KEITHLEY

EXP-16 and EXP-16/A

User's Guide

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Safety Precautions

The following safety precautions should be observed before using this product and any associated instrumentation. Although some instruments and accessories would normally be used with non-hazardous voltages, there are situations where hazardous conditions may be present.

This product is intended for use by qualified personnel who recognize shock hazards and are familiar with the safety precautions required to avoid possible injury. Read and follow all installation, operation, and maintenance information carefully before using the product. Refer to the manual for complete product specifications.

If the product is used in a manner not specified, the protection provided by the product may be impaired.

The types of product users are:

Responsible body is the individual or group responsible for the use and maintenance of equipment, for ensuring that the equipment is operated within its specifications and operating limits, and for ensuring that operators are adequately trained.

Operators use the product for its intended function. They must be trained in electrical safety procedures and proper use of the instrument. They must be protected from electric shock and contact with hazardous live circuits.

Maintenance personnel perform routine procedures on the product to keep it operating properly, for example, setting the line voltage or replacing consumable materials. Maintenance procedures are described in the manual. The procedures explicitly state if the operator may perform them. Otherwise, they should be performed only by service personnel.

Service personnel are trained to work on live circuits, and perform safe installations and repairs of products. Only properly trained service personnel may perform installation and service procedures.

Keithley products are designed for use with electrical signals that are rated Installation Category I and Installation Category II, as described in the International Electrotechnical Commission (IEC) Standard IEC 60664. Most measurement, control, and data I/O signals are Installation Category I and must not be directly connected to mains voltage or to voltage sources with high transient over-voltages. Installation Category II connections require protection for high transient over-voltages often associated with local AC mains connections. Assume all measurement, control, and data I/O connections are for connection to Category I sources unless otherwise marked or described in the Manual.

Exercise extreme caution when a shock hazard is present. Lethal voltage may be present on cable connector jacks or test fixtures. The American National Standards Institute (ANSI) states that a shock hazard exists when voltage levels greater than 30V RMS, 42.4V peak, or 60VDC are present. **A good safety practice is to expect that hazardous voltage is present in any unknown circuit before measuring.**

Operators of this product must be protected from electric shock at all times. The responsible body must ensure that operators are prevented access and/or insulated from every connection point. In some cases, connections must be exposed to potential human contact. Product operators in these circumstances must be trained to protect themselves from the risk of electric shock. If the circuit is capable of operating at or above 1000 volts, **no conductive part of the circuit may be exposed.**

Do not connect switching cards directly to unlimited power circuits. They are intended to be used with impedance limited sources. NEVER connect switching cards directly to AC mains. When connecting sources to switching cards, install protective devices to limit fault current and voltage to the card.

Before operating an instrument, make sure the line cord is connected to a properly grounded power receptacle. Inspect the connecting cables, test leads, and jumpers for possible wear, cracks, or breaks before each use.

When installing equipment where access to the main power cord is restricted, such as rack mounting, a separate main input power disconnect device must be provided, in close proximity to the equipment and within easy reach of the operator.

For maximum safety, do not touch the product, test cables, or any other instruments while power is applied to the circuit under test. ALWAYS remove power from the entire test system and discharge any capacitors before: connecting or disconnecting cables or jumpers, installing or removing switching cards, or making internal changes, such as installing or removing jumpers.

Do not touch any object that could provide a current path to the common side of the circuit under test or power line (earth) ground. Always make measurements with dry hands while standing on a dry, insulated surface capable of withstanding the voltage being measured.

The instrument and accessories must be used in accordance with its specifications and operating instructions or the safety of the equipment may be impaired.

Do not exceed the maximum signal levels of the instruments and accessories, as defined in the specifications and operating information, and as shown on the instrument or test fixture panels, or switching card.

When fuses are used in a product, replace with same type and rating for continued protection against fire hazard.

Chassis connections must only be used as shield connections for measuring circuits, NOT as safety earth ground connections.

If you are using a test fixture, keep the lid closed while power is applied to the device under test. Safe operation requires the use of a lid interlock.

If  or  is present, connect it to safety earth ground using the wire recommended in the user documentation.

The  symbol on an instrument indicates that the user should refer to the operating instructions located in the manual.

The  symbol on an instrument shows that it can source or measure 1000 volts or more, including the combined effect of normal and common mode voltages. Use standard safety precautions to avoid personal contact with these voltages.

The **WARNING** heading in a manual explains dangers that might result in personal injury or death. Always read the associated information very carefully before performing the indicated procedure.

The **CAUTION** heading in a manual explains hazards that could damage the instrument. Such damage may invalidate the warranty.

Instrumentation and accessories shall not be connected to humans.

Before performing any maintenance, disconnect the line cord and all test cables.

To maintain protection from electric shock and fire, replacement components in mains circuits, including the power transformer, test leads, and input jacks, must be purchased from Keithley Instruments. Standard fuses, with applicable national safety approvals, may be used if the rating and type are the same. Other components that are not safety related may be purchased from other suppliers as long as they are equivalent to the original component. (Note that selected parts should be purchased only through Keithley Instruments to maintain accuracy and functionality of the product.) If you are unsure about the applicability of a replacement component, call a Keithley Instruments office for information.

To clean an instrument, use a damp cloth or mild, water based cleaner. Clean the exterior of the instrument only. Do not apply cleaner directly to the instrument or allow liquids to enter or spill on the instrument. Products that consist of a circuit board with no case or chassis (e.g., data acquisition board for installation into a computer) should never require cleaning if handled according to instructions. If the board becomes contaminated and operation is affected, the board should be returned to the factory for proper cleaning/servicing.

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Preface

The *EXP-16 and EXP-16/A User's Guide* describes how to set up, install, program, and use the EXP-16 and EXP-16/A expansion accessories. This guide also explains how to calibrate and troubleshoot.

This guide serves data acquisition system designers, engineers, programmers, and other users responsible for setting up, cabling, and wiring signals to the EXP-16 and EXP-16/A. To follow the information and instructions contained in this guide, you must be familiar with data-acquisition principles and your DAS board.

The *EXP-16 and EXP-16/A User's Guide* is organized as follows:

- Chapter 1 provides an overview of the hardware features, typical applications, and accessories.
- Chapter 2 provides a functional description of the EXP-16 and EXP-16/A, including block diagrams.
- Chapter 3 describes how to set up your EXP-16 or EXP-16/A.
- Chapter 4 describes how to connect accessories and signals to your EXP-16 or EXP-16/A.
- Chapter 5 describes calibration procedures.
- Chapter 6 explains how to troubleshoot problems that may arise with your EXP-16 or EXP-16/A and provides information on obtaining technical support.
- Appendix A lists the specifications for the EXP-16 and EXP-16/A.
- Appendix B lists the pin assignments for the main I/O connectors of the EXP-16 and EXP-16/A.
- Appendix C contains miscellaneous additional material on the operation of the EXP-16 and EXP-16/A.

- Appendix D explains how to assign logical channel numbers for purposes of software control of your EXP-16 or EXP-16/A.
- An index completes this manual.

1

Overview

The EXP-16 is an expansion interface board equipped with half-inch standoffs. The EXP-16/A is an expansion interface board mounted in a plastic enclosure.

An EXP-16 or EXP-16/A can multiplex 16 analog input signals into a single signal for amplification and input to one single-ended input channel of a data acquisition system. The two EXPs can amplify the multiplexed signal at switch-selectable gains, and each of their 16 inputs contains circuitry for filtering, current measuring, and open-thermocouple detection. The two EXPs also contain a CJC (cold junction compensation) circuit for correcting thermocouple readings.

This chapter briefly describes the EXP-16 and EXP-16/A and their features, applications, and accessories.

Features

Principal features of an EXP-16 or EXP-16/A are as follows:

- Expands a single-ended analog input channel of any data acquisition system into 16 differential inputs
- Works with the Keithley MetraByte DAS-8, DAS-800, DAS-16, DAS-1200, DAS-1400, and DAS-1600 Series boards
- Offers a CJC channel that supports the use of type B, E, J, K, R, S, and T thermocouples
- Offers open-thermocouple detection at each input
- Contains terminals for a current-measuring resistor at each input

- Connects in a daisy chain of up to eight EXP-16s or EXP-16/As to provide up to 128 analog input channels
- Contains an instrumentation amplifier with a choice of eight switch-selectable gain settings
- Offers filtering at each input

Applications

Typical applications for EXP-16s and EXP-16/As are as follows:

- Input channel expansion
- Energy management
- Signal amplification
- Signal conditioning

Accessories

Accessories for the EXP-16 and EXP-16/A are as follows:

- **C-1800** is a cable for connecting an EXP-16 or EXP-16/A to a DAS-8 or DAS-800 Series board, or to another EXP-16 or EXP-16/A.
- **S-1600** is a cable for connecting an EXP-16 or EXP-16/A to a DAS-16/1200/1400/1600 Series board.
- **PG-408A** is a snap-in DC/DC converter module for an EXP-16 or EXP-16/A that is used with a DAS-8AO/16/1200/1400/1600 Series board.

Refer to Chapter 4 for instructions on attaching these accessories to an EXP-16 or EXP-16/A.

2

Functional Description

This chapter describes features and operating options of the EXP-16 and EXP-16/A. Figure 2-1 shows the block diagram.

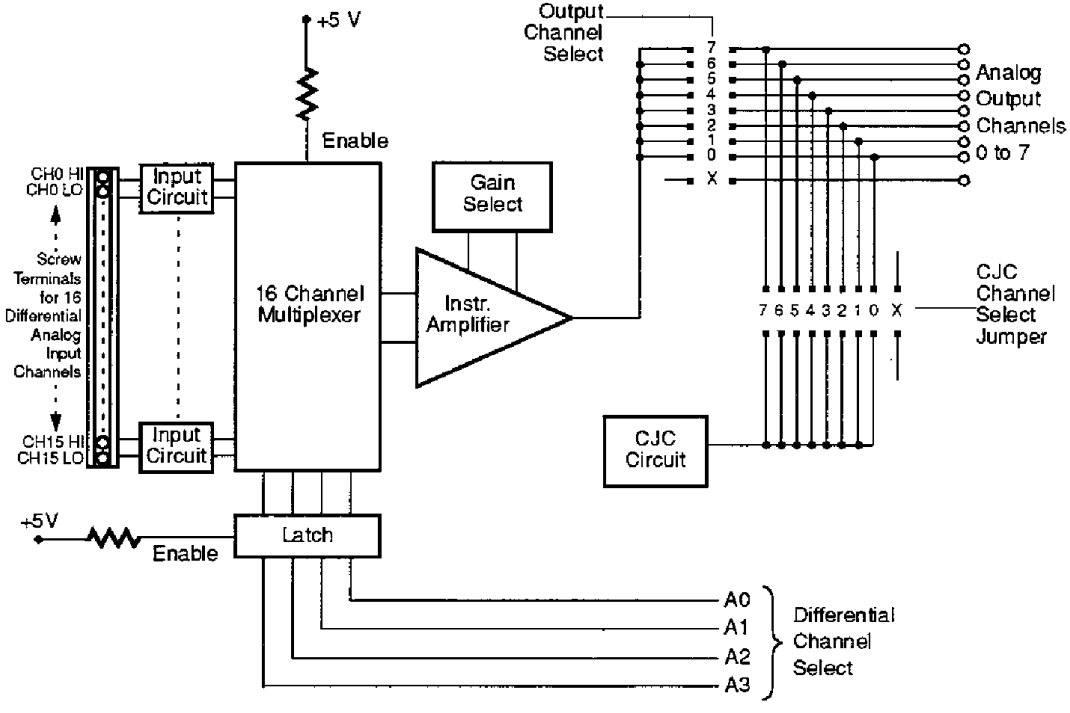

Figure 2-1. Block Diagram of an EXP-16 and EXP-16/A

Each input channel of an EXP-16 or EXP-16/A contains circuitry configured as shown in Figure 2-2 to offer open-thermocouple detection, signal filtering, and terminals for a current-measuring shunt resistor.

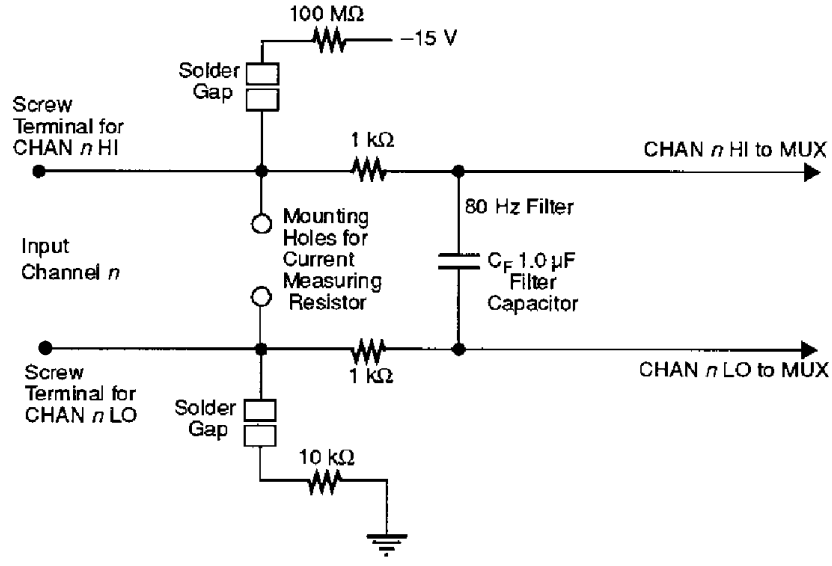

Figure 2-2. Input Circuit for Each Analog Input Channel

Open-Thermocouple Detection

Each input circuit uses biasing resistors to enable open-thermocouple detection. Note that the 10 kΩ resistor on the low input allows common-mode voltages on the thermocouple. When you activate open-thermocouple detection, the biasing resistors respond to an open thermocouple by slowly changing the input voltage to −15 V. As this voltage is much larger than the voltage a thermocouple can produce, you can develop a software routine to sense any input voltage above a certain threshold and flag the open thermocouple. Refer to "Activating Open-Thermocouple Detection" on page 3-3 for instructions on bridging the solder gaps.

Signal Filtering

The 1.0 µF filter capacitor and the two 1 kΩ resistors make up an 80 Hz filter for the input signal. If you need faster settling response for a particular channel, you can remove the capacitor to disable the filter for that channel.

Current-Measuring Resistor

A pair of mounting holes for a current-measuring resistor is located next to the screw terminals for each channel. The holes are plated-through to allow you to solder the resistor into place. You must determine the resistor size and power rating for the current you want to measure. You may also find it more convenient to place the resistor across the channel screw terminals rather than in the mounting holes.

Multiplexer

An EXP-16 or EXP-16/A multiplexes signals from the 16 differential analog input channels into one signal for the analog output. Each channel to be sampled for multiplexing is selected by a 4-bit TTL/CMOS-compatible address on the differential-channel-select lines, shown in Figure 2-1. An address of 0h selects channel 0, 1h selects channel 1, 2h selects channel 2, and so on.

When you use an EXP-16 or EXP-16/A with a DAS-8 Series board, you control the address with DAS-8 digital outputs OP1 to OP4. The DAS-8 outputs are activated by DAS-8 CALL Mode 14 (see the DAS-8 user's guide and Appendix C for more information).

Refer to Appendix D for information on the numbering of expansion channels for software control.

Instrumentation Amplifier

The multiplexer output feeds to an instrumentation amplifier with switch-selectable gains of 0.5, 1, 2, 10, 50, 100, 200, and 1000. You can also set the amplifier for other gains by installing a gain-adjustment resistor (see "Setting Gain" on page 3-3). The instrumentation amplifier is a high-performance device suitable for use with strain gauges and other low-level transducers.

CJC Circuit

An EXP-16 or EXP-16/A includes cold-junction sensing and compensation circuitry that delivers 0.0 V at 0°C and 24.4 mV/°C. The latter value corresponds to 10 bits/°C with most 12-bit A/D converters. You can connect the CJC output voltage to any of the EXP-16 Series output lines using jumper J3 (refer to Figure 2-1 on page 2-1). The CJC circuit can support a data acquisition system performing temperature measurements with types B, E, J, K, R, S, and T thermocouples.

If you plan to use the CJC circuit, refer to the cautionary note on page 3-5.

Power

An EXP-16 or EXP-16/A uses the +5 V and ±12 V from the computer or the +5 V alone from the computer with the optional PG-408A DC/DC converter module. The accessory also has jumper arrangements for setting up the +5 V according to the type of DAS board used. Refer to "Setting Up Power" on page 3-7 for information on setting up power to an EXP-16 or EXP-16/A.

3

Setup

This chapter describes setup options for the EXP-16 and EXP-16/A. Read this chapter before you attempt to install and use your EXP.

Unwrapping and Inspecting Your Board

After you remove the wrapped board from its outer shipping carton, proceed as follows:

1. Your EXP-16 or EXP-16/A is packaged at the factory in an anti-static wrapper that must not be removed until you have discharged any static electricity by either of the following methods:
   - If you are equipped with a grounded wrist strap, you discharge static electricity as soon as you hold the wrapped EXP.
   - If you are not equipped with a grounded wrist strap, discharge static electricity by holding the wrapped EXP in one hand while placing your other hand firmly on a metal portion of the computer chassis (your computer must be turned off but grounded).
2. Carefully unwrap your EXP from its anti-static wrapping material. (You may wish to store the wrapping material for future use.)
3. Inspect the board for signs of damage. If damage is apparent, arrange to return the board to the factory (see "Technical Support" on page 6-4).
4. Check the remaining contents of your package against the packing list to be sure your order is complete. Report any missing items, immediately.
5. When you are satisfied with the inspection, proceed with the software and hardware setup instructions.

Locating Components

Figure 3-1 and Figure 3-2 show the locations for key components of the EXP-16 and EXP-16/A.

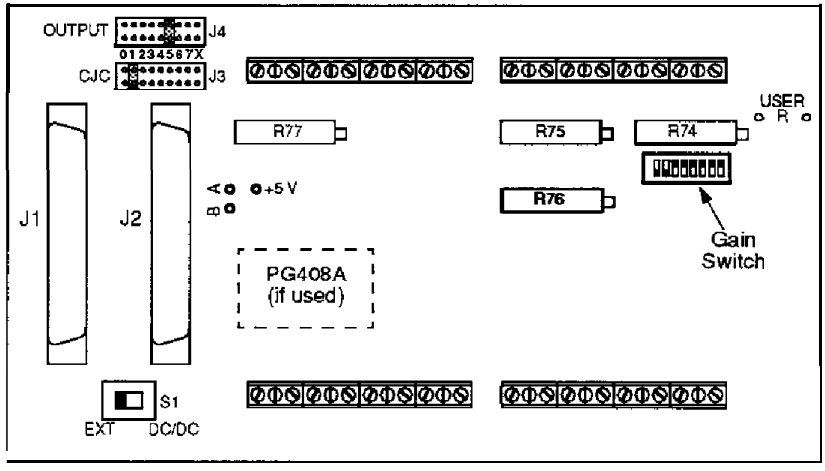

Figure 3-1. Locations of EXP-16 Key Components

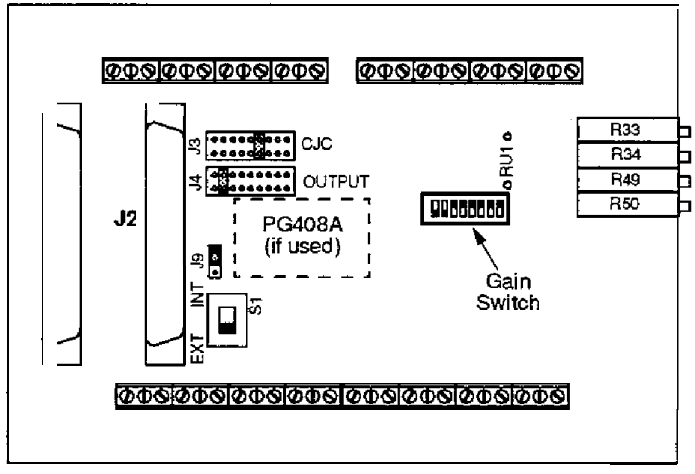

Figure 3-2. Locations of EXP-16/A Key Components

Activating Open-Thermocouple Detection

To activate the open-thermocouple detection circuit for a channel, you must bridge the two solder gaps for that channel. The solder gaps for the EXP-16 are located under the board, beneath the screw terminals; the solder gaps for the EXP-16/A are located on top of the board, in front of the screw terminals.

Caution: To avoid damaging the printed circuitry and components, use a soldering iron that is isolated, grounded, operates on less than 40 V, and develops no more than 40 W.

Setting Gain

You control gain on an EXP-16 or EXP-16/A either with the gain switch or by installing a resistor in special mounting holes. Either method configures the entire board for the selected gain.

The gain switch is an 8-position DIP switch that offers settings for gains of 0.5, 1, 2, 10, 50, 100, 200, and 1000. Positions of the switch are labeled as shown in Figure 3-3.

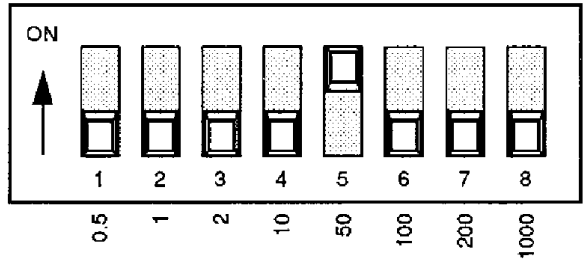

Figure 3-3. Gain Switch (set for gain of 50)

In applications calling for a gain other than the switch-selectable offerings, you may set a gain of your choosing by inserting a resistor of appropriate value on the board space labeled USER (on the EXP-16) or RU1 (on the EXP-16/A). Use the following calculation to determine the appropriate resistance value:

Resistance (ohms) = 200,000 / (desired gain)

The largest differential analog input must always be considered when choosing a value of gain, or the output of the amplifier may saturate. Also you can mix thermocouples of different types on one board so long as they all use the same gain. For mixed thermocouples requiring different gains, use a separate EXP-16 or EXP-16/A for each different gain. Table 3-1 lists recommended gains for different thermocouple types.

Table 3-1. Recommended Gains for Thermocouple Types

Thermocouple Type	Maximum Output	Maximum °C	Suitable Gain
B	14 mV	1760	200
E	76 mV	1000	50
J	43 mV	760	100
K	55 mV	1370	50
R	21 mV	1760	200
S	19 mV	1760	200
T	21 mV	400	200

Note: Higher gains can be used for less than a full-scale span. Gains are based on a ±5 V output.

Setting the Output Jumpers

The EXP-16 and EXP-16/A contain two 9-position jumper blocks: J3 for the selection of a CJC channel and J4 for the selection of an analog output channel. The nine jumper positions include eight channel positions, marked 0 to 7, and a blank position, marked X. The eight channel positions connect through external cabling to the inputs of an 8-channel board (such as the DAS-8). The following subsections describe the use of each jumper block.

Selecting a CJC Channel

If CJC is required for a particular DAS board channel, jumper the corresponding pins of J3 for that channel. The DAS board channel you choose for CJC must be different from the channel you choose for analog output.

If no cold-junction compensation is required, place the CJC jumper in position X of J3.

Caution: To ensure a uniform temperature between the CJC sensor and the screw terminals, you are advised to use an EXP-16/A with a cover or to place an EXP-16 in a covered enclosure.

Selecting a DAS Board Channel

The eight jumper-selectable outputs of an EXP-16 or EXP-16/A allow you to connect up to eight of these accessories to an 8-channel DAS board (such as a DAS-8 Series board) without the need for special cables.

Note: You cannot use the same channel for analog output that you are using for CJC, or the performance of your system will be seriously degraded.

In a given system, each EXP-16 or EXP-16/A connects to a separate input channel of a DAS board. Make sure the jumper on J4 of each EXP-16 or EXP-16/A matches the selected input channel of the attached DAS board. Table 3-2 details channel selection configurations for an attached DAS-8 Series board.

Output Jumper Location	DAS Board Input Channel Number	Connector J1/J2 Pin Number
0	0	37
1	1	36
2	2	35
3	3	34
4	4	33
5	5	32
6	6	31
7	7	30

As Table 3-2 shows, the output channel of the EXP-16 or EXP-16/A matches the input channel of the DAS board.

Note: Before connecting an EXP-16 or EXP-16/A to a DAS-8 Series board, you are advised to refer to the Call Mode descriptions in the DAS board user's guide.

Setting Up Power

The following subsections describe the setup of available power supply arrangements for the EXP-16 and EXP-16/A.

Using +5 V and ±12 V External Supplies

To use external +5 V and ±12 V supplies with the EXP-16 and EXP-16/A, perform the following procedure:

1. Set switch S1 to EXT.
2. Connect +5 V (30 mA maximum) to pin 29 of the EXP-16 or EXP-16/A main I/O connector.
3. Connect +12 V (10 mA maximum) to pin 1 and −12 V (10 mA maximum) to pin 20 of the EXP-16 or EXP-16/A main I/O connector.
4. Connect all power supply returns to pin 11 of the EXP-16 or EXP-16/A main I/O connector.

Using External +5 V Only

To use an external +5 V supply only with the EXP-16 and EXP-16/A, perform the following procedure:

1. Install a PG408A DC/DC converter module (refer to "Installing a PG-408A DC/DC Converter" on page 3-7).
2. Set switch S1 to INT (DC/DC on some boards).
3. Connect the +5 V (250 mA maximum) to pin 29 of the EXP-16 or EXP-16/A main I/O connector.
4. Connect the +5 V return to pin 11 of the EXP-16 or EXP-16/A main I/O connector.

Installing a PG-408A DC/DC Converter

The PG-408A DC/DC converter module is an ecapsulated package with pins protruding from its bottom surface. The socket for this package is a space on the EXP-16 or EXP-16/A marked as shown in Figure 3-1 and Figure 3-2.

Pin 1 on the PG-408A is indicated either by a beveled corner on the module or a beveled corner on the module label. Be sure to match pin 1 of the PG-408A with pin 1 of the socket (pin 1 is marked on the board) when snapping the module onto the EXP-16 or EXP-16/A. Figure 3-4 shows a diagram of the pin 1 location.

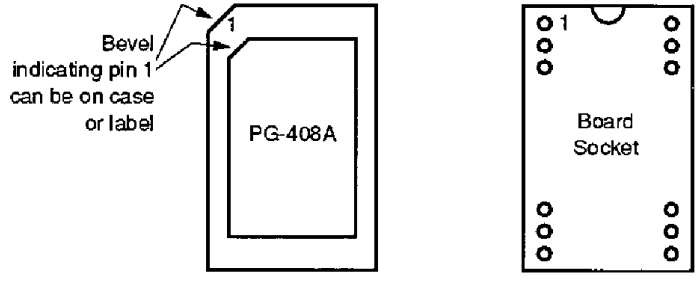

Figure 3-4. Locating Pin 1 on the PG-408A and Board Socket

Setting the +5 V Jumper

An EXP-16 and EXP-16/A receive +5 V power on pin 29 by way of a C-1800 cable when connected to a DAS-8/800 Series board or by way of an S-1600 cable when connected to a DAS-16/1600/1400/1200 Series board. The +5 V power from a DASCON-1 board, however, arrives on pin 20 by way of a C-1800 cable. The following two subsections explain how to set the EXP-16 or EXP-16/A jumpers for these situations.

Setting the Jumper for an EXP-16

When an EXP-16 is connected to DAS-8/800/1200/1600/1400 Series boards, you need no jumper for the +5 V because the +5 V connection to pin 29 is hard-wired (on the EXP-16, see the trace between the plated-through holes labeled A and +5 V, which are shown shown in Figure 3-1). When an EXP-16 is connected to a DASCON-1 board, you must solder a wire between the plated-through holes labeled B and +5 V (also shown in Figure 3-1).

Setting the Jumper for an EXP-16/A (Jumper J9)

When an EXP-16/A is connected to a DAS-8/800/1200/1600/1400 Series board, the jumper at J9 must be on the two pins farthest from switch S1 (the factory default position, as shown in Figure 3-2 on page 3-2). When an EXP-16/A is connected to a DASCON-1 board, the jumper at J9 must be on the two pins closest to switch S1.

Power Notes

When used with a DAS-8 board, an EXP-16 or EXP-16/A receives +5 V and ±12 V power through the C-1800 cable that connects the two boards. If a PG-408A module is installed on the EXP-16 or EXP-16/A, set switch S1 to INT (or DC/DC). If a PG-408A is not installed, set switch S1 to EXT.

Note that the computer I/O bus has a limited output capability. In the INT (or DC/DC) mode, an EXP-16 or EXP-16/A draws up to 250 mA from the +5 V supply. In the EXT mode, the board draws up to 30 mA from the +5 V and 10 mA from the ±12 V supplies. Be sure you do not overload the computer power supply.

Also note that the computer bus supplies are ±12 V. If you plan to use an input common-mode range of ±10 V, you must install a PG-408A and set switch S1 to INT; the ±12 V computer supply is inadequate for this range.

4

Wiring and Cabling

This chapter describes the I/O connectors and the cabling or wiring of EXP-16s or EXP-16/As to DAS boards and accessories.

Using the Main I/O Connectors

The EXP-16 and EXP-16/A contain two, parallel-wired main I/O connectors: J1 and J2. Use either connector for connection to a DAS board and the other for connection to an STA-XX or an additional EXP-16 or EXP-16/A. The two connectors are 37-pin, D-type and are labeled J1 and J2. Figure 4-1 shows the pin assignments for J1 and J2.

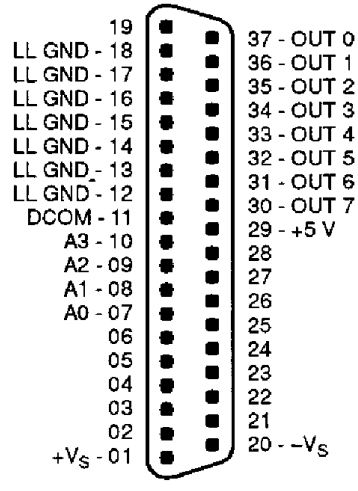

Figure 4-1. Pin Assignments of Main I/O Connectors J1 and J2

Connecting Multiple EXP-16s or EXP-16/As

Use C-1800 cables to connect a daisy chain of up to eight EXP-16s or EXP-16/As with a DAS board. A daisy chain allows development of a system of up to 128 channels for standard voltage or current measurement or up to 112 channels for thermocouple measurement (with cold-junction compensation).

You must select a different output channel on each EXP-16 or EXP-16/A in a daisy chain. Set each board for an output channel that corresponds to a DAS board input channel.

Direct connection is also possible between an EXP-16 or EXP-16/A and an STA-XX screw terminal accessory. The STA-XX can accommodate the 16 differential inputs of an EXP-16 or EXP-16/A and still have six or seven single-ended inputs remaining, depending on whether cold-junction compensation is used. Figure 4-2 illustrates a daisy chain of a DAS board, several EXP-16s or EXP-16/As, and an STA-XX.

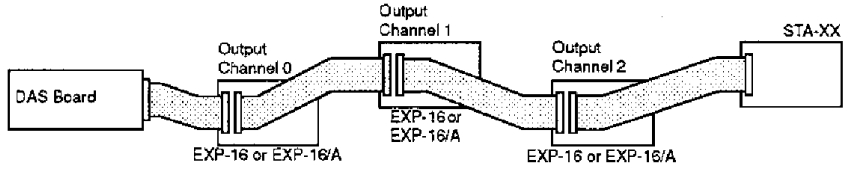

Figure 4-2. Daisy Chain of a DAS Board with EXP-16 or EXP-16/A and an STA-XX (all cables are C-1800)

The following subsections give specifics on connecting multiple EXP-16s or EXP-16/As to various DAS boards.

Using EXP-16s or EXP-16/As with DAS-16/1600/1400/1200 Series Boards

You can add up to eight EXP-16 or EXP-16/As to the analog input section of a DAS-16/1600/1400/1200 Series board to gain up to 128 channels. Digital outputs OP0 to OP3 drive the multiplexer address lines of the EXP-16 or EXP-16/A. Check your application software to determine how it exercises the digital outputs while performing A/D conversions.

Use an S-1600 adapter cable to connect the first EXP-16 or EXP-16/A to the DAS-16/1600/1400/1200 Series board. Use C-1800 cables to add more EXP-16s or EXP-16/As. Refer to Figure 4-3 for a diagram of the 3-foot S-1600 cable.

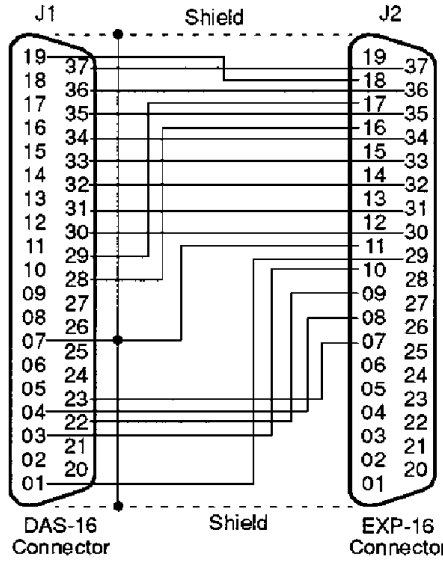

Figure 4-3. S-1600 Cable Wiring

When connecting EXP-16 or EXP-16/As to the DAS-16/1600/1400/1200 Series boards, you must use the optional PG-408A DC/DC converters and set switch S1 to INT or DC/DC. On the EXP-16/A, the jumper at J9 should be on the two pins farthest from switch S1 (in its default position), as shown in Figure 3-2. Figure 4-4 is a diagram showing the use of additional EXP-16s or EXP-16/As. You must set the DAS-16/1600/1400/1200 Series boards for single-ended inputs.

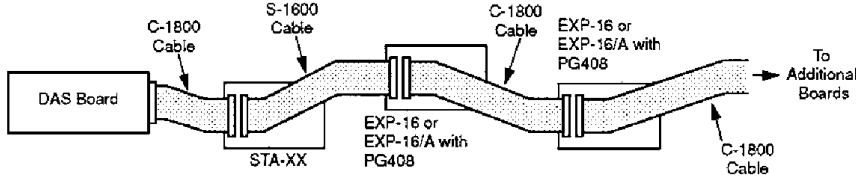

Figure 4-4. A Daisy Chain of a DAS-16/1600/1400/1200 Series board with an STA-XX and up to Eight EXP-16s or EXP-16/As

Note that in Figure 4-4, the analog outputs of additional DAS boards can be wired to the STA-XX.

When you connect an EXP-16 or EXP-16/A to a DAS-16/1600/1400/1200 Series board, you cannot sample the added EXP-16 channels in the fast DMA sampling mode because you drive the EXP-16 multiplexer address lines through the digital output port. However, you can partition your channels into some high-speed direct inputs (that are sampled directly by the DAS board) and some low-speed indirect inputs (sampled through the EXP-16 or EXP-16/A). The EXP-16 EXP-16/A is best suited to handling high-gain, low-rate-of-change inputs such as thermocouples, pressure transducers, and so on.

All analog input channel connections are made through screw connectors, and each EXP-16 or EXP-16/A (group of 16 channels) can operate at a different gain. In this way, a system can be configured with a variety of different channel functions, gains, and input modes (single-ended and differential).

Using EXP-16s or EXP-16/As with a DAS-8PGA/µCDAS-8PGA Board

You can add EXP-16s or EXP-16/As to any or all of the eight analog inputs of a DAS-8PGA/µCDAS-8PGA. An EXP-16 or EXP-16/A multiplexes 16 inputs into a single output channel. Therefore, a single DAS-8PGA/µCDAS-8PGA supports up to eight EXP-16s or EXP-16/As for a total of 128 input channels. The EXP-16 multiplexer address lines are set by digital outputs OP1 to OP4, so that a typical scan uses Mode 4 or 5, increments the multiplexer address with Mode 14, and repeats the scan of Mode 4 or 5 on the next set of multiplexer channels, and so on.

When using the DAS-8PGA/µCDAS-8PGA with EXP-16s or EXP-16/As, you must configure channels 1, 2, 3, and 5 as single-ended inputs using switch S2 (on the DAS board); this requirement is necessitated by the wiring configuration of the EXP-16 or EXP-16/A. In addition, you must also set the DAS-8PGA/µCDAS-8PGA channels that correspond to the analog output and CJC jumper settings of each EXP-16 or EXP-16/A for single-ended configuration. On the EXP-16/A, the jumper at J9 must be on the two pins farthest from switch S1 (in its default position), as shown in Figure 3-2.

An EXP-16 or EXP-16/A is designed to connect with flat cable and connectors similar to those used for the DAS-8PGA/µCDAS-8PGA. One cable should be provided for each EXP-16 or EXP-16/A. All analog input channel connections are made through screw terminals, and each EXP-16 or EXP-16/A (group of 16 channels) can operate at a different gain. In this way, a system can be configured with a variety of different channel functions, gains, and input modes (single-ended and differential).

Use a C-1800 cable for connecting a DAS board to an EXP-16 or EXP-16/A and for connecting a daisy chain of EXP-16s or EXP-16/As. The EXP-16s or EXP-16/As do not require a PG408A unless signals to be measured are near ±10 V.

Using EXP-16s and EXP-16/As with DAS-8AO/LT Boards

Use a C-1800 cable to connect an EXP-16 or EXP-16/A to a DAS-8AO/LT Series board. These DAS boards also require each connected EXP-16 or EXP-16/A to be used with a PG408A DC/DC converter module and that switch S1 be set for INT or DC/DC. On an EXP-16/A, the jumper at J9 must be on the two pins farthest from switch S1 (in its default position), as shown in Figure 3-2.

Using EXP-16s and EXP-16/As with a DASCON-1 Board

Use only a C-1800 cable to connect an EXP-16 or EXP-16/A to a DASCON-1 board. You should be aware, however, that a C-1800 cable can properly connect only the first three channels of the DASCON-1 and the EXP-16s or EXP-16/As and that you should connect the low side of the input channels to analog ground.

The DASCON-1 requires each connected EXP-16 or EXP-16/A to be used with a PG408A DC/DC converter and that switch S1 be set for INT or DC/DC.

To use a DASCON-1 with an EXP-16, you must modify the EXP-16 as follows:

1. Cut the etch between the point on the board marked A and the point marked +5 V.
2. Add a jumper between the point marked B and the point marked +5 V.

To use a DASCON-1 with an EXP-16/A, you must place the J9 jumper on the two pins closest to switch S1.

Avoiding Ground Loops

An EXP-16 or EXP-16/A provides 16 channels of differential analog input. While differential inputs are better than single-ended inputs for many applications, they require more care in their configuration to avoid ground loops and other undesirable effects. The following rules are offered to help you avoid the pitfalls of configuring these inputs:

- If you are driving an EXP-16 or EXP-16/A from a signal source that is already grounded, do not connect the EXP's low-level ground (LL GND) to its channel's low input (LO). Figure 4-5 illustrates the correct connections for a grounded source.

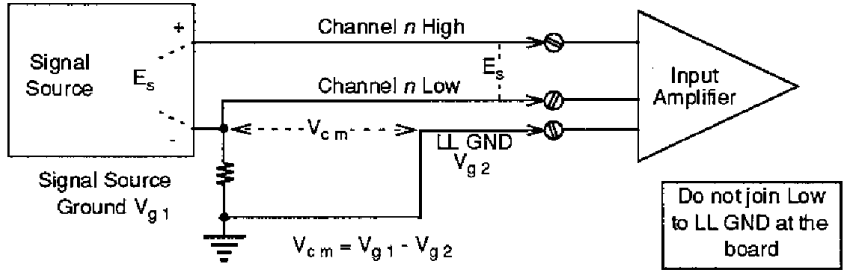

Figure 4-5. Connecting a Grounded Signal Source

- If you are connecting an EXP-16 or EXP-16/A to a floating signal source (such as a thermocouple), the low-level ground (LL GND) must be connected to the channel's low input by installing a jumper wire at the appropriate screw terminals. Figure 4-6 illustrates the correct connections for a floating source.

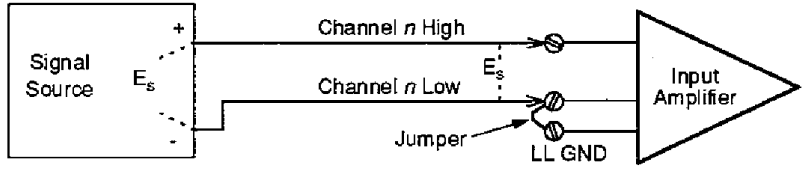

Figure 4-6. Connecting a Floating Signal Source

5

Calibration

This chapter describes calibration requirements for your EXP-16 or EXP-16/A.

Each EXP-16 and EXP-16/A is factory calibrated; it requires no further adjustment prior to installation. However, periodic calibration may be required to compensate for component aging, environmental changes, and so on. The calibration period in a clean, temperature-stable environment can be one year or more. In a dusty or varying-temperature environment, the calibration period can be as little as three months.

Equipment Requirements

You must have the following equipment to calibrate an EXP-16 or EXP-16/A:

- A 4 1/2 digit digital voltmeter
- A voltage calibrator (or a stable noise-free DC voltage source that can be used with the digital voltmeter)
- If the CJC circuitry is to be calibrated, you need a digital thermometer or other temperature-measuring device accurate to ±2° C

Instrumentation Amplifier Calibration

To calibrate the instrumentation amplifier of your EXP-16 or EXP-16/A, perform the following steps:

1. Connect power to the EXP-16 Series board (refer to "Setting the Output Jumpers" on page 3-5 for instructions).
2. Wire the CH15 HI terminal to the CH15 LO terminal and to the LL GND terminal to short them together.
3. Select channel 15 either by tying the channel-select pins (pins 7 to 10) to +5 V or, if connected to a DAS board, by setting all four digital outputs high with your application software.
4. Connect the digital multimeter from LL GND to one of the jumper pins on the upper side of the output channel jumper connector (J4), as shown in Figure 5-1 and Figure 5-2, below.
5. Set the gain switch to 1000.
6. Adjust the zero in potentiometer (EXP-16: R75; EXP-16A: R49) until the multimeter reads 0 VDC.
7. Set the gain switch to 0.5.
8. Adjust the zero out potentiometer (EXP-16: R76; EXP-16A: R34) until the multimeter reads 0 VDC.
9. One at a time, connect each of the other input channels (0 to 14) as in step 2 of this procedure; select a channel using the channel-select bits, and make sure the channel is at 0 VDC ±1 mV.
10. Set the gain switch to the desired value.
11. Connect the positive terminal of the voltage calibrator to CH15 HI and the negative terminal to CH15 LO and to LL GND.
12. Set the input voltage so that the input voltage times the gain equals +5 V; for example, if you are to run at a gain of 10, set the input voltage to 5 V / 10 = 0.5 V.
13. Adjust the gain potentiometer (EXP-16: R74; EXP-16A: R50) for a +5.000 ±1 mV output reading.

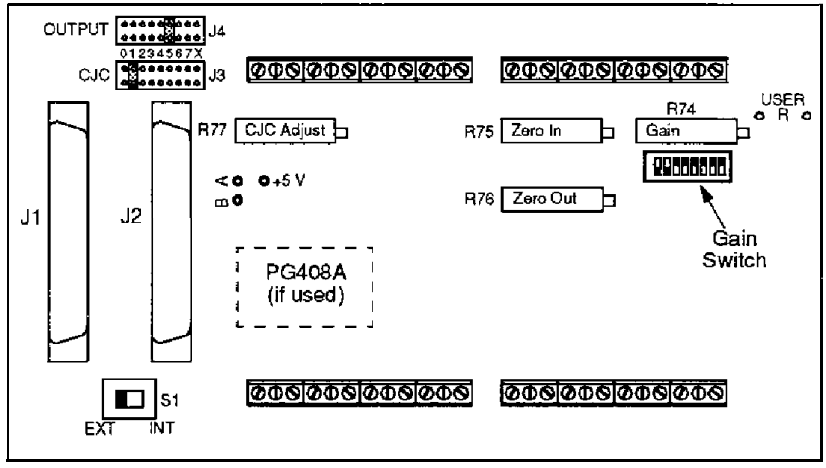

Figure 5-1. Locations of EXP-16 Calibration Components

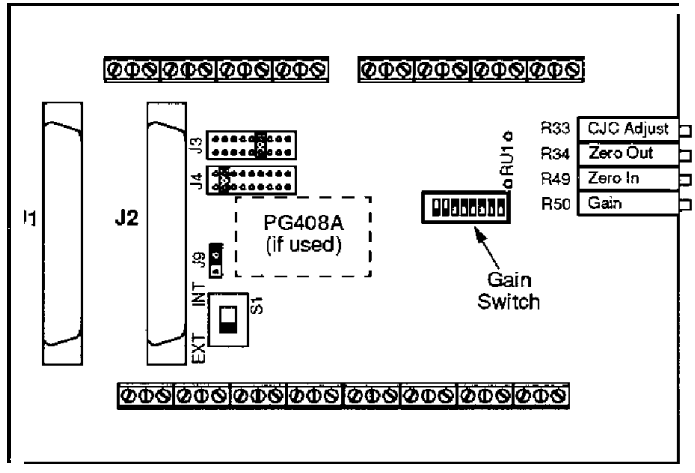

Figure 5-2. Locations of EXP-16/A Calibration Components

CJC Circuit Calibration

1. Connect the multimeter from LL GND to one of the jumper pins on the upper side of the output channel jumper (J3).
2. Monitor the temperature in the vicinity of CR2, the CJC sensor.
3. Adjust the CJC ADJ potentiometer (EXP-16: R77; EXP-16A: R33) to obtain a multimeter reading of 24.4 mV per °C; for example, if the digital thermometer reads 17.0 °C, adjust the CJC ADJ potentiometer until the multimeter reads 0.0244 × 17.0 or 0.4148 V).

6

Troubleshooting

This chapter guides you in resolving problems with measurement systems using an EXP-16 or EXP-16/A.

Problem Isolation

If you suspect a problem with faulty hardware or with cabling and wiring, try to isolate the problem to a major system component. Figure 6-1 shows the components in a simple measurement system using an EXP-16 or EXP-16/A.

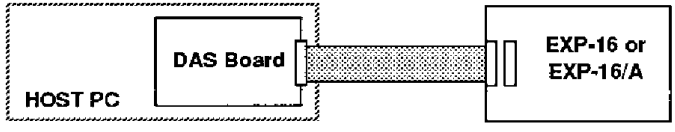

Figure 6-1. EXP-16 or EXP-16/A System Components

Measurement systems that use the EXP-16 or EXP-16/A vary in configuration and complexity, so it is not possible to provide one problem isolation procedure that applies to all systems. Two general techniques you can use to isolate a system problem are as follows:

- Remove a suspected component from the system and test it separately.

An example of this kind of test is checking the signal path through an EXP-16 or EXP-16/A by applying known input signals at the input connector and observing the outputs at the output connector. Another example is using an ohmmeter to test the continuity of wiring or cable conductors.

- Replace a suspected component with one that works. For example, if you have another DAS board that is functional, use it to replace the DAS board in a malfunctioning system. If the malfunctioning system then works, you have isolated the problem to the original DAS board.

Common Problems and Solutions

Table 6-1 lists symptoms and suggested solutions for problems with measurement systems using the EXP-16 or EXP-16/A. If you cannot solve the problem with this table, refer to "Technical Support" on page 6-4.

Table 6-1. Problems and Suggested Solutions

Symptom	Possible Cause	Suggestions
No response from EXP-16 or EXP-16/A during data acquisition	Bad physical connection or cable	Check the DAS/EXP-16 cabling. Make sure all the connectors are firmly tightened. To verify that the problem is not with the cable itself, remove the cable and try a different one.
	Wrong cable	Refer to Chapter 4 for cabling information.
	No power or inadequate power	Make sure the EXP-16 or EXP-16/A is configured to use the power from the correct source (DAS or external). If the configuration is correct, make sure the power supply rating is sufficient to handle the current demand. Make sure the wires or cable are not too long. Refer to Chapter 3.

Table 6-1. Problems and Suggested Solutions (cont.)

Symptom	Possible Cause	Suggestions
No response from EXP-16 or EXP-16/A during data acquisition (cont.)	Problem with DAS board or PC	Refer to the DAS board user's guide for assistance.
Intermittent operation	Vibrations or loose connections	Cushion source of vibration and tighten connections.
	Overheating	Check for external heat sources and try to position the EXP-16 or EXP-16/A away from them.
	Electrical noise	Make sure you are using the correct cable to connect the DAS board to the EXP-16 or EXP-16/A. Make sure the PC cover is installed. Re-route the cable away from likely sources of emissions, such as video monitors.
	Inadequate power	Make sure the power supply rating is sufficient to handle the current demand. Make sure the wires or cable are not too long. Refer to Chapter 4.
Miscellaneous	Damaged EXP-16 or EXP-16/A	Contact the Keithley MetraByte Hardware Application Engineering Department. Refer to "Technical Support" on page 6-4.
Invalid data	Bad input connections	Check cabling or wiring from sensors to EXP-16 or EXP-16/A inputs.
	Electrical noise	Use shielded input wiring. Make sure the PC cover is installed. Re-route the wiring away from likely sources of emissions, such as video monitors.

Table 6-1. Problems and Suggested Solutions (cont.)

Symptom	Possible Cause	Suggestions
Invalid data (cont.)	Swapped channels	Trace all signals from the sensors to the DAS board to make sure they connect to the correct DAS inputs. Check the output channel jumpers on the EXP-16 or EXP-16/A.
	Gain too high or too low	Check gain calculations. Check gain settings on EXP-16 or EXP-16/A and DAS board. Measure signal levels at EXP-16 or EXP-16/A and DAS inputs.
	Calibration required	Run the DAS calibration and EXP-16 or EXP-16/A zero calibration procedures.
	Inadequate power	Make sure the power supply rating is sufficient to handle the current demand. Make sure the wires or cable are not too long. Refer to Chapter 4.
	Problem with DAS board or PC	Refer to the DAS board user's

Technical Suppor

An applications engineer will help you try to diagnose and resolve your board problem over the telephone. To save time, be ready to furnish the following information:

EXP-16 or EXP-16/A configuration	Model	_____
	Serial #	_____
	Revision code	_____
	Number of channels	_____
	Number of EXP-16s.	_____
DAS board configuration	Model	_____
	Serial #	_____
	Revision code	_____
	Base address setting	_____
	Interrupt level setting	_____
	Number of channels	_____
	Input (S.E. or Diff.)	_____
	Mode (uni. or bip.)	_____
	DMA channel(s)	_____
Computer	Manufacturer	_____
	CPU type	_____
	Clock speed (MHz)	_____
	KB of RAM	_____
	Video system	_____
	BIOS type	_____
Operating System	DOS version	_____
	Windows version	_____
	Windows mode	_____
Software package	Name	_____
	Serial #	_____
	Version	_____
	Invoice/Order #	_____
Compiler (if applicable)	Language	_____
	Manufacturer	_____
	Version	_____
Accessories	Type	_____
	Type	_____

If a telephone resolution is not possible, the applications engineer will issue you a Return Material Authorization (RMA) number and ask you to return the equipment. Please reference the RMA number in any documentation regarding the equipment and on the outside of the shipping container.

When returning equipment for repair, please include the following information:

- Your name, address, and telephone number.
- A description of the problem or its symptoms.
- The RMA number on the outside of the package.

Note: If you are subı for repair under warranty, you must furnish the invoice nu

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Repackage the equipment. Use i possible.

A

Specifications

The following tables contain specifications for EXP-16 and EXP-16/A.

Table A-1. Analog Data

Feature	Specification
Input bias current	2 nA typical; 6 nA maximum
Temperature coefficient	5 ppm typical; 15 ppm maximum
Overvoltage protection	±30 V continuous
Common mode range	±10 V maximum
Analog output voltage	±5 V maximum
Analog output current	20 mA maximum
Analog output short-circuit current	25 mA maximum for ±5 V output voltage and indefinite duration

Table A-2. Cold-Junction Compensation

Feature	Specification
Output scaling	+24.4 mV/°C (0.1 °C/bit)
Output at 0.0 C	0.0 V

Table A-3. Gain Relationships

Gain	Maximum Input Offset Voltage Drift	Common Mode Rejection	Nonlinearity	Instrumentation Amplifier Settling Time[1]
1000	1 µV/°C	125 dB	0.005	50 µs
100	2 µV/°C	125 dB	0.005	15 µs
10	12 µV/°C	110 dB	0.007	13 µs
1	120 µV/°C	90 dB	0.015	12 µs

Notes

[1] Settling times were obtained without an input filter. Settling times obtained with standard input filter (two 1 kΩ resistors and a 1 µF capacitor) are greater.

Table A-4. Power Requirements

Feature	Specification
+5 V current With PG-408A Without PG-408A	 • 175 mA typical; 250 mA maximum • 20 mA typical; 30 mA maximum
+12 V current	8 mA typical; 10 mA maximum (without PG-408A)
–12 V current	8 mA typical; 10 mA maximum (without PG-408A)

Table A-5. Environmental Specifications

Feature	Specification
Operating temperature range	0 to 60 °C
Storage temperature range	–40 to 100 °C
Humidity	0 to 90% non-condensing

Table A-6. Physical Specifications

Feature	Specification
Dimensions: EXP-16 without standoffs EXP-16 with standoffs EXP-16/A	 8 x 4.74 x 0.75 inches 8 x 4.74 x 1.25 inches 6.25 x 4.75 x 0.75 inches
Weight	0.5 lb
Screw terminal wire spacing	0.197 inches
Screw terminal wire sizes	12 to 22 AWG

B

Connector Pin Assignments

An EXP-16 or EXP-16/A contains two, parallel-wired, 37-pin, male D connectors. While both connectors carry the main I/O signals, the first connector (J1) is normally cabled to the DAS board, and the second (J2) is normally cabled to an additional EXP-16 or EXP-16/A or to another types of accessory. Pin assignments for the main I/O connectors are shown in Figure B-1.

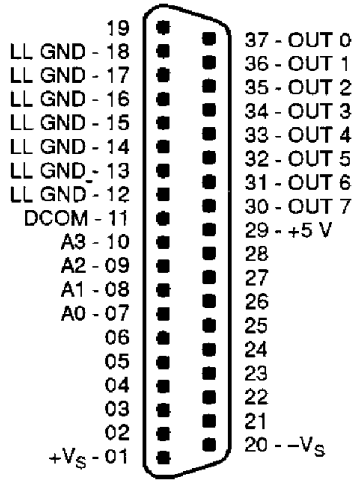

Figure B-1. Pin Assignments for Main I/O Connectors J1 and J2

C

Operating Notes

This appendix contains miscellaneous additional material on the operation of an EXP-16 or EXP-16/A with DAS-8 Calls.

Input Channel Selection with DAS-8 Calls

Each channel to be sampled for multiplexing is selected by a 4-bit TTL/CMOS-compatible address on the differential-channel-select lines, shown in Figure 2-1. An address of 0h selects channel 0, 1h selects channel 1, 2h selects channel 2, and so on.

When you use an EXP-16 or EXP-16/A with a DAS-8, you control the address with the DAS-8 digital outputs OP1 to OP4. These DAS-8 outputs are activated by DAS-8 CALL Mode 14 (see the DAS-8 user's guide for a description of CALL modes).

Upon execution of the Mode 14 CALL, the OP0 to OP3 outputs of the DAS-8 remain fixed; any subsequent DAS-8 routines are performed on the selected channel. To read other channels, use the Mode 14 CALL again to select a new input channel.

Input channels of an EXP-16 or EXP-16/A can be scanned using a simple BASIC *for...next* loop. The following example shows the programming steps required to scan the channels of an EXP-16 or EXP-16/A, read the A/D (in Mode 4), and store the data in an array called DIO%. Note that the DAS-8 must be ready to run; that is, the DAS-8 base address must be set, the DAS-8 binary code must be loaded, and so on. Refer to the DAS-8 user's guide for details.

```
xxx10    DIM DIO% (16)
xxx20    MD% = 1: LT% (0) = 1: LT% (1) = 1    'Sets DAS-8 input
                                              'channel.
xxx30    CALL DAS* (MD%, LT%(0), FLAG%)       'This must be set equal
                                              'to the EXP-16 out
                                              'channel selected by the
                                              'EXP-16 jumpers.
xxx40    FOR I = 0 TO 15                      'Sets up channel scan
                                              'routine.
xxx50    MD% = 14: OP% = I                    'Sets up MODE 14,
                                              'channel 1.
xxx60    CALL DAS8 (MD%, OP%, FLAG%)          'Sets channel.
xxx70    MD% = 4:                             'Set MODE 4.
xxx80    CALL DAS8 (MD%, DIO%(I), FLAG%)      'Perform conversion.
xxx90    NEXT I                               'Return to next scan.
```

The data from channel 0 is in Array DIO%, channel 1 is in DIO%(1), channel 2 in DIO%(2), and so on. If more than one of the DAS-8 input channels are to be used, they can be scanned simply by nesting *for....next* loops.

Software Support for Low-Level Devices

The outputs of low-level transducers, such as thermocouples and strain-gage bridges (load cells, pressure and force transducers), require amplification before their application to the high level of many A/D (analog-to-digital) inputs (including the DAS-8). An EXP-16 or EXP-16/A incorporates an instrumentation amplifier that provides stable amplification and includes circuitry allowing cold-junction compensation of thermocouples. The EXP-16 or EXP-16/A can handle most interface requirements for DC output transducers.

Included in EXP-16 or EXP-16/A software package is a diskette labelled *Thermolab*. This diskette contains BASIC programs illustrating use of an EXP-16 or EXP-16/A with a DAS-8. Though this package of programs is intended to interface directly with the DAS-8, the thermocouple linearization routines are adaptable to perform linearization on any set of thermocouple data that can be brought into the BASIC workspace. Thermolab programs include the following:

- **ONE-EXP.BAS** - A program for using one EXP-16 or EXP-16/A with a DAS-8
- **MANY-EXP.BAS** - A program for using three EXP-16s or EXP-16/As with a DAS-8
- **EXP-J** to **R** - Examples of using thermocouples
- **J.BAS** to **R.BAS** - Subroutines for thermocouple linearization

Before running these routines, copy DAS-8.ADR and DAS8.BIN onto the EXP-16 software diskette. You may also wish to copy BASICA.COM from your DOS diskette to the EXP-16 software diskette. The thermocouple subroutines are in ASCII to facilitate merging them into your own BASIC programs. Each subroutine has different line numbering to allow merging for use with different thermocouple types. The subroutines are commented and consist of a data section that should be GOSUB'd in the initialization section of your program. This loads a look-up array (that may require a few seconds of load time). The second section of each subroutine performs a linear interpolation. This method is both fast and accurate over the full operating temperature range of the thermocouples. To avoid error messages, data should be bounded to physically realizable minimum/maximum values before entering the subroutines.

The examples are just one way of programming an EXP-16 or EXP-16/A for use with a DAS-8, but they can serve as a starting point for programming your own applications.

D

Channel Numbers for Software

This appendix describes the assignment of channel numbers for a DAS board and all attached EXP-16s for use in software such as the Control Panel utility.

Channel Numbering for 8-Channel DAS Boards

DAS-8/800 Series boards contain eight analog input channels, numbered 0 through 7. If you require additional channels, you can use up to eight 16-channel EXP-16 Series expansion accessories to increase the number of available channels to 128. Expansion accessories are assigned to consecutive analog input channels of the DAS-8/800 Series board, beginning with onboard channel 0. Table D-1 lists the software (logical) channels associated with each expansion accessory.

Table D-1. Channels in Maximum EXP-8/800 Configuration

DAS-8/800 Series Onboard Channel	EXP-16 and EXP-16/A Software (Logical) Channels
0	0 to 15
1	16 to 31
2	32 to 47
3	48 to 63
4	64 to 79
5	80 to 95
6	96 to 111
7	112 to 127

Figure D-1 illustrates the use of three EXP-16s or EXP-16/As and the five remaining onboard channels on a DAS-8/800 Series board configured for single-ended mode. In software such as the Control Panel utility, you refer to the physical channels on the EXP-16 or EXP-16/A attached to analog input channel 0 as logical channels 0 to 15, the physical channels on the EXP-16 or EXP-16/A attached to analog input channel 1 as logical channels 16 to 31, and the physical channels on the EXP-16 or EXP-16/A attached to analog input channel 2 as logical channels 32 to 47. You refer to the remaining 13 onboard analog input channels (physical channels 3 through 7) in software as logical channels 48 through 52.

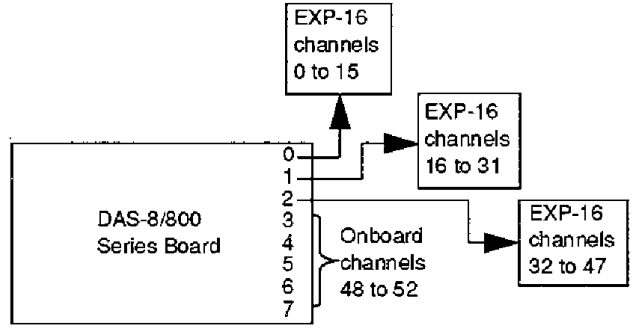

Figure D-1. Analog Input Channel Numbering for Software Control

You can perform an analog input operation on a single channel or on multiple channels.

Channel Numbering for 16-Channel DAS Boards

DAS-16/1600/1400/1200 Series boards are switch-configurable for either 16 single-ended analog input channels (numbered 0 through 15) or eight differential analog input channels (numbered 0 through 7). If you require more than the 16 single-ended onboard channels, you can use up to 16 EXP-16s or EXP-16/As to increase the number of available channels to 256.

EXP-16s or EXP-16/As are assigned to consecutive onboard analog input channels, beginning with onboard channel 0. Table D-2 lists the software (or logical) channels associated with each EXP-16 or EXP-16/A.

Table D-2. Channels in Maximum EXP-16 Series Configuration

Onboard Channel	EXP-16 and EXP-16/A Software (Logical) Channels
0	0 to 15
1	16 to 31
2	32 to 47
3	48 to 63
4	64 to 79
5	80 to 95
6	96 to 111
7	112 to 127
8	128 to 143
9	144 to 159
10	160 to 175
11	176 to 191
12	192 to 207
13	208 to 223
14	224 to 239
15	240 to 255

Figure D-2 illustrates the use of three EXP-16s or EXP-16/As and the 13 remaining onboard channels on a DAS-16/1600/1400/1200 Series board configured for single-ended mode. In software such as the Control Panel utility, you refer to the physical channels on the EXP-16 or EXP-16/A attached to analog input channel 0 as logical channels 0 to 15, the physical channels on the EXP-16 or EXP-16/A attached to analog input

channel 1 as logical channels 16 to 31, and the physical channels on the EXP-16 or EXP-16/A attached to analog input channel 2 as logical channels 32 to 47. You refer to the remaining 13 onboard analog input channels (physical channels 3 to 15) in software as logical channels 48 to 60.

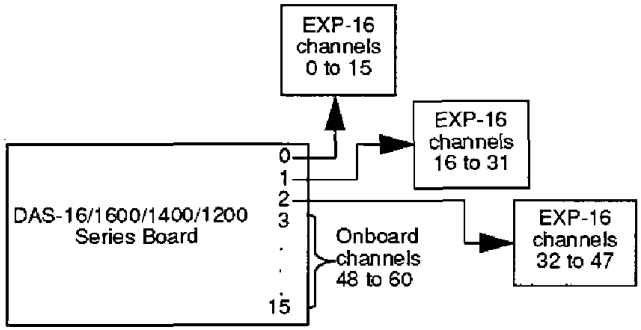

Figure D-2. Analog Input Channels

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Specifications are subject to change without notice.

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