Counter/Timer Overview

You can use the versatile National Instruments counter/timer devices to create a wide variety of measurement solutions, including measuring a number of time-related quantities, counting events or totalizing, and monitoring position with quadrature encoders. You can also use counter/timers to generate pulses and pulse trains. Counter/timers often fulfill critical timing functions as components of complex measurement systems.

The NI 660x counter/timers use the NI-TIO, a National Instruments ASIC chip specifically designed to meet the counting and timing requirements of measurement applications that are beyond the capabilities of off-the-shelf components. The wider functionality and simple programming interface make the NI 660x your best choice for counting and timing applications.

Example applications include frequency measurement, position measurement, generation of retriggerable pulses, frequency shift-keying, two-signal edge separation measurements, continuous buffered event counting, and continuous buffered pulse train measurements. The NI 660x counter/timer devices are readily integrated into measurement systems that require synchronization across multiple hardware devices because they are equipped with the National Instruments PXI trigger bus or the RTSI bus. See the counter/timer tutorial on page 789 for more information.

In addition to counter/timer functionality, the NI 660x products include TTL/CMOS-compatible digital I/O ports that are bit configurable for input or output.

Counter/Timer Considerations

Number of Counter/Timers

The counter/timer is a basic unit of hardware functionality on a measurement device. The more counter/timers there are on a device, the more counting/timing operations that device can simultaneously perform. The number of DMA channels determines how many buffered, high-speed operations can be simultaneously performed. See page 393 for more information.

Counter/Timer Size or Number of Bits

The counter size or number of bits indicates how high a counter can count. For example, a 32-bit counter can count up to 2^{32}-1 or 4,294,967,295 before it rolls over. A high number of bits is beneficial in cases such as pulse width measurements where a wide dynamic range is required. For example, if you measure pulse widths with a 12.5 ns resolution (80 MHz timebase) using a counter/timer with 32 bits, you can measure pulse widths up to 53 s [$(2^{32}$-1) x 12.5 ns)] with 12.5 ns resolution.

Maximum Source Frequency

Maximum source frequency represents the speed of the fastest signal the counter can count. If you use a higher source frequency, you can achieve higher resolution. For example, an 80 MHz counter can count pulses that are 12.5 ns ($\frac{1}{80 \times 10^6}$) apart. You can use prescalers to increase the maximum source frequency for event counting and frequency measurement.

Family	Bus	Counter/ Timers	Size	Max Source Frequency	Compatibility	Digital I/O	Pulse Generation	Buffered Operations	Debouncing/ Glitch Removal	Oscillator Stability	GPS Synchr.	Buffered Operations[2] DMA	Buffered Operations[2] Interrupt	Page
NI 6601	PCI	4	32 bits	20 MHz[1]	5 V TTL/CMOS	Up to 32	✓	✓	✓	50 ppm	–	1	3	388
NI 6602	PCI PXI	8	32 bits	80 MHz[1]	5 V TTL/CMOS	Up to 32	✓	✓	✓	50 ppm	–	3	5	388
NI 6608	PXI	8	32 bits	80 MHz[1]	5 V TTL/CMOS	Up to 32	✓	✓	✓	75 ppb	✓	3	5	388

[1]Max Source Frequency with prescalers is 60 MHz for the NI 6601 and 125 MHz for the NI 6602 and NI 6608. These frequencies are dependent on drive strength of input signal and cable length. Consider these speeds to be the maximum.
[2]DMA transfers have higher throughput than interrupt transfers. See page 393 for detailed specifications.

Counter/Timer Overview

Signal Compatibility

Signal compatibility indicates the signal levels a counter/timer can measure or output, such as TTL/CMOS.

Buffered Operations and DMA

The National Instruments counter/timers can capture numerous data points without dead times. These types of measurements, called buffered operations, are valuable in applications that range from statistical analysis on production lines to experiments in molecular chemistry. For instance, when you configure a counter for buffered period measurement, data is moved from the counter into a buffer. Each edge that initiates a measurement also causes a transfer of the count into the buffer, as shown in Figure 1. With buffered operations, data is transferred to the computer memory using DMA or interrupts. DMA offers a considerable performance advantage; if your application requires this performance simultaneously on multiple counter/timers, you must know how many DMA channels are available on a particular counter/timer device. For example, if a device contains three DMA channels and eight counter/timers, you can simultaneously perform three high-speed and five lower-speed, interrupt-based, buffered operations. On NI 660x devices, National Instruments implements DMA with the NI MITE chip, which is optimized for measurement applications.

Timebase Stability

Timebase stability can be important when you need to make high-quality measurements. Crystal oscillators typically form the basis of electrical circuits used to drive timing of a measurement application. In an ideal case, the oscillation frequency would be constant, but in reality, many factors influence the the behavior of an oscillator. A commonly used measure of quality for an oscillator is stability.

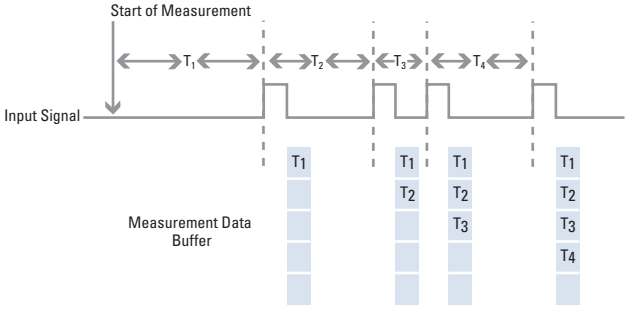

Figure 1. Buffered Period Measurement with Counter/Timers

Units used for stability are typically parts per million (ppm) and parts per billion (ppb). For example, the frequency of a 10 MHz oscillator with 10 ppm stability can be 10 MHz ± 100 Hz; with 100 ppb stability it can be 10 MHz ± 1 Hz.

The best technique for improving oscillator stability is to precisely control its temperature as is done in an oven-controlled crystal oscillator (OCXO). The PXI-6608 features such an oscillator.

Debouncing and Glitch Removal

Noisy signals containing glitches and/or bouncing effects pose special challenges for some counter/timer measurements. Noise may be introduced in the source of the signal, such as with electromechanical relays, or in the connection if there are strong sources of interference in the vicinity of the system. NI 660x devices contain programmable digital filters that eliminate measurement errors caused by spurious spikes and bouncing. Figure 2 shows an example of digital filtering.

Calibration

Calibration is a key component of any measurement solution. In the case of counter/timers, timebase calibration ensures that the frequency and time measurements are accurate. Calibration certificates enclosed with the National Instruments counter/timers and periodic calibration satisfy your ISO-9000 requirements, certifying that your instrument has been properly calibrated. See page 21 for more information.

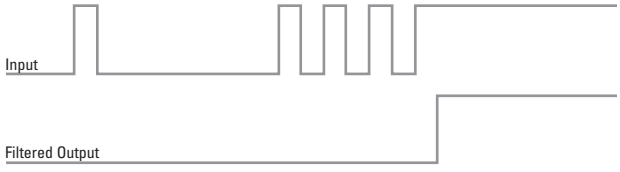

Figure 2. Debouncing and Glitch Removal

32-Bit Counter/Timers

NI 660x

- Up to eight 32-bit counter/timers
- 80 MHz maximum source frequency (125 MHz with prescalers)
- Debouncing and glitch removal
- High-stability timebase (PXI-6608 only)
- GPS-based synchronization (PXI-6608 only)
- NI DAQ driver simplifies configuration and measurements

Models

- NI PCI-6601
- NI PCI-6602
- NI PXI-6602
- NI PXI-6608

Operating Systems

- Windows 2000/NT/XP
- Real-time performance with LabVIEW (p. 134)
- Others such as Linux and Mac OS X (page 187)

Recommended Software

- LabVIEW
- LabWindows/CVI
- Measurement Studio

Other Compatible Software

- Visual Basic
- Visual C/C++, C#

Driver Software (included)

- NI-DAQ 7

Calibration Certificate Included

See page 21.

Overview and Applications

NI 660x devices are timing and digital I/O (DIO) modules for PCI and PXI. They offer up to eight 32-bit counter/timers and up to 32 lines of 5 V TTL/CMOS-compatible digital I/O. You can perform a wide variety of buffered measurements or other counter/timer tasks with NI 660x devices, including position or quadrature encoder measurement, event counting, period measurement, pulse-width measurement, frequency measurement, pulse generation, and pulse-train generation.

Features

Counter/Timers

The NI 660x devices are equipped with the NI-TIO ASIC, a National Instruments counter and digital I/O ASIC for advanced timing and counting applications. Each NI 6602 and NI 6608 device features two NI-TIO ASICs to provide a total of eight counter/timers.

The PCI-6601 board features one NI-TIO ASIC for a total of four counter/timers. The counters are software-compatible with those found on E Series multifunction DAQ devices, but NI 660x devices offer additional capabilities.

Each counter has a gate, up/down, and source signal, which can be controlled by external or internal signals. Each counter has one output that can be routed externally or to other counters on the device. 20 MHz and 100 kHz timebases are available on each device for use with each counter/timer. In addition, an 80 MHz timebase is available on the NI 6602 and NI 6608 devices. A hardware trigger can be used to start multiple counters simultaneously. See Table 1 for more information.

Family	Bus	Counter/ Timers	Size	Max Source Frequency	Compatibility	Digital I/O	Pulse Generation	Buffered Operations	Debouncing/ Glitch Removal	Oscillator Stability	GPS Synchr.	Buffered Operations[2]	
												DMA	Interrupt
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NI 6608	PXI	8	32 bits	80 MHz[1]	5 V TTL/CMOS	Up to 32	✓	✓	✓	75 ppb	✓	3	5

[1]Max Source Frequency with prescalers is 60 MHz for the NI 6601 and 125 MHz for the NI 6602 and NI 6608. These frequencies are dependent on drive strength of input signal and cable length. Consider these speeds to be the maximum. [2]DMA transfers have higher throughput than interrupt transfers.

Table 1. NI 660x Products Specifications Summary (See page 393 for detailed specifications.)

32-Bit Counter/Timers

High-Stability, Oven-Controlled Oscillator

The NI PXI-6608 module includes a high-stability 10 MHz oven-controlled crystal oscillator (OCXO) for high-precision applications. When the PXI-6608 is installed in the star trigger slot of a PXI chassis (Slot 2), you can drive the OCXO signal to the PXI backplane for high-stability timing of your entire measurement system. The PXI-6602 and PXI-6608 feature phase-lock loop (PLL) circuitry so that the devices can synchronize their reference clocks to the backplane.

Debouncing and Glitch Removal

Each input on the NI 660x devices can be passed through a digital debouncing filter to eliminate glitches on the input signal. You can use defined filter settings to remove noise/glitches narrower than 2.5 µs, 500 ns, 250 ns, and 50 ns from your input signal, or you can use one of the counters to create custom filter settings.

Buffered Measurements

NI 660x devices use the National Instruments MITE bus interface controller to implement bus-master DMA transfers. As a result, you can perform high-speed, continuous operations such as buffered position encoder measurement and buffered period measurement. You can perform one high-speed DMA-based transfer on the NI 6601 devices and up to three simultaneous DMA transfers on the NI 6602 and NI 6608 devices. You can use interrupts for additional simultaneous buffered transfers.

Digital I/O

The NI-TIO ASIC also provides up to 32 DIO lines on the NI 660x devices. Eight lines are dedicated to DIO, while the others can be used for DIO when not used by the counter/timers. DIO lines are individually software configurable for input or output.

RTSI Bus and PXI Trigger Bus

NI 660x devices are equipped with the RTSI bus or PXI trigger bus for multidevice synchronization. Timing signals on an NI 660x device can be routed to or from other devices in your system to perform advanced timing and synchronization.

PFI31/SOURCE2	34	68	GND
GND	33	67	PFI30/GATE2
PFI28/OUT2	32	66	PFI29/UP_DOWN2
PFI27/SOURCE3	31	65	GND
GND	30	64	PFI26/GATE3
PFI24/OUT3	29	63	PFI25/UP_DOWN3
PFI23/SOURCE4	28	62	GND
GND	27	61	PFI22/GATE4
PFI20/OUT4	26	60	PFI21/UP_DOWN4
PFI19/SOURCE5	25	59	GND
GND	24	58	PFI18/GATE5
PFI16/OUT5	23	57	PFI17UP_DOWN5
PFI15/SOURCE6	22	56	Reserved
PFI14/GATE6	21	55	GND
GND	20	54	PFI13/UP_DOWN6
Reserved	19	53	PFI12/OUT6
GND	18	52	PFI11/SOURCE7
PFI9/UP_DOWN7	17	51	PFI10/GATE7
PFI8/OUT7	16	50	GND
PFI7/DIO7	15	49	GND
GND	14	48	PFI6/DIO6
PFI4/DIO4	13	47	PFI5/DIO5
PFI3/DIO3	12	46	GND
GND	11	45	PFI2/DIO2
PFI0/DIO0	10	44	PFI1/DIO1
PFI32/OUT1	9	43	Reserved
PFI34/GATE1	8	42	GND
PFI35/SOURCE1	7	41	GND
PFI33/UP_DOWN1	6	40	PFI37/UP_DOWN0
PFI36/OUT0	5	39	GND
Reserved	4	38	Reserved
PFI38/GATE0	3	37	Reserved
PFI39/SOURCE0	2	36	GND
+5V	1	35	Reserved

Figure 1. NI 660x I/O Connector

Synchronizing Networked Measurements with GPS

You can correlate measurements performed in a wide area using the Global Positioning System (GPS). With the PXI-6608, you can correlate data from several PXI chassis, determine the time when a hardware event occurs, or generate a pulse at a user-specified time.

I/O Connector

The NI 660x devices each have a 68-pin shielded, latching connector, with a SOURCE, GATE, UP/DOWN, and OUT signal for each of the counter/timers. PFI<8..31> can be used as general-purpose DIO lines when not used as counter/timer I/O signals. The DIOn lines are the eight dedicated DIO lines. The PCI-6601 devices have the same I/O interface, except that only counters 0-3 are present.

Driver Software

With NI-DAQ driver software, you can configure your devices interactively, write custom programs, and perform counter/timer I/O easily. NI-DAQ provides the counter/timer functions natively, so you can programmatically select whether you want to measure position with a quadrature encoder, measure a frequency, output a pulse train, or perform one of the other provided counter/timer functions. NI-DAQ also includes numerous example programs for LabVIEW and other ADEs to quickly get you started with your application.

Ordering Information

NI PCI-6601 777918-01
NI PCI-6602 777531-01
NI PXI-6602 777557-01
NI PXI-6608 777937-01

Includes NI-DAQ driver software and calibration certificate.

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

Recommended Configurations

Family	DAQ Device	Accessory	Cable
NI 6601	PCI-6601	CB-68LP (777145-01)	SH68-68-D1 (183432-01)
NI 6602	PCI-6602	BNC-2121 (778289-01)	SH68-68-D1 (183432-01)
	PXI-6602	TB-2715 (778242-01)	None required
NI 6608	PXI-6608	TB-2715 (778242-01)	None required

See page 390 for accessory and cable information.

BUY ONLINE!

Visit ni.com/info and enter pci6601, pci6602, pxi6602, and/or pxi6608.

Counter/Timer Accessories and Cables

Figure 1. BNC-2121 Connector Block

Figure 2. CA-1000 Configurable Signal Conditioning Solution

Accessory and Cable Selection Process

Step 1. Select your counter/timer device from Tables 1 and 2.

Step 2. Using Tables 1 and 2 as a guide, determine which accessories are appropriate for that device. Select an accessory using Table 3 as reference.

Step 3. Using Tables 1 and 2, determine the appropriate cable solution for your selected counter/timer device and accessory.

Accessories

BNC-2121 (See Figure 1)

Connector block with BNC and spring terminal connections for easy connection of I/O signals to counter/timer devices. The BNC-2121 offers spring terminals, as well as eight dedicated and six user-defined BNC connectors, which provide access to all I/O signals. This connector block is also a full-featured test accessory that provides pulse-train, trigger, and quadrature encoder signals. For the connections, refer to the BNC-2121 user guide at ***ni.com/manuals***

BNC-2121 778289-01

Dimensions – 26.7 by 11.2 by 5.5 cm (8.0 by 4.4 by 2.2 in.)

CA-1000 (See Figure 2)

Configurable signal connectivity solution for connecting counter/timers to different types of standard I/O connectors. You can also incorporate switches and LED indicators. You can place the CA-1000 under a laptop PC, on a benchtop, or in a 19 in. rack.

CA-1000 .....See page 351

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

PCI-6601, PCI-6602

Accessories	Cables
BNC-2121, CA-1000, SCB-68, TBX-68, CB-68LP, and CB-68LPR	– R6868 or SH68-68-D1
TB-2715	N/A

Table 1. Accessories and Cables for PXI-6601 and PCI-6602

PXI-6602, PXI-6608

Accessories	Cables
BNC-2121, CA-1000, SCB-68, TBX-68, CB-68LP, and CB-68LPR	– R6868 or SH68-68-D1
TB-2715	Connects directly to the device

Table 2. Accessories and Cables for PXI-6602 and PXI-6608

Accessory	Description	Page
BNC-2121	BNC connector block with built-in test features	390
CA-1000	Configurable connector accessory	390
SCB-68	Shielded screw connector block	391
TB-2715	Front-mount terminal block for PXI-660x	391
TBX-68	DIN-rail connector block	391
CB-68LP	Low-cost screw connector block	391
CB-68LPR	Low-cost screw connector block	391

Table 3. Overview of Accessories

Counter/Timer Accessories and Cables

SCB-68 Shielded I/O Connector Block (See Figure 3)

Shielded I/O connector block for easy connection of I/O signals to the counter/timer devices. The screw terminals are housed in a metal enclosure for protection from noise corruption. Combined with a shielded cable, the SCB-68 provides rugged, very low-noise signal termination. The SCB-68 also includes two general-purpose breadboard areas.

SCB-68 776844-01

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

Figure 3. SCB-68 Shielded I/O Connector Block

TB-2715 Terminal Block (See Figure 4)

With the TB-2715 terminal block for PXI counter/timer devices, you can connect signals directly without additional cables. Screw terminals provide easy connection of I/O signals. The TB-2715 latches to the front of your PXI module with locking screws and provides strain relief.

TB-2715 778242-01

Dimensions – 8.43 by 10.41 by 2.03 cm (3.32 by 4.1 by 0.8 in.)

Figure 4. TB-2715 I/O Terminal Block

TBX-68 I/O Connector Block with DIN-Rail Mounting (See Figure 5)

Termination accessory with 68 screw terminals for easy connection of field I/O signals to the counter/timer devices. 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.)

Figure 5. TBX-68 I/O Connector Block

CB-68LP and CB-68LPR I/O Connector Blocks (See Figure 6)

Low-cost termination accessories with 68 screw terminals for easy connection of field I/O signals to the counter/timer devices. The connector blocks include standoffs for use on a desktop or mounting in a custom panel. The CB-68LP has a vertically mounted 68-pin connector. The CB-68LPR has a right-angle mounted connector for use with with the CA-1000.

CB-68LP 777145-01

Dimensions – 14.35 by 10.74 cm (5.65 by 4.23 in.)

CB-68LPR 777145-02

Dimensions – 7.62 by 16.19 cm (3.00 by 6.36 in.)

Figure 6. CB-68LP and CB-68LPR I/O Connector Blocks

Counter/Timer Accessories and Cables

Figure 7. RTSI Bus Cable

Figure 8. Extended RTSI Bus Cable

Figure 9. SH68-68-D1 Shielded Cable

Figure 10. R6868 Ribbon I/O Cable

Figure 11. 68-Pin Custom Cable Kit

Cables

RTSI Bus Cables (See Figures 7 and 8)

Use RTSI bus cables to connect timing and synchronization signals among measurement, vision, motion, and CAN boards for PCI. For systems using long and short boards, order the extended RTSI cable.

2 boards 776249-02
3 boards 776249-03
4 boards 776249-04
5 boards 776249-05
Extended, 5 boards 777562-05

SH68-68-D1 Shielded Cable (See Figure 9)

Shielded 68-conductor cable terminated with two 68-pin female 0.050 series D-type connectors. This cable connects counter/timer devices to accessories.

1 m 183432-01
2 m 183432-02

R6868 Ribbon I/O Cable (See Figure 10)

68-conductor flat ribbon cable terminated with two 68-pin connectors. Use this cable to connect the NI PCI-6601 to an accessory. For signal integrity with high-frequency signals, use the SH68-68-D1 with the NI 6602 and NI 6608.

1 m 182482-01

Custom Connectivity Components

68-Pin Custom Cable Connector/Backshell Kit (See Figure 11)

68-pin female mating custom cable kit for use in making custom 68-conductor cables. Solder-cup contacts are available for soldering of cable wires to the connector.

68-pin custom cable kit 776832-01

PCB Mounting Connectors

Printed circuit board (PCB) connectors for use in building custom accessories that connect to 68-conductor shielded and ribbon cables. Two connectors are available, one for right-angle and one for vertical mounting onto a PCB.

68-pin, male, right-angle mounting.....777600-01
68-pin, male, vertical mounting.....777601-01

Counter/Timer Specifications

Specifications

These specifications are typical for 25 °C unless otherwise noted.

Timing I/O

General-Purpose Up/Down Counter/Timers

Number of channels
- NI 6601 ..... 4 up/down counters
- NI 6602/6608 ..... 8 up/down counters

Counter size/number of bits ..... 32 bits
Prescalers (per counter) ..... 3 bits (divided by 8)
1 bit (divided by 2)

Disabled (by default)
Power-on state ..... Input (high-Z), pulled low
Pull down current: 10 µA (min) to 200 µA (max)
Hysteresis ..... 300 mV Schmitt triggers
Compatibility ..... 5 V TTL/CMOS

Digital logic levels

Level	Minimum	Maximum
Input low voltage	-0.3 V	0.8 V
Input high voltage	2.0 V	5.25 V
Output low voltage (I_{out} = 4 mA)	–	0.4 V
Output high voltage (I_{out} = 4 mA)	2.4 V	–

Base clocks available
- NI 6601 ..... 100 kHz and 20 MHz
- NI 6602/6608 ..... 100 kHz, 20 MHz, and 80 MHz

Base clock accuracy (NI 6601 and NI 6602) ..... ±0.005% (50 ppm)[1]
Base clock (OCXO) accuracy (NI 6608) ..... ±0.0000075% (75 ppb)
Maximum source frequency
External source selections ..... I/O connector, RTSI/PXI Trigger lines, software selectable
External gate selections ..... I/O connector, RTSI/PXI Trigger lines, software selectable

[1] If a PXI-6608 is installed in slot 2 of a PXI chassis, then the PXI-6608 and any PXI-6602 installed in that chassis inherit a base clock accuracy of ±0.0000075% (75 ppb).

Family	Without Prescaling	With Prescaling
NI 6601	20 MHz	60 MHz
NI 6602	80 MHz	125 MHz
NI 6608	80 MHz	125 MHz

Minimum source pulse duration
- With prescalers ..... 3.5 ns; edge-detect mode
- Without prescalers ..... 5 ns; edge-detect mode

Minimum gate pulse duration ..... 5 ns; edge-detect mode
Frequency ranges to measure or generate

Data Transfers

Family	Frequency to Measure	Min/Max Frequency to Generate
NI 6601	20 MHz	10 MHz
NI 6602	80 MHz	40 MHz
NI 6608	80 MHz	40 MHz

For more information, please visit ***ni.com/info*** and enter exatzz.

Transfer modes ..... DMA, interrupts, programmed I/O

Transfer rates

DMA[1,2]		Interrupt[1,3]	
Finite Operation Buffer Size (S)	Rate (MS/s)	Finite Operation Buffer Size (S)	Rate (kS/s)
100	5.0	100	55
1,000	4.2	1,000	49
10,000	2.0	10,000	49
100,000	1.8	100,000	48

[1]Values may vary depending on your computer hardware, operating system and system activity. Benchmark data was determined on a Pentium II 400 MHz computer with 64 MB RAM running Windows 98 and LabVIEW using one counter of a PCI-6602. [2]The number of simultaneous DMA transfers you can perform is equivalent to the DMA channels available on your device. [3]The rate is based on one counter using the interrupts. If multiple counters share interrupts, the transfer rate per counter is lower.

Continuous Operation		Continuous Operation	
Buffer Size (MS)	Rate (kS/s)	Buffer Size (kS)	Rate (kS/s)
50	28	50	15

DMA channels
- NI 6601 1
- NI 6602/6608 3

Oven-Controlled Crystal Oscillator (OCXO) (NI 6608 Only)

Frequency ..... 10 MHz
OCXO accuracy ..... ±0.0000075% (75 ppb)
Warm-up time (to within 0.02 ppm of operating frequency) ..... 5 minutes
Frequency stability versus supply voltage change (±5%) ..... ≤ 0.005 ppm
Temperature stability (0 to 50 °C) ..... ≤ 0.005 ppm
Drift in frequency ..... ≤ 0.00045 ppm/day
≤ 0.045 ppm/year
Allowed frequency adjustment ..... 0.5 ppm, typical

Note: You can use the OCXO to replace the PXI 10 MHz backplane clock when the PXI-6608 is installed in the PXI star trigger slot (Slot 2). You can also use it as the counter source or gate in any slot.

Digital I/O

Number of channels ..... Up to 32 input/output
Compatibility ..... 5 V TTL/CMOS
Power-on state ..... Input (high-Z), pulled low
Pulldown current ..... 10 µA (min) to 200 µA (max)
Hysteresis ..... 300 mV Schmitt triggers
Data transfers ..... Unstrobed I/O

Digital logic levels

Level	Minimum	Maximum
Input low voltage	-0.3 V	0.8 V
Input high voltage	2.0 V	5.25 V
Output low voltage (I_{out} = 4 mA)	–	0.4 V
Output high voltage (I_{out} = 4 mA)	2.4 V	–

RTSI Bus (PCI Only)

Trigger lines 7
Minimum pulse width for trigger and clock ..... 25 ns

PXI Trigger Bus (PXI Only)

Trigger lines 6
Star trigger 1

Bus Interface

PCI, PXI ..... Master, slave

Power Requirements

Device	+5 VDC (±5%)*	Power Available at I/O Connector
NI 6601	0.4 to 0.75 A	+4.65 to +5.25 VDC, 1 A
NI 6602	0.5 to 1.5 A	+4.65 to +5.25 VDC, 1 A
NI 6608	1 to 2.5 A	+4.65 to +5.25 VDC, 1 A

*Excludes power consumed through I/O connector

Physical

Dimensions (not including connectors)
- PCI ..... 17.5 by 9.9 cm (6.9 by 3.9 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 50 °C
Storage temperature ..... -20 to 70 °C
Relative humidity ..... 10 to 90%, noncondensing

Certifications and Compliances

CE Mark Compliance CE

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The counter/timer is a basic unit of hardware functionality on a measurement device. The more counter/timers there are on a device, the more counting/timing operations that device can simultaneously perform. The number of DMA channels determines how many buffered, high-speed operations can be simultaneously performed. See page 393 for more information.

Counter/Timer Size or Number of Bits

The counter size or number of bits indicates how high a counter can count. For example, a 32-bit counter can count up to 2^{32}-1 or 4,294,967,295 before it rolls over. A high number of bits is beneficial in cases such as pulse width measurements where a wide dynamic range is required. For example, if you measure pulse widths with a 12.5 ns resolution (80 MHz timebase) using a counter/timer with 32 bits, you can measure pulse widths up to 53 s [$(2^{32}$-1) x 12.5 ns)] with 12.5 ns resolution.

Maximum Source Frequency

Maximum source frequency represents the speed of the fastest signal the counter can count. If you use a higher source frequency, you can achieve higher resolution. For example, an 80 MHz counter can count pulses that are 12.5 ns ($\frac{1}{80 \times 10^6}$) apart. You can use prescalers to increase the maximum source frequency for event counting and frequency measurement.

Family	Bus	Counter/ Timers	Size	Max Source Frequency	Compatibility	Digital I/O	Pulse Generation	Buffered Operations	Debouncing/ Glitch Removal	Oscillator Stability	GPS Synchr.	Buffered Operations[2] DMA	Buffered Operations[2] Interrupt	Page
NI 6601	PCI	4	32 bits	20 MHz[1]	5 V TTL/CMOS	Up to 32	✓	✓	✓	50 ppm	–	1	3	388
NI 6602	PCI PXI	8	32 bits	80 MHz[1]	5 V TTL/CMOS	Up to 32	✓	✓	✓	50 ppm	–	3	5	388
NI 6608	PXI	8	32 bits	80 MHz[1]	5 V TTL/CMOS	Up to 32	✓	✓	✓	75 ppb	✓	3	5	388

[1]Max Source Frequency with prescalers is 60 MHz for the NI 6601 and 125 MHz for the NI 6602 and NI 6608. These frequencies are dependent on drive strength of input signal and cable length. Consider these speeds to be the maximum.
[2]DMA transfers have higher throughput than interrupt transfers. See page 393 for detailed specifications.

Counter/Timer Overview

Signal Compatibility

Signal compatibility indicates the signal levels a counter/timer can measure or output, such as TTL/CMOS.

Buffered Operations and DMA

The National Instruments counter/timers can capture numerous data points without dead times. These types of measurements, called buffered operations, are valuable in applications that range from statistical analysis on production lines to experiments in molecular chemistry. For instance, when you configure a counter for buffered period measurement, data is moved from the counter into a buffer. Each edge that initiates a measurement also causes a transfer of the count into the buffer, as shown in Figure 1. With buffered operations, data is transferred to the computer memory using DMA or interrupts. DMA offers a considerable performance advantage; if your application requires this performance simultaneously on multiple counter/timers, you must know how many DMA channels are available on a particular counter/timer device. For example, if a device contains three DMA channels and eight counter/timers, you can simultaneously perform three high-speed and five lower-speed, interrupt-based, buffered operations. On NI 660x devices, National Instruments implements DMA with the NI MITE chip, which is optimized for measurement applications.

Timebase Stability

Timebase stability can be important when you need to make high-quality measurements. Crystal oscillators typically form the basis of electrical circuits used to drive timing of a measurement application. In an ideal case, the oscillation frequency would be constant, but in reality, many factors influence the the behavior of an oscillator. A commonly used measure of quality for an oscillator is stability.

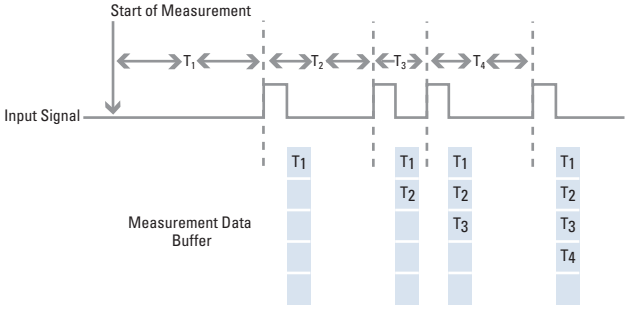

Figure 1. Buffered Period Measurement with Counter/Timers

Units used for stability are typically parts per million (ppm) and parts per billion (ppb). For example, the frequency of a 10 MHz oscillator with 10 ppm stability can be 10 MHz ± 100 Hz; with 100 ppb stability it can be 10 MHz ± 1 Hz.

The best technique for improving oscillator stability is to precisely control its temperature as is done in an oven-controlled crystal oscillator (OCXO). The PXI-6608 features such an oscillator.

Debouncing and Glitch Removal

Noisy signals containing glitches and/or bouncing effects pose special challenges for some counter/timer measurements. Noise may be introduced in the source of the signal, such as with electromechanical relays, or in the connection if there are strong sources of interference in the vicinity of the system. NI 660x devices contain programmable digital filters that eliminate measurement errors caused by spurious spikes and bouncing. Figure 2 shows an example of digital filtering.

Calibration

Calibration is a key component of any measurement solution. In the case of counter/timers, timebase calibration ensures that the frequency and time measurements are accurate. Calibration certificates enclosed with the National Instruments counter/timers and periodic calibration satisfy your ISO-9000 requirements, certifying that your instrument has been properly calibrated. See page 21 for more information.

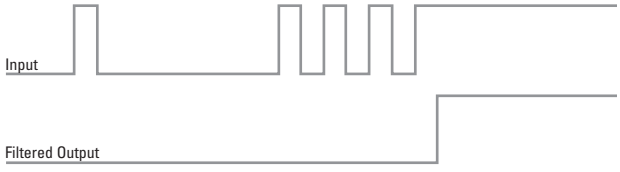

Figure 2. Debouncing and Glitch Removal