Choosing the right DAQ for your applications & test systems
Agenda

• Data Acquisition system overview 10 min.

• Key Specifications/features to consider 20 min.

• Agilent’s solutions for DAQ system and their features 10 min,
  • 34970/72A
  • 34980A
  • USB-solutions

• Agilent software solutions 10 min.
  • Benchlink software
  • Vee Pro
  • IO Libraries

• Demo 10 min.
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• **Demo** 10 min.
### Differences between Electronic Functional Test and Data Acquisition

<table>
<thead>
<tr>
<th>Electronic Functional Test</th>
<th>Data Acquisition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transactional: single-point measurements</td>
<td>Observational: multi-point readings</td>
</tr>
<tr>
<td>Small log files</td>
<td>Very large log files</td>
</tr>
<tr>
<td>Many kinds of instruments</td>
<td>Few instruments, many switches</td>
</tr>
<tr>
<td>Typical large amount of signals</td>
<td>Relative small amount of signals</td>
</tr>
<tr>
<td>Relative fast changing signals</td>
<td>Relative slow changing signals</td>
</tr>
</tbody>
</table>

Product Characterization

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Product characterization is the process of using electrical and physical measurements to gain insight and improve a design.

Typical measurements to characterize a product include:

- Temperature
- Voltage AC and DC
- Current AC and DC
- Relative humidity / CO2
- Flow
- Speed
- Sound / Frequency
- Pressure
- Displacement
- Velocity
- Acceleration
Data acquisition system overview

Data/Measurements: Pressure, Force, Vibration, Strain, Temperature, Humidity, CO₂, Voltage

Transducers/Sensors

Signal Conditioning

DAQ Hardware

Computer

The Physical Link for the Data Acquisition System

Gathers & stores data for actions, analysis and/or control

Agilent Technologies
The Physical Link for The Data Acquisition System

Converting from physical... to electrical

- Temperature
- Relative humidity
- Flow
- Speed
- Sound
- pressure
- Displacement
- Velocity
- Acceleration

- DC volts
- DC current
- AC volts
- AC current
- Resistance
- Frequency
- Modulation

Transducer

Transducers / Sensors
Transducer Outputs

• **Voltage:**
  – DC – from µvolts to 100’s of volts
  – AC – Sine, pulse, varying amplitude, duty cycle, phase and frequency

• **Resistance:**
  – 2-wire and 4-wire techniques

• **Current:** 4-to-20 mA loop, 250Ω termination
  – 1 volt = 4 mA
  – 5 volts = 20 mA
  – 0 volts = open circuit
Signal Conditioning - Examples

Convert signal to be compatible with system:

- Shunt resistor for indirect current measurement
- Filter / Snubber
- Strain gauge bridge completion circuit
- Amplifier / Attenuator
- AC converter
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• Demo 10 min.
Key Specifications/features to consider

- Sampling DAQ or Switch/measure DAQ
- Sampling rate/scanning speed & switching time
- Resolution and accuracy
- Channel count and configuration flexibility
- System throughput
- Instrument IO and software
Sampling DAQ

Typical for Sampling DAQ based instruments, they have as many digitizers as input channels.
Sampling rate calculation is typical for sampling DAQs; used for fast acquisition and for inherently fast varying signals

The minimum sample rate can be calculated with the theorem of Nyquist.
Sampling rate/scanning speed for a sampling DAQ

Theorem of Nyquist:
A band limited analog signal can be perfectly reconstructed from an infinite sequence of samples if the sampling rate exceeds twice the highest frequency of the original signal.

E.g. To log signals on 2 channels, channel 1 – 50Hz and channel 2 100KHz, what will a multiplexed ADC based DAQ with 250K Samples/sec suffice?

YES – for 50Hz signal, a sampling rate of 200 Samples/sec will suffice and for the 100KHz signal we can configure the sampling rate at 249K samples/sec which is just about enough for logging.
Typical for Switch/measure DAQ is this instrument has one digitizer. Common is a digital multimeter configuration.

The DMM is accessed through many multiplexed channels.
For switch/measure type of DAQ systems, scanning speed and switching time are more important parameters to be considered.

A switch / measure DAQ can handle, compared with “sample based DAQ’s” only slow varying signals.

A switch / measure DAQ system has a lower price compared with ADC Based systems.
Sampling rate/scanning speed & switching time

For switch/measure type of DAQ systems scanning speed and switching time are more important parameters to be considered.

- E.g. For logging signals across 2 channels on a DAQ with the open time = close time of the switch = 0.5ms. What is the maximum frequency of the signal per channel that can be logged?

- For 2 channels the scan time will be 2ms (2 X open times + 2 X close time). Applying Nyquist criteria 2ms amounts to a sampling frequency per channel = 1/2ms = 500Hz per channel. Ideally the signal shouldn’t change value at a rate more than 250Hz.
Resolution & Accuracy

Resolution is inversely related to sampling frequency.

<table>
<thead>
<tr>
<th>Function</th>
<th>Resolution [9]</th>
<th>reading/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>dcV, 2-wire Resistance</td>
<td>6½ digits (10 plc)</td>
<td>6 (5)</td>
</tr>
<tr>
<td></td>
<td>5½ digits (1 plc)</td>
<td>57 (47)</td>
</tr>
<tr>
<td></td>
<td>4½ digits (0.02 plc)</td>
<td>490</td>
</tr>
</tbody>
</table>

Sample from datasheet 34970A
In an ADC based DAQ the quantization error and minimum range of measurement should be considered.

Quantization error is the difference between the actual analog value and quantized digital value.

The error signal is sometimes considered as an additional random signal called quantization noise.
Resolution & Accuracy

The accuracy of the switching and the measuring unit needs to be taken into account.

The amount of error can be found in datasheets:

**Accuracy Specifications**  \(\pm (\% \text{ of reading} + \% \text{ of range})\)^[1]

Includes measurement error, switching error, and transducer conversion error

<table>
<thead>
<tr>
<th>Range[^2]</th>
<th>Frequency, etc.</th>
<th>24 Hour[^2]</th>
<th>90 Day</th>
<th>1 Year</th>
<th>Temperature Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>23°C±1°C</td>
<td>23°C±5°C</td>
<td>23°C±5°C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DC Voltage</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100.0000 mV</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.000000 V</td>
<td></td>
<td>0.0030 + 0.0035</td>
<td>0.0040 + 0.0040</td>
<td>0.0050 + 0.0040</td>
<td>0.0005 + 0.0005</td>
</tr>
<tr>
<td>10.0000 V</td>
<td>0.0020 + 0.0006</td>
<td>0.0030 + 0.0007</td>
<td>0.0040 + 0.0007</td>
<td>0.0050 + 0.0007</td>
<td>0.0005 + 0.0001</td>
</tr>
<tr>
<td>100.0000 V</td>
<td>0.0015 + 0.0004</td>
<td>0.0020 + 0.0005</td>
<td>0.0035 + 0.0005</td>
<td>0.0055 + 0.0005</td>
<td>0.0005 + 0.0001</td>
</tr>
<tr>
<td>300.000 V</td>
<td>0.0020 + 0.0006</td>
<td>0.0035 + 0.0006</td>
<td>0.0045 + 0.0006</td>
<td>0.0055 + 0.0006</td>
<td>0.0005 + 0.0003</td>
</tr>
<tr>
<td>True RMS AC Voltage[^3]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100.0000 mV</td>
<td>to 100.0000mV</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 Hz–5 Hz</td>
<td>1.00 + 0.03</td>
<td>1.00 + 0.04</td>
<td>1.00 + 0.04</td>
<td>0.100 + 0.004</td>
<td></td>
</tr>
<tr>
<td>5 Hz–10 Hz</td>
<td>0.35 + 0.03</td>
<td>0.35 + 0.04</td>
<td>0.35 + 0.04</td>
<td>0.035 + 0.004</td>
<td></td>
</tr>
<tr>
<td>10 Hz–20 kHz</td>
<td>0.04 + 0.03</td>
<td>0.05 + 0.04</td>
<td>0.06 + 0.04</td>
<td>0.005 + 0.004</td>
<td></td>
</tr>
</tbody>
</table>

Sample from datasheet Agilent 34972A
Resolution & Accuracy

For example: What’s the accuracy when measuring 9 Vdc with a 34972A:

The range of instrument: 10 V dc

We take the 1-year accuracy specifications at normal operating temperature (18°C–28°C)

From the datasheet we read a specification of: 0.0035% of reading + 0.0005% of range

So we can calculate:

\[(0.0035/100 \times 9 \, \text{V}) + (0.0005/100 \times 10 \, \text{V}) = 365\, \mu\text{V}\]

The total accuracy is: \[365\, \mu\text{V} / 9 \, \text{V} = 0.0041\%\]
Resolution & Accuracy

Accuracy is dependent on the overall system accuracy. Be aware that sometimes the biggest error comes from the sensor.

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Type</th>
<th>1-Year Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermocouple</td>
<td>B</td>
<td>1.2°C</td>
</tr>
<tr>
<td></td>
<td>E</td>
<td>1.0°C</td>
</tr>
<tr>
<td></td>
<td>J</td>
<td>1.0°C</td>
</tr>
<tr>
<td></td>
<td>K</td>
<td>1.0°C</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>1.0°C</td>
</tr>
<tr>
<td></td>
<td>R</td>
<td>1.2°C</td>
</tr>
<tr>
<td></td>
<td>S</td>
<td>1.2°C</td>
</tr>
<tr>
<td></td>
<td>T</td>
<td>1.0°C</td>
</tr>
<tr>
<td>RTD</td>
<td>R0 from 49Ω to 2.1 kΩ</td>
<td>0.06°C</td>
</tr>
<tr>
<td>Thermistor</td>
<td>2.2 k, 5k, 10k</td>
<td>0.08°C</td>
</tr>
</tbody>
</table>

Resolution & Accuracy

For example: what is the accuracy of a temperature Measurement of 150°C, done with a J-type thermocouple?

The datasheet shows a Thermocouple probe accuracy of +/- 1.0°C. The probe vendor specifies accuracy of 1.1°C or 0.4%, whichever is greater. This is pretty common spec for thermocouples.

Total error is then: **1.0°C + 1.1°C = 2.1°C total, or 1.4%**

The same measurement with a PT100 sensor with an error of 0.05°C produces with the same instrument a error of **0.11°C or 0.073%**
Channel count and configuration flexibility

- Number of channels that a system provides and the number of channels that can be added when required at minimal cost.
- Flexibility of configuring each channel for different types of measurement.
- Choice for either scanning a channel or routing signals from/to a channel.
- Choice for selecting the number of bits to get an optimum level for throughput and resolution.
- Facility for 1-wire, 2-wire and 4-wire measurements for obtaining desired accuracy and throughput.
- Built-in or external signal conditioning.
Throughput is a measure of the time it takes to test a device or product. Main considerations for maximizing system throughput are:

- Minimizing time consuming instructions in the test plan such as resets and data downloads
- Employ burst sampling wherever possible instead of single sampling
- Choice of measuring instruments, switching and choice of backplane
Instrument I/O and Software

Virtually there is no limitation in the choice of software.

However...

- The most expensive part for any test system can be expensive software upgrades.
- The more easy-to-use customizable software increases fast setup but reduces flexibility.
- Flexibility requires an open architecture that connects to multiple instruments and eliminates proprietary I/O and software.
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• Demo 10 min.
Agilent’s solutions for DAQ system and their features

• For Low sampling Rate or static applications
  • 34970A / 34972A Data acquisition control & switch units
  • 34980A Multifunction Switch/Measure Unit
  • L4400 Series LXI Switch and Control Instruments

• For high sampling Rate, fast acquisition applications
  • USBDAQ – U2300A series

• For simultaneous sampling and phase-critical applications
  • USB DAQ – U2500A series
34970A / 72A data acquisition control & switch units

- Data logger, DAQ system or low-cost switching unit
- Three-slot mainframe
- Maximum 60 channels Multiplexer and 120 channels single ended.
- Eight plug-in modules
- Built-in 6½-digit DMM (optional)
- GPIB & RS-232 interfaces for 34970A and LAN / USB for 34972A
- BenchLink data logger Pro software
- IntuiLink for Excel
Agilent 34972A – A Closer Look

Choose from 8 plug-in modules with on-board screw terminals

Easy to use front panel control
Optional internally mounted 6 ½ digit DMM

Gigabit LAN and USB 2.0 for instant connection to a PC

USB flash drive for standalone applications:
Copy BenchLink data logger files to instrument
Log measurements directly to USB stick
Copy internal memory data to USB stick

LXI-C
Agilent 34972A – Eight modules to choose from

- 34901A 20 Channel Multiplexer (2/4-wire) Module;
- 34902A 16 Channel Multiplexer (2/4-wire) Module;
- 34903A 20 Channel Actuator/GP Switch Module;
- 34904A 4 x 8 Two-Wire Matrix Module;
- 34905A 2 GHz Dual 1:4 RF Mux, 50 Ohm Module;
- 34906A 2 GHz Dual 1:4 RF Mux, 75 Ohm Module;
- 34907A Multifunction Module;
- 34908A 40 Channel Single-Ended Multiplexer Module.
34980A Multifunction Switch/Measure Unit

“Expandable and reconfigurable platform with 19 mix and match switch & measurement modules, mainframe and built-in DMM.”

Product Highlights

✓ Broad offering of modules
  • 8-slots mainframe with integrated 6 ½ digit DMM
  • 19 plug-in modules – LF/RF/uW switch, DIO, D/A converter, counter
  • 560 2-wire mux or 1024 2-wire matrix cross-points in one mainframe

✓ Ease of integration
  • Standard LAN, USB, GPIB connectivity to PC
  • Standard cables, terminal cards or mass interconnect

✓ Low Cost
  • Priced up to 40% less than comparable modular solutions in VXI or PXI
Agilent 34980A – A Closer Look

- 8 slots
- 3U high, full rack
- Optional, internally mounted DMM

- 4 analog buses
- Connect to external instruments

- Std 50/78 pin Dsub connectors
- High quality 300V cables

- Terminal cards for discrete wiring
- Mass interconnect from 3rd parties

GPIB, LAN, USB Trigger/Arm
34980A - 19 Plug-in Modules to choose from

- 40/70-Channel Multiplexers
- High density Matrix Switches
- General Purpose Switching

Scan multiple points, connect multiple, or control external devices in a system

- RF Multiplexers to 3GHz
- Microwave switching up to 20GHz
- uW switch/attenuator driver

Route high frequency signals and share expensive uW instruments

- High-Speed Digital I/O
- 4-Chan D/A Converter
- Multifunction module

Create and read digital patterns, create waveforms and count events

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34980A - Graphical Web Interface Over Ethernet
Remote access and control via standard Web Browser

Set up, troubleshoot and debug

- Check configurations
- Open/close/monitor
- Switch sequencer
- SCPI commands
- OS independent
- Password protection/LAN lockout

Status and maintenance

- Error queue, I/O analyzer
- Status report - cal status, switch counter
L4400 Series LXI Switch and Control Instruments

Based on 7-modules of the 34980A but now operating without a mainframe

Product Highlights

• LXI Class C Compliant
• Ethernet connection ready
• Small, 1 U half-rack size
• Graphical web interface
• Software drivers for most programming environments
• Low cost
7 Switching & System Control LXI Instruments

- Low Frequency Switching
  - L4421A 40-ch armature multiplexer
  - L4433A Dual 4x8 reed matrix
  - L4437A 32-ch General Purpose switch

- High Frequency Switching
  - L4445A Microwave switch/atten driver

- Digital I/O, Analog Outputs, Counter
  - L4450A 64-bit Digital I/O w/ memory
  - L4451A 4 channel D/A converter w/ memory
  - L4452A Multifunction w/ 32 DIO, 2 D/A, counter

LXI Class C compliant

Agilent Technologies
L4400 - How it’s beneficiary?

Small size and low cost

- Lower cost than mainframe + plug-in module
- Saves space and takes less room in test rack or on a bench
- Flexible and reusable
- Allows for phased migration into existing systems without a big investment
- Part of the LXI industry standard for easy integration with other products
U2300A Series Multifunction DAQ

USB DAQ Modular Multifunction DAQ

Key Features:

- 16 Up to 3 MSa/s for a single channel use
- Bit resolution, 384 Maximum Channel
- Multifunction, analog input/output, digital input/output & counter in a single module.
- Dual Play, upgradeable single to multi modules by using card cage
- Out of the box bundled software shipped with the product
- Slot 0 processor not require for the card cage
- Compatible with a wide range of Application Development Environments (Agilent VEE, NI LabVIEW, Microsoft Visual Studio)
- Device class: USBTMC 488.2 Standards

Agilent Technologies
# U2500A Series Simultaneous Sampling DAQ

<table>
<thead>
<tr>
<th>Model Number</th>
<th>U2531A</th>
<th>U2541A</th>
<th>U2542A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analog Input</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resolution</td>
<td>14 bits</td>
<td>16 bits</td>
<td></td>
</tr>
<tr>
<td>Number of channels</td>
<td>4 Differential Input Channels (software selectable/channel)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum sampling rate</td>
<td>2 MSa/s</td>
<td>250 kSa/s</td>
<td>500 kSa/s</td>
</tr>
</tbody>
</table>

Agilent Technologies
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• Demo 10 min.
Agilent software solutions

Example how to select software

IO Library suite

Flexibility required, Yes or no

No, then consider Benchlink Pro software

Yes: then consider Agilent Vee Pro software

Else Agilent provides drivers, examples and tools for environments like:
- MatLab
- .NET Visual Studio
- LabView
- Etc.
IO Libraries suite

*Is supplied with every instrument or downloadable from the Agilent website*

- Automatically detects instruments connected to your PC and configures the interfaces.
- Compatible with the most common instruments including: AXIe, PXI, GPIB, USB, Ethernet/LAN, RS-232 and VXI test instruments.
- Enables instrument communication for a variety of development environments (Mathworks MATLAB, Agilent VEE Pro, NI LabVIEW, Microsoft Visual StudioR and more).
- Includes access to Command Expert, a new software tool for easy instrument control.
Agilent Benchlink Pro software (34970A/72A & 34980A)

Product Highlights

- Advanced data logging and decision making with no programming
- Quick test setup and execution
- Create multiple scan lists
- Execute events based on predefined limits
- Use advanced math functions
- Collect, monitor and manage data
- Present data on a single or multiple graphs
- Export data to other applications for presentation and analysis
Agilent Vee Pro software

Agilent VEE (Visual Engineering Environment) is an easy-to-use graphical language environment that provides a quick path to measurement and analysis.

Agilent VEE allows seamless operation with hardware and software from Agilent and other manufacturers.
Wrap up

• It is not very hard to set-up a basic data acquisition system but it is hard to decide what is best for your environment.

• The choice of software creates flexibility for the future…or not.

• Engineers of Acal Bfi and Agilent Technology are skilled and ready to give you advice.

• Acal Bfi can provide a turn-key solution, inclusive sensors, transducers and signal conditioners.
As last: some very useful websites

- [www.acal.nl](http://www.acal.nl)
- [www.bfioptilas.nl](http://www.bfioptilas.nl)
- [www.agilent.nl](http://www.agilent.nl)
- [www.agilent.com/find/34970A](http://www.agilent.com/find/34970A)
- [www.agilent.com/find/34972A](http://www.agilent.com/find/34972A)
- [www.agilent.com/find/34980A](http://www.agilent.com/find/34980A)
- [www.agilent.com/find/dataacquisition](http://www.agilent.com/find/dataacquisition)
- [www.agilent.com/find/adn](http://www.agilent.com/find/adn)
- [www.agilent.com/find/vee](http://www.agilent.com/find/vee)
- [www.agilent.com/find/iolibraries](http://www.agilent.com/find/iolibraries)
- [www.agilent.com/find/drivers](http://www.agilent.com/find/drivers)
QUESTIONS?
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Thank you