Optimizing wireless measurements with the PXI platform

By Wayne Larson

Larson Automation has developed an 802.11 board test station. This tester fully integrates the chip-set standard manufacturing test plan with engineering tools to control the test station and the Device Under Test (DUT) from a simple drill-down GUI interface. This system is used for production testing, engineering evaluation, or for manufacturing a debug station. In this article, Wayne explains how Larson Automation conducted testing on the PXI platform.

One of the compelling reasons to move to the PXI platform is to take advantage of the instrumentation connected to the test controller's bus. In addition, portions of the measurements are performed in the host CPU. This simplifies custom measurement techniques, and optimizes each portion of the measurement cycle.

An automated test system can be simplified to include a test controller, stimulus instruments, measurement instruments, and the DUT. There are also requirements for communication, triggering, and synchronization between the blocks. Figure 1 shows a functional schematic of a test controller, but for simplicity, does not include the electrical and mechanical interfaces.

An automated test station performs a series of measurements, much like a manual test station. Each measurement is a process of discreet steps. In Figure 2, we have represented these as:

- System setup: The DUT is powered up, instrument paths are set for the input and output signals, and any configuration on the DUT is performed as required for the measurement.
- Stimulate DUT: The instrument that supplies the stimulus is commanded to apply the proper signal to the input of the DUT, as required for the measurement.
- Collect raw data: The DUT is in the proper state for measuring and transforming the supplied stimulus as required. The measurement instrument is used to collect the raw data.

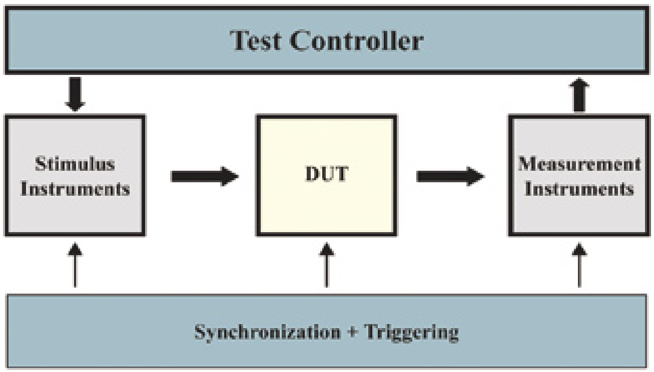


Figure 1

For a box instrument, it may not be accessible as part of the overall measurement. Additionally, the user may choose to let the instrument perform the entire process. For example, this may be the process of triggering a measurement on a spectrum analyzer. The spectrum analyzer will sweep a band-pass filter over a frequency range and record the value of the A/D converter. This converter is subject to a voltage measurement with relation to the power applied.

- Process information: This step converts the raw data into useable information. It also transforms the data that was collected by the sensor, scales it into a log format, removes any internal instrument error, and applies the proper frequency scale for the x-axis. Ultimately, it produces a trace on the screen that represents power vs. frequency.
- Perform measurement: The requested information is extracted from the processed data. It may be the peak power of the trace, the power at a certain frequency, or the frequency of the highest power point.
- Transfer data to controller: The measurement result is transferred to the test controller. A traditional box instrument will perform this over a GPIB bus, Ethernet, RS-232, or some other medium of data transfer.

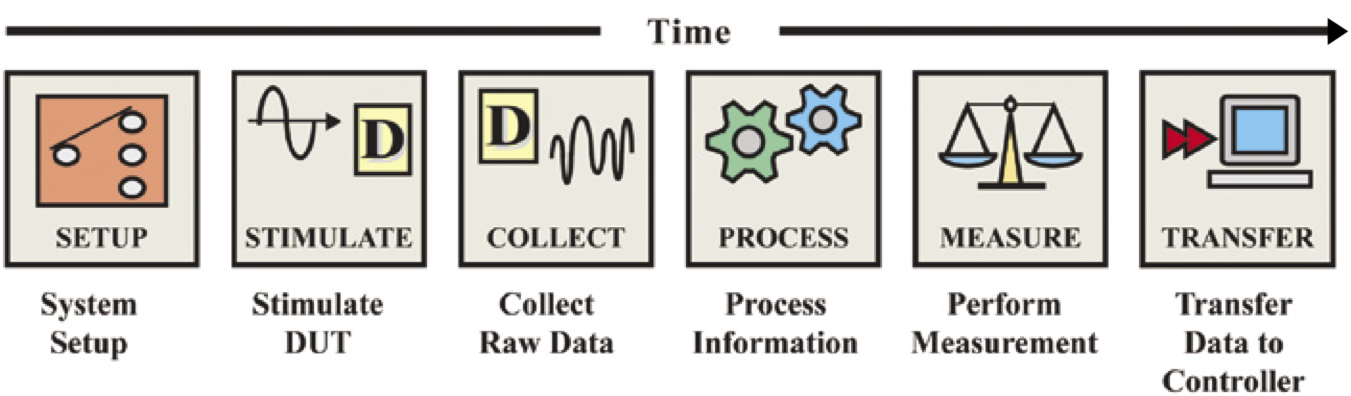


Figure 2

Most automated measurement systems are derived from manual test methods. Engineers typically use discreet box instruments to make the measurements that they are interested in. Traditional box instruments have the advantage of specialized displays and measurement routines to process and display the information they are best suited to handle. Each standalone instrument is typically optimized to measure a particular parameter such as:

- Power vs. frequency (spectrum analyzer)
- Frequency (frequency counter)
- Total RF power (power meter)
- Down-converted I and Q vs. time (vector signal analyzer)

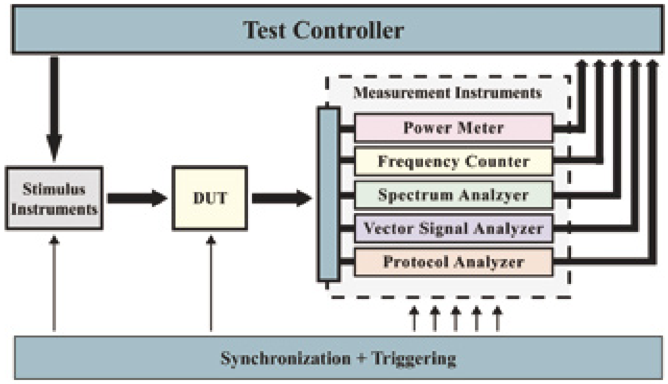


Figure 3

The disadvantage, from a test station point of view, is the serial method of processing required. For each measurement, the engineer needs to connect the appropriate instrument, stimulate the DUT, collect the raw information, process and analyze it, and then send it over an instrumentation bus (usually GPIB) in a non-optimized, relatively slow shared bus to the test controller.

Using the approach of multiple discreet measurement instruments adds a fair amount of complication for routing signals to the different instruments and increases the difficulties communicating to the test controller. New issues arrive in the synchronization, timing, and triggering as well. This operation is shown in Figure 3.

The user must repeat the measurement cycle for each instrument. The timing diagram is represented in Figure 4. Each measurement requires setup of the stimulus and routing of the proper signal to the proper measurement instrument independently. The next example will measure peak power, frequency accuracy, power in band, EVM, and will verify the integrity of the data packet.

By rethinking the measurement strategy to take advantage of the PXI instrumentation architecture, the user can streamline this process significantly. Using the PXI instrument model, the RF analyzer is a combination of an RF down-converter that covers the frequency and bandwidth desired, and a digitizer that performs the desired measurements at a base-band frequency. This architecture is similar to modern standalone RF instruments. The processing of the signals is performed in the host processor using digital signal processing techniques. Digital filters are applied to the waveform rather than switching in the proper electrical filter. I and Q demodulation is an algorithm instead of a vector demodulator that is optimized for a unique frequency.

This step allows the user to acquire one set of raw data from a digitizer and process it for whatever parameter is desired. This simplifies a number of things:

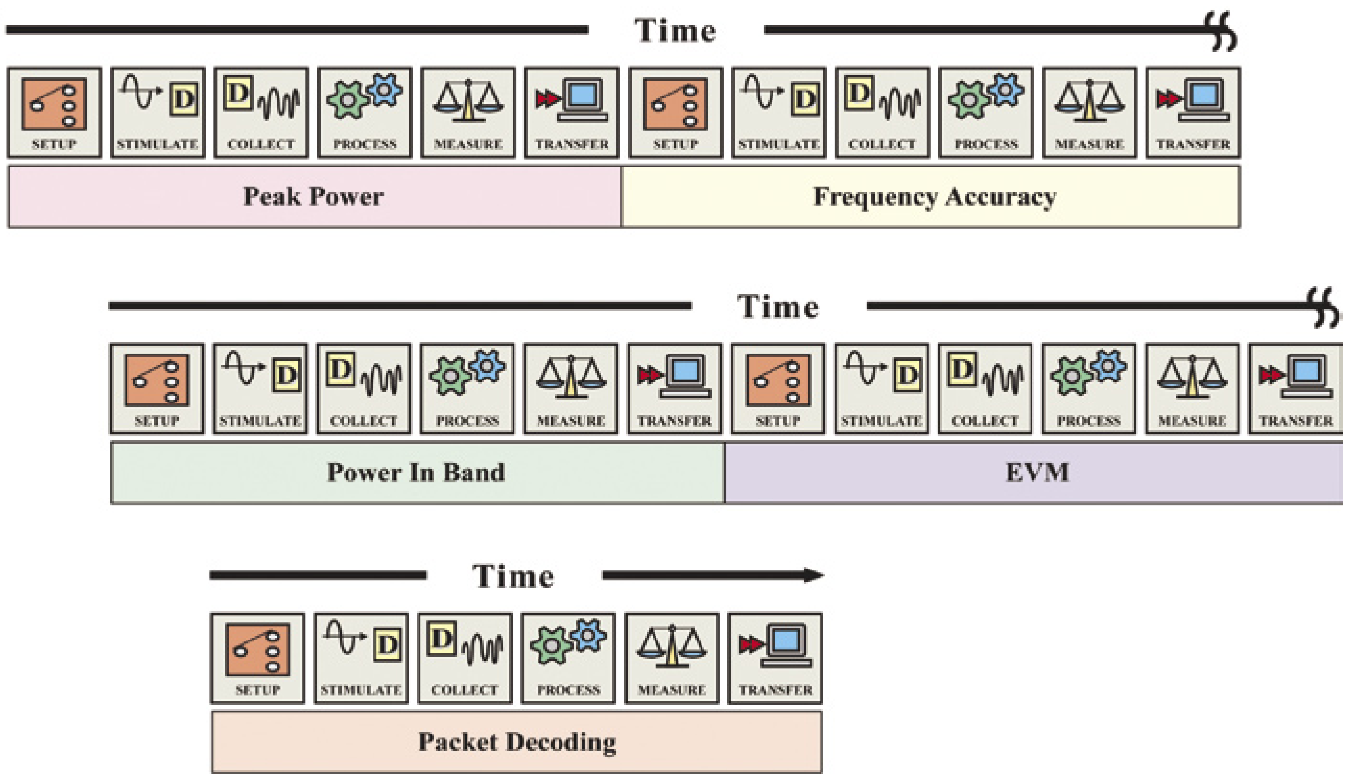


Figure 4

802.11 Board Test Station

- It reduces the overall cost of the system
- It reduces the overall test time significantly
- It reduces the complexity of the switching, synchronization, timing, and triggering interface

As a side advantage, all measurements naturally correlate to each other because they are based on the same raw data. If the oscillator occasionally loses lock, all measurements would be either locked or unlocked. A block diagram is shown in Figure 5.

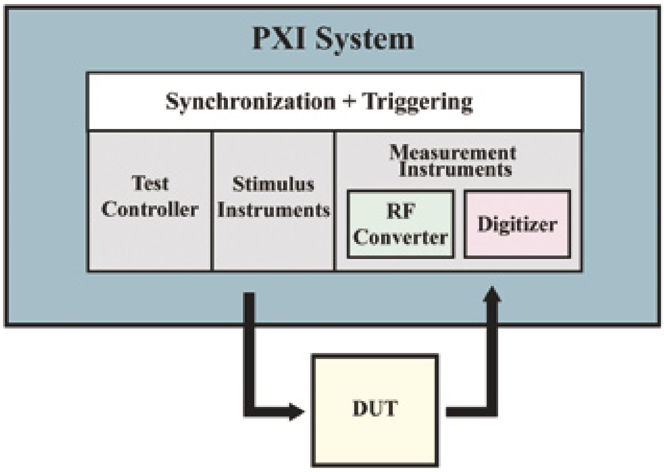


Figure 5

It is clear from the sequencing diagram in Figure 6 that the process is much more efficient and quicker. There are also 11 functional blocks, as opposed to 30 as shown in Figure 4. What is not initially obvious is the speed advantage of having the instrumentation and the test controller share a PCI bus. An example of the digitizer output vs. time is shown in Figure 7.

RF spectrum

The RF down-converter is tuned to the center frequency of the 802.11b channel, and the test system is set up to make the measurement. The burst is captured by the digitizer. This is a simple packet that covers less than 300 µsecs. Starting with the raw data, the user can perform a standard FFT to show the power with respect to frequency for a standard spectrum analyzer display. The user can utilize this to calculate power in band. This process is shown in Figure 8.

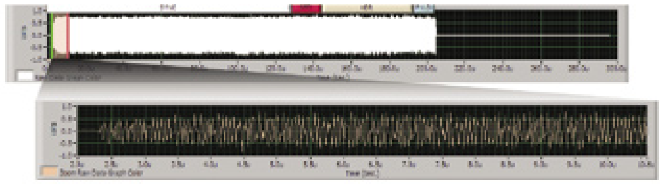


Figure 7

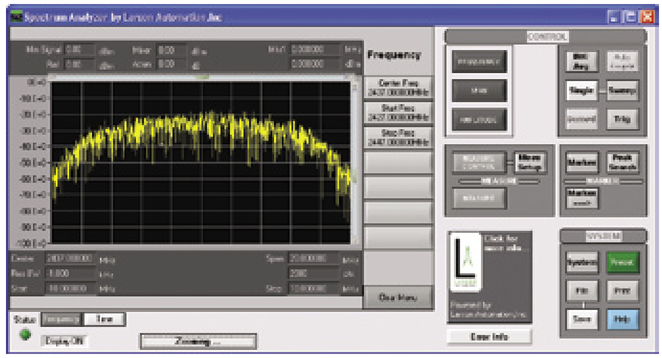


Figure 8

Modulation power

Starting with the raw data again, the user can process the data slightly differently, and extract the magnitude vs. time information. This display is useful to determine power ramp uptime, overshoot, peak power, and power ramp downtime. The representation of this function is shown in Figure 9.

Baseband conversion

The raw data is processed by digitally down-converting the data to baseband, and representing it as I and Q data streams. The user then extracts the exact carrier frequency and, thus, the frequency error, and resamples the data at the clock rate. This step releases the BPSK/QPSK demodulated data stream as I and Q chips, as represented in Figure 10.

Calculate EVM

From the I and Q bit stream, the user can calculate the error for each chip as an error vector, and can consolidate this information into an Error Vector Magnitude (EVM) value for the packet. Figure 11 shows how this can be plotted on a constellation diagram with the center of the circles representing the ideal location.

Decode frame/decode data

Starting from the I and Q bit stream again, the user can continue to decode the information contained in the frame.

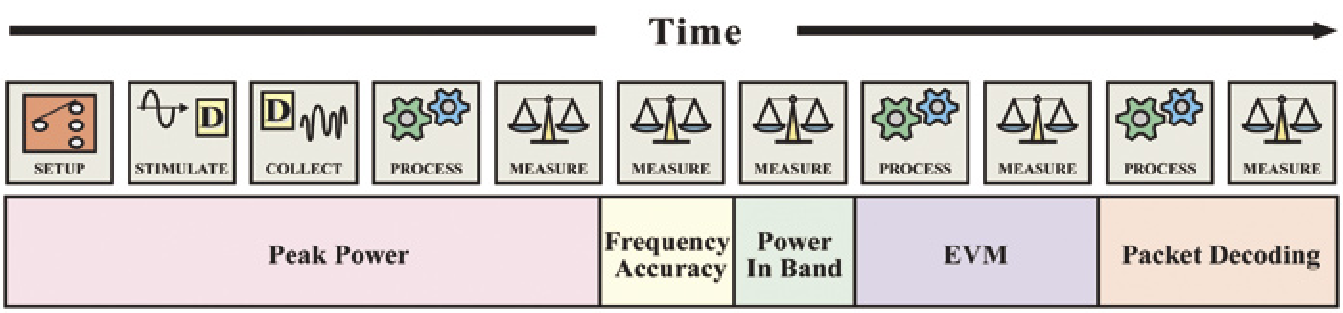


Figure 6

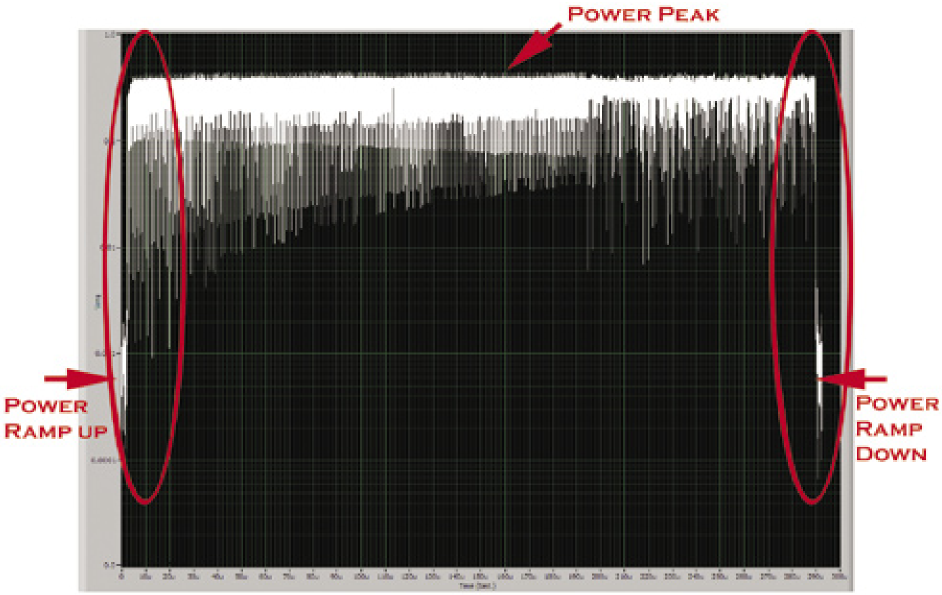


Figure 9

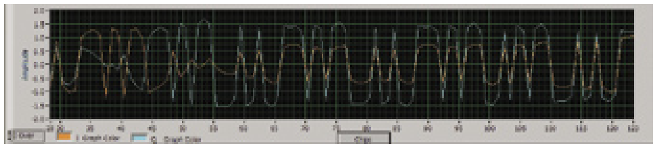


Figure 10

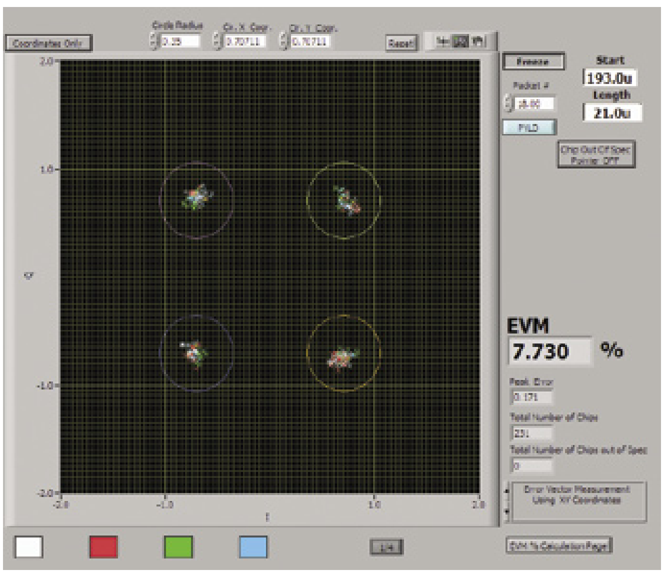
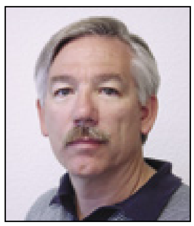


Figure 11

A breakdown of the frame can be seen in Figure 12. The user performs a Barker Correlation, descrambles the data, locates the Start Frame Delimiter (SFD), and checks the header CRC to ensure proper decoding. The rest of the header information can be used to determine how to decode the payload. The user can then work down the protocol stack to decode the actual information contained in the payload.

These steps can all be performed on one small data acquisition sample (<1 msec). Data is captured once, and analyzed in many different ways. The test time is dependent upon the processing speed of the computer and the amount of analysis desired. In addition, configuration can easily be done through software.

Bringing this idea one step further is the concept of a synthetic test station. This is where integration of basic components takes place to support different devices or protocols. By changing the down-converter frequency range, it is possible to convert a test station to support 802.11a from one designed to support 802.11g. With the plethora of wireless protocols and standards being introduced all the time, this technology helps preserve an investment in test equipment and test development for future projects.



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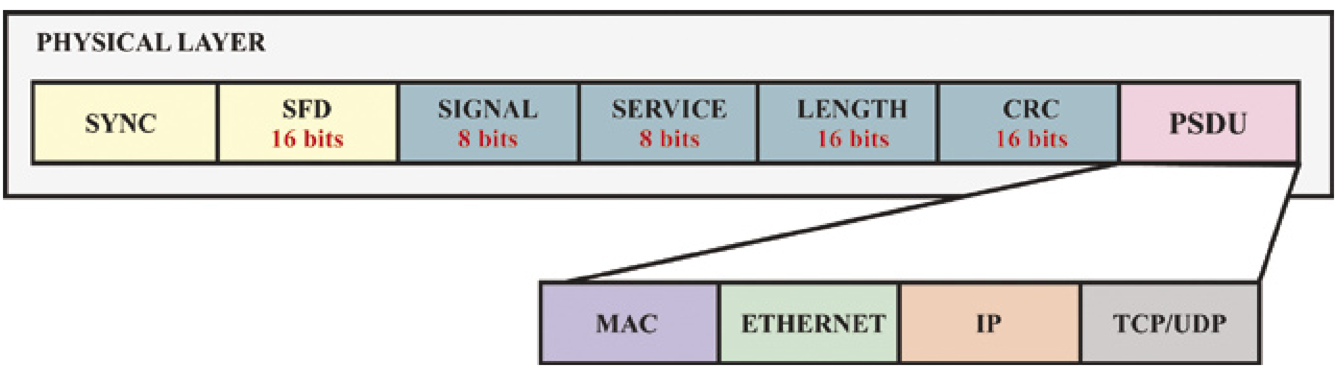

Figure 12