# Head to Head: NI PXIe-5665 Versus Traditional Boxed Instruments

## Overview

This paper discusses the setup details for the demo shown in this video Head to Head: NI 5665 vs. Traditional Boxed Instruments. The demo compares the performance and speed of the NI PXIe-5665 with the Agilent PXA. Rather than comparing the datasheet specifications of both instruments, this video compares the two instruments while performing real- world test scenarios.

## Hardware Setup

For the LTE and WCDMA test, the NI PXIe-5673 vector signal generator is used. The filter is used for only the WCDMA signal to improve the dynamic range of the signal as much as possible. For the linearity test, two CW sources are used to generate tones that are combined using a combiner from Mini-Circuits. All signals are split to the NI PXIe-5665 VSA and the Agilent PXA.

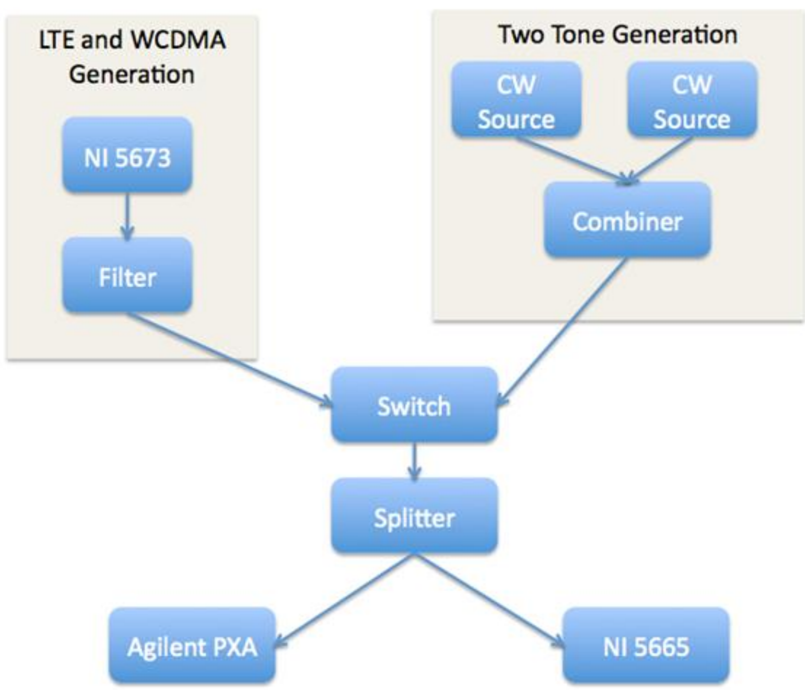


**Figure 1.** *Hardware Setup and Connectivity*

This setup ensures that the same signal is reaching the NI PXIe-5665 and the Agilent PXA at the same time.

Note: There is a slight loss through the splitter.

### Instruments Used

- NI PXIe-5665 14 GHz high-performance vector signal analyzer
- NI PXI-2596 26.5 GHz 4x1 dual RF multiplexer
- NI PXIe-5673 6.6 GHz vector signal generator
- NI PXIe-1075 18-slot 3U PXI Express chassis with NI PXIe-8133 embedded controller
- Mini Circuits Combiner
- Mini Circuits Splitter

- Agilent N9030A PXA signal analyzer (N9030A-513, N9030A-B40, N9030A-MPB, N9030A-P03)
- SMA-to-SMA cables (X3)
- WCDMA SAW filter (248.6 MHz nominal frequency)
- Phase Matrix QuickSyn modules / NI PXIe-5652 generators (X2)

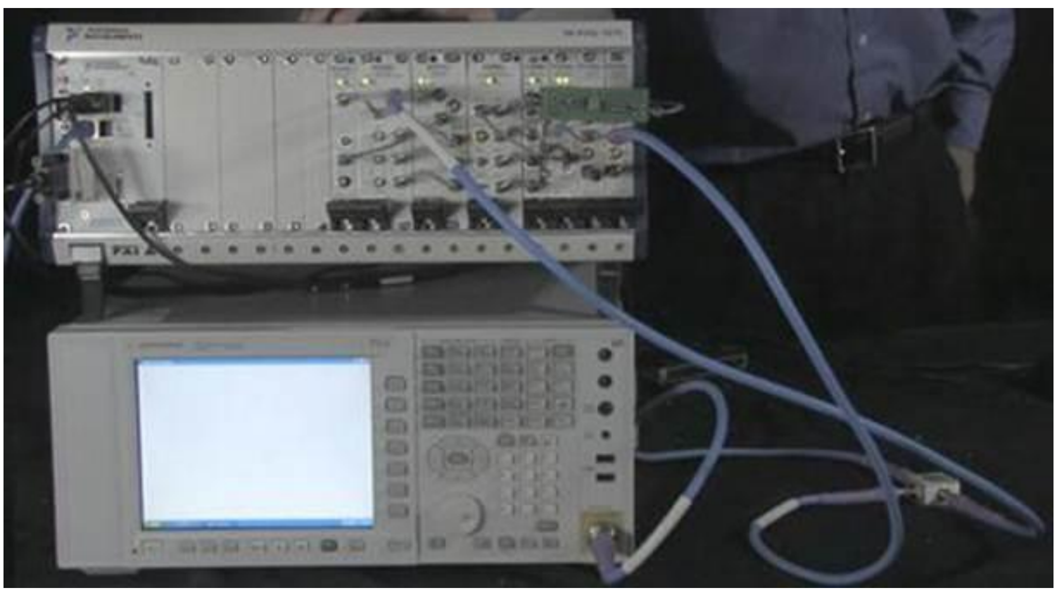

**Figure 2.** *Hardware Setup Showing Instruments and Connections*

## Instrument Control and Data Transfer

The NI PXIe-5665 is enclosed in an NI PXIe-1075 chassis with the NI PXIe-8133 controller that features PXI Express technology to transfer data from the instrument to the host PC. The Agilent PXA is controlled through an LXI connection (Ethernet). The amount of time taken to transfer the data through LXI on the PXA is about 900 µs, but the NI PXIe-5665 takes about 1 µs because it uses PCI Express technology. Figure 3 shows that the bandwidth for PXI Express is above 1 GB/s whereas the latency is less than 1 µs.

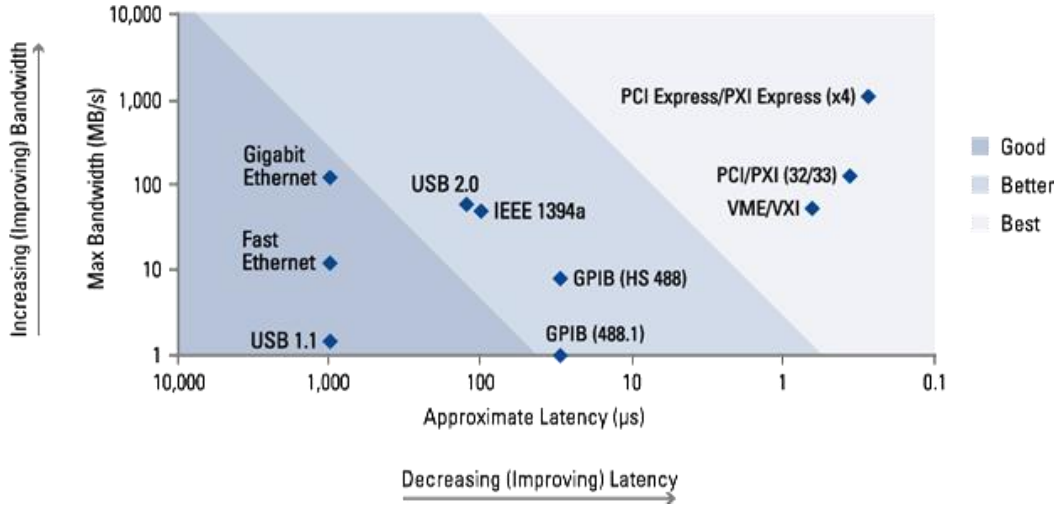


**Figure 3.** *Bandwidth Versus Latency Chart for Multiple Instrument Control Buses]*

# Software Setup

The primary programming language used is NI LabVIEW. The following toolkits and drivers are used to control the NI PXIe-5665:

- NI LTE Measurement Suite
- NI Measurement Suite for WCDMA/HSPA+
- NI-RFSA driver
- NI LabVIEW Modulation Toolkit

The following software is loaded on the Agilent PXA:

- LTE measurement application
- WCDMA measurement application
- Phase noise application

The PXA is controlled through SCPI commands using LabVIEW and instrument control drivers.

**LTE Standard Details:** The LTE standard that is generated is an UPLINK signal with a center frequency of 1 GHz and a bandwidth of 5 MHz. It is generated at a power of -10 dBm.

Five averages are being performed on both the NI PXIe-5665 and the Agilent PXA.

**WCDMA Standard Details:** The filter being used is a SAW filter with a 248.6 MHz nominal frequency. This filter has a 6 MHz bandwidth. The WCDMA is a DPCCH UPLINK and has a center frequency of 248.6 MHz.

# Results

# WCDMA ACPR Test

Note: We are not testing for the best ACPR readings possible on the analyzers; we are only measuring the best results possible in the current set up. The SAW filter used provides good results on both the upper and lower channels.

For WCDMA ACLR, both the Agilent PXA and the NI PXIe-5665 were reading about -81 dBc ACLR in the upper channel. We applied the following conditions to both instruments.

- Noise correction (IBW mode on the Agilent PXA)
  - 30kHz RBW
  - 0 dB attenuation
  - 10 averages

Important Note: The time calculated is acquisition time + measurement time + transfer time across the GPIB / LAN bus

On the Agilent PXA, only the ACPR readings are transferred back to the host PC, not the entire trace.

In a typical real-world scenario, test engineers need to transfer the readings back to the host PC for pass/fail type of tests, so we are including that in the total time for each device. Also, ten averages are performed on all tests shown in the video. For characterization and validation labs, test engineers typically apply some kind of averaging for more accurate results.

<u>Other possible options on the Agilent PXA</u>

The PXA also includes a Fast ACPR option, which does not allow noise correction. With the FAST ACPR option, you lose out on dynamic range. The NI PXIe-5665 has no such limitations. All measurements are made using noise correction and with optimized speed.

| | | Agilent PXA | | NI 5665 | |
|---|---|---|---|---|---|
| State | | Time (ms) | ACPR (dBc) | Time (ms) | ACPR (dBc) |
| Averaging On | Fast ACPR Mode | 180 | -75 | 30 | -75 |
| | IBW Mode | 420 | -82 | NA | -81 |
| Averaging Off | Fast ACPR Mode | 60 | -75 | 5 | -75 |
| | IBW Mode | 100 | -81 | NA | -81 |

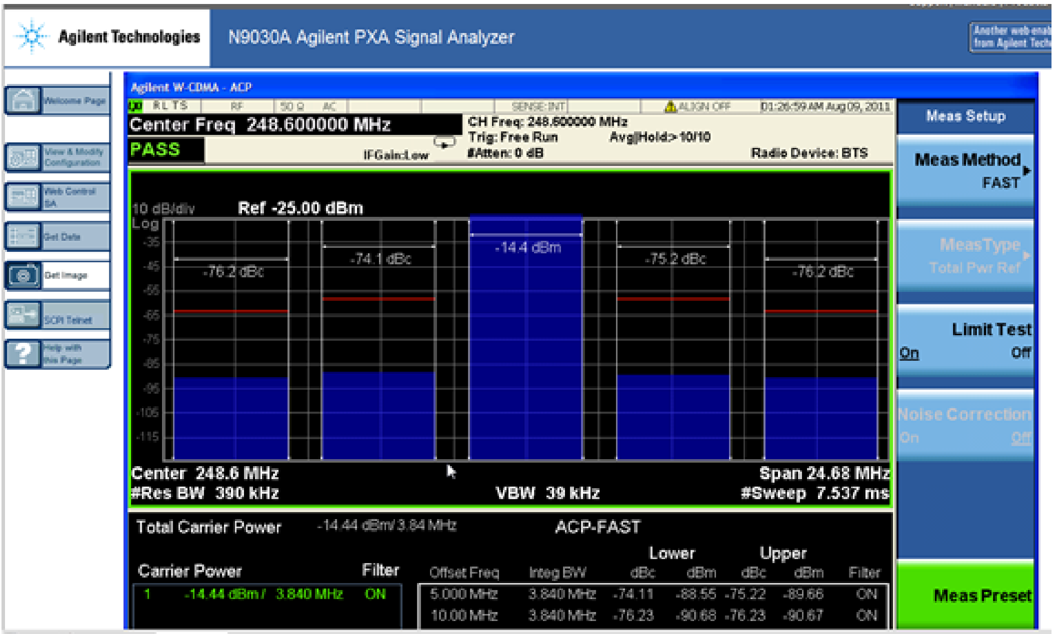


**Figure 4.** The figure above shows the PXA in fast mode. The best ACPR number that you can get is close to -75 dBc using the SAW filter in the setup.

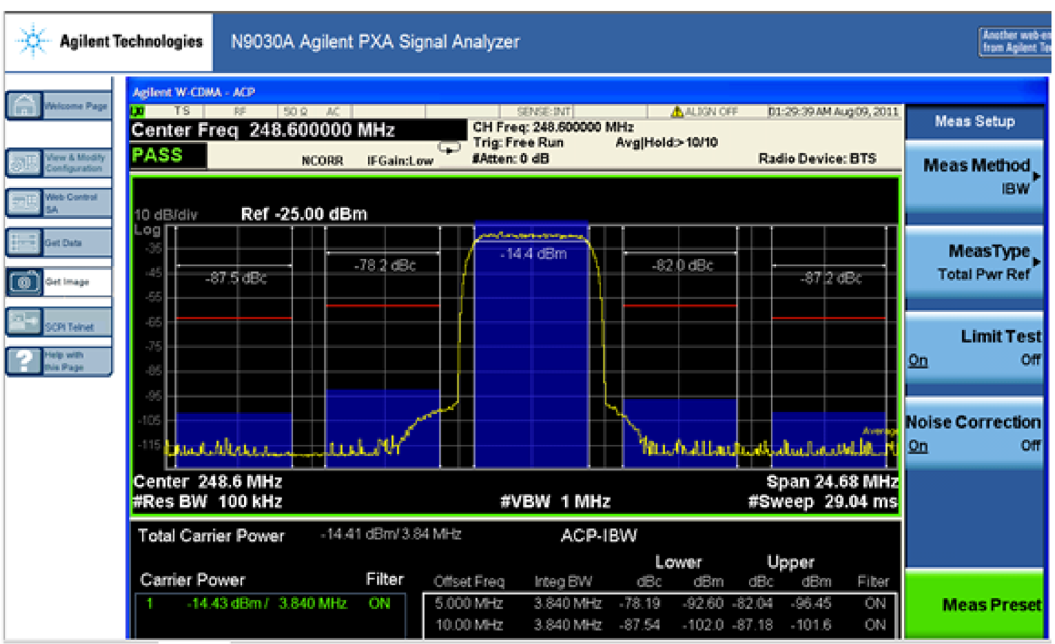


**Figure 5.** Using the IBW mode and noise correction, you can get about -82 dBc in the upper channels, which is similar to the results you get on the NI PXIe-5665.


**Figure 6.** As shown in the video, the NI 5665 can make -81 dBc types of measurements with noise correction turned on and still be 14-15X faster than the Agilent PXA.

# TOI Test

For this test, we are generating two tones that are spaced 1 MHz apart. Without sufficient isolation between the two sources, intermodulation distortion generated by the sources can mask the distortion of the receiver under test. AtlanTec (ACC-20010 series) Isolators at the outputs of each source along with the Mini-Circuits <ZFSC-2-10G+(for 10 GHz) and ZFSC-2-11-s (for 1GHZ)> Power Splitters are used for signal combination ensure that the source distortion falls below the level of the receiver under test distortion. Both upper and lower TOI are calculated (only the upper TOI is shown in the video). The method of calculating the upper and lower TOI is as follows.

IP3 Lower = P1 + (P2- IMD lower)/2

IP3 Upper = P2 + (P1 - IMD Upper)/2

The following settings are applied to both instruments.

- 0 dB RF Input attenuation
- 1 kHz RBW
- No averaging

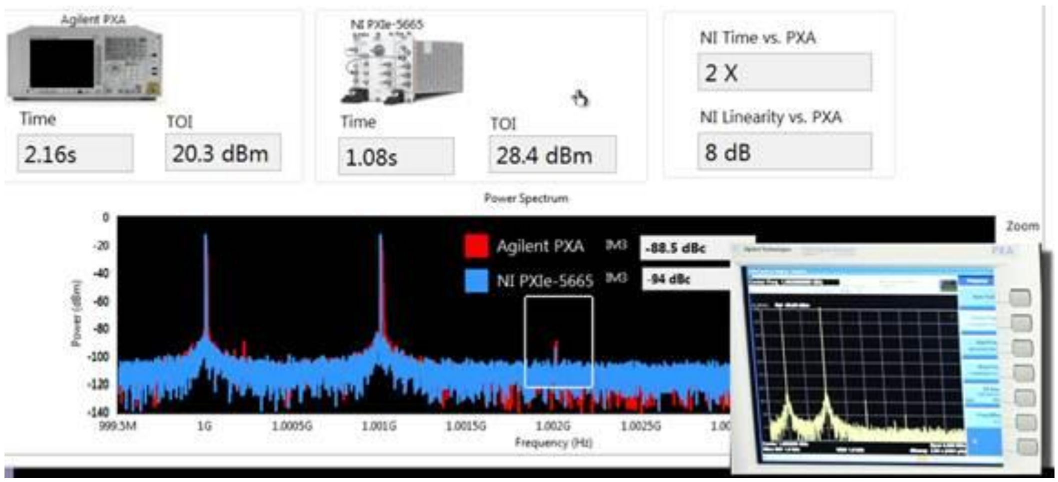


**Figure 7.** Third order products on the NI PXIe-5665 and the Agilent PXA. The absolute power of the third order product on the NI PXIe-5665 is close to -95 dBm.

| Measurement | Agilent PXA | NI 5665 |
|---|---|---|
| Upper TOI with 0 dB attenuation | +20 dBm | +27 dBm |
| Lower TOI with 0 dB Attenuation | +19 dBm | +26 dBm |

If you apply more attenuation, you will get better TOI results.

# List Mode Test

For the list mode test, a 1 GHz signal is generated and read on the Agilent PXA and the NI PXIe-5665. Random harmonics of 2, 5, 10 and 14 GHz were selected because both instruments have a band change at 3.6 GHz and we wanted to correctly measure the time taken to jump to higher harmonics. Even though this is not a standard, this test best shows off the flexibility of both instruments when it comes to list mode.

Note: List mode is used on both instruments.

Time is calculated as Sweep time in list mode + peak search time at every frequency jump + time taken to return data to host PC for both instruments.

| | Agilent PXA Time (ms) | NI 5665 Time (ms) |
|---|---|---|
| Time Taken for List Mode + Peak Detect Test | 700 | 400 |


**Figure 8.** Use of list mode on the NI PXIe-5665 and the Agilent PXA. For most list mode tests, the NI 5665 is 1.5-2X faster.

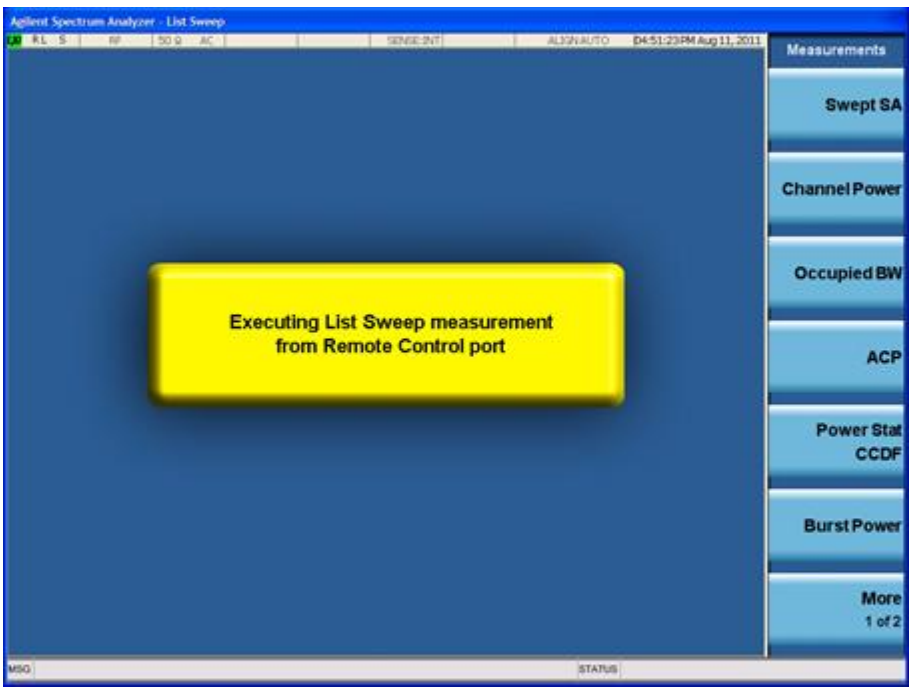


**Figure 9.** Implementation of list mode remotely on the Agilent PXA takes about 700 ms for the above mentioned scenario.

Note: The Agilent PXA is optimized for certain harmonics. The NI 5665 is about 1.7-2X faster for all list mode capabilities.

## EVM Measurements

For the EVM test, an LTE signal was generated using an NI PXIe-5673 vector signal generator. Both instruments were set up using the following

- RBW = 30 kHz
- 10 dB attenuation
- 10 averages
- Auto Detection Off

| | NI PXIe-5665 | Agilent PXA |
|---|---|---|
| EVM Measurement (RMS) | .15% | .29% |
| Time Taken (ms) | 390 | 1200 |

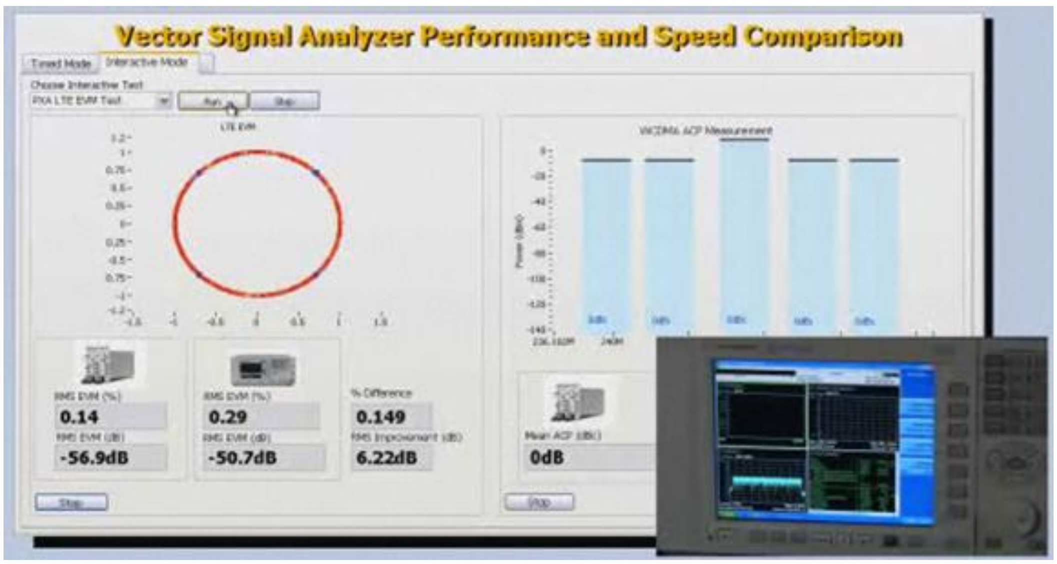


**Figure 10.** LTE EVM test on the Agilent PXA and the NI PXIe-5665.

# Use of User-Programmable FPGA for In-Line Processing

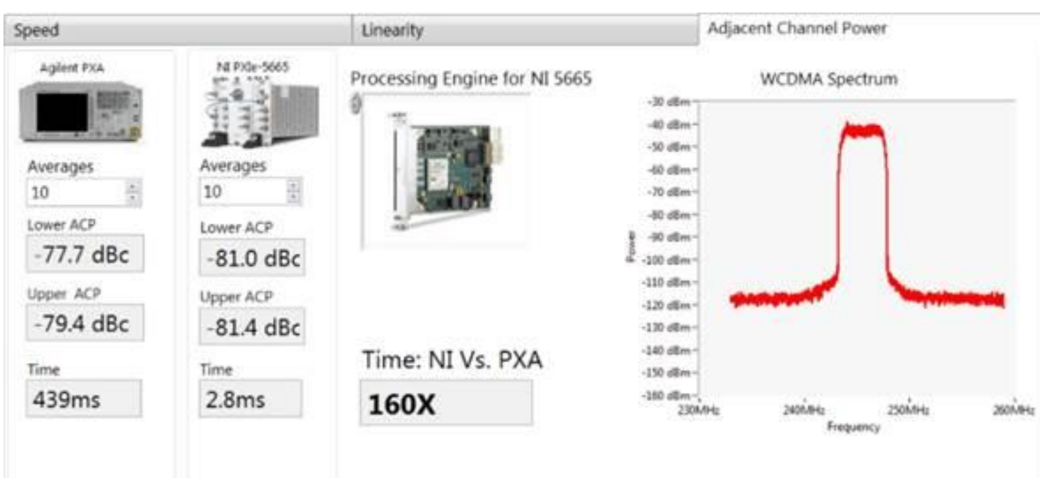


**Figure 11.** *Moving the processing to an onboard FPGA saves time.*

This is an example of the flexibility provided by NI FlexRIO when using it as a co-processor. All data coming from the NI PXIe-5665 is processed on the FPGA in this setup as opposed to the embedded controller on previous setups. Other use cases include hardware implementation of algorithms, protocol implementation, and real-time stimulus-response applications.

## Test Time Comparison Including Setup Times

All the previous demos in this white paper show only single measurement times. The test below includes setup times in addition to measurement times. This is typical of an automated test environment where multiple standards need to be used, for example power amplifier testing.

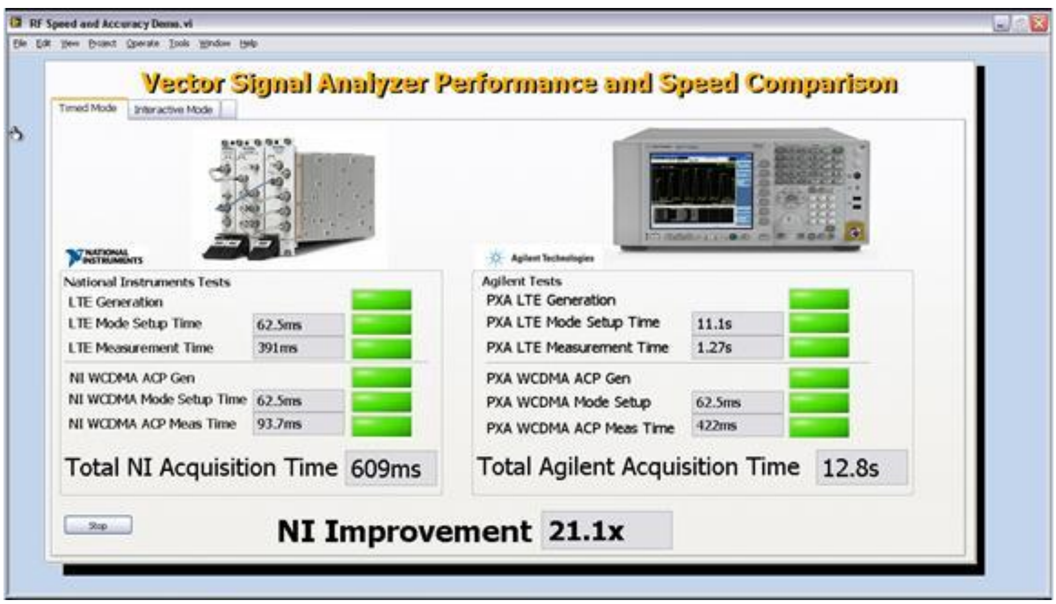

**Figure 12.** The NI 5665 is 20X faster when setup times are included.

## Summary

For a typical test setup, the NI PXIe-5665 provides equal or better performance than the Agilent PXA, while being 14-15X faster for most tests. The NI PXIe-5665 is also smaller and a fraction of the cost of traditional boxed instruments. The table below shows a comparison of the NI 5665 and an equivalent Agilent PXA.

| Frequency Range | PXA<br><br>(Based on pricing listed on Agilent.com on Aug 9th, 2011) | NI PXIe-5665 |
|---|---|---|
| 10 Hz to 13.6 GHz | $61,956 | $54,999 |
| 50 MHz BW<br><br>(Agilent offers 40 MHz) | $15,435 | Included |
| Electronic attenuator, 3.6 GHz | $3,093 | Included |
| Preamp, 3.6 GHz | $1,900 | Included |
| Microwave preselector bypass | $5,361 | Included |
| PXIe Chassis & MXIe controller | Included | Starting at<br><br>$3,198[1] |
| TOTAL | $87,745 | $58,197<br><br>29% savings |

[1]In automated test systems the PXI chassis and MXI controller are typically amortized over all the instrumentation included in the test system. For example, if a test system included two NI PXIe-5665s VSAs which fit into one PXIe chassis the cost of the chassis and controller only occurs once, hence the total cost would be less than 2 x $58,597. On the other hand, a test system that includes includes two PXAs would cost 2 x $87,745.

Note: For Automated Test use case, cost associated with PC and programming language of choice (LabVIEW, CVI, Visual Studio, etc) which is required for both the Agilent PXA and the NI PXIe-5665 is not included in pricing above and would be the same for both solutions.