Introduction to Automating Standalone Instruments

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NI Southern Africa
Challenges with Manual Measurement Systems

Manual measurements become increasingly complex as system requirements become more challenging.

- Error-Prone Repetitive Measurements
- Mixed Signals From Multiple Instruments
- Data Processing and Analysis
- Storing and Sharing Data

Automated testing solutions can reduce time, cost, and errors.
What is Instrument Control?

Instrument Control | A PC-based approach that uses software and a bus to control instruments in place of manual interactions.
Types of Instrumentation

Standalone Instrumentation

Modular Instrumentation
Connectivity Options
Connectivity Options

Instrument

Bus

Computer

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Hardware Connectivity

Standalone Buses
- GPIB
- Serial
- USB
- Ethernet

Modular Buses
- PCI
- PXI
- PCI Express
- PXI Express

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Hardware Connectivity

<table>
<thead>
<tr>
<th>Bandwidth (MB/s)</th>
<th>Latency (µS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gigabit Ethernet</td>
<td>0.1</td>
</tr>
<tr>
<td>Fast Ethernet</td>
<td>1</td>
</tr>
<tr>
<td>USB 1.1</td>
<td>10</td>
</tr>
<tr>
<td>USB 2.0</td>
<td>100</td>
</tr>
<tr>
<td>IEEE 1394a</td>
<td>1000</td>
</tr>
<tr>
<td>GPIB (HS 488)</td>
<td>10000</td>
</tr>
<tr>
<td>PCI Express/PXI Express (x4)</td>
<td>10000</td>
</tr>
<tr>
<td>PCI/PXI</td>
<td>1000</td>
</tr>
<tr>
<td>VME/VXI</td>
<td>100</td>
</tr>
</tbody>
</table>

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## Bus Considerations

<table>
<thead>
<tr>
<th>Bus</th>
<th>Bandwidth (MB/s)</th>
<th>Latency (μs)</th>
<th>Range (m) (without extender)</th>
<th>Setup and Installation</th>
<th>Connector Ruggedness</th>
</tr>
</thead>
<tbody>
<tr>
<td>GPIB</td>
<td>1.8 (488.1) 8 (HS488)</td>
<td>30</td>
<td>20</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>Serial</td>
<td>0.11</td>
<td>30</td>
<td>15.6 (RS232) 1200 (RS485)</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>USB</td>
<td>60 (Hi-Speed)</td>
<td>1,000 (USB) 125 (Hi-Speed)</td>
<td>5</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>Ethernet</td>
<td>12.5 (Fast) 125 (Gigabit)</td>
<td>1,000 (Fast) 1,000 (Gigabit)</td>
<td>100</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
</tbody>
</table>
Connectivity Options

Instrument

Bus

Computer

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Additional Interfaces

Form Factors
- USB
- Serial
- Ethernet
- PCI/PCIe
- PXI/PXIe

GPIB Options
- IEEE 488.2 and HS488
- Analyzers
- Serial-to-GPIB Controllers & Converters
- PXI Ethernet and GPIB Combo

Serial Options
- RS232 and RS485
- Isolated or Non-Isolated
- 1, 2, 5, or 16 ports
GPIB-USB-HS+

- Released August 4\textsuperscript{th}
- Replaces the GPIB-USB-HS
  - Includes analyzer functionality.
  - Improved performance through decreased latency.
  - Smaller size allows it to fit more instruments.
Software

Driver Software  Application Software
Instrument Setup & Verifying Communication

Measurement and Automation Explorer (MAX)

Manage all of your hardware from one location

- Find connected instruments
- Assign aliases
- Launch test panels
- Configure IVI drivers
Test Applications Use Diverse Hardware
Test Applications Use Diverse Hardware

NI-VISA

- GPIB
- USB
- LXI
- Serial
- PXI
- VXI

Your Application

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Communicating with an Instrument using NI-VISA

Pros | Bus agnostic, abstracts communication protocols
Cons | Still low level, time consuming to program a full application
What Commands Can You Send?

Command Groups

This section lists the commands organized by function. The Command Description section, starting on page 2-33, contains a list of commands alphabetically.

The oscilloscope GPIB and RS-232 interfaces conform to the standard codes and formats except where noted. They also conform to IEEE Std 488.2-1987 except where noted.

Acquisition Commands

Acquisition commands affect the acquisition of waveforms. Commands control modes, averaging, enveloping, and form acquisition.

Table 2-4: Acquisition Commands

<table>
<thead>
<tr>
<th>Header</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACQquire</td>
<td>Return acquisition status</td>
</tr>
<tr>
<td>ACQquireMODe</td>
<td>Softly acquire</td>
</tr>
<tr>
<td>ACQquireMUlt</td>
<td>Return full acquisition</td>
</tr>
<tr>
<td>ACQquireSTATE</td>
<td>Return number of completed acquisitions</td>
</tr>
<tr>
<td>ACQquireStatE</td>
<td>Start or stop acquisition</td>
</tr>
<tr>
<td>ACQquireSTEM</td>
<td>Softly acquire</td>
</tr>
</tbody>
</table>

Calibration and Diagnostic Commands

Calibration and Diagnostic commands let you initiate the oscilloscope self-calibration routines and examine the results of tests.

Table 2-5: Calibration and Diagnostic Commands

<table>
<thead>
<tr>
<th>Header</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAL</td>
<td>Perform an internal self-test</td>
</tr>
<tr>
<td>CALibrate:ABORT</td>
<td>Stop an in progress test</td>
</tr>
<tr>
<td>CALibrate:EXTERNAL</td>
<td>Perform an internal self-test</td>
</tr>
<tr>
<td>CALibrate:FACTory</td>
<td>Initialize the factory calibration</td>
</tr>
<tr>
<td>CALibrate:CONTINUE</td>
<td>Perform the next step of calibration sequence</td>
</tr>
<tr>
<td>CALibrate:STATUS</td>
<td>Return PASS or FAIL state of self-calibration</td>
</tr>
<tr>
<td>DIAG RESULT</td>
<td>Return diagnostic tests</td>
</tr>
<tr>
<td>DIAG RESULT:LOG</td>
<td>Return diagnostic test results</td>
</tr>
<tr>
<td>ERRLOG:FIRST</td>
<td>Return first entry from ERRLOG</td>
</tr>
<tr>
<td>ERRLOG:NEXT</td>
<td>Return next entry from ERRLOG</td>
</tr>
</tbody>
</table>

Measurement Commands

Measurement commands control the automated measurement system. Up to four automated measurements can be displayed on the oscilloscope screen. In the command, these four measurement readouts are named M1-M4, where <n> can be 1, 2, 3, or 4.

In addition to the four measurement readouts displayed, the measurement commands let you specify a fifth measurement, M5M6. The immediate measurement has no front-panel equivalent, and the instrument never displays immediate measurements. Because they are computed only when they are requested, immediate measurements show the waveform update rate less than displayed measurements.

Use the QUERY? query to display either displayed or immediate measurements.

Several measurement commands set and query measurement parameters. You can assign some parameters, such as waveform sources, differently for each measurement readout.

Table 2-10: Measurement Commands

<table>
<thead>
<tr>
<th>Header</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MEASurement?</td>
<td>Return all measurement parameters</td>
</tr>
<tr>
<td>MEASurement:IMMed?</td>
<td>Return immediate measurement parameters</td>
</tr>
<tr>
<td>MEASurement:IMMed:SOURCE</td>
<td>Select the immediate measurement from</td>
</tr>
<tr>
<td>MEASurement:IMMed:TYPE</td>
<td>Select the immediate measurement type</td>
</tr>
<tr>
<td>MEASurement:IMMed:UNItes?</td>
<td>Return the immediate measurement units</td>
</tr>
<tr>
<td>MEASurement:IMMed:VALUE?</td>
<td>Return the immediate measurement value</td>
</tr>
<tr>
<td>MEASurement:MEAS&lt;-&gt;t</td>
<td>Return parameters on the periodic measurement</td>
</tr>
</tbody>
</table>
Test Applications Use Diverse Hardware

Integrated Development Environment (IDE)

- Instrument Drivers
- Direct I/O (SCPI)

NI-VISA

- GPIB
- USB
- LXI
- Serial
- PXI
- VXI

Instrument

- Modular Instruments
What is an Instrument Driver?

Organized API that controls a programmable instrument

- Each API call performs multiple instructions
- Grouped by operation type (configuration, data, etc)

Reduce development time

- Simplify instrument control
- Reusable
- Common architecture and interface
Instrument Driver Model

1. Initialize Session
2. Configure Instrument
3. Perform Operation
4. Close Session
5. Handle Errors
Choosing The Right IDE

Considerations:

- Driver Availability
- Ease of Programming
- Analysis Capabilities
- Data Storage & Recording
- Building a Flexible UI
- Training and Support
Choosing The Right IDE

<table>
<thead>
<tr>
<th>Feature</th>
<th>LabVIEW</th>
<th>LabWindows™/CVI</th>
<th>Measurement Studio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Driver Availability</td>
<td><img src="#" alt="Circle" /></td>
<td><img src="#" alt="Crescent" /></td>
<td><img src="#" alt="Half-Circle" /></td>
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<tr>
<td>Ease of Programming</td>
<td><img src="#" alt="Circle" /></td>
<td><img src="#" alt="Crescent" /></td>
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<td>Analysis Capabilities</td>
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<td>Data Storage and Recording</td>
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<tr>
<td>Building a Flexible UI</td>
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<td><img src="#" alt="Crescent" /></td>
<td><img src="#" alt="Circle" /></td>
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<tr>
<td>Training and Support</td>
<td><img src="#" alt="Circle" /></td>
<td><img src="#" alt="Crescent" /></td>
<td><img src="#" alt="Half-Circle" /></td>
</tr>
</tbody>
</table>

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Head to Head Comparison

LabVIEW Code:
Head to Head Comparison

C Code:

```c
#include <formatio.h>
#include <ansi_c.h>

/*@ == Sample Oscilloscope Instrument Module ============================== */
#include "scope.h"

int scope_device_closed (void);
int scope_invalid_integer_range (int, int, int, int);
int scope_invalid_real_range (double, double, double, int);
int scope_write_data (char *, int);

int scope_err = 0;

/*@ ============================================================== */
static int bd;
static char cmd[100];
static double ch1_volts_per_div;
static double ch2_volts_per_div;
static double sec_per_div;
static int ch1_coupling;
static int ch2_coupling;

/*@ ============================================================== */
int CVIFUNC scope_init (int addr)
{
    if (scope_invalid_integer_range (addr, 0, 30, -1) != 0)
        return scope_err;
    if (addr != 1) {
        scope_err = 223;
        return scope_err;
    }
    bd = 1;
    ch1_volts_per_div = 1.0;
    ch2_volts_per_div = 1.0;
    ch1_coupling = 1;
    ch2_coupling = 1;
    sec_per_div = 0.001;
    scope_err = 0;
    return scope_err;
}
```
LabVIEW Is the Standard for Instrument Control

Software Used for Data Acquisition and Instrument Control

- NI LabVIEW
- Microsoft Visual C/C++
- Microsoft Visual Basic
- Microsoft Visual Basic 6.0
- NI - LabWindows™/CVI
- Microsoft C#
- The MathWorks, Inc. - MATLAB®
- NI Measurement Studio
- Agilent VEE
- NI TestStand
- Agilent IO Libraries Suite
- Python
- GeoTest ATEasy
- Other
- Don't use

MATLAB® is a registered trademark of The MathWorks, Inc.
Unrivaled Hardware Integration in a Single Environment

- NI hardware
  - 200+ data acquisition devices
  - 450+ modular instruments
  - Cameras
  - Motion control

- Third-party hardware
  - Instrument Driver Network
    - 10,000+ instrument drivers
    - 350+ instrument vendors
    - 100+ instrument types
  - Communicate over any bus
Get Results from Your Measurements

Accelerate simulation, prototyping, and deployment with over 850 built-in analysis functions.

- Curve Fitting
- Interpolation
- Signal measurement
- Signal generation
- Digital IIR and FIR filtering
- Windowing
- Spectral Analysis
- Waveform measurements
  
  ... and more
LabVIEW MathScript RT Module

Combine the benefits of textual math and graphical programming

- Reuse many of your .m file scripts created with The MathWorks, Inc. MATLAB® software and others

A native LabVIEW solution

- Interactive and programmatic interfaces
- Does not require 3rd-party software

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Presentation and Reporting

Visualization

• Built-In user interface design objects
• Charting and graphing utilities
• Remote application viewing and control

Report Generation

• Documentation Tools
• HTML reports for the Web
• Microsoft Word & Excel reports

Data Management & Connectivity

• NI DIAdem
• Database Connectivity
• File I/O
Demonstration

Build a software application to automate data collection and analysis
NI VirtualBench

A radically practical approach to benchtop instrumentation.

5 Instruments, 1 Device
- Mixed Signal Oscilloscope (100MHz)
- Function Generator (20MHz)
- Digital Multimeter (5½-Digits)
- Programmable DC Power Supply (3 Outputs)
- Digital I/O

Software-Based
- Connect Over Wireless or USB
- See All Instruments Together in One Screen
- Interact with Mouse and Multi-Touch Gestures
- Save Data or Screenshots in Seconds
- Save and Share Configurations
- Easily Automate with NI LabVIEW

Only $1,999 (USD)

ni.com/virtualbench
Troubleshooting Tools

NI I/O Trace

- Quickly debug instrument communication
- Capture commands for every instrument on every bus
- Displays full command, process ID, thread ID, status, etc
Instrument Driver Network (IDNet)

Industry’s largest source of instrument drivers

10,000+ instrument drivers
360+ manufacturers
100+ instrument types
Introducing the Instrument Driver Development Studio

Speed up development time when creating new LabVIEW instrument drivers

- Easily create an instrument driver framework via drag-and-drop commands
- Automatically generate LabVIEW source code from your defined driver framework
A Complete Instrument Control Solution

LabVIEW

Instrument Drivers

Direct I/O (SCPI)

Measurement and Automation Explorer

NI-VISA

GPIB

USB

LXI

Serial

PXI

VXI

Instrument

Instrument

Instrument

Modular Instruments

Modular Instruments
Next Steps

Download an Instrument Driver  
ni.com/idnet
IDNet has over 10,000 drivers from 450 different companies. Find your driver today.

Evaluate LabVIEW  
ni.com/trylabview
Get started with LabVIEW right away, and evaluate with sample code, tutorials, and videos specific to automating instruments.

Register for a Course  
ni.com/training
Learn how to program in LabVIEW and build an instrument control application. Delivered in-person or online.

Get someone else to assist  
ni.com/alliance
More than 600 technical consultants, developers, and system integrators with LabVIEW experience.
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