Computer-Based Instruments

NI 2501/2503 User Manual

24-Channel Two-Wire Multiplexer

NATIONAL INSTRUMENTS™

July 1998 Edition
Part Number 321906B-01

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Conventions

The following conventions are used in this manual.

<> — Angle brackets containing numbers separated by an ellipsis represent a range of values associated with a port, bit, or signal name (for example, CH<0..7> stands for the signals CH0 through CH7).

☞ — This icon to the left of bold italicized text denotes a note, which alerts you to important information.

This icon to the left of bold italicized text denotes a caution, which advises you of precautions to take to avoid injury, data loss, or a system crash.

This icon to the left of bold italicized text denotes a warning, which advises you of precautions to take to avoid being electrically shocked.

bold italic — Bold italic text denotes a note, caution, or warning.

italic — Italic text denotes variables, emphasis, a cross reference, or an introduction to a key concept. This font also denotes text from which you supply the appropriate word or value, as in CH*x*.

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1

Routing Signals with Your NI 2501/2503

This manual describes the electrical and mechanical aspects of the NI 2501 FET multiplexer and the NI 2503 mechanical relay multiplexer and contains information concerning their installation and operation. This manual uses the term *NI 2501/2503* whenever information applies to both instruments.

About the NI 2501/2503

This section summarizes the features and operation of the NI 2501/2503 switch card. Refer to Chapter 2, *NI 2501/2503 Operation*, for more complete details. In addition, refer to Appendix A, *Specifications*, for detailed specifications of the two switch cards.

The NI 2501 is a FET switch card, and the NI 2503 is an armature relay switch card. Each consists of a 24 x 1 two-wire multiplexer in PXI/Compact PCI format. You can take advantage of the switch card's flexibility to handle a wide variety of test systems through the use of various accessories and software configurations. You can use the National Instruments NI-SWITCH software included with your kit to configure and operate the NI 2501/2503 switch card.

The NI 2501/2503 can also operate as two 12 x 1 or four 6 x 1 two-wire multiplexers. You can use software-configurable switches to configure the switch card as a 48 x 1 one-wire multiplexer for making large numbers of common referenced measurements. In addition, the NI 2501/2503 can operate as a 12 x 1 four-wire multiplexer to handle resistive measurements, such as thermistors or RTDs. Finally, you can use a National Instruments TB-2606 terminal block to further configure the NI 2501/2503 as a 6 x 4 two-wire matrix.

The *Connecting Signals* section of this chapter contains more information on one-wire, two-wire, four-wire, and matrix configurations, and includes diagrams of the pinout connections to make.

Refer to Appendix B, *Accessories*, for more information on terminal blocks you can order from National Instruments.

You can also use multiple NI 2501/2503 cards together to expand the size of the multiplexer or matrix. For example, you can connect two cards to create a 48 x 1 two-wire multiplexer or a 12 x 4 two-wire matrix.

Caution ***The maximum voltage is different for the NI 2501 and NI 2503 switch cards. If you intend to use more than one type of card, be sure you do not exceed the maximum voltage of any card in your system. Refer to Appendix A, Specifications, for information.***

Analog Bus

The NI 2501/2503 works with a four-wire analog bus. You connect the analog bus to the switch card through its main front-panel connector. You can use the analog bus to simplify connecting multiple cards to an instrument such as a digital multimeter (DMM). This bus makes it possible to create large systems using multiple switch cards.

For example, if you have two NI 2501/2503 cards—or one of each—in two adjacent slots, you can connect them through the analog bus and create a 48 x 1 two-wire multiplexer. With this flexibility, you keep the wiring of the modules to a minimum while you create large switching solutions. In such cases, the scanning architecture uses some of the PXI trigger lines for synchronization and delivers full access to all of the scanning features for the cards. The National Instruments software you receive with the NI 2501/2503 handles the complexity of programming the cards.

Triggers

Two triggers are used to handshake the NI 2501/2503 switch with PXI instruments or other external instruments. The *Scanner Advanced* trigger indicates when the card has closed all the necessary switches for the next scan and the switches have settled, or *debounced*. This trigger is typically wired to a measurement device, such as a DMM, which is configured to take a reading when it receives the trigger.

The *External Trigger Input* trigger is sourced by another instrument, such as the DMM, and causes the NI 2501/2503 to advance to the next entry in the scan list. The triggers can be routed to the front connector of the NI 2501/2503, to any of the PXI TTL triggers, or to the PXI star trigger. If no external trigger input is available, you can have the software trigger the NI 2501/2503 to advance to the next entry in the scan list.

Refer to Chapter 2, *NI 2501/2503 Operation*, for more information on triggers.

Cold-Junction Sensor Channel

For low-voltage measurements, such as those provided by thermocouples, the NI 2503 has very low thermal offset—less than 2 µV—to ensure accurate measurements. For cold-junction compensation when switching thermocouples, the NI 2501/2503 has a dedicated channel for a temperature sensor. The National Instruments TB-2605 and TBX-68S terminal blocks both have onboard temperature sensors that connect to the dedicated cold-junction sensor channel.

NI 2501 Amplifier

The NI 2501 has an amplifier with a gain of 1. This amplifier can be switched in-line before the COM0 signal and the AB0 signal. The amplifier helps to decrease the settling time of the FET switch. The amplifier's high impedance isolates the FET from the resistance, capacitance, and inductance in the external wiring. This isolation decreases the resistance/capacitance time constant seen by the FET, which improves settling time.

The amplifier has an offset that should be calibrated for more accurate measurements. The calibration data can be stored into and retrieved from the EEPROM on the board. The software you received with your switch card includes API function calls to retrieve and store calibration data.

When the amplifier is used, the switch card becomes directional, where CH*x* is for signal inputs and COM0 or AB0 are for signal outputs.

The NI 2501 also has an amplifier in the CJS0+ to COM0+ signal path. This amplifier in the cold-junction sensor signal path is used to improve settling time performance. It prevents the impedance of the cold-junction sensor from increasing the settling time when switching the CJS channel. As a result, when scanning thermocouples, the settling time for the cold-junction sensor channel should be about the same as for the channels with the thermocouples.

Connecting Signals

This section describes the signal connections to the NI 2501/2503 module via the module front connector. This section also includes specifications and connection instructions for the signals on the NI 2501/2503 module connectors.

Caution ***Static electricity is a major cause of component failure. To prevent damage to the electrical components in the module, observe antistatic precautions whenever removing a module from the chassis or whenever working on a module.***

Front Connector

The pinout assignments for the NI 2501/2503 front connector vary depending on the wiring mode you use. The following four diagrams show the pin assignments for two-wire mode, one-wire mode, four-wire mode, and matrix mode, respectively. Two-wire mode is shown first because it is the most common configuration. Table 1-1, following the diagrams, describes the connector signals. For more information on the wiring modes, refer to the *Multiplexer* section in Chapter 2, *NI 2501/2503 Operation*.

Warning ***Any connections that exceed the maximum settings for the NI 2501/2503 can result in an electrical shock hazard and damage to the NI 2501/2503 module and any or all of the boards connected to the PXI backplane. National Instruments is NOT liable for any damages or injuries resulting from exceeding maximum voltage ratings. Refer to Appendix A, Specifications, for information.***

CJS0–	34	68	CJS0+
CH0–	33	67	CH0+
CH1–	32	66	CH1+
CH2–	31	65	CH2+
CH3–	30	64	CH3+
CH4–	29	63	CH4+
CH5–	28	62	CH5+
COM0–	27	61	COM0+
COM1–	26	60	COM1+
CH6–	25	59	CH6+
CH7–	24	58	CH7+
CH8–	23	57	CH8+
1_WIRE_LO_REF[1]	22	56	GND
CH9–	21	55	CH9+
CH10–	20	54	CH10+
CH11–	19	53	CH11+
AB0–	18	52	AB0+
AB1–	17	51	AB1+
CH12–	16	50	CH12+
CH13–	15	49	CH13+
CH14–	14	48	CH14+
CH15–	13	47	CH15+
CH16–	12	46	CH16+
CH17–	11	45	CH17+
COM2–	10	44	COM2+
COM3–	9	43	COM3+
+5 V	8	42	SCAN_ADV
GND	7	41	EXT_TRIG_IN
CH18–	6	40	CH18+
CH19–	5	39	CH19+
CH20–	4	38	CH20+
CH21–	3	37	CH21+
CH22–	2	36	CH22+
CH23–	1	35	CH23+

[1]not used in two-wire mode

Figure 1-1. Front Connector Pinout Assignments for Two-Wire Mode

CJS–[1]	34	68	CJS+[1]
CH24	33	67	CH0
CH25	32	66	CH1
CH26	31	65	CH2
CH27	30	64	CH3
CH28	29	63	CH4
CH29	28	62	CH5
COM0–	27	61	COM0+
COM1– (CH30–CH35)[1]	26	60	COM1+ (CH6–CH11)[1]
CH30	25	59	CH6
CH31	24	58	CH7
CH32	23	57	CH8
1_WIRE_LO_REF	22	56	GND
CH33	21	55	CH9
CH34	20	54	CH10
CH35	19	53	CH11
AB0–	18	52	AB0+
AB1–[1]	17	51	AB1+[1]
CH36	16	50	CH12
CH37	15	49	CH13
CH38	14	48	CH14
CH39	13	47	CH15
CH40	12	46	CH16
CH41	11	45	CH17
COM2– (CH36–CH41)[1]	10	44	COM2+ (CH12–CH17)[1]
COM3– (CH42–CH48)[1]	9	43	COM3+ (CH18–CH23)[1]
+5 V	8	42	SCAN_ADV
GND	7	41	EXT_TRIG_IN
CH42	6	40	CH18
CH43	5	39	CH19
CH44	4	38	CH20
CH45	3	37	CH21
CH46	2	36	CH22
CH47	1	35	CH23

[1]not used in one-wire mode

Figure 1-2. Front Connector Pinout Assignments for One-Wire Mode

CJS–[1]	34	68	CJS+[1]
CH0A–	33	67	CH0A+
CH1A–	32	66	CH1A+
CH2A–	31	65	CH2A+
CH3A–	30	64	CH3A+
CH4A–	29	63	CH4A+
CH5A–	28	62	CH5A+
COM0A–	27	61	COM0A+
COM1A–	26	60	COM1A+
CH6A–	25	59	CH6A+
CH7A–	24	58	CH7A+
CH8A–	23	57	CH8A+
1_WIRE_LO_REF[1]	22	56	GND
CH9A–	21	55	CH9A+
CH10A–	20	54	CH10A+
CH11A–	19	53	CH11A+
AB0A–	18	52	AB0A+
AB0B–	17	51	AB0B+
CH0B–	16	50	CH0B+
CH1B–	15	49	CH1B+
CH2B–	14	48	CH2B+
CH3B–	13	47	CH3B+
CH4B–	12	46	CH4B+
CH5B–	11	45	CH5B+
COM0B–	10	44	COM0B+
COM1B–	9	43	COM1B+
+5 V	8	42	SCAN_ADV
GND	7	41	EXT_TRIG_IN
CH6B–	6	40	CH6B+
CH7B–	5	39	CH7B+
CH8B–	4	38	CH8B+
CH9B–	3	37	CH9B+
CH10B–	2	36	CH10B+
CH11B–	1	35	CH11B+

[1]not used in four-wire mode

Figure 1-3. Front Connector Pinout Assignments for Four-Wire Mode

Signal	Pin	Pin	Signal
CJS–[1]	34	68	CJS+[1]
COL0–	33	67	COL0+
COL1–	32	66	COL1+
COL2–	31	65	COL2+
COL3–	30	64	COL3+
COL4–	29	63	COL4+
COL5–	28	62	COL5+
ROW0–	27	61	ROW0+
ROW1–	26	60	ROW1+
COL0–	25	59	COL0+
COL1–	24	58	COL1+
COL2–	23	57	COL2+
1_WIRE_LO_REF[1]	22	56	GND
COL3–	21	55	COL3+
COL4–	20	54	COL4+
COL5–	19	53	COL5+
AB0– (ROW0–)	18	52	AB0+ (ROW0+)
AB1– (ROW2–)	17	51	AB1+ (ROW2+)
COL0–	16	50	COL0+
COL1–	15	49	COL1+
COL2–	14	48	COL2+
COL3–	13	47	COL3+
COL4–	12	46	COL4+
COL5–	11	45	COL5+
ROW2–	10	44	ROW2+
ROW3–	9	43	ROW3+
+5 V	8	42	SCAN_ADV
GND	7	41	EXT_TRIG_IN
COL0–	6	40	COL0+
COL1–	5	39	COL1+
COL2–	4	38	COL2+
COL3–	3	37	COL3+
COL4–	2	36	COL4+
COL5–	1	35	COL5+

[1] not used in matrix mode

Figure 1-4. Front Connector Pinout Assignments to Create a 6 x 4 Matrix

For matrix mode, connect all pins with the same name together external to the switch card. The National Instruments TB-2606 terminal block connects the necessary pins to create the 6 x 4 matrix.

Table 1-1. Front Connector Signal Description

Signal Name	Type	Description
+5 V	Output	+5 VDC Source—Powers the temperature sensor on the terminal block. 0.2 mA of source protected by a resettable poly fuse.
GND	Output	Ground
CJS±	Input	Cold-junction Temperature Sensor Input—Connects to the temperature sensor of the terminal block.
1_WIRE_LO_REF	Input	The common reference signal used in one-wire mode.
EXT_TRIG_IN	Input	External Trigger Input—Trigger from an instrument to advance the switch card to the next scan entry.
SCAN_ADV	Output	Scanner Advanced—Trigger to an instrument that indicated the switch card has advanced to the next scan and relays are debounced.
CH<0..47> (one wire) CH<0..23>± (two wire) CH<0..11>A± (four wire) CH<0..11>B± (four wire)	Input/Output	Channels—Where signals are connected to the switch card. CH*x*+ and CH*x*– are switched together.
COM0± (one wire) COM<0..3>± (two wire) COM<0..1>A± (four wire) COM<0..1>B± (four wire)	Input/Output	Common—The common for each bank.
AB0± (one wire) AB<0..1>± (two wire) AB0A± (four wire) AB0B± (four wire)	Input/Output	Analog Bus—Used to wire multiple switch cards to an instrument such as a DMM.
COL<0..5>±	Input/Output	Columns—Where signals are connected to the switch card. The card behaves as a matrix when proper external wiring is added.
ROW<0..3>±	Input/Output	Rows—Where signals are connected to the switch card. In matrix configuration any row can be connected to any column.

Contact Protection

Caution ***When inductive loads are connected to the relays, a large counter electromotive force may occur at relay switching time due to the energy stored in the inductive load. These flyback voltages can severely damage the relay contacts and greatly shorten the life of the relay.***

It is best to limit flyback voltages at your inductive load by installing a flyback diode for DC loads or a movistor for AC loads.

Terminal Blocks

Several terminal blocks with screw terminals are available for easy signal connection to the NI 2501/2503 inputs. Refer to Appendix B, *Accessories*.

Software Choices

You have several options to choose from when programming your National Instruments switch card. You can use the NI-SWITCH driver software, or National Instruments application software.

NI-SWITCH Driver Software

The NI-SWITCH instrument driver is an Intelligent Virtual Instrument (IVI) compliant instrument driver that is bundled with NI-SWITCH cards at no cost.

NI-SWITCH features a set of operations and attributes that exercise all the functionality of the switching hardware, including configuration, opening/closing, and scanning. In addition, NI-SWITCH comes with an interactive soft front panel and online documentation.

NI-SWITCH eliminates the need to understand complex register programming and interrupt handling in the Microsoft operating systems, and frees you to focus on creating your test system.

National Instruments Application Software

LabVIEW and LabWindows/CVI are innovative program development software packages for data acquisition and control applications. LabVIEW uses graphical programming, whereas LabWindows/CVI enhances traditional programming languages. Both packages include extensive libraries for data acquisition, instrument control, data analysis, and graphical data presentation. Using LabVIEW or LabWindows/CVI can significantly reduce the development time for your data acquisition and control application.

LabVIEW features interactive graphics, a state-of-the-art user interface, and a powerful graphical programming language. The LabVIEW NI-SWITCH VI Library, a series of virtual instruments (VIs) for using LabVIEW with National Instruments switch hardware, is included with the NI-SWITCH driver.

LabWindows/CVI features interactive graphics, a state-of-the-art user interface, and uses the ANSI standard C programming language. The LabWindows/CVI NI-SWITCH Library, a series of functions for using LabWindows/CVI with National Instruments switch hardware, is included with the NI-SWITCH driver.

Third Party Software

The NI-SWITCH instrument driver also includes support files for Microsoft Visual C++ and Microsoft Visual Basic. Please see the NI-SWITCH readme file for version support information.

2

NI 2501/2503 Operation

This chapter contains a functional overview of the NI 2501/2503 module and explains the operation of each functional unit making up the NI 2501/2503 module.

Functional Overview

The block diagrams on the following pages illustrate the key functional components of the switch card modules. Figure 2-1 shows the NI 2501 and Figure 2-2 shows the NI 2503.

The major components of the NI 2501/2503 modules are as follows:

- Multiplexer
- Relay/FET switch control circuitry
- Random scanning
- PXIbus interface
- Triggers

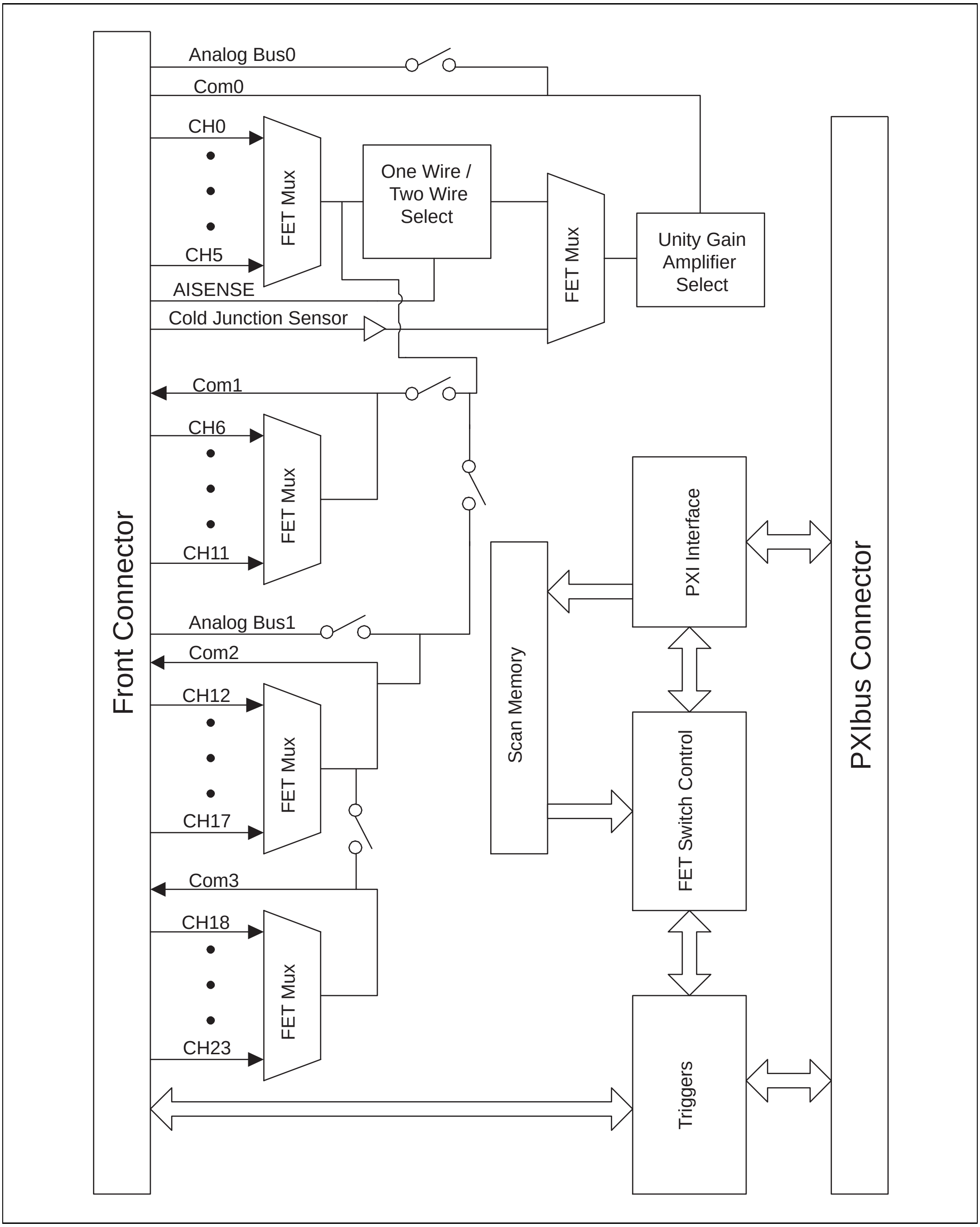

Figure 2-1. NI 2501 Module Block Diagram

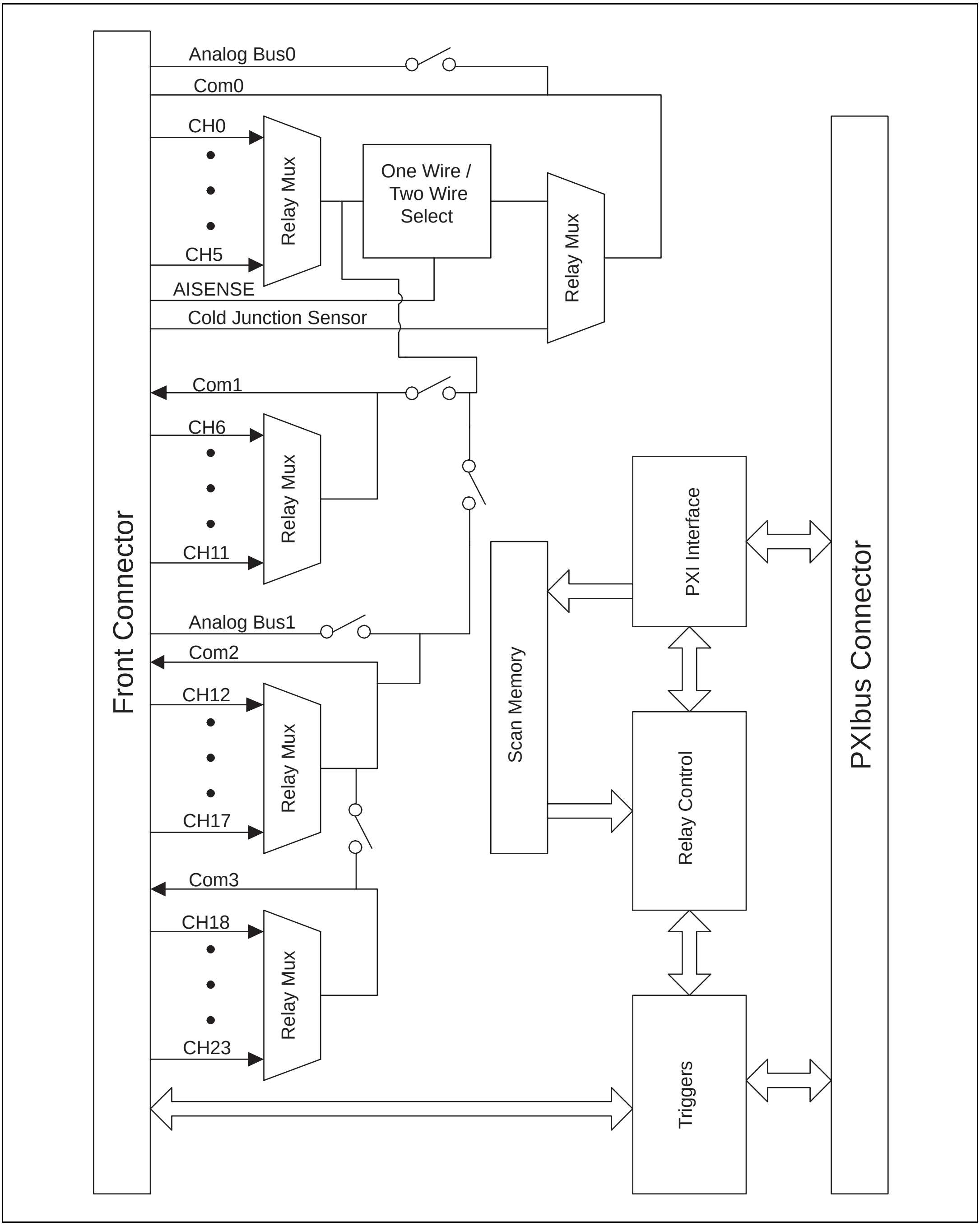

Figure 2-2. NI 2503 Module Block Diagram

Multiplexer

The relay multiplexer consists of four banks of six channels. The switches for the six channels in each bank connect the channels to a common output for each bank.

- Bank 0 consists of Channels 0–5 and Common 0.
- Bank 1 consists of Channels 6–11 and Common 1.
- Bank 2 consists of Channels 12–17 and Common 2.
- Bank 3 consists of Channels 18–23 and Common 3.

Each channel connects to the corresponding bank common by closing its relay/FET switch. You can have multiple channels connected to the bank common at the same time. Bank connection relay/FET switches can combine the commons of the four banks. See Appendix D, *Architecture Drawings*, for illustrations of the NI 2501 and NI 2503 architecture.

The NI 2503 relays are single-side stable. When power is removed from the relay coil, the relay returns to its de-energized state. The de-energized state opens all the relays, disconnecting the device from external inputs and outputs.

See Figures 1-1 through 1-4 in Chapter 1, *Routing Signals with Your NI 2501/2503*, for the pin names used for the different modes of operation. Different names are used for the pin assignments in the different modes to better reflect the operation in the different modes and to simplify the task of wiring.

Two-Wire Mode

Two-wire mode is the default and most common configuration for the NI 2501/2503 switch cards. The CH*x*+ and CH*x*– channels are switched together to the COM*x*+ and COM*x*– signals for the corresponding bank.

One-Wire Mode

One-wire mode doubles the channel count of what is available in two-wire mode. However, the signals connected to the switch card need a common reference. For one-wire measurements, Bank 0 includes extra relays between the multiplexed channel relays and COM0. The 1WIRE relay switch connects COM0– to the 1-Wire Lo Ref signal. The HLSELECT relay connects COM0+ to either CH*x*+ or CH*x*–. The de-energized states for these relays configure the device for two-wire measurements.

Four-Wire Mode

Four-wire mode is typically used for resistance measurements. In this mode, CH*x*A+, CH*x*A–, CH*x*B+, and CH*x*B–, are switched together to COM*x*A+, COM*x*A–, COM*x*B+, and COM*x*B–.

Matrix Mode

By adding some external wiring, you can configure the switch card as a two-wire 6 x 4 crosspoint matrix. (See Figure 1-4 in Chapter 1.) The TB-2606 terminal block simplifies your wiring task by connecting the necessary pins on the switch card's front connector to create the 6 x 4 matrix.

In the matrix configuration, you can connect any ROW*x* signal to any COL*x* signal.

Switch Control Circuitry

The switch control circuitry (SCC) is responsible for opening and closing FET switches on the NI 2501 or relays on the NI 2503. You can load commands for the SCC into memory storage using the driver software you received with your kit. Consult the online help or your software documentation for specific information on the appropriate commands. There are two reasons for storing the commands in memory before the SCC can process them:

- The operate/release time for the NI 2503 is 3 to 5 ms. Using memory storage, the software can send multiple commands to the SCC without having to wait for a relay action to complete.
- The memory is used to store a scan list necessary for hardware random scanning.

Random Scanning

The NI 2501/2503 can perform random scanning. In random scanning, the switch card can scan the channels in any order.

The scan list is downloaded to onboard memory. Commands in the scan list can:

- Open or close relays
- Wait for an external trigger

- Generate a scanner advanced trigger
- Generate a breakpoint interrupt

You can use the driver software to configure the switch card for continuous or one-time scanning. In continuous scanning, the switch card cycles through the scan list until you disable scanning. For one-time scanning, the switch card cycles through the scan list only once.

You can also use software commands to clear the scan list or reset it to the beginning at any time.

The onboard control logic for the NI 2501/2503 switch card gives you direct access to open and close the relays, and also the capability to download up to 1024 random scanning instructions. The software included with the card automatically configures the NI 2501/2503 and downloads the scan list to hardware for you. The scan list itself downloads directly into the memory of the card to deliver the fastest scan possible with no controller intervention. You can configure the switch card to process the scan list once or to continuously loop through the scan list.

When configured to operate as a single switch card with multiple multiplexers—such as four 6 x 1 two-wire multiplexers—the scan architecture makes it possible for each multiplexer to have its own parallel scan list (which must be triggered together). Also, if the switch card is configured as a matrix, the scanning architecture scans the matrix through a series of user-definable states.

PXI Interface

The NI 2501/2503 switch card has a PXI interface through which you can use your driver software to configure and control the card. The NI 2501/2503 takes advantage of PXI features. It uses the PXI TTL triggers to synchronize scanning with a measurement device such as a National Instruments NI-4060 PXI digital multimeter (DMM).

Triggers

External Trigger Input

The NI 2501/2503 can use an external trigger input to advance between scan setups in a scan list. Using the driver software, you can configure the switch card to route the external trigger from any of the PXI TTL trigger lines, the PXI star trigger, or the EXT TRIG IN pin on the front connector. Alternatively, you can use a software command to trigger the switch card.

Routing the external trigger from the front connector to the PXI trigger lines gives you the capability to trigger multiple switch cards with only one board connected to the external trigger from the measurement device.

All external trigger lines are compatible with TTL voltage levels and are edge sensitive.

The external trigger from the front connector requires a minimum pulse width of 500 ns. The line has a low pass filter to prevent false triggering. The minimum pulse width from the PXI TTL triggers and PXI star trigger is 70 ns.

Scanner Advanced

The NI 2501/2503 can generate a scanner advanced trigger to indicate when the switch card is set up and ready to take measurements. Using the driver software, you can configure the switch card to route the scanner advanced (SCANADV) trigger to any PXI TTL trigger line, the PXI star trigger, or the SCAN_ADV pin on the front connector. You can configure the switch card to generate the SCANADV trigger when a relay has settled (or debounced).

All SCANADV trigger lines are compatible with TTL voltage levels.

Because the NI 2501/2503 has open collector drives on the PXI TTL trigger lines, you can have multiple switch cards using the same trigger line in the multicard SCANADV mode.

Modes

SCANADV has two modes of operation. In its default mode, the SCANADV trigger asserts for 1 µs after the relay has debounced. You can also configure the switch card for handshaking mode, in which the SCANADV trigger goes high after a relay settles, and the SCANADV trigger goes low after the external trigger input asserts. Use this handshaking mode for multicard scanning.

Note ***The NI 2501/2503 ignores external triggers when it is not in a wait-for-trigger state while scanning.***

Initiating Scanning

When you use the NI 2501/2503 to initiate a scan, make sure the measurement device is armed (waiting for trigger) before enabling scanning on the switch card. Enabling scanning causes the first switch(es) in the scan list to close and generates a scanner advanced trigger after the relay/FET switches have settled or debounced.

When you use the measurement device to initiate a scan, make sure scanning is enabled on the NI 2501/2503 before the measurement device starts to take measurements. This ensures that the switch card has the correct signal routed and that the switch card is waiting for an external trigger from the measurement device.

Always configure the triggers in a system before configuring the measurement device or the NI 2501/2503 for scanning. When triggers are configured, a state change or pulse could occur on the trigger line. This is also possible when you reset the switch card.

Multicard Triggering

You can use multiple NI 2501/2503 switch cards together in conjunction with an instrument such as a DMM. In multiple switch-card systems, be sure to identify one switch card as the master switch card.

All other switch cards for the system are identified as slave switch cards. The master switch card can route an external trigger from the front connector to a PXI backplane trigger. In addition, the master switch card can route the SCANADV trigger from the PXI backplane to the front connector. This functionality makes it possible to wire external triggers from/to only one switch card in the system, which simplifies the wiring scheme.

For more information, refer to the *NI-SWITCH Software User Manual*.

A

Specifications

This appendix lists the specifications for the NI 2501 and NI 2503 switch cards. These specifications are typical at 25° C unless otherwise noted.

NI 2501

Input Characteristics

Number of Channels 24

Maximum Working Voltage .... ± 10 VDC from chassis ground

Overvoltage Protection
- Signals CH<0..23>, COM<0..3>
  - Powered on or off .... ± 25 VDC
- Signals AB<0..1>
  - Powered on .... ± 25 VDC
  - Powered off.............................. ± 15 VDC

FET Switch On Resistance
- Typical .... 50 Ω
- Max @ 25° C.................................. 85 Ω
- Max @ 85° C.................................. 100 Ω

Total Signal Path Resistance (Channel *x* to Analog Bus *x*)
- Typical .... 1650 Ω
- Maximum.. 1900 Ω

Total Signal Path Resistance (Channel *x* to Common *x*)
- Typical .... 1900 Ω
- Maximum.. 2150 Ω

Transfer Characteristics

Channel Amplifier (Unity Gain)

Offset Voltage (Differential) ....1.2 mV max

Cold-Junction Sensor Channel Amplifier (Unity Gain)

Offset Voltage

Maximum ....60 µV

Frequency Bandwidth (50 Ω source, 1 MΩ 25 pF load)

–3 dB ....400 KHz

–10 dB ....1 MHz

Channel to Channel
Crosstalk/Isolation ....50 dB

Dynamic Characteristics

Operating Speed

Typical..25,000 cycles/s

Maximum ....250,000 cycles/s

Settling Time (+5 V to –5 V Step) 6 in. AB connector to PXI-MIO

0.012% Accuracy

With output buffer selected......8.5 µs

Without output buffer...............9.0 µs

0.006% Accuracy

With output buffer selected......10 µs

Without output buffer...............11.5 µs

0.0015% Accuracy

With output buffer selected......16 µs

Without output buffer...............18 µs

Settling Time (+5 V to –5 V Step) 3 m cable to PXI-MIO

0.012% Accuracy

With output buffer selected......21 µs

Without output buffer...............45 µs

0.006% Accuracy

With output buffer selected ..... 30 µs

Without output buffer .... 60 µs

0.0015% Accuracy

With output buffer selected ..... 80 µs

Without output buffer .... 160 µs

Note ***Settling time is greatly affected by the external wiring to the switch card. You can improve the settling time by minimizing the wiring from the analog bus connection to the measurement device.***

PXI Bus Interface

Slave

PXI Trigger Bus

Trigger Lines... 8

Star Trigger 1

Power Requirement

+5 V

Typical .... 300 mA

+12 V

Typical .... 30 mA

–12 V

Typical .... 30 mA

Physical

Dimensions.. 10 by 16 cm (3.9 by 6.3 in.)

Weight.. 0.254 kg (0.56 lb.)

I/O Connector.. 68-pin male SCSI

Environment

Operating Temperature .... 0° to 50° C

Storage Temperature............................ –55° to 150° C

Relative Humidity..................................5% to 90% non-condensing

Shock and Vibration

Functional Shock

MIL-T-28800E Class 3 (30 g half-sine shock pulse)
Also meets IEC 60068-2-27

Random Vibration

MIL-T-28800E, MIL-STD-810E Category 1

Operational...............................5 to 500 Hz, 0.3 g_{rms}

Non-operational........................5 to 500 Hz, 2.4 g_{rms}

Certifications and Compliances

CE Mark Compliance CE

This product meets applicable EU directives as follows:

Safety Isolation................................low-voltage safety,
EN 61010-1:1993

EMC Directive

Immunity ....EN 50082-1:1992

Emissions ....EN 55011:1991,
Group 1 Class A at 10 m

NI 2503

Input Characteristics

Number of Relays Available
as Channels 24

Common Mode Voltage
Channel to Channel......................... 30 V_{rms}/60 VDC
Channel to Earth .... 30 V_{rms}/60 VDC

Maximum Allowed Voltage—Differential Mode or Single ended
AC.. 30 V_{rms}
DC.. 60 VDC

Maximum Switching Capacity—Differential Mode or Single ended
DC.. 1 A @ 30 VDC

Maximum Switching Power per
Differential Channel or Single ended..... 60 VA, 30 W

Contact on Resistance (Initial)............... 100 mΩ

Contact Material..................................... Gold-clad Silver Alloy

Transfer Characteristics

Thermal E.M.F. (Differential)................ <2 µV

Maximum Frequency Bandwidth 50 Ω Termination
Worst case channel .... 35 MHz

Channel to Channel Crosstalk/Isolation
Differential..50 Ω termination

Frequency	Crosstalk
10 KHz	< –100 dB
100 KHz	< –80 dB
1 MHz	< –55 dB
10 MHz	< –30 dB
35 MHz	< –25 dB

Dynamic Characteristics

Maximum Operating Speed....................200 cycles/s

Relay Operate Time (@ 20° C).............3 ms typical, 5 ms max

Relay Release Time (@ 20° C).............1.5 ms typical, 5 ms max

Expected Life
- Mechanical (@ 180 cpm)................5×10^7 operations
- Electrical at Maximum Load...........2×10^6 operations

PXI Bus Interface

Slave

PXI Trigger Bus

Trigger Lines 8

Star Trigger..1

Power Requirement

+5 V
- Typical..370 mA
- Maximum ....700 mA

Physical

Dimensions .... 10 by 16 cm (3.9 by 6.3 in.)

Weight .... 0.118 kg (0.4 lb.)

I/O Connector .... 68-pin male SCSI

Environment

Operating Temperature ....0° to 50° C

Storage Temperature ....–55° to 150° C

Relative Humidity .... 5% to 85% non-condensing

Shock and Vibration

Functional Shock

MIL-T-28800E Class 3 (30 g half sine shock pulse)
Also meets IEC 60068-2-27

Random Vibration

MIL-T-28800E, MIL-STD-810E Category 1

Operational .... 5 to 500 Hz, 0.3 grams
Non-operational .... 5 to 500 Hz, 2.4 grams

Certifications and Compliances
CE Mark Compliance CE

This product meets applicable EU directives as follows:

Safety Isolation .... low-voltage safety, EN 61010-1:1993

EMC Directive

Immunity .... EN 50082-1:1992
Emissions................................. EN 55011:1991, Group 1 Class A at 10 m

B

Accessories

This appendix lists various National Instruments products you can use with your NI 2501/2503 module.

- The TB-2605 terminal block has screw terminal connections for all channels, bank commons, analog bus, and trigger signals. You can use this card for multiplexer switching applications. The terminal block has a temperature sensor that is used for thermocouple cold-junction compensation.
- The TB-2606 terminal block converts the switch card to a 6 x 4 two-wire matrix configuration. This terminal block creates the matrix configuration by connecting channels (0, 6, 12, 18) (1, 7, 13, 19) … (5, 11, 17, 23).
- Analog bus connectors plug into TB-2605 and TB-2606 terminal blocks. These analog bus plugs connect the analog bus of two cards and terminate in banana plugs.
- The TBX-68S I/O connector block is a DIN rail-mounted terminal block with screw terminal connections you can use for all channels, bank outputs, analog bus, and trigger signals. You can use this card for multiplexer switching applications. The terminal block has a temperature sensor that is used for thermocouple cold-junction compensation. This is connected to the switch card through the SH68-68S cable.
- SH68-68S shielded 68-conductor cable connects the NI 2501/2503 to the TBX-68S, TBX-68LP, or TBX-68LPR.
- The TBX-68LP and TBX-68LPR are low-cost termination accessories with 68 screw terminals.
- CA-1000 is a configurable signal conditioning enclosure. It uses the TBX-68LPR terminal block.

Contact National Instruments for more specific information about these products.

C

Customizing Your Card

This appendix describes options for customizing your NI 2501/2503 card.

Current-Loop Receivers

The NI 2501/2503 modules have sockets for transforming individual channels to current-to-voltage converters. National Instruments offers a process-current pack of four 249 Ω, 0.1%, 5 ppm, 0.25 W resistors. The reference designator format for the current-loop resistors is such that for input channel *x*, the resistor is RCL*x*. For example, the resistor for channel 14 is RCL14.

Caution ***Before installing the resistors in your module, make sure that no signals are connected to your module front connector.***

Before installing your module in the PXI chassis, you must install the resistors by performing the following steps:

1. Ground yourself via a grounding strap or a ground connected to your PXI chassis. Properly grounding yourself prevents damage to your PXI module from electrostatic discharge.
2. Bend and trim the resistor lead as shown in Figure C-1. Be sure that the resistor does not extend more than 0.5 in. above the surface of the circuit board.
3. Insert the resistor into the appropriate socket, labeled RCL*x*.

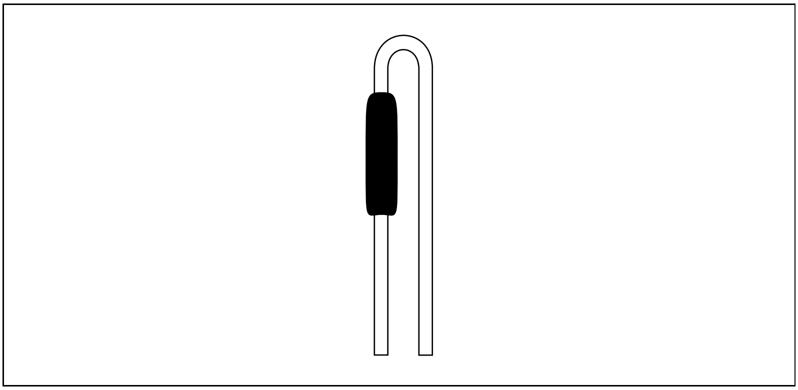

Figure C-1. Bent and Trimmed Resistor

D

Architecture Drawings

This appendix contains architecture drawings for the NI 2501 and NI 2503 switch cards. The drawings show the signal names that are used when the boards are in two-wire mode. To make these drawings relevant for one-wire mode, four-wire mode, or 6 x 4 matrix mode, use the signal names shown in Figures 1-2 through 1-4, respectively, in Chapter 1, *Routing Signals with Your NI 2501/2503*.

Relay or switch names are based on the signal names where applicable. For example, the switch that connects CH9+ to COM1 and CH9– to COM1– is named CH9.

For the other configuration relays, the names are as follows:

- For the relays that connect banks, the switch name is BC*x*-*y*, where *x* and *y* are the bank numbers that are being connected.
- For the relay that switches 1-Wire Lo Ref to COM0–, the name is 1WIRE.
- For the relay that switches CH*x*+ or CH*x*– to COM0+, the name is HLSELECT.
- For the Amp Select switches (NI 2501 only), the names are AMP0 and AMP1.

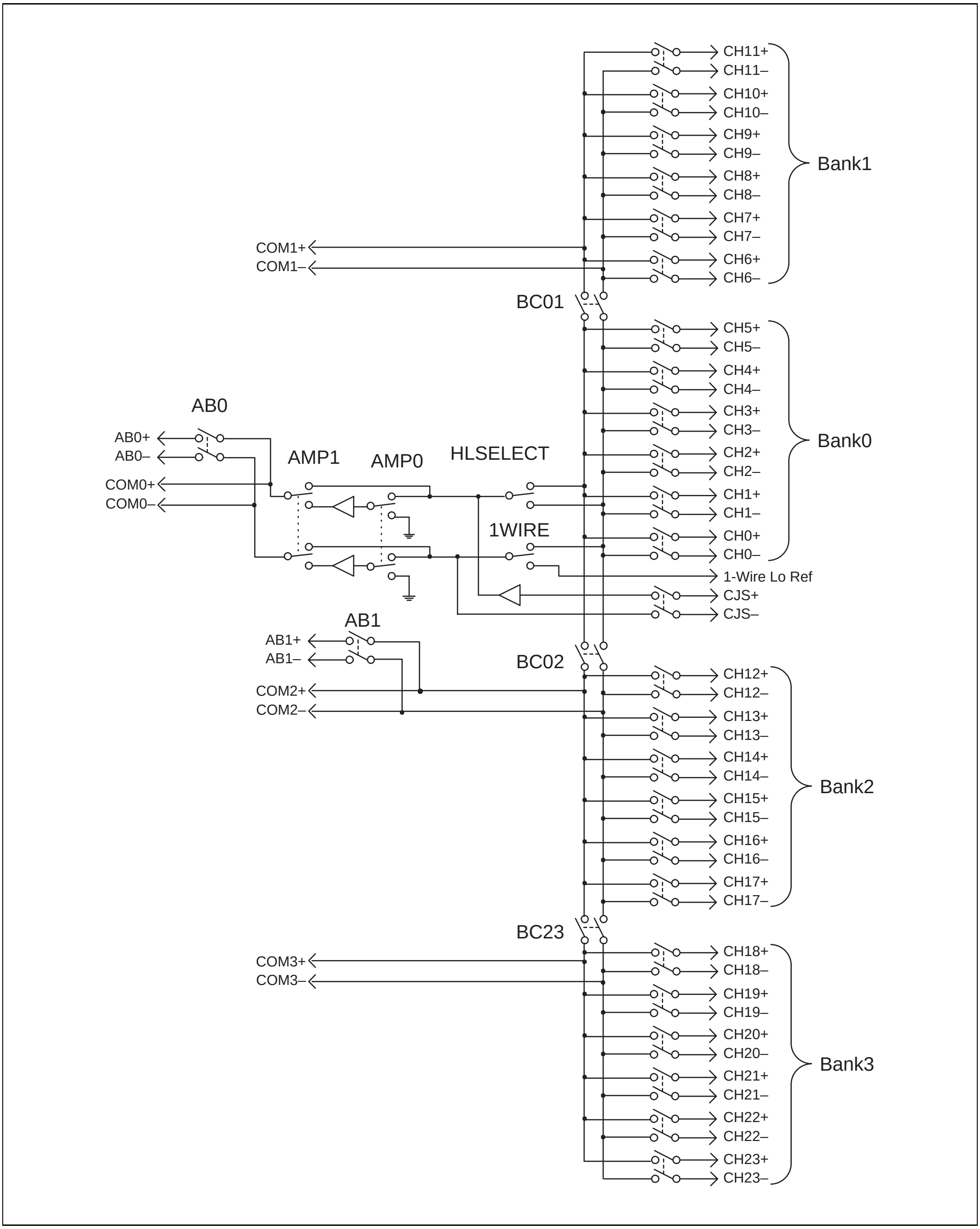

Figure D-1. NI 2501 Switch Architecture

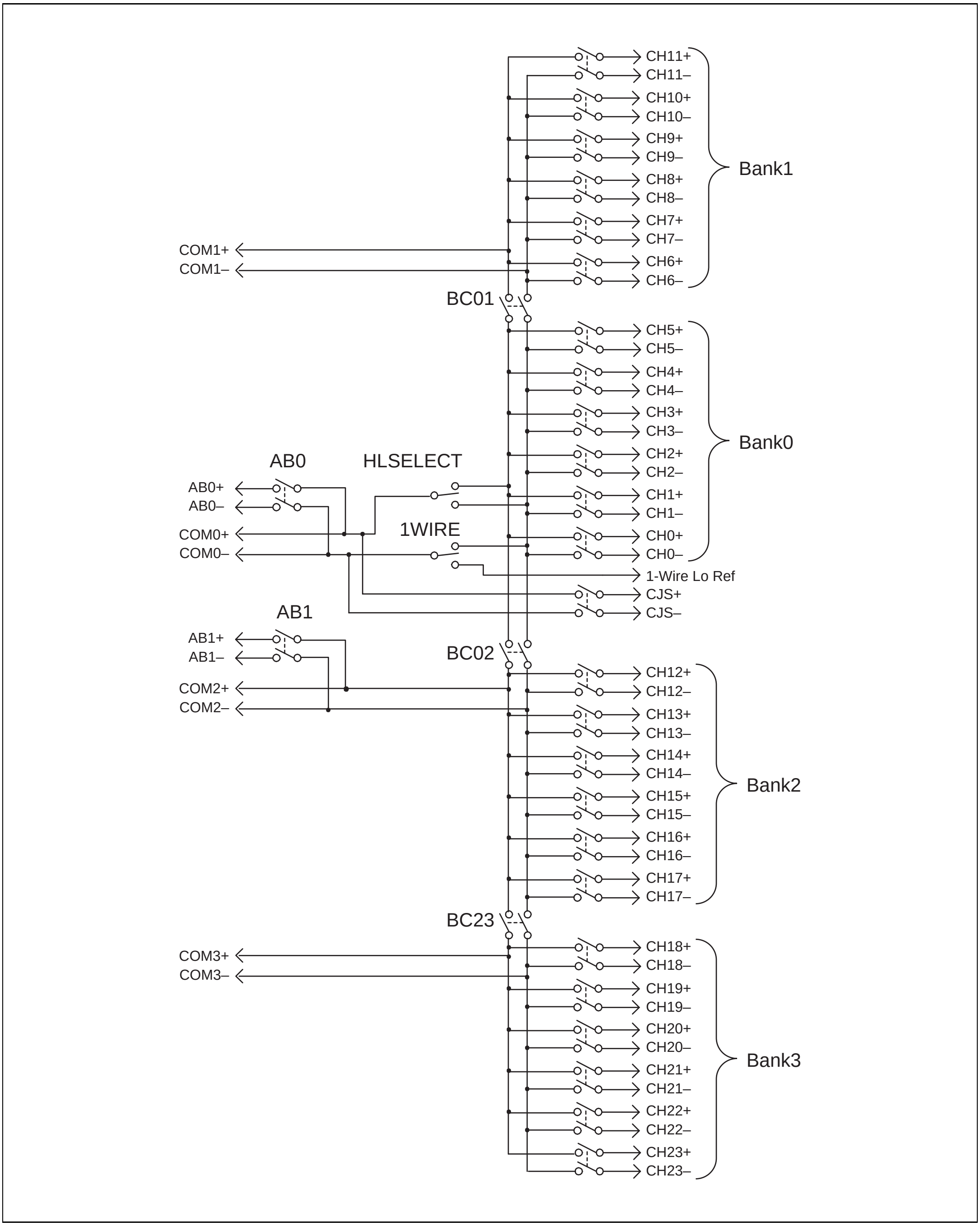

Figure D-2. NI 2503 Switch Architecture

E

Common Questions

This appendix addresses common questions you may have while using your NI 2501 or NI 2503 switch card.

How fast can I scan with the NI 2501 switch card?

The NI 2501 can be scanned as fast as 250 Kscans/s. However, at faster scan rates, the accuracy of the card declines due to the settling time of the card. National Instruments recommends you set the scan rate to allow for enough settling time to ensure the desired accuracy.

How fast can I scan with the NI 2503 switch card?

The NI 2503 uses relays that have typical operate and release times of 3 ms. In addition to the operate and release times, the NI 2503 also requires from 0.5 to 1.0 ms for the relay contacts to stop bouncing. The combination of these two times are known as *debounce time*. The default debounce time for the NI 2503 switch card is set to just under 5 ms. This setting allows the card to be scanned at 200 scans/s. However, if the software implements break-before-make, this would reduce the scan rate to 100 scans/s. Typically, when using a DMM to make accurate measurements, the DMM requires hundreds of ms. Consequently, the DMM becomes the limiting factor in determining the scan rate.

What should I do if the software detects the board but the switches do not switch?

- Verify that the switches do not switch. Close your application program and then launch the soft front panel as described in the *Setup and Test* document you received with your kit. The soft front panel shows the state of each relay or FET switch on the board. Try closing and opening the switches.
- Also be sure to check the return codes of the NI-SWITCH operation to ensure that there are no errors (negative value) or warnings (positive value). You can also use the NI-Spy utility to check for error codes.

- Finally, verify that your code is correct. For reference, see the examples described in the *NI-SWITCH Software User Manual*. The NI-SWITCH driver also ships with several examples in source code. Compare your algorithm to the ones in the examples.

What should I do if scanning does not work?

- First, ensure that you have configured the switch card and the instrument to match trigger lines. The output trigger of the instrument should connect to the trigger input of the switch card. In addition, the scanner advanced trigger of the switch card should be connected to the input trigger of the instrument.
- If the switch card is used to initiate the scan, make sure the DMM is waiting for a trigger before enabling scanning on the switch card. This is the recommended method for hardware scanning.
- If the DMM is used to initiate the scan, enable scanning on the switch card before configuring the DMM to start taking measurements.
- Also be sure to check the return codes of the NI-SWITCH operation to ensure that there are no errors (negative value) or warnings (positive value). You can also use the NI-Spy utility to check for error codes.
- Finally, verify that your code is correct. For reference, see the examples described in the *NI-SWITCH Software User Manual*. The NI-SWITCH driver also ships with several examples in source code. Compare your algorithm to the ones in the examples.

Do I need to program the switch card myself?

The NI 2501/2503 comes with the NI-SWITCH driver software, which exports the full functionality of the card. NI-SWITCH handles the complex issues of direct memory access, interrupts, and operating system interfacing.

F

Customer Communication

For your convenience, this appendix contains forms to help you gather the information necessary to help us solve your technical problems and a form you can use to comment on the product documentation. When you contact us, we need the information on the Technical Support Form and the configuration form, if your manual contains one, about your system configuration to answer your questions as quickly as possible.

National Instruments has technical assistance through electronic, fax, and telephone systems to quickly provide the information you need. Our electronic services include a bulletin board service, an FTP site, a fax-on-demand system, and e-mail support. If you have a hardware or software problem, first try the electronic support systems. If the information available on these systems does not answer your questions, we offer fax and telephone support through our technical support centers, which are staffed by applications engineers.

Electronic Services

Bulletin Board Support

National Instruments has BBS and FTP sites dedicated for 24-hour support with a collection of files and documents to answer most common customer questions. From these sites, you can also download the latest instrument drivers, updates, and example programs. For recorded instructions on how to use the bulletin board and FTP services and for BBS automated information, call 512 795 6990. You can access these services at:

United States: 512 794 5422
Up to 14,400 baud, 8 data bits, 1 stop bit, no parity

United Kingdom: 01635 551422
Up to 9,600 baud, 8 data bits, 1 stop bit, no parity

France: 01 48 65 15 59
Up to 9,600 baud, 8 data bits, 1 stop bit, no parity

FTP Support

To access our FTP site, log on to our Internet host, `ftp.natinst.com`, as `anonymous` and use your Internet address, such as `joesmith@anywhere.com`, as your password. The support files and documents are located in the `/support` directories.

Fax-on-Demand Support

Fax-on-Demand is a 24-hour information retrieval system containing a library of documents on a wide range of technical information. You can access Fax-on-Demand from a touch-tone telephone at 512 418 1111.

E-Mail Support (Currently USA Only)

You can submit technical support questions to the applications engineering team through e-mail at the Internet address listed below. Remember to include your name, address, and phone number so we can contact you with solutions and suggestions.

`support@natinst.com`

Telephone and Fax Support

National Instruments has branch offices all over the world. Use the list below to find the technical support number for your country. If there is no National Instruments office in your country, contact the source from which you purchased your software to obtain support.

Country	Telephone	Fax
Australia	03 9879 5166	03 9879 6277
Austria	0662 45 79 90 0	0662 45 79 90 19
Belgium	02 757 00 20	02 757 03 11
Brazil	011 288 3336	011 288 8528
Canada (Ontario)	905 785 0085	905 785 0086
Canada (Québec)	514 694 8521	514 694 4399
Denmark	45 76 26 00	45 76 26 02
Finland	09 725 725 11	09 725 725 55
France	01 48 14 24 24	01 48 14 24 14
Germany	089 741 31 30	089 714 60 35
Hong Kong	2645 3186	2686 8505
Israel	03 6120092	03 6120095
Italy	02 413091	02 41309215
Japan	03 5472 2970	03 5472 2977
Korea	02 596 7456	02 596 7455
Mexico	5 520 2635	5 520 3282
Netherlands	0348 433466	0348 430673
Norway	32 84 84 00	32 84 86 00
Singapore	2265886	2265887
Spain	91 640 0085	91 640 0533
Sweden	08 730 49 70	08 730 43 70
Switzerland	056 200 51 51	056 200 51 55
Taiwan	02 377 1200	02 737 4644
United Kingdom	01635 523545	01635 523154
United States	512 795 8248	512 794 5678

Technical Support Form

Photocopy this form and update it each time you make changes to your software or hardware, and use the completed copy of this form as a reference for your current configuration. Completing this form accurately before contacting National Instruments for technical support helps our applications engineers answer your questions more efficiently.

If you are using any National Instruments hardware or software products related to this problem, include the configuration forms from their user manuals. Include additional pages if necessary.

Name ____

Company ____

Address ____

____

Fax (___) ________________Phone (___) ___________________________________

Computer brand____________ Model ___________________Processor_____________________

Operating system (include version number) ____________________________________

Clock speed ______MHz RAM _____MB Display adapter __________________________

Mouse ___yes ___no Other adapters installed_______________________________________

Hard disk capacity _____MB Brand____

Instruments used ____

____

National Instruments hardware product model _____________ Revision ____________________

Configuration ____

National Instruments software product ___________________ Version ____________________

Configuration ____

The problem is: ____

____

____

____

____

List any error messages: ____

____

____

The following steps reproduce the problem: ____________________________________

____

____

____

____

NI 2501/2503 Hardware and Software Configuration Form

Record the settings and revisions of your hardware and software on the line to the right of each item. Complete a new copy of this form each time you revise your software or hardware configuration, and use this form as a reference for your current configuration. Completing this form accurately before contacting National Instruments for technical support helps our applications engineers answer your questions more efficiently.

National Instruments Products

Using NI 2501 or NI 2503? ______________________________

Hardware revision ______________________________

Switching mode ______________________________

List National Instruments Software Installed and Version

NI-SWITCH version ______________________________

LabVIEW version ______________________________

LabWindows/CVI version ______________________________

Other National Instruments software version ______________________________

____

Programming choice ______________________________

Other Products

PXI Chassis make and model ______________________________

Microprocessor ______________________________

Clock frequency or speed ______________________________

Type of video board installed ______________________________

Operating system version ______________________________

Operating system mode ______________________________

Programming language ______________________________

Programming language version ______________________________

Switch accessories ______________________________

____

Instruments connected to switch ______________________________

____

List All Boards in PXI Mainframe

PXI Slot	Manufacturer, Description, and Function
1	
2	
3	
4	
5	
6	
7	
8	

Documentation Comment Form

National Instruments encourages you to comment on the documentation supplied with our products. This information helps us provide quality products to meet your needs.

Title: *NI 2501/2503 User Manual*

Edition Date: July 1998

Part Number: 321906B-01

Please comment on the completeness, clarity, and organization of the manual.

If you find errors in the manual, please record the page numbers and describe the errors.

Thank you for your help.

Name ____________________

Title ____________________

Company ____________________

Address ____________________

E-Mail Address ____________________

Phone (___) ________________ Fax (___) ________________

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National Instruments Corporation
6504 Bridge Point Parkway
Austin, Texas 78730-5039

Fax to: Technical Publications
National Instruments Corporation
512 794 5678

Glossary

Prefix	Meanings	Value
n-	nano-	10^{-9}
μ-	micro-	10^{-6}
m-	milli-	10^{-3}
k-	kilo-	10^{3}
M-	mega-	10^{6}
G-	giga-	10^{9}

Symbols

°	degrees
Ω	ohms
%	percent
±	plus or minus

A

A	amperes
AC	alternating current
ANSI	American National Standards Institute

B

breakpoint	a specified point in program code where the program pauses to perform some action; a breakpoint interrupt can be added to a scan list for debugging or other special needs.

bus	the group of conductors that interconnect individual circuitry in a computer. Typically, a bus is the expansion vehicle to which I/O or other devices are connected. Examples of PC buses are the ISA and PCI bus.

C

C	Celsius
channel	pin or wire lead on the multiplexer to which you apply or from which you read the analog or digital signal. Signals can be single-ended or differential.
cold-junction compensation	a method of compensating for inaccuracies in thermocouple circuits
contact bounce	the intermittent switching that occurs when the movable metal parts of a relay make or break contact

D

DC	direct current
debounced	indicates when the contact bounce has ended. *See* contact bounce.
device	a plug-in board, card, or pad that can contain multiple channels and conversion devices. Some examples of devices are computers, multimeters, multiplexers, oscillators, operator interfaces, and counters.
digital multimeter	a multifunction meter used to make measurements such as voltage, current, resistance frequency, temperature, and so on
DIN	Deutsche Industrie Norme
DMA	direct memory access—a method by which data can be transferred to/from computer memory from/to a device or memory on the bus while the processor does something else. DMA is the fastest method of transferring data to/from computer memory.
DMM	*See* digital multimeter.
drivers/driver software	software that controls a specific hardware device such as a switch card

E

external trigger	a voltage pulse from an external source that triggers an event such as A/D conversion

F

FET	Field Effect Transistor

H

handshaking	the use of two trigger lines between two instruments, such as a switch and a DMM, to synchronize their actions
Hz	hertz—the number of scans read or updates written per second

I

in.	inches
I/O	input/output—the transfer of data to/from a computer system involving communications channels, operator interface devices, and/or data acquisition and control interfaces
Intelligent Virtual Instrument	an advanced architecture for instrument drivers that includes features such as simulation and state caching
ISA	Industry Standard Architecture
IVI	*See* Intelligent Virtual Instrument.

M

MB	megabytes of memory
matrix	superset of multiplexer; consists of connected rows and columns that allows for a direct connection from any row to any column
movistor	transient suppression device

multiplexer	a switching device with multiple inputs that sequentially connects each of its inputs to its output, typically at high speeds, in order to measure several signals with a single analog input channel
mux	*See* multiplexer.

N

NI-SWITCH	an IVI-based instrument driver that supports the National Instruments line of switch cards

P

PXI	PCI with extensions for instrumentation

R

random scanning	scanning the channels in a mux in any order
relay	a switch that connects or disconnects the signal to a common through the physical movement of a metal arm
RMA	Return Material Authorization
rms	root mean square—the square root of the average value of the square of the instantaneous signal amplitude; a measure of signal amplitude
RTD	resistance temperature detector—a metallic probe that measures temperature based upon its coefficient of resistivity

S

s	seconds
scan	the data acquisition of signals connected to multiple channels of a multiplexer. Typically, the measurement device uses a trigger to advance the multiplexer to the next channel in the scan.
scan list	a list of channels supplied to NI-SWITCH that indicates the order in which channels will be scanned

scanner advanced trigger	the trigger generated by the switch card when scanning. The trigger occurs after the switch card has closed a switch and the switch has settled.
sensor	a device that responds to a physical stimulus (heat, light, sound, pressure, motion, flow, and so on), and produces a corresponding electrical signal
settling time	the amount of time required for a voltage to reach its final value within specified limits
soft front panel	a graphical program included with NI-SWITCH that you can use to interactively control the switch

T

TBX	Terminal Block Extension
terminal block	an accessory containing wire connection points, typically screw terminals
thermistor	a semiconductor sensor that exhibits a repeatable change in electrical resistance as a function of temperature. Most thermistors exhibit a negative temperature coefficient.
thermocouple	a temperature sensor created by joining two dissimilar metals. The junction produces a small voltage as a function of the temperature.
trigger	any event that causes or starts some form of data capture
TTL	Transistor-Transistor Logic

V

V	volts
VDC	volts, direct current
VI	virtual instrument—(1) a combination of hardware and/or software elements, typically used with a PC, that has the functionality of a classic stand-alone instrument (2) a LabVIEW software module (VI), which consists of a front panel user interface and a block diagram program

W

W	watts
wire	data path between nodes

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Numbers

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