

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

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

Table 1. Analog Voltage and Current Output Devices

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 μ A.

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 outputSee 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 PXI	16 voltage, 16 current	16 bits	Static	± 10 V, 0 to 20 mA ¹	8	–	✓	–

¹The current output varies when set between 0 and 100 μ A.

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

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

	Nominal Range	Absolute Accuracy			Offset	Temp Drift (%/°C)	Absolute Accuracy at Full Scale
		24 hrs	90 days	1 year			
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 varies when set between 0 and 100 µA.

Table 2. NI 670X Analog Output Accuracy Specifications

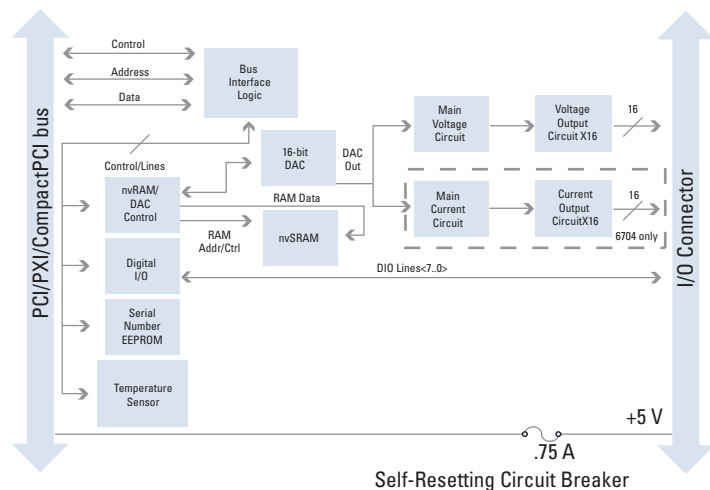


Figure 1. NI 670X Hardware Block Diagram

+5V	1	35	D_GND
P00	2	36	D_GND
P01	3	37	D_GND
P02	4	38	RFU
P03	5	39	D_GND
P04	6	40	RFU
P05	7	41	D_GND
P06	8	42	D_GND
P07	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-6704777306-01
 NI PXI-6704777796-01
 NI PCI-6703778316-01

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*.

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/√1,000 h (NI 671x) ±6 ppm/√1,000 h (NI 673x)

RTSI Bus (PCI Only)

Trigger lines.....	7
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PXI Trigger Bus (PXI Only)

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

Bus Interface

PCI, PXI.....	Master, Slave
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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

Device	Channels		
	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/√1,000 h

Bus Interface

PCI, PXI.....	Slave
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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**

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	SCB-68, TBX-68
	SHC68U-68-EP	CB-68LP, CB-68LPR
	RC68-68	BNC-2110
	Above cables plus 68M-50F	CA-1000
NI 6703	SH68-68-D1	CB-50LP
NI 6704	R6868	SCB-68, TBX-68
		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-2110777643-01

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-68776844-01

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-1000See 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-68777141-01

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