Keysight Technologies
Bridging the Gap from Benchtop to PXI

Application Note
Using a Common Software Platform from Design to Manufacturing

Today, engineers developing wireless and aerospace/defense communications devices have become more aware of how their design choices impact the cost of manufacturing test, particularly for high-volume devices. An attempt is made to design products that will need less test and reduce overall test time while ensuring the device meets its specifications.

Test and measurement companies play an important role by providing hardware and software tools that enable designers to efficiently transfer test methodologies and preserve integrity of measurements used in design to their manufacturing colleagues. A common software methodology can bridge the gap from benchtop instruments commonly used for design and development test to modular instruments commonly used for design validation and manufacturing.

Keysight’s design tools, benchtop and modular instruments with the common measurement science used across its product portfolio, provide a mechanism that simplifies the transfer from the lab to the production floor with the same user interface, minimizing code changes before making measurements. The benefit of this approach is that product feedback across the whole lifecycle is based on a common understanding of the measurements that determine the product’s performance.

Measurement integrity from concept to completion

When we make a measurement, what do we REALLY want, and how do we get it? Typically, we want to see a physical parameter – maybe voltage – versus another variable – frequency or time, for example – that will tell us something about a characteristic of our device.

Figure 1 shows the steps that take us there. The process begins with the capture of the physical data, then moves to preparing the data for conversion to the digital domain (scaling, filtering). The data is manipulated in the digital domain before presentation to the software that will turn it into the meaningful form that gives us the desired insight.

![Figure 1. From physical measurement to real knowledge.](image-url)
Early in product development, a new product can be simulated in a system-level design environment such as Keysight’s SystemVue, which includes virtual measurement tools that can be attached to nodes in the simulation to provide a view of expected performance. As the design moves from simulation to reality, completed modules of the device can be substituted into the simulation, real measurements, or hardware-in-the-loop replace the virtual tools and we can compare simulated and actual performance.

In a classic benchtop instrument all the steps from physical measurement to insight are combined and packaged together, with the insight shown on anything from a simple pass/fail indicator to a comprehensive display screen. In this case the software is integrated with the hardware and provides easy, front panel control for the user.

In a modular instrument environment, the physical measurement, signal conditioning and signal processing components of the instrument may be housed in one or more hardware modules, with the measurement software housed in a separate PC (external or embedded), and the final result might be the routing of the product to its next production station, along with a record of its performance characteristics.

Keysight’s rigorously specified benchtop and modular hardware offers guaranteed specifications backed up with regular calibration as a service, ensuring your measurements are reliable and repeatable and can be traceable back to a standard. Whether the measurement is made in a simulation environment, with a benchtop instrument and its embedded firmware, or with a modular instrument and separate PC, the measurement IP, algorithms, and measurement libraries and methodologies are common and provide consistent and reliable measurement integrity.

Taking a product from early design to volume manufacturing involves rigorous testing at all stages to ensure the product is reliable, meets its specifications, and complies with appropriate interoperability and standards requirements. This typically involves making and documenting thousands of measurements over a prolonged period and under different controlled operating conditions. While there is a common need to automate these measurements, the test equipment and measurement scenarios used for prototype product development will not be the same as those used in manufacturing test. However, making the correct choices of software environment and test equipment allows significant gains in both efficiency and understanding of the product.
Elements of a common software architecture

The layered architecture of a common modular software environment begins at the lowest level with the kernel driver, which communicates directly with certain aspects of the hardware, such as the memory and control registers, as shown in Figure 2. Above this sits the Virtual Instrument Software Architecture (commonly known as VISA) I/O libraries, a widely used and standardized I/O Application Programming Interface (API) that communicates directly with test and measurement hardware. The instrument driver builds on this foundation to set up the specific functions of the instrument, make raw measurements and collect data. IVI-class drivers share similar command libraries per instrument type which makes it easy to migrate from one platform to another. To support all popular programming languages and development environments, IVI drivers provide either an IVI-C or an IVI-COM API. Although the functionality is similar, IVI-C drivers are optimized for use in ANSI C development environments while IVI-COM drivers are optimized for environments that support COM (Common Object Mode). Keysight supplies both types to suit your choice of environment. The measurement application software layer translates the raw data into the performance characteristics that we want to measure. For example, raw IQ data obtained through the driver can be processed by the 89600 VSA software to produce an error vector magnitude (EVM) measurement. While the lower layers may differ to account for specifics of the hardware, the measurement application software is common across many of Keysight’s instruments and uses the same measurement methods, algorithms, libraries and methodologies.

Engineers have the option of making manual measurements and visualizing them on the screen of a benchtop instrument or on the PC display of a connected PC in the case of modular instruments. They can also execute a sequence of measurements using their choice of software development environment. Users can have the development environment communicate with any of the lower layers, depending on their application – the measurement application is hardware-agnostic and gives the most complete result while communication directly with the VISA layer may give raw data more quickly.
Measurement application software examples

Signal Studio is a measurement application used to create custom and standards-compliant test signals for wireless communications formats from GSM to LTE-Advanced. It can be used with a number of Keysight’s signal generators and vector signal generators ranging from UXG to PXI modular products. (Figure 3).

Similarly, the X-Series measurement applications provide one-button measurements for many wireless formats, and share the same algorithms and measurement science regardless of the hardware platform being used. Users of the X-Series benchtop signal analyzers, such as the MXA or PXA, will recognize these measurement applications as the various “modes” available for standards-compliant measurements of EVM, adjacent channel power, spectral emissions mask, and more. The same software is now available to run on any PC and connect to Keysight’s PXI VSAs for the same measurement experience while using a different hardware platform.

Keysight’s 89600 VSA software is an industry-leading tool for modulation analysis that runs on a large number of Keysight analyzers from basic spectrum analyzers to wide-bandwidth digital oscilloscopes. It has recently been extended to make fast stepped-FFT analysis on wide spectrum sweeps for harmonics and spurious emission tests.

Figure 4. Examples of hardware and software pairings - Signal Studio with benchtop and modular instruments, X-Series measurement applications and 89600 VSA software with benchtop and modular instruments.
The example in Figure 5 shows a configuration of two analyzers measuring the same LTE uplink signal, generated using Signal Studio. The resulting measurement is always the sum of the instrument’s measurement floor and the DUT actual performance so it is important to select equipment that has a sufficiently-low measurement floor relative to the DUT performance and your test margins. Figure 6 shows an example of two different instrument models measuring EVM of an LTE uplink signal using the same measurement software and the same device under test. Note that the signal analyzer measurement displays and screen menus for both the benchtop instrument and the modular system look the same. There is a small measurement all discrepancy due to different instrument hardware specifications such as gain and phase flatness, phase noise, and linearity therefore it is important to select the hardware platform that provides adequate test margins.
System 1: Modular M9393A PXIe Vector Signal Analyzer

System 2: Benchtop N9020A MXA Analyzer

Figure 6. The EVM measurement result (in thousandths of a percent, m%), pictured in lower right segment and shown numerically below the displays, is affected by the measuring equipment’s intrinsic performance.

System 1: Modular M9375A PXIe VNA

System 2: Benchtop N5245A PNA

Figure 7. VNA and PNA software applications calculate s-parameter and gain compression measurements using the same measurement algorithms and provide the same user interface.
Programming the systems is identical apart from selecting the device IP address, as these program fragments show:

**MXA Signal Analyzer**

```matlab
% Create connection object and IO settings
instrument = visa('agilent', 'TCPIP0::192.168.0.221::hislip0::INSTR');
instrument.ByteOrder = 'bigEndian';
instrument.InputBufferSize = 1e5;
instrument.Timeout = 10;

% Open connection
fopen(instrument);

% Get identification string (vendor, model #, serial #, etc)
IDN1 = query(instrument,'*IDN?')

% Preset/clear instrument
fprintf(instrument,'*RST');
fprintf(instrument,'*CLS');

% Set up instrument to measure 50% 400-Hz AM signal and set horizontal and vertical scales to show waveforms
fprintf(instrument,':INST:SEL ADEMOD');
fprintf(instrument,':FREQ:CENT 118 MHz');
fprintf(instrument,':AM:FREQ:SPAN 10 kHz');
fprintf(instrument,':AM:BAND:CHAN 6.8 kHz');
fprintf(instrument,':AM:DWSW:TIME 10 ms');
fprintf(instrument,':DISP:AM:WIND1:TRAC:Y:PDIV 15');
fprintf(instrument,':DISP:AM:WIND3:TRAC:Y:PDIV 20');
fprintf(instrument,':AM:AFSP:FREQ:STOP 3 kHz');

% Begin measurement (including averaging if ON)
fprintf(instrument,':INIT:IMM');
query(instrument,'*OPC?');

% Query measurement table results
query(instrument,':FETC:AM?')
```

**M9393A PXIe Vector Signal Analyzer**

```matlab
% Create connection object and IO settings
instrument = visa('agilent', 'TCPIP0::192.168.0.249::hislip0::INSTR');
instrument.ByteOrder = 'bigEndian';
instrument.InputBufferSize = 1e5;
instrument.Timeout = 10;

% Open connection
fopen(instrument);

% Get identification string (vendor, model #, serial #, etc)
IDN1 = query(instrument,'*IDN?')

% Preset/clear instrument
fprintf(instrument,'*RST');
fprintf(instrument,'*CLS');

% Set up instrument to measure 50% 400-Hz AM signal and set horizontal and vertical scales to show waveforms
fprintf(instrument,':INST:SEL ADEMOD');
fprintf(instrument,':FREQ:CENT 118 MHz');
fprintf(instrument,':AM:FREQ:SPAN 10 kHz');
fprintf(instrument,':AM:BAND:CHAN 6.8 kHz');
fprintf(instrument,':AM:DWSW:TIME 10 ms');
fprintf(instrument,':DISP:AM:WIND1:TRAC:Y:PDIV 15');
fprintf(instrument,':DISP:AM:WIND3:TRAC:Y:PDIV 20');
fprintf(instrument,':AM:AFSP:FREQ:STOP 3 kHz');

% Begin measurement (including averaging if ON)
fprintf(instrument,':INIT:IMM');
query(instrument,'*OPC?');

% Query measurement table results
query(instrument,':FETC:AM?')
```
Products

Shown below are the key products mentioned in this document.

SystemVue System Level Design Software
www.keysight.com/find/systemvue

Signal Studio
www.keysight.com/find/SignalStudio

89600 VSA Software
www.keysight.com/find/VSA

X-Series Measurement Applications
www.keysight.com/find/Xseriesapps
Products (continued)

Shown below are the key products mentioned in this document.

- **M9393A PXIe Performance Vector Signal Analyzer**
  
  www.keysight.com/find/m9393a

- **X-Series Signal Analyzers (PXA, MXA, EXA, CXA)**
  
  www.keysight.com/find/X-Series

- **M937xA PXIe Vector Network Analyzer**
  
  www.keysight.com/find/pxivna

- **PNA X-Series Network Analyzers**
  
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