KEITHLEY

DAS-1600/1400 Series

User's Guide

WARRANTY

Hardware

Keithley Instruments, Inc. warrants that, for a period of one (1) year from the date of shipment (3 years for Models 2000, 2001, 2002, 2010 and 2700), the Keithley Hardware product will be free from defects in materials or workmanship. This warranty will be honored provided the defect has not been caused by use of the Keithley Hardware not in accordance with the instructions for the product. This warranty shall be null and void upon: (1) any modification of Keithley Hardware that is made by other than Keithley and not approved in writing by Keithley or (2) operation of the Keithley Hardware outside of the environmental specifications therefore.

Upon receiving notification of a defect in the Keithley Hardware during the warranty period, Keithley will, at its option, either repair or replace such Keithley Hardware. During the first ninety days of the warranty period, Keithley will, at its option, supply the necessary on site labor to return the product to the condition prior to the notification of a defect. Failure to notify Keithley of a defect during the warranty shall relieve Keithley of its obligations and liabilities under this warranty.

Other Hardware

The portion of the product that is not manufactured by Keithley (Other Hardware) shall not be covered by this warranty, and Keithley shall have no duty of obligation to enforce any manufacturers' warranties on behalf of the customer. On those other manufacturers' products that Keithley purchases for resale, Keithley shall have no duty of obligation to enforce any manufacturers' warranties on behalf of the customer.

Software

Keithley warrants that for a period of one (1) year from date of shipment, the Keithley produced portion of the software or firmware (Keithley Software) will conform in all material respects with the published specifications provided such Keithley Software is used on the product for which it is intended and otherwise in accordance with the instructions therefore. Keithley does not warrant that operation of the Keithley Software will be uninterrupted or error-free and/or that the Keithley Software will be adequate for the customer's intended application and/or use. This warranty shall be null and void upon any modification of the Keithley Software that is made by other than Keithley and not approved in writing by Keithley.

If Keithley receives notification of a Keithley Software nonconformity that is covered by this warranty during the warranty period, Keithley will review the conditions described in such notice. Such notice must state the published specification(s) to which the Keithley Software fails to conform and the manner in which the Keithley Software fails to conform to such published specification(s) with sufficient specificity to permit Keithley to correct such nonconformity. If Keithley determines that the Keithley Software does not conform with the published specifications, Keithley will, at its option, provide either the programming services necessary to correct such nonconformity or develop a program change to bypass such nonconformity in the Keithley Software. Failure to notify Keithley of a nonconformity during the warranty shall relieve Keithley of its obligations and liabilities under this warranty.

Other Software

OEM software that is not produced by Keithley (Other Software) shall not be covered by this warranty, and Keithley shall have no duty or obligation to enforce any OEM's warranties on behalf of the customer.

Other Items

Keithley warrants the following items for 90 days from the date of shipment: probes, cables, rechargeable batteries, diskettes, and documentation.

Items not Covered under Warranty

This warranty does not apply to fuses, non-rechargeable batteries, damage from battery leakage, or problems arising from normal wear or failure to follow instructions.

Limitation of Warranty

This warranty does not apply to defects resulting from product modification made by Purchaser without Keithley's express written consent, or by misuse of any product or part.

Disclaimer of Warranties

Limitation of Liability

DAS-1600/1400 Series
User's Guide

Keithley Instruments, Inc.

28775 Aurora Road, Cleveland, OH 44139

Telephone: (440) 248-0400 ● FAX: (440) 248-6168

http://www.keithley.com

KEITHLEY   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.

Table of Contents

D   CE Mark Information

List of Figures

List of Tables

Preface

This guide describes how to set up, install, and operate the following Keithley products:

- The DAS–1601 and DAS–1602 boards, which are referred to collectively as DAS–1600 Series boards.

- The DAS–1401 and DAS–1402 boards, which are referred to collectively as DAS–1400 Series boards.

Unless this manual refers specifically to a particular board, it refers to all models collectively as the DAS–1600/1400 Series boards.

To follow the information and instructions contained in this manual, you must be familiar with the operation of an IBM® PC AT®, or equivalent computer in the Windows™ (3.x, 95/98, or NT) environment. You must also be familiar with data acquisition principles and the requirements of your applications.

Manual Organization

The following table lists the topics this guide focuses on and indicates
where you can find information about a topic.

To learn more about	See
The capabilities of DAS-1600/1400 Series boards	Chapter 1
What software is available for the boards	Chapter 1
What accessories are available for the boards	Chapter 1
Functionality of DAS-1600/1400 Series boards	Chapter 2
Installing the DAS-1600/1400 Series standard software package	Chapter 3
Setting up switch-selectable options	Chapter 3
Installing your boards	Chapter 3
Attaching accessories	Chapter 4
Precautions to observe when connecting signals	Chapter 4
Using the DriverLINX Analog I/O Panel software for test and data acquisition	Chapter 5
Calibrating the board	Chapter 6
Troubleshooting and obtaining technical support	Chapter 7
DAS-1600/1400 Series specifications	Appendix A
I/O connector pin assignments	Appendix B
The register level I/O map	Appendix C
CE Mark information	Appendix D

Related Documents

You can find more information on DAS-1600/1400 Series software and accessories in the related documents listed in the following table.

Document
EXP-16 & EXP-16/A Expansion Multiplexer/Amplifier System User's Guide
EXP-GP Signal Conditioning Multiplexer User's Guide
MB Series User's Guide
SSH-4/A Simultaneous Sample & Hold Module User's Guide
SSH-8 User's Guide
ISO-4 User's Guide
EXP-800/1600 User's Guide

1

Overview

The DAS-1600/1400 Series is a family of high-performance analog and digital I/O boards with DriverLINX software requiring:

- an IBM PC or compatible AT (386, or Pentium CPU) with 2 MB of memory.

- at least one floppy disk drive, and one fixed disk drive.

- MS-DOS/PCDOS 3.1 or higher.

- Microsoft Windows 3.x or Windows 95/98.

- a compiler supporting Microsoft Windows development.

- a mouse is highly recommended.

The DAS-1601 and DAS-1401 are high-gain boards, while the DAS-1602 and DAS-1402 are low-gain boards.

This chapter describes features of the DAS-1600/1400 Series boards, the software that supports them, and available accessories.

Features

Features shared by the DAS-1600 Series and DAS-1400 Series are as follows:

- Boards are switch-configurable for 16 single-ended or eight differential analog input channels.

- Analog inputs are switch-configurable for either unipolar (0 to 10 V) or bipolar (± 10 V) signals.

- Analog input channels are individually programmable for gain. The DAS-1601/1401 boards have programmable gains of 1, 10, 100, and 500. The DAS-1602/1402 boards have programmable gains of 1, 2, 4, and 8.

- Analog input sampling is a maximum of 100 ksamples/s with 12-bit resolution.

- The base I/O address and Direct Memory Address (DMA) channel are switch-configurable; interrupt levels are software-configurable.

- Burst mode sampling capability emulates simultaneous sample-and-hold (SSH) operation.

- Analog-to-digital (A/D) conversions run by any of the following methods:

  – software command

  – onboard pacer clock

  – external pacer clock

- External SSH hardware is supported.

- Data transfers can run by any of the following methods:

  – program control

  – interrupt service routines

  – DMA transfer

- The boards perform 8-bit data transfers on the ISA bus.

- A 3-channel programmable counter/timer (82C54) provides timing for analog input operations or generation of output pulses at any rate from 1 pulse/hour to 100 kHz. The 82C54 counter/timer can also be used to measure frequency, period, and pulse width.

- The boards have four unidirectional digital inputs and four unidirectional digital outputs.

- The boards are backward compatible with the DAS-16G1 and DAS-16G2 boards.

  Programs for the DAS-16G1 and DAS-16G2 boards run on the DAS-1600 Series without modification. The DAS-1400 Series maintains backward compatibility with the analog input section of the DAS-16G1.

DAS-1600 Series boards provide the following additional features:

- Two 12-bit digital-to-analog converter (DAC) channels. The outputs of these channels have switch-configurable output ranges of 0 to 5 V, 0 to 10 V, ±5 V, and ±10 V full scale. In addition, you can apply an external reference to provide analog outputs in other ranges or to use the DACs as programmable attenuators.

- An additional 24 bits of bidirectional digital I/O by way of the PIO cable connector (J2). These 24 bits are configured as two 8-bit ports and two 4-bit ports that you can set independently for input or output.

  The 24-bit digital port is compatible with the Keithley MetraByte PIO-12 board. You can use these ports to gate the counter/timer, control multiplexers, and read the status of external devices.

For more information on these features, refer to the functional description in Chapter 2.

Supporting Software

The following software is available for operating DAS-1600/1400 Series boards:

- **DAS-1600/1400 Series standard software package** - Shipped with DAS-1600/1400 Series boards. Includes DriverLINX® for Microsoft® Windows and function libraries for writing application programs under Windows™ in a high-level language such as Microsoft Visual C++; Microsoft Visual Basic; Borland Delphi®; utility programs; and language-specific example programs.

- **DriverLINX-** the high-performance real-time data-acquisition device drivers for Windows application development including:

  - *DriverLINX API DLLs* and drivers supporting the DAS-1600/1400 Series hardware

  - *Analog I/O Panel* - A DriverLINX program that verifies the installation and configuration of DriverLINX to your DAS-1600/1400 Series board and demonstrates several virtual bench-top instruments

- *Learn DriverLINX* - an interactive learning and demonstration program for DriverLINX that includes a Digital Storage Oscilloscope

- *Source Code* - for the sample programs

- *DriverLINX Application Programming Interface files* - for the DAS-1600/1400 Series compiler

- *DriverLINX On-line Help System* - provides immediate help as you operate DriverLINX

- *Supplemental Documentation* - on DriverLINX installation and configuration; analog and digital I/O programming; counter/timer programming; technical reference; and information specific to the DAS-1600/1400 Series hardware.

- **DAS-1600/1400 Series utilities -** The following utilities are provided as part of both the DAS-1600/1400 Series standard software package:

  - Calibration Utility

  - Test Utility

Accessories

The following accessories are available for use with the DAS-1600/1400 Series boards.

- **STA-16** - Screw-terminal adapter accessory that connects to the main I/O connector of a DAS-1600/1400 Series board through a C-1800 cable.

- **STA-U** - Universal screw-terminal accessory that connects to the PIO cable of a DAS-1600/1400 Series board through a C-1800 cable.

- **STC-37** - Direct DAS-1600/1400 Series board to screw terminal interface.

- **STP-37** - Screw-terminal panel that connects to the main I/O connector of a DAS-1600/1400 Series board through a C-1800 cable.

- **ISO-4** - 4-channel isolated expansion multiplexer.

- **SSH-4/A** - 4-channel simultaneous sample-and-hold accessory that connects to the main I/O connector of a DAS-1600/1400 Series board through a C-1800 cable. You can cascade additional SSH4/A accessories through CACC-2000 cables.

- **SSH-8** - 8-channel simultaneous sample-and-hold accessory that connects to the main I/O connector of a DAS-1600/1400 Series board through a C-1800 cable.

- **MB Series modules and backplanes** - Plug-in, isolated, signal-conditioning modules and the backplanes that hold them. Supported backplanes include the MB01, MB02, and MB05.

- **STA-MB** - Screw terminal accessory for MB Series modules. The STA-MB connects to a DAS-1600/1400 Series board through a C-1800 cable and contains mounting holes for up to four MB Series modules. The STA-MB brings all signal lines from the DAS-1600/1400 Series board and all inputs and outputs from the MB Series modules out to external screw terminals.

- **STA-SCM16** - Screw terminal accessory that attaches to the main I/O of a DAS-1600/1400 Series board through a C-1800 cable and attaches to up four MB02 backplanes through C-2600 cables.

- **EXP-16 and EXP-16/A** - 16-channel expansion multiplexer and signal conditioning boards; requires the S-1600 cable and the PG-408A option.

- **PG-408A** is a snap-in DC/DC converter module for an EXP-16 or EXP-16/A used with a DAS-1600/1400 Series board.

- **EXP-1600** - 16-channel expansion accessory that connects directly to DAS-1600 Series boards. Refer to the *EXP-1600 User's Guide* for more information.

- **SSIO-24** - 24-channel mounting panel for up to 24 solid-state, miniature I/O modules with functions of DC input, DC output, AC input, and AC output. The SSIO-24 connects to the PIO cable of a DAS-1600/1400 Series board through a C-1800 cable.

- **ERB-24** - electrical relay board. This accessory provides 24 electromechanical double-pole, double-throw relays for controlling and switching up to 3 A at 120 V_{rms}. The ERB-24 connects to the PIO cable of a DAS-1600/1400 Series board through a C-1800 cable.

- **C-1800** - Cable for attaching the main I/O connector of a DAS-1600/1400 Series board to an STA-16, STA-MB, STA-SCM-16, STP-37, SSH8, or SSH4/A accessory. This cable can also be used to connect the PIO cable of a DAS-1600 Series board to an STA-U, SSIO-24, ERB-24 accessory, or to cascade additional EXP-GP, EXP-16, or ISO-4 accessories.

- **S-1800** - Shielded version of the C-1800 cable.

- **CACC-2000** - Cable for cascading additional SSH-4/A accessories.

- **S-1600** - Cable for attaching an STA-16 or STA-MB to an EXP-16, EXP-GP, or ISO-4 accessory.

- **CAB-3740** - Cable for attaching the main I/O connector of a DAS-1600/1400 Series board to an EXP-1600 accessory.

- **CAB-40/1** - Cable for cascading additional EXP-1600 accessories.

- **C-16MB1** - Cable for attaching the main I/O connector of a DAS-1600/1400 Series board to an MB01/05 backplane.

- **C-2600** - Cable for attaching an STA-SCM16 to an MB02 backplane.

2

Functional Description

This chapter describes the following features of DAS-1600/1400
Series boards:

- Analog input
- Analog output
- Digital I/O
- 82C54 counter/timer
- Wait state selection
- Power

These descriptions are offered to familiarize you with the operating
options and to enable you to make the best use of your board. The block
diagram in Figure 2-1 represents both the DAS-1600 and DAS-1400
Series boards.
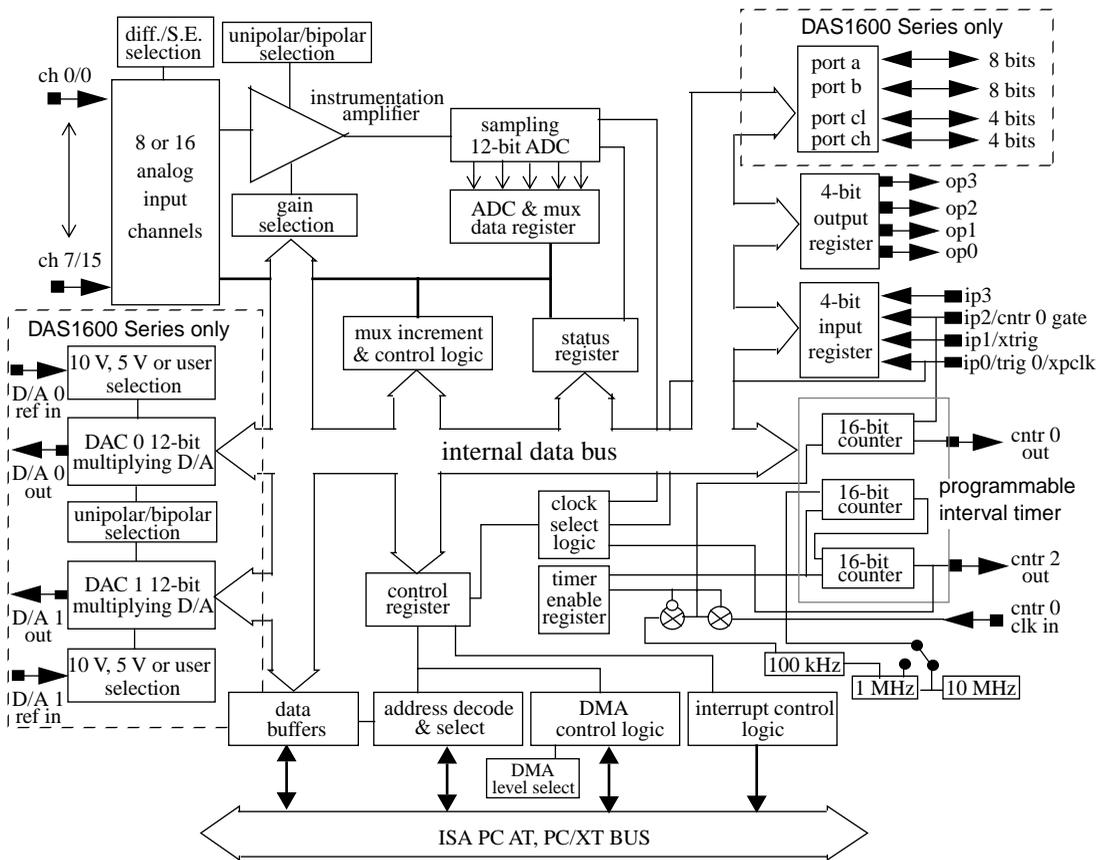
Figure 2-1. Functional Block Diagram

Analog Input Features

The analog input section of a DAS-1600/1400 Series board multiplexes all the active input channels (up to 16 single-ended or eight differential) into a single, 12-bit, sampling, analog-to-digital converter (ADC).

Other features of this section include input configurations, gain selection, conversion modes, triggers, clock sources, and data transfer modes. These features are described in the following subsections.

Differential/Single-Ended Selection

Using configuration switches, you can select either eight differential or 16 single-ended inputs. Differential inputs measure the difference between two signals. Single-ended inputs are referred to a common ground.

Generally, you want to use differential inputs for low-level signals whose noise component is a significant part of the signal or for signals that have nonground common mode. You want to use single-ended inputs for high-level signals whose noise component is not significant.

The specific level at which input configurations work best depends on the application. However, you generally use differential inputs for voltage ranges of 100 mV and less.

Unipolar/Bipolar Selection

Using configuration switches, you can set the DAS-1600/1400 Series boards to operate in either unipolar or bipolar input mode. A unipolar signal is always positive (0 to 10 V, for example), while a bipolar signal can swing up and down between negative and positive peak values (–10 V to +10 V, for example).

The DAS-1600/1400 Series boards use left-justified, offset binary to represent signals. In a given input range with the same peak-voltage capacity for both modes, unipolar mode doubles the converter's resolution.

Channel Selection in Expanded Configurations

As previously mentioned, the DAS-1600/1400 Series supports 16 single-ended or eight differential analog input channels. If you require additional analog input channels or signal conditioning for transducer inputs, you can attach EXP-16, EXP-16/A, EXP-GP, or EXP-1600 expansion accessories. Attaching any combination of up to eight 16-channel EXP-16 or EXP-16/A accessories, and/or eight 8-channel EXP-GP accessories can increase the number of available channels to 128. Attaching up to sixteen 16-channel EXP-1600 accessories can increase the number of available channels to 256.

When you daisy-chain expansion boards from the analog inputs, you are advised to make the first expansion board multiplex onboard channel 0, the next expansion board multiplex channel 1, and so on. You select an onboard channel using jumper settings on the expansion board.

You can access any unused onboard channels by placing an STA-16 screw terminal accessory first in the daisy-chain configuration. Figure 2-2 illustrates how expansion boards and accessories interface with the analog channels of DAS-1600/1400 Series boards.
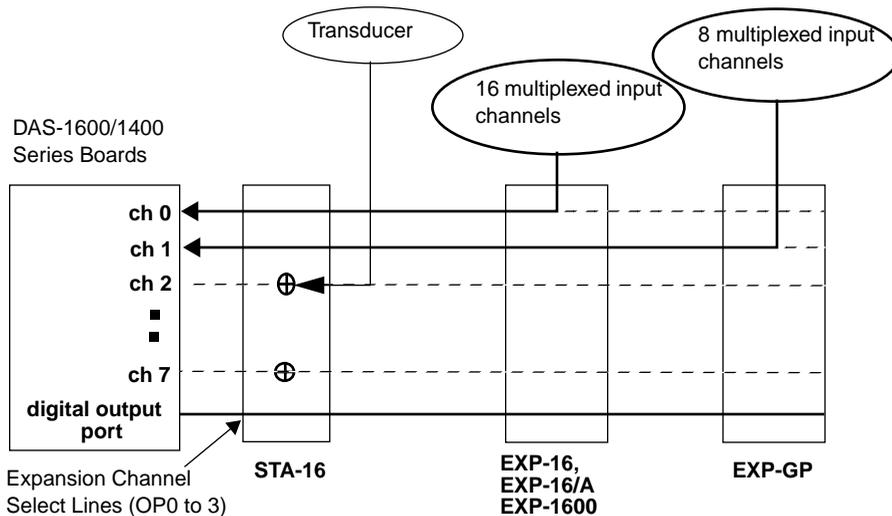
Figure 2-2. Expanding the Analog Inputs of DAS-1600/1400 Series Boards

You can also use up to four MB02 backplanes to increase the number of available channels to 64 isolated or 12 nonisolated. For more information about connecting channel expansion boards, refer to Chapter 4.

Notes: You must specify a single-ended input configuration for all onboard channels associated with channels on MB02 backplanes.

If you are using EXP-16, EXP-16/A, EXP-GP, or EXP-1600 expansion accessories or MB Series backplanes, the digital output lines of the DAS-1600/1400 Series board select a particular channel on the expansion board or backplane to read.

Gain Selection

The programmable gain you select is applied to an incoming signal as a multiplication factor; gain allows you to amplify a signal to a range that the ADC can accurately measure.

For example, if the ADC handles signals in the ±10 V range and you want to measure a signal in the range of ±1.0 V, you would use a gain of 10 to amplify the signal to the ±10 V range. Similarly, if you wanted to measure a signal that was already in the ±10 V range, you would select a gain of 1.

The available gains, their corresponding input ranges, and throughput rates are listed in Table 2-1 for the DAS-1601/1401 and Table 2-2 for the DAS-1602/1402.

Table 2-1. DAS-1601/1401 Gains, Ranges, and Throughput Rates for Unipolar and Bipolar Selections

Gain	Unipolar Range	Bipolar Range	Maximum Throughput Rate
1	0.0 to +10.0 V	−10.0 to +10.0 V	100 ksamples/s
10	0.0 to +1.0 V	−1.0 to +1.0 V	100 ksamples/s
100	0.0 to +100 mV	−100 to +100 mV	70 ksamples/s
500	0.0 to +20 mV	−20 to +20 mV	30 ksamples/s

Table 2-2. DAS-1602/1402 Gains, Ranges, and Throughput Rates for Unipolar and Bipolar Selections

Gain	Unipolar Range	Bipolar Range	Maximum Throughput Rate
1	0.0 to +10.0 V	−10 to +10 V	100 ksamples/s
2	0.0 to +5.0 V	−5.0 to +5.0 V	100 ksamples/s
4	0.0 to 2.5 V	−2.5 to + 2.5 V	100 ksamples/s
8	0.0 to 1.25 V	−1.25 to +1.25 V	100 ksamples/s

Conversion Modes

DAS-1600/1400 Series boards support the following conversion modes:

- **Paced mode** - Paced mode is the default data conversion mode and is the mode best-suited for continuous scanning of multiple channels at a constant rate. In paced mode, the conversion rate equals the pacer clock rate. The sample rate, which is the rate at which a single channel is sampled, is the pacer clock rate divided by the number of channels sampled.

- **Burst mode** - In burst mode, each pulse from the pacer clock begins a scan of one to 16 channels. The conversion rate during a burst mode scan is equal to the rate of the burst mode conversion clock. The sample rate, which is the rate at which a single channel is sampled, is equal to the pacer clock rate.

  DAS-1600/1400 Series software allows you to program the pacer clock to adjust the interval between burst mode scans. This software also allows you to adjust the burst mode conversion rate. The burst mode conversion clock frequency is programmable for a range of 3.94 kHz to 100 kHz.

  DAS-1600/1400 Series boards support burst mode only during DMA operations. You can also use burst mode for pseudo-simultaneous sample-and-hold in conjunction with DMA operations.

  The sample rate (pacer clock rate) should be set for no more than the burst mode conversion clock rate divided by the number of channels in the burst. The maximum burst mode conversion clock rate is gain-sensitive, as shown in Table 2-1 and Table 2-2.

Figure 2-3 shows the timing relationships of the paced and burst modes for analog input channel 4 to channel 7.
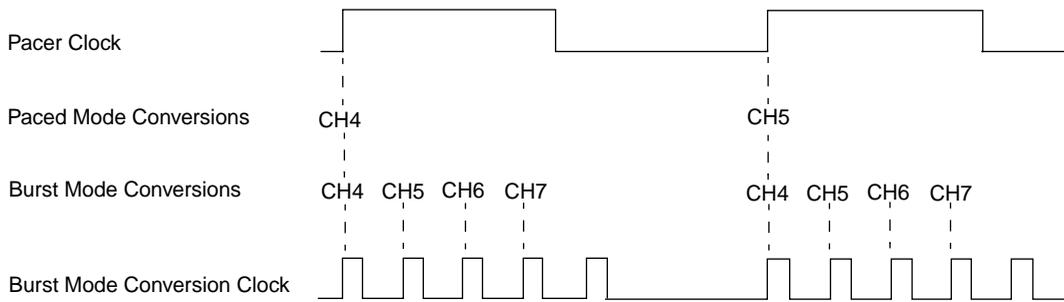
Figure 2-3. Timing Relationships of Conversion Modes

Clock Sources

The following clock sources are available for conversions on DAS-1600/1400 Series boards:

- **Software** - DAS-1600/1400 Series boards allow you to acquire single or multiple samples under program control.

- **Hardware (internal clock source)** - The internal pacer clock is derived from the onboard 82C54 counter/timer and a switch-configurable, crystal-controlled 1 MHz or 10 MHz timebase. The pacer clock uses two cascaded counters of the 82C54. The maximum allowable rate is 100 ksamples/s, and the minimum conversions per hour is determined as follows:

$$\frac{10MHz}{2^{32}} = 2.328 \times 10^{-3} = 8.38 \qquad \frac{1MHz}{2^{32}} = 2.328 \times 10^{-4} = 0.838$$

When not used to pace the analog input, the internal clock source can pace other events, such as digital I/O and analog outputs (on the DAS-1600 Series boards), through the use of interrupts.

- **Hardware (external clock source)** - The external pacer clock source must be an externally applied, TTL-compatible, rising-edge signal attached to the IP0/TRIG 0/XPCLK pin (25) of the main I/O connector (J1).

An external clock source is useful if you want to pace at rates not available with the 82C54 counter/timer, if you want to pace at uneven intervals, or if you want to pace on the basis of an external event. An external clock also allows you to synchronize multiple boards with a common timing source.

Notes: The ADC acquires samples at a maximum of 100 ksamples/s (one sample every 10.0 µs). If you are using an external clock, make sure it does not initiate conversions at a faster rate than the ADC can handle.

If you are acquiring samples from multiple channels, the maximum sampling rate for each channel is equal to 100 ksamples/s divided by the number of channels.

Triggers

A trigger starts an analog input operation. The polarity of external triggers in the DAS-1600/1400 Series boards is software-configurable. You can use one of the following trigger sources to start an analog input operation:

- **Internal** - When you enable the analog input operation, conversions begin immediately.

- **External Analog** - While an analog trigger is not a hardware feature of the DAS-1600/1400 Series boards, you can program an analog trigger using one of the analog input channels as the trigger channel. DriverLINX provides functions for an analog trigger; refer to the *DriverLINX Installation and Configuration Guide* and *Appendix F: Configuration and Implementation Notes—for Keithley MetraByte DAS-16/1600* manuals for more information.

- **External Digital** - While a digital trigger is not a hardware feature of the DAS-1600/1400 Series boards, you can apply a digital trigger to the digital input IP1/XTRIG pin (6) of the main I/O connector (J1). Refer to the *DriverLINX Installation and Configuration Guide* and *Appendix F: Configuration and Implementation Notes—For Keithley MetraByte DAS-16/1600* manuals.

  Trigger types are as follows:

  – *Positive-edge trigger* - Conversions begin on the rising edge of the trigger signal.

– *Negative-edge trigger* - Conversions begin on the falling edge of the trigger signal.

– *Positive-level trigger* - Conversions begin when the signal is above a positive level. See Table A-3 on page A-5 for logic levels.

– *Negative-level trigger* - Conversions begin when the signal is below a negative level. See Table A-3 on page A-5 for logic levels.

Data Transfer Modes

You can transfer data from the DAS-1600/1400 Series boards to the computer using the following data transfer modes:

- **Single mode** - In a single-mode operation, a data acquisition board acquires a single sample from a single channel; you cannot perform any other operation until the single-mode operation is complete.

- **Synchronous** - In a synchronous-mode operation, a data acquisition board acquires one or more samples from one or more channels; you cannot perform any other operation until the synchronous-mode operation is complete.

- **Interrupt** - You can program the board to acquire data, then generate an interrupt when data is available for transfer. When interrupt mode is used, data is transferred by an interrupt service routine; you can perform other operations while an interrupt mode operation is in progress. The interrupt level is software-configurable.

  Unpredictable interrupt latencies in the Windows environment tend to make maximum board speeds unachievable in the interrupt mode. When in the Windows environment, you are advised to use DMA mode instead of interrupt mode.

- **DMA** - DMA is a method of bypassing the CPU to transfer data directly between an I/O device and computer memory. In the IBM PC family, DMA is directed by the DMA controller and executes independently while the CPU is executing other instructions. Therefore, you can perform other operations while a DMA mode operation is in progress. The ability to run independently of the CPU and at high-transfer rates makes DMA an attractive method for transferring data in data acquisition systems.

DAS-1600/1400 Series boards can use either DMA channel 1 or 3 to perform single-cycle DMA transfers of A/D data from the board to memory.

Analog Output Features (DAS-1600 Series Only)

The analog output section of DAS-1600 Series boards consists of two digital-to-analog converters (DACs) with 12-bit resolution and a precision voltage source. Both DACs have switch-configurable output ranges of 0 to 5 V, 0 to 10 V, ±5 V, ±10 V. In addition, you can use external references to generate analog outputs in other ranges. The DACs power up to 0 V at reset.

The two DACs have a capacitive load drive up to 100 μF and an output current drive of up to ±5 mA.

You can pace the analog output with interrupts generated by the onboard pacer clock when the analog inputs are disabled.

You can write single values to the DACs using synchronous mode or single mode. You can write multiple values to the DACs using synchronous mode or interrupt mode.

The DAS-1600 Series provides a –5 V (±0.05 V) precision reference voltage that is derived from the DAC reference voltage. Typical applications for precision voltages are providing a DC reference input for the DACs and providing offsets and bridge excitation to user-supplied input circuits.

Digital I/O Features

DAS-1600/1400 Series boards contain four digital inputs (IP0 to IP3) and four digital outputs (OP0 to OP3) that are accessible through the main I/O connector (J1).

Logic 1 on an I/O line indicates that the input/output is high; logic 0 on an I/O line indicates that the input/output is low (see Table A-3 on page A-5 for logic levels). The digital inputs are compatible with TTL-level signals.

These inputs are provided with 10 kΩ pull-up resistors to +5 V; therefore, the inputs appear high (logic 1) with no signal connected.

The DAS-1600 Series boards have an additional 24 bits of bidirectional digital I/O available on the PIO cable connector (J2). These 24 bits are configured as two 8-bit ports (A and B) and two 4-bit ports (CL and CH); you can set each port independently for input or output.

You can use the digital inputs and outputs for any general-purpose tasks except the following:

- If you are using an external digital trigger or gate, you must use digital input line IP1/XTRIG to attach the trigger and digital input line IP2/CTR 0 GATE to attach the counter 0 gate signal. In either of these cases, you cannot use the corresponding bit for general-purpose digital input.

- If you are using an external pacer clock, you must use digital input line IP0/TRIG 0/XPCLK to attach the external pacer clock signal; in this case, you cannot use IP0/TRIG 0/XPCLK for general-purpose digital input.

When the analog inputs are disabled, you can pace the digital I/O with interrupts generated by the onboard pacer clock.

You can read or write a single value from or to a DAS-1600/1400 Series board using synchronous mode or single mode. You can read or write multiple values from or to a DAS-1600/1400 Series board using synchronous mode or interrupt mode.

Counter/Timer Features

The DAS-1600/1400 Series includes an 82C54 with three programmable counters. Counters 1 and 2 are permanently cascaded and are used as the internal A/D pacer clock.

Counter 0 is not used by the board, but can be used for functions such as waveform generation, measuring frequency and period, and generating time delays. You access counter 0 functions through the board's I/O registers or through DriverLINX.

> **Note:** Attempts to combine register-level programing of counter/timer functions with DriverLINX programming can produce unexpected results.

You can use software to select IP0/TRIG 0/XPCLK (pin 25) of the main I/O connector for use as a hardware gate. The gate provides a means of holding off clock pulses (from counters 1 and 2) to the ADC until IP0/TRIG 0/XPCLK goes high.

Wait State Selection

Although most current-generation PCs and compatibles extend bus cycles during 8-bit data transfers, the DAS-1600/1400 Series provides a switch-configurable option that allows you to enable or disable wait states that extend bus cycles during 8-bit data transfers.

Inclusion of this option maintains backward compatibility with DAS-16Gx Series boards that may be used in early generation machines.

Power

+5 V power is available from the main I/O connector. The +5 V supply is brought out from your host computer.

3

Setup and Installation

Read this chapter and all related DriverLINX documentation before you attempt to install and use your DAS-1600/1400 Series board.

Unwrapping and Inspecting Your Board

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

1. Your board 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 board.

   – If you are not equipped with a grounded wrist strap, discharge static electricity by holding the wrapped board 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 board 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 7-6).

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.

Note: DAS-1600/1400 Series boards are factory calibrated; they require no further adjustment prior to installation. If at a later time you decide to re-calibrate the board, refer to Chapter 6 for instructions.

Installing and Configuring DriverLINX for DAS-1600/1400 Series Boards

---

Important: As a precaution against a system crash the first time you install and test any new hardware, you should exit all other programs and, if you use a disk cache, disable write caching. If the system does crash and you're using disk compression software or a disk cache utility, as a precaution after any crash, run the utility that checks the directory structures.

This section describes how to install the DAS-1600/1400 Series standard software package. The contents of these software packages are described as follows:

● **DAS-1600/1400 Series standard software package** - Shipped with DAS-1600/1400 Series boards. Includes DriverLINX® for Microsoft® Windows and function libraries for writing application programs under Windows™ in a high-level language such as Borland® C/C++, Borland Turbo Pascal®, and Mircrosoft Visual Basic; Delphi®, Test Point®, LabVIEW® support files; utility programs; and language-specific example programs.

● **DriverLINX-** the high-performance real-time data-acquisition device drivers for Windows application development includes:

  – *DriverLINX API DLLs* and drivers supporting the DAS-1600/1400 Series hardware

  – *Analog I/O Panel* - A DriverLINX program that verifies the installation and configuration of DriverLINX to your DAS-1600/1400 Series board and demonstrates several virtual bench-top instruments

  – *Learn DriverLINX* - an interactive learning and demonstration program for DriverLINX that includes a Digital Storage Oscilloscope

- *Source Code* - for the sample programs

- *DriverLINX Application Programming Interface files* - for the DAS-1600/1400 Series compiler

- *DriverLINX On-line Help System* - provides immediate help as you operate DriverLINX

- *Supplemental Documentation* - on DriverLINX installation and configuration; analog and digital I/O programming; counter/timer programming; technical reference; and information specific to the DAS-1600/1400 Series hardware.

- **DAS-1600/1400 Series utilities -** The following utilities are provided as part of both the DAS-1600/1400 Series standard software package:

  - Calibration Utility

  - Test Utility

- **LV-1600 -** LabVIEW driver for the DAS-1600/1400 Series boards.

Installing the DAS-1600/1400 Series Standard Software Package

---

Important—Before you begin installing any hardware or software for the DAS-1600/1400, read the *DriverLINX Installation and Configuration Guide* and the *Using DriverLINX with your Hardware—Keithley DAS-16/1600 Series* manuals that are packaged with the DriverLINX software. They are accessed from the DriverLINX CD-ROM after you have installed Adobe Acrobat®.

Before Installing DriverLINX

1. Inventory your DAS-1600/1400 board's configuration settings.

2. Determine the resources your DAS-1600/1400 Series board requires.

3. Inventory your computer's resources already allocated to other installed devices.

4. Determine whether your computer has sufficient resources for your DAS-1600/1400 board.

5. Determine whether your DAS-1600/1400 board can use your computer's free resources.

6. Set any jumpers/switches to configure your DAS-1600/1400 board to use your computer's free resources.

7. Set any other jumpers/switches to configure your DAS-1600/1400 board the way you want.

8. Install your DAS-1600/1400 board into an appropriate free slot in your computer.

Selecting the DriverLINX components to Install

For your convenience in installing and uninstalling just the DriverLINX components you need, the DriverLINX CD Browser will assist you in selecting the components to install:

*   **Install Drivers**—This required component installs only the files you need for configuring your hardware and running third-party data-acquisition applications that require DriverLINX.

*   **Install Interfaces**—This optional component installs the files and example programs that you will need to develop custom applications for DriverLINX using C/C++, Visual Basic, Delphi, and LabVIEW.

*   **Install Documentation**—This optional component installs electronic documentation for DriverLINX that you can read, search, and print using the Adobe Acrobat Reader.

*   **Install Acrobat**—This optional component installs the Adobe Acrobat Reader for the DriverLINX electronic documentation.

Installing DriverLINX

1. Insert the DriverLINX CD-ROM into your computer's CD-ROM Drive.

2. Start the DriverLINX setup program. On most systems, wait a few seconds for automatic startup. Otherwise, run the setup.exe program from the CD-ROM.

3. The DriverLINX CD-ROM Browser Map window appears on the screen. Click 'Install Drivers,' and follow the series of on-screen instructions.

Note: To display an explanation of a menu option on the DriverLINX CD browser map that appears next and on subsequent setup screens, place the mouse pointer over the menu item. A star next to a menu item means that the item was selected previously.

4. Select 'Read Me First,' and follow the instructions.

5. Select 'Install Documentation.' If you do not have Adobe Acrobat installed on your computer, install it by selecting 'Install Adobe Acrobat.'

6. Open the manuals appropriate to the DAS-1600/1400 installation and read them before installing your DAS-1600/1400 board or configuring DriverLINX:

   – *Installation and Configuration*

   – *Appendix F: Configuration and Implementation Notes—for Keithley DAS-16/1600*

   – *DriverLINX Technical Reference Manual*

   – *DriverLINX Analog I/O Programming Guide*

   – *DriverLINX Digital I/O Programming Guide*

   – *DriverLINX Counter/Timer Programming Guide*

   – *Appendix, I/O Port, Interrupt, and DMA Channel Usage*

   – *Other manuals appropriate to your installation.*

Configuration with DriverLINX

Follow the DriverLINX on-screen instructions for installation of drivers and interfaces. Refer to the *DriverLINX Installation and Configuration Guide* and *Appendix F: Configuration and Implementation Notes—for Keithley DAS-16/1600* manuals.

Note: Be sure to note and follow all programming differences between installations for Windows NT and Windows 95/98.

Before you configure DriverLINX for operation with the DAS-1600/1400 Series board, you must specify the base address, interrupt level, and input configuration by setting switches on the board.

Setting Switch-Configurable Options

This section contains information and illustrations that you can use to verify default switch configurations and reconfigure switch-configurable options. Chapters 1 and 2 contain information about product features that help you determine the board configuration that best suits the needs of your application.

Be sure to make note of the configuration of all switches and jumpers on the board. You will use this information to enter the correct configuration parameters using DriverLINX. Also locate any information or notes about the interrupt and DMA channels used by the other hardware devices in your computer system.

Figure 3-1 shows the switches for DAS-1600 Series boards; Figure 3-2 shows the switches for the DAS-1400 Series boards. The remaining subsections describe the switches and how to configure them.
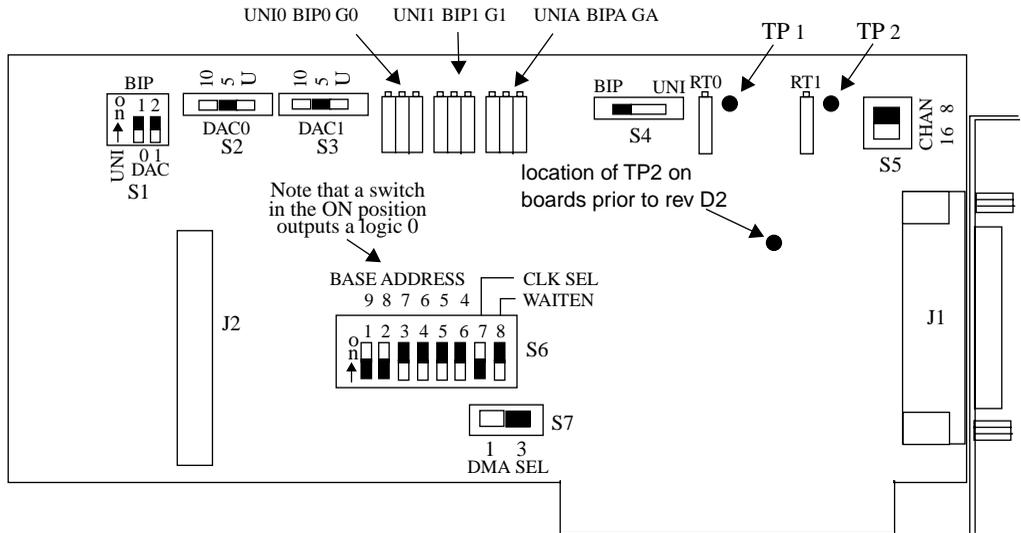
Figure 3-1. Default Switch Configuration for DAS-1600 Series Boards
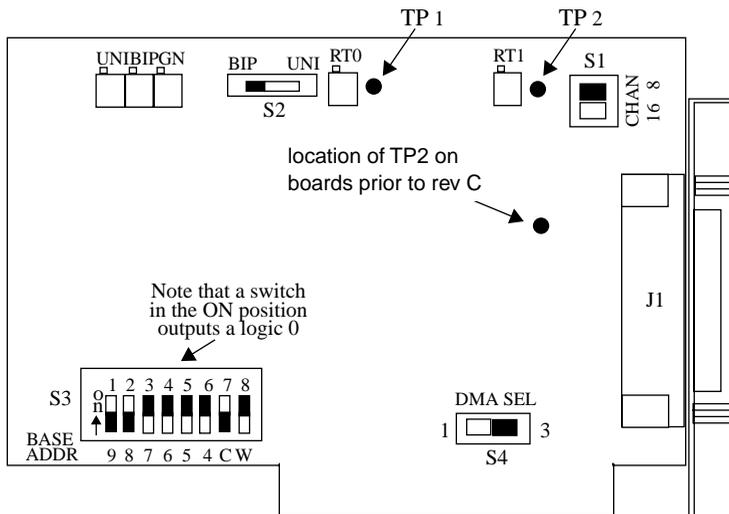
Figure 3-2. Default Switch Configuration for DAS-1400 Series Boards

Setting the DAC Bipolar/Unipolar Switch
(DAS-1600 Series Only)

Switch S1 is a 2-position switch that sets DAC 0 and DAC 1 for unipolar (UNI) or bipolar (BIP) mode. The left switch (labeled 0) is for DAC 0; the right switch (labeled 1) is for DAC 1. Switch either section On for bipolar or Off for unipolar. The default is bipolar.

Setting the DAC0 and DAC1 Reference Voltage Switches
(DAS-1600 Series Only)

Switches S2 and S3 are 3-position switches offering 10, 5, and U selections. When you set up a DAC for bipolar (BIP), the 5 and 10 positions select ±5 V and ±10 V, respectively. When you set up a DAC for unipolar, the 5 and 10 positions output 0 to 5 V and 0 to 10 V, respectively.

The U position on both switches selects the external reference voltage that you connect to D/A 0 REF IN (pin 10) and D/A 1 REF IN (pin 26). The default setting selects a +5 V reference signal for both DAC 0 and DAC 1.

For additional information on user-supplied reference voltages, see Vin definitions given in Table C-2 and Table C-3.

Setting the ADC Bipolar/Unipolar Switch

Switch S4 on the DAS-1600 Series board (S2 on the DAS-1400 Series) is a 2-position switch that sets A/D operation to bipolar (BIP) or unipolar (UNI) mode. The default setting is bipolar (BIP).

Setting the Chan 8/16 Switch

Switch S5 on the DAS-1600 Series board (or switch S1 on the DAS-1400 Series board) is a 2-position switch that configures the A/D inputs as eight differential or 16 single-ended inputs. The default setting is eight differential inputs.

Setting a Base Address

Switch S6 on the DAS-1600 Series board (S3 on the DAS-1400 Series) is a single, 8-position DIP switch that accommodates the base address, the clock select, and the wait state enable parameters. The default base address setting is 300h (786 decimal).

Figure 3-3 shows the default switch positions for the base address, clock select, and wait state enable switches.

Address Line	Hex Value	Decimal Value
A4	10	16
A5	20	32
A6	40	64
A7	80	128
A8	100	256
A9	200	512

CLK SEL On = 1 MHz / Off = 10 MHz

WAITEN On = No / Off = Yes

Note that a switch in the ON position outputs a logic 0.

1 2 3 4 5 6 7 8

9 8 7 6 5 4 C W
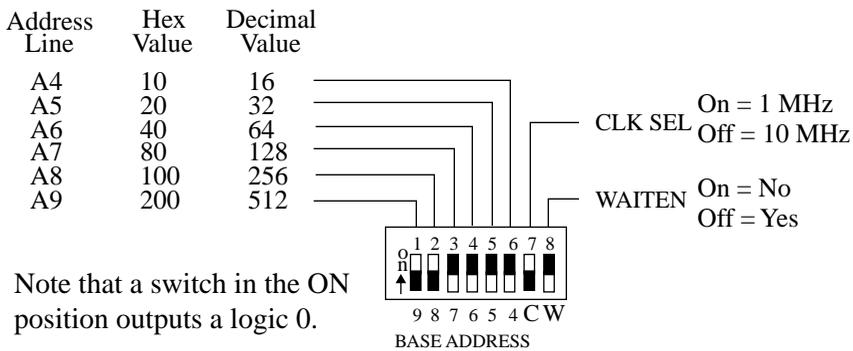
BASE ADDRESS

Figure 3-3. Base Address, Clock Select, and Wait State Enable Switch

The base address is read from the 8-position DIP switch located as shown in Figure 3-1 for a DAS-1600 Series board and Figure 3-2 for a DAS-1400 Series board. The base address switch on DAS-1600/1400 Series boards is preset at the factory for a hexadecimal value of 300h (768 decimal). If this address conflicts with the address of another device in the computer (including another DAS-1600/1400 Series board), you must reconfigure the base address switch.

To reconfigure this switch for another address, perform the following steps:

1. Select an alternate address that does not conflict with another installed device.

2. Make note of this address for configuration using DriverLINX.

3. Set up the base address switch to match the new base address.

Note: The settings for the base-address switch must match the settings that are configured in DriverLINX.

Setting the Clock Select Switch

Position number 7 of the base address switch (see Figure 3-3) selects either a 1 MHz or 10 MHz clock for the internal pacer clock. The default is 10 MHz (Off).

Setting the Wait State Enable Switch

Position number 8 of the base address switch (see Figure 3-3) enables wait states. The default setting is NO (On). If you experience intermittent errors, you may correct the problem by setting this option to YES (Off).

Setting the DMA Channel Select Switch

Switch S7 (S4 on the DAS-1400 Series) is a 2-position slide switch that selects DMA channel 1 or 3. The default setting is 3.

Installing the Board

Caution: Installing or removing a board while power is on can damage your computer.

After reviewing your computer manufacturer's documentation for accessing computer internals, use the following steps to install a DAS-1600/1400 Series board in an accessory slot of your computer:

1. Turn off power to the computer and all attached equipment.

   Note: You must observe the current-capacity limits of the PC supply; allow for the power used by any other boards that may be in use. See Table A-6. for DAS-1600/1400 Series power requirements.

   ---

2. Remove the computer chassis cover.

3. Select an unoccupied accessory slot, and remove the corresponding blank plate and retaining screws from the I/O connector panel. Save the retaining screws for re-use in later steps.

4. If you are installing a DAS-1600 Series board and your application uses the additional 24-bit digital I/O, remove the blank plate and retaining screws of the adjacent slot. Save the retaining screws for re-use in later steps.

5. Make sure the option switch settings match the settings shown in the configuration-utility switch diagram.

6. Insert the board in the selected slot and secure the main I/O connector mounting flange with the retaining screws.

7. When using the additional 24-bit digital I/O of a DAS-1600 Series board, connect the board end of the PIO cable to the PIO cable connector (J2) on the board. When connecting the cable, align the raised arrow of the PIO cable with the arrow imprinted on the PIO cable connector (J2). Secure the mounting flange on the PIO cable to the connector panel next to the main I/O connector (J1) with the retaining screws.

8. Replace the computer cover.

9. Turn on power to the computer.

Configuring DriverLINX

After you have successfully installed the DAS-1600/1400 Series board in your computer, start Windows to install DriverLINX. For detailed instructions on installing DriverLINX, see the documentation provided on the DriverLINX CD-ROM; especially the *DriverLINX Installation and Configuration Guide* and *Appendix F: Configuration and Implementation Notes—for Keithley DAS-16/1600* manuals.

Run "Learn DriverLINX" **(LearnDL.exe)** from the DriverLINX program group to tell DriverLINX how you configured your DAS-1600/1400 Series board and to verify that everything is properly installed and configured.

1. Start Windows as you normally would and select the Program Manager window. Install DriverLINX if you have not previously done so.

2. Either select the "Learn DriverLINX" icon created when you installed DriverLINX or enter "<drive>:/DRVLNX/LEARNDL" in the *Command Line* edit box. The Command Line edit box is activated by selecting *Run...* option from the *File* menu. <drive> is the letter of the hard disk drive where DriverLINX is installed.

3. Immediately after loading Learn DL, the Open DriverLINX DLL dialog box appears. Select the name of the hardware-specific DLL from the list for your DAS-1600/1400 board. The name is an abbreviation of the board's model number.

4. From the main menu bar of **Learn DL,** select the *Device* menu and choose *Select...*

5. Select the Logical Device you wish to configure and then click on the *OK* button (return).

6. Again select the *Device* menu and then choose the *Configure...* option to display the Device Configuration Dialog Box.

7. From the *Model* list, select the model name for your DAS-1600/1400 Series board you are configuring.

8. If the value displayed in the *Address* edit box is not correct, type the correct value into the box. You may enter the address in decimal or hexadecimal using the c-notation for hex, (that is, 768 decimal = 0x300 hexadecimal).

9. Choose the correct options for the *Analog, Digital,* and *Counter/Timer Sections* by first clicking on the appropriate radio button in the middle of the dialog box and then completing the group of dialog fields in the lower third of the dialog box. Be sure to click on both the *Input* and *Output* radio buttons for the *Analog* and *Digital* groups to see all the dialog fields.

10. After you have made your selections, save the configuration parameters by clicking on the *OK* button. This will create or update the configuration file, KMBDAS16.INI, in the Windows directory.

11. Repeat the preceding steps starting at step 5, for each Logical Device you wish to configure.

You can use DriverLINX to verify board operation:

1. To physically initialize the DAS-1600/1400, select *Device/Initialize* from the main menu in Learn DriverLINX.

2. The first time the DAS-1600/1400 is initialized, or after a configuration change, DriverLINX runs a diagnostic program to verify the operation and accuracy of the configuration settings.

You are now ready to make I/O connections. Refer to Chapter 4 for descriptions of common I/O accessories and connections for DAS-1600/1400 Series Boards

You can use the control panel (see Chapter 5) to verify board operation.

4

Cabling and Wiring

In most applications, you use accessories to connect external I/O devices to the DAS-1600/1400 Series boards. Keithley accessories extend signals from the main I/O connector (J1) and the PIO cable connector (J2) to corresponding screw terminals of the accessory.

In the case of DAS-1600 Series boards, 24 bits of parallel bidirectional digital I/O is channeled to the rear panel of the host PC by a flat ribbon cable known as the PIO cable. The board end of the PIO cable attaches to the PIO cable connector (J2) on the board. The other end of the PIO cable is fitted with a standard 37-pin D-type connector and a mounting flange that installs in the connector panel next to the main I/O connector (J1). The PIO cable comes with all DAS-1600 Series boards.

This chapter describes the cabling and accessories required for attaching field wiring to your DAS-1600/1400 Series boards.

Caution: To avoid electrical damage, turn off power to the computer and any attached accessories before making connections to DAS-1600/1400 Series boards.

Attaching Screw Terminal Accessories

You can use the following screw terminal connectors and accessories to simplify connection of field wiring to DAS-1600/1400 Series boards:

- STC-37 screw terminal connector; when using a DAS-1600 Series board, your application may require two connectors

- STP-37 screw terminal panel; when using a DAS-1600 Series board, your application may require two panels

- STA-16 screw terminal accessory

- STA-U universal screw terminal accessory

The following sections describe how to attach these accessories to DAS-1600/1400 Series boards.

Attaching an STC-37

The screw terminals on the STC-37 screw-terminal connector allow you to connect field wiring to a DAS-1600/1400 Series board. The screw terminals accept wire sizes 12-22 AWG.

To connect an STC-37 to the main I/O connector (J1) of a DAS-1600/1400 Series board, attach the 37-pin connector on the STC-37 directly to the main I/O connector (J1). Figure 4-1 illustrates the connection of an STC-37 to a DAS-1400 Series board.

Note: Your application may require connections to the main I/O connector (J1) and connections to the PIO cable connector (J2). When two STC-37 connectors are required, you should consider wire sizes and service area requirements. These considerations may suggest the use of an alternate accessory.
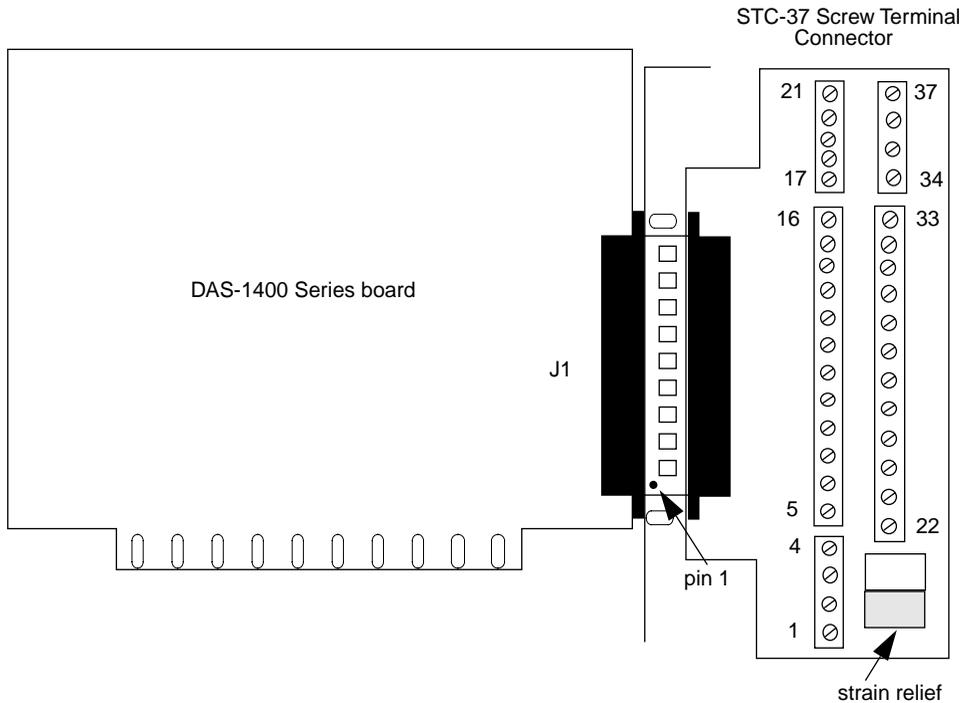
Figure 4-1. Attaching an STC-37 Screw Terminal Connector

The screw terminals are labeled from 1 to 37 and correspond directly to the functions of the pins on the main I/O connector (see Figure 4-2). For example, since pin 25 is assigned to IP0/TRIG 0/XPCLK, use screw terminal 25 to attach a digital signal to bit 0 of the standard digital input port.

Rear View

LL GND	Pin 19	
Ch0 LO IN / Ch8 HI IN	Pin 18	
Ch1 LO IN / Ch9 HI IN	Pin 17	
Ch2 LO IN / Ch10 HI IN	Pin 16	
Ch3 LO IN / Ch11 HI IN	Pin 15	
Ch4 LO IN / Ch12 HI IN	Pin 14	
Ch5 LO IN / Ch13 HI IN	Pin 13	
Ch6 LO IN / Ch14 HI IN	Pin 12	
Ch7 LO IN / Ch15 HI IN	Pin 11	
D/A 0 REF IN*	Pin 10	
D/A 0 OUT*	Pin 9	
VREF (-5)*	Pin 8	
POWER GND	Pin 7	
IP 1 / XTRIG	Pin 6	
IP 3	Pin 5	
OP 1	Pin 4	
OP 3	Pin 3	
CTR 0 OUT	Pin 2	
+5 V PWR	Pin 1	

Pin 37	Ch0 HI IN
Pin 36	Ch1 HI IN
Pin 35	Ch2 HI IN
Pin 34	Ch3 HI IN
Pin 33	Ch4 HI IN
Pin 32	Ch5 HI IN
Pin 31	Ch6 HI IN
Pin 30	Ch7 HI IN
Pin 29	LL GND
Pin 28	LL GND
Pin 27	D/A 1 OUT*
Pin 26	D/A 1 REF IN*
Pin 25	IP 0 / TRIG 0 / XPCLK
Pin 24	IP 2 / CTR 0 GATE
Pin 23	OP 0
Pin 22	OP 2
Pin 21	CTR 0 CLOCK IN
Pin 20	CTR 2 OUT

* Not connected in DAS-1400 Series

Figure 4-2. Pin Assignments of the Main I/O Connector (J1)

When using an STC-37 to make connections to the bidirectional digital I/O, first attach the board end of the PIO cable to the PIO cable connector (J2) on the DAS-1600/1400 board, then install the 37-pin D-type connector of the PIO cable in the connector panel next to the main I/O connector (J1) of the DAS-1600/1400 Series board, and finally attach the second STC-37 to the 37-pin D-type connector of the PIO cable. For more information about making field connections, see "Connecting Analog Input Signals" on page 4-23.

Attaching an STP-37

The screw terminals on the STP-37 screw terminal panel allow you to connect field wiring to DAS-1600/1400 Series boards. The STP-37 contains the following components:

- A 37-pin male connector for cabling to the main I/O connector of a DAS-1600/1400 Series board.

- Labeled screw terminals for connecting sensor outputs and test equipment. These terminals accept wire sizes 12-22 AWG.

You attach an STP-37 screw terminal panel to the main I/O connector (J1) on the DAS-1600/1400 Series board with a C-1800 or S-1800 cable. The C-1800 is the unshielded version of the cable; the S-1800 is the shielded version of the cable. Figure 4-3 shows how to attach an STP-37 to a DAS-1400 Series board.
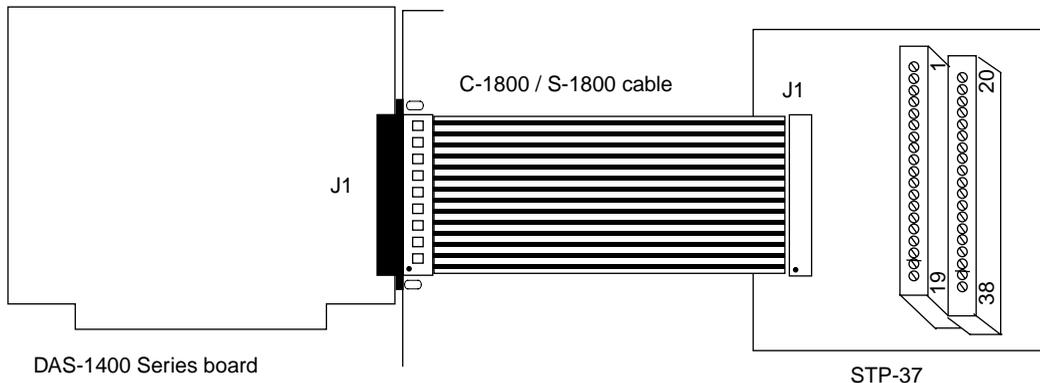
Figure 4-3. Attaching an STP-37 to the Main I/O Connector

The screw terminals are labeled 1 to 38 and correspond directly to the functions of the main I/O connector. See Figure 4-2 for the pin assignments of the main I/O connector (J1).

When using an STP-37 to make connections to the bidirectional digital I/O, first attach the board end of the PIO cable to the PIO cable connector (J2) on the DAS-1600/1400 Series board, then install the 37-pin D-type connector of the PIO cable in the connector panel next to the main I/O connector (J1) of the DAS-1600/1400 Series board, and finally attach the STP-37 to the 37-pin D-type connector of the PIO cable. See Figure 4-8 for the pin assignments of the 37-pin D-type connector of the PIO cable.

Attaching an STA-16

The screw terminals on the STA-16 screw terminal accessory allow you to connect field wiring to DAS-1600/1400 Series boards. The STA-16 contains the following components:

● Two 37-pin male connectors. One for cabling to the main I/O connector of a DAS-1600/1400 Series board and a second for daisy-chaining additional accessories.

● Labeled screw terminals for connecting sensor outputs and test equipment. These terminals accept wire sizes 12-22 AWG.

● A breadboard area for user-installed circuitry.

Attach an STA-16 screw terminal accessory to the main I/O connector (J1) on the DAS-1600/1400 Series board with a C-1800 or S-1800 cable. The C-1800 is the unshielded version of the cable; the S-1800 is the shielded version of the cable. Figure 4-4 shows how to attach an STA-16 to a DAS-1400 Series board.
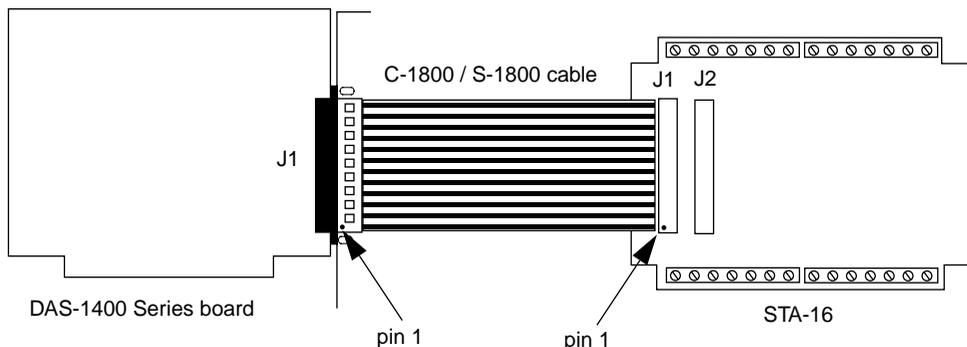
Figure 4-4. Attaching an STA-16

Figure 4-5 shows the screw terminal names on the STA-16.
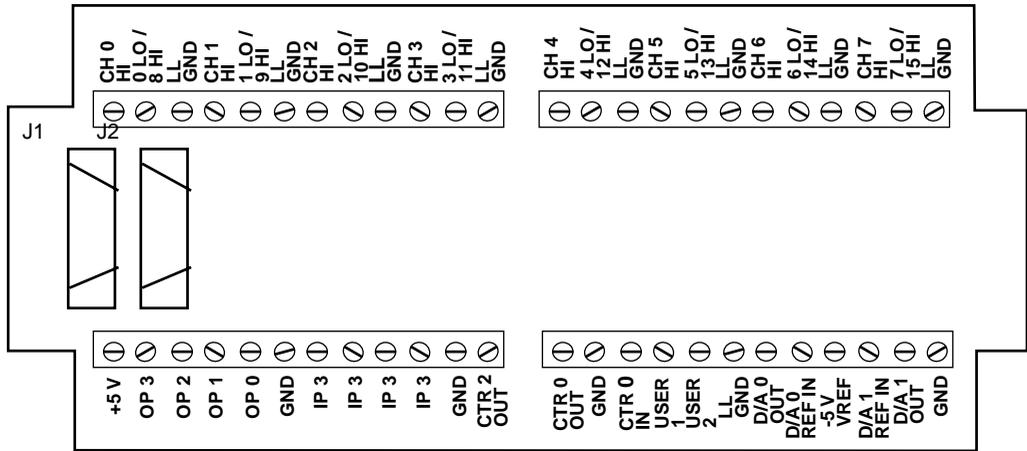
Figure 4-5. STA-16 Terminal Names

Attaching an STA-U

The screw terminals on the STA-U universal screw terminal accessory allow you to connect field wiring to the DAS-1600 Series PIO cable connector (J2). The STA-U contains the following components:

- A 37-pin male connector for cabling to the PIO cable connector (J2) on a DAS-1600 Series board.

- Labeled screw terminals for connecting digital inputs and outputs. These terminals accept wire sizes 12-22 AWG.

- A breadboard area for user-installed circuitry.

First, attach the board end of the PIO cable to the PIO cable connector (J2) on the DAS-1600/1400 board. Next, install the 37-pin D-type connector of the PIO cable in the connector panel next to the main I/O connector (J1) of the DAS-1600/1400 Series board. Finally, attach connector J2 on the STA-U screw terminal accessory to the 37-pin D-type connector of the PIO cable with a C-1800 or S-1800 cable. The C-1800 is the unshielded version of the cable; the S-1800 is the shielded version of the cable.

Figure 4-6 shows how to attach an STA-U to a DAS-1600 Series board.
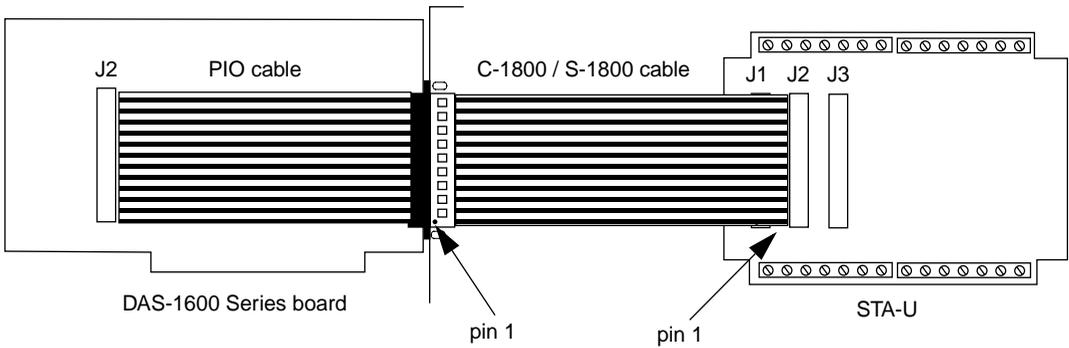
**Figure 4-6. Cabling and Connections for Attaching an STA-U**

Figure 4-7 shows the screw terminal names on an STA-U. The screw terminals map directly to the pins of the PIO cable connector (J2) shown in Figure 4-8.
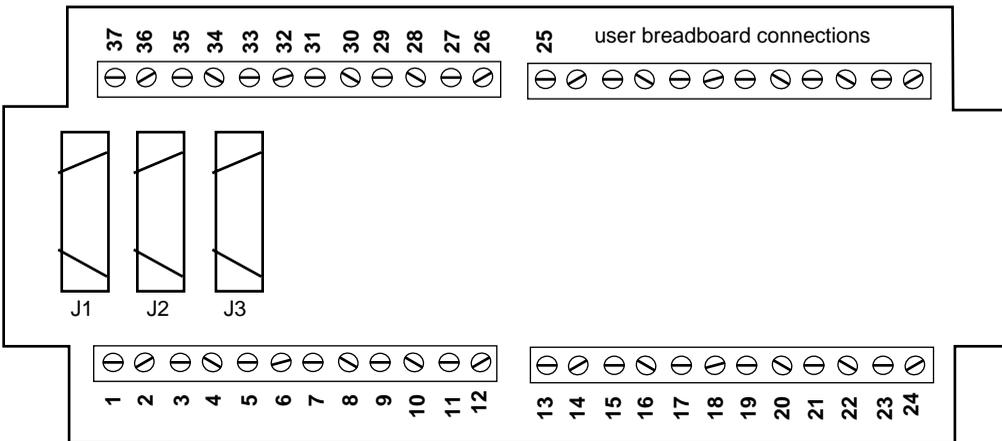
Figure 4-7. STA-U Terminal Names

Rear View

DIG.COM.	Pin 19		Pin 37	PA 0	
+5 V	Pin 18		Pin 36	PA 1	
DIG. COM.	Pin 17		Pin 35	PA 2	
not connected	Pin 16		Pin 34	PA 3	PORT A
DIG. COM.	Pin 15		Pin 33	PA 4	
not connected	Pin 14		Pin 32	PA 5	
DIG. COM.	Pin 13		Pin 31	PA 6	
not connected	Pin 12		Pin 30	PA 7	
DIG.COM.	Pin 11		Pin 29	PC 0	
PB 0	Pin 10		Pin 28	PC 1	PORT CL
PB 1	Pin 9		Pin 27	PC 2	
PB 2	Pin 8		Pin 26	PC 3	
PB 3	Pin 7		Pin 25	PC 4	
PB 4	Pin 6		Pin 24	PC 5	PORT CH
PB 5	Pin 5		Pin 23	PC 6	
PB 6	Pin 4		Pin 22	PC 7	
PB 7	Pin 3		Pin 21	DIG. COM.	
not connected	Pin 2		Pin 20	+5 V	
not connected	Pin 1				

PORT B (Pins PB 0 – PB 7)

Figure 4-8. Pin Assignments of PIO Cable Connector (J2)

Attaching Expansion Accessories

You can use the following expansion accessories to increase the number of channels available and add signal conditioning to your application:

- EXP-16

- EXP-16/A

- EXP-GP

- EXP-1600

The following section describes how to attach these expansion accessories to DAS-1600/1400 Series boards.

Attaching an EXP-16 or EXP-16/A Expansion Accessory

Each expansion multiplexer/amplifier accessory provides up to 16 analog input channels (labeled 0 to 15). Table 4-1 lists the terminal names used on EXP-16 and EXP-16/A expansion accessories.

Table 4-1. EXP-16 and EXP-16/A Terminal Names

Terminal Name	Signal
LL GND	low-level ground
CHn HI	positive input; where n indicates the channel number
CHn LO	negative input; where n indicates the channel number

To connect an EXP-16 or EXP-16/A to a DAS-1600/1400 Series board, you must first connect an STA-16 or STA-MB accessory, as shown in Figure 4-9.
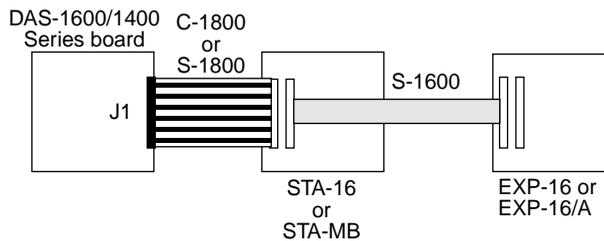
Figure 4-9. Attaching an EXP-16 or EXP-16/A Expansion Accessory

---

Note: The S-1600 cable must be used to connect the first EXP to the DAS-1600/1400 Series board.

Cabling and Wiring

Refer to the EXP-16 and EXP-16/A expansion board documentation for more information about these accessories and instructions for installing the PG-408A option on the board.

Caution: Do not attach an EXP-16 or EXP-16/A to the PIO cable connector (J2) on the DAS-1600 Series board.

Attaching an EXP-GP Expansion Accessory

Each EXP-GP expansion multiplexer/signal conditioner board provides up to eight analog input channels (labeled 0 to 7). Table 4-2 lists the terminal names used on each EXP-GP channel.

Table 4-2. EXP-GP Terminal Names

Terminal Name	Signal
+IEXC	positive current excitation
+SENSE	positive input
–P	negative voltage excitation
–IEXC	negative current excitation
–SENSE	negative input
+P	positive voltage excitation

To connect an EXP-GP to a DAS-1600/1400 Series board, attach one end of an S-1600 cable to the DAS-1600/1400 Series main I/O connector (J1) and the other end of the cable to the J1 connector on the EXP-GP. Figure 4-10 illustrates the connection of an EXP-GP to a DAS-1400 Series board.
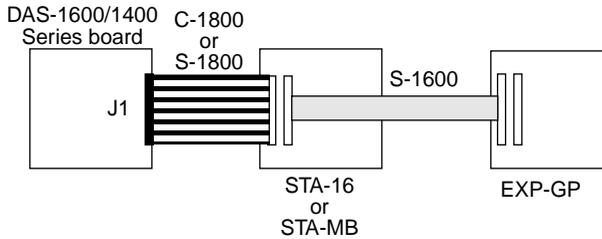
Figure 4-10. Attaching an EXP-GP Expansion Accessory

Refer to the EXP-GP expansion board documentation for more information about this expansion accessory.

Attaching an EXP-1600 Accessory

Before connecting an EXP-1600 to a DAS-1600/1400 Series board, configure the channels of the DAS board as single-ended inputs. An EXP-1600 connects directly to the main I/O connector of a DAS-1600/1400 Series board through a CAB-3740 cable, as shown in Figure 4-11.
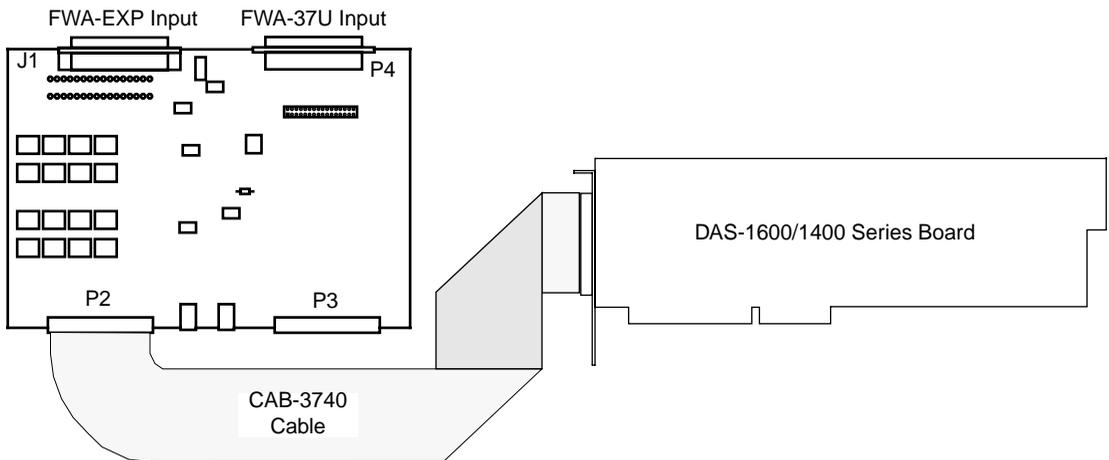
Figure 4-11. Attaching an EXP-1600 to a DAS-1600/1400 Series Board

Attaching Multiple Expansion Accessories

You can cascade up to eight EXP-16, EXP-16/A, and/or EXP-GP expansion accessories to provide up to 128 analog input channels, or you can attach up to 16 EXP-1600 expansion accessories to provide up to 256 analog input channels.

Figure 4-12 shows how to attach multiple EXP-16, EXP-16/A, and EXP-GP accessories to a DAS-1600/1400 Series board.

Notes: In a mix of EXP-16, EXP-16/A, and EXP-GP accessories, the EXP-16 and EXP-16/A accessories must be placed ahead of the EXP-GP accessories.

All multiple EXP-16 and EXP-16/A accessories attached to a DAS-1600/1400 Series board, as shown in Figure 4-12, must contain a PG408A accessory.
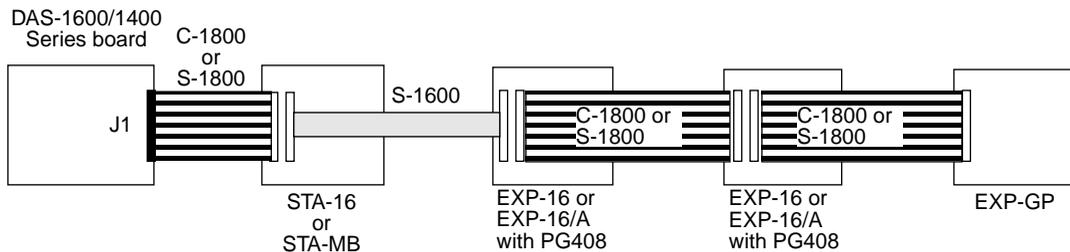
Figure 4-12. Attaching Multiple EXP-16, EXP-16/A, and /or EXP-GP Accessories

---

Notes: Each EXP-16, EXP-16/A, or EXP-GP expansion accessory is associated with an analog input channel on a DAS-1600/1400 Series board. You specify the associated DAS-1600/1400 input channel by setting a jumper on each expansion accessory. Use a unique jumper setting for each expansion accessory you are using. Refer to your expansion board documentation for more information.

Figure 4-13 shows how to attach multiple EXP-1600 expansion accessories to a DAS-1600/1400 Series board.
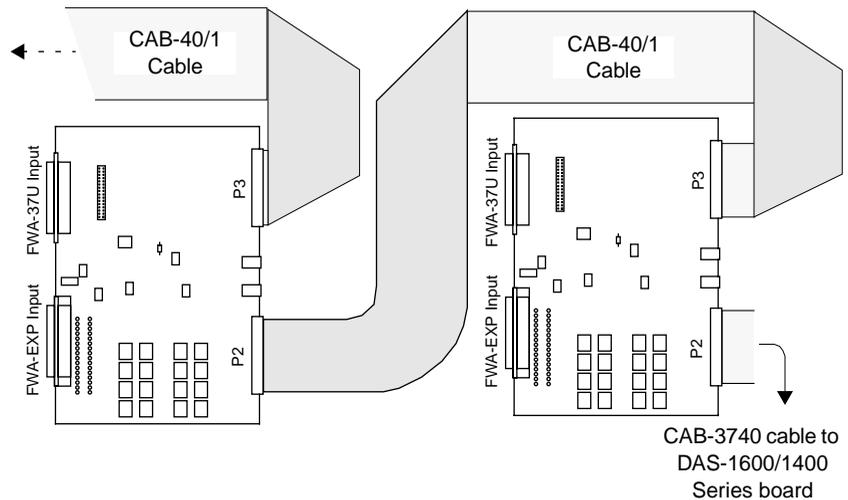
Figure 4-13. Attaching Multiple EXP-1600 Accessories

Attaching SSIO-24 and ERB-24 Accessories

Figure 4-14 shows how to attach an SSIO-24 or ERB-24 accessory to a DAS-1600/1400 Series board. Refer to SSIO-24 and ERB-24 documentation for more information.
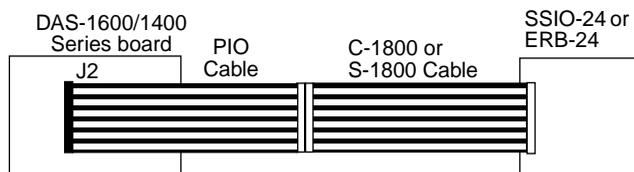
Figure 4-14. Attaching an SSIO-24 or ERB-24 Accessory

Attaching an ISO-4 Accessory

The ISO-4 is a high speed, universal expansion interface and isolation amplifier. The ISO-4 contains four fully isolated, differentially measured input channels supporting seven jumper-selectable gains of 1, 2, 10, 50, 100, 200, and 1000 on a per channel basis. You can further customize gains to meet your specific requirements with user-installable resistors.

Refer to the *ISO-4 User's Guide* for more information about ISO-4 features and applications.

To connect an ISO-4 accessory to a DAS-1600/1400 Series board, attach one end of an S-1600 cable to the DAS-1600/1400 Series main I/O connector (J1) and the other end of the cable to the J1 connector on the ISO-4 accessory. Figure 4-15 illustrates the connection of an ISO-4 accessory to a DAS-1400 Series board.
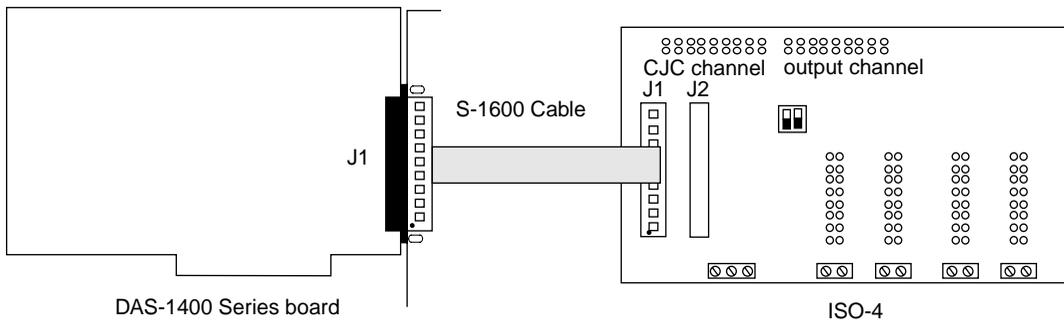
Figure 4-15. Attaching an ISO-4 Accessory

Attaching SSH Accessories

Simultaneous sample-and-hold (SSH) accessories allow you to acquire analog input data from multiple inputs simultaneously. SSH accessories available for DAS-1600/1400 Series boards are the SSH-4/A and the SSH-8.

The following subsections describe how to attach SSH-4/A and SSH-8 boards to DAS-1600/1400 Series boards.

Attaching an SSH-4/A

The SSH-4/A is a 4-channel simultaneous sample-and-hold board whose functions and capabilities are described in the *SSH-4/A User Guide*. The SSH-4/A serves as a front-end analog interface for DAS-1600/1400 Series boards.

Figure 4-16 shows how to attach the SSH-4/A to a DAS-1400 Series board through a C-1800 cable.
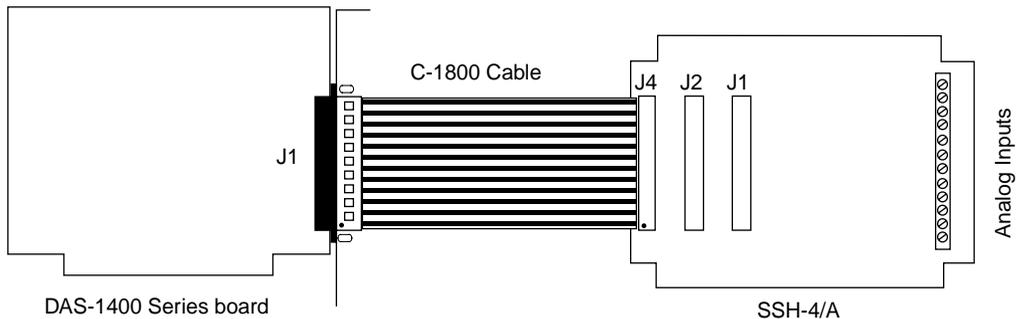
Figure 4-16. Attaching an SSH-4/A Accessory

Additional SSH-4/A accessories are attached in daisy-chain fashion with CACC-2000 cable.

Attaching an SSH-8

The SSH-8 is a high performance 8-channel simultaneous sample-and-hold board whose functions and capabilities are described in the *SSH-8 User's Guide*. The SSH-8 serves as a front-end analog interface for DAS-1600/1400 Series boards.

Figure 4-17 and Figure 4-18 show how to attach SSH-8 boards to a DAS-1600/1400 Series board.
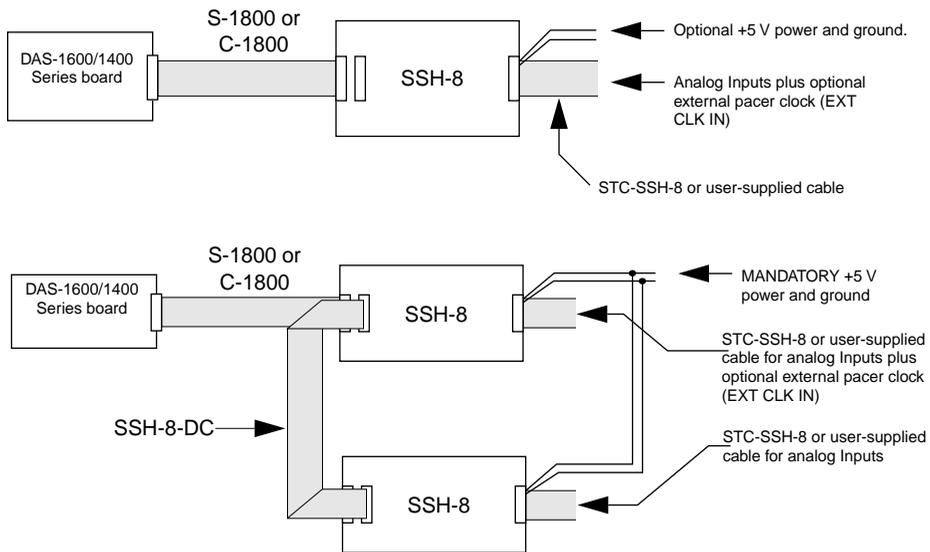
Figure 4-17. Attaching SSH-8 Accessories

When you use the cabling shown in Figure 4-17, observe the following rules:

- For best results, the length of any cable should not exceed 30 inches. The length of two cables should not exceed 36 inches. Total length for all cables in series should not exceed 50 inches. Total cable length does not include analog input cables.

- You can use the STC-SSH-8 screw terminal interface instead of a cable.

- Use eight feet maximum of #18 AWG wire (or heavier) for optional external power and ground.

- When daisy-chaining two SSH-8 accessories to a DAS-1600/1400 Series board, put the first in master mode and the second in slave mode.

- Optional channel jumpers are 0 to 7 for the first SSH-8 accessory and 8 to 15 for the second.

● Where the S-1800 cable is called out, other options include C-1800, S-1801, and C-1801. Crosstalk, shielding, and cost trade-offs are factors in the selection of these options.
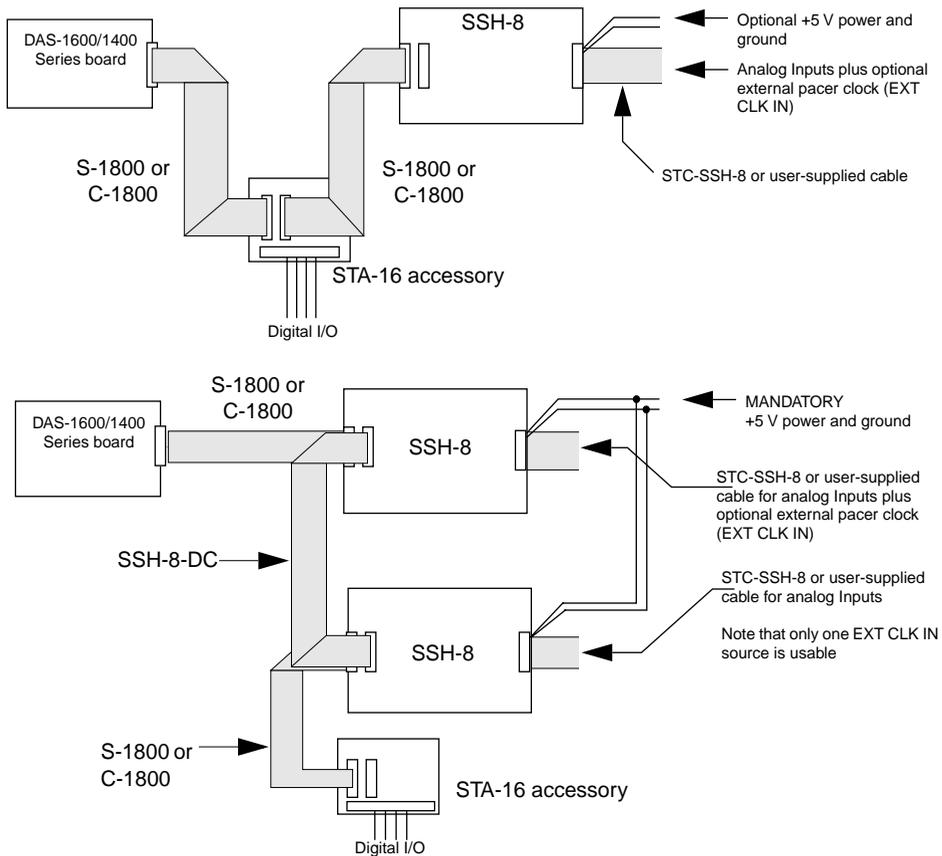
Figure 4-18. Attaching SSH-8 and STA-16 Accessories

Caution: Do not connect analog inputs to STA-16 pins that are driven by SSH-8 outputs.

Refer to the *SSH-8 User's Guide* for more information.

Attaching an MB Series Backplane

MB Series modules are ideally suited to applications where monitoring and control of temperature, pressure, flow, and other analog signals are required. Figure 4-19 shows a block diagram of a typical MB Series measurement and control application.
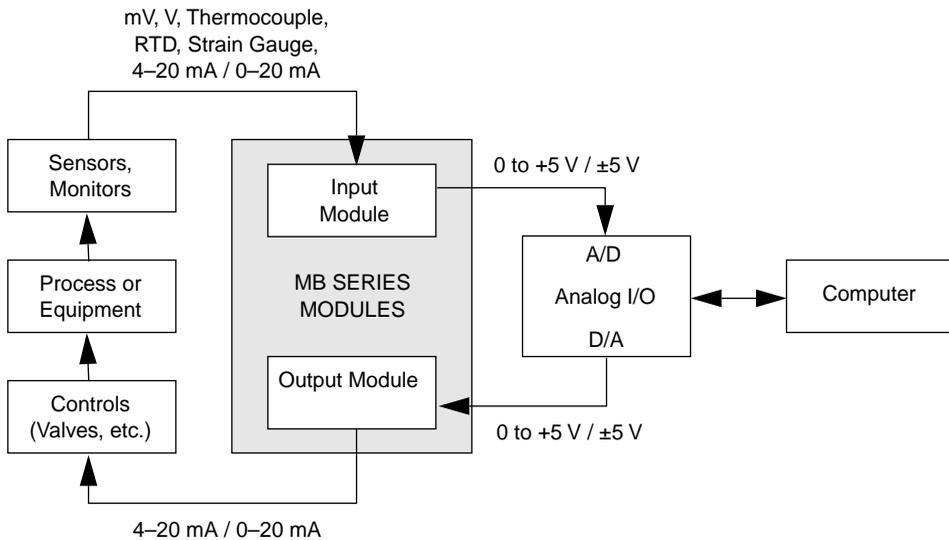
Figure 4-19. Typical Measurement and Control Application

Table 4-3 provides a brief summary the backplanes available for use with MB Series modules.

Table 4-3. MB Series Backplanes

Model	Description
MB01	Holds up to 16 modules and mounts in a 19-inch equipment rack. Provides direct channel-to-channel connection to a DAS-1600/1400 Series board.
MB02	Holds up to 16 modules and mounts in a 19-inch equipment rack. Up to four MB02s can be multiplexed together, providing a total of 64 channels. This makes it suitable for larger systems.
MB05	Functionally equivalent to half an MB01, the MB05 backplane accepts eight modules. Provides direct channel-to-channel connection to a DAS-1600/1400 Series board.
STA-MB	Holds up to four modules and provides general-purpose screw terminal connections for all other signals on the DAS1600/1400 Series board.

Attaching an MB01/05 Backplane

Use the C16-MB1 cable to connect a DAS-1600/1400 Series board to an MB01/05 backplane. This cable connects MB01/05 channels 0 through 15 to analog input channels 0 through 15 on the DAS-1600/1400 Series board. Refer to Figure 4-20 for a cabling diagram.
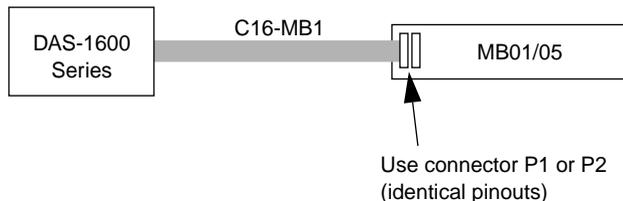
Figure 4-20. Attaching an MB01/05 Backplane

Note: The channel connections are single-ended. Make sure that the DAS-1600/1400 Series board is set for 16-channel, single-ended operation.

Attaching an MB02 Backplane

Figure 4-21 shows how to connect a DAS-1600/1400 Series board to up to four MB02 backplanes. The STA-SCM16 interface connects one MB02 board to one analog input channel of the DAS-1600/1400 Series board. One C-2600 cable connects each MB02 to the STA-SCM16, and the C-1800 cable connects the STA-SCM16 to the DAS-1600/1400 Series board.
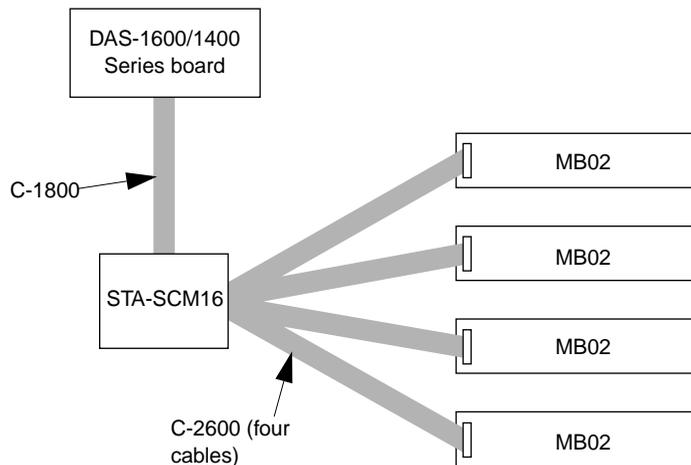
Figure 4-21. Attaching Multiple MB02 Backplanes

Figure 4-22 shows how the STA-SCM16 connects DAS-1600/1400 Series boards with MB02 backplanes.

MB02 Backplane Interfaces
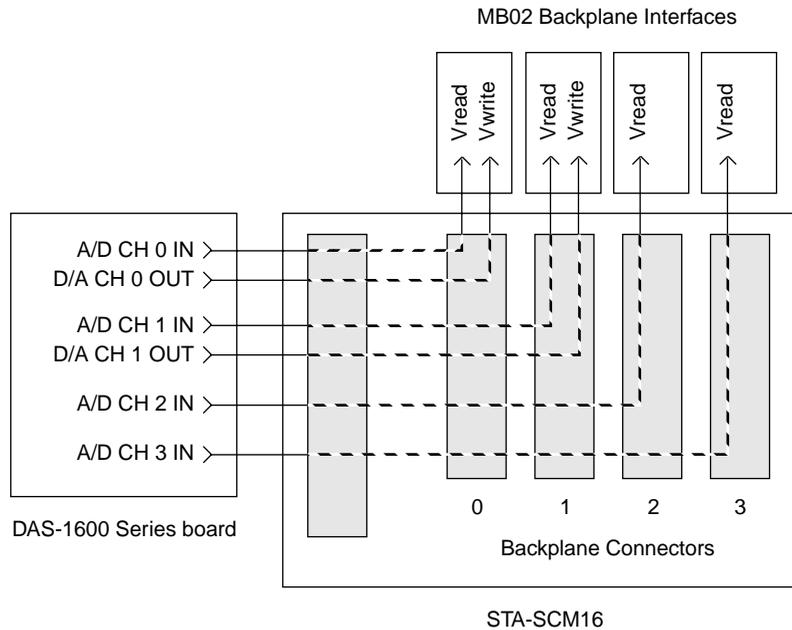
Figure 4-22. MB02 I/O Connections

The four digital output lines on the DAS-1600/1400 Series boards select one of the 16 MB02 channels. For example, if you set the digital output lines to 1000 (8 decimal), MB02 channel 8 is selected on all four backplanes. Analog input channels 0 to 3 on the DAS-1600/1400 Series board map directly to the connectors labeled 0 to 3 on the STA-SCM16. In this arrangement, the channel connections are single-ended. Make sure that the DAS-1600/1400 Series board is set for single-ended, 16-channel operation. Refer to the *MB Series User's Guide* for more information.

Attaching an STA-MB

The screw terminals on the STA-MB screw-terminal accessory accept field wiring to up to four MB Series modules whose outputs are brought through an C-1800/S-1800 cable to the main I/O connector of a DAS-1600/1400 Series board.

The STA-MB contains the following components:

● Two 37-pin male connectors. One for cabling to the main I/O connector of a DAS-1600/1400 Series board and a second for cascading additional accessories.

● Labeled screw terminals for connecting sensor outputs and test equipment. These terminals accept wire sizes 12-22 AWG.

● Mounts for up to four MB Series modules.

Attach an STA-MB screw terminal accessory to the main I/O connector (J1) on the DAS-1600/1400 Series board with a C-1800 or S-1800 cable. The C-1800 is the unshielded version of the cable; the S-1800 is the shielded version of the cable. Figure 4-23 shows how to attach an STA-MB to a DAS-1400 Series board.
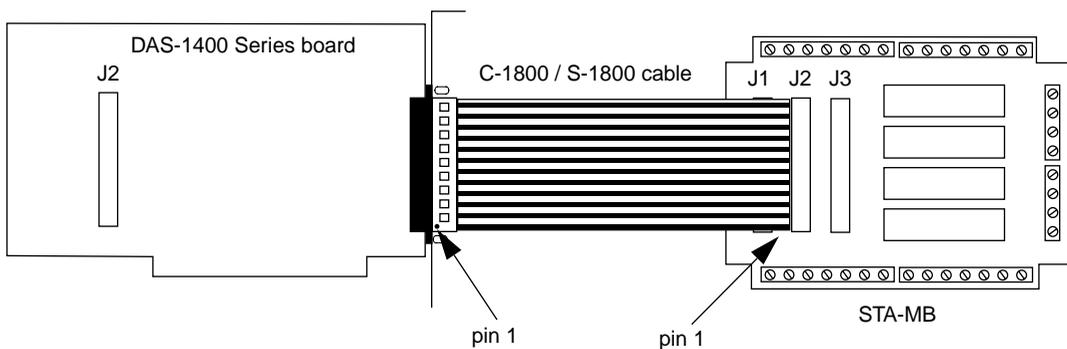
Figure 4-23. Cabling and Connections for Attaching an STA-MB

Connecting Analog Input Signals

This section shows circuits for wiring signal sources to input channels of DAS-1600/1400 Series boards. While the circuit diagrams show direct connections to channel input pins of the main I/O connector, you must make actual connections through corresponding inputs of an accessory, such as a screw terminal panel.

The circuit diagrams represent a single signal source wired to a single channel (channel *n*). In reality, you can wire eight separate signal sources to eight differential inputs or 16 separate signal sources to 16 single-ended inputs.

If you expect to use a DAS-1601 or DAS-1401 board at high gain, read the precautionary information in "Precautions for Operating at High Gains" on page 4-28. Other considerations for I/O connections are offered under "Additional Precautions" on page 4-29.

Connecting a Signal to a Single-Ended Analog Input

Figure 4-24 shows the connections between a signal source and a channel of a DAS-1600/1400 Series board configured for single-ended input mode.
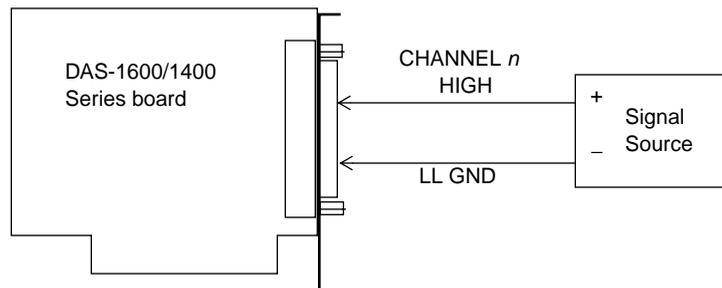
Figure 4-24. Connections for Wiring a Signal Source to a DAS-1600/1400 Series Board Configured for Single-Ended Inputs

The main I/O connector (J1) contains the following two ground connections:

- POWER GND is the noisy or "*dirty*" ground that carries all digital signal and power supply currents.

- LL GND or low level ground is the ground reference for all analog input functions and it only carries signal currents that are less than a few mA.

Contact resistance and cable resistance can make difference voltage of many millivolts between the two grounds although they are connected to each other.

> **Note:** When you wire signals to the analog input channels, you are
> advised to wire all unused channels to LL GND. This action prevents the
> input amplifiers from saturating, and it ensures the accuracy of your data.

Connecting a Signal to a Differential Analog Input

Figure 4-25 shows three methods of wiring a signal source to a channel of
a DAS-1600/1400 Series board configured for differential input mode.
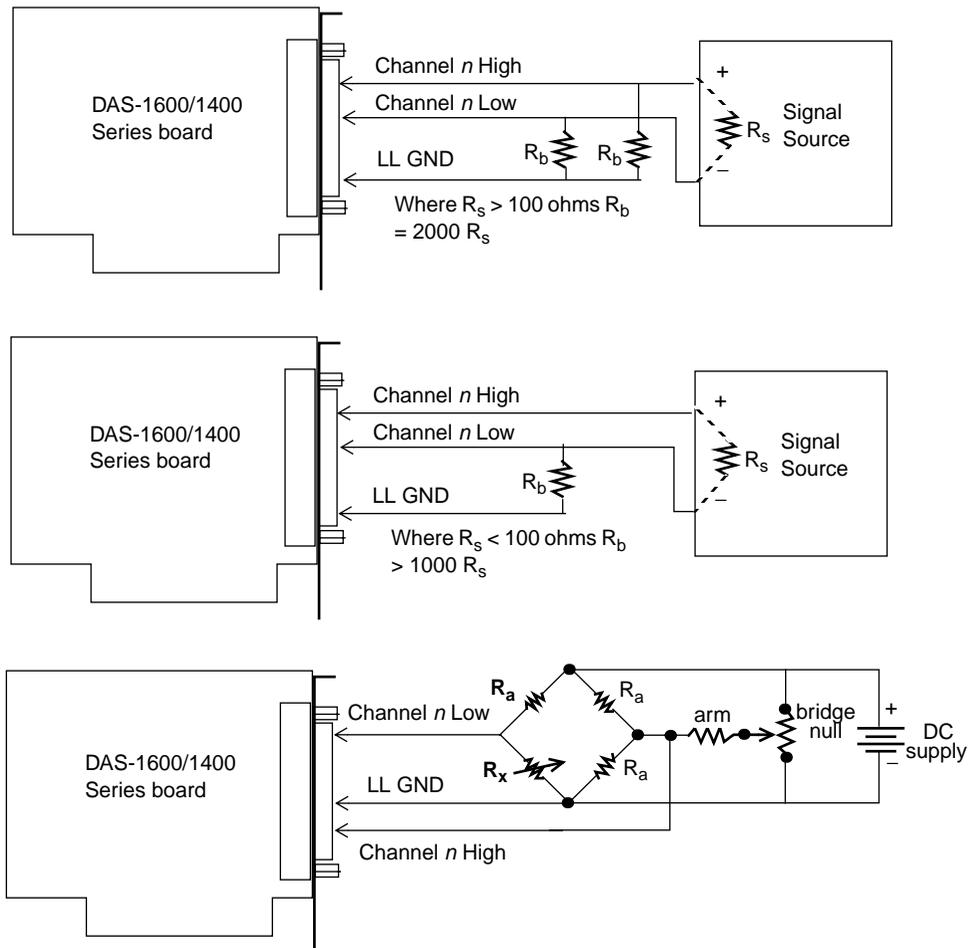
Figure 4-25. Three Methods of Wiring Differential Inputs

The upper two circuits of the diagram require the addition of resistors to provide a bias-current return. You can determine the value of the bias return resistors (R_b) from the value of the source resistance (R_s), using the following relationships:

- When R_s is greater than 100 Ω, use the connections in the upper circuit. The resistance of each of the two bias return resistors must equal 2000 R_s.

- When R_s is less than 100 Ω, use the connections in the middle circuit. The resistance of the bias return resistor must be greater than 1000 R_s.

In the lower circuit, bias current return is inherently provided by the source. The circuit requires no bias resistors.

Avoiding a Ground Loop Problem

Very often, the signal-source ground and the DAS-1600/1400 Series board ground are not at the same voltage level because of the distances between equipment wiring and the building wiring. This difference is referred to as a *common-mode voltage* (Vcm) because it is normally common to both sides of a differential input (it appears between each side and ground).

Using a differential input lets you avoid a ground loop problem. Since a differential input responds only to the difference in the signals at its high and low inputs, its common-mode voltages cancel out and leave only the signal. However, if your input connections contain a ground loop, your input could see incorrect data readings resulting from the sum of the signal-source and common-mode voltages. Figure 4-26 shows the proper way to connect a differential input while Figure 4-27 illustrates the effect of a ground loop on a differential channel converted to a single-ended channel by the installation of a wire jumper between Channel n Low and LL GND on the DAS board side of the cable. Figure 4-27 also illustrates the ground loop problem for a channel already configured in the configuration utility as single-ended.
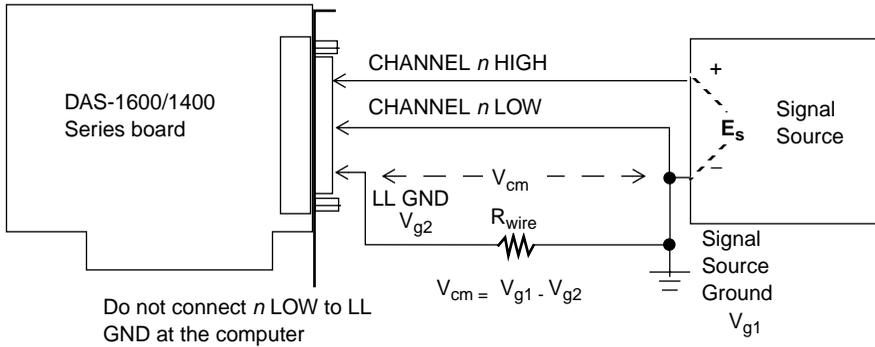
Figure 4-26. A Differential Input Connection that Avoids a Ground Loop Problem
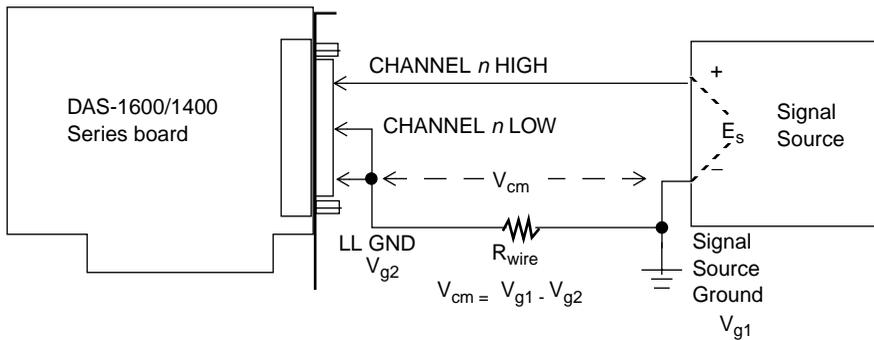
Figure 4-27. Differential or Single-Ended Input Connection that Introduces a Ground Loop Problem

Connecting Analog Output Signals

DAS-1600 Series boards include two DACs. Refer to the specifications in Appendix A for voltages, current limits, and other loading information. Make your connections to the DAC output terminals through corresponding screw terminals of your accessory. Table 4-4 lists the input and output connections of the DACs in the DAS-1600 Series boards.

Table 4-4. DAC Input and Output Connections

Signal	Main I/O Connector (J1)
D/A 0 User Reference Voltage In	pin 10
D/A 1 User Reference Voltage In	pin 26
D/A 0 Out	pin 9
D/A 1 Out	pin 27

Precautions for Operating at High Gains

Operating DAS-1601 or DAS-1401 boards at gains of 100 or 500 can lead to problems if your application is unable to cope with noise. At a gain of 500, with a bipolar input range of −10.0 V to + 10.0 V, each bit of A/D output corresponds to 10 μV of analog input. Thus, with the high speed and bandwidth of this board, analog noise and performance degradation come easily unless you take precautions to avoid them. The following collection of ideas and suggestions is aimed at avoiding these problems:

- Operate DAS-1601 and DAS-1401 boards in 8-channel differential mode. Using the board in 16-channel, single-ended mode at high gains introduces enough ground-loop noise to produce large fluctuations in readings.

- Minimize noise from crosstalk and induced-voltage pickup in the flat cables and screw terminal accessories by using shielded cable. Connect the shield to LL GND and the inner conductors to Channel LO and HI. Channel LO and LL GND should have a DC return (or connection) at some point; this return should be as close to the signal

source as possible. Induced noise from RF and magnetic fields can easily exceed tens of microvolts, even on one- or two-foot cables; shielded cable eliminates this problem.

- Avoid bi-metallic junctions in the input circuitry. For example, the kovar leads, used on reed relays, typically have a thermal emf to copper of 40 μV/˚C. Thermals can introduce strange random variations caused by air currents and so on.

- Consider filtering. This approach can use hardware (resistors, capacitors, and so on) but is often accomplished more easily with software. Instead of reading the channel once, read it 10 or more times in quick succession and average the readings. If the noise is random and gaussian, it will be reduced by the square-root of the number of readings.

Additional Precautions

Do not mix your data acquisition inputs with the AC line, or you risk damaging the computer. Data acquisition systems provide access to inputs of the computer. An inadvertent short between data and power lines can cause extensive and costly damage to your computer. The manufacturer can accept no liability for this type of accident. To prevent this problem, use the following precautions:

- Avoid direct connections to the AC line.

- Make sure all connections are tight and sound so that signal wires are not likely to come loose and short to high voltages.

- Use isolation amplifiers and transformers where necessary.

5

DriverLINX Analog I/O Panel

The DriverLINX Analog I/O Panel is an application that demonstrates analog input/output using DriverLINX. With the Analog I/O Panel you can:

- Analyze analog signals using the simulated two-channel Oscilloscope.

- Measure analog voltages using the simulated Digital Volt Meter.

- Generate Sine, Square and Triangle waves using the SST Signal Generator.

- Output DC Level voltages using the Level Control.

The Analog I/O Panel is useful for:

- Testing the DAS-1600/1400 DriverLINX installation and configuration.

- Verifying signal inputs to your DAS-1600/1400 board.

- Sending test signals to external devices.

To access this DriverLINX Analog I/O Panel:

1. Start the Analog I/O Panel with the "AIO Panel item on the Windows™ start menu. Then perform the following steps:

2. Click the [...] button in the Driver Selection section.

3. Select the driver for your board using the *Open DriverLINX* dialog.

4. Click *OK*.

5. Select the Logical Device you want to operate by dragging the pointer in the Device Selection section. The Analog I/O Panel displays the Scope, Meter, SST, and Level control tabs, depending on the capabilities of your DAS-1600/1400 board.

6. The Scope uses two analog input channels, referred to as ChA and ChB. Drag the channel selectors in the AI Channel Mapping section to map them to different channel numbers.

7. The SST Signal Generator uses two analog output channels, referred to as ChA and ChB. Drag the channel selectors in the AO Channel Mapping section to map them to different channel numbers.

You can now select the Scope, Meter, SST and Level Control tabs to operate your DAS-1600/1400 board.

Test Panel Application

Depending upon the DriverLINX drivers you have installed on your system, you will have one or more of the following example applications:

- *Single-Value AI* for analog input

- *Single-Value AO* for analog output

- *PIO Panel* for digital input and output

- *CTM Test Bench* for counter/timer applications.

To access this DriverLINX Test Panel, select Test Panel with the "Test Panel" item on the Windows start menu.

6

Calibration

Your DAS-1600/1400 Series board is initially calibrated at the factory. You are advised to check the calibration of a board every six months and to calibrate again when necessary. This chapter provides the information you need to calibrate a DAS-1600/1400 Series board.

Equipment Requirements

The equipment requirements for calibrating a DAS-1600/1400 Series board are as follows:

- A digital voltmeter accurate to a minimum of 5 1/2 digits

- An adjustable ±10 V power source

Potentiometers and Test Points

Figure 3-1 on page 3-7 and Figure 3-2 on page 3-7 show the locations of the potentiometers and test points that are used during the calibration of a DAS-1600 Series or DAS-1400 Series board.

The calibration utility, described in the next section, directs you to components and explains what to do with them during the calibration process.

Calibration Utility

DriverLINX Calibration Utility will guide you through the calibration procedure. Before calibration, specify the following parameters in the setup panel to get the correct instructions:

- **Logical Device**—Board's device number, model and address

- **Accessory**—Connection method used to connect the board to the calibration stimulus

- **Shorted channel**—Input channel to be "shorted" high to low

- **Voltage Channel**—Input channel to use to apply the various calibration voltage levels

- **Calibration range**—Input range to be calibrated

7

Troubleshooting

If your DAS-1600/1400 Series board is not operating properly, use the information in this chapter to isolate the problem. If the problem appears serious enough to warrant technical support, refer to "Technical Support" on page 7-6 for information on how to obtain technical support.

Problem Isolation

If you encounter a problem with a DAS-1600/1400 Series board, use the instructions in this section to isolate the cause of the problem before calling Keithley for technical support.

Using the DriverLINX Event Viewer

The DriverLINX Event Viewer displays the Windows™ system event log. Applications and hardware drivers make entries in the system event log to assist in predicting and troubleshooting hardware and software problems.

DriverLINX uses the event log to report problems during driver loading or unexpected system errors. The event log can assist in troubleshooting resource conflicts and DriverLINX configuration errors. If you are having trouble configuring or initializing a Logical Device, check the event log for information from the DriverLINX driver.

Using the DriverLINX Event Viewer, you can view, save and e-mail DriverLINX event log entries under Windows 95/98 or Windows NT. DriverLINX event log entries can help you or technical support troubleshoot data-acquisition hardware and software problems.

Device initialization error messages

During device initialization, DriverLINX performs a thorough test of all possible subsystems on DAS-1600/1400 Series boards as well as the computer interface. If DriverLINX detects any problems or unexpected responses, it reports an error message to help isolate the problem. The device initialization error messages fall into three basic categories:

- **"Device not found"**—Board address does not match hardware setting or conflicts with another board. Verify the board's address settings. Also, don't confuse hexadecimal with decimal addresses in the DriverLINX *Device Configure* dialog box.

- **"Invalid IRQ level"** or **"Invalid DMA level"**—Selected level does not match hardware setting, conflicts with another board's IRQ/DMA levels, or is dedicated to the computer's internal functions (COM port, disk drive controller, network adapter, etc.)

- **"Hardware does not match configuration"**—Operating mode/range switch or jumper setting does not match selection(s) made in the DriverLINX *Device Configuration* dialog box.

Identifying Symptoms and Possible Causes

Use the troubleshooting information in Table 7-1 to try to isolate the problem. Table 7-1 lists general symptoms and possible solutions for problems with DAS-1600/1400 Series boards.

Table 7-1. Troubleshooting Information

Symptom	Possible Cause	Possible Solution
Board does not respond	Base address is incorrect.	Make sure the base address switch on the board is set correctly and that your program references the same base address. If the base address is set correctly, make sure no other computer device is using any of the I/O locations beginning at the specified base address. If necessary, reconfigure the base address. Refer to page 3-9 for instructions on setting the base address.
	The interrupt level is incorrect.	Make sure no other computer device is using the interrupt level specified in your program. If necessary, reset the interrupt level.
	The board is incorrectly aligned in the accessory slot.	Check installation.
	The board is damaged.	Contact Keithley for technical support; see page 7-6.
Intermittent operation	The most common cause of this problem is that the I/O bus speed is in excess of 8 MHz.	Reduce I/O bus speed to a maximum of 8 MHz (to change the I/O bus speed, run BIOS setup). See the documentation for your computer for instructions on running BIOS setup.
	Vibrations or loose connections exist.	Cushion source of vibration and tighten connections.
	The board is overheating.	Check environmental and ambient temperature. See the documentation for your computer.
	Electrical noise exists.	Provide better shielding or reroute wiring.
	Bus cycles require wait state.	Enable wait states on the DAS-1600/1400 Series board.

Table 7-1. Troubleshooting Information (cont.)

Symptom	Possible Cause	Possible Solution
Data appears to be invalid	The most common cause of this problem is that the I/O bus speed is in excess of 8 MHz.	Reduce I/O bus speed to a maximum of 8 MHz (to change the I/O bus speed, run BIOS setup). See the documentation for your computer for instructions on running BIOS setup.
	An open connection exists.	Check wiring to screw terminal.
	Another device is using the specified base address.	Reconfigure the base address of the DAS-1600/1400 Series board; refer to page 3-9 for more information. Check the I/O assignments of other system devices and reconfigure, if necessary.
Computer does not boot	Board not seated properly.	Check that the board is properly installed.
	The base address setting of the DAS-1600/1400 Series board conflicts with that of another device.	Verify that the base address setting of your DAS-1600/1400 Series board is unique. Refer topage 3-9 for instructions on setting the base address.
	The power supply of the host computer is too small to handle all the devices installed in your system.	Check the needs of all system devices and obtain a larger power supply if necessary.

If your board is not operating properly after using the information in Table 7-1, continue with the next two sections to further isolate the problem.

Testing the Board and Host Computer

To isolate the problem to the DAS-1600/1400 Series board or to the host computer, use the following steps:

1. Turn the power to the host computer OFF, and remove power connections to the computer.

Caution: Removing a board with the power ON can cause damage to your board and/or computer.

---

2. While keeping connections to accessories intact, unplug the accessory connector(s) or cable(s) from the DAS-1600/1400 Series board(s).

3. Remove the DAS-1600/1400 Series board(s) from the computer and visually check for damage. If a board is obviously damaged, refer to "Technical Support" on page 7-6 for information on returning the board.

4. With the DAS-1600/1400 Series board(s) out of the computer, check the computer for proper operation. Power up the computer and perform any necessary diagnostics.

At this point, if you have another DAS-1600/1400 Series board that you know is functional, you can test the slot and I/O connections using the instructions in the next section. If you do not have another board, refer to page 7-6 for instructions on calling Keithley for technical support.

Testing the Accessory Slot and I/O Connections

When you are sure that the computer is operating properly, test the computer accessory slot and I/O connections using another DAS-1600/1400 Series board that you know is functional. To test the computer accessory slot and the I/O connections, follow these steps:

1. Remove computer power again, and install a DAS-1600/1400 Series board that you know is functional. Do not make any I/O connections.

2. Turn computer power ON and check operation with the functional board in place. This test checks the computer accessory slot. If you were using more than one DAS-1600/1400 Series board when the problem occurred, use the functional board to test the other slot(s) as well.

3. If the accessory slots are functional, use the functional board to check the I/O connections. Reconnect and check the operation of the I/O connections, one at a time.

4. If operation fails for an I/O connection, check the individual inputs one at a time for shorts and opens.

5. If operation remains normal to this point, the problem is in the DAS-1600/1400 Series board(s) originally in the computer. If you were using more than one board, try each board one at a time in the computer to determine which is faulty.

6. If you cannot isolate the problem, refer to the next section for instructions on obtaining assistance.

Technical Support

Before returning any equipment for repair, call Keithley for technical support at:

1-888-KEITHLEY
Monday - Friday, 8:00 A.M.. - 6:00 P.M., Eastern Time

An applications engineer will help you diagnose and resolve your problem over the telephone. Please make sure that you have the following information available before you call:

DAS-1600/1400 Series board configuration	Model	
	Serial Number	
	Revision Code	
	Base address setting	
	Interrupt level setting	
	Number of channels	
	Input (S.E. or Diff.)	
	Mode (uni. or bip.)	
	DMA chan(s)	

	Number SSH-8 boards	
	Number EXP boards	
Computer	Manufacturer	
	CPU type	
	Clock speed (MHz)	
	KB of RAM	
	Video system	
	BIOS type	
Operating system	Windows version	
	Windows mode	
Software package	Name	
	Serial Number	
	Version	
	Invoice/Order Number	
Compiler (if applicable)	Language	
	Manufacturer	
	Version	
Accessories	Type	
	Type	
	Type	
	Type	
	Type	
	Type	
	Type	
	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. Include the RMA number with any documentation regarding the equipment.

When returning equipment for repair, include the following information:

- Your name, address, and telephone number.

- The invoice or order number and date of equipment purchase.

- A description of the problem or its symptoms.

- The RMA number on the **outside** of the package.

Repackage the equipment, using the original anti-static wrapping, if possible, and handle it with ground protection.

Note: If you are submitting your equipment for repair under warranty, you must include the invoice number and date of purchase.

To enable Keithley to respond as quickly as possible, you must include the RMA number on the outside of the package.

A

Specifications

The following tables list specifications for the DAS-1600/1400 Series boards.

Table A-1. Analog Input Specifications

Feature	DAS-1601/1401 Boards	DAS-1602/1402 Boards
Number of channels	Switch-configurable as eight differential or 16 single-ended	
Input mode	Switch-configurable as unipolar or bipolar	
Resolution	12-bits (1 part in 4096 or 244 ppm)	
Gain (range)	1 (0.0 to +10.0 V for unipolar) 1 (±10.0 V for bipolar)	1 (0.0 to +10 V for unipolar) 1 (±10 V for bipolar)
	10 (0.0 to +1.0 V for unipolar) 10 (±1.0 V for bipolar)	2 (0.0 to +5.0 V for unipolar) 2 (±5.0 V for bipolar)
	100 (0 to +100 mV for unipolar) 100 (±100 mV for bipolar)	4 (0.0 to +2.5 V for unipolar) 4 (±2.5 V for bipolar)
	500 (0 to +20 mV for unipolar) 500 (±20 mV for bipolar)	8 (0.0 to 1.25 V for unipolar) 8 (±1.25 V for bipolar)
Gain (settling time)	1 (10 μs) 10 (10 μs) 100 (14 μs) 500 (34 μs)	1 (10 μs) 2 (10 μs) 4 (10 μs) 8 (10 μs)
Throughput[1]	100 kHz for gains of 1 to 10 70 kHz for a gain of 100 30 kHz for a gain of 500	100 kHz for all gains

Table A-1. Analog Input Specifications (cont.)

Feature	DAS-1601/1401 Boards	DAS-1602/1402 Boards
Absolute accuracy	Typical: 0.01% of reading ±1 LSB for all ranges	
	Maximum error: For gain < 500: 0.02% of reading ±1 LSB maximum @ 25˚C For gain = 500: 0.03% of reading ±1 LSB maximum @ 25˚C	
Temperature coefficient of accuracy (includes ADC)	Gain: • ±50 ppm/ ˚C for gains of 1,2,4,8, and 10 • ±55 ppm/ ˚C for a gain of 100 • ±50 ppm/ ˚C for a gain of 500	
	Offset: • Bipolar: 10 µV/ ˚C ±10 ppm/˚ C • Unipolar: ±10 µV/ ˚C ±5 ppm/˚ C	
Dynamic parameters	Acquisition time: 1.4 µs	
	Aperture delay: 20.0 ns	
	Aperture uncertainty: 300 ps rms	
	Conversion time: 8.0 µs maximum 7.5 µs typical	
Non-linearity	±1 LSB	
Input impedance	Greater than 25 megohms	
Input current	250 nA maximum (125nA typ.) @ 25˚ C	
Input bias current	±40 nA maximum @ 25˚ C	
	±60 nA maximum over operating range	
Input overvoltage	±35.0 V continuous powered	
Minimum common mode rejection ratio	74 dB for gain = 1	74 dB for gain = 1
	90 dB for gain = 10	80 dB for gain = 2
	100 dB for gain = 100	80 dB for gain = 4
	100 dB for gain = 500	86 dB for gain = 8

Table A-1. Analog Input Specifications (cont.)

Feature	DAS-1601/1401 Boards	DAS-1602/1402 Boards
Noise[2]	Bipolar electrical noise (in counts) • Gain = 1: p-p = 1; rms = 0.1 • Gain = 10: p-p = 1; rms = 0.1 • Gain = 100: p-p = 2; rms = 0.2 • Gain = 500: p-p = 3; rms = 0.5	Bipolar electrical noise (in counts) • Gain = 1: p-p = 1; rms = 0.1 • Gain = 2: p-p = 1; rms = 0.1 • Gain = 4: p-p = 1; rms = 0.1 • Gain = 8: p-p = 1; rms = 0.1
	Unipolar electrical noise (in counts): • Gain = 1: p-p = 1; rms = 0.1 • Gain = 10: p-p = 1; rms = 0.1 • Gain = 100: p-p = 2; rms = 0.2 • Gain = 500: p-p = 3; rms = 0.5	Unipolar electrical noise (in counts): • Gain = 1: p-p = 1; rms = 0.1 • Gain = 2: p-p = 1; rms = 0.1 • Gain = 4: p-p = 1; rms = 0.1 • Gain = 8: p-p = 1; rms = 0.1
DMA channels	1 and 3	
Interrupt levels	2, 3, 4, 5, 6, and 7	
Minimum external pacer clock pulse width	10 ns	
Maximum external pacer clock rate	100 kHz	

Notes

[1] Throughput is the maximum rate at which multiple channels can be scanned and still yield the same result (within ±1 LSB) as a single channel scan (note that all channels must be within range of the selected gain to assure proper settling). If using a single channel, the maximum sampling rate is 100 kHz for all gains.

[2] The figures in the table show the electrical noise introduced by the analog front end but do not include the uncertainty inherent in the quantization process. The inherent quantization noise introduced by any ADC is due to uncertainty at code boundaries and adds a peak-to-peak value of 1 LSB to the electrical noise; it also makes the rms level 0.5 LSBs.

Table A-2. Analog Output Specifications

Feature	DAS-1600 Series Boards
DAC Channels	2
Resolution	12-bit (one part in 4096 or 224 ppm)
Data format	Left-justified, offset binary
Range	User input ±10.00 volts in multiplying DAC mode
	0.000 to +5.000 V
	0.000 to +10.000 V
	±5.000 V
	±10.000 V
Linearity	Integral: ±∫ LSB typical; ±1 LSB maximum
	Differential: ±1 LSB
	Monotonicity: guaranteed over operating range
Maximum output current	±5 mA maximum
Settling time	4 μs to 0.01% typical
Output impedance	< 0.1 ohm
Gain accuracy	Adjustable to ±1 LSB
Offset accuracy	Adjustable to 0
Power up	DACs power up to 0.0 V at reset
Reference output voltage	Accuracy: −5.0 V ±50 mV
	Temperature coefficient: ±30 ppm/ ˚C
	Load current: ±5.0 mA maximum

Table A-3. Digital I/O Specifications (8-bits on Main I/O Connector)

Feature	DAS-1600/1400 Series Boards
Outputs (standard LSTTL)	Output bits: 4
	Low voltage: 0.5 V maximum @ Isink= 8.0 mA
	High voltage: 2.7 V minimum @ Isource = −0.4 mA
Inputs and interrupts (standard LSTTL)[1]	Input bits: 4
	Low voltage: 0.8 V maximum
	Low current: −0.2 mA maximum
	High voltage: 2.0 V minimum
	High current: 20 µA maximum

Notes
[1] IP0/TRIG 0/XPCLK minimum pulse width = 10.0 ns.

Table A-4. Digital I/O Specifications (24-bits on PIO Cable Connector)

Feature	DAS-1601/1602 Boards
Device type	NMOS S8255A-5
I/O	24 bits
Outputs	Low Voltage: 0.45 V maximum @ Isink = 1.7 mA
	High voltage: 2.4 V minimum @ Isource = −0.2 mA
Inputs (and interrupts)	Low voltage: 0.8 V maximum
	Low current: −10 µA maximum
	High voltage: 2.0 V minimum
	High current: 10 µA maximum

Table A-5. Programmable Counter/Timer Specifications

Feature	DAS-1600/1400 Series Boards
Device type	82C54-2
Number of counters	3 down counters, 16-bit 2 permanently connected to 1/10 MHz
Outputs (buffered)	Low voltage: 0.5 V maximum @ Isink = 25 mA
	High voltage: 2.0 V minimum @ Isource = −15 mA
Inputs (buffered)	Low voltage: 0.8 V maximum.
	Low current: −0.2 mA maximum
	High voltage: 2.0 V minimum
	High current: 20 μA maximum
Input and gate	TTL/CMOS compatible
Clock input	DC to 10 MHz
Active count edge	Negative
Minimum clock pulse widths	30 ns high / 50 ns low

Table A-6. Power Supply Requirements

Feature	DAS-1600 Series Boards	DAS-1400 Series Boards
+5 VDC supply	800 mA typical; 1.0 A maximum	500 mA typical; 750 mA maximum
+12 VDC supply	30 mA typical; 40 mA maximum	30 mA typical; 40 mA maximum
−12 VDC supply	Not used	

Table A-7. Environmental Specifications

Attribute	DAS-1600 Series Boards	DAS-1400 Series Boards
Operating temperature	0 to 70 ˚C	
Storage temperature	−20 to 70 ˚C	
Humidity	0 to 95% noncondensing	
Dimensions	9 in L x 4.25 in H x 0.90 in D (22.9 cm x 10.8 cm x 2.29 cm)	5.5 in L x 4.25 in H x 0.75 in D (14.0 cm x 10.8 cm x 1.9 cm)
Weight	8 oz. (227 g)	

B

Connector Pin Assignments

This appendix contains pin assignments for the I/O connectors of the DAS-1600/1400 Series boards. See Figure 3-1 and Figure 3-2 for the location of the main I/O connector (J1).

Main I/O Connector (J1)

The pin assignments of the main I/O connector (J1) on the DAS-1600/1400 Series board are shown in Figure B-1.

LL GND	Pin 19		Pin 37	Ch0 HI IN
Ch0 LO IN / Ch8 HI IN	Pin 18		Pin 36	Ch1 HI IN
Ch1 LO IN / Ch9 HI IN	Pin 17		Pin 35	Ch2 HI IN
Ch2 LO IN / Ch10 HI IN	Pin 16		Pin 34	Ch3 HI IN
Ch3 LO IN / Ch11 HI IN	Pin 15		Pin 33	Ch4 HI IN
Ch4 LO IN / Ch12 HI IN	Pin 14		Pin 32	Ch5 HI IN
Ch5 LO IN / Ch13 HI IN	Pin 13		Pin 31	Ch6 HI IN
Ch6 LO IN / Ch14 HI IN	Pin 12		Pin 30	Ch7 HI IN
Ch7 LO IN / Ch15 HI IN	Pin 11		Pin 29	LL GND
D/A 0 REF IN*	Pin 10		Pin 28	LL GND
D/A 0 OUT*	Pin 9		Pin 27	D/A 1 OUT*
VREF (-5)*	Pin 8		Pin 26	D/A 1 REF IN*
POWER GND	Pin 7		Pin 25	IP 0 / TRIG 0 / XPCLK
IP 1 / XTRIG	Pin 6		Pin 24	IP 2 / CTR 0 GATE
IP 3	Pin 5		Pin 23	OP 0
OP 1	Pin 4		Pin 22	OP 2
OP 3	Pin 3		Pin 21	CTR 0 CLOCK IN
CTR 0 OUT	Pin 2		Pin 20	CTR 2 OUT
+5 V PWR	Pin 1			

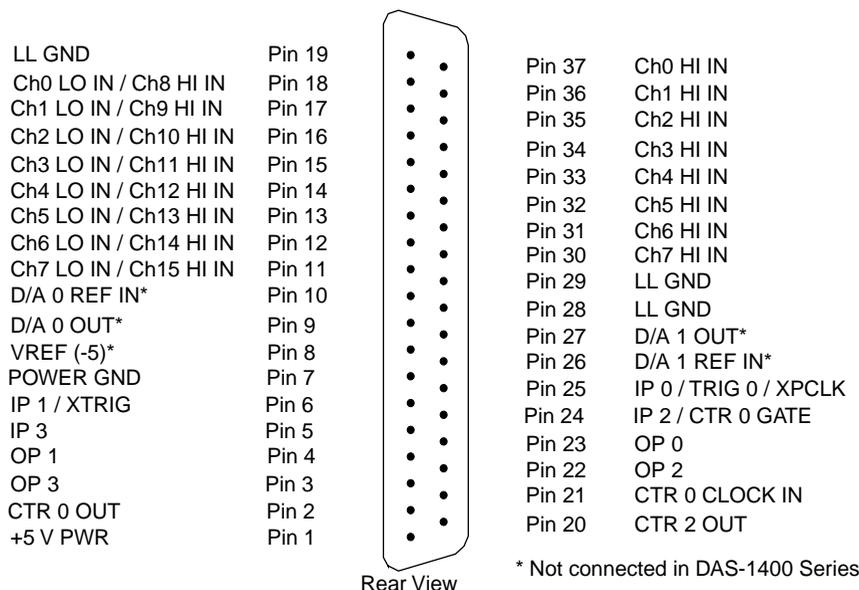Rear View

* Not connected in DAS-1400 Series

Figure B-1. Pin Assignments of Main I/O Connector (J1) on DAS-1600/1400 Series

PIO Cable Connector (J2) (DAS-1600 Series Only)

The pin assignments of PIO cable connector (J2) are shown in Figure B-2.

Rear View

DIG.COM.	Pin 19	
+5 V	Pin 18	Pin 37 PA 0
DIG. COM.	Pin 17	Pin 36 PA 1
not connected	Pin 16	Pin 35 PA 2
DIG. COM.	Pin 15	Pin 34 PA 3
not connected	Pin 14	Pin 33 PA 4
DIG. COM.	Pin 13	Pin 32 PA 5
not connected	Pin 12	Pin 31 PA 6
DIG.COM.	Pin 11	Pin 30 PA 7
PB 0	Pin 10	Pin 29 PC 0
PB 1	Pin 9	Pin 28 PC 1
PB 2	Pin 8	Pin 27 PC 2
PB 3	Pin 7	Pin 26 PC 3
PB 4	Pin 6	Pin 25 PC 4
PB 5	Pin 5	Pin 24 PC 5
PB 6	Pin 4	Pin 23 PC 6
PB 7	Pin 3	Pin 22 PC 7
not connected	Pin 2	Pin 21 DIG. COM.
not connected	Pin 1	Pin 20 +5 V

PORT A — Pin 37 PA 0 through Pin 30 PA 7

PORT CL — Pin 29 PC 0 through Pin 26 PC 3

PORT CH — Pin 25 PC 4 through Pin 22 PC 7
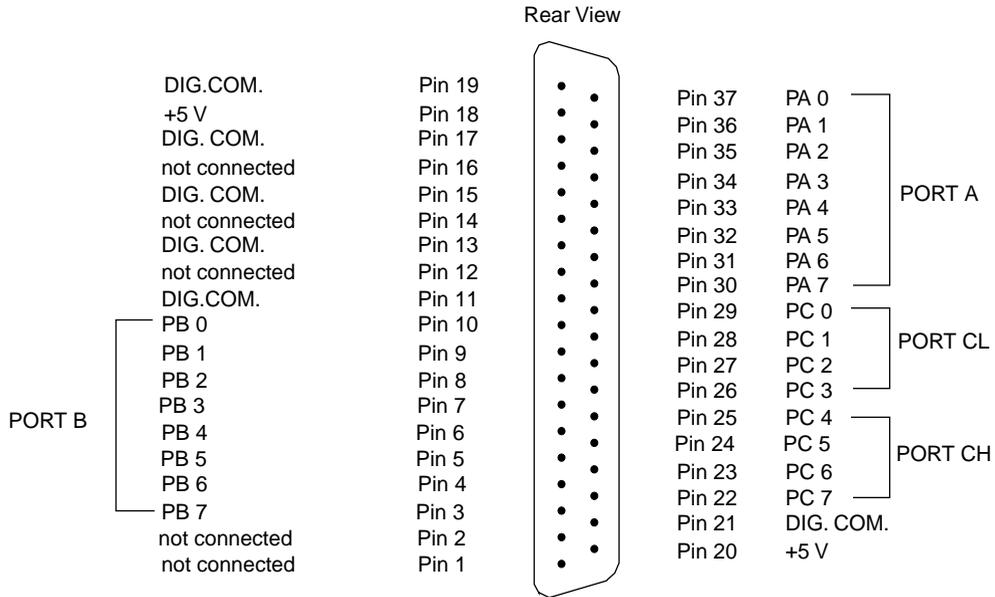
PORT B — PB 0 through PB 7

Figure B-2. Pin Assignments of PIO Cable Connector (J2)

C

Register-Level Address Map

DAS-1600/1400 Series boards are programmable at the register-level using I/O instructions. In BASIC, I/O instructions are **INP(X)** and **OUT X,Y**. In assembly and most other low-level languages, the I/O instructions are similar to BASIC's I/O instructions; for example, the assembly language equivalents are **IN AL,DX** and **OUT DX,AL**.

As an aid to register-level programming, this chapter describes each I/O register in terms of function, address, bit structure, and bit functions. The chapter does not describe how to program at the register-level.

Register Functions

DAS-1600/1400 Series register functions are categorized as follows:

- Analog-to-Digital converter (ADC) registers

- MUX scan register

- Digital input and output registers

- Digital-to-Analog converter (DAC) output registers (DAS-1600 Series only)

- Status registers

- Control register

- Programmable gain selection and burst rate register

- Counter enable and burst length register

- 82C54 programmable interval counter/timer registers

- 8255 programmable I/O registers (DAS-1600 only)

● 1600 mode and burst mode enable registers

DAS-1600/1400 Series boards use 32 I/O mapped addresses. The first 16 locations start at the base address in the computer's I/O space. The next eight locations start at the base address +400h. The remaining eight locations are for future use; they have no current function.

The addresses start at the base address and extend as shown in the I/O map of Table C-1.

Table C-1. Register-Level Address Map

Location	Function	Type	Name
Base Address +0h	Low-byte of ADC register, A/D conversion	Read/Write	AD0
Base Address +1h	High-byte of ADC register	Read	AD1
Base Address +2h	ADC MUX scan register	Read/Write	MUX
Base Address +3h	Digital input byte (IP0-3), Board ID	Read	DIO
	Digital output byte (OP0-3)	Write	
DAC Output Registers Base Address +4h to +7h (DAS-1600 Series only)			
Base Address +4h	Low-byte of DAC0 (DAS-1600 only)	Write	DAOLB
Base Address +5h	High-byte of DAC0 (DAS-1600 only)	Write	DA0HB
Base Address +6h	Low-byte of DAC1 (DAS-1600 only)	Write	DA1LB
Base Address +7h	High-byte of DAC1 (DAS-1600 only)	Write	DA1HB
Base Address +8h	Status register A	Read/Write	STATUS A
Base Address +9h	Control register	Read/Write	CTRL
Base Address +Ah	Counter enable and burst length register	Read/Write	CNTEN
Base Address +Bh	Gain selection and burst rate register	Read/Write	GAIN
82C54 Programmable Interval Timer			
Base Address +Ch	Counter 0 register	Read/Write	TIMER0
Base Address +Dh	Counter 1 register	Read/Write	TIMER1
Base Address +Eh	Counter 2 register	Read/Write	TIMER2

Table C-1. Register-Level Address Map (cont.)

Location	Function	Type	Name
Base Address +Fh	82C54 Counter Control	Write	TIMERCTL
Bidirectional digital ports A,B, CL, and CH (82C55 Programmable I/O) (DAS-1600 Series only)			
Base Address +400h	Digital port A	Read/Write	PIOPA
Base Address +401h	Digital port B	Read/Write	PIOPB
Base Address +402h	Digital port CL and CH	Read/Write	PIOPC
Base Address +403h	82C55 control register	Write	PIOCTL
Base Address +404h	Conversion disable register	Write	DISARM
Base Address +405h	Burst mode enable register	Write	BMDEN
Base Address +406h	1600/1400 mode enable register	Write	1600MDEN 1400MDEN
Base Address +407h	Status register B	Read	STATUSB

The following sections describe the I/O registers in more detail.

ADC Registers (Base Address +0h and +1h)

Base address +0h and base address +1h are used for the following:

- A/D conversion data

- MUX channel number from which data is converted

- Start a software controlled A/D conversion

The ADC registers are read in standard Intel 8088 Lo/Hi-byte sequence. A write to base +0 initiates an A/D conversion.

Data is left-justified true binary, and the MUX channel address is in the least-significant nibble; thus, data is tagged according to its channel of origin. ADC data is latched so that data from the previous conversion is available until the end of the following conversion. You can mask or discard channel information, as required.

A write to base address +0h initiates an A/D conversion. Any data written to these addresses is ignored.

Bit assignments of base address +0h are as follows:

7	6	5	4	3	2	1	0
CD3	CD2	CD1	CD0	MA3	MA2	MA1	MA0

The bit names are defined and used as follows:

- **MA0 to MA3** = Number of MUX channel converted.

- **CD0 to CD3** = Four least significant bits of data converted from MUX channel specified by MA0 to MA3.

Bit assignments of base address +1h are as follows:

7	6	5	4	3	2	1	0
CD11	CD10	CD9	CD8	CD7	CD6	CD5	CD4

- **CD4 to CD11** = Eight most significant bits of data converted from MUX channel specified by MA0 to MA3.

MUX Scan Register (Base Address +2h)

The MUX scan register is a read and write register that controls the channel-scan limits of the ADC multiplexer. The high nibble provides the *end of scan address* and the low nibble provides the *start of scan address*.

The MUX scan register is set to 00h on power-up (reset).

About 400 ns after the ADC multiplexer begins a conversion (and the sample-and-hold is holding the previous channel) the multiplexer address increments to be ready for the next conversion.

On finishing the conversion performed with the *end of scan address*, the cycle repeats starting with the *start of scan address*. On writing to the MUX scan register, the counter is automatically initialized to the start of scan address.

To perform conversions on a single channel, the *end of scan* and *start of scan addresses* should both be made equal to the target channel. If the DAS-1600/1400 Series board is to operate in 8-channel differential mode, insure that the AH3 and AL3 bits are zero. The operating mode can always be determined by reading bit 5 in status register A.

Bit assignments of base address +2h are as follows:

7	6	5	4	3	2	1	0
AH3	AH2	AH1	AH0	AL3	AL2	AL1	AL0

The bit names are defined and used as follows:

- **AL0 to AL3** = Start of scan address.

- **AH0 to AH3** = End of scan address.

Unidirectional Digital Input and Output Registers (Base Address +3h)

DAS-1600/1400 Series unidirectional digital input and output consists of two hardware-configured ports: a 4-bit latched output port (OP0 to 3) and a 4-bit input port (IP0 to 3).

These ports share the same I/O address but are independent; that is, data written to the output port is not readable by the input port unless the OP0 to OP3 lines are externally connected to the IP0 to IP3 lines. The output port is set to 0h on power-up (reset).

In addition, some input port lines perform secondary functions. IP0 is also XPCLK and TRIG 0. XPCLK provides an external pacer clock to initiate A/D conversions and TRIG 0 is used as a gate for the 82C54 counters one and two. IP2 is also CTR 0 GATE, which controls operation of counter 0 in the 82C54 counter/timer.

Depending on your application, you may or may not use these secondary functions. However, if you want to know the state of these inputs, read base address +3h.

Bit assignments of base address +3h during a write are as follows:

7	6	5	4	3	2	1	0
X	X	X	X	OP3	OP2	OP1	OP0

The bit names are defined and used as follows:

- **OP0 to OP3** = Bits 0 to 3 of the digital output port.

- **X** = Data insensitive.

Bit assignments of base address +3h during a read are as follows:

7	6	5	4	3	2	1	0
1	1	0	0	IP3	IP2	IP1	IP0

The bit names are defined and used as follows:

- **IP0 to IP3** = Bits 0 to 3 of the digital input port.

- **Bits 7 to 4** = Board ID; these bits have a fixed value of 1100 for DAS-1600 Series boards and 1110 for DAS-1400 Series boards.

DAC Output Registers (Base Address +4h to +7h) (DAS-1600 Series Only)

DAC output registers are write only and in standard Lo/Hi-byte sequence. DAC output registers are double-buffered so that the 12-bit DAC converters are not updated until the second (high) byte is written. This insures a single-step transition on the analog output of the DAC.

Note: DACs power up with 0 V out regardless of selected range. The DAC output register data formats are true-binary and left-justified.

Base address +4h and +5h correspond to DAC 0; base address +6h and +7h correspond to DAC 1.

DAC0

Bit assignments of base address +4h are as follows:

7	6	5	4	3	2	1	0
DD3	DD2	DD1	DD0	X	X	X	X

The bit names are defined and used as follows:

- **X** = Data insensitive.

- **DD0 to DD3** = Four least significant bits of DAC0 data.

Bit assignments of base address +5h are as follows:

7	6	5	4	3	2	1	0
DD11	DD10	DD9	DD8	DD7	DD6	DD5	DD4

The bit names are defined and used as follows:

- **DD4 to DD11** = Eight most significant bits of DAC0 data.

DAC1

Bit assignments of base address +6h are as follows:

7	6	5	4	3	2	1	0
DD3	DD2	DD1	DD0	X	X	X	X

The bit names are defined and used as follows:

- **X** = Data insensitive.

- **DD0 to DD3** = Four least significant bits of DAC1 data.

Bit assignments of base address +7h are as follows:

7	6	5	4	3	2	1	0
DD11	DD10	DD9	DD8	DD7	DD6	DD5	DD4

The bit names are defined and used as follows:

- **DD4 to DD11** = Eight most significant bits of DAC1 data.

DAC Controller Modes

The DAS-1601 and DAS-1602 have five switch-configurable output ranges that power-up at 0 V out. The ranges are 0-5 V, 0-10 V, ±5 V, ±10 V, and User Input. Each of the two models have a 3-position-slide switch that selects full-scale range (5, 10, User) and a 2-position switch that selects unipolar or bipolar mode. The switches for selecting range are stand-alone, while the switches for selecting unipolar/bipolar are in a single DIP switch.

Coding of the DACs is in straight binary format. The lowest output voltage corresponds to zero code and the highest to 4095. In the bipolar ranges this means that zero code produces negative full scale and a code of 4095 produces positive full scale minus 1 LSB.

Table C-2 lists the DAC bipolar output modes; Table C-3 lists the DAC unipolar output modes.

Table C-2. DAC Bipolar Output Modes

DAC Input Code			Vout IN ±5.0 Mode (2.44 mV/CNT)	Vout IN ±10.0 Mode (4.88 mV/CNT)
Binary	Decimal	Analog Output[1]		
1111 1111 1111	4095	$-(Vin)\,(2047/2048)$	+4.998V	+9.995V
1000 0000 0001	2049	$-(Vin)\,(1/2048)$	+2.44mV	+4.88mV
1000 0000 0000	2048	0	0 V	0 V
0000 0000 0001	1	$+(Vin)\,(2047/2048)$	−4.99 V	−9.99 V
0000 0000 0000	0	$+(Vin)\,(2048/2048)$	−5.00V	−10.00V

Notes

[1] Vin = −5.0 volts for the ±5 volt range.
Vin = −10.0 volts for the ±10 volt range.
Vin = Any DC input voltage from −10 to +10 volts for the user input range.

Note: Bipolar mode should not be selected for AC attenuation for user input on DAC input.

For bipolar output, the general relationship for a given Vin is as follows:

$$Vout = Vin\,((2048 - Code) / 2048)$$

Table C-3. DAC Unipolar Output Modes

DAC Input Code			Vout IN ±5.0 Mode (2.44 mV/CNT)	Vout IN ±10.0 Mode (4.88 mV/CNT)
Binary	**Decimal**	**Analog Output[1]**		
1111 1111 1111	4095	−(Vin)*(4095/4096)	+4.999 V	+9.998 V
1000 0000 0000	2049	−(Vin)*(2048/4096)	+2.500 V	+5.000 mV
0000 0000 0001	1	−(Vin)*(1/4096)	+1.22 mV	+2.44 mV
0000 0000 0000	0	−(Vin)*(0/4096)	0.000 V	+0.00 V

Notes
[1] Vin = −5.0 volts for the +5 volt range.
Vin = −10.0 volts for the +10 volt range.
Vin = Any DC or AC input voltage from −10 to +10 volts for the user input range.

For unipolar output, the general relationship for a given Vin is:

$$Vout = (-Vin \times code) / 4096$$

Status Register A (Base Address +8h)

Status register A is read only and provides information on the operation and configuration of the DAS-1600/1400 Series board. Writing to the status register address clears the interrupt request.

Bit assignments of base address +8h are as follows:

7	6	5	4	3	2	1	0
EOC	U/B	MUX	INT	MA3	MA2	MA1	MA0

The bit names are defined and used as follows:

- **MA0 to MA3** = Current multiplexer address. This is the MUX address (channel number) of the next channel to be converted if EOC = 0. The channel address changes about 400 ns after EOC goes high. These status bits provide information on the setup for the next conversion.

- **INT** = Interrupt status. A 1 in this bit position indicates that an ADC conversion has taken place and an interrupt has been set. The state of this bit is not gated by the interrupt enable bit in the DAS-1600/1400 Series control register. A write of any value to the status register A location clears the interrupt bit.

- **MUX** = Single-ended or differential. The bit value is controlled by the position of the channel configuration (CHAN) switch (see "Setting the Chan 8/16 Switch" on page 3-8).

Table C-4 defines the logic states of the MUX bit.

Table C-4. Logic State of Status Register A; MUX (Bit 5)

Channel Selection	State
16-channel single-ended	logic 1
8-channel differential	logic 0

- **U/B** = Unipolar/bipolar. This bit can be useful in scaling routines. The U/B bit indicates whether the ADC input is operating in unipolar or bipolar mode (as set by UNI/BIP switch). See Figure 3-1 on page 3-7. Table C-4 defines the logic states of the U/B bit.

Table C-5. Logic State of Status Register A; UB (Bit 6)

Mode Selection	State
unipolar	logic 1
bipolar	logic 0

- **EOC** = End of conversion. If EOC = 1, the ADC is busy. EOC = 0 implies that the ADC is ready to perform the next conversion and the ADC data registers contain valid data from the previous conversion.

Control Register (Base Address +9h)

The control register is read/write and controls the DAS-1600/1400 Series operating modes. The control register is cleared on power-up (reset), thereby disabling DMA, interrupt, and external A/D start modes.

Bit assignments of base address +9h are as follows:

7	6	5	4	3	2	1	0
INTE	IL2	IL1	IL0	X	DMAE	S1	S0

The bit names are defined and used as follows:

- **S0 to S1** = Pacer clock source. These bits control the pacer clock source for the ADC. Table C-6 lists pacer clock sources selected by the states of S0 and S1.

Table C-6. Control Register: Pacer Clock Source Selection

S1	S0	Pacer Clock Source
0	X[1]	software start only
1	0	start on rising IP0/TRIG 0/XPCLK
1	1	start on falling counter/timer output

Notes
[1] X = data insensitive.

Note: Regardless of the state of the S0 and S1 bits, an A/D conversion can always be initiated by a write to register AD0.

- **DMAE** = Enable/Disable DMA. Direct memory access transfers are enabled when DMAE = 1 and disabled when DMAE = 0.

Note: You must set up the computer's DMA controller and page registers before enabling DMA on a DAS-1600/1400 Series board.

- **X** = This bit has no assigned function but can be written to and read from.

- **IL0 to IL2** = Interrupt level select. Selects the interrupt level for processing interrupts. Avoid using a level already assigned to another I/O device (for example, Level 6 is used by the floppy disk drive(s)). Table C-7 lists the interrupt levels selected by the states of IL0 through IL2.

Table C-7. Control Register:
Interrupt Level Selection Bits 4, 5, and 6

IL2	IL1	IL0	Interrupt Level
0	0	0	none (disabled)
0	0	1	none (disabled)
0	1	0	level 2
0	1	1	level 3
1	0	0	level 4
1	0	1	level 5
1	1	0	level 6
1	1	1	level 7

- **INTE** = Interrupt enable. This bit enables and disables the generation of interrupts. Interrupts are enabled when INTE = 1 and disabled when INTE = 0.

  If INTE = 1 and DMAE = 0, an interrupt is generated at the end of each A/D conversion when valid data is available. If INTE = 1 and DMAE = 1, an interrupt is generated when a Terminal Count (T/C) is received from the computer's DMA controller to signify completion of the DMA transfer.

Counter Enable/Burst Length Register
(Base Address +Ah)

This 8-bit read/write register controls the operation of the following:

- 82C54 counter/timer
- 100 kHz pacer clock
- Burst length counter

The counter enable register is set to 00h upon power-up (reset).

DAS-1600/1400 Series boards use an Intel 82C54 programmable interval counter/timer for pacing the ADC. Counters 1 and 2 of the 82C54 are cascaded and are driven by a 1 MHz or 10 MHz switch-configurable clock so that periods ranging from 10 microseconds to 0.12 pulses per hour for 10 MHz and 1.192 pulses per hour for 1 MHz can be programmed.

When programming the board for A/D conversions using the internal timer, bit 0 (CEN0) of this register and the IP0/TRIG 0/XPCLK input signal can be used to enable counters 1 and 2 of the 82C54, thereby initiating A/D conversions. To accomplish this, bits CEN0 and IP0 are NANDed and the output is routed to counter gates 1 and 2 of the 82C54.

The function of CEN1 is somewhat different. When CEN1 and CTR 0 CLOCK IN are both high, counter 0 input of the 82C54 is internally connected to a 100 kHz clock source.

The CTR 0 CLOCK IN, CTR 0 GATE, and CTR 0 OUT of counter 0 are all brought out to external connections, so that the counter can be used as a waveform generator, a secondary timer, or a period counter using the gate and internal clock.

By disabling the internal 100 kHz clock (by setting CEN1 = 0), external clock pulses can be connected to the CTR 0 CLOCK IN pin (21). In this mode, counter 0 functions as an event counter, or if the CTR 0 GATE input is connected to a timebase (for example, CTR 2 OUT), counter 0 can be used to determine frequency.

Bit assignments of base address +Ah are as follows:

7	6	5	4	3	2	1	0
BL3	BL2	BL1	BL0	X	X	CEN1	CEN0

The bit names are defined and used as follows:

- **CEN0 =** Counter/timer enable. In conjunction with the state of IP0/TRIG 0/XPCLK, this bit enables and disables counters 1 and 2 to provide a means of holding off trigger pulses from the counter/timer to the ADC until IP0 goes high. If CEN0 is low, IP0 has no control over the programmable interval timer.

  When CEN0 is logic 0, the counter/timers are enabled.

  When CEN0 is a logic 1 and IP0/TRIG 0/XPCLK is logic 0, the counter/timers are enabled.

  When CEN0 is a logic 1 and IP0/TRIG 0/XPCLK is logic 1, the counter/timers are disabled**.**

- **CEN1** = Counter 0 clock input control. If CEN1 = 0, then the external clock input, CTR 0 CLOCK IN, is enabled. If CEN1 = 1 then counter 0 is connected to the 100 kHz internal crystal clock.

  This is useful if counter 0 is used for pulse width measurement, delay generation, frequency synthesis, or a secondary timer.

- **X** = These bits have no assigned function but can be written to and read from.

- **BL0 to BL3** = Burst length. During burst mode acquisition, these bits determine the number of conversions that are performed for each trigger. These four bits have no function if Burst Mode is not enabled.

  A value of 0h written to these bits creates a burst length of 1; a value of Fh creates a burst length of 16.

Gain Selection/Burst Rate Register
(Base Address +Bh)

The gain selection/burst rate register is an 8-bit read/write register that selects the gain applied to the analog input channels and the burst rate during burst mode acquisition. Power-up (reset) sets this register to 00h.

Bit assignments of base address +Bh are as follows:

7	6	5	4	3	2	1	0
BR5	BR4	BR3	BR2	BR1	BR0	GN1	GN0

The bit names are defined and used as follows:

- **GN0 to GN1** = Gain code select bits. These are used to select the gain.

**Table C-8. Gain Selection/Burst Rate Register:
Gain Selection Bits 0 and 1**

GN1	GN0	DAS-1601/1401 Gain	DAS-1602/1402 Gain
0	0	1	1
0	1	10	2
1	0	100	4
1	1	500	8

- **BR0 to BR5** = Burst rate value. These bits determine the rate of conversions during a burst mode acquisition. They have no function if burst mode is not enabled. The burst rate is determined by the following equation:

$$\text{BURST RATE} = 1 \text{ MHz} / (4 \text{ x BURST RATE VALUE}) + 2$$

Burst mode allows DAS-1600/1400 Series boards to perform multiple conversions from a single clock pulse. The clock source can be any of the following:

- external counter/timer
- an external pacer clock
- software clock

To set up a burst mode acquisition, perform the following steps:

1. Enable the 1600/1400 mode by writing a value of 40h to the 1600/1400 mode enable register (base address +406h).

2. Write a value of 40h to the burst mode enable register (base address +405h).

3. Set up the *burst length*. The upper four bits of the counter enable register (base address +Ah) are programmable for 1 to 16 conversions per trigger.

   Because this register supports both counter enable and burst length functions, it should first be read and ORed with the masked, updated contents of either counter enable or burst length.

   A value of 0h written to the upper nibble of the counter enable/burst length register creates a burst length of 1; a value of Fh creates a burst length of 16. It is up to you to program the correct burst length value when used in combination with multiple channel conversions.

4. Program the *burst rate* (time between conversions). The upper six bits of the gain selection register (base address +Bh) is programmable for 100 kHz to 3.94 kHz (10 µs to 254 µs).

   Because this register contains both the gain select and burst rate functions, it should first be read ORed with the masked, updated contents of either gain selection or burst rate.

Note: It is suggested that you use a number not less than 2h for the burst rate value. Valid burst rate values are within 2h to 3Fh, inclusive.

Burst mode can be disabled by writing a value of 00h to either the burst mode enable register (base address +405h) or the 1600 mode enable register (base address +406h).

Note: To guarantee correct operation at high data rates, Burst Mode should be used only in conjunction with Demand Mode DMA.

Programmable Interval Counter/Timer (Base Addresses +Ch, +Dh, +Eh, +Fh)

The Intel 82C54 programmable interval counter/timer is a flexible device consisting of three, independent, 16-bit, presettable down counters and a control register. Figure H-1 shows the configuration of the 82C54.
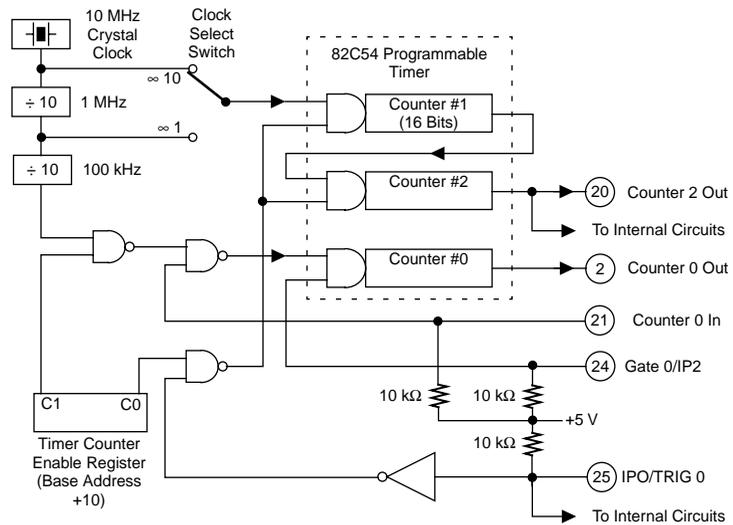
Figure H-1. Programmable Timer Configuration

Table C-9 maps counter/timer registers to their addresses.

Table C-9. Counter/Timer Address Map

Address	Register	Type
Base Address +Ch	Counter 0	Read/Write
Base Address +Dh	Counter 1	Read/Write
Base Address +Eh	Counter 2	Read/Write
Base Address +Fh	Counter control	Write Only

You can program each counter to divide by any integer in the range 2 to 65,535. Counters 1 and 2 are cascade-connected to form a 32-bit counter. The counter/timer clock source is a 10 MHz precision, crystal oscillator. Principal uses of the 82C54 are as follows:

● A programmable timer for generating interrupts and clocking for periodic A/D conversions.

● A variable-frequency square-wave generator for testing and frequency synthesis.

● An event counter of external input pulses.

● A time-delay generator.

In addition, the 82C54 allows you to set up frequency and pulse width measurements. If you are interested in detailed information, a full description of the 82C54 programmable interval counter/timer is available in the Intel data sheet (or equivalent manufacturer's literature).

The maximum clock input frequency on any counter is 10 MHz with minimum clock duty cycles of 30 ns high and 50 ns low. The usual function of these two counters is to provide programmable pulse rates to trigger the ADC.

Counter 0 is uncommitted and can be used as a secondary pulse-rate generator, a square-wave generator, a programmable monostable delay, or an event counter.

Counters 1 and 2 are initialized by the DAS-1600/1400 Series driver to operate in the rate generator configuration (mode 2) and output 1 kHz (10 kHz with 10 MHz clock) after running an initializing call from the call interface. However, six operating configurations for each counter are possible. The configurations are as follows:

- **Pulse On Terminal Count** - The output is initially low for this configuration. After the count loads and the counter decrements through zero, the output goes high and remains high until the counter is reloaded.

  The counter continues to decrement after passing through zero. Counting can be inhibited by a low gate input. This mode produces a single, positive-going output transition such as may be required in a time delay initiated by the program.

- **Programmable One-Shot** - The output goes low after a rising edge of the gate input and goes high when the counter passes through zero. The period that the output is low is set by the loaded count.

  If the gate input goes high again before the one-shot has timed out, a new timing cycle is initiated (the one-shot is retriggerable and, if a new count is loaded, it will not become effective until any cycle in progress has terminated). This provides a hardware triggered delay or one-shot.

- **Rate Generator (or Divide-By-N counter)** - The output goes low for one input clock period every N counts, where N is the count loaded. The gate input, when low, forces the output high which reloads the counter. Thus, the gate input can be used to synchronize the counter. This configuration is useful for generating periodic interrupts to trigger A/D conversions.

- **Square Wave Generator** - Similar to the rate generator except that the output is high for half of the count and low for the other half.

  If N is even, a symmetrical square wave output is obtained. If N is odd, the output is high for $(N+1)/2$ counts and low for $(N-1)/2$ counts (has a 1-count asymmetry). This configuration can be used in the same way as the rate generator for periodic triggering or for frequency synthesis.

- **Software Triggered Strobe** - After the mode is set, the output is high. When a count of N is loaded, the counter begins counting and the output goes low for one input clock period as it passes through zero.

The cycle is repeated on loading another count. The gate input may be used to inhibit counting.

● **Hardware Triggered Strobe** - This is essentially the same as the programmable one-shot, except that the output goes low for one clock period at the end of the cycle and returns high again. The start of the cycle is triggered by the rising edge of the gate input, and as in the programmable one-shot, it is retriggerable.

Generating Square Waves of Programmed Frequency

Both the counter 1 and 2 combination and counter 0 can be used to generate square waves of programmable frequency. With the CEN 1 bit of the counter enable register (+Ah) set high and counter 0 clock input open or high, counter 0 is internally connected to a 100 kHz clock signal.

Counter 0 can be operated as a square wave generator with a maximum divisor of 65,535. The lowest output frequency obtainable from counter 0 directly is about 1.5 Hz (100000 / 65535). The minimum divisor can be as low as 2 to obtain a maximum output frequency of 50 kHz.

The DAS-1600/1400 Series Function Call Driver always sets counters 1 and 2 to the rate generator configuration, but you can use BASIC OUT statements to alter their operating configuration to the square wave configuration. The frequency range obtainable is identical to that obtained in the rate generator configuration.

Counters 1 and 2 provide considerable flexibility in frequency range, a minimum division ratio of 4 (2 x 2) with a 10 MHz clock providing a 2.5 MHz output at one extreme, and a division ratio of 2^{32} (65,535 x 65,535) with a 1 MHz clock providing an output of about 1 pulse/hour at the other extreme.

In practice, to obtain a symmetrical square wave, the divisor loaded into the counter should be an even number. If it is an odd number, one half of the square wave is one input clock pulse period longer than the other half.

Calculating the divisor is straightforward. Assume you desire an output frequency of 1 kHz. The input frequency to the counter 0 is 100 kHz so you must divide this by 100 to obtain 1 kHz. Counter 0 should be set in the square wave generator configuration and loaded with 100. Counter 0 will then output a 1 kHz square wave.

Measuring Frequency and Period

It is possible to use the 82C54 to measure frequency by raising the gate input of counter 0 for some known interval of time, say 10, 100, or 1000 ms and counting the number of pulses clocked into the counter for that interval.

The gating signal can be derived from counters 1 and 2 operating in square-wave mode. Also, the computer has to be informed about the start and finish of the measurement cycle, so one of the DAS-1600/1400 digital inputs can be used to monitor the gate input to achieve this requirement.

Counter 0 can also be used to measure pulse width or half period of a periodic signal. The signal should be applied to the gate input of counter 0 and a known frequency applied to counter 0 clock input (100 kHz) from the internal crystal.

During the interval when the gate input is low, counter 0 is loaded with a full count (65,535). The gate input then goes high at the beginning of the measurement, and the counter decrements until the gate input goes low at the end of the pulse.

The counter is then read and the change in the count is the duration of the gate input signal. If counter 0 is fed with 10 microsecond duration clock pulses (100 kHz), the maximum pulse duration that can be measured is 65,535 x 10 = 655 milliseconds.

Longer pulse durations can be measured using counters 1 and 2 as an input clock source for counter 0. One of the digital inputs should also be connected to the gate of counter 0 to synchronize the loading and reading operations.

Using Counter 0 for Generating Programmable Time Delays

Another use for counter 0 is generating programmable time delays. Several one-shot modes can be used. The counter configurations have the following characteristics when used for time delay generation:

- **[Configuration 0: Pulse On Terminal Count]** - After loading the counter the output goes low. Counting is enabled when the gate input is high and continues until the count reaches zero when the output

goes high. The output remains high until the counter is reloaded by program command. Taking the gate input low during the count down disables counting as long as it is low.

- **[Configuration 1: Programmable One-Shot]** - The counter need only be loaded once. The timing delay is initiated by the gate input going high. At this point, the output goes low. If the gate input goes low, counting continues but a new cycle is initiated if the gate input goes high again before the time out delay has expired (is re-triggerable).

  At the end of the time out, as the counter reaches zero, the output goes high and remains high until re-triggered by the gate input. This is the programmable equivalent of a one-shot or monostable, hence the name.

- **[Configuration 4: Software-Triggered Strobe]** - This is similar to configuration 0, except that after loading, the output goes high and only goes low for one clock period on timing out. This produces a negative strobe pulse for a programmed duration after loading the counter.

- **[Configuration 5: Hardware-Triggered Strobe]** – This is similar to configuration 1 except that the time out is triggered by the gate input going high and the output is normally high, going low for one clock period on time-out and producing a negative going strobe pulse. Like configuration 1, the time out is retriggerable (a new cycle will commence if the gate input is taken high before a current cycle has timed out).

Counter 0 is good for directly producing delays up to 650 ms. If the output of counter 0 operated in configuration 0 is connected to IP0/XPCLK with counters 1 and 2 used as a programmable clock source for the A/D (CEN0=1, CEN1=1), then after loading counter 0 and taking the gate input high, a programmable delay occurs before the A/D receives a clock pulse. This is a way to hold off conversions for a period after receipt of an external trigger signal.

Before loading or reading any of the individual counters, the 82C54 control register must be loaded with data setting the counter operating configuration as above, the type of read or write operation that is performed (see following), and the modulus or binary (0 to 65,535) or BCD (Binary Coded Decimal 0 to 9,999). The format of the control byte is shown in the following section.

82C54 Counter/Timer Control Register (Base Address +Fh)

Bit assignments of base address +Fh are as follows:

7	6	5	4	3	2	1	0
SC1	SC0	RL1	RL0	M2	M1	M0	BCD

The bit names are defined and used as follows:

- **BCD** = The BCD bit (0) can be used to program the counter to count in binary (modulus 2) or binary coded decimal (modulus 10) modes.

  Binary mode, with a full count of 65,535, provides a greater count range than the BCD mode, which has a 9,999 full-scale range.

  16-bit binary is enabled when BCD = 0 and 4-decimal decades is enabled when BCD = 1.

- **M0 to M2** = These bits control the functionality of the counters as shown in Table C-10.

Table C-10. 82C54 Counter/Timer Control Register: Selecting Functionality

M2	M1	M0	Function
0	0	0	Pulse on terminal count
0	0	1	Programmable one-shot
X^1	1	0	Rate generator
X	1	1	Square wave generator
1	0	0	Software triggered strobe
1	0	1	Hardware triggered strobe

Notes
[1] X = data insensitive.

- **RL0 to RL1** = Control the type of read/load operations performed on counters, as shown in Table C-11.

**Table C-11. 82C54 Counter/Timer Control Register:
Bits 4 and 5**

RL1	RL0	Operation
0	0	Counter latch
0	1	Read/load least significant byte (LSB)
1	0	Read/load most significant byte (MSB)
1	1	Read/load least significant byte (LSB), followed by most significant byte (MSB)

To minimize I/O port usage, the 16-bit counters of the 82C54 can be loaded or read by successive 8-bit writes or reads to the same I/O address if the RL0 and RL1 bits of the 82C54 counter/timer control register are both set high.

In the IBM PC 80X86 architecture, setting RL0 and RL1 both high is usually the most convenient setting. Data is written in least significant/most significant order and the 82C54 uses an internal flip-flop to keep track of the byte order. It is important not to get this flip-flop out of step when programming in this way (make sure your read/load instructions are in pairs).

If you are programming an IBM PC AT in assembly language, make sure that you put delays (short jumps) between back-to-back I/O instructions for correct operation. This precaution is based on the design of the IBM PC AT (see the IBM PC AT Technical Reference Manual) and does not apply to the 8088-based PC and 8086-based PC XT.

If you attempt to read the counters "on the fly" at a high input frequency, you will probably obtain erroneous data. This error is due partly to the rippling of the counter during the read operation and partly to the fact that the low and high bytes are read sequentially rather than simultaneously, making it highly probable that carries are propagated from the low to high byte during the read cycle.

To circumvent these problems, you can perform a *counter latch operation* in advance of the read cycle. You can latch the counter by loading the RL0 and RL1 bits of the control register with 0s, which instantaneously latches the count of the selected counter in a 16-bit hold register.

An alternative method of counter latching (which has an advantage of operating simultaneously on several counters) is to use the *Readback Command*.

A subsequent read operation on the selected counter returns the held value. Counter latching is the only way of correctly reading a counter "on the fly" without disturbing the counting process. If you do not specify a counter-latching operation, the counter itself is read. You can rely only on directly read counter data if the counting operation is suspended while reading (by removing the clock input or taking the counter gate low).

For each counter, you are required to specify in advance the type of read or load operation that you intend to perform. You have a choice of loading/reading the high or the low byte of the count, or the low byte followed by the high byte.

This last mode is most generally used and is selected for each counter by setting the RL1 and RL0 bits to 1s. Subsequent read/load operations must be performed in pairs in this sequence, otherwise the internal sequencing flip-flop of the 82C54 gets out of step.

- **SC0 and SC1** = These bits control counter selection, as shown in Table C-12.

Table C-12. 82C54 Counter/Timer Control Register: Readback Command

SC1	SC0	Counter
0	0	0
0	1	1
1	0	2
1	1	Readback Command

If the SC0 and SC1 bits are both set to 1, you can perform two types of operations. When CNT = 0 (see below), counters selected by C0 through C2 are latched simultaneously. When STA = 0, the counter status byte is read on accessing the counter I/O location. The status byte provides information on the current output state of the counter and its operating configuration.

Readback Command Byte (Returned when SC1 and SC0 are 1)

The format of the readback command byte is as follows:

7	6	5	4	3	2	1	0
SC1	SC0	CNT	STA	C2	C1	C0	0

The bit names are defined and used as follows:

- **C0 to C2** = Select the counters that are affected by CNT and STA. Table C-13 lists the bit conditions that select each counter.

Table C-13. Counter Status Byte Selection: Bits 0, 1, and 2

C2	C1	C0[1]	Selects
X	X	1	Counter 0
X	1	X	Counter 1
1	X	X	Counter 2

Notes
[1] X = data insensitive.

- **STA** = When set to 0, STA returns the Status Byte of the counter selected by C0 to C2.

- **CNT** = When set to 0, CNT latches the counter selected by C0 to C2. See Table C-13 for counter selected by C0 to C2.

- **SC0 and SC1** = The readback command occurs when SC1 and SC0 are both set to 1.

Status Byte Format (Returned if STA =0)

The format of the status byte is as follows:

7	6	5	4	3	2	1	0
OUT	NC	RL1	RL0	M2	M1	M0	BCD

With the exception of bits 6 and 7, the definitions are the same as those defined at the beginning of this section. Bits 6 and 7 are defined and used as follows:

- **NC** = Null count; indicates when the last count loaded into the counter register has actually been loaded into the counter itself. The exact time of load depends on the selected configuration. Until the count is loaded into the counter itself, it cannot be read from the counter.

- **OUT** = Current state of counter output.

Bidirectional Digital Ports A, B, CL, and CH 8255A-5 (Base Address +400h to +403h)

The DAS-1600 Series includes an 8255A-5 Programmable Peripheral Interface (PPI) that provides 24 bidirectional lines of parallel digital I/O.

The PPI interface features three TTL/CMOS-compatible, digital I/O ports: PA, PB, and PC. PA and PB are both byte wide (8-bit) and can be used as inputs or outputs. PC is also byte wide but is adaptable for use as two separate 4-bit ports: PC Lower and PC Upper, each of which can be used as an input or output.

The PPI interface communicates with the PC bus as an 8-bit peripheral. The address map uses four consecutive I/O addresses at base address +400h through +403h (Table C-14).

Table C-14. PPI Register Address Map

Base Address	Function	Type
+400h	PA port	Read/Write
+401h	PB port	Read/Write
+402h	PC port	Read/Write
+403h	control	Write Only

The 37-pin D connector of this digital interface is pin-compatible with other Keithley MetraByte products such as the PIO-12 and PIO-24 and can be used with all the accessories of these products. +5V power is available at the 37-pin D connector from the PC supply.

Applications for this programmable I/O (PIO) digital interface include all parallel digital I/O activities such as communicating with peripherals, operating relays, and reading switch inputs.

Each port or half port is software configurable as an input or an output according to the contents of a write-only control register. Thus, the PA, PB, and PC ports can be read from or written to.

In addition, configurations for unidirectional and bidirectional strobed I/O are possible when the PC ports are used for control of data transfer. For a complete description of the PPI operating modes, refer to the Intel 8255A-5 data sheet.

Port descriptions are as follows:

- Port A - Consists of one 8-bit data output latch/buffer and one 8-bit data input latch.

- Port B - Consists of one 8-bit data output latch/buffer and one 8-bit data input buffer.

- Port C - Consists of one 8-bit data output latch/buffer and one 8-bit data input buffer. This port can be divided into two 4-bit ports.

Control Register (Base Address +403h)

Bit assignments of the control register at base address +403h are as follows:

7	6	5	4	3	2	1	0
D7	PA/PCH1	PA/PCH0	PA	PCH	PB/PCL	PB	PCL

The bit names are defined and used as follows:

- **PCL** = Selects the transfer direction of port CL (lower nibble of port C). When you set the bit to logic 1, the port is an input. When the bit is set to 0, the port is an output.

- **PB** = Selects the transfer direction of port B. When you set the bit to logic 1, the port is an input. When the bit is set to 0, the port is an output.

- **PB/PCL** = Selects operating mode for PB and PCL (lower nibble of port C). When you set the bit to logic 1, mode 1 is selected. When the bit is set to 0, mode 0 is selected. See Table C-15 for definitions of operating mode selected.

- **PCH** = Selects the transfer direction of port CH (upper nibble of port C). When you set the bit to logic 1, the port is an input. When the bit is set to 0, the port is an output.

- **PA** = Selects the transfer direction of port A. When you set the bit to logic 1, the port is an input. When the bit is set to 0, the port is an output.

- **PA/PCH0 - PA/PCH1** = Selects operating mode for PA and PCH (upper nibble of port C). See Table C-15 for definitions of operating mode selected.

Table C-15. Mode Selection for Ports A and CH

PA/PCH1	PA/PCH0	Mode Selected	Operation
0	0	mode 0	Basic I/O; all ports are I/O ports.
0	1	mode 1	Strobed I/O; part of Port C controls data transfer.
1	0	mode 2	Bidirectional I/O on Port A only; part of Port C controls data transfer.
1	1	mode 2	Bidirectional I/O on Port A only; part of Port C controls data transfer.

- **D7** = 0 selects bit set/reset mode. 1 selects mode set active. Note that D7 must be high (1) to set the port configurations.

To simplify your selection of a control word to match your choice of port directions, use the following table. Table C-16 summarizes information from the Intel Peripheral Data book on control words and their port directions for mode 0.

Table C-16. PIO Control Word

CONTROL WORD	PORT A	PORT B	PORT C Lower 0-3	PORT C Upper 4-7
80h	out	out	out	out
81h	out	out	in	out
82h	out	in	out	out
83h	out	in	in	out
88h	out	out	out	in
89h	out	out	in	in
8Ah	out	in	out	in
8Bh	out	in	in	in
90h	in	out	out	out

Register-Level Address Map

Table C-16. PIO Control Word (cont.)

CONTROL WORD	PORT A	PORT B	PORT C Lower 0-3	PORT C Upper 4-7
91h	in	out	in	out
92h	in	in	out	out
93h	in	in	in	out
98h	in	out	out	in
99h	in	out	in	in
9Ah	in	in	out	in
9Bh	in	in	in	in

Conversion Disable Register (Base Address +404h)

This register enables/disables conversions. Conversions can be disabled with this register only if the 1600/1400 mode enable register (+406h) is enabled first.

The conversion disable register disables conversions to allow software to perform setup procedures without losing synchronization of the MUX scan counter, DMA controller, etc. from unwanted trigger events. This register resets during power-up (reset) (conversions enabled) and is write only.

Writing a value of 40h to this register disables conversions (sets this register). Writing a value of 00h to this register enables conversions (resets this register).

A write of 40h to the conversion disable register (base address +404h) allows the DAS-1600/1400 Series to ignore all conversion clock sources and disable further conversions (valuable during initialization and setup). A write of 00h to the conversion disable register re-enables conversions.

At the end of a single cycle DMA (with the 1600 mode enabled) and when the DAS-1600/1400 Series receives the terminal count signal from the computer's DMA controller, the conversion disable register becomes set (1), preventing further conversions and DMA transfers. To allow

conversions to take place again, you must reset this register by writing a value of 00h to base address +404h.

To use these registers effectively, set both the 1600 mode enable and the conversion disable registers upon initial setup; this will disable all conversions. Before data is to be acquired, reset the conversion disable register and collect data. At the end of data acquisition, set the conversion disable register to disable conversions. This process insures a clean software interface.

Burst Mode Enable Register (Base Address +405h)

This register enables/disables burst mode acquisition; it is reset (burst mode disabled) during power-up (reset). Burst mode can be enabled only if 1600/1400 mode is enabled first. This register is write only.

Writing a value of 40h to this register enables the burst mode. Writing a value of 00h to this register disables the burst mode.

1600/1400 Mode Enable Register (Base Address +406h)

This register enables/disables the 1600 mode and is reset during power-up (reset) (1600 mode disabled); that is, a DAS-1600/1400 Series board looks just like a DAS-16Gx board on power-up.

This register is write only. Writing a value of 40h to this register enables the 1600 mode. Writing a value of 00h to this register disables the 1600 mode.

This register allows the following functions:

- disabling of conversions during initialization and setup
- the cessation of conversions at the end of single cycle DMA

Status Register B (Base Address +407h)

This register allows the user to observe the status of the following signals:

- 1 MHz/10 MHz clock select switch

- wait state enable switch

- 1600/1400 mode enable setting

- conversion disable setting

- burst mode enable setting

This register is read only and is set to a value of 0001 00XX (binary) upon power-up reset, where XX can be 1s or 0s, depending on the setting of the wait state and clock select switches.

Bit assignments of base address +407h are as follows:

7	6	5	4	3	2	1	0
0	BMDE	AMDE	DARM	0	0	WSEN	CLKSL

The bit names are defined and used as follows:

- **CLKSL** = 0 indicates the 1 MHz clock is selected and 1 indicates the 10 MHz clock is selected.

- **WSEN** = 0 indicates that wait states are not selected and 1 indicates that wait states are selected.

- **DARM** = 0 indicates that the conversion disable register is set; conversions disabled. 1 indicates that the conversion disable register is reset; conversions allowed.

- **AMDE** = 0 indicates that the 1600/1400 mode enable register is reset; conversions cannot be disabled and burst mode cannot be enabled. 1 indicates that the 1600/1400 mode enable register is set; conversions can be disabled and burst mode can be enabled.

- **BMDE** = 0 indicates that the burst mode enable register is reset; burst mode is disabled. 1 indicates that the burst mode enable register is set; burst mode is enabled.

D

CE Mark Information

Note: Products that contain the CE Mark are certified to meet European EMC directive 89/336 EEC. If this directive is not of importance to your application, please disregard the information in this appendix.

Keithley MetraByte certifies that this product has been tested and found to be in compliance with the EMC directive and relevant harmonized standards. This appendix describes the limitation of certification, the declaration of conformity, and the cabling required for the CE Mark configuration.

Limitation of Certification

This certification applies only to the operation of the product (with specified cables and accessories) in the stated configuration and under the stated operational and environmental specifications. Any modification, misuse, or improper or inadequate maintenance of the product by the user voids this certification.

Any deviation from the specific configuration may cause emissions or susceptibility not within the allowed limits required by the stated directive. It is the user's responsibility to demonstrate and maintain compliance with the directive and standards.

Please read the next section for the specific testing configuration for this product. Consult the Keithley Instruments GMBH office (European importer) or Technical Support in Cleveland, OH, USA, for further information regarding the exact configuration details and testing.

Declaration of Conformity

Application of Council Directive(s)	89/336/EEC
Standard(s) to which Conformity is Declared	EN50081-1, EN50082-1
Manufacturer's Name	Keithley MetraByte
Importer's Name	Keithley Instruments GMBH
Importer's Address	Landsberger Str.65 D-82110 Germering, Munich
Type of Equipment	Data Acquisition Plug-in Boards
Model Numbers	DAS-1600/1400 Series board with STA-16 or STA-U and S-1800 (refer to Chapter 4 for connections).
Year of Manufacture	1996

I, the undersigned, hereby declare that the equipment specified above conforms to the above Directive(s) and Standard(s).

Place: Taunton, MA USA

(Signature)

Date: 01 January 1996

Mark Urban
(Name)

Quality Assurance Manager
(Position)

Index

Numerics

A

A (continued)

B

C

C (continued)

D (continued)

digital
    external trigger 2-8
    I/O register C-5
    input 2-10
    output 2-10
digital-to-analog converter 2-10
DMA 2-6
    channel 2-10, A-3
        setting 3-10
    single cycle 2-10, C-31
    transfers 2-9, C-31
DMA mode 2-9
documentation
    for DriverLINX installation 3-4
    installing in DriverLINX 3-5
DriverLINX
    analog I/O panel
        description 1-3
        using 5-1
    API DLLs
        description 1-3
    browser map 3-5
    calibration utility 6-2
    CD ROM installation 3-4
    computer resource requirements 1-1
    configuration 3-5
    description 1-3
    event viewer 7-1
    preparation for installation 3-3
    selecting components to install 3-4
    test panel procedure 5-2
    using to verify board operation 3-13
drivers
    for DriverLINX installation 3-4

E

emf, thermal 4-29
ERB-24 1-6
event
    counter C-13
    external 2-8
event viewer
    in DriverLINX 7-1
EXP-16 1-5, 2-3
    terminal names 4-10
EXP-16/A 1-5, 2-3
EXP-1600 1-6
EXP-GP 2-3
    terminal names 4-11
external trigger C-5

F

factory calibration note 3-2
falling edge 2-9
filtering 4-29
frequency
    burst mode 2-6
    determining C-13
    measuring C-21
functional description 2-1

G

gain
    bipolar ranges 2-5
    precautions 4-28
    programmable 2-5
    selection 2-5, C-15
    settling time A-1
    unipolar ranges 2-5
gate 2-12, C-5
gating the counter/timer 2-12

R (continiued)

reference voltage
    precision 2-10
    setting 3-8
register
    1600/1400 mode enable C-32
    82C54 control C-23
    ADC C-3
    burst mode enable C-32
    control C-11
    conversion disable C-31
    counter enable/burst length C-13
    DAC output C-6
    digital I/O C-5
    gain selection/burst rate C-15
    MUX scan C-4
    PIO control C-29
    status A C-9
    status B C-33
register level programming C-1
resistors, bias return 4-26
resolution A-1
rising edge 2-8

S

sample rate 2-6
schematic, 82C54 configuration C-17
screw terminal accessories 1-5
setting
    82C54 clock 3-9
    ADC bipolar/unipolar 3-8
    base address 3-9
    bipolar/unipolar 3-8
    DAC reference voltage 3-8
    DMA channel 3-10
    wait state 3-9
setting up burst mode C-16
settling time A-1

signal
    bipolar 2-3
    conditioning 1-5, 2-3
    high-level 2-3
    low-level 2-3
    representation 2-3
    unipolar 2-3
simultaneous sample-and-hold accessory 1-5
single mode 2-9
single-ended input 2-2, 2-3
    attaching 4-24
    selecting 2-3
software
    installation procedure 3-3
    used with DAS-1600 and DAS-1400 1-3
specifications
    82C54 counter/timer A-6
    analog input A-1
    analog output A-4
    digital I/O A-5
        auxiliary A-5
    power A-6
SSH
    mode 2-6
SSH-4/A 1-5
SSH-8 1-5
SSIO-24 1-6
SST signal generator
    in analog I/O panel 5-1
STA-16 1-5, 2-4, 4-2
    terminal names 4-7
STA-MB 1-5, 4-20, 4-22
STA-SCM16 1-5, 4-21
status register A C-9
STA-U 1-5, 4-2
    terminal names 4-8
STC-37 1-5, 4-2
STP-37 1-5, 4-2
switches
    setting prior to installation 3-4
synchronous mode 2-9

T

terminal names
    EXP-16 4-10
    EXP-GP 4-11
    STA-16 4-7
    STA-U 4-8
test panel
    procedure 5-2
Test Point
    function libraries for programming in 1-3
test points 6-1
thermal emf 4-29
throughput 2-5, A-1
timebase 2-7
timing, paced and burst mode 2-6
trigger
    channel 2-8
    edge sensitive 2-8
    external C-5
    external analog 2-8
    external digital 2-8, 2-11
    inhibiting 2-12
    internal 2-8
    level sensitive 2-9
    negative-edge 2-9
    positive-edge 2-8
    sources 2-8
    types 2-8
troubleshooting procedures 7-1

Turbo Paxcal
    function libraries for programming in 1-3

U

unipolar 2-3
universal screw terminal 1-5
utility
    calibration 6-1

V

Visual Basic
    function libraries for programming in 1-3
volt meter
    in analog I/O panel 5-1
voltage output
    using analog I/O panel 5-1
voltages, common-mode 4-26

W

wait state
    selecting 2-12
    setting 3-9
wrapper, anti-static 3-1

Specifications are subject to change without notice.

All Keithley trademarks and trade names are the property of Keithley Instruments, Inc. All other trademarks and trade names are the property of their respective companies.

KEITHLEY