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Find the *National Instruments PXI-6704* at our website: *Click HERE*

# Analog Output Overview

## Analog Output

National Instruments analog voltage and current output devices cover a full spectrum of applications from basic software-timed output to complex high-speed waveform generation.

Analog output (AO) is accomplished using a digital-to-analog converter (DAC). In hardware, the DAC is given a binary value, which it converts to an analog level that is within a given voltage or current range. A common voltage range is ±10 V. DACs come with set resolution – commonly 12 or 16 bits. A 12-bit DAC can produce 4,096 voltage steps within its range. A 16-bit DAC can produce 65,536. Taking advantage of the NI-DAQ device driver, the user is able to define named analog output channels and update their values based on voltage levels or other defined engineering scales.

AO capabilities can be separated into two categories – static analog output and high-speed output.

### Static Outputs

All National Instruments AO devices can generate software-timed single-point values. software-timed updates are typical for control applications. NI 6704 devices, for example, are software-timed devices that feature 32 channels of 16-bit AO that are updated by software commands.

### Waveform Generation

Select AO devices are capable of high-speed or waveform output. Such devices typically have a FIFO and use DMA, so they can perform waveform generation at high rates with accurately timed updates. For example, NI 671x and NI 673x devices use both FIFOs and DMA to generate dynamic signals. You can use high-speed updates to generate simple waveforms, such as sine, square, and triangle waves, or more complex user-defined waveforms.

AO devices come in several configurations. You have the options with regard to channel count, update speed, output voltage range, digital I/O lines, and counter/timers.

Applications for waveform generation AO include stimulus for circuit testing, automotive component testing, audio signal generation, stimulus for vibration testing, and much more.



## Multidevice Synchronization

Each AO device offers and uses integration technologies such as RTSI bus, PXI trigger bus, and PFI pins to trigger and synchronize to a wide variety of I/O types. These I/O types range from image acquisition, motion control, and high-speed digitizers to multifunction data acquisition (DAQ) devices. These integration infrastructures enable engineers/scientists to create powerful, custom test systems with ease.

## Real-Time Control

All PXI AO devices can be used with LabVIEW Real-Time to deliver real-time, deterministic control loop execution. These densely packed AO devices can be integrated with other DAQ devices to serve a wide range of control needs. See page 134 for more details about LabVIEW Real-Time as well as other DAQ devices that are compatible with LabVIEW Real-Time.

| Product | Bus | Analog Outputs | Output Resolution | Update Rate | Output Range | Digital I/O | Counter/Timers | Current Source/Sink | Triggers | Page |
|---|---|---|---|---|---|---|---|---|---|---|
| NI 6733 | PCI, PXI | 8 | 16 bits | 1 MS/s[1] | ±10 V | 8[3] | 2, 24-bit | – | ✓ | 363 |
| NI 6731 | PCI | 4 | 16 bits | 1 MS/s | ±10 V | 8[3] | 2, 24-bit | – | ✓ | 363 |
| NI 6713 | PCI, PXI | 8 | 12 bits | 1 MS/s[1] | ±10 V | 8 | 2, 24-bit | – | ✓ | 363 |
| NI 6715 | PCMCIA | 8 | 12 bits | 1 MS/s[1] | ±10 V | 8 | 2, 24-bit | – | ✓ | 363 |
| NI 6711 | PCI, PXI | 4 | 12 bits | 1 MS/s | ±10 V | 8 | 2, 24-bit | – | ✓ | 363 |
| NI 6704 | PCI, PXI | 32 | 16 bits | Static | ±10 V, 0 to 20 mA[2] | 8 | – | ✓ | – | 366 |
| NI 6703 | PCI | 16 | 16 bits | Static | ±10 V | 8 | – | – | – | 366 |

[1]Maximum update rate decreases when all 8 channels updating simultaneously. [2]The current output varies when set between 0 and 100 µA. [3]Static, high-speed pattern generation and acquisition.

*Table 1. Analog Voltage and Current Output Devices*



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# Software-Timed Analog Output – 16-Bit, 16 or 32 Channels

## NI 670x

- 16 voltage and 16 current outputs
- 16-bit resolution
- 8 (5 V TTL/CMOS) lines
- User-defined power up states
- NI-DAQ driver simplifies configuration and measurements

### Models
- NI PCI-6703
- NI PCI-6704
- NI PXI-6704

### Operating Systems
- Windows 2000/NT/XP
- Real-Time performance with LabVIEW (page 134)
- Other such as Linux and Mac OS X (page 187)

### Recommended Software
- LabVIEW
- LabWindows/CVI
- Measurement Studio

### Other Compatible Software
- Visual Basic
- C/C++

### Driver Software (included)
- NI-DAQ 7

**Calibration Certificate Included**

See page 21.






## Overview

NI 670x devices are software-timed voltage and current output devices for PCI and PXI. With NI 6704 devices, you get 16 voltage outputs and 16 current outputs that you can use at the same time independently, as well as eight digital I/O (DIO) lines. You can independently set each output from ±10 V or 0 to 20 mA. The NI 6703 delivers 16 voltage outputs in addition to eight DIO lines.

## Hardware

### Voltage Output Channels

All 16 voltage outputs on the NI 6703 and NI 6704 are identical. You can set each channel for a bipolar voltage output of ±10 V. Each output is accurate to ±1 mV.

### Current Output Channels (NI 6704 only)

All 16 current outputs are identical. You can set each channel to source current from 0 to 20 mA – it does not sink current. The channels source current without requiring an external excitation source. Each output is accurate to ±2 µA.

### I/O Connector

The analog outputs are available at a 68-pin SCSI II shielded connector. VCH<0..15> are the voltage output channels. ICH<16..31> are the current output channels. Each channel is referenced to a ground line, AO GND<0...31>, which is shared between a voltage and current channel. A fused 5 VDC power signal from the PCI or PXI bus is available at the I/O connector as well.

## Related Products

SCC and SCXI for isolated analog output .....See page 251 or 270

| Product | Bus | Analog Outputs | Resolution | Output Rate | Output Range | Digital I/O | Counter/Timers | Current Sinks | Triggers |
|---|---|---|---|---|---|---|---|---|---|
| NI 6703 | PCI | 16 voltage | 16 bits | Static | ± 10 V | 8 | – | – | – |
| NI 6704 | PCI<br>PXI | 16 voltage,<br>16 current | 16 bits | Static | ±10 V,<br>0 to 20 mA[1] | 8 | – | ✓ | – |

[1]The current output varies when set between 0 and 100 µA.

*Table 1. NI 670x Channel, Speed, and Resolution Specifications (See page 373 for detailed specifications.)*



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# Software-Timed Analog Output – 16-Bit, 16 or 32 Channels



| | | Absolute Accuracy | | | | | |
|---|---|---|---|---|---|---|---|
| | | % of Reading | | | | | |
| | Nominal Range | 24 hrs | 90 days | 1 year | Offset | Temp Drift (%/°C) | Absolute Accuracy at Full Scale |
| Voltage output | ±10 V | 0.0019% | 0.0026% | 0.0035% | ±710 µV | 0.0001% | 1.060 mV |
| Current output (NI 6704 only) | 0 -20m A* | 0.0034% | 0.0088% | 0.0150% | ±1435.0 nA | 0.0002% | 4.44 µA |

Note: Temp Drift applies only if ambient is greater than ±10°C of previous external calibration. Absolute Accuracy calculations assume full-scale output after one year. *The current output vaies when set between 0 and 100 µA.

*Table 2. NI 670X Analog Output Accuracy Specifications*

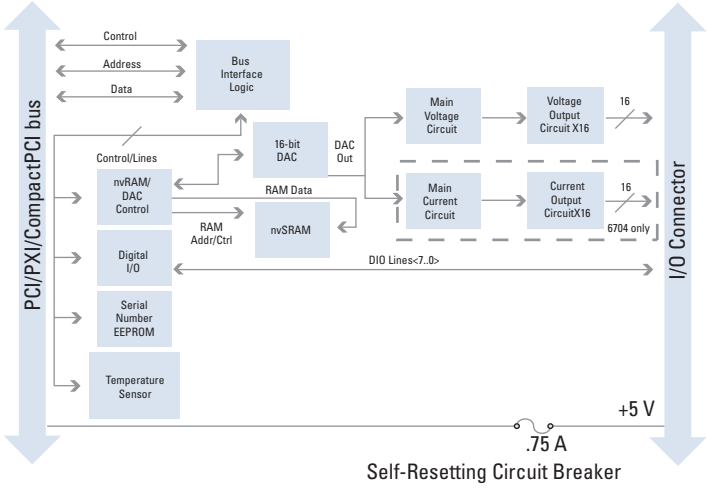



*Figure 1. NI 670x Hardware Block Diagram*

| | | | |
|---|---|---|---|
| +5V | 1 | 35 | D_GND |
| PO0 | 2 | 36 | D_GND |
| PO1 | 3 | 37 | D_GND |
| PO2 | 4 | 38 | RFU |
| PO3 | 5 | 39 | D_GND |
| PO4 | 6 | 40 | RFU |
| PO5 | 7 | 41 | D_GND |
| PO6 | 8 | 42 | D_GND |
| PO7 | 9 | 43 | A_GND |
| ICH_31[1] | 10 | 44 | VCH_15 |
| A_GND_15/A_GND_31 | 11 | 45 | ICH_30[1] |
| VCH_14 | 12 | 46 | A_GND_14/A_GND_30 |
| ICH_29[1] | 13 | 47 | VCH_13 |
| A_GND_13/A_GND_29 | 14 | 48 | ICH_28[1] |
| VCH_12 | 15 | 49 | A_GND_12/A_GND_28 |
| ICH_27[1] | 16 | 50 | A_GND_11/A_GND_27 |
| VCH_11 | 17 | 51 | ICH_26[1] |
| A_GND_10/A_GND_26 | 18 | 52 | VCH_10 |
| A_GND | 19 | 53 | ICH_25[1] |
| A_GND_9/A_GND_25 | 20 | 54 | VCH_9 |
| ICH_24[1] | 21 | 55 | A_GND_8/A_GND_24 |
| VCH_8 | 22 | 56 | A_GND |
| ICH_23[1] | 23 | 57 | VCH_7 |
| A_GND_7/A_GND_23 | 24 | 58 | ICH_22[1] |
| VCH_6 | 25 | 59 | A_GND_6/A_GND_22 |
| ICH_21[1] | 26 | 60 | VCH_5 |
| A_GND_5/A_GND_21 | 27 | 61 | ICH_20[1] |
| VCH_4 | 28 | 62 | A_GND_4/A_GND_20 |
| ICH_19[1] | 29 | 63 | VCH_3 |
| A_GND_3/A_GND_19 | 30 | 64 | ICH_18[1] |
| VCH_2 | 31 | 65 | A_GND_2/A_GND_18 |
| ICH_17[1] | 32 | 66 | VCH_1 |
| A_GND_1/A_GND_17 | 33 | 67 | ICH_16[1] |
| VCH_0 | 34 | 68 | A_GND_0/A_GND_16 |

[1] No Connect on NI 6703

*Figure 2. NI 670x I/O Connector*

## Ordering Information

NI PCI-6704 .....777306-01
NI PXI-6704 .....777796-01
NI PCI-6703 .....778316-01

Includes NI-DAQ driver software and calibration certificate.

For information on extended warranty and value-added services, see page 20.

### Recommended Configuration

| Family | Bus | Accessory | Cable |
|---|---|---|---|
| NI 6704 | PCI, PXI | SCB-68 (776844-01) | SH68-68-D1 (183432-01) |
| NI 6703 | PCI | SCB-68 (776844-01) | SH68-68-D1 (183432-01) |

See page 368 for accessory and cable options.

***BUY ONLINE!***

*Visit ni.com/info and enter pci6703, pxi6704 or pci6704.*





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# Analog Output Specifications



## Specifications – NI 671x and NI 673x (continued)

### Calibration

Recommended warm-up time ..... 15 minutes
Calibration interval ..... 1 year
Onboard calibration reference
- DC Level ..... 5.000 V (±2.5 mV); actual value stored in EEPROM
- Temperature coefficient ..... ±5 ppm/°C maximum (NI 671x)
  ± 0.6 ppm/°C maximum (NI 673x)
- Long-term stability ..... ±15 ppm/ $\sqrt{1{,}000}$ h (NI 671x) ±6 ppm/$\sqrt{1{,}000}$ h (NI 673x)

### RTSI Bus (PCI Only)

Trigger lines ..... 7

### PXI Trigger Bus (PXI Only)

Trigger lines ..... 6
Star trigger ..... 1

### Bus Interface

PCI, PXI ..... Master, Slave

### Power Requirements

+5 VDC (±5%) ..... 1.0 A max for NI 6711
1.5 A max for NI 6713
250 mA max for NI 6715
1.8 A max for NI 6733
1.25 A max for NI 6731
+3.3 VDC (±5%) ..... 250 mA max for NI 6731/6733
Power available at I/O connector ..... +4.65 to +5.25 VDC, 1 A

### Physical

Dimensions
- PCI ..... 17.5 by 10.7 cm (6.9 by 4.2 in.)
- PXI ..... 16 by 10 cm (6.3 by 3.9 in.)
- PCMCIA ..... Type II PC Card

I/O connectors
- PCI, PXI ..... 68-pin male SCSI II
- PCMCIA ..... 68-pin female Honda connector

### Environment

PCI, PXI
- Operating temperature ..... 0 to 55 °C
- Storage temperature ..... -20 to 70 °C
- Relative humidity ..... 10 to 90%, noncondensing

PCMCIA
- Operating temperature ..... 0 to 50 °C
- Storage temperature ..... -20 to 70 °C
- Relative humidity ..... 10 to 90%, noncondensing

### Certifications and Compliances

CE Mark Compliance CE

## Specifications – NI 6703, NI 6704

These specifications are typical at 25 °C unless otherwise stated.

### Analog Output

#### Output Characteristics

| | Channels | | |
|---|---|---|---|
| Device | Voltage | Current | Total |
| NI 6703 | 16 | 0 | 16 |
| NI 6704 | 16 | 16 | 32 |

Resolution ..... 16 bits, 1 in 65,536
Type of DAC ..... Enhanced R-2R
Data transfers ..... Programmed I/O

#### Transfer Characteristics

Relative accuracy (INL) ..... ±1.0 LSB maximum
DNL ..... ±1.0 LSB maximum
Monotonicity ..... 16 bits, guaranteed after calibration

#### Voltage Output

Ranges ..... ±10.1 V
Output coupling ..... DC
Output impedance ..... 0.1 Ω maximum
Current drive ..... ±10 mA maximum
Load capacitance ..... 10,000 pF maximum
Protection ..... Short-circuit to ground
Absolute accuracy ..... ±1 mV maximum
Power-on state ..... Independent, user-defined

#### Current Output (NI 6704 Only)

Range ..... 0.0; 0.1 to 20.2 mA
Type ..... Source, does not require external excitation source
Output impedance ..... 1 GΩ minimum
Output compliance ..... 0 to 10 V
Protection ..... Short circuit and open circuit
Absolute accuracy ..... ±2 µA maximum
Power-on state ..... Independent, user-defined

#### Dynamic Characteristics

Settling time
- NI 6703 ..... 7.2 ms to ± 0.001% typ.
- NI 6704 ..... 14.4 ms to ± 0.001% typ.

#### Stability

Offset temperature coefficient
- Voltage ..... 5 µV/°C
- Current ..... 10 nA/°C

Gain temperature coefficient
- Voltage ..... ±1 ppm/°C
- Current ..... ±2 ppm/°C

### Digital I/O

Digital logic levels

| Level | Minimum | Maximum |
|---|---|---|
| Input low voltage | 0V | 0.8 V |
| Input high voltage | 2 V | 5 V |
| Output low voltage ($I_{out}$ = 16 mA) | – | 0.45 V |
| Output high voltage ($I_{out}$ = 16 mA) | 2.4 V | – |

Number of channels ..... 8 input/output
Compatibility ..... 5 V TTL/CMOS
Power-on state ..... Input (high impedance)

### Calibration

Recommended warm-up time ..... 15 minutes
Calibration interval ..... 1 year
Onboard calibration reference
- DC Level ..... 10.000 V (±1 mV, actual value stored in EEPROM)
- Temperature coefficient ..... ±0.6 ppm/°C max
- Long-term stability ..... ±6 ppm/ $\sqrt{1{,}000}$ h

### Bus Interface

PCI, PXI ..... Slave

### Power Requirements

+5 VDC (±5%)
- NI 6703 ..... 1.1 A maximum
- NI 6704 ..... 1.8 A maximum

+12 VDC (±5%) ..... 70 mA maximum
-12 VDC (±5%) ..... 70 mA maximum
Power available at I/O connector ..... +4.65 to +5.25 VDC, 0.75 A

### Physical

Dimensions (not including connectors)
- PCI ..... 17.5 by 10.7 cm (6.9 by 4.2 in)
- PXI ..... 16.0 by 10.0 cm (6.3 by 3.9 in.)

I/O connector ..... 68-pin male SCSI-II type

### Environment

Operating temperature ..... 0 to 55 °C
Storage temperature ..... -20 to 70 °C
Relative humidity ..... 10 to 90%, noncondensing

### Certifications and Compliances

CE Mark Compliance CE





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# Analog Output Accessories and Cables



*Figure 1. BNC-2110 I/O Connector Block*



*Figure 2. SCB-68 Shielded I/O Connector Blocks*



*Figure 3. CA-1000 Custom Connectivity Enclosure*



*Figure 4. TBX-68 I/O Connector Block*

| Device | Cables | Accessories |
|---|---|---|
| NI 6711 | SH68-68-EP | SCB-68, TBX-68 |
| NI 6713 | SH68-68R1-EP | CB-68LP, CB-68LPR |
| NI 6731 | R6868 | BNC-2110 |
| NI 6733 | | CA-1000 |
| | SH68-50 | CB-50LP |
| | N/A | TB-2705 (PXI only) |
| NI 6715 | SHC68-68-EP<br>SHC68U-68-EP<br>RC68-68 | SCB-68, TBX-68<br>CB-68LP, CB-68LPR<br>BNC-2110<br>CA-1000 |
| | Above cables plus 68M-50F | CB-50LP |
| NI 6703 | SH68-68-D1 | SCB-68, TBX-68 |
| NI 6704 | R6868 | CB-68LP, CB-68LPR |
| | | CA-1000 |

*Table 1. Accessory and Cable Selection Guide*

## I/O Connector Blocks

### BNC-2110 I/O Connector Block (See Figure 1)

The BNC-2110 is a shielded connector block with signal-labeled BNC connectors for easy connectivity of your analog output (AO), digital I/O (DIO), and counter/timer signals.

BNC-2110 .....777643-01

Dimensions – 20.3 by 11.2 by 5.5 cm (8.0 by 4.4 by 2.2 in.)

### SCB-68 Shielded I/O Connector Blocks (See Figure 2)

The SCB-68 is a shielded I/O connector block giving you rugged, very low-noise signal termination. The SCB-68 also houses silk-screened component locations for easy addition of simple signal conditioning circuitry for your AO channels.

SCB-68 .....776844-01

Dimensions – 19.5 by 15.2 by 4.5 cm (7.7 by 6.0 by 1.8 in.)

### CA-1000 Custom Connectivity Enclosure (See Figure 3)

The CA-1000 is a configurable enclosure that gives you user-defined connectivity and flexibility through customized panelettes.

CA-1000 .....See page 351

Dimensions – 30.7 by 25.4 by 4.3 cm (12.1 by 10 by 1.7 in.)

### TBX-68 I/O Connector Block with DIN-Rail Mounting (See Figure 4)

The TBX-68 is a termination accessory with 68 screw terminals for easy connection of field signals to 68-pin DAQ devices. It includes one 68-pin male connector for direct connection to 68-pin cables. The TBX-68 is mounted in a protective plastic base with hardware for mounting on a standard DIN rail.

TBX-68 .....777141-01

Dimensions – 12.50 by 10.74 cm (4.92 by 4.23 in.)





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