is between 30 MHz and 1 GHz, and based on the regulation, can go up to 6 GHz and higher. These higher test frequencies are based on the highest internal clock frequency of the EUT. This preliminary testing is called pre-compliance testing.

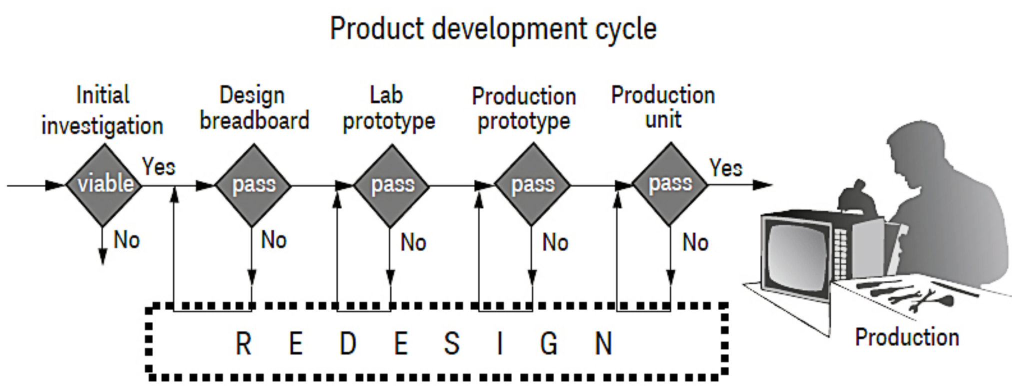

Figure 1. A typical product development cycle

In order to maximize the benefit of pre-compliance testing, the EMI pre-compliance measurements should be made under conditions that closely resemble the actual EMI compliance testing environment. This means performing measurements with the same detectors, resolution bandwidths (RBWs) and measurement times required by the appropriate commercial and military compliance regulations. Using the same software that compliance testing centers use will also give design teams more confidence in the accuracy of their pre-compliance testing.

This application note covers some of the key software capabilities that will help you efficiently make EMI pre-compliance measurements with an X-Series signal analyzer running the N6141C EMI measurement application software.

Key Software Capabilities

The following key features in the Keysight Technologies, Inc. N6141C EMI measurement application can help you make EMI pre-compliance measurements more easily and efficiently: limit lines, correction factors (for transducers), signal lists with sorting capability, signal maximization, time domain scanning, and more.

Limit Lines

A primary goal of EMI testing is to detect signals that are in violation of a specification. Limit lines are used to find those suspect signals in combination with the following features on a pre-compliance analyzer:

- Built in limit lines for the required tests
- Multiple limits
- Limit margins
- Custom limits that can be added alongside the built in limits
- Ability to save custom limits
- Simple pass/fail indicators

A limit line library, containing a common set of limits, makes it convenient to set up common test scenarios. With the custom limits, a user can easily set up any type of measurement.

Limit lines, combined with internal testing that identify signals over a certain limit, help pinpoint suspect signals for further analysis. Limit margins can be specified to provide room for error, particularly in a poorly characterized test environment. Many EMI software suites include built-in capability to add margins to limits.

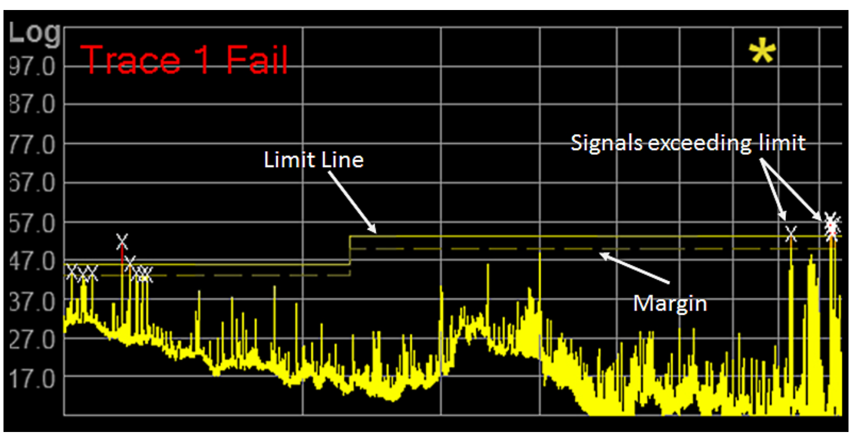

Figure 2. An illustration of a limit line and margin with pass/fail indicator. With internal testing, signals that failed the limit can be identified automatically and added to a signal list.

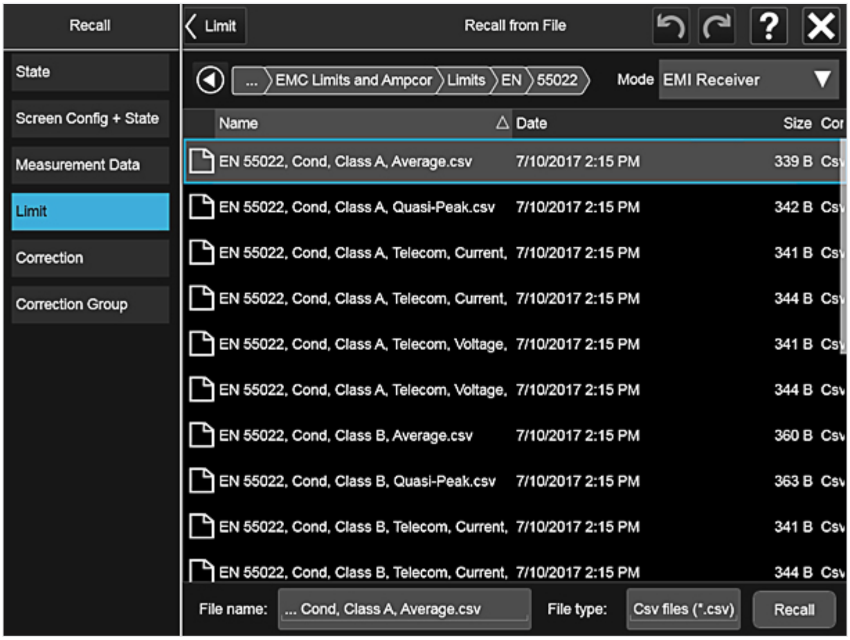

Figure 3. A built-in limit line library.

Correction Factors

Transducers such as antennas, LISNs (Line Impedance Stabilization Networks), current probes, current clamps, cables and amplifiers have unique frequency-dependent correction factors that are usually supplied by the manufacturer or calibration facility. These correction factors are added to or subtracted from the measured amplitude values to compensate for the transducer gain or loss, which allows the receiver to display the actual emission field strength amplitude at the transducer. A good pre-compliance software package should include a library of built-in correction factors. It should also enable custom, user designed corrections.

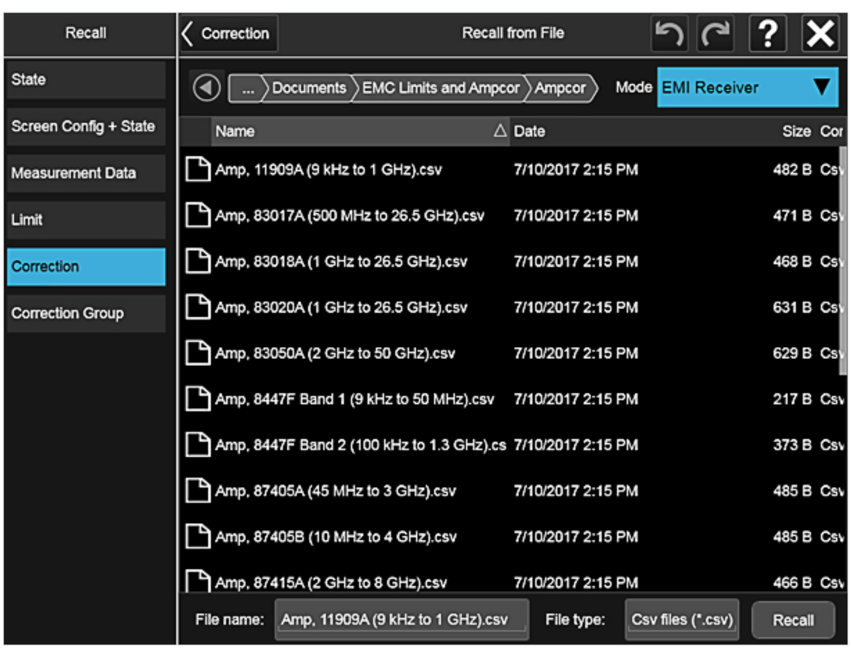

Figure 4. A library of correction factors.

Signal List

Scan results that exceed the limit lines are stored in a signal list, or suspect list. Typically a suspect list applies to commercial measurements because the emission values are not measured with weighted detectors (the limits are Quasi Peak or EMI-Average, not Peak). Emissions are suspected to be over the limit when the Peak value is over the limit. These suspect signals are listed so they can be checked in more detail with the weighted detectors. A signal list, particularly one which identifies duplicate signals or can be edited or sorted, is handy for debugging and troubleshooting failed signals. Some EMI software suites enable the signal list to be shared between different applications. This feature is extremely convenient because the user can perform different measurements with the same signal list.

Once a suspect signal list has been compiled, the user can perform signal maximization (discussed below), followed by final measurements on each of the suspect signals. Some EMI software suites automate the final measurements on each signal in the suspect list, for even greater efficiency.

Sig		Trc	Freq	Peak Amptd	QPD Amptd	EAvg Amptd	Peak LL1 Δ	QPD LL1 Δ	EAvg LL1 Δ	Composite AmpC
1	✓	1	37.380 MHz	31.542 dBµV	25.816 dBµV	17.816 dBµV	-1.458 dB	-7.184 dB	-15.184 dB	0.000 dB
2	✓	1	38.580 MHz	33.106 dBµV	27.901 dBµV	19.911 dBµV	0.106 dB	-5.099 dB	-13.089 dB	0.000 dB
3		1	38.820 MHz	33.997 dBµV	27.534 dBµV	19.589 dBµV	0.997 dB	-5.466 dB	-13.411 dB	0.000 dB
4	✓	1	102.42 MHz	30.188 dBµV	25.332 dBµV	17.618 dBµV	-2.812 dB	-7.668 dB	-15.382 dB	0.000 dB
5	✓	1	105.84 MHz	39.680 dBµV	37.345 dBµV	33.024 dBµV	6.680 dB	4.345 dB	0.024 dB	0.000 dB
6		1	108.66 MHz	32.176 dBµV	26.414 dBµV	18.552 dBµV	-0.824 dB	-6.586 dB	-14.448 dB	0.000 dB
7	✓	1	118.32 MHz	35.015 dBµV	23.199 dBµV	15.456 dBµV	2.015 dB	-9.801 dB	-17.544 dB	0.000 dB

Figure 5. Signal list example with suspect signals identified.

Multiple Traces

Having the ability to view and compare multiple traces is very useful for diagnosing EMI issues. Common comparisons include signals from different test setups, and before and after design/shielding adjustments. The addition of a Max Hold capability (the trace holds maximum values from repeated scans), further facilitates identification of suspect emissions. The multiple trace capability also allows you to compare the results from different detector types. For troubleshooting purposes, it is desirable to be able to export trace results which can then be forwarded to other engineering teams.

Multiple traces can also be used to generate a suspect list prior to performing final measurements. Using side by side comparisons, multiple traces can be used to capture and record the maximum values of the peak emissions while rotating the turntable and moving antennas. Since a significant amount of time is often spent in turntable and antenna manipulation, multiple trace support will significantly reduce test time.

Signal Maximization

Before making final measurements, it is important to adjust the final measurement frequencies to obtain the maximum signal amplitudes. This is a CISPR recommendation for improved measurement accuracy. During the pre-scan, these maximum frequencies and amplitudes might not be captured because of the nature of time-varying measurements or the resolution bandwidth selected by the user. The maximization process requires the device under test (DUT) to be rotated, usually with a turntable, while the antenna height is varied. Software tools can help capture the maximum signal amplitudes while the DUT is being physically adjusted.

One way to perform signal maximization involves peaking a signal around a small span. The monitor spectrum can be used to identify the frequencies of maximum emissions in your suspect list. This feature offers both live-spectrum and meter displays that make it easy to see emission levels and the maximum while adjusting the center frequency. With an editable signal list, each suspect signal can be maximized prior to final measurement. After maximization, the frequency of each signal in the list can be replaced with the value found after maximization. Final measurements are then based on the frequencies of the maximized signals.

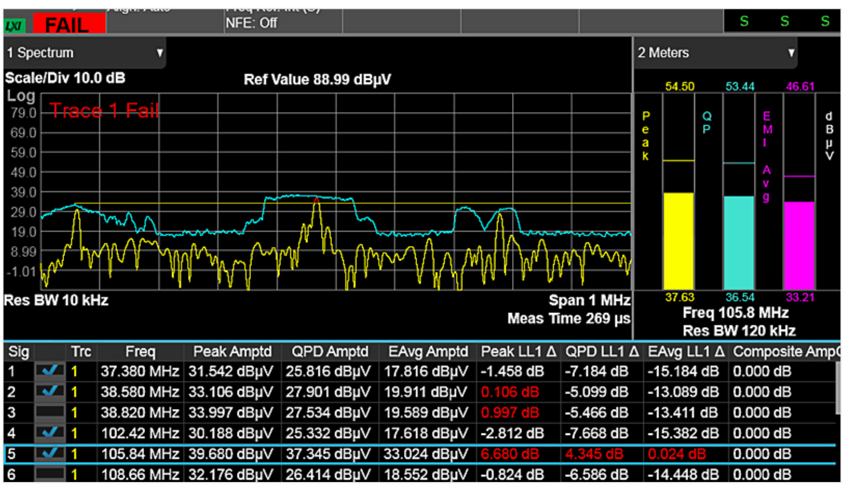

Figure 6. Off-centered signal. Performing maximization will center the peak signal.

For an in-depth discussion on maximization using a signal analyzer, see the application note *Streamline EMC Compliance Testing with Prescan Analysis Tools,* literature number 5991-4817EN.

Time Domain Scan

An FFT-based alternative to sweep/frequency scans, the time domain scan is a powerful tool that can help complete pre-scans much more quickly. It uses high overlap FFTs to make measurements in larger frequency increments. Unlike the traditional swept methodology which dwells for each resolution bandwidth, time domain scan only dwells once per FFT bandwidth. The time savings can vary, but it is not uncommon for it to be around two orders of magnitude. Time domain scan capability is usually a paid option for most EMI software, but given the time savings it is often a worthwhile consideration. This type of FFT scanning is gaining popularity among automotive companies and test setups that require long pre-scan times.

Measuring Unsteady Emissions

When measuring unsteady emissions, including turntable setups, it can be helpful to have a time domain based measurement view that plots emissions over time and displays the highest emission values. This produces a history of the device's emissions which can be analyzed in detail. If a turntable is used, this information can be mapped back to its rotation and the point of maximum emissions can be found. In pre-compliance testing, it is critical to have diagnostic tools that identify the sources of problem signals.

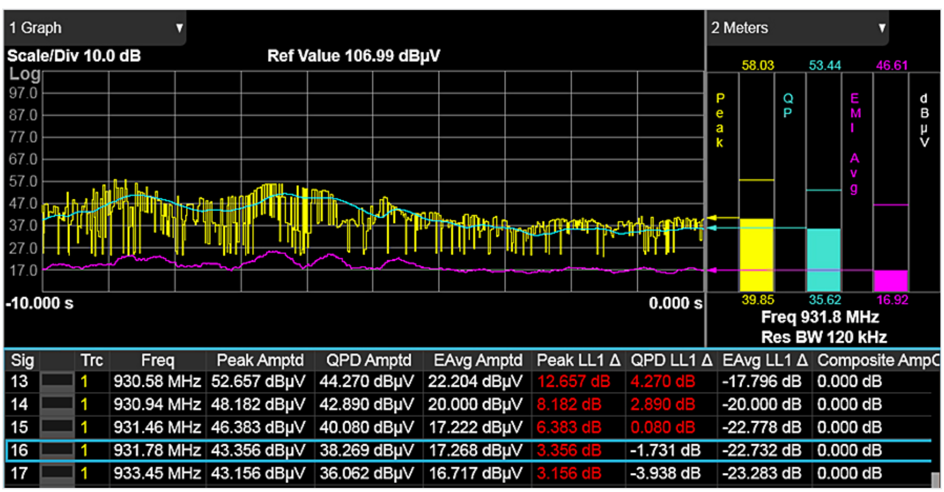

Figure 7. Time based emissions plot with three detectors. The x-scale is read from left to right chronologically.

Testing Household Appliances

Design teams testing household appliances need to test according to CISPR 16 and CISPR 11 regulations. Such testing usually revolves around detecting certain disturbances known as clicks. These requirements are rather rigorous and early detection of possible issues can shorten test cycles. The EMI software should not only detect problematic signals, but also produce a report containing a list of the rules that the device under test failed. CISPR defines a number of exceptions related to the number and nature of the clicks found. The software should account for these exceptions when determining the pass/fail results.

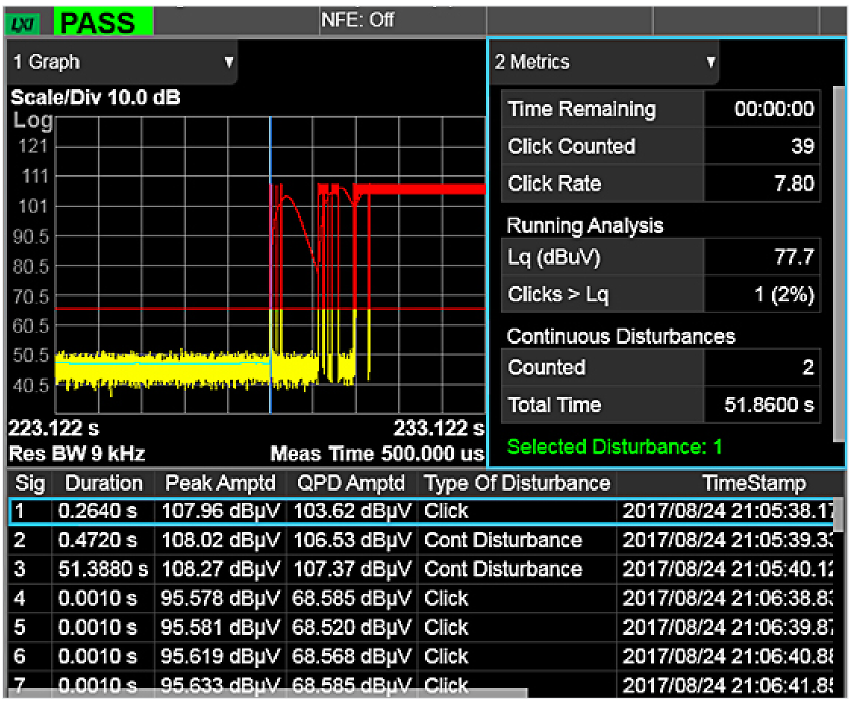

Figure 8. Disturbance Analyzer for household appliances. The panel on the right shows a running tally of important test parameters.

Report Generation

A reporting feature helps communicate EMI issues for other engineering teams to analyze and resolve. Such a report can contain trace data, signal list, limits, correction factors, screen shots, along with important header information. In the case of click analysis, matching EMI failures with the relevant CISPR standard can aid interpretation and resolution.

Conclusion

EMI pre-compliance testing can be enhanced with the use of appropriate software tools. An effective pre-compliance testing methodology will reduce test cycle times which ultimately impacts a company's bottom line. The Keysight N6141C EMI measurement application, when combined with a Keysight X-Series analyzer, can be a powerful addition to a company's EMI pre-compliance portfolio. It has a rich feature suite with tools such as the ones described above, and much more.

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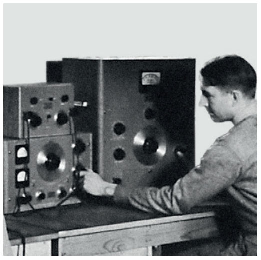
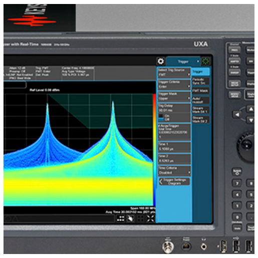


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