New Test Methodologies Improve EMI Testing Efficiency

Application Note

Agilent Technologies

Introduction

The EMI measurement receiver, based on the PSA Series high-performance spectrum analyzer offers a unique combination of attributes that are turning heads in the electromagnetic compatibility (EMC) world. Testing for electromagnetic interference (EMI) involves a compromise between speed and accuracy. To achieve testing efficiency requires resolution of the conflict between the need for pass/fail answers in a minimal time set and insight into failed product issues. The PSA offers measurable improvements to the time it takes to characterize a device. This paper discusses a sampling of PSA features of interest to the EMI community that will increase both the quality of data and speed by which results can be derived. Slow EMI detectors, rotating turntable and antenna height movement are still bottlenecks to the speed an EMI tester can evaluate noise issues but the PSA feature set offers the possibility of new test methodologies to change the way testing can be done.

Fully synthesized sweeps

Though modern spectrum analyzers have fully synthesized sweeps, the PSA was the first spectrum analyzer to have this feature. Legacy solutions, like the Agilent 8566/68 or 8542/46 (formerly HP 8566/68 and 8542/46), used open loop sweeps for spans greater than 10 MHz. Span accuracy specifications for these solutions came in at 2 percent. For this reason, test methodologies centered on these legacy solutions would use wide spans to find suspect frequencies but narrow down to spans less than 10 MHz to verify the frequency.

The typical span accuracy for the PSA is two orders of magnitude better (0.02 percent span accuracy) than legacy solutions. In the all important 30-1000 MHz band, this means that a sweep determined by the need for frequency fidelity can be much larger than 10 MHz. For instance, a span of 300 MHz creates a typical frequency uncertainty of 60 kHz which is half of the CISPR IF bandwidth for bands C and D.

Measuring broadband signals with a low duty cycle involves either using many successive sweeps to increase the probability of intercept of these difficult to measure signals or increasing the sweep time to dwell long enough during the measurement of each data point to guarantee worst case amplitudes. Test methodologies based on either of these types of measurements will benefit from the PSA architecture. The process of measuring for signals in a wide span using multiple sweeps and many successive narrow spans to determine an accurate frequency is time consuming. The PSA allows one measurement in a wide span without the need to take a multiple of narrow spans to determine frequency accuracy. Because of a lack of frequency accuracy and limited data points in legacy solutions, test methodologies based on dwelling a given time per data point were forced to take successive 10 MHz spans to resolve frequency components. The PSA with a large number of available data points, long sweep times and frequency accuracy allows for wide spans with the needed frequency resolution and yet slow sweep times to capture the worst case amplitudes.

Variable number of native data points (101-8192)

Frequency accuracy by itself is not going solve the issue of frequency fidelity. If there are not enough data points to characterize the emission there would still be a need to narrow the span to the point where the frequency can be accurately measured. Is that frequency 200 MHz or 200.1 MHz?

Having a variable number of data points is a benefit to EMI testers wanting to characterize each point in the measured spectrum by one IF bandwidth or a set fraction of the IF bandwidth. In legacy solutions, there were a fixed number of data points offered per sweep. The Agilent 8566/68 spectrum analyzers had fixed 1001 data points while the Agilent 8542/46 offered 401 data points. In either of these two solutions testing in CISPR bands C and D combined (30 MHz to 1 GHz) meant that each data point would encompass many IF bandwidth.

Data points	1 data point (MHz)	# of IF bandwidths
401	2.42	20
1001	0.97	8

The PSA, having a maximum of 8192 data points, can offer one data point per 120 kHz IF bandwidth in bands C and D combined (8085 native data points). Note: native means that the PSA is not concatenating a number of individual sweeps to create a larger number of data points. Concatenating sweeps, though very useful for providing frequency resolution, create overhead to the instrument as each sweep segment is initiated and processed.

The PSA offers a variable number of data points that may be arbitrarily set between 101 and 8192, unlike other solutions in the market that have predefined number of data points. Should the user require three data points per IF bandwidth for a span of 100 MHz in band C the PSA could be set to:

$$\text{Number of data points} = \frac{\text{Span X number of points per IF bandwidth}}{\text{IF bandwidth}} + 1$$

$$\text{Number of data points} = \frac{100 \text{ X } 3}{0.12} + 1 = 2501$$

Making a remote measurement using the span accuracy and the variable number of data points to characterize the suspect frequencies without the need to remeasure using a narrow span is going to significantly reduce the prescan part of EMI testing. As an added note, the amplitude accuracy of these suspect frequencies will typically be within approximately 0.25 dB. There will be more discussion of this topic later.

Flexible and fast I/O (USB, GPIB, LAN) VISA with flexible protocol

The variable number of data points and fully synthesized sweeps by themselves may not provide a satisfactory solution if the user has no way to expedite the data remotely. The PSA offers GPIB, LAN and USB 2.0 as a means to transfer commands and data. Historically, GPIB was the dominant means of talking with an instrument. If the software is centered on collecting a number of peaks remotely there is not much difference in speed pulling a marker frequency using GPIB or faster protocol. Collecting a trace with 8000 data points, on the other hand, and retrieving it over the GPIB bus will take in excess of 400 ms (see Figure 1). If the remote software is limited to GPIB, the testing methodology must center on the PSA handling most of the data with the occasional retrieval by the PC. Unfortunately, this restricts the wealth of information the PSA is collecting. It is not practical for an analyzer to hold onto thousands of traces collected, while the remote software is manipulating turntables, masts and antennae, which might provide insight into spatial data as that information is gathered. But with fast data transfer, the information can be transferred real time.

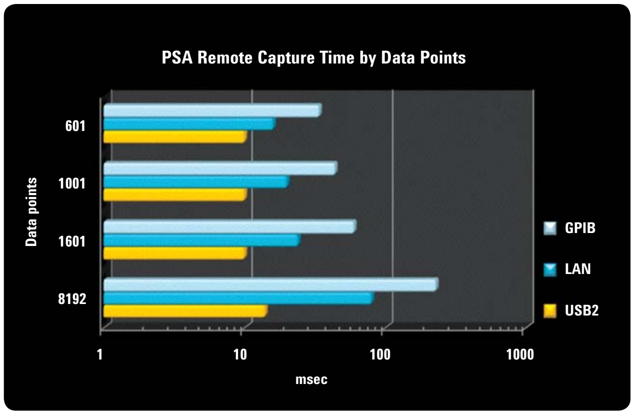

Figure 1. Data collection time using Real,32

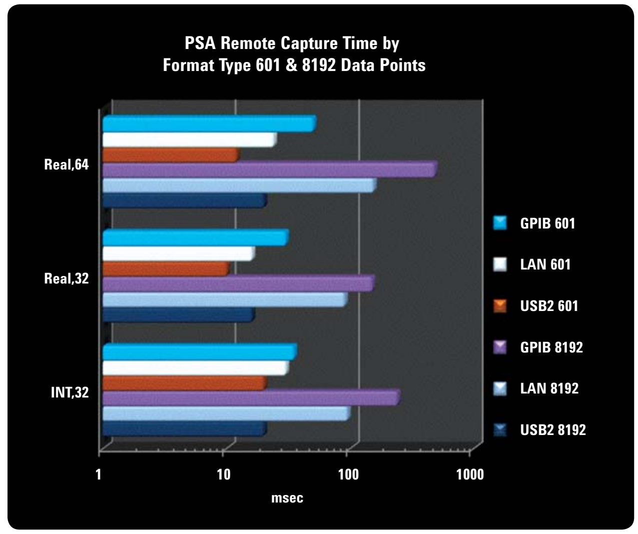

Figure 2. Effect of numeric data format using 601 or 8192 data points

The PSA offers 10BaseT LAN connectivity. This provides a marked improvement to the speed by which the remote PC can retrieve data (approximately 180 ms / 8000 data points). The PSA also offers USB 2.0 connectivity. This connection allows a full 8192 data points to be sent remotely in 15 msec using Real,32. Using any of the bus protocols to pull a single data point over the bus will not be adversely affected by the issue of speed.

With the remote software pulling data using the USB 2.0 bus it is possible to keep track of a full compliment of trace data as the device under test (DUT) is being spatially manipulated with respect to the antenna. The data being collected by the PSA is frequency and amplitude accurate and with sweep times faster than any previous EMI receiver because of the all digital IF.

Formatting numeric data for remote commands

Corrected trace data can be pulled as ASCII, 32 bit integer, 32 bit real or 64 bit real. ASCII format sends the trace as amplitude units separated by commas. This format is easiest to interpret but unfortunately is the slowest type to read. The 32 bit integer format offers the data as internal units (dBm) in a finite length block. Both Real,32 and Real,64 offer the user amplitude units in a finite length block as well. Using the USB 2.0 bus and Real,32 format provides the opportunity of remote capture with a minimum time delay as spatial data is being captured.

Impact of increasing the resolution bandwidth

The PSA with its all digital IF offers more resolution bandwidth settings compared to solutions reliant on an analog IF. If the test methodology is focused on sweeping a multitude of times to find broadband suspects the resolution bandwidth is usually set to the CISPR bandwidth. As an example, when testing in CISPR band D the 6 dB bandwidth is set to 120 kHz. The PSA offers far more than the usual 1-3-10 sequence of resolution bandwidths. For narrowband measurements there is no issue as to which resolution bandwidth to choose but for broadband signals the greater the resolution bandwidth the greater the amplitude measured with a peak detector. For this reason testers will choose the CISPR bandwidth.

What would be the benefit in selecting a wider resolution bandwidth? The algorithms used to set the sweep time are reduced as the resolution bandwidth is increased. Figure 3 shows how the PSA sweep time is reduced as the resolution bandwidth is increased. The sweep times are shown for the following conditions.

- Start frequency: 300 MHz
- Stop frequency: 1 GHz
- VB/RB ratio: 10

The CISPR 120 kHz resolution bandwidth (6 dB) is the equivalent of 91 kHz (3 dB). The sweep time for this setting using the CISPR bandwidth is 78.18 msec. The minimum sweep time is 16.34 msec for the 200 kHz 3 dB resolution bandwidth. By reducing the sweep time by half the probability of intercept for finding a broadband signal doubles. This can play a significant role in finding difficult signals without resorting to extraordinarily long sweep times.

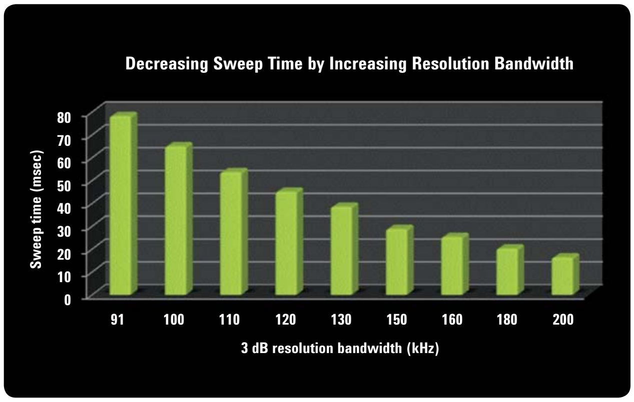

Figure 3. The PSA offers many more resolution bandwidth filters whose associated sweep time may benefit EMI testing

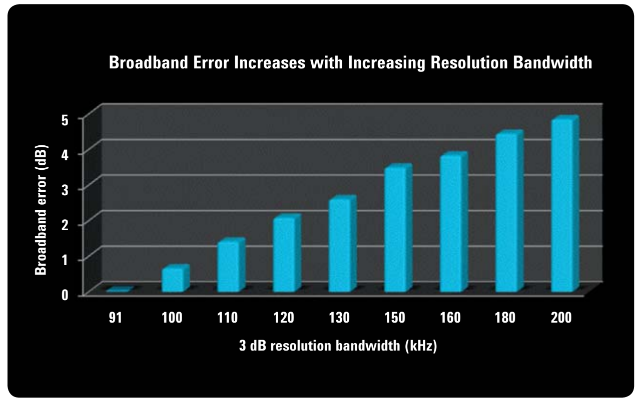

Figure 4. Error for broadband signals measured increase as the resolution bandwidth increases

With an increase in resolution bandwidth comes an additional error in amplitude. Figure 4 shows how an error associated with the increased bandwidth may result. The data was collected by measuring a multitone signal in band D. Thirty tones separated by 10 kHz creates a signal footprint of 290 kHz. This broadband signal, though not necessarily typical, may be characterized much quicker in the prescan, using a wider bandwidth, as long as limit thresholds are adjusted accordingly. All final measurements would be done with the correct detector and bandwidth to guarantee compliance. This technique offers a faster method to uncover broadband energy in the prescan stage.

Amplitude accuracy

By using the features unique to the PSA it is possible to reduce the number of sweeps required to characterize the noise being measured. So far, the focus of this paper has been on the frequency abilities of the PSA and its fast I/O capability. The PSA also offers an all digital 14 bit linear digital IF for all measurements. This digital IF provides a typical absolute amplitude accuracy of approximately 0.25 dB through 3.6 GHz. Unlike previous solutions requiring an approximation of a log amplifier to allow for large dynamic range, the logging of data is a numerical operation within the IF. A measurement made on a linear scale or log scale will result in the same conclusion. Any measurement not affected by the signal plus noise-to-noise ratio or not pushing the PSA into overload conditions will be a reliable measurement. Signals 20 dB above the reference level can be accurately measured manually and remotely. Measurements without the PSA all digital linear IF required signals to be accurately measured within a fixed position of the reference level. This required the user to move the signal to the reference level before accurate measurements could be qualified. With this issue solved in the PSA, it is not necessary to remeasure signals with a changed reference level. As with frequency accuracy and plentiful data points the problematic issue of re-measuring broadband signals significantly reduces the number of sweeps required to characterize a suspect frequency.

Summary

In this application note we have shown how the EMI measurement receiver, based upon the PSA Series high-performance spectrum analyzer, will increase both the quality of data and speed by which EMI test results can be derived. The most satisfied customers of the EMI receiver have been those willing to look under the hood at the PSA features that allow a new way to approach testing. Switching from GPIB to LAN or USB 2.0 can be a challenge. Moving from ASCII based data to Real,32 can be a difficult task. Pulling an entire trace rather than a single data point is more complex, but building familiarity with the PSA in order to build confidence about frequency and amplitude accuracy will take much less time. Taking the time to explore what capabilities the PSA brings to the issues of throughput and quality of data will allow for a new way at looking at EMI test methodologies. These test methodologies are still unique to the type of product being tested and to the EM environment that exists, but the EMI measurement receiver has shown itself to create measureable improvements to the time it takes to characterize a device.

Related Agilent Literature

Agilent EMI Measurement Receiver,
Product Overview,
Literature number 5989-6807EN

Making Compliance Measurements with the
N9039A-Based EMI Measurement Receiver,
Application Note,
Literature number 5989-6899EN

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Revised: March 27, 2008

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Printed in USA, May 28, 2008
5989-8673EN

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