Electromagnetic Interference Testing Using Real-Time Scan Measurement

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Introduction

As the next generation of 5G mobile networks, autonomous driving vehicles, and the Internet of Things (IoT) takes shape, engineers are racing to design more wireless devices to meet accelerating market demand. Simultaneously, the density and complexity of the electromagnetic environment are increasing as a result of the tremendous number of devices that connect wirelessly to the network. These dynamics pose a challenge for electromagnetic compatibility (EMC) testing due to the fact that wireless devices require certification to regulatory compliance standards that are also growing in number.

It is important to identify and isolate EMC issues quickly during EMC compliance testing to help you bring devices to market faster and more efficiently. The Keysight N9048B PXE electromagnetic interference (EMI) test receiver provides a new feature called real-time scan (RTSC) measurement. The new feature significantly improves the diagnostic capabilities of the EMC application and rapidly troubleshoots EMC issues in your device.

This application note will discuss how to use RTSC measurement to perform EMC testing that can detect and evaluate fast transient signal measurements using 350 MHz wide fast Fourier transform (FFT) bandwidth.

Real-Time Scan Basics

RTSC measurement provides gapless signal capture and analysis with a very wide FFT analysis bandwidth up to 350 MHz. The measurement simultaneously displays the frequency domain, time domain, and spectrogram results with up to three EMC detectors. It also allows users to perform gapless radiated measurements to detect and analyze intermittent disturbance signals. These signals are easy to miss using conventional scan modes due to the long dwell times the test standards specify at each frequency.

An EMI receiver has multiple preselector filters on the radio frequency (RF) section to filter out any signals that do not appear on the screen. These filters are essential to prevent an overload condition when measuring an impulsive signal. In recent years, time-domain scan (TDS) has become more prevalent, replacing the conventional stepped scan analysis in many cases. A TDS scan involves multiple FFT acquisitions working on different preselector filters (see Figure 1). However, switching FFT acquisition on the preselector filters requires hardware settling. Therefore, these acquisitions have a time gap in between.

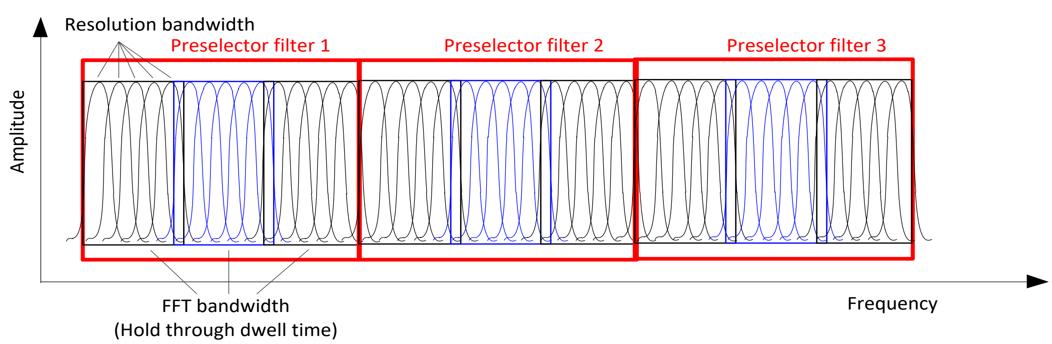

Figure 1. Time domain scan in frequency spectrum

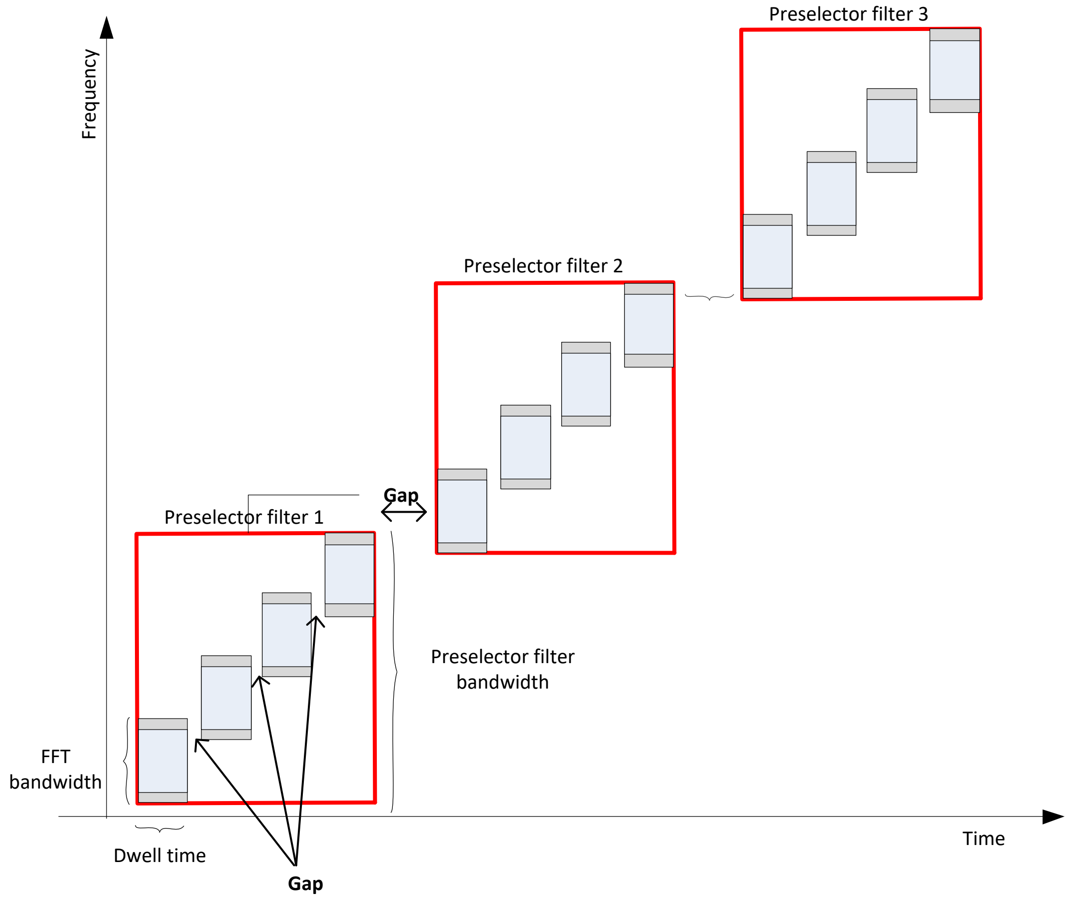

Figure 2. Time domain scan in time domain

Measuring emission with the time gaps between acquisitions (see Figure 2) is intolerable since you never quite know what signals are present in EMI measurement. Traditionally, you can address the gaps in one of two ways with a smooth or stepped scan. You can prolong the dwell time in each frequency step to increase the probability of detection. Or you can pause the turntable at each angular position and perform a continuous quick scan with short dwell time across the frequency range of interest. This method enables a Maximum Hold trace until you capture the disturbances on the display.

However, repeating these steps for every antenna and turntable angular position will lead to excessively long EMI measurement times (see Figure 3).

Achieving emission spectrum for each turntable angle at different frequencies is not a straightforward process. The Maximum Hold trace is aggregated in the measurement and every time slice captured is not traceable at the end of the measurement. It is difficult to determine whether the signals are continuous wave (CW) or pulses and it is time-consuming to identify the source of emission.

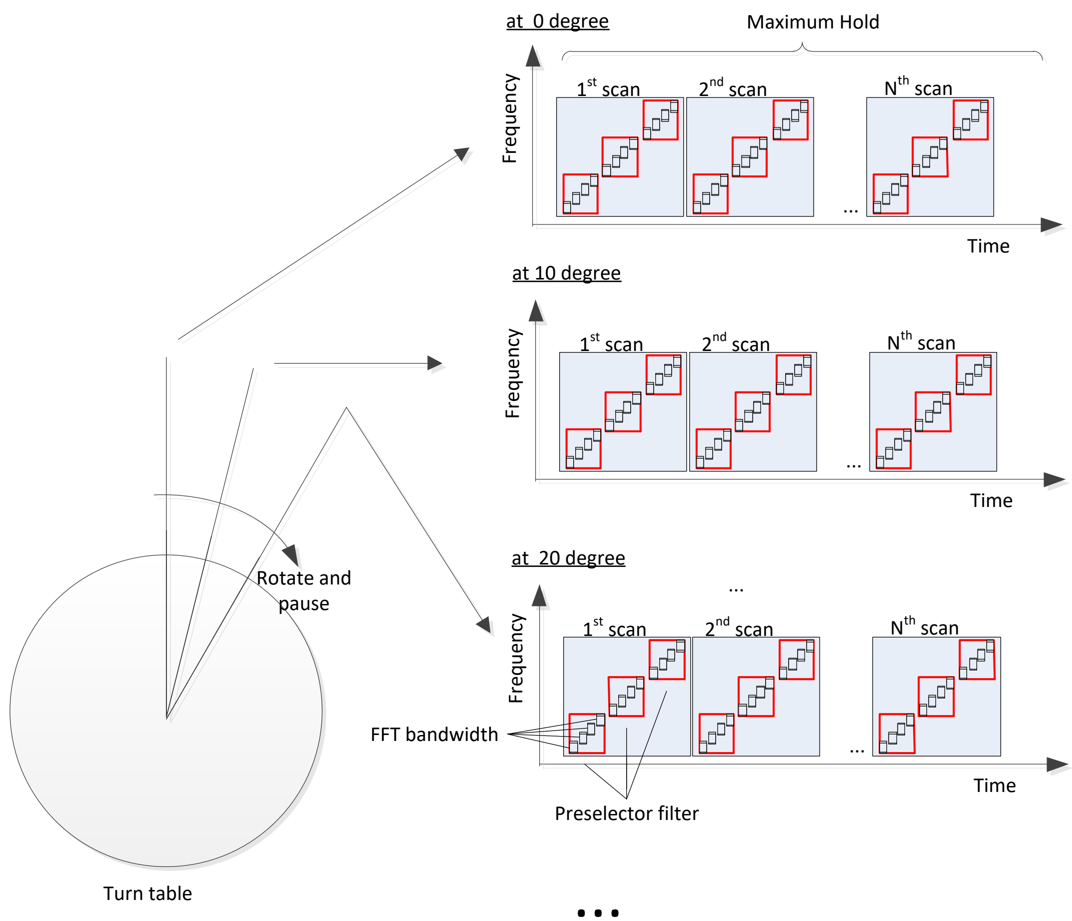

Figure 3. Example of EMI measurement setup

Solution

Real-time scan measurement overcomes the shortfalls in modern EMI measurement. The capability to continuously process all the samples in a single FFT acquisition bandwidth with EMI detectors enables signal analysis without gaps or missing signal behavior. Instead of performing scans per every turntable angular position, the EMI measurement can run in real-time while the turntable rotates continuously. See Figure 4.

If you need a span wider than 350 MHz, repeat the measurement a few times. For example, for a measurement from 30 MHz to 1 GHz, you repeat the measurement three times using 350 MHz bandwidth. In addition, you can record spectrum data from the last 12,000 time slices and trace them back and forth for post-measurement analysis. Finding the source of an issue is much easier when you have the data on-hand.

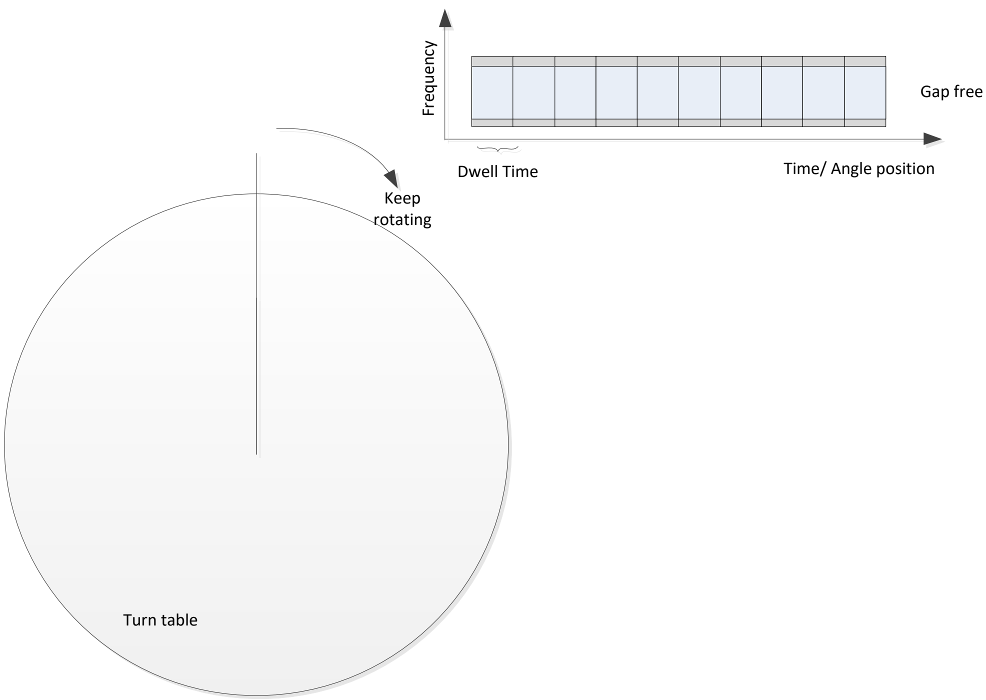

Figure 4. EMI measurement setup with real-time scan

Design

RTSC measurement provides real-time results of the spectrum at the receiver input by limiting the measurement to a single FFT acquisition. It sets the local oscillator (LO) to a fixed frequency, captures data, and performs FFTs simultaneously. The process provides gapless and historical data in both time and frequency domain for the respective frequency ranges. See Figure 5.

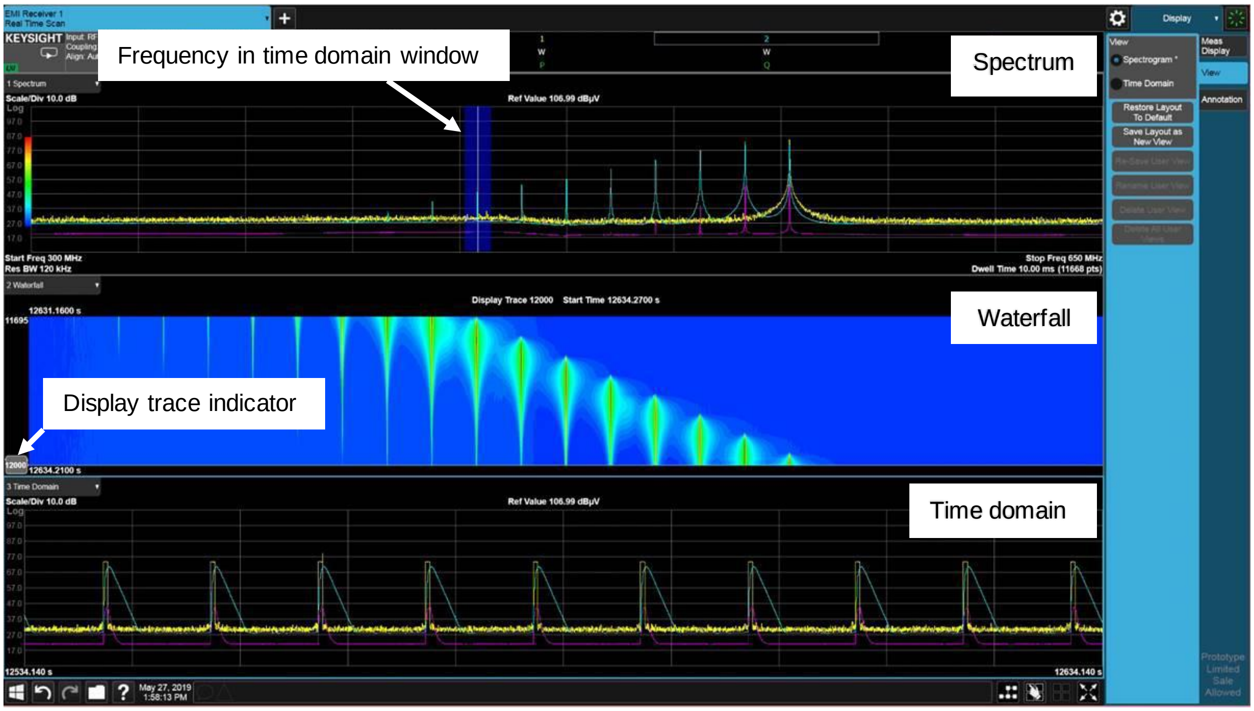

Figure 5. Real-time scan measurement view

RTSC measurement provides an intuitive user interface and a rich set of information with three windows:

Spectrum window

The spectrum or frequency domain window shows a spectral display of the input radio frequency (RF) signal with amplitude in the vertical y-axis, and frequency in the horizontal x-axis. The spectrum window shows the single-time slice spectrum separately from the waterfall/spectrogram buffer. Up to six traces are included in this window, which includes three *Clear Write* and three *Maximum Hold* traces with different EMI detectors.

Waterfall window

The waterfall or spectrogram window shows the data of the last 12,000 time slices for the current selected trace for one of the three *Clear Write* traces. Each horizontal line in the waterfall display represents one historical trace. The data streams upwards from newest to oldest; the latest trace displays on the bottom while the oldest trace appears on the top. When you select a time, the trace that appears in the spectrum window will change when you move the display trace slider top or bottom. You can configure the colors in the waterfall window; they represent signal amplitude.

Time domain window

The time domain window displays the signal amplitude over a user-defined time and corresponds to the selected frequency in the spectrum window. The trace consists of all the accumulated time slices where one frequency bin emanates from each time slice and gets stitched to form a trace. The data streams leftward from newest to oldest. The latest trace displays on the right, while the oldest trace appears on the left. When the time domain frequency changes, the trace that appears in the window updates accordingly.

Advantages of Real-Time Scan Measurement

Historical Data

A scan captures time slices and stores them as part of the spectrogram data. The time slices are accessible even after the turntable stops through Standard Commands for Programmable Instruments (SCPI) by simply inputting the display trace of interest. Using marker functionality enables you to analyze the time slices which can offer valuable insight into the sources of emissions. See Figure 6.

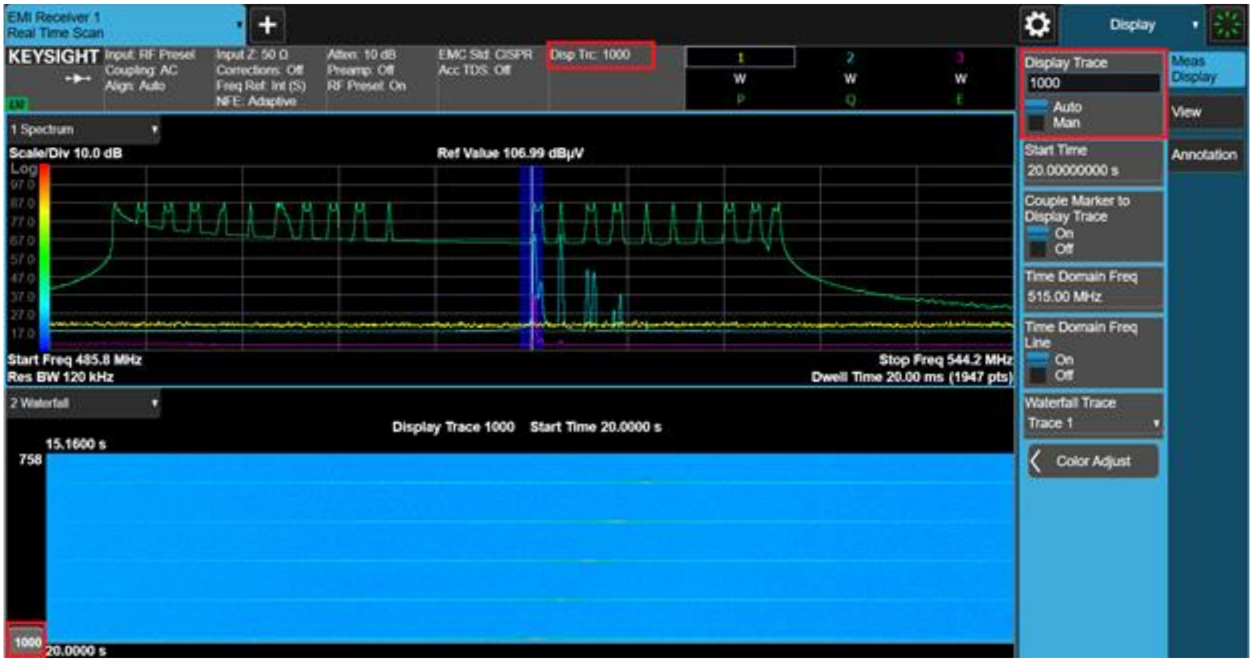

Figure 6. Changing display trace control to browse through time slices

3D display

Displaying an EMI measurement result in a two-dimensional display does not adequately show the source of emissions especially when broadband and narrowband signals appear concurrently. But using a waterfall display enables you to select which trace to show out of the three supported traces. You can enable the marker readout in the waterfall view so that moving among time slices becomes straightforward. See Figure 7.

Figure 7. Waterfall 3D view with marker readout

Built-in strip chart

Instead of switching to strip chart measurement to monitor and record a signal amplitude over time, RTSC measurement offers a built-in time domain window. When you synchronize RTSC with the rotation of the turntable, you can identify the maximum signal emission from the device under test (DUT).

Troubleshooting tool

During a typical product life cycle, research and development (R&D) engineers will spend most of their time analyzing and troubleshooting disturbances that DUT emits when it fails regulatory tests in the test lab.

In most use cases, conventional spectrum analyzers (SA) scan across frequencies of interest to duplicate or capture the same failures that regulatory tests record. But this is often challenging and time-consuming when the failures are not easily reproducible. This is specifically the case when the DUT emits non-periodical disturbances — short pulses with a long pulse interval, for example.

RTSC measurement can show gapless data across different frequencies, times, and detectors, while users are free to customize these parameters. RTSC's ample bandwidth (up to 350 MHz) enables you to greatly reduce the total scan time to properly capture disturbances with long pulse intervals. The reduction is due to the fact that you can analyze a much wider frequency span at the same time.

Now, consider three use cases for typical EMI measurements.

Use Case 1: Accelerate Electromagnetic Interference Debugging Work

The EMI testing is essential for the release of a high-quality product. Improvements to the debugging process will help accelerate the product development cycle. However, understanding existing EMI measurement methods to locate true noise behavior requires a high level of knowledge that eludes even the most skilled engineers.

By using RTSC and enabling Accelerated Time Domain Scan, you can easily observe true noise behavior in a short amount of time, depending on the test set up. Figure 8 shows how you can analyze the complex noise in various views.

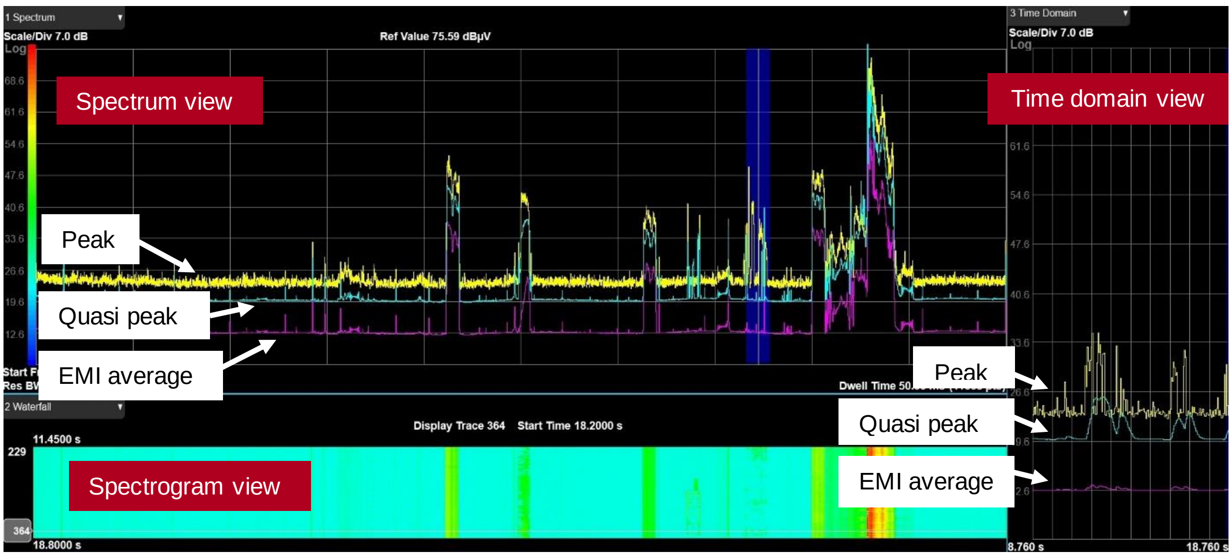

Figure 8. Multi-domain view enables users to analyze true noise behavior with gapless measurement

- **Spectrum view:** Traces with peak / quasi peak / EMI average detectors simultaneously
- **Spectrogram view:** Whole traces based across multi domains (frequency, time, power)
- **Time domain view:** Time domain trace of specific frequency signal selected by marker on Spectrum view

Use Case 2: Distinguish Between Broadband and Narrowband Signals

Spectrum view is not the most efficient way to measure a concurrent broadband and narrowband signal. However, with waterfall view, the chronological arrangement of the data paired with colored amplitude display enhances the data representation. In some cases, the broadband noise may not be an issue due to the test environment. If this is the case, you can focus on the narrowband signal. The height or width of the pulse in the waterfall window offers a quick understanding of the emission characteristic as you can see in Figure 9.

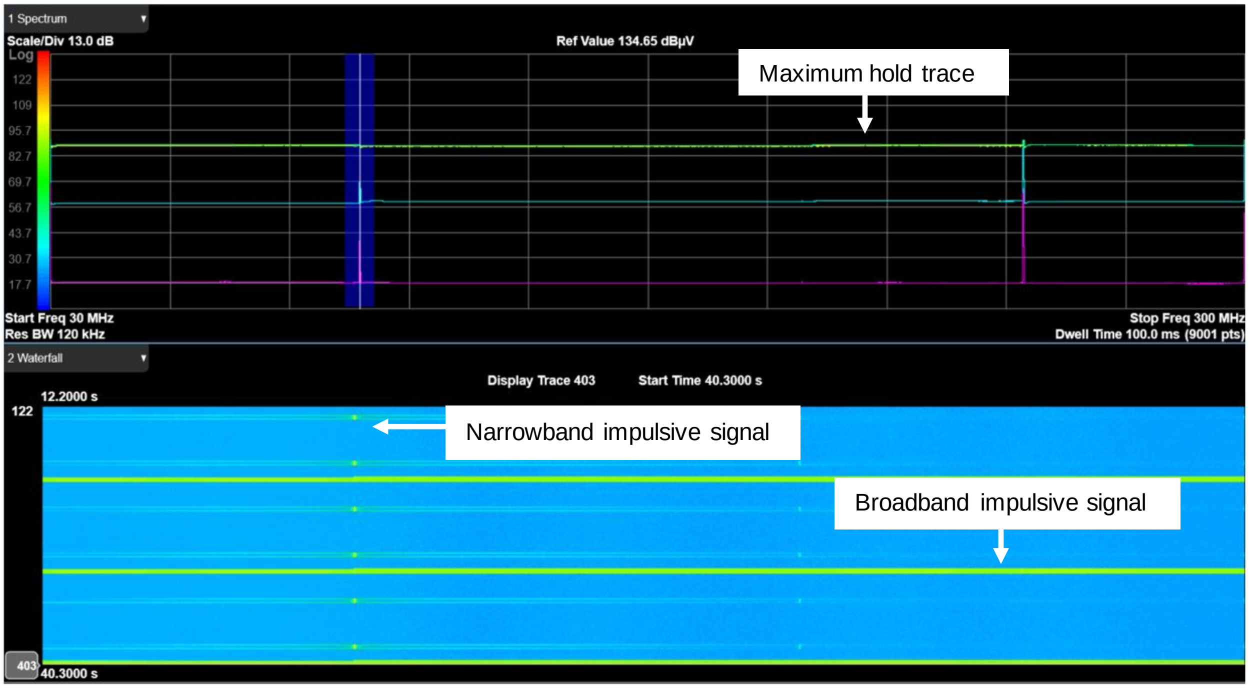

Figure 9. Distinguish between broadband and narrowband signal

Use Case 3: Analyze Interference

When debugging interference emanating from a DUT, we need to look at the time variant data to better understand the source of emission. Configure the measurement to scan continuously around the frequency range of interest and then move the frequency of interest (the white bar in frequency view) to the frequency with maximum amplitude (interference signal). The corresponding time domain trace will appear on-screen, allowing you to understand the characteristic of the emission. See Figure 10. Export the spectrogram data to an Excel file for further analysis.

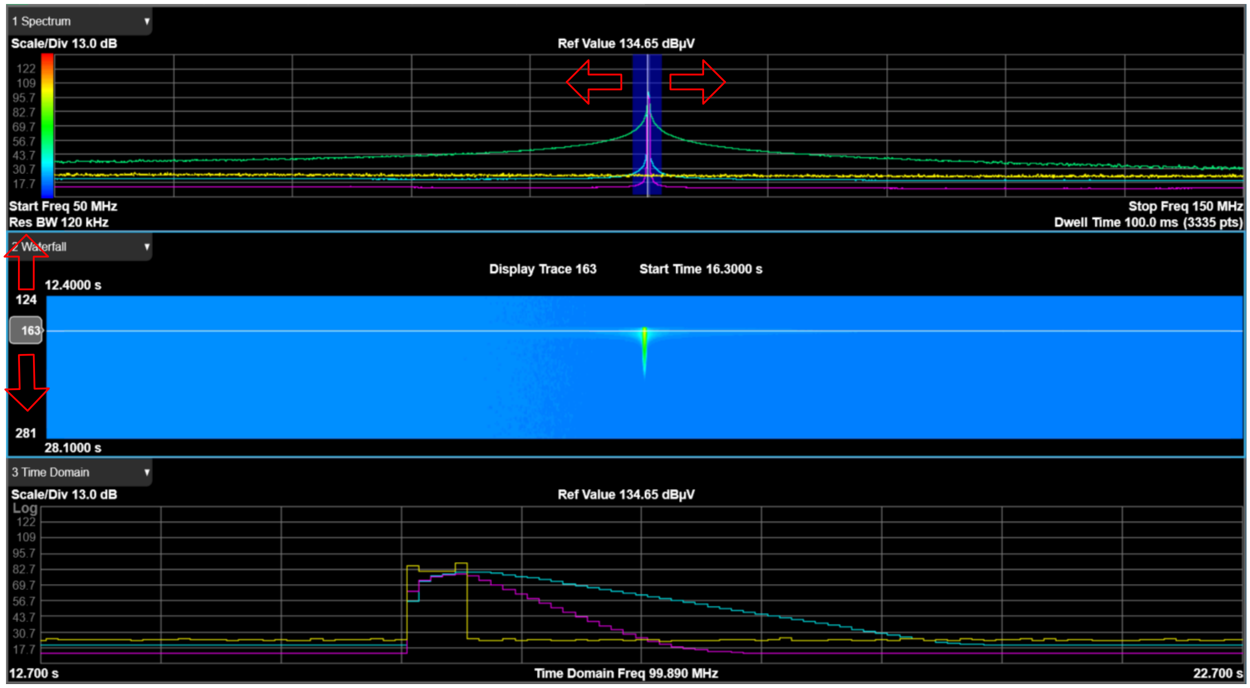

Figure 10. Analyze interference signal with Real-time scan measurement

Conclusion

The RTSC measurement on the N9048B PXE EMI receiver provides excellent diagnostic capabilities for full signal visibility. The N9048B PXE EMI offers gapless signal capture up to 350 MHz bandwidths and simultaneously displays the frequency domain, time domain, and spectrogram. The RTSC measurement's gapless signal capture capabilities help you detect unwanted noise much faster than conventional approaches, to reduce EMC measurement test time. In addition, the RTSC measurement can improve the throughput of EMC laboratories to enable you to test more products and certify them in a shorter amount of time.

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