Lesson 5
Digital I/O

TOPICS

A. Digital Overview

B. Digital I/O

C. Hardware-Timed Digital I/O

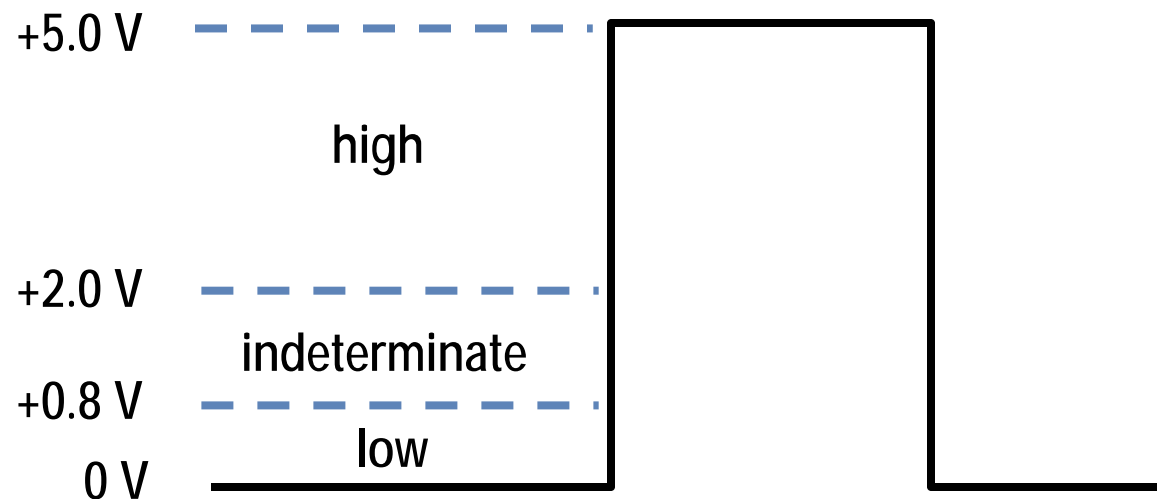**NATIONAL INSTRUMENTS**™ | ni.com/training

A. Digital Overview

- A digital signal has two discrete levels
  - High (5 V, 24 V, etc)
  - Low (0 V)
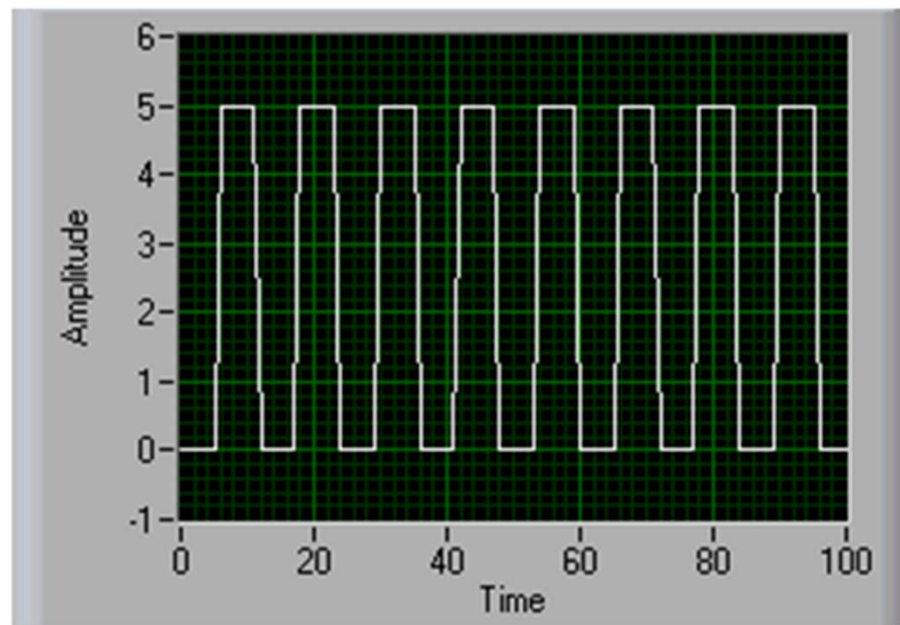
Digital Signals

Digital lines on a DAQ device accept and generate TTL compatible signals

Definition of a TTL Signal

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Digital Terminology

- **Bit** – The smallest unit of data. Each bit is either a 1 or a 0

- **Byte** – A binary number consisting of 8 related bits of data

- **Line** – One individual signal in a port. Bit refers to the data transferred. Line refers to the hardware

- **Port** – A collection of digital lines (usually four or eight)

- **Port Width** – Number of lines per port (usually four or eight)

- **Mask** – Determines which lines are read from or written to

NI-DAQmx Digital Terminology
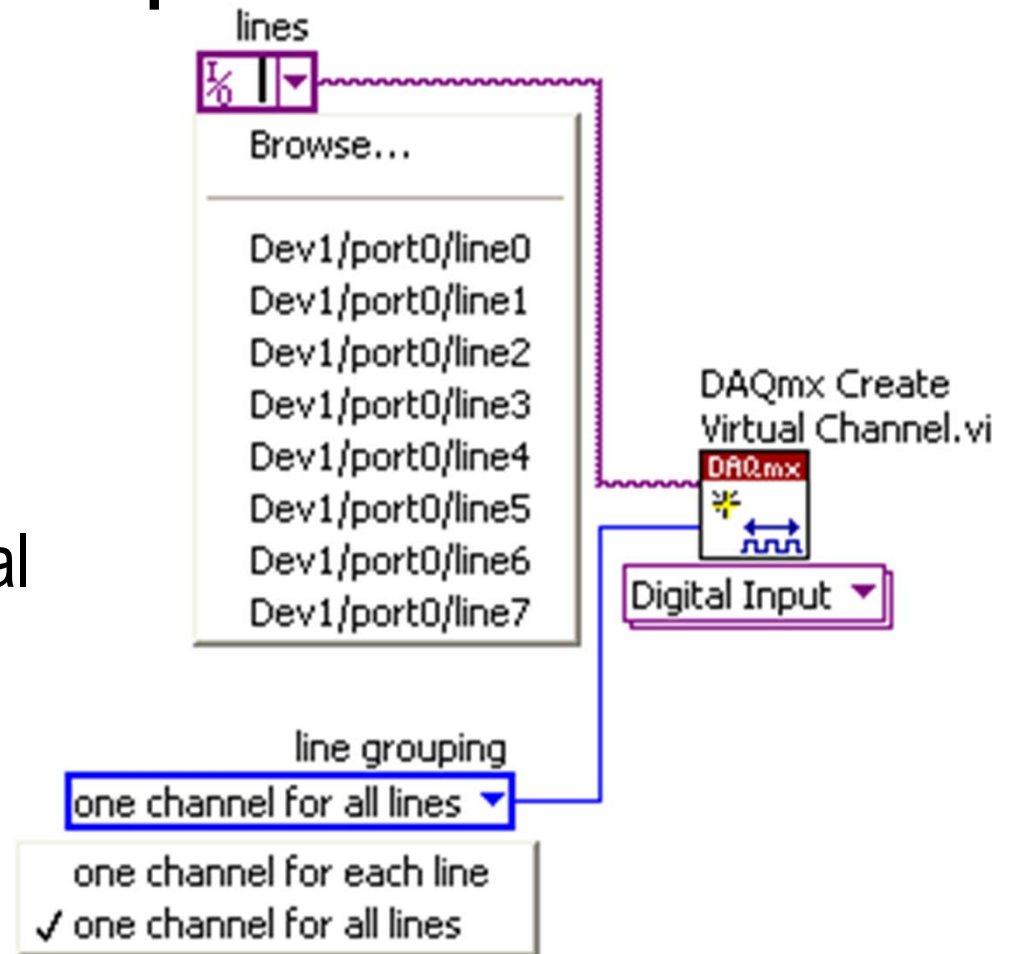
Port Notation (specifying a single port)

- Dev x / Port y

- cDAQ a Mod b / Port c

Line Notation (specifying single or multiple lines)

- Dev x / Port y / Line a

- cDAQ a Mod b / Port c / Line m : n

- Dev x / Port y / Line a, Dev x / Port y / Line b

Digital Virtual Channel Options

- Create a digital channel to be a port, line, or collection of lines

- Choose how to group digital lines into one or more virtual channels
  - Affects how to configure DAQmx Read VI

lines

Browse...

Dev1/port0/line0
Dev1/port0/line1
Dev1/port0/line2
Dev1/port0/line3
Dev1/port0/line4
Dev1/port0/line5
Dev1/port0/line6
Dev1/port0/line7

DAQmx Create Virtual Channel.vi

Digital Input

line grouping

one channel for all lines

one channel for each line
✓ one channel for all lines

Digital Constant I/O Filtering Options

- By default, only lines are displayed as options in digital channel constants

- I/O Filtering gives the option to selectively display lines and ports

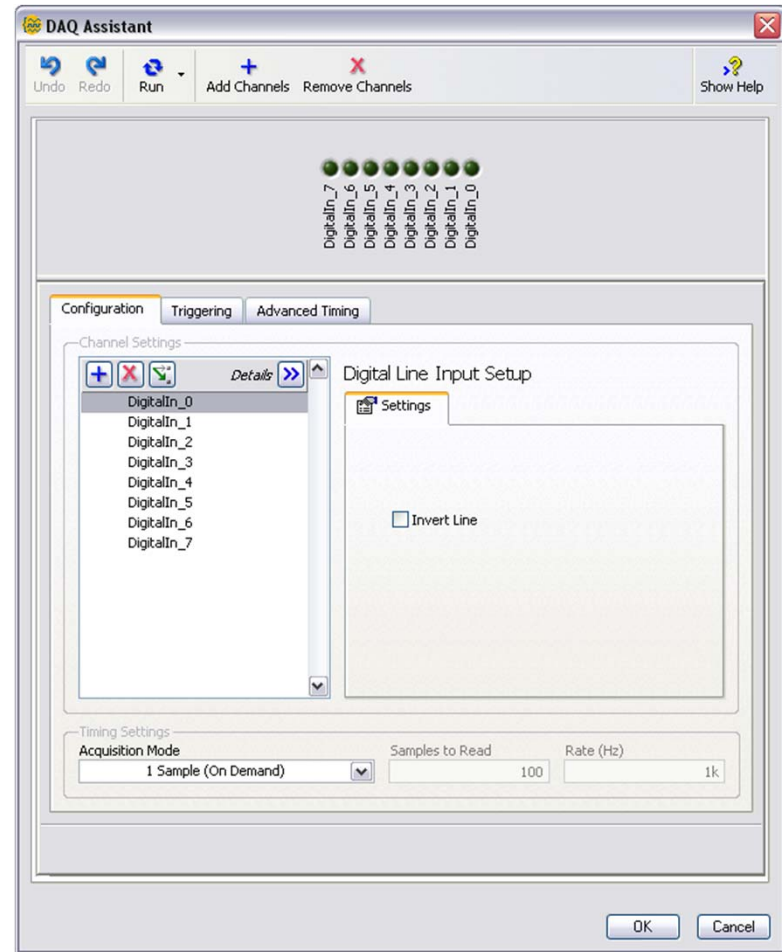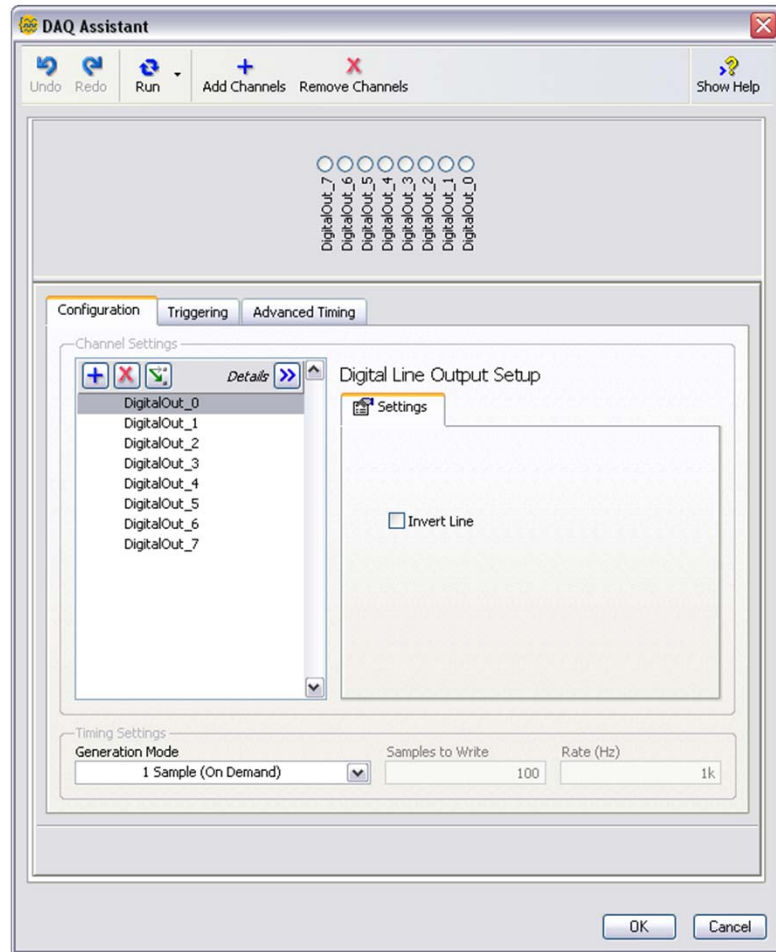- Right-click on channel constant/control and choose I/O Filtering
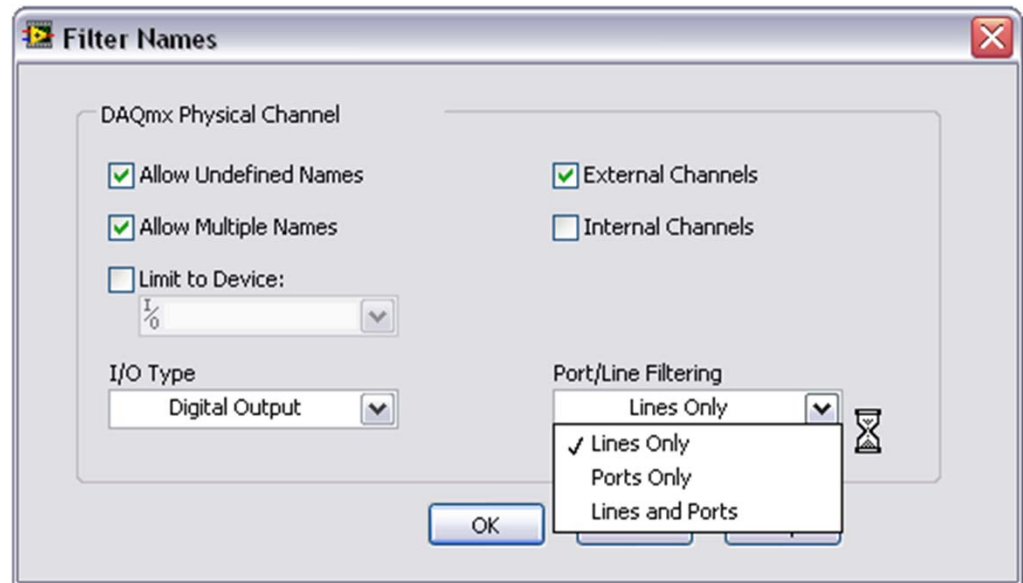
DAQ Assistant – Digital I/O

- Default setting is Active High
- Can invert the lines to Active Low
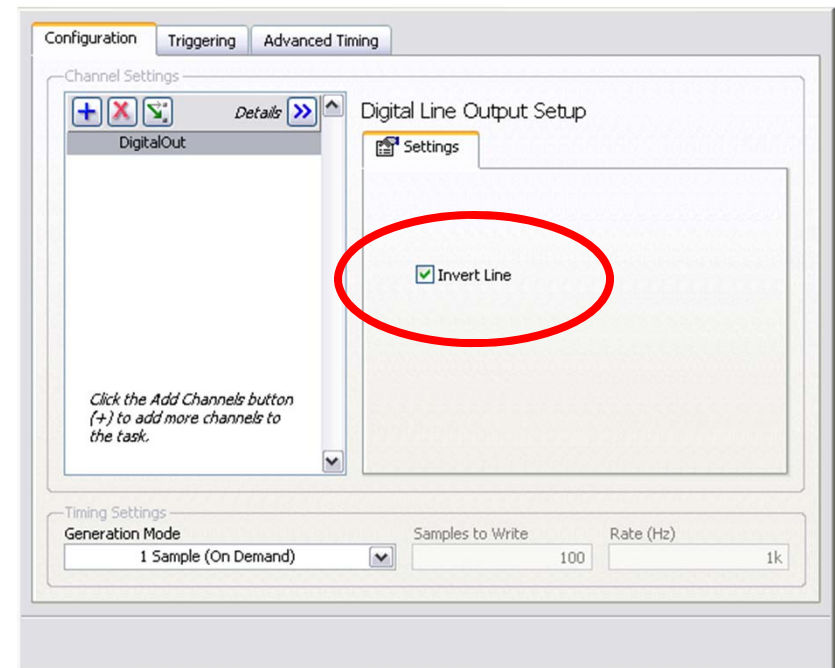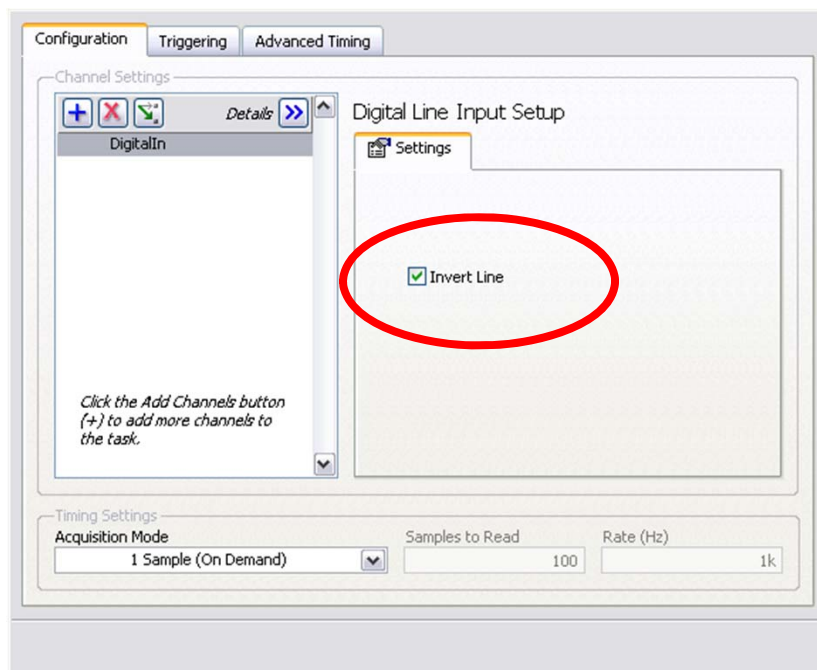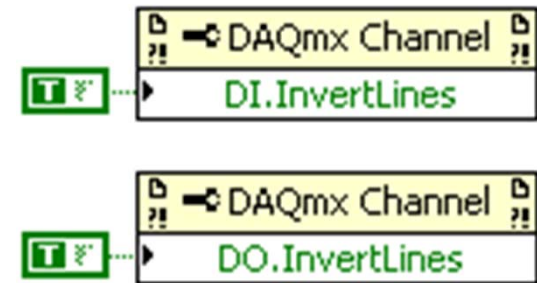
DAQ Assistant – Digital Test Panels

Digital Channel Data Formats

Line Formats

- One line per channel
  - Represented by a single Boolean value

- Multiple lines per channel
  - Represented by a 1D array of Booleans with each element corresponding to a line in the channel in the order in which they are specified
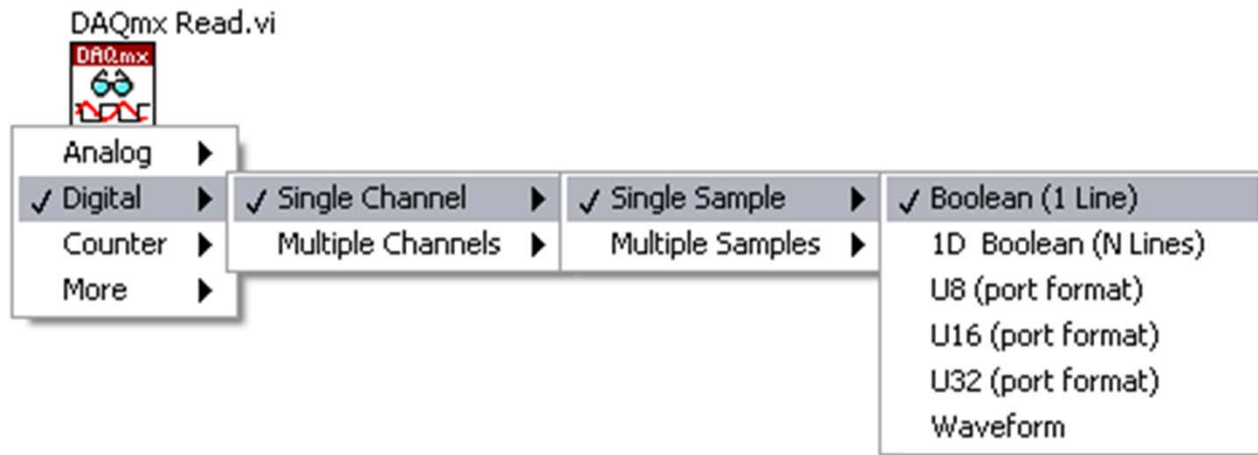
Digital Channel Data Formats

Port Formats

- A port organizes individual lines into collection
- Represented by a U8, U16, or U32 integer where each line requires one bit
  - Most efficient in terms of space

Waveform Format

- Couples channel and timing information to data
- Not used for static digital I/O

B. Digital I/O – DAQmx Read VI

DAQmx Read.vi

Analog ▶
✓ Digital ▶
Counter ▶
More ▶

✓ Single Channel ▶
Multiple Channels ▶

✓ Single Sample ▶
Multiple Samples ▶

✓ Boolean (1 Line)
1D Boolean (N Lines)
U8 (port format)
U16 (port format)
U32 (port format)
Waveform

- Can choose line, port, or waveform data format
  - Line data types are only available for single sample read and writes

- Reading and writing multiple samples for static I/O is not very practical – Use handshaking or clocked operations instead

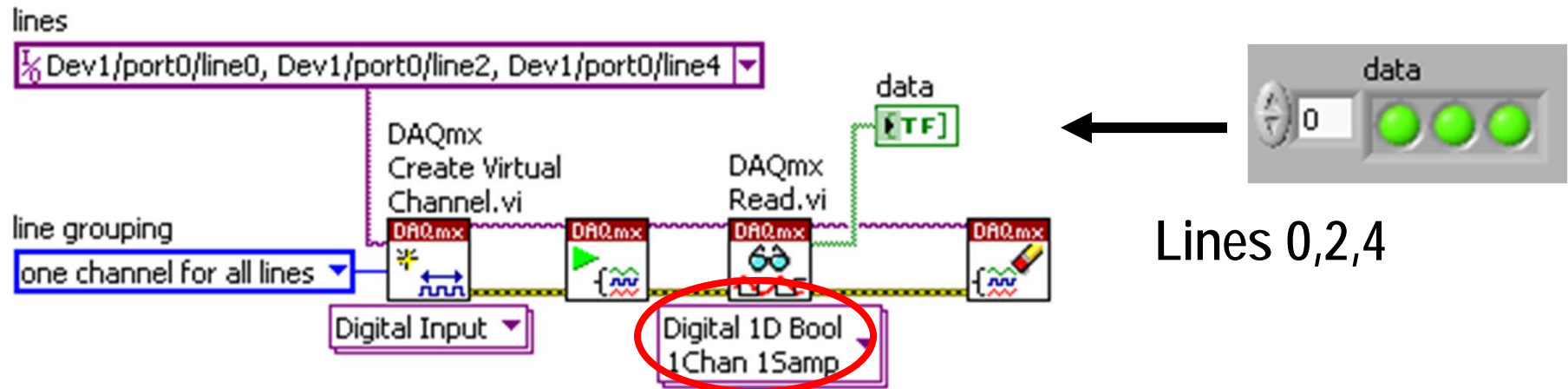**NATIONAL INSTRUMENTS™**

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Read Single Sample, Single Line Channel

Using line format, the DAQmx Read VI reads one sample
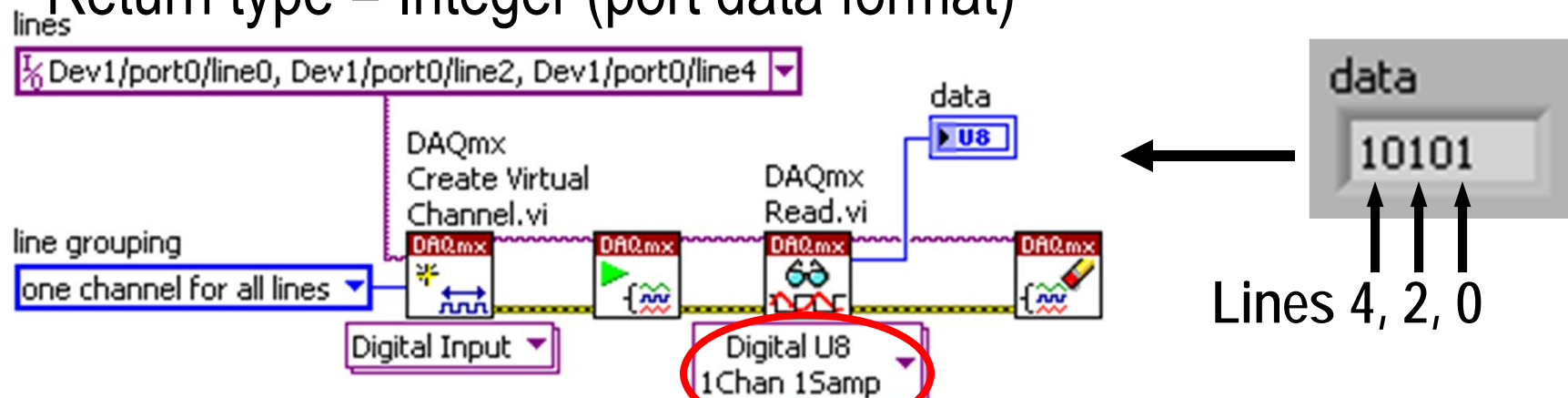from a channel with one line and returns a single Boolean

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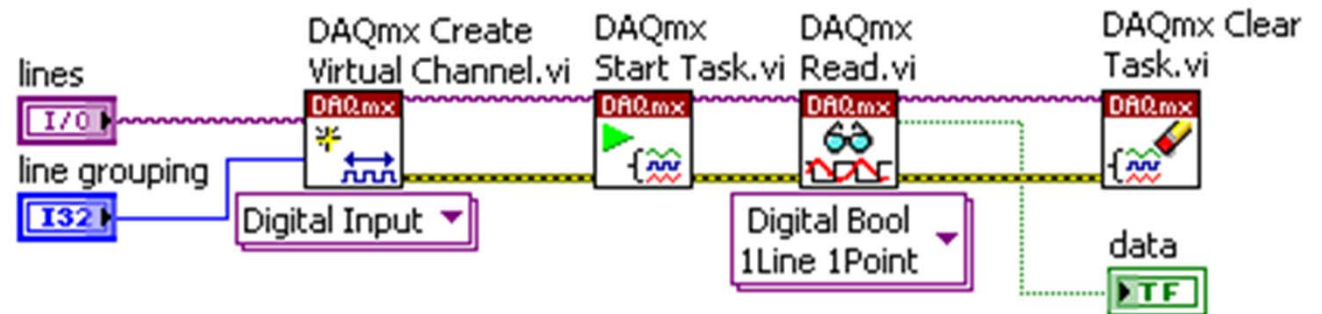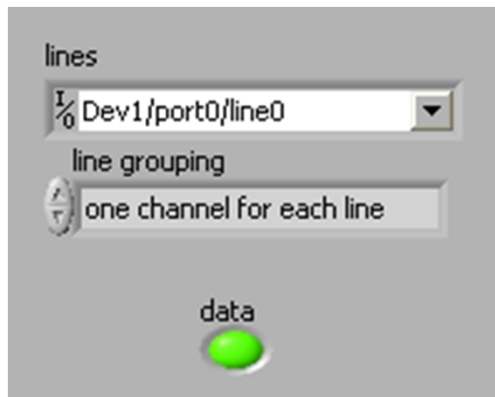
Read Single Sample, Multiple Line Channel

Return type = Array of Booleans (line data format)
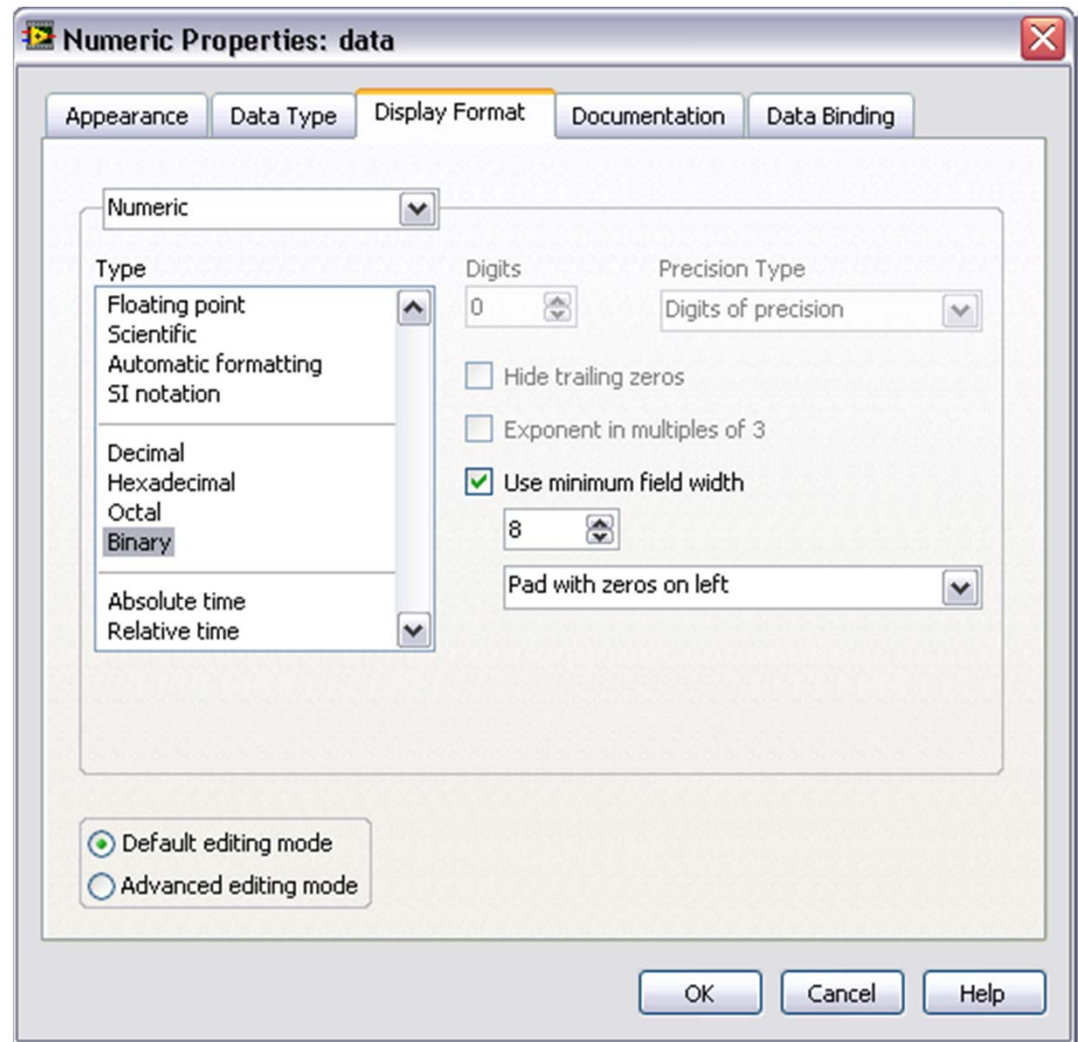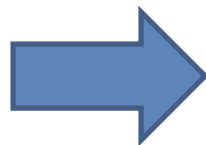

Lines 0,2,4

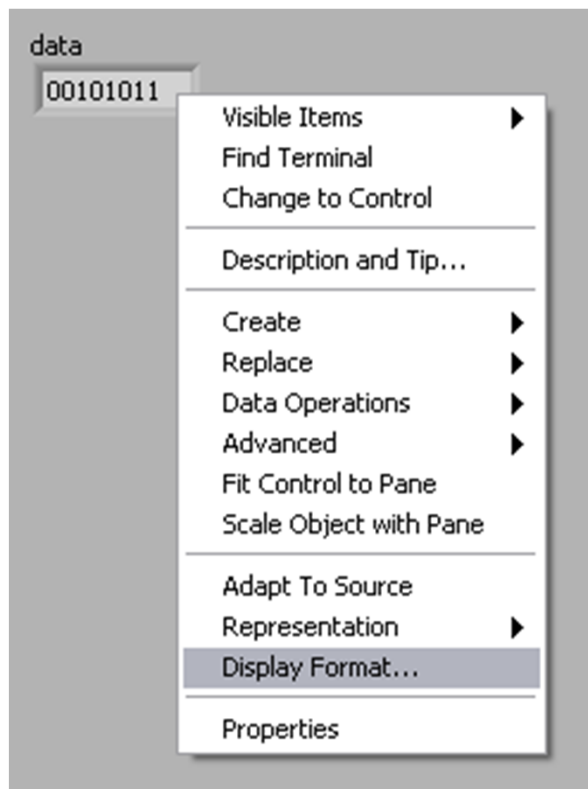Return type = Integer (port data format)

Lines 4, 2, 0

Displaying Digital Data

To display leading zeros on binary numbers…

Exercise 5-1: Digital Read

To acquire digital data using the DAQ device, and display the digital data on the front panel of a LabVIEW VI.
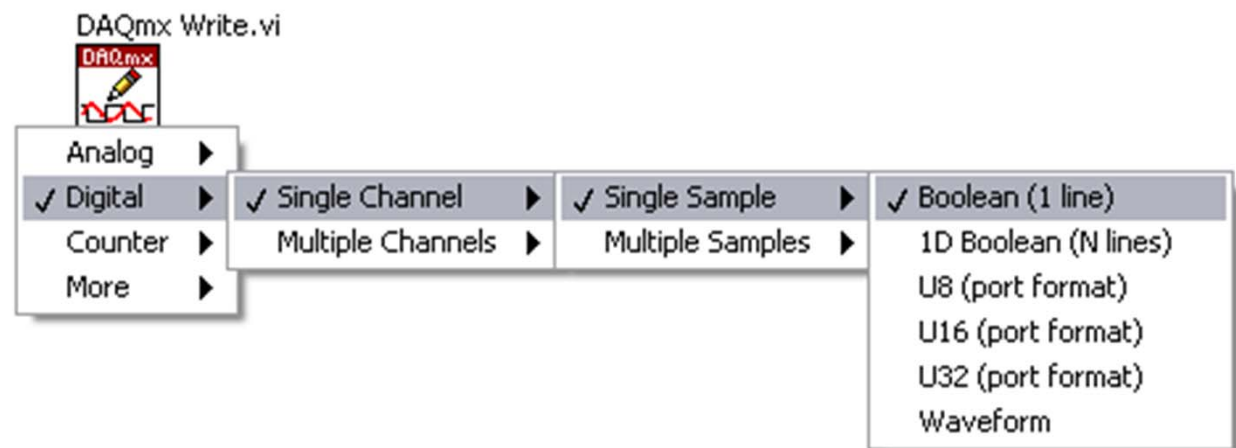
GOAL

Exercise 5-1: Digital Read

- How would you modify the VI if you wanted to read from both port0/line0 and port0/line7?

DISCUSSION

Digital I/O – DAQmx Write VI

- Use with Digital Output task to generate digital data on digital output channel
- Same data formats as Digital Input task
  - Line
  - Port
  - Waveform

DAQmx Write.vi

Analog ▶			
✓ Digital ▶	✓ Single Channel ▶	✓ Single Sample ▶	✓ Boolean (1 line)
Counter ▶	Multiple Channels ▶	Multiple Samples ▶	1D Boolean (N lines)
More ▶			U8 (port format)
			U16 (port format)
			U32 (port format)
			Waveform

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Digital I/O – DAQmx Write VI Example

- Software-timed digital output
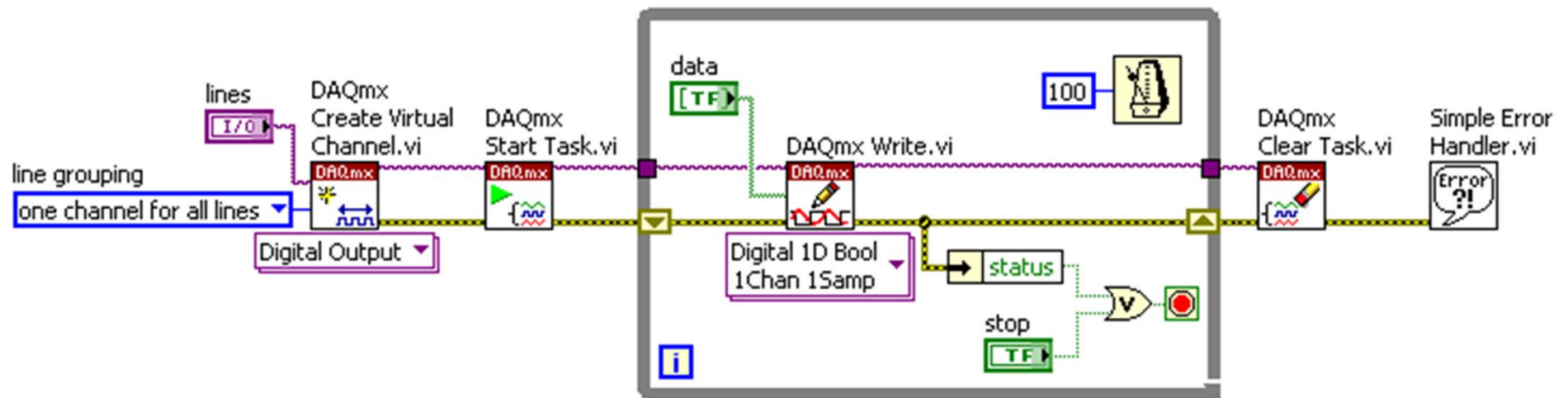
Exercise 5-2: Digital Write

To output digital data from the DAQ device and display updates on LEDs of the BNC-2120.

GOAL

Exercise 5-2: Digital Write

- What happens if you run this VI when the Boolean array is not initialized to 8 elements of data?

DISCUSSION

C. HW-timed DIO – Onboard DIO Sample Clock

Some DAQ devices (X Series) have a dedicated onboard sample clock for digital I/O

• Subject to same rules as buffered analog input and output

• Use sample clock for hardware-timed digital I/O

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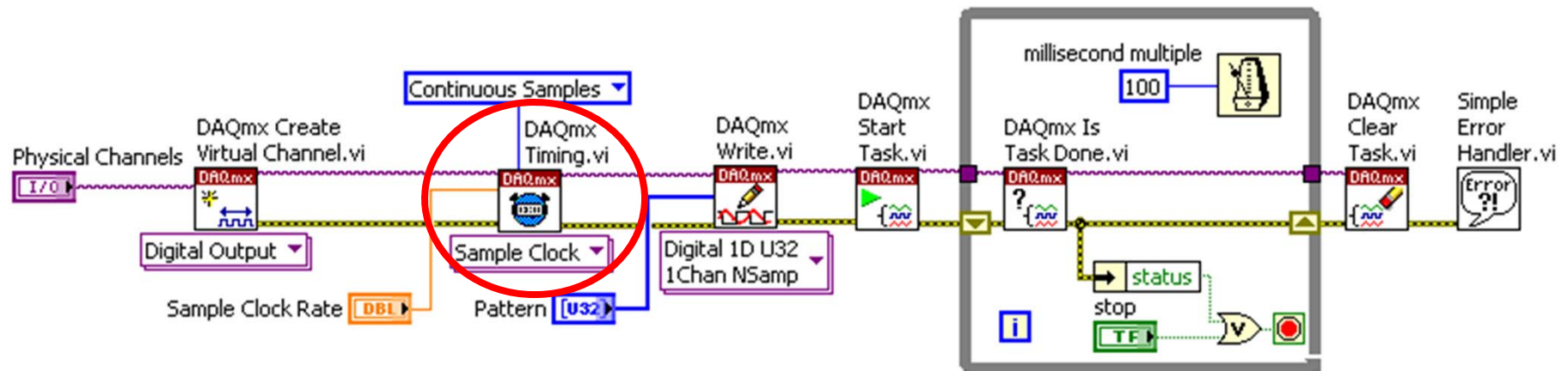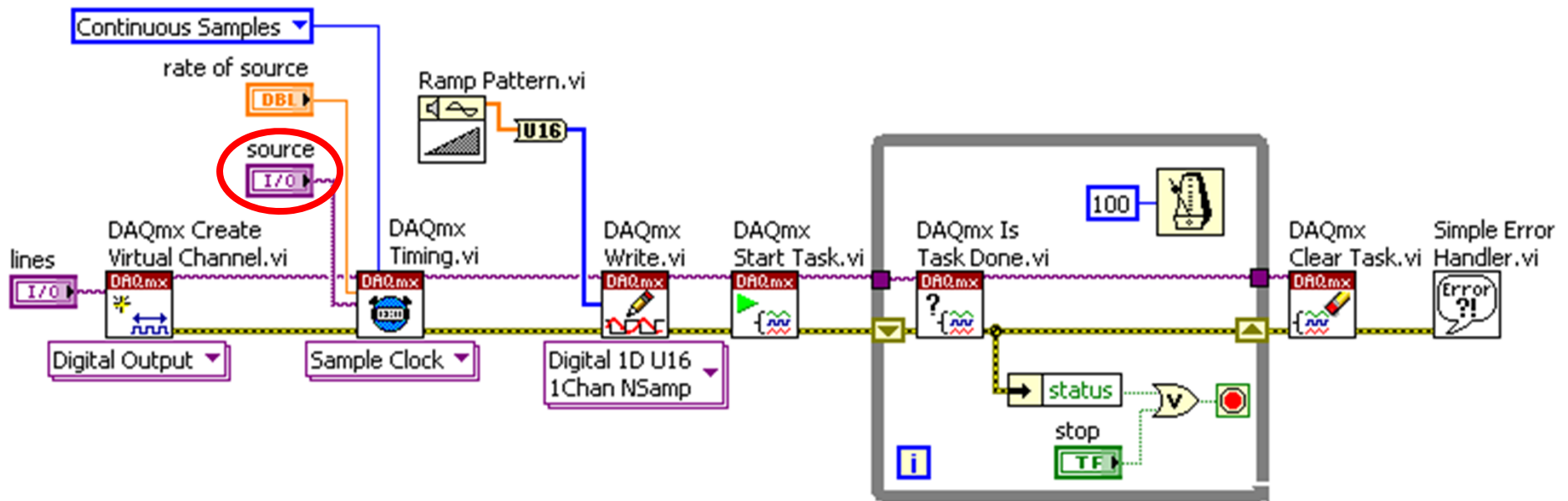
HW-timed DIO – Correlated Digital I/O

Some DAQ devices (i.e. M Series) do not have a dedicated onboard sample clock for digital I/O timing but do support correlated digital I/O

- Correlated digital I/O is digital input or output that is correlated to another clock signal (i.e. AI or AO sample clock, external clock)
- Subject to same rules as buffered analog input and output

HW-timed DIO – Correlated Digital I/O Example

Can use correlated digital I/O to create a digital waveform

- Waveform can be used to transfer digital data
- Digital input can read information from a port

Exercise 5-3: Correlated Digital Output

To output digital data from the DAQ device using the Analog Output Sample Clock as the sample clock and view the digital data on the LEDs of the BNC-2120.

GOAL

Exercise 5-3: Correlated Digital Output

- What clock is the digital output task in this VI using?

- What other clocks could this task use?

DISCUSSION

Summary—Quiz

1. Digital signals are always between 0 and 5 Volts.

    a) True

    b) False

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Summary—Quiz Answer

1. Digital signals are always between 0 and 5 Volts.
   a) True
   b) False

Summary—Quiz

2. All DAQ devices have a dedicated onboard sample clock for digital I/O.

    a) True

    b) False

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Summary—Quiz Answer

2. All DAQ devices have a dedicated onboard sample clock for digital I/O.

   a) True
   b) **False**