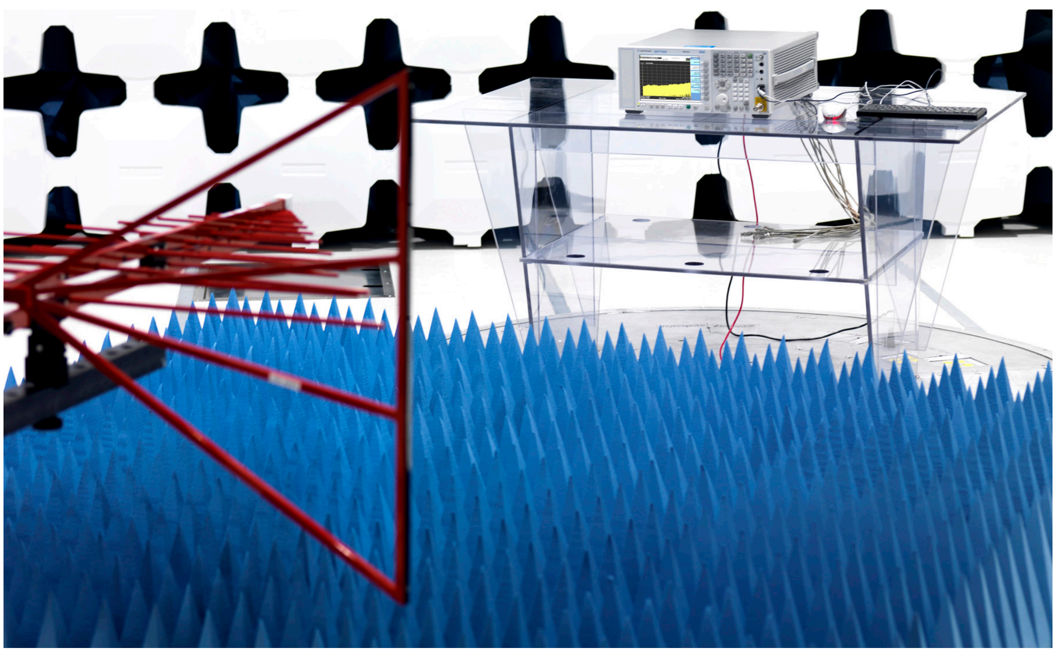
Keysight
Application Note

Streamline EMC Compliance Testing with Prescan Analysis Tools

Introduction

Today's fast-paced, high-growth electronics market requires electromagnetic compliance (EMC) test facilities to develop shorter product test cycles while maintaining test accuracy. Commercial test requirements recommend emissions prescan methodologies to help reduce overall test times and improve facility throughput. However, these measurements can introduce frequency and amplitude errors into the suspect list. As a compliance test engineer, you need to understand the benefits and challenges associated with prescan data to ensure that final measurements are being made at the correct frequencies.

This application note provides an overview of the errors associated with prescan analysis and how to overcome them using spectrum analysis and intermediate-frequency (IF) spectrum monitoring capabilities.



Benefits and Challenges of Prescan Analysis

Making final measurements can be a time-consuming process, depending on the dwell time and the detector used for the measurement as well as the number of frequencies measured. Making a final measurement at every frequency in the compliance frequency range, whether there is an emission or not, is extremely inefficient. Conducting prescans to create a suspect list of emissions from a device under test (DUT) allows you to focus final measurement efforts only on frequencies with known emissions–saving time and money.

However, prescanning methodologies can introduce frequency and amplitude errors into the suspect list, preventing you from accurately characterizing DUT emissions. Prescan measurements may not accurately represent the characteristics of peak emissions because of how stepping and sweeping receivers collect and display information as well as the characteristics of the emission itself.

Prescan errors caused by receiver function

When scanning for suspect emissions using a stepping or sweeping receiver, measurements are made at every resolution bandwidth (RBW) spacing and typically at fractional resolution bandwidth spacing. For example, when making CISPR-based emissions scans from 30 MHz to 1 GHz using a 120 kHz CISPR RBW, most engineers collect prescan data at every 60 kHz (two points per RBW) or every 30 kHz (4 points per RBW).

Amplitude and frequency errors are introduced when the emission frequency is not exactly at the receiver tune frequency, in the center of the RBW. When using a stepping receiver, the measured amplitude will be less than the maximum emission level due to the filtering effects of the RBW. For example, when using a 120 kHz (-6 dB) RBW, a measurement scan at every 120 kHz will record an emissions signal that falls exactly between two measurement points at an amplitude 6 dB lower than the maximum. The result is a suspect that may fall beneath the limit line, when it is actually over it.

Overall prescan amplitude accuracy can be improved by using a greater number of prescan data points. In the example given above, doubling the number of data points by measuring at every 60 kHz results in a recorded amplitude error of 1.5 dB. However, this approach adds to overall prescan measurement time, as the required dwell time needs to be added for each measurement point, reducing the benefits of prescan.

In addition, the stepping receiver reports the amplitude at the current measurement frequency. In the above example, the lower amplitude would be reported as being 60 kHz away from the actual measurement frequency.

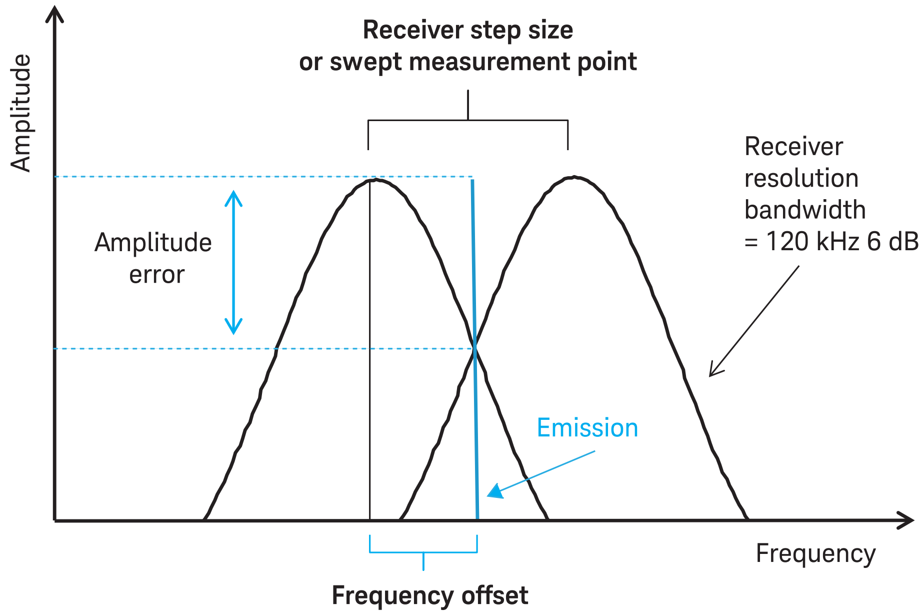


Figure 1. Amplitude and frequency errors due to misalignment between receiver measurement frequencies and emissions frequency with a worst-case error situation depicted

	Stepped and swept scan		Stepped scan only
# Meas. per RBW	Step size	Frequency offset	Amplitude error
1	120 kHz	60 kHz	6 dB
2	60 kHz	30 kHz	1.2 dB
3	40 kHz	40 kHz	0.5 dB
4	30 kHz	20 kHz	0.3 dB

Figure 1 shows this scenario as well as a summary of the potential frequency and amplitude errors as a function of prescan step size for a 120 kHz RBW. This example highlights the worst-case where the emission frequency falls exactly between two receiver measurement frequencies, and the reported value is 6 dB lower than the actual emission level.

When using a swept receiver to make this same measurement, the maximum emission amplitude will be captured correctly but the displayed emission frequency will be recorded at the measurement point, offset from the actual frequency. Sweeping receivers record all the amplitude information as the RBW is swept through the frequency range, [+/- (step size)/2 around the measurement point] but they report the maximum amplitude emission as if it occurred at the selected measurement point. Using the example above of a measurement at every 120 kHz and an emission exactly halfway between two points, a sweeping receiver would report the correct emissions amplitude as occurring at one of the selected measurement points, a 60 kHz offset.

In order to ensure that both the correct emissions amplitude and frequency are accurately recorded during final measurement, you must review each signal in the suspect list using a single-frequency measurement and adjust the list frequency as needed prior to making a final measurement.

Prescan errors due to signal variations

Frequency and amplitude values measured during prescan are dependent on the characteristics of the input signal during the measurement period. When DUT emissions have significant amounts of frequency and/or amplitude modulation, the emission values in the suspect list recorded during prescan can differ significantly from the peak emission values. If the emission being measured for the suspect list does not exhibit its maximum amplitude during the dwell time of the prescan measurement, the amplitude recorded for that frequency will not accurately reflect the true emissions profile of the DUT.

An example of this type of emission is one with a significant amount of frequency modulation, such as a local oscillator, clock frequency, or digital power supply frequency that employs frequency modulation (also known as “dithering”) to spread out the spectral energy in order to reduce its peak emission profile. This is a common design technique to help products meet compliance limits.

Ensure the Accuracy of Prescan Data Prior to Final Measurements

Prescan amplitude and frequency errors call for close examination of each signal collected during prescan prior to making a final measurement. For commercial compliance, CISPR requires that you monitor the weighted emission amplitude prior to final measurement to characterize the amplitude change as a function of frequency. It also requires you to adjust final measurement dwell times based on DUT amplitude variation. Modern EMC receivers offer two capabilities that facilitate this examination: full spectrum analysis and IF spectrum monitoring.

Full spectrum analysis

Spectrum analyzers are the most powerful tools available for observing the characteristics of an emission. They offer a full complement of detectors, resolution bandwidths, and video bandwidths to analyze a suspect signal. Multi-trace capability allows you to observe both the instantaneous value and envelope of a modulated signal. Spectrum analyzers also have powerful marker capabilities which allow you to easily identify peak emission frequencies and emission envelope bandwidths.

However, commercially-available spectrum analyzers only have one downconversion signal path, preventing you from both rapidly scanning a suspect signal and measuring the single-frequency weighted detector value of the suspect signal at the same time. Scanning with both peak and weighted detectors simultaneously is possible, but a weighted detector can significantly slow down the marker update rate used to follow the amplitude fluctuations of the peak emission.

IF spectrum monitoring

IF spectrum monitoring provides both simultaneous single-frequency weighted measurements and span-limited spectrum displays of suspect emissions. The instrument local oscillator is fixed at the frequency of interest and the receiver measures the single-frequency amplitude at the center of the IF passband, typically on a meter. The instrument also displays the spectral content of the information within the IF bandwidth around the center frequency using a fast Fourier transform (FFT). This capability makes it is easy for you to manually tune the receiver to peak the emission response while observing the spectral content. In addition, receivers that offer multi-trace capability for the IF spectrum monitoring display provide views of both instantaneous spectrum and signal envelope.

While powerful, IF spectrum monitoring also has limitations. The displayed frequency span is only a portion of the receiver IF bandwidth. In addition, available bandwidths are limited to values less than the RBW used to measure the center frequency amplitude, typically the RBW required by the regulatory agency. For these reasons, IF spectrum monitoring is not as flexible as full spectrum analysis for performing diagnostics on the suspect signal.

Using full spectrum analysis and spectrum monitoring to improve prescans

The Keysight N9038A MXE EMI receiver offers both full spectrum analysis and spectrum monitoring capabilities. The spectrum analyzer is linked to the receiver by activating global center frequency, which couples the center frequency of the spectrum analyzer to that of the receiver. When the receiver is tuned to a suspect signal in the list, the user can easily switch to the spectrum analyzer and that signal will be at the center of the spectrum display. The diagnostic capabilities of the analyzer enable you to identify the frequency of the peak emission and quickly update the frequency in the suspect list.

You can also use monitor spectrum to simultaneously display and update both the receiver meter values and a banded IF spectrum display. Monitor spectrum mode provides direct access to the suspect list for easy signal navigation. Using meters, you can measure up to three detector values of the displayed center frequency.

For example, consider the measurement of a 550 MHz signal with an FM modulation deviation of 1 MHz and a modulation rate of 1 kHz. This signal is injected into the MXE receiver and measured using a 120 kHz CISPR bandwidth, 2 points per RBW, and a 62 μs dwell time (equaling a scan time of 1 s, just over the minimum CISPR scan time of 970 ms for this frequency range). As shown in Figure 2, the interaction of the FM characteristics and the measurement dwell time appears as five independent signals collected to the suspect list using the built-in search algorithm, which identifies all signals that exceed the selected limit line (in this example, the displayed limit line is for EN55022, Class A, 3 meters).

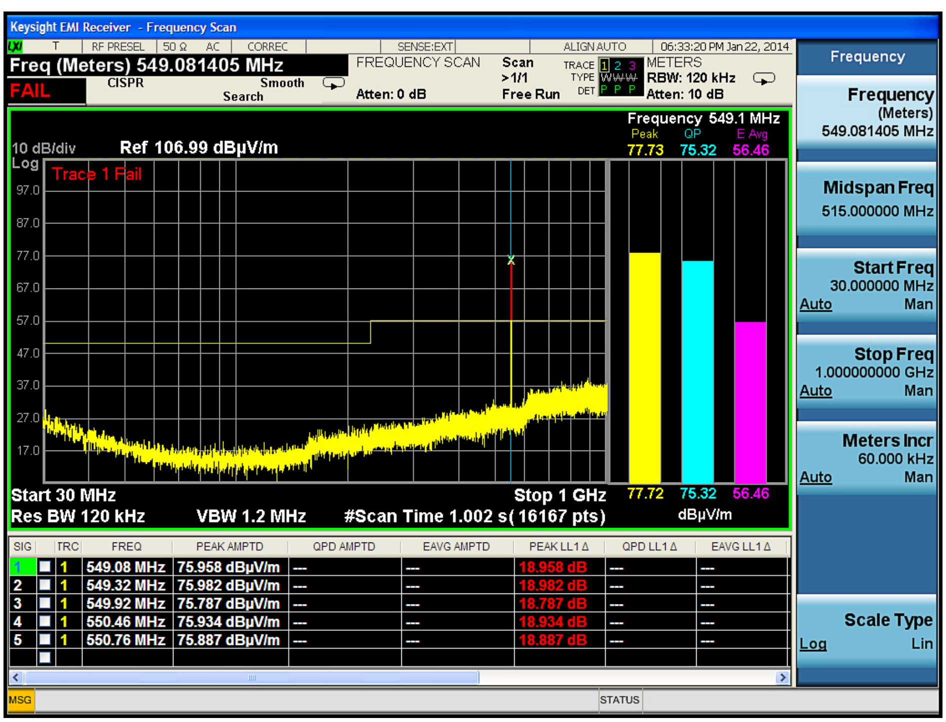


Figure 2. FM modulated signal measured against a limit line and recorded to the signal list using the built-in testing function in the MXE

This signal is displayed in detail using the monitor spectrum feature shown in Figure 3, which provides a clear view of the frequency modulation on the signal, something that is not identified in Figure 2. In Figure 3, a max hold (blue) trace is used to display the modulation envelope of the signal and an additional clear write (yellow) trace displays the instantaneous value and frequency of the signal. This demo signal has a very flat amplitude characteristic, so one measurement could be made at the frequency exhibiting the highest amplitude, which is easy to identify using the marker peak search function on the max hold trace.

The list frequencies can be updated easily with the new value and ready for final measurement. A real-world signal can have an amplitude variation versus frequency, requiring additional measurements for all signal peaks. Monitor spectrum, with its powerful multi-trace and marker tools, provides a clear view of emission signal characteristics. This information saves measurement time by reducing the number of measurements required to evaluate a signal.

Figure 3. A monitor spectrum view of the signal highlighted in Figure 2, which makes it easy to see the FM modulation of the signal

Summary

Analyzing emission suspect signals collected during prescan prior to final measurement is important to ensure final measurement accuracy and properly characterize the DUT. Spectrum analysis and IF spectrum monitoring are powerful tools for prescan analysis. These tools increase measurement accuracy while helping to reduce compliance test time by making it easy to view and characterize suspect signals.

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