Lesson 5
Data Acquisition and Waveforms

You Will Learn:

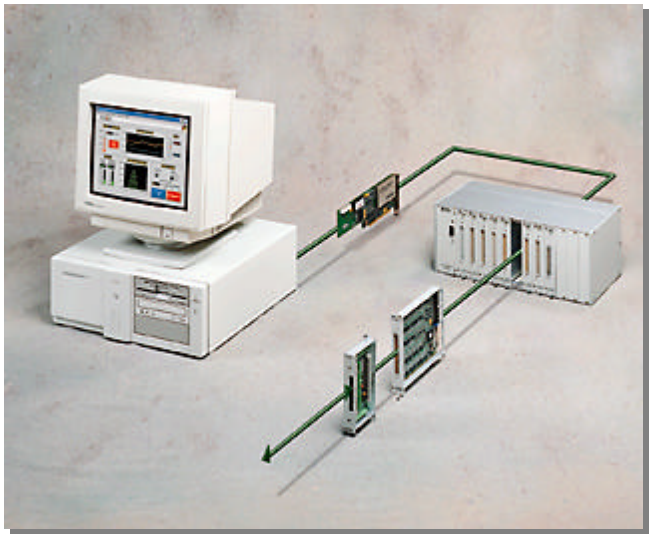
- **A. About plug-in data acquisition (DAQ) boards**
- **B. About the organization of the DAQ VIs**
- **C. How to perform a single analog input**
- **D. About the DAQ Wizards**
- **E. About waveform analog input**
- **F. How to write waveforms to file**
- **G. How to output an analog signal**
- **I. How to use counter/timers**
- **J. USB DAQ--NI-DAQ mx Base devices**

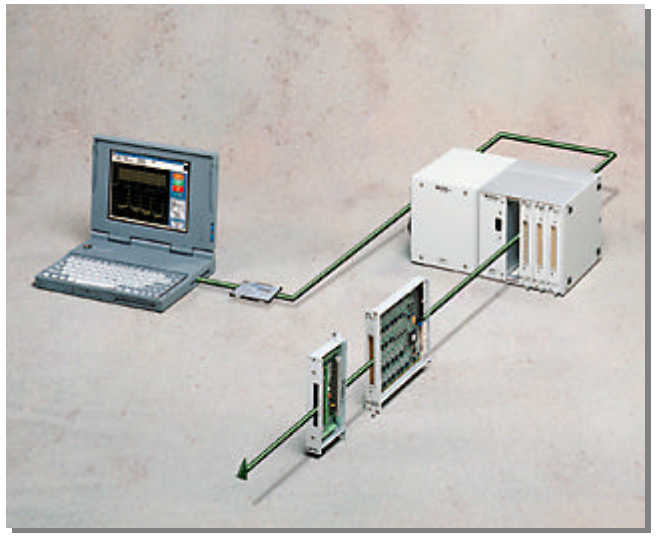
Overview

The fundamental task of all measurement systems is the measurement and/or generation of real-world physical signals. Measurement devices help you acquire, analyze, and present the measurements you take.

We acquire and convert physical signals, such as voltage, current, pressure, and temperature, into digital formats and transfer them into the computer.

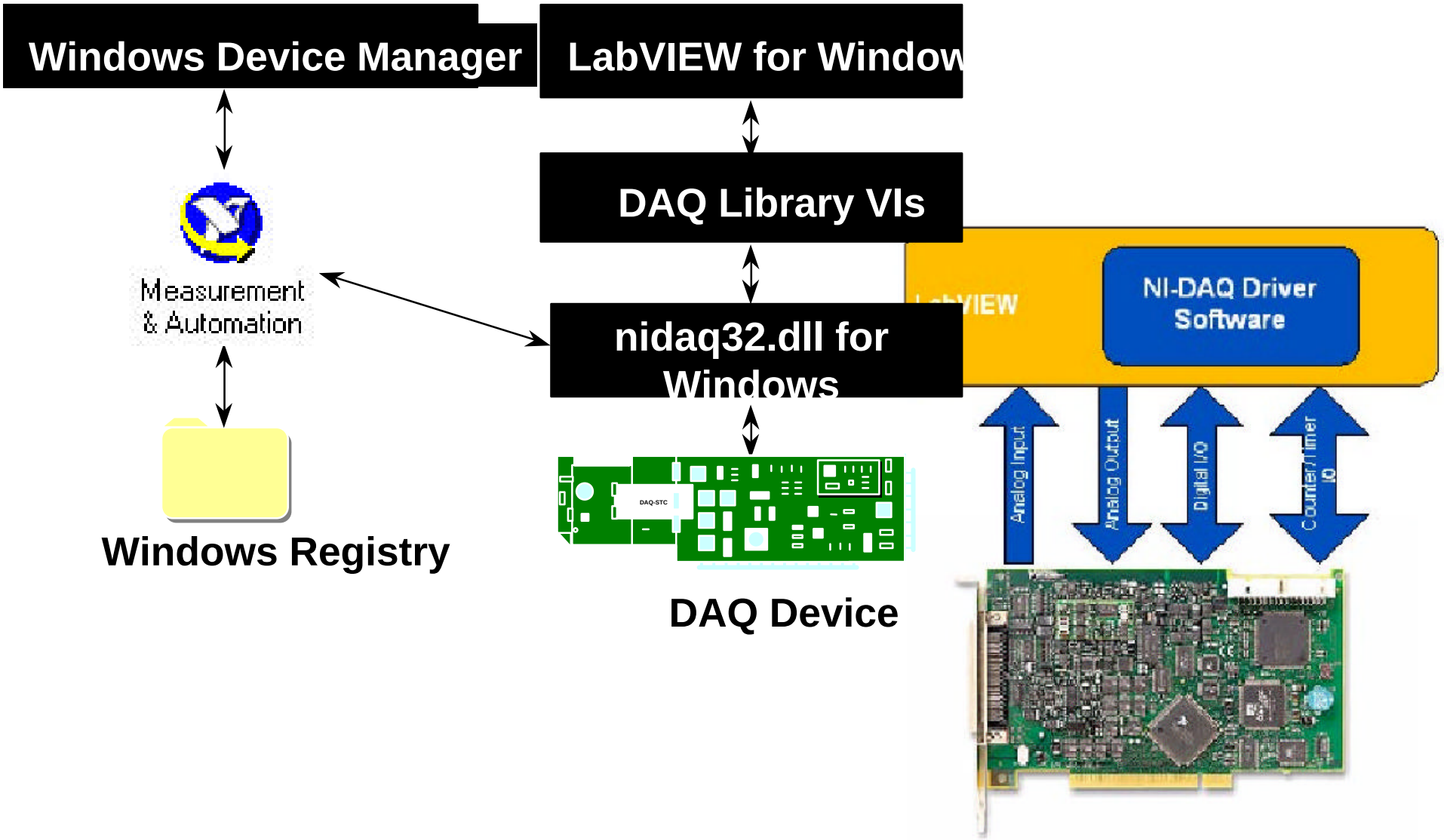
Popular methods for acquiring data: plug-in DAQ and instrument devices, GPIB instruments, PXI (PCI eXtensions for Instrumentation) instruments, and RS-232 instruments.





- **Data acquisition (DAQ) library supports all DAQ boards**
- **LabVIEW uses the NI-DAQ driver-level software**
- **DAQ boards for**
  - **Analog I/O**
  - **Digital I/O**
  - **Counter/timer I/O**
- **Data acquisition system components**

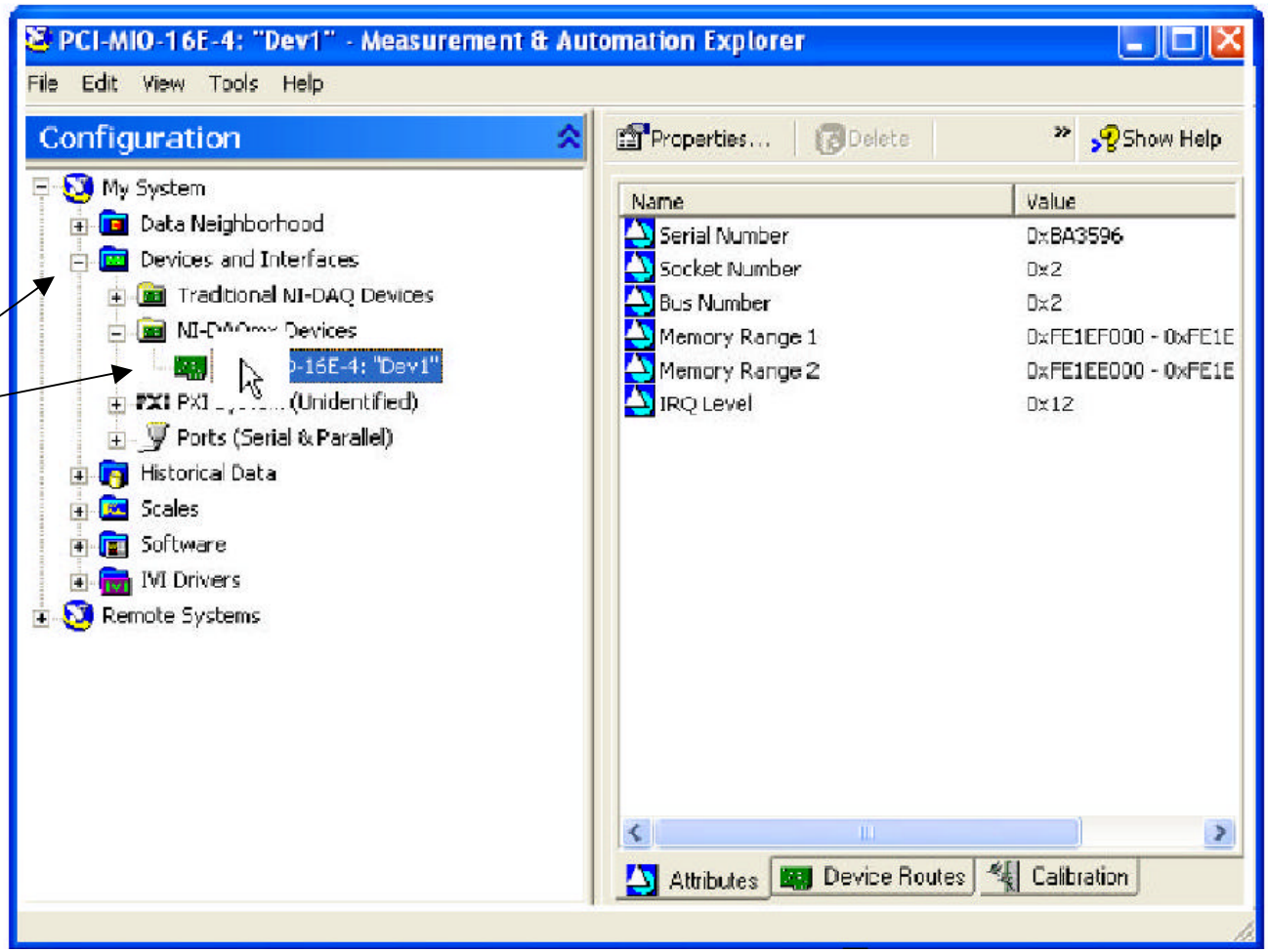
DAQ Software Architecture – Windows



DAQ Hardware Configuration

- **Measurement & Automation Explorer (MAX) by selecting Tools>>Masurement & Automation Explorer…in LabVIEW**

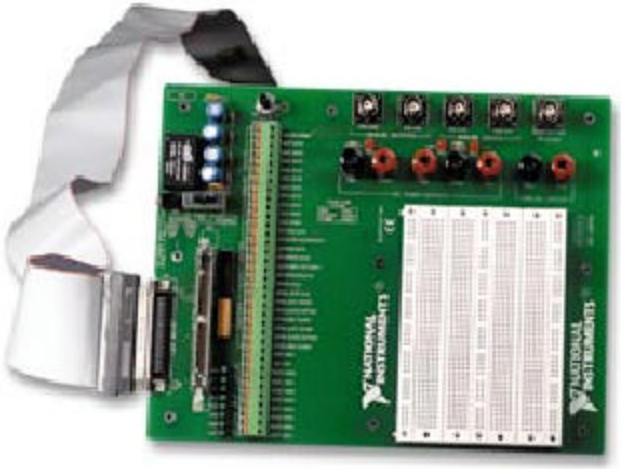
View Configure and Test



Hardware Connections

BNC-2120

SC-2075



SCB-68

Hardware Connections

ACH8	34	68	ACH0
ACH1	33	67	AIGND
AIGND	32	66	ACH9
ACH10	31	65	ACH2
ACH3	30	64	AIGND
AIGND	29	63	ACH11
ACH4	28	62	AISENSE
AIGND	27	61	ACH12
ACH13	26	60	ACH5
ACH6	25	59	AIGND
AIGND	24	58	ACH14
ACH15	23	57	ACH7
DAC0OUT[1]	22	56	AIGND
DAC1OUT[1]	21	55	AOGND[2]
EXTREF[3]	20	54	AOGND[2]
DIO4	19	53	DGND
DGND	18	52	DIO0
DIO1	17	51	DIO5
DIO6	16	50	DGND
DGND	15	49	DIO2
+5V	14	48	DIO7
DGND	13	47	DIO3
DGND	12	46	SCANCLK
PFI0/TRIG1	11	45	EXTSTROBE*
PFI1/TRIG2	10	44	DGND
DGND	9	43	PFI2/CONVERT*
+5V	8	42	PFI3/GPCTR1_SOURCE
DGND	7	41	PFI4/GPCTR1_GATE
PFI5/UPDATE*	6	40	GPCTR1_OUT
PFI6/WFTRIG	5	39	DGND
DGND	4	38	PFI7/STARTSCAN
PFI9/GPCTR0_GATE	3	37	PFI8/GPCTR0_SOURCE
GPCTR0_OUT	2	36	DGND
FREQ_OUT	1	35	DGND

[1] No connect on the DAQCard-AI-16E-4, DAQCard-AI-16XE-50, NI PCI-6023E, NI PCI-6032E, NI PCI-6033E, and NI PCI-6034E

[2] No connect on the DAQCard-AI-16E-4 and DAQCard-AI-16XE-50

[3] No connect on the DAQCard-AI-16E-4, DAQCard-AI-16XE-50, DAQCard-6024E, NI PCI-6023E, NI PCI-6024E, NI PXI-6030E, NI PXI-6031E, NI PCI-6032E, NI PCI-6033E, NI PCI-6034E, NI PCI-6035E, NI PCI-6036E, PCI-MIO-16XE-10, and PCI-MIO-16XE-50

Figure 1-4. SCB-68 E Series I/O Connector Pinout (Full)

Note:
The channels available depends on the DAQ card we use.

For instance, DAQCard-AI-16E-4 NI lent to us, there is no output channels available

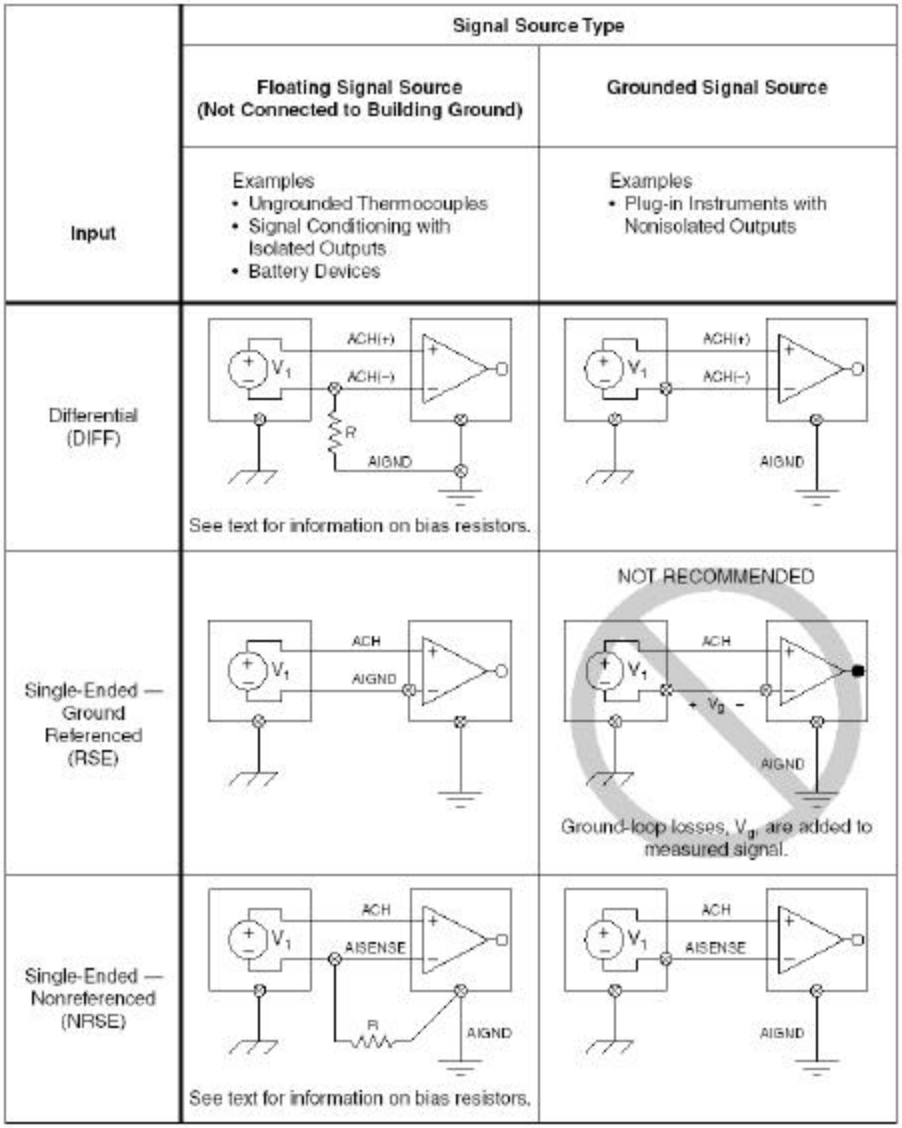
Let's configure the Card with **Measurement & Automation Explorer**

Measurement Fundamentals

In Analytical Instrumentation, we convert physical phenomena into data, using a **transducer** to convert a physical phenomenon into an electrical

Phenomena	Transducer
Temperature	Thermocouples Resistance temperature detectors (RTDs) Thermistors Integrated circuit sensors
Light	Vacuum tube photosensors Photoconductive cells
Sound	Microphones
Force and pressure	Strain gages Piezoelectric transducers Load cells
Position (displacement)	Potentiometers Linear voltage differential transformers (LVDT) Optical encoders
Fluid flow	Head meters Rotational flowmeters Ultrasonic flowmeters
pH	pH electrodes

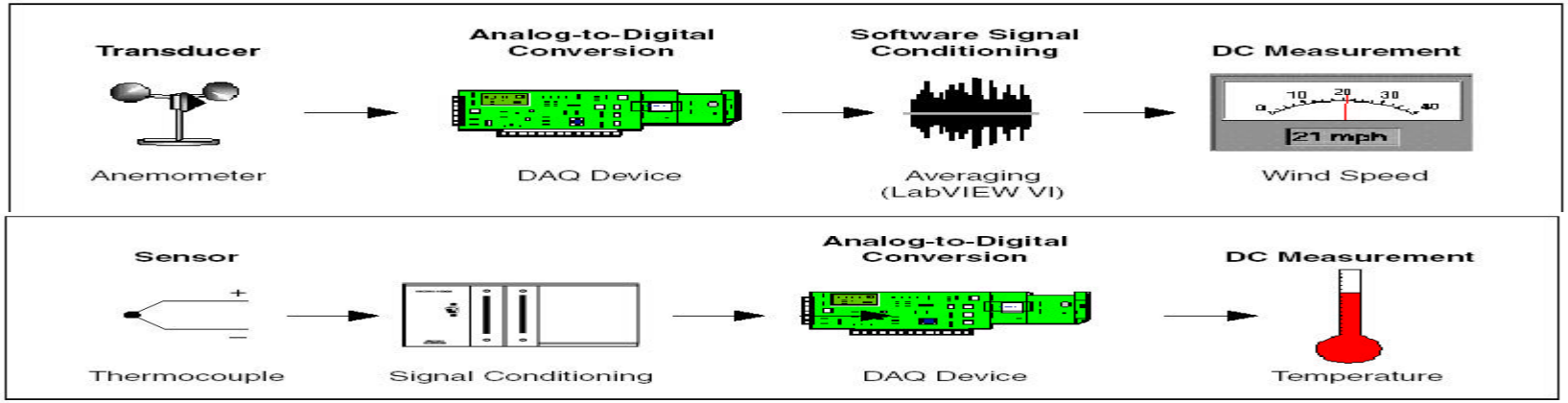
Summary of signal sources and masurement systems

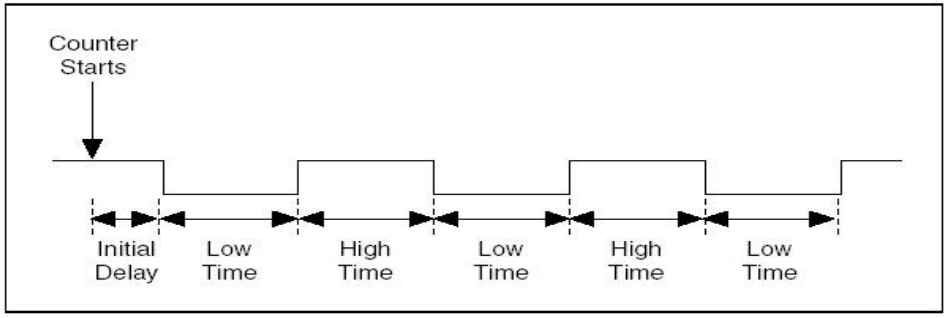


Measurement Fundamentals

There are two types of voltage: direct current (DC) and alternating current(AC). DC signals are analog signals that slowly vary with time. Common DC signals include voltage, temperature, pressure, and strain. AC signals are alternating analog signals that continuously increase, decrease, and reverse polarity on a repetitive basis.

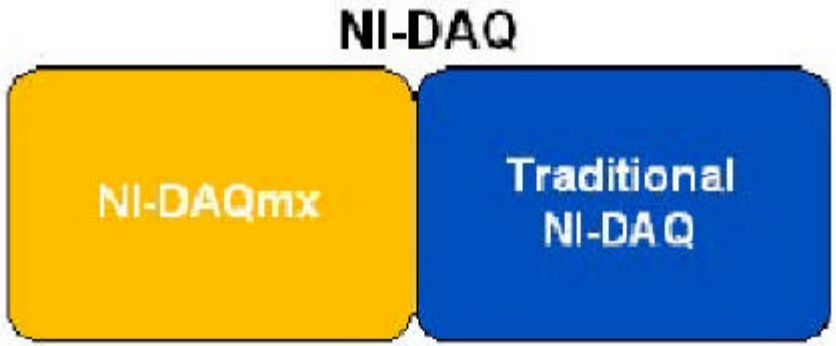
However, any physical signals will be converted into almost two types of measurement by transducers: voltage and counting.





DAQ VI Organization in LabVIEW software

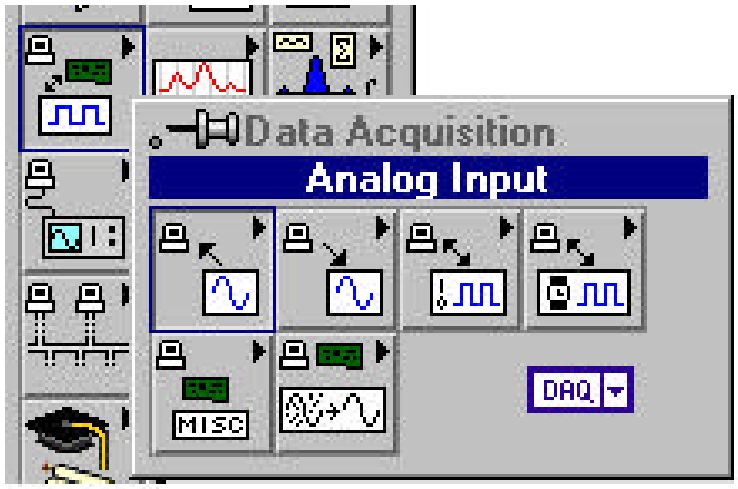
- **Analog Input**
- **Analog Output**
- **Digital I/O**
- **Counter**
- **Calibration and Configuration**
- **Signal Conditioning**



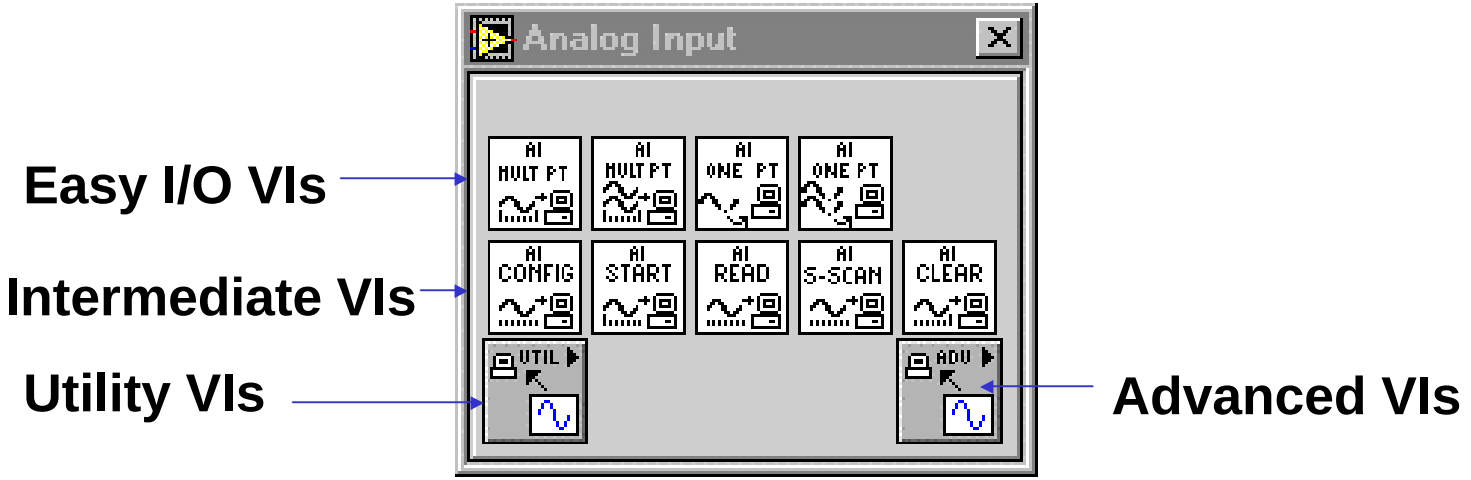
A. labVIEW Traditional NI-DAQ

NI-DAQ

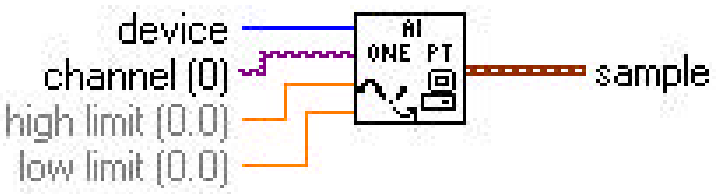
NI-DAQ contains two data acquisition drivers--Traditional NI-DAQ and NI-DAQmx--each with its own application programming interface (API), hardware configuration, and software configuration.



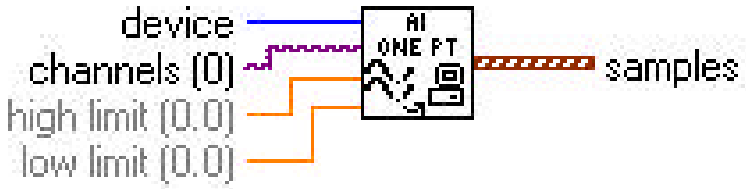
Analog Input VI Organization



- **Single-point VIs**

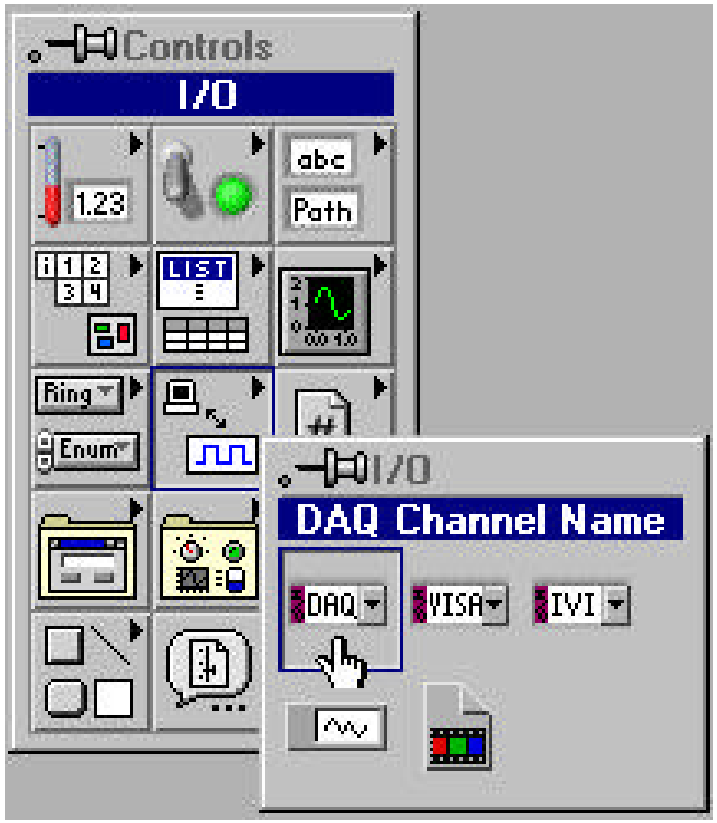


AI Sample Channel.vi

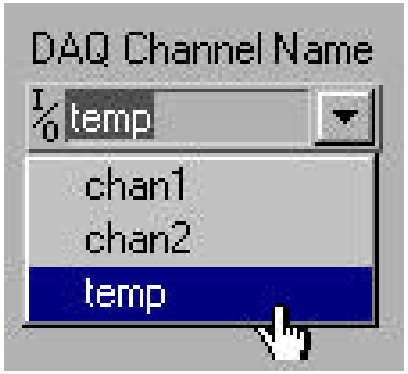


AI Sample Channels.vi

DAQ Channel Name Control

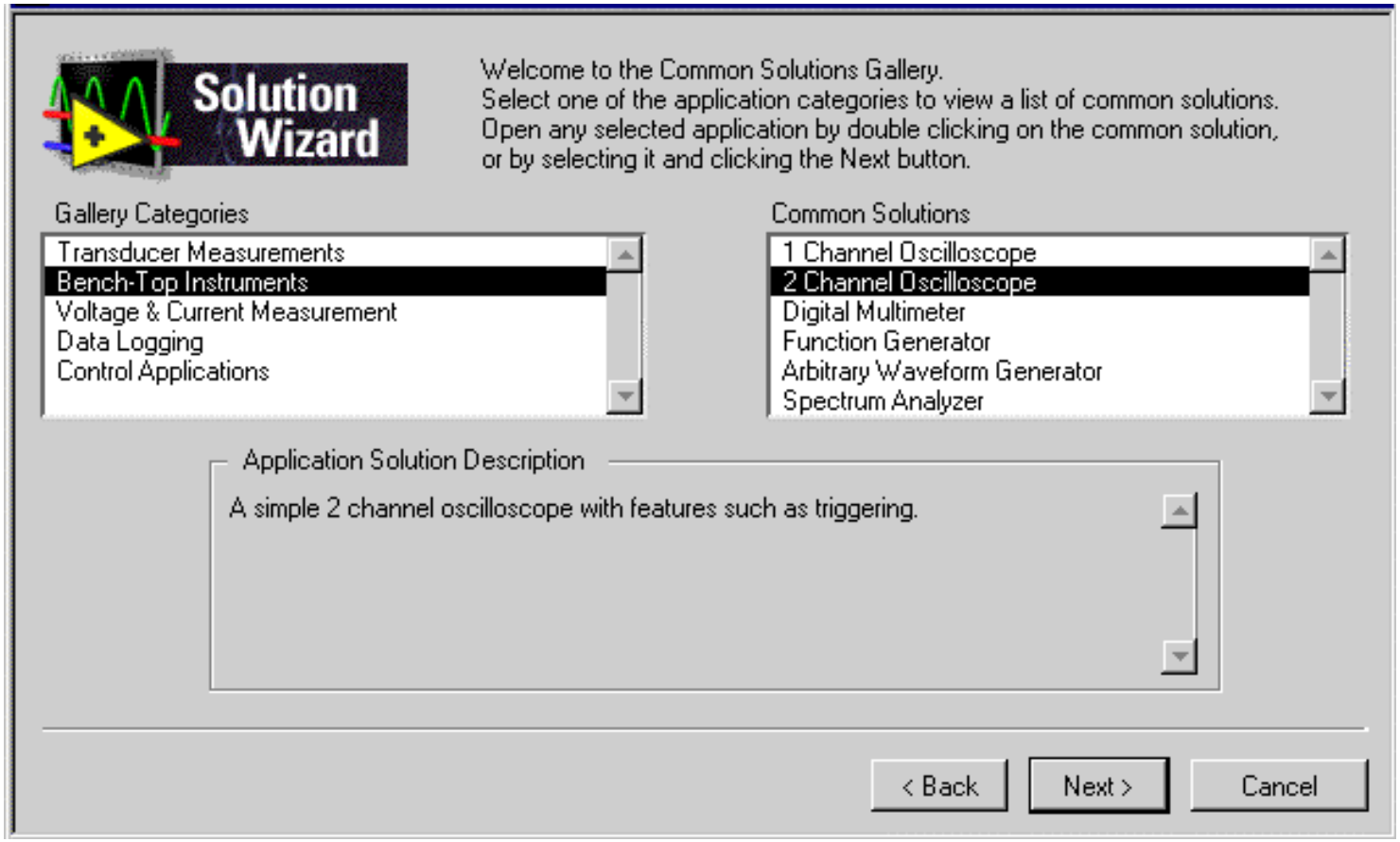


- **Data type used to communicate with DAQ boards**
- **Enter channel names by number or by virtual channel name defined in MAX**



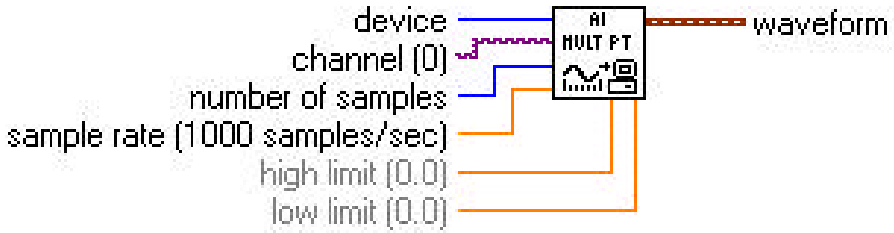
DAQ Wizards

- **DAQ Channel Wizard**
- **DAQ Solution Wizard**

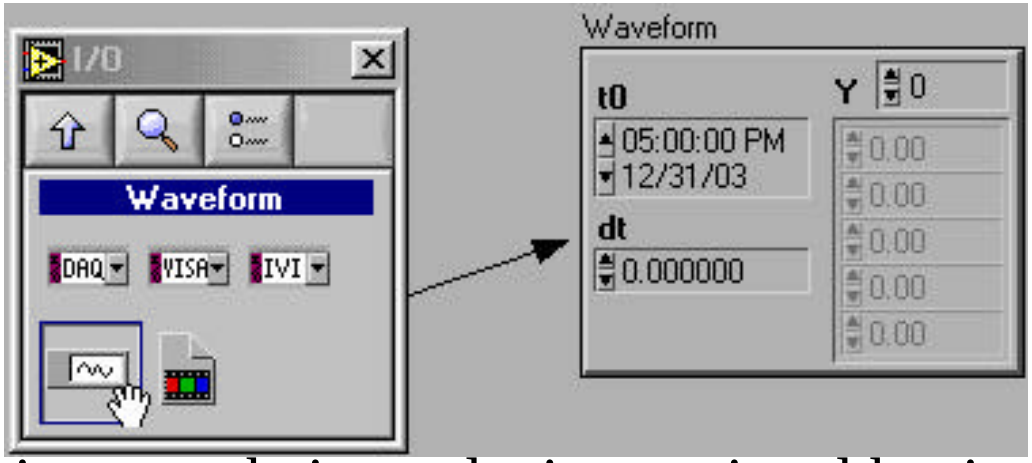


Waveform Analog Input

- **AI Acquire Waveform**
- **VI displays a dialog box if an error occurs**



- **VI returns a waveform datatype**

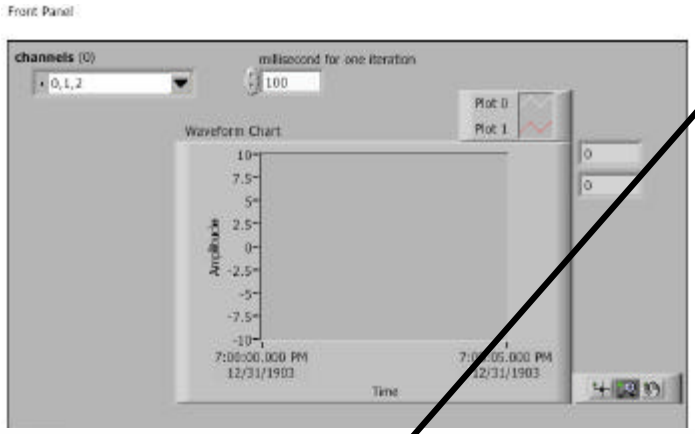


Analog-Pertaining to or being a device or signal having the property of continuously varying in strength or quantity, such as voltage or audio.

DAQ – Data Acquisition

Let's do Simple Acquisition Example Test.vi

Click to see



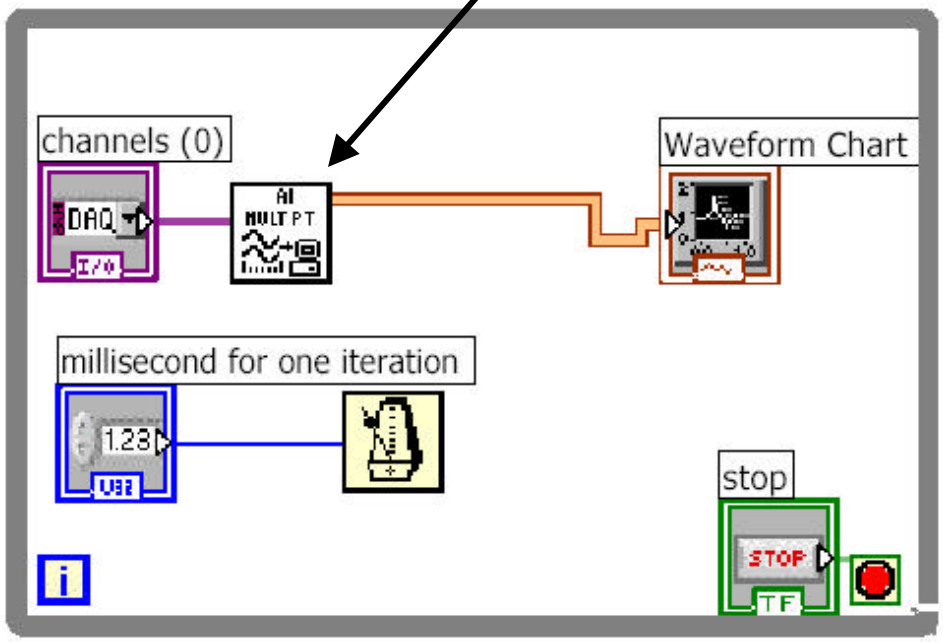
Two parameters

- Device = 1
- Channel = 0

with

SCB-68

connection board



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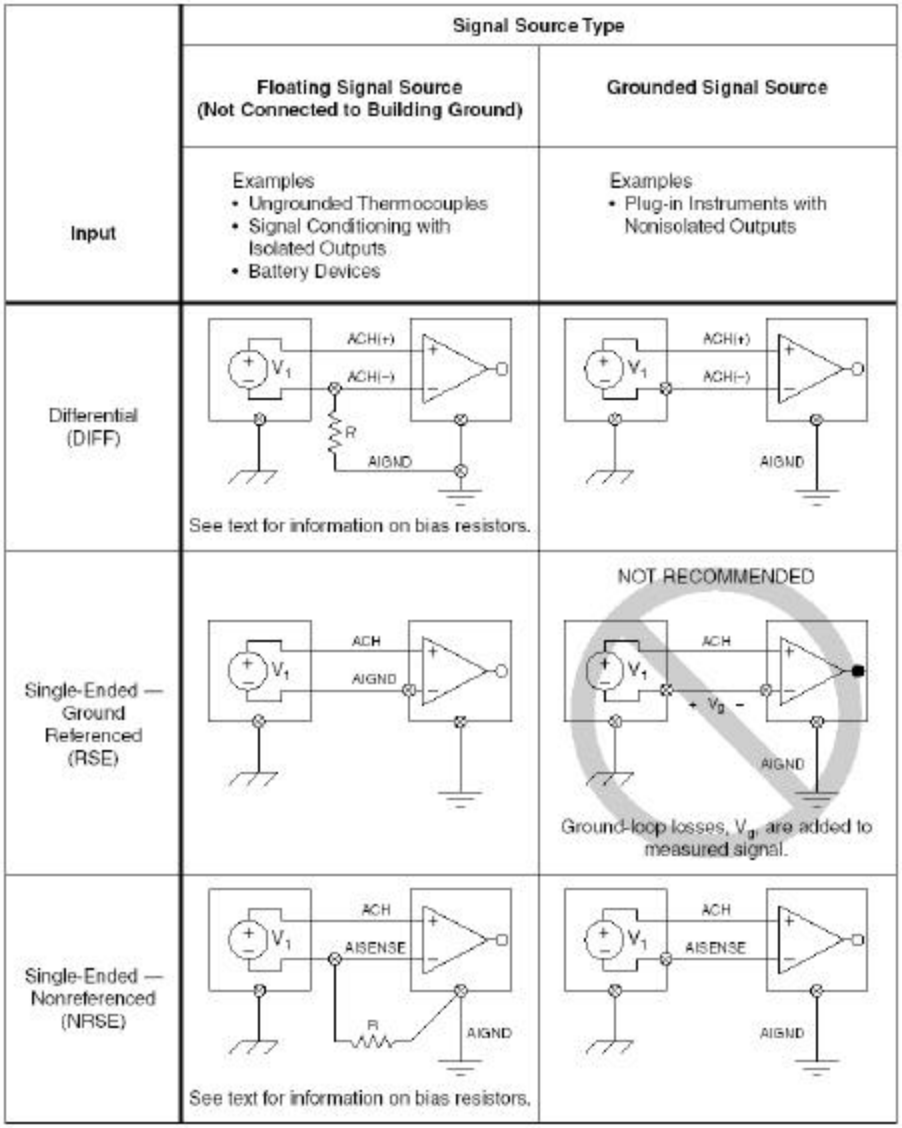


DAQ – Data Acquisition

Simple Acquisition Example Test.vi

Two parameters

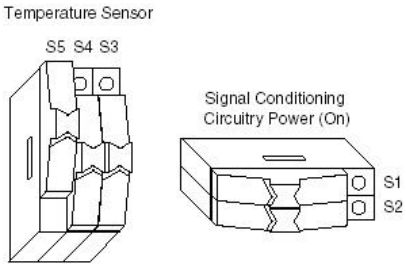
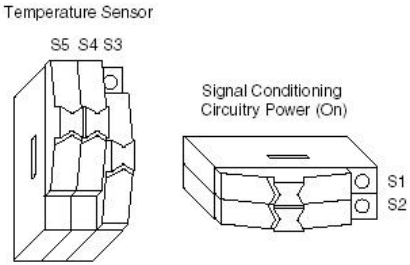
- Device = 1
- Channel = 0

We can try different input modes Single ended Differential by configuring MAX and the board

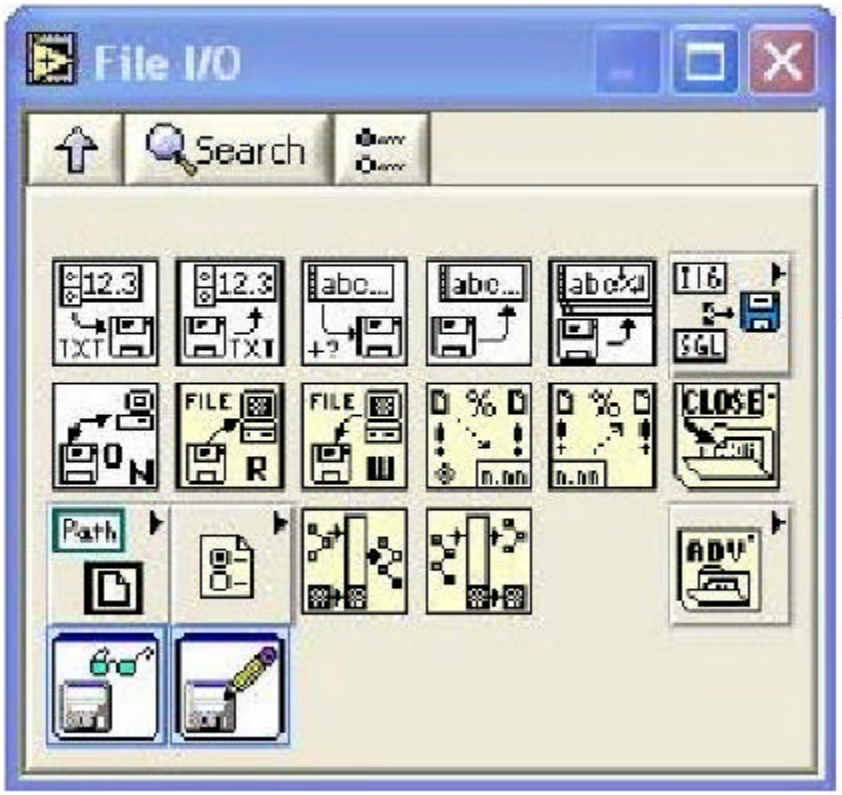
with

SCB-68

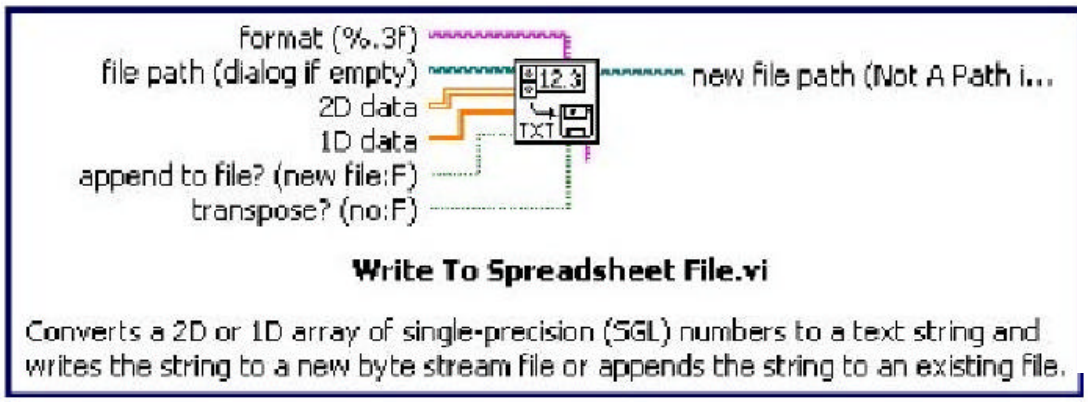
connection board

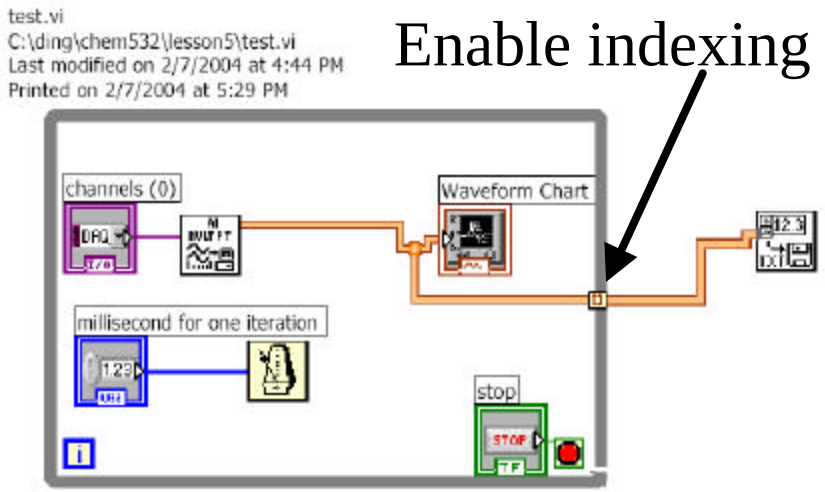
Switch Setting	Applicable Signals
 Single-ended temperature sensor, with accessory power enabled[2]	Single-ended analog input[3]
 Differential temperature sensor, with accessory power enabled[2]	Differential analog input

Writing Waveform Data to File



- **Waveform File I/O subpalette of the Waveform palette**
- **Three VIs for writing waveform data to file but Write To Spreadsheet File.vi is the most important**



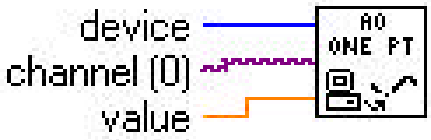


Data Acquisition Terminology

- **Resolution -** Determines How Many Different Voltage Changes Can Be Measured
  - Larger Resolution → More Precise Representation of Signal
- **Range -** Minimum and Maximum Voltages
  - Smaller range → More Precise Representation of Signal
- **Gain -** Amplifies or Attenuates Signal for Best Fit in Range
- **Quiz -** what's the resolution with a 16 bits board in the range of ±12 V?

Analog Output VIs

- **Single-point VI**

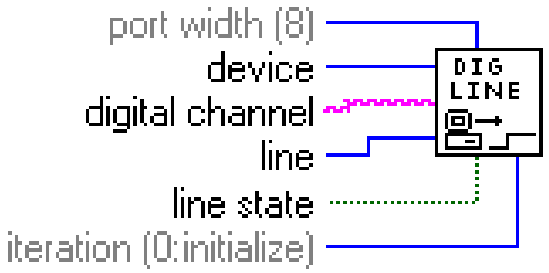


AO Update Channel.vi

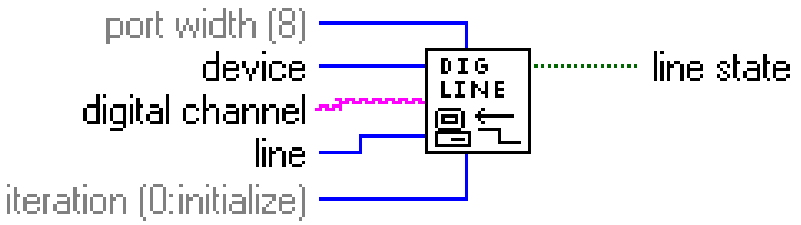
AO Generate Waveform.vi

Digital Input and Output VIs

- **Line = single TTL signal**

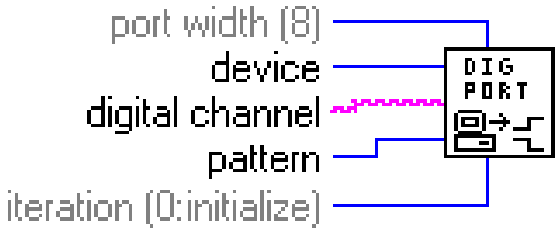


Write to Digital Line.vi

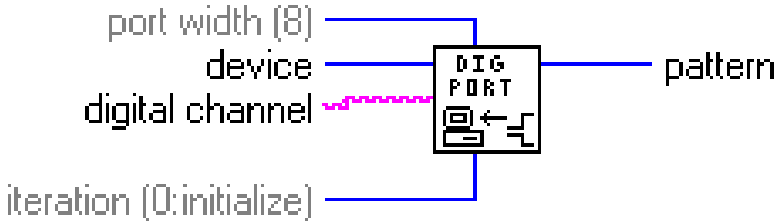


Read from Digital Line.vi

- **Port = collection of lines (4 or 8)**



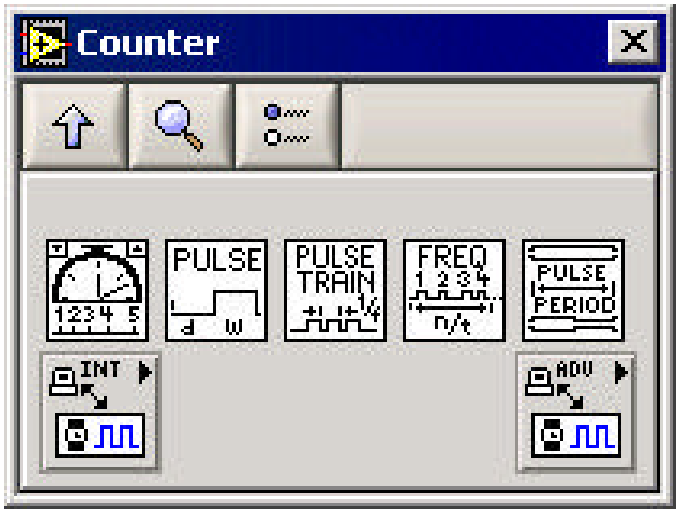
Write to Digital Port .vi



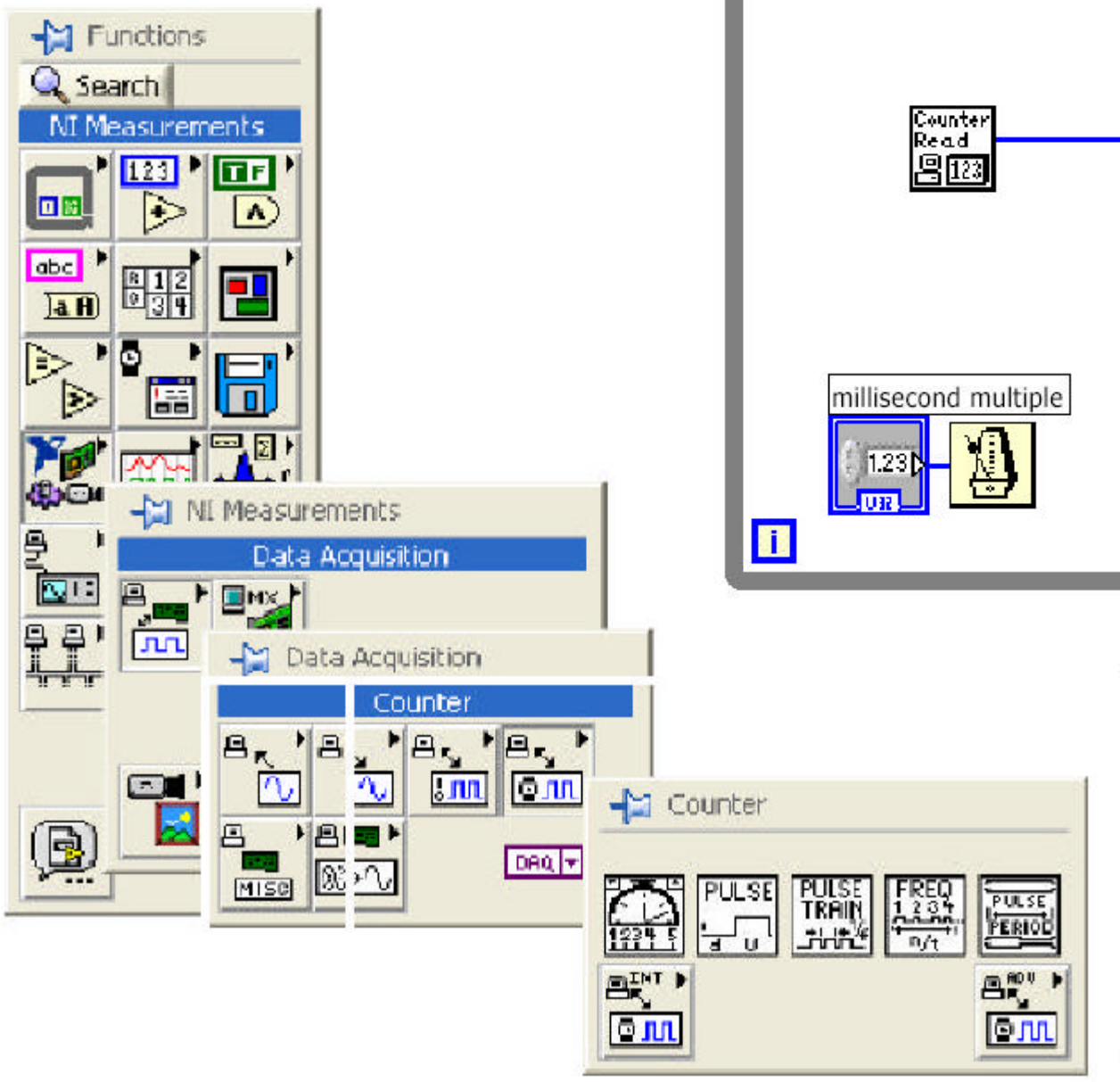
Read from Digital Port.vi

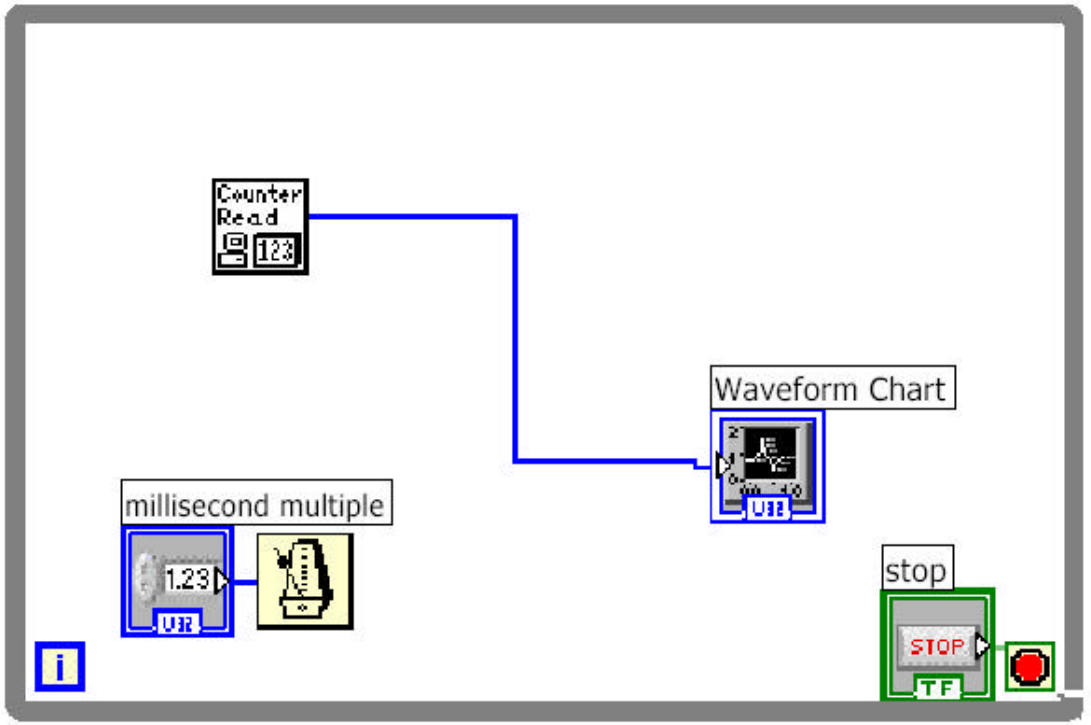
Counters

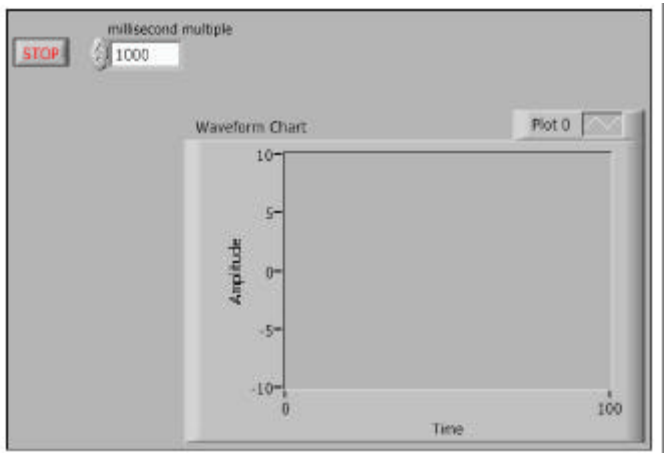
- **A counter is a digital timing device.**
- **Typically used for:**
  - **event counting for PMT, EMT**
  - **frequency measurement**
  - **period measurement**
  - **position measurement**
  - **pulse generation**



Counters

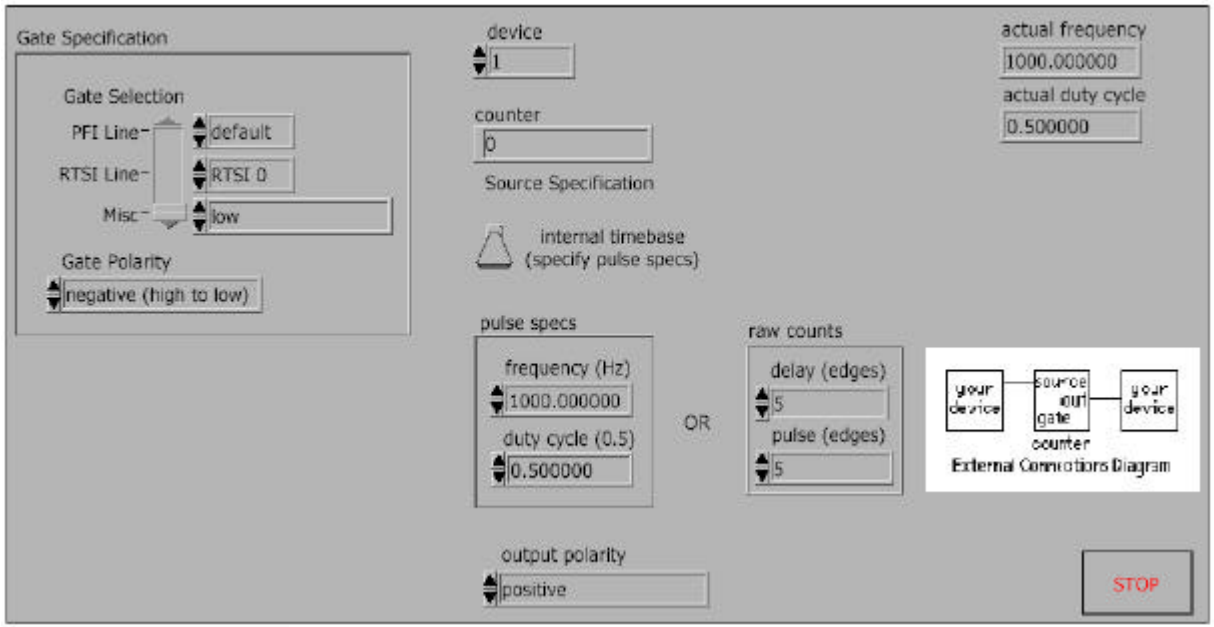

Functions
Search
NI Measurements
NI Measurements
Data Acquisition
Data Acquisition
Counter
MISC
DAQ
Counter
PULSE
PULSE TRAIN
FREQ
PULSE PERIOD
INT
ADV


Counter Read
Waveform Chart
millisecond multiple
1.23
stop
STOP
TF


STOP
millisecond multiple
1000
Waveform Chart
Plot 0
Amplitude
Time

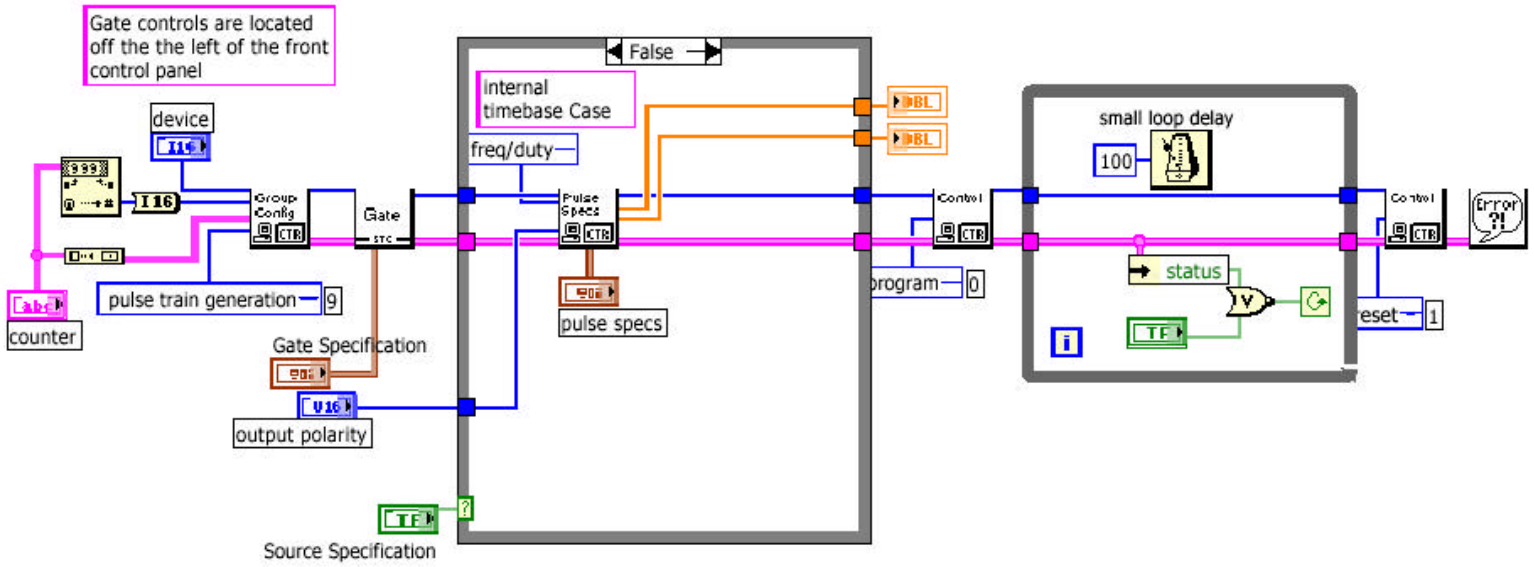
Counters-pulse generation

Front Panel



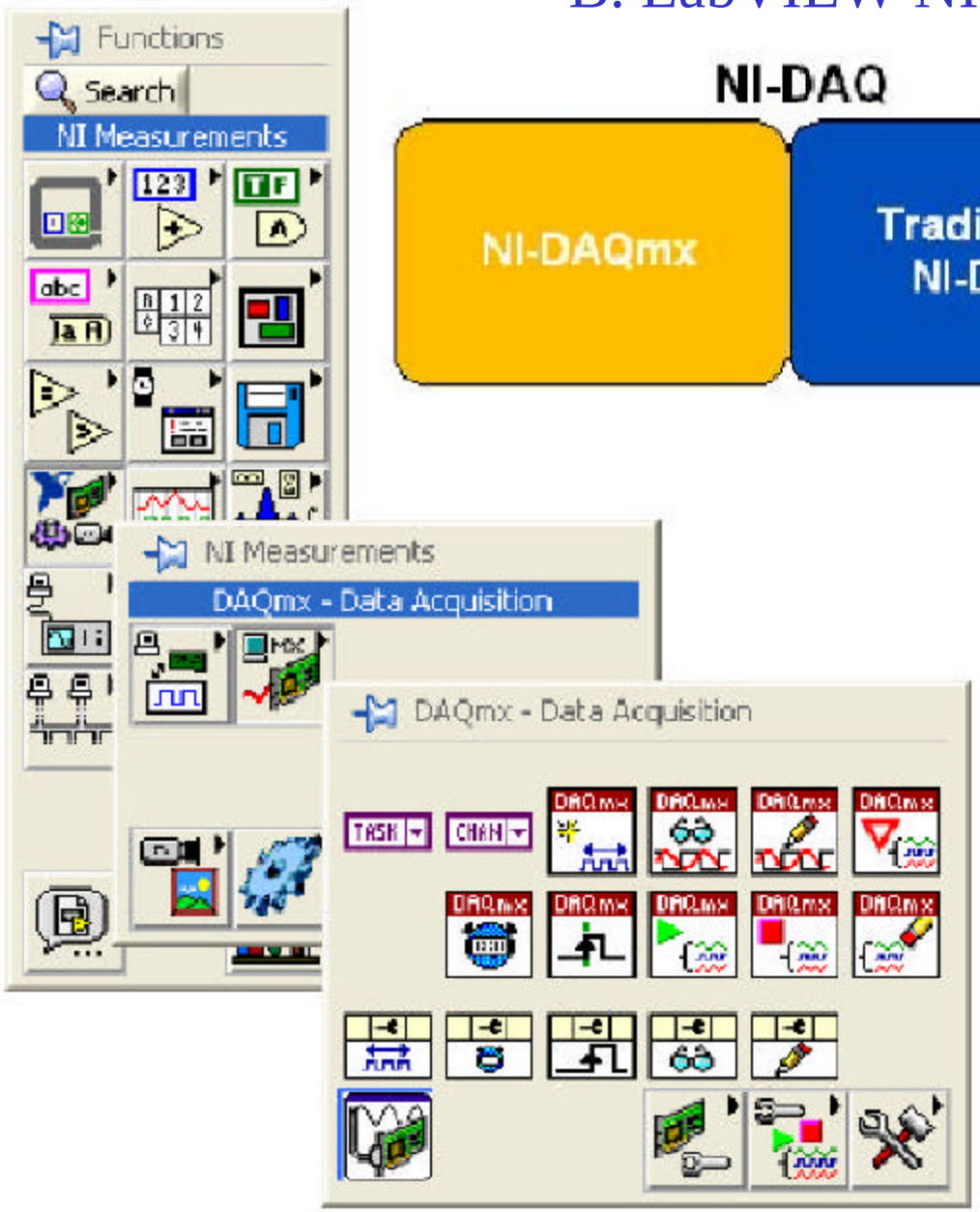
1. Find the **VI from Help»Find Examples...»Search**
2. **Type in "**counter**" and search**
3. Choose **Generate Pulse Train (DAQ-STC).vi**

Block Diagram



DAQ VI Organization in LabVIEW software

B. LabVIEW NI-DAQmx

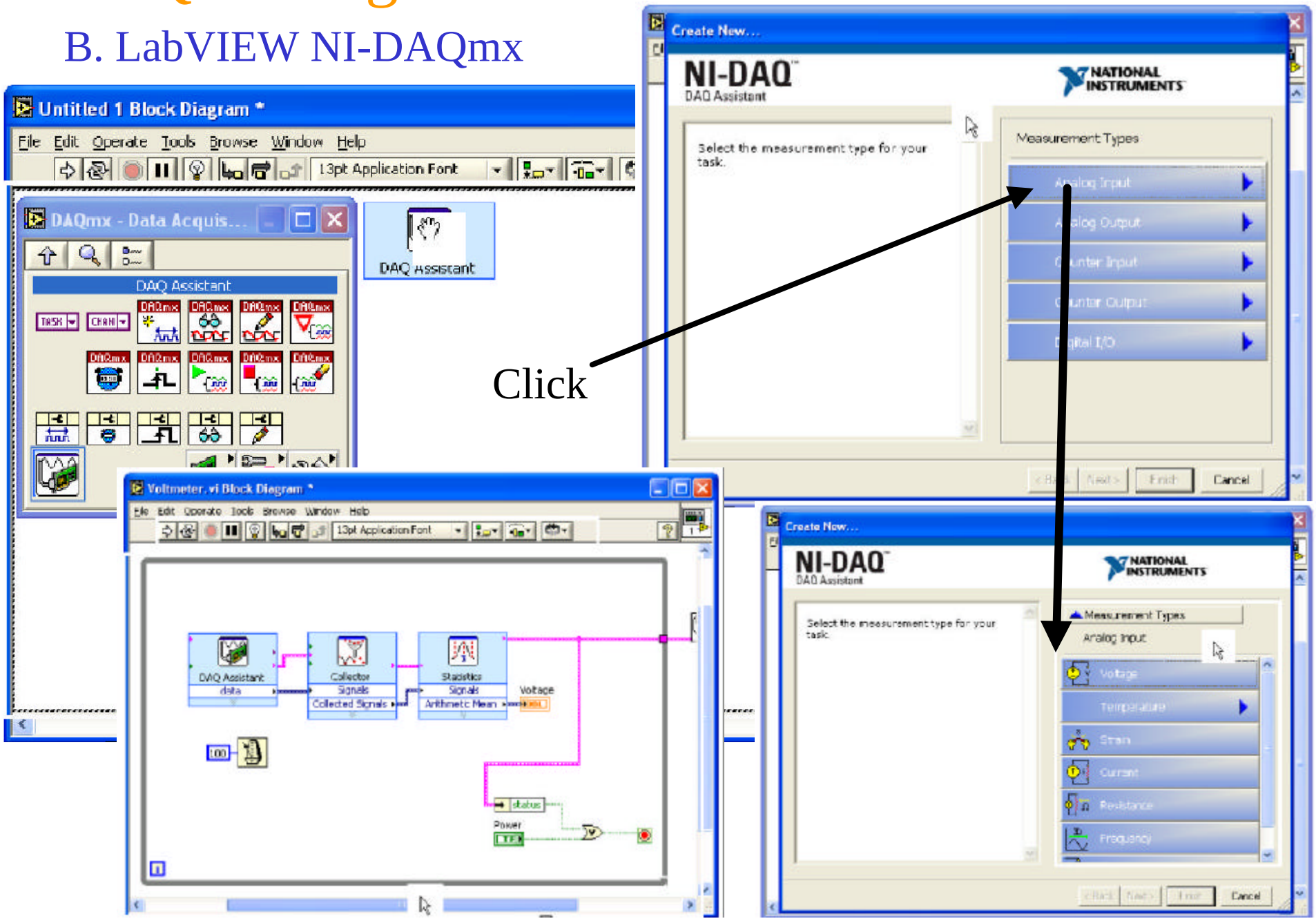


NI-DAQmx

NI-DAQmx is the latest NI-DAQ driver with new VIs, functions and development tools for controlling measurement devices. The advantages of NI-DAQmx include the DAQ Assistant for configuring channels and measurement tasks for a device; increased performance, including faster single-point analog I/O and multithreading; and a simpler API for creating DAQ applications using fewer functions and VIs than earlier versions of NI-DAQ.

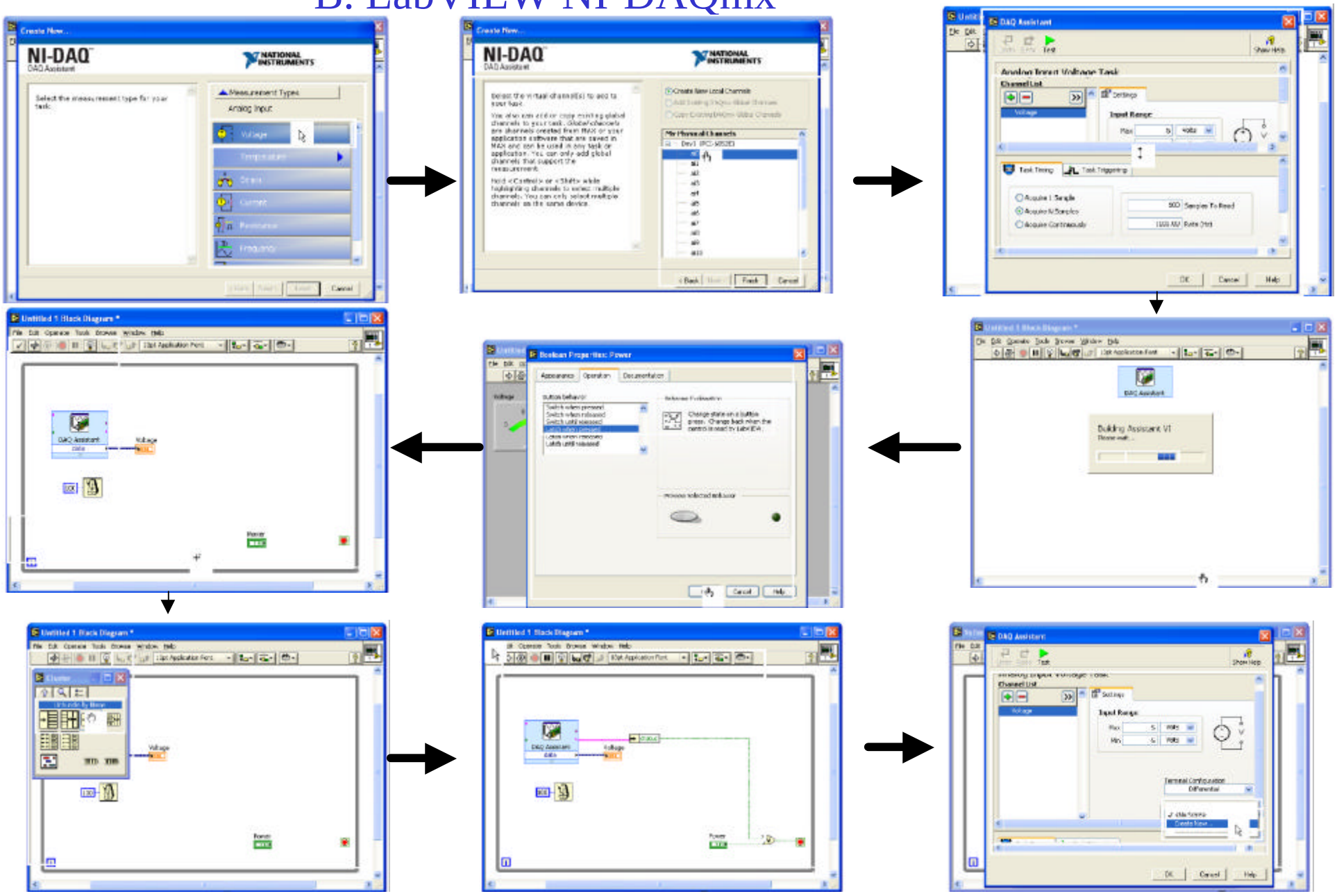
DAQ VI Organization in LabVIEW software

B. LabVIEW NI-DAQmx



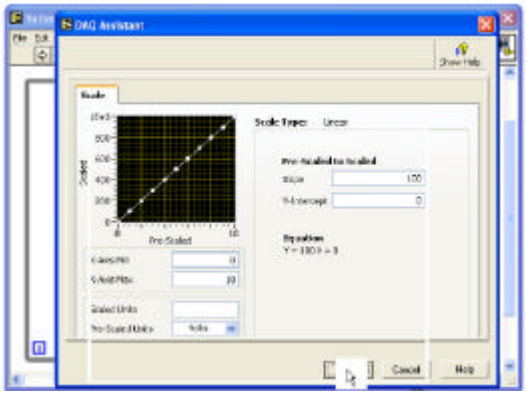
DAQ VI Organization in LabVIEW software

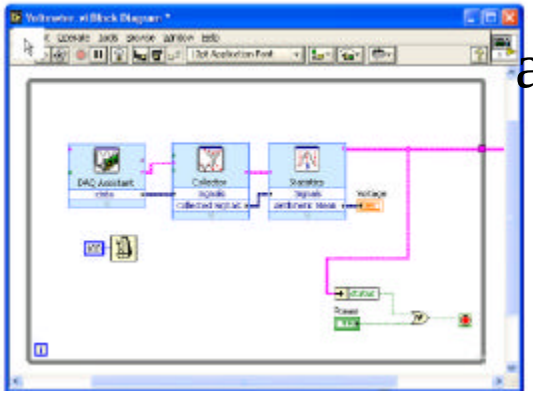
B. LabVIEW NI-DAQmx



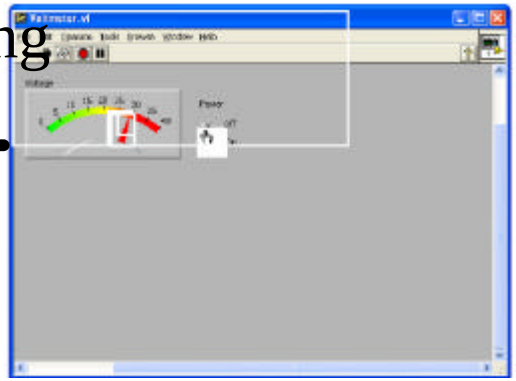
DAQ VI Organization in LabVIEW software

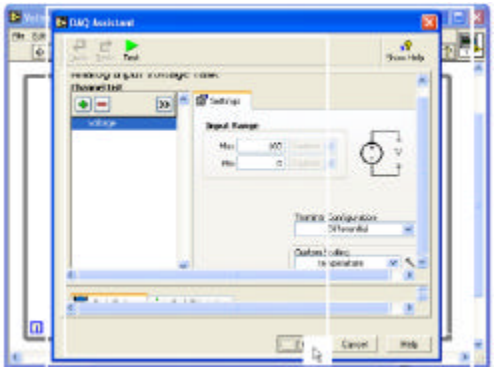
B. LabVIEW NI-DAQmx



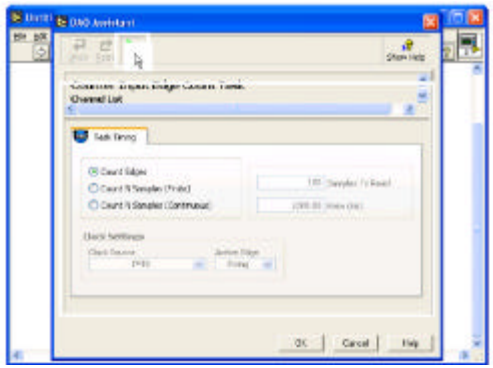


averaging





Counter



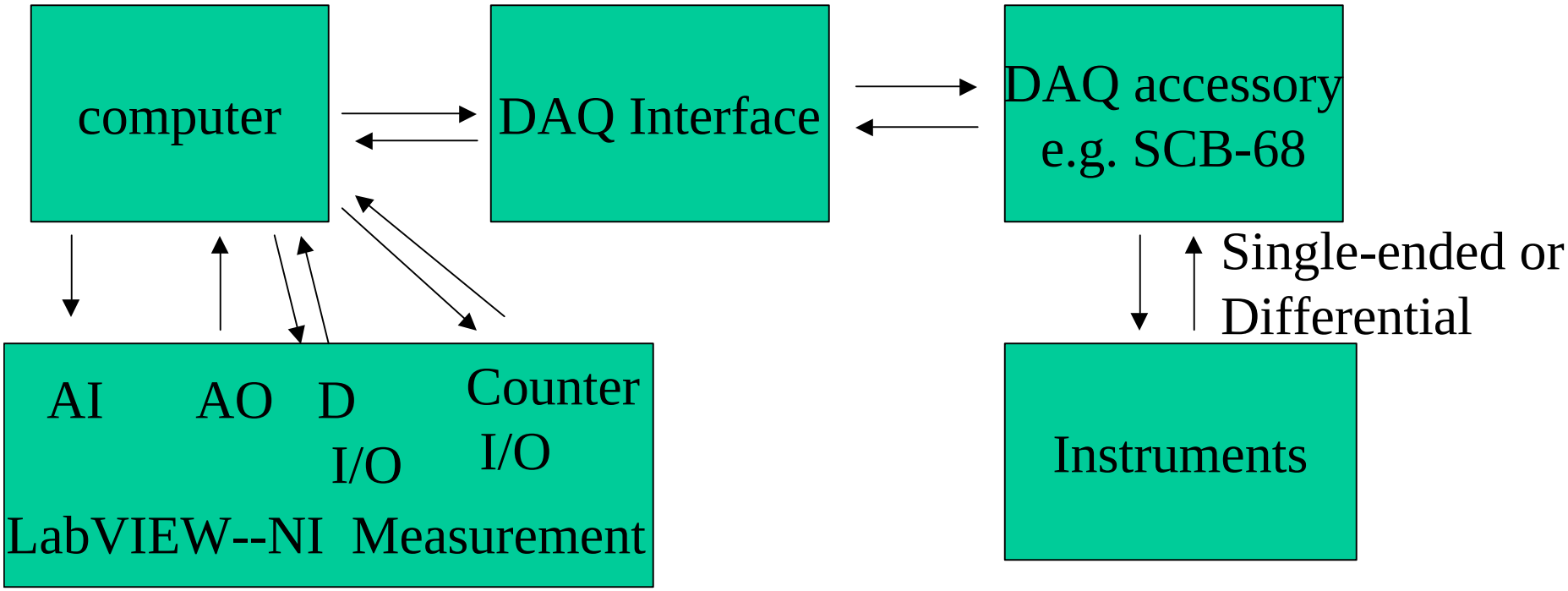
Summary

- **Use the Measurement & Automation Explorer to configure DAQ boards and virtual channels**
- **DAQ VIs organized into six subpalettes – Analog Input, Analog Output, Digital I/O, Counter, Configuration and Calibration, and Signal Conditioning**
- **Analog Input and Output subpalettes are divided into levels – Easy I/O, Intermediate, Advanced, and Utility VIs**
- **Easy I/O contains VIs for**
  - **Single-channel analog input and output**
  - **Single-channel waveform input and output**
  - **Multichannel waveform input and output**
  - **Digital input and output**
  - **Counter / Timers**

Summary

Connections and configuration

Connections:



Configuration:

1. Traditional NI-DAQ
2. NI-DAQmx

J. USB DAQ--NI-DAQ mx Base devices

$195 CAD!!!

The NI USB-6008/6009 provides connection to eight analog input (AI) channels, two analog output (AO) channels, 12 digital input/output (DIO) channels, and a 32-bit counter when using a full-speed USB interface.

Table 1-1. Differences Between the USB-6008 and USB-6009

Feature	USB-6008	USB-6009
AI Resolution	12 bits differential, 11 bits single-ended	14 bits differential, 13 bits single-ended
Maximum AI Sample Rate*	10 kS/s	48 kS/s
DIO Configuration	Open-drain	Open-drain or push-pull
* Might be system dependent		

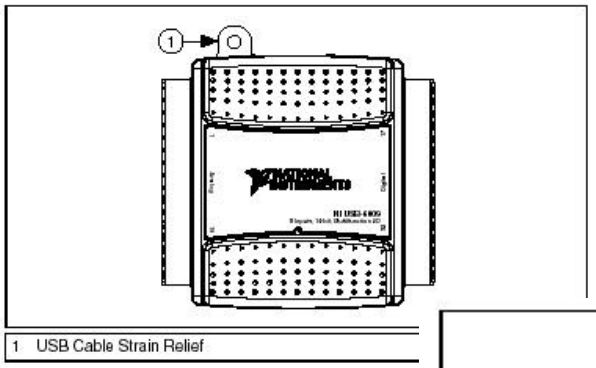


Figure 2. USB-6008/6009

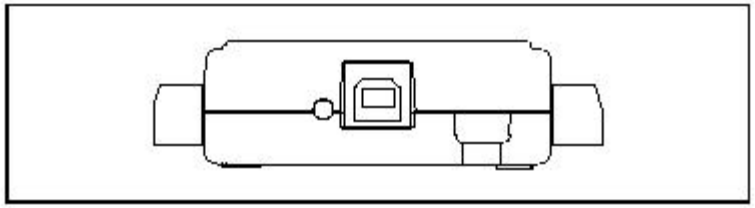


Figure 3. USB-6008/6009 Back View

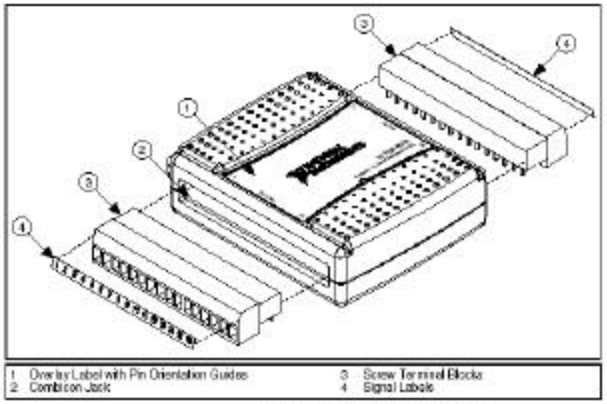


Figure 5. Signal Label Application Diagram

I/O Connector

Table 1. Analog Terminal Assignments

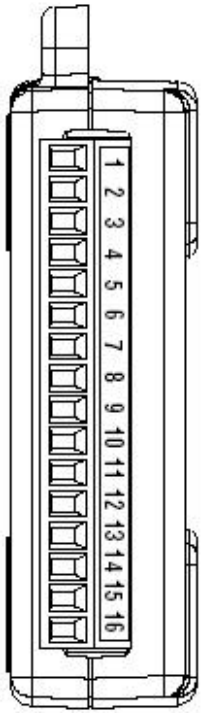
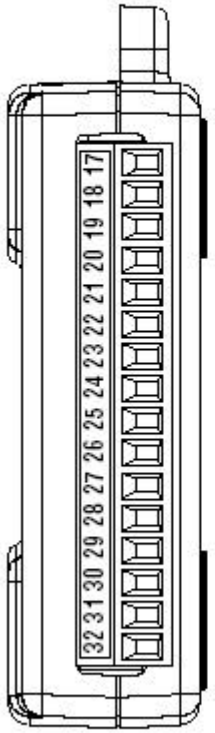
Module	Terminal	Signal, Single-Ended Mode	Signal, Differential Mode
	1	GND	GND
	2	AI 0	AI 0+
	3	AI 4	AI 0–
	4	GND	GND
	5	AI 1	AI 1+
	6	AI 5	AI 1–
	7	GND	GND
	8	AI 2	AI 2+
	9	AI 6	AI 2–
	10	GND	GND
	11	AI 3	AI 3+
	12	AI 7	AI 3–
	13	GND	GND
	14	AO 0	AO 0
	15	AO 1	AO 1
	16	GND	GND

Table 2. Digital Terminal Assignments

Module	Terminal	Signal
	17	P0.0
	18	P0.1
	19	P0.2
	20	P0.3
	21	P0.4
	22	P0.5
	23	P0 6
	24	P0.7
	25	P1.0
	26	P1.1
	27	P1.2
	28	P1.3
	29	PFI 0
	30	+2.5 V
	31	+5 V
	32	GND

Let’s try remote VI:

532ai
532ao
532ctr