APPLICATION NOTE

Boost EMC Test Throughput with Accelerated Time Domain Scan

KEYSIGHT

Introduction

EMC testing in the automotive industry requires exacting methodologies to measure all emissions accurately. Long test times impact test facility availability and potentially reduces the number of devices that are certified. It's also easy to miss intermittent disturbance signals with conventional scans since an extended dwell time must occur at each frequency.

Keysight's N9048B PXE EMI receiver has Time Domain Scan (TDS) and Accelerated TDS capabilities that enable independent compliance test laboratories and in- house certification labs to shorten their overall test time.

This application note provides you with an overview of TDS and Accelerated TDS capabilities to meet EMI measurement requirements and comply with EMC standards such as CISPR 16-1-1 and MIL-STD-461. Learn how you can easily reduce receiver scan and test time from multiple hours to seconds so you can get your products to market faster.

How Time Domain Scan Works

Figure 1 shows how TDS reduces receiver scan time using highly-overlapped fast Fourier transform (FFT) to collect emissions data simultaneously. This process is over a frequency span that includes multiple resolution bandwidths.

Frequency domain scanning sequentially collects data in respective resolution bandwidths. The FFT acquisition bandwidths used for time domain scan are in the range of 1 to 10 MHz or greater. These bandwidths are significantly wider than the required CISPR and MIL-STD resolution bandwidths. The receiver collects the data in the wider FFT acquisition bandwidth to process into the appropriate resolution bandwidths. This procedure ensures that the bandwidth measurements meet regulatory requirements.

The TDS saves measurement time because it applies the regulatory dwell time only once for all data in a given FFT acquisition bandwidth. In comparison, frequency domain scanning requires that the receiver dwells for each measurement made.

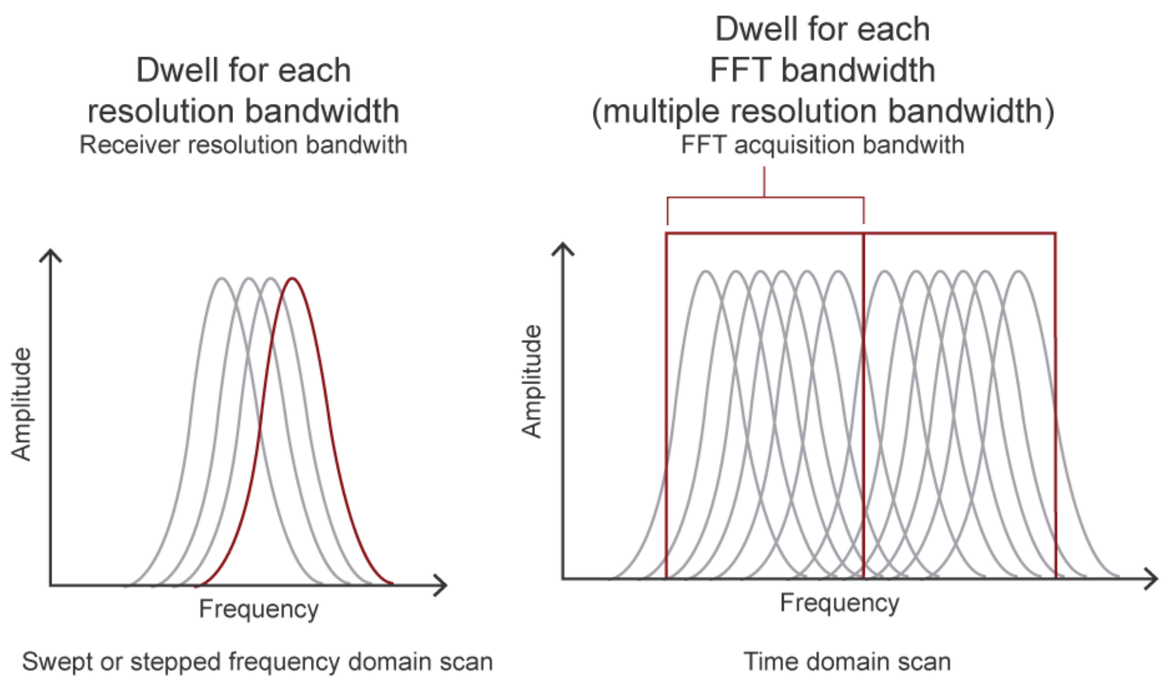

Figure 1. Comparison of resolution bandwidth and FFT acquisition bandwidths

Time domain scan reduces test time also because the wider acquisition bandwidths require fewer frequency steps. Frequency domain scanning needs frequency stepping to cover an entire band of interest. Each frequency step requires the local oscillator to change frequencies — and fewer steps give lower total LO relock time.

TDS measurements must comply with CISPR 16-1-1 and MIL-STD-461 amplitude accuracy requirements. Designers use a very high level of overlap of greater than 90% when calculating the FFTs to achieve the required amplitude accuracy. Unlike a frequency domain scan receiver, a TDS receiver experiences amplitude accuracy variations with frequency due to intermediate frequency (IF) effects that must remain within requirements.

The high degree of FFT overlap in the time domain ensures that impulsive signals are captured and measured accurately. Figure 2 shows an impulsive signal in the time domain when using contiguous, non-overlapped FFTs. The envelope of the impulsive signal appears in the upper part of the graph. The shaded region shows the weighting function of each FFT.

The envelope of the signal is weighted (multiplied) by the weighting function. Weighting functions are required to maintain an acceptable shape to the effective passband of each resolution bandwidth filter that results from the FFT processing, otherwise, the signal amplitude may be reduced if the shape of the passband filter is not good enough. Figure 2 shows that the first and second FFT's weighting functions values are very low — resulting in significant attenuation of the maximum detected signal level.

Figure 3 displays the same signal in the time domain when using 50% overlapped FFTs. In this example, the second FFT (the first in the bottom row) gives a full response because the impulsive envelope occurred at the time of maximum weighting.

With 90% overlap, the worst-case error from the windowing occurs when the envelope peak is displaced from the weighting peak by 5% of the FFT duration. Because the peak is broad, this worst-case result gives minimal attenuation at the peak.

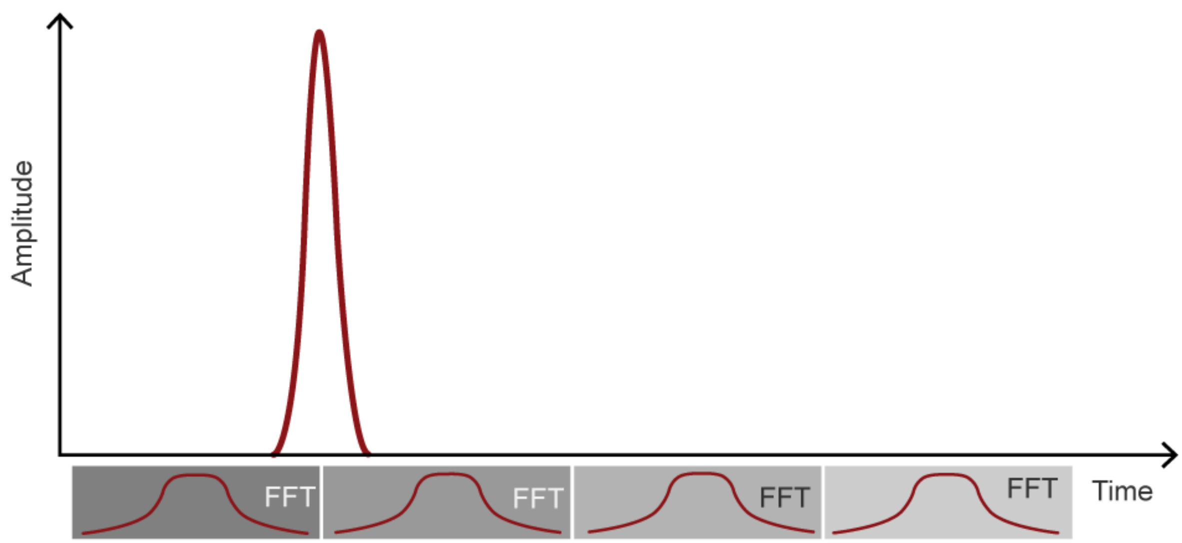

Figure 2. Traditional critically-sampled FFTs with contiguous windows has the potential for missing an input impulsive signal

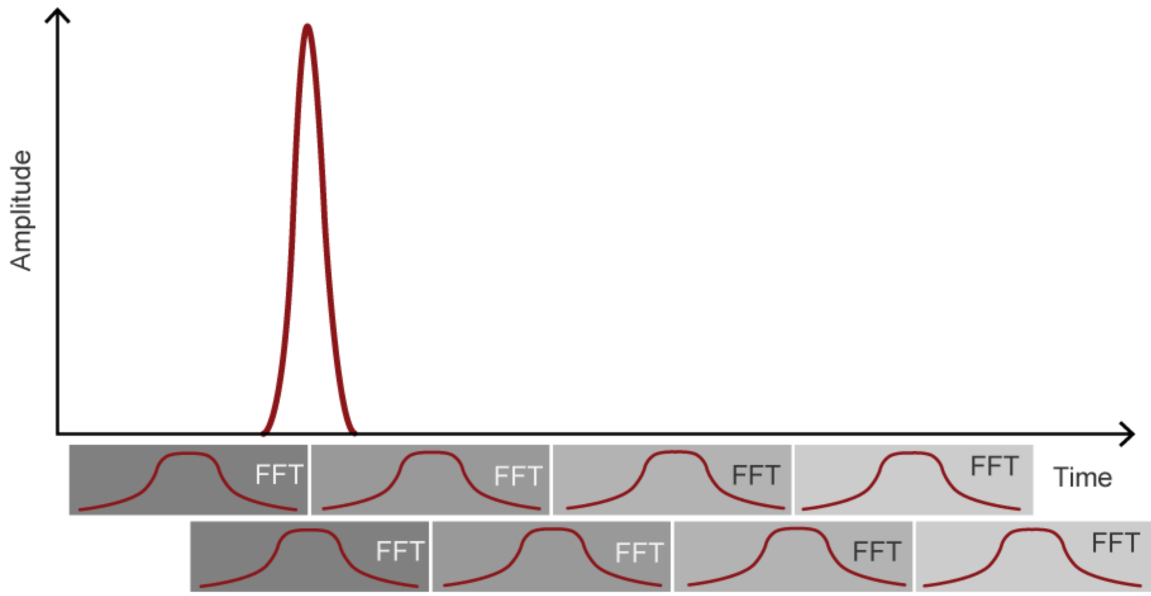

Figure 3. Measurements made with FFTs highly overlapped in the time domain increase probability of intercept and minimize amplitude measurement scalloping

Time domain scan acquisition bandwidths must also take RF and microwave preselector bandwidths into account. When measuring impulsive signals, preselector filters band-limit the RF energy that can reach the receiver's first mixer by improving the available dynamic range.

To ensure FFT amplitude accuracy, the following are two ways the time domain scan accounts for preselector filters:

- adjusts the amplitude versus frequency response across the FFT acquisition bandwidth to compensate for the preselector edge-of-band response
- reduces the maximum FFT acquisition bandwidth so that FFT amplitude versus frequency effects do not significantly add to preselector amplitude versus frequency response

Accelerated Time Domain Scan Boosts Throughput

The Keysight N9048B PXE EMI receiver is a high-performance EMI receiver and diagnostic signal analyzer built on a scalable platform. Get the accuracy, repeatability, and reliability you need to test with confidence. It provides 59 MHz bandwidth for its standard TDS and up to 350 MHz bandwidth for Accelerated TDS in a single FFT acquisition. Figure 4 is a simplified block diagram for the N9048B PXE EMI receiver that displays the enhancements to the circuit blocks to implement an Accelerated TDS.

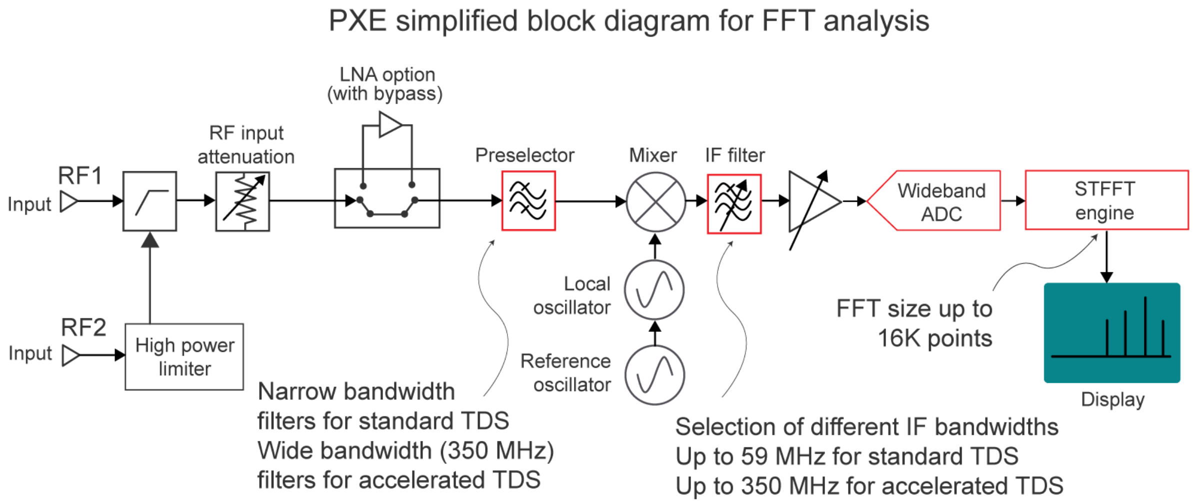

Figure 4. N9048B PXE EMI receiver simplified block diagram

The N9048B PXE solution has conventional RF preselector filters to make standard TDS measurements with additional 350 MHz bandwidth filters for Accelerated TDS measurements. The IF filters at the output of the mixer determine the maximum bandwidth possible for each FFT acquisition.

You can implement the IF section with different selectable IF bandwidths, up to 350 MHz, for both standard and Accelerated TDS use cases. The PXE uses high-performance analog-to-digital converter (ADC) to enable wide bandwidth digitization for IF signals. The PXE's short-time fast Fourier transform (STFFT) engine can perform frequency domain analysis of up to 16 thousand frequency points in a single acquisition to support much wider FFT spans than traditional EMI receivers.

With up to 350 MHz bandwidth in each FFT acquisition, Accelerated TDS could greatly improve testing throughput. Typically, a non-Accelerated TDS scan needs about 25 FFT acquisitions to scan the CISPR band C / D in the 30 MHz to 1 GHz frequency range.

This process is already significantly faster than a conventional stepped scan. In most cases, when using the same frequency range, only three acquisitions are necessary when Accelertated TDS is active. The scanning speed of Accelerated TDS can be up to 8 times faster than the traditional TDS.

In an EMC test lab, radiated emission pre-scanning takes a significant amount of time to capture any suspected disturbances from the equipment under test (EUT) before the test engineer can make the final, compliant measurements. Accelerated TDS can replace the conventional stepped scan or normal TDS method for pre-scan measurements.

Using an Accelerated TDS greatly reduces the measurement time spent by an EMC lab for each EUT. For example, the automotive industry requires conducting a CISPR 12 band C / D broadband noise test to ensure compliance. This test uses a quasi-peak detector at 120 kHz resolution bandwidth with one second dwell time.

The test time could be as long as nine hours using the conventional stepped scan process for a single scan. A four-position test (left and right side with vertical and horizontal orientations) can take days to complete the scans. The PXE EMI receiver with Accelerated TDS reduces the scan time to less than 30 seconds, making it more than 1,000 times faster.

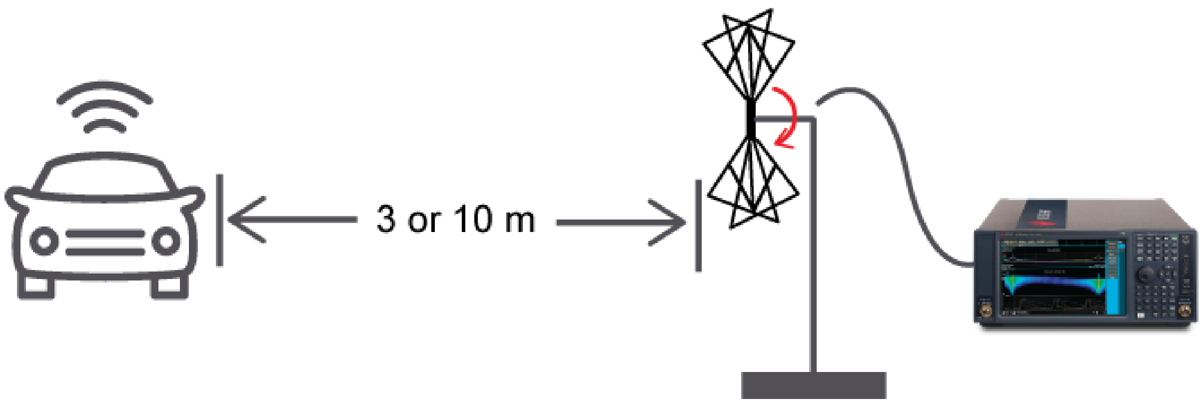

Figure 5. EMC test

Table 1. Speed comparison for traditional stepped scan, TDS and Accelerated TDS

CISPR band C / D	Stepped scan	TDS	Accelerated TDS
30 MHz to 1 GHz Quasi-peak detector, one second dwell time; 120 kHz resolution bandwidth	9 hours	46 seconds	6 seconds
Four antenna positions (Left and right sides / vertical and horizontal orientations)	36 hours	184 seconds	24 seconds

An accelerated TDS also increases data capture bandwidth during real-time scan measurement more than non-accelerated TDS. To quickly troubleshoot EMC issues, you can analyze the data spectrum up to 350 MHz in a single segment.

Use Time Domain Scan for Final Measurements

The N9048B PXE EMI receiver is CISPR 16-1-1 compliant when using its standard time domain scan with any EMC detector or Accelerated TDS with peak, EMI-average, or root mean square (RMS) average detector. The Accelerated TDS is also CISPR 16-1-1 compliant when using the quasi-peak detector to measure signals with pulse repetition frequency (PRF) greater than 10 Hz. The N9048B PXE EMI receiver meets all CISPR requirements before shipping since it's factory calibrated and verified.

You can use the standard and Accelerated TDS functionality to obtain CISPR-compliant readings directly on the device under test (DUT) across multiple frequency ranges. This method would eliminate the need to perform a pre-scan. We recommend using standard TDS to measure all types of unknown signals. When measuring signals with a pulse repetition frequency (PRF) ≥10 Hz, use the accelerated TDS for fastest throughput. In many actual use cases, signals below 10 Hz are infrequent.

The N9048B PXE can achieve full CISPR 16-1-1 compliance with the quasi-peak detector for all PRFs, not just those of 10 Hz and above, with much wider bandwidths (59 MHz for standard TDS or 350 MHz for Accelerated TDS) than previous TDS implementations, thus improving throughput for those most difficult cases with low PRF EMI issues.

Summary

Time Domain Scan and Accelerated Time Domain Scan provide superior measurement speed that significantly reduces test time of doing EMC measurements. This can improve throughput of EMC laboratories and increase number of devices that can be certified in a given time, thus accelerating time-to-market. In EMC testing, success depends on tools that can help you do more in less time — today and tomorrow. The N9048B PXE EMI receiver is a standards-compliant EMI receiver and diagnostic signal analyzer built on an upgradeable platform. In the lab and on the bench, it provides the accuracy, repeatability, and reliability you need to test with confidence.