

KEITHLEY

DAS-1200 Series

User's Guide

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DAS-1200 Series User's Guide

Revision C - November 1999
Part Number: 80930

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

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

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

The types of product users are:

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

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

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

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

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

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

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

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

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

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

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

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



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


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


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

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

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

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

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

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

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

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

Instrumentation and accessories shall not be connected to humans.

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

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

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

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Preface

This guide is for persons needing to understand the installation, interface requirements, functions, and operation of the DAS-1201 and DAS-1202 boards. This manual uses the term DAS-1200 Series boards to refer to both boards.

To follow the information and instructions contained in this manual, you must be familiar with the operation of an IBM PC or compatible in the Windows 95/98 or Windows NT environment. You must also be familiar with data acquisition principles and their applications.

Manual Organization

Table 1 lists the topics that this guide focuses on and indicates where you can find information about a topic.

Table 1. Finding Information

To learn more about:	See:
The capabilities of DAS-1200 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-1200 Series boards	Chapter 2
Setting up DAS-1200 Series board switch-configurable options	Chapter 3
Installing DriverLINX software	Chapter 3
Installing the DAS-1200 Series boards	Chapter 3
Configuring the DAS-1200 Series board using DriverLINX	Chapter 3
Attaching accessories	Chapter 4
Precautions to observe when connecting signals	Chapter 4
Using the DriverLINX Control Panel for test and data acquisition	Chapter 5
Calibrating the board	Chapter 6
Troubleshooting and obtaining technical support	Chapter 7
DAS-1200 Series specifications	Appendix A
I/O connector pin assignments	Appendix B
The register-level I/O map	Appendix C

Related Documents

You can find more information on DAS-1200 Series software and accessories in the related documents listed in Table 2.

Table 2. Related Documents

Document
DriverLINX Installation and Configuration Guide
DriverLINX Appendix F: Configuration and Implementation. Notes for Keithley DAS-16/1600 (<i>this manual also includes DAS-1200 Series boards</i>).
DriverLINX Analog I/O Programming Guide
DriverLINX Digital I/O Programming Guide
DriverLINX Counter/Timer Programming Guide
EXP-16 & EXP-16A 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

Overview

The DAS-1200 Series is a family of high-performance analog and digital I/O boards with DriverLINX software that requires:

- an IBM PC or compatible AT (386 or Pentium CPU) with minimum of 2 MB of memory
- at least one floppy disk drive and one fixed disk drive
- Microsoft Windows 95/98, or Windows NT 4.0 or higher
- a compiler supporting Microsoft Windows development
- a mouse is highly recommended.

This section describes the features of the DAS-1200 Series boards, the software that supports them, and available accessories.

Features

The DAS-1200 Series features are as follows:

- Boards are switch-configurable for 16 single-ended or eight differential analog input channels.
- Analog inputs are bipolar with a maximum range of ± 5 V.
- The gain applied to analog input channels is switch-configurable. The DAS-1201 has switch-configurable gains of 1, 10, 100, and 500. The DAS-1202 has switch-configurable gains of 1, 2, 4, and 8.

- Analog inputs are sampled with 12-bit resolution at a maximum of 50 ksamples/s for the DAS-1201 and 100 ksamples/s for the DAS-1202.
- 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 can be started through any of the following methods:
 - software command
 - onboard pacer clock
 - external pacer clock
- External Simultaneous Sample-and-Hold (SSH) hardware is supported.
- Data transfers can be performed 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 DAS-1200 Series boards provide a total of 32 bits of digital I/O. Four unidirectional digital inputs and four unidirectional digital outputs are provided on the main I/O connector; 24 bits of bidirectional digital I/O are provided on the PIO cable connector (J4). These 24 bits are configured as two 8-bit ports and two 4-bit ports that can be set independently for input or output.

The 24-bits of bidirectional digital I/O are compatible with the Keithley PIO-12 board. You can use these ports to gate the counter/timer, control multiplexers, and read the status of external devices.

- The boards are backward compatible with the DAS-16 and DAS-16F boards. Programs for the DAS-16 and DAS-16F run on the DAS-1200 Series without modification.

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

Supporting Software

This section describes how to install the DAS-1200 Series standard software package and supporting software packages. The contents of these software packages are described as follows:

- **DAS-1200 Series standard software package** — Shipped with DAS-1200 Series boards. Includes DriverLINX for Microsoft Windows 95/98 or Windows NT and function libraries for writing application programs under Windows in a high-level language such as Microsoft Visual C++, Microsoft Visual Basic, Borland Delphi support files, LabVIEW, 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-1200 Series hardware.

- *Analog I/O Panel* — A DriverLINX program that verifies the installation and configuration of DriverLINX to your DAS-1200 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-1200 Series.
- *DriverLINX On-line Help System* — provides immediate help as you operate DriverLINX.
- *LabVIEW* — support for 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-1200 Series hardware.
- **DAS-1200 Series utilities** — The following utilities are provided as part of the DAS-1200 Series standard software package:
 - *Analog I/O Utility* — DriverLINX utility used for data acquisition and testing board operation.
 - *Test Utility* — DriverLINX utility used for testing board operation.
 - *Calibration Utility* — DriverLINX utility used for calibration.

Accessories

The following accessories are available for use with the DAS-1200 Series boards.

- **STA-16** — Screw terminal adapter accessory. You can use this accessory to connect signals from the main I/O connector (J1) to screw terminals.
- **STA-U** — Universal screw terminal accessory. You can use this accessory to connect interface signals from the PIO cable connector (J4) to screw terminals.
- **STC-37** — Direct DAS-1200 Series board to screw terminal interface.
- **STP-37** — Screw terminal panel with a 37-pin D-type connector.
- **ISO-4** — 4-channel isolated expansion multiplexer.
- **SSH-4/A** — 4-channel simultaneous sample-and-hold accessory.
- **SSH-8** — 8-channel simultaneous sample-and-hold accessory.
- **MB Series modules and backplanes** — Plug-in, isolated, signal-conditioning modules and the backplanes that hold them.
- **EXP-16 and EXP-16/A** — 16-channel expansion multiplexer and signal conditioning accessory; requires the S-1600 cable and the PG-408A option.
- **EXP-GP** — 8-channel signal conditioning accessory with Wheatstone bridge and RTD interface; requires the S-1600 cable.

2

Functional Description

This section describes the following features of DAS-1200 Series boards:

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

Together with the DAS-1200 Series block diagram shown in Figure 2-1, these descriptions are offered to familiarize you with the operating options and to enable you to make the best use of your board.

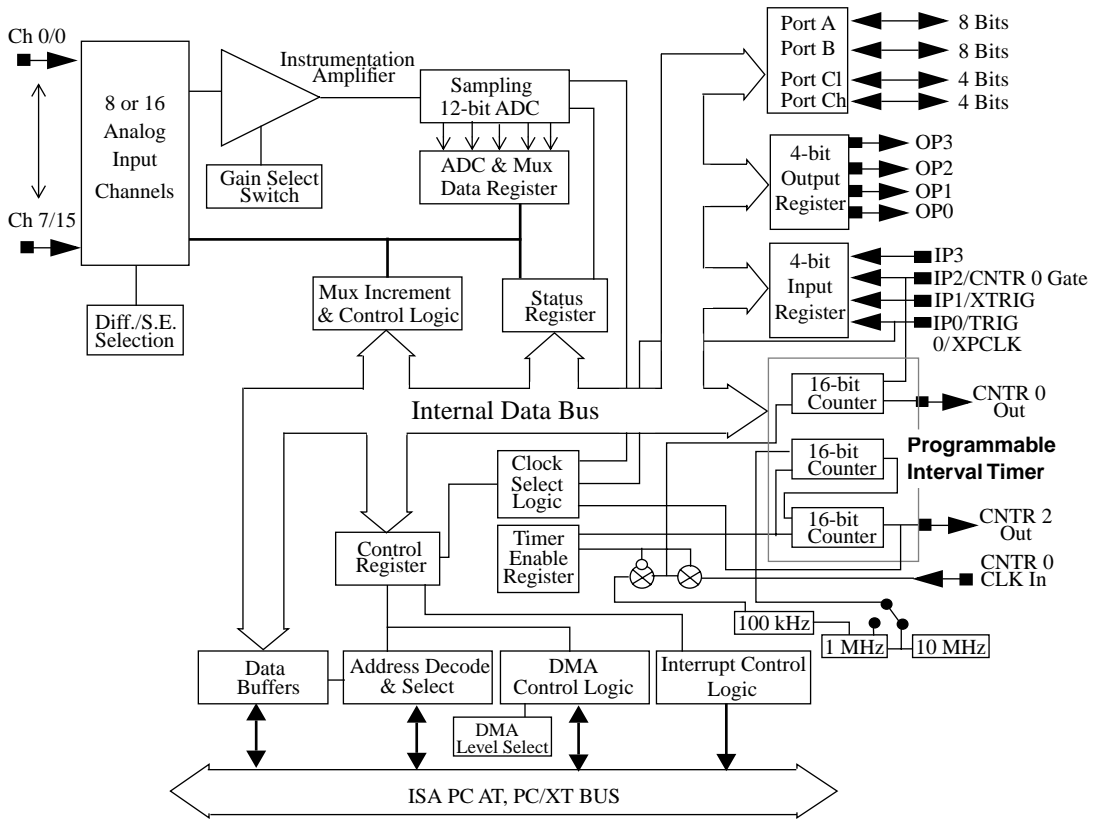


Figure 2-1. Functional Block Diagram

Analog Input Features

The analog input section of a DAS-1200 Series board multiplexes all the active input channels (up to 16 single-ended or eight differential) down to a single, 12-bit sampling analog-to-digital converter (ADC).

DAS-1200 Series boards operate in bipolar input mode only. Bipolar signals can swing up and down between negative and positive peak values. The DAS-1200 Series boards have a maximum range of -5 V to +5 V and use left-justified, offset binary to represent signals.

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 sections.

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 non-ground 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 is dependent upon the application. However, you generally use differential inputs for voltage ranges of 100 mV and less.

Channel Selection in Expanded Configurations

As previously mentioned, the DAS-1200 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 use any combination of up to eight 16-channel EXP-16 or EXP-16/A expansion accessories, and/or eight 8-channel EXP-GP expansion accessories to increase the number of available channels to 128.

When you daisy-chain expansion accessories from the analog inputs, it is recommended that the first expansion accessory multiplex onboard use channel 0, the next expansion accessory multiplex channel 1, and so on. Selection of an onboard channel is made via jumper settings on the expansion accessory.

You can access any unused onboard channels by including an STA-16 screw terminal accessory in the daisy-chain configuration. Figure 2-2 illustrates how expansion boards and accessories interface with the analog channels of DAS-1200 Series boards.

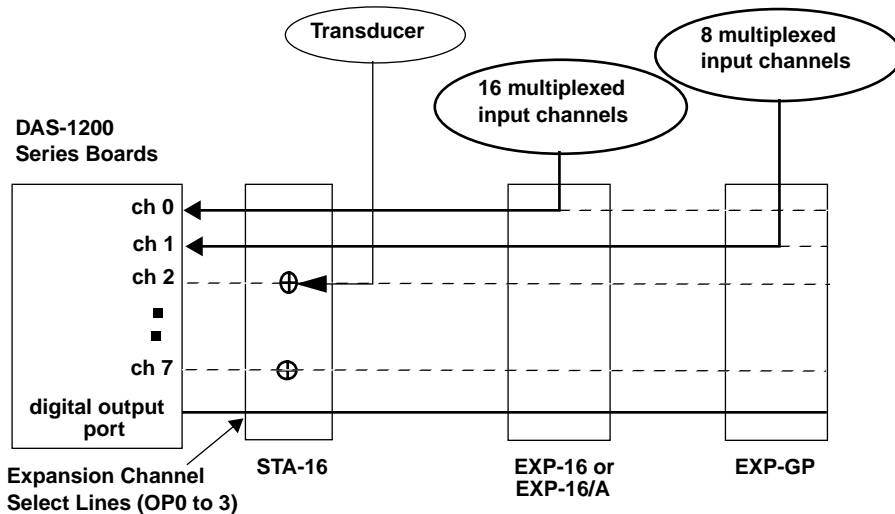


Figure 2-2. Expanding the Analog Inputs of DAS-1200 Series Boards

You can also use up to four MB02 backplanes to increase the number of available channels to 64 isolated or 12 non-isolated. For more information about connecting channel expansion boards, refer to Section 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, or EXP-GP expansion accessories or MB Series backplanes, the digital output lines of the DAS-1200 Series board select a particular channel on the expansion accessory or backplane to read.

Gain Selection

The switch-configurable gain that 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 ± 5 V range and you want to measure a signal in the range of ± 0.5 V, you would use a gain of 10 to amplify the signal to the ± 5 V range. Similarly, if you wanted to measure a signal that was already in the ± 5 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-1201 and Table 2-2 for the DAS-1202.

Table 2-1. DAS-1201 Gains, Ranges, and Throughput Rates

Gain	Input Range	Maximum Throughput Rate
1	± 5.0 V	50 ksamples/s
10	± 0.5 V	50 ksamples/s
100	± 50 mV	50 ksamples/s
500	± 10 mV	10 ksamples/s

Table 2-2. DAS-1202 Gains, Ranges, and Throughput Rates

Gain	Input Range	Maximum Throughput Rate
1	± 5.0 V	100 ksamples/s
2	± 2.5 V	100 ksamples/s
4	± 1.25 V	100 ksamples/s
8	± 0.625 V	100 ksamples/s

Conversion Modes

DAS-1200 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 being sampled.
- **Burst mode** — In burst mode, each pulse from the pacer clock begins a scan of one to sixteen 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-1200 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.

Burst mode can also be used for pseudo-simultaneous sample-and-hold in conjunction with DMA or interrupt 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.

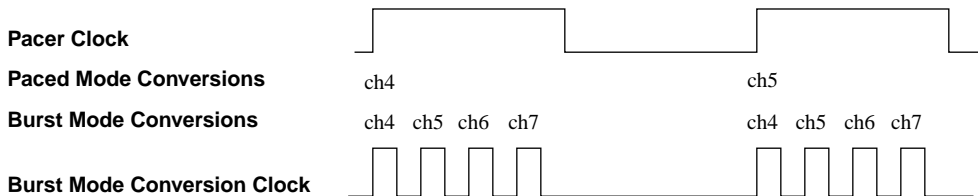


Figure 2-3. Timing Relationships of Conversion Modes

Clock Sources

The following clock sources are available for conversions on DAS-1200 Series boards:

- **Software** — DAS-1200 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 (for the DAS-1202) or 50 ksamples/s (for the DAS-1201).

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, 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 on the DAS-1202 acquires samples at a maximum of 100 ksamples/s (one sample every 10.0 μ s); the ADC on the DAS-1201 acquires samples at a maximum of 50 ksamples/s (one sample every 20.0 μ s). If you are using an external clock, make sure that 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 (for the DAS-1202) or 50 ksamples/s divided by the number of channels (for the DAS-1201).

Triggers

A trigger starts an analog input operation. The polarity of external triggers in the DAS-1200 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-1200 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 Appendix F: Configuration and Implementation. Notes for Keithley DAS-16/1600* (this manual also includes DAS-1200 Series boards).
- **External Digital** — While a digital trigger is not a hardware feature of the DAS-1200 Series boards, you can program a digital trigger using one of the digital input channels as the trigger channel. DriverLINX provides functions for an analog trigger; refer to the *DriverLINX Appendix F: Configuration and Implementation. Notes for Keithley DAS-16/1600* (this manual also includes DAS-1200 Series boards).

Connect the digital trigger to the digital input IP1/XTRIG pin (6) of the main I/O connector (J1). 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.
- *Negative-level trigger* - Conversions begin when the signal is below a negative level.

Data Transfer Modes

You can transfer data from the DAS-1200 Series boards to the computer using the following data transfer modes:

- **Single mode** — In 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 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-1200 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.

Generally, if you are programming an operation in the Windows Enhanced Mode, you should use DMA to acquire data reliably at maximum board speeds.

Digital I/O Features

DAS-1200 Series boards contain 32 bits of digital I/O.

Four unidirectional digital inputs (IP0 to IP3) and four unidirectional digital outputs (OP0 to OP3) are accessible through the main I/O connector (J1).

24 bits of bidirectional digital I/O are available on the PIO cable connector (J4). These 24 bits are configured as two 8-bit ports (A and B) and two 4-bit ports (CL and CH) that you can set independently for input or output.

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-2 on page A-3 for logic levels). The digital inputs are compatible with TTL-level signals. These inputs are provided with 10 k Ω pull-up resistors to +5 V; therefore, the inputs appear high (logic 1) with no signal connected.

You can use the digital inputs and outputs for any general-purpose task 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 and write a single value from and to a DAS-1200 Series board using synchronous mode or single mode. You can read and write multiple values from and to a DAS-1200 Series board using synchronous mode or interrupt mode.

Counter/Timer Features

The DAS-1200 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 the Function Call Driver.

Note: Attempts to combine register-level programming of counter/timer functions with Function Call Driver programming can produce unexpected results because the Function Call Driver relies on structures it sets up.

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-1200 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 also maintains backward compatibility with DAS-16 and DAS-16F Series boards that may be used in early generation machines.

Power

+5 V power is available from the main I/O connector (J1). The +5 V supply is brought out from your host computer.

Setup and Installation

This section describes inspection, software installation, configuration, and hardware installation for DAS-1200 Series boards.

Read this chapter and all related DriverLINX documentation before you attempt to install and use your DAS-1200 Series board.

Inspecting Your Package

Caution: A discharge of static electricity from your hands can seriously damage certain electrical components on any circuit board. Before handling any board, discharge static electricity from yourself by touching a grounded conductor such as your computer chassis (your computer must be turned off). Whenever you handle a board, hold it by the edges and avoid touching any board components, cable connectors, or gold-plated edge connectors.

Use the following procedure to unwrap and inspect a DAS-1200 Series board:

1. Factory packaging of the DAS-1200 Series board includes a final wrap of protective, anti-static material. Remove the board from its anti-static wrapping material. You may store the wrapping material for possible future use.
2. 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).

3. Check the remaining contents of your package against the packing list to be sure your order is complete. Report any missing items immediately.
4. When you are satisfied with the inspection, proceed with the software and hardware setup instructions.

Note: Data acquisition products are factory calibrated; they require no further adjustment prior to installation. If at a later time you decide to recalibrate the board, refer to Section 6 for instructions.

Setting Switch-Configurable Options

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

Figure 3-1 shows the switches for DAS-1200 Series boards. The remaining sections describe the switches and how to configure them.

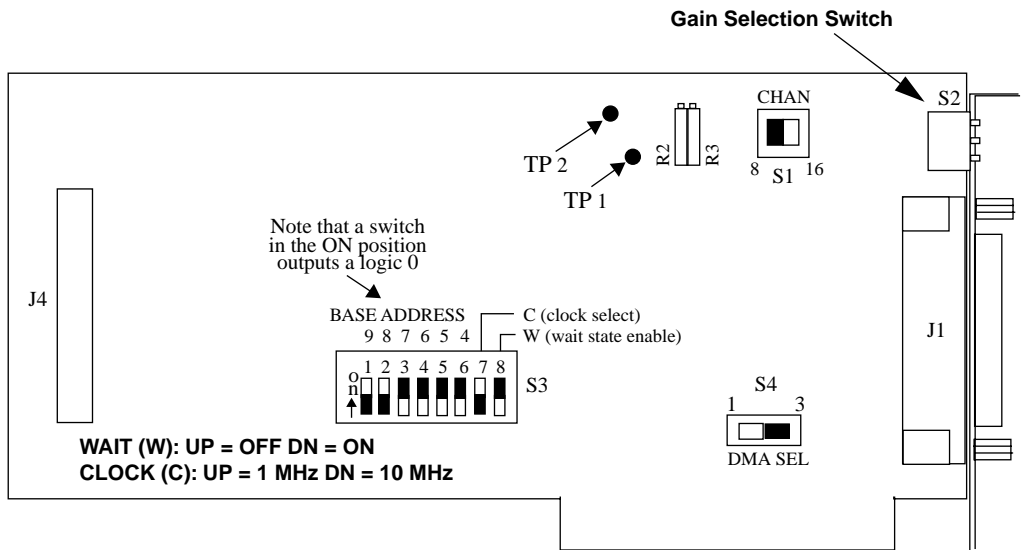


Figure 3-1. Default Switch Configuration for DAS-1200 Series Boards

Setting the Gain Selection Switch

Switch S2 on the DAS-1200 Series board is a 3-position switch that selects the gain that you want applied to all of your analog input channels.

Note: Switch S2 is a direct input to the instrumentation amplifier. You do not have to reset or power-up the board to apply the change in gain to analog input channels.

Figure 3-2 shows the 3-position gain selection switch that is set up through the rear mounting flange.

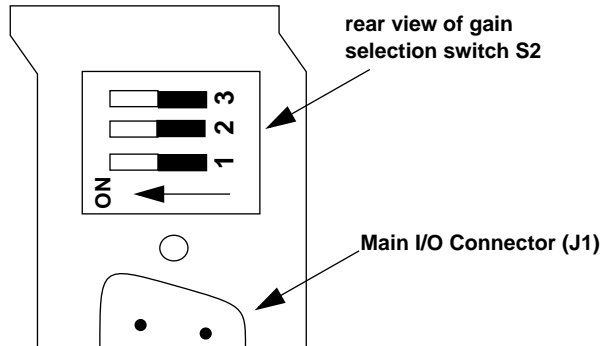


Figure 3-2. Gain Selection Switch as Viewed Through Mounting Flange

Table 3-1 lists the switch positions for each of the gains available.

Table 3-1. Gain Selection Switch Positions

GAIN		Switch Position		
DAS-1201	DAS-1202	1	2	3
1	1	OFF	OFF	OFF
10	2	ON	OFF	OFF
100	4	OFF	ON	OFF
500	8	OFF	OFF	ON

Setting the Chan 8/16 Switch

Switch S1 on the DAS-1200 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 an Alternate Base Address

Switch S3 on the DAS-1200 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 (768 decimal).

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

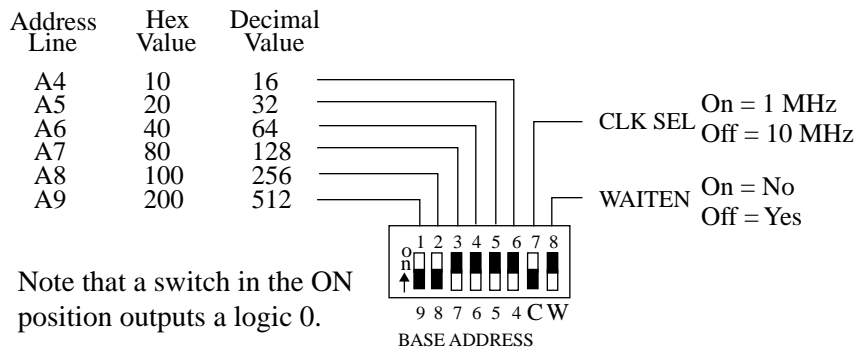


Figure 3-3. Base Address, Clock Select, and Wait State Enable Switch

The base address is read from the 8-position DIP switch located as shown in Figure 3-1 for a DAS-1200 Series board. The base address switch 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-1600/1400/1200 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. See Table 3-2.
2. Use the configuration utility to create a new configuration file and view the corresponding switch settings in the menu-box diagram.
3. Set up the base address switch to match the settings in the menu-box diagram.

Note: The settings for the base-address switch must match the settings shown by the switch diagram in the menu box of the configuration utility.

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 S4 on the DAS-1200 Series is a 2-position slide switch that selects DMA channel 1 or 3. The default setting is 3.

Installing and Configuring DriverLINX for DAS-1200 Series Boards

Caution: 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.

Installing the DAS-1200 Series Standard Software Package

Important: Before you begin installing any hardware or software for the DAS-1200, read the *DriverLINX Installation and Configuration Guide* and the *Using DriverLINX with your Hardware — Keithley DAS-16/1600 Series (this manual contains DAS-1200 information)* 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-1200 board's configuration settings.
2. Determine the resources your DAS-1200 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-1200 board.
5. Determine whether your DAS-1200 board can use your computer's free resources.
6. Set any jumpers/switches to configure your DAS-1200 board to use your computer's free resources.

7. Set any other jumpers/switches to configure your DAS-1200 board the way you want it to operate. Make a note of the switch and jumper settings in order to configure the board using DriverLINX.
8. Install your DAS-1200 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, and Delphi.
- **Install LabVIEW Interface** — This component installs the files and example programs that you will need to develop applications for DriverLINX using 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-1200 installation and read them before installing your DAS-1200 board or configuring DriverLINX:
 - *Installation and Configuration*
 - *Appendix F: Configuration and Implementation Notes—for Keithley DAS-16/1600 (manual used for DAS-1200 Series installation information)*
 - *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.
7. Following the DriverLINX prompts, turn off your computer and install your DAS-1200 board into an appropriate free slot in your computer.

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-1200 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-5 for DAS-1200 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 your application uses the 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. Insert the board in the selected slot and secure the main I/O connector mounting flange with the retaining screws.
6. When using the 24-bit digital I/O, connect the board end of the PIO cable to the PIO cable connector (J4) on the DAS-1200 Series board. When connecting the cable, align the raised arrow of the PIO cable with the arrow imprinted on the PIO cable connector (J4). Secure the mounting flange on the PIO cable to the connector panel next to the main I/O connector (J1) with the retaining screws.

7. Replace the computer cover.
8. Turn on power to the computer.

You can use the DriverLINX Control Panel (see Section 5) to verify board operation.

Configuring the DAS-1200 Board with DriverLINX

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

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.

Table 3-2 lists I/O addresses commonly used by IBM PC/XT, AT, and compatible computers. Determine an even boundary of eight I/O addresses within the range of 000H to 3F8H that is not being used by another resource in your system (including another DAS-1200 Series board), and set the switches to the appropriate base address.

Table 3-2. I/O Address Map (000H to 3FFH)

Address Range	Use
000H to 00FH	8237 DMA #1
020H to 021H	8259 PIC #1
040H to 043H	8253 timer
060H to 063H	8255 PPI (XT)
060H to 064H	8742 controller (AT)
060H to 06FH	8042 Keyboard controller
070H to 071H	CMOS RAM and NMI mask register (AT)
080H to 08FH	DMA page registers

Table 3-2. I/O Address Map (000H to 3FFH) (cont.)

Address Range	Use
0A0H to 0A1H	8259 PIC #2 (AT)
0A0H to 0AFH	NMI mask register (XT)
0C0H to 0DFH	8237 DMA #2 (AT - word-mapped)
0F0H to 0FFH	80287 numeric processor (AT)
170H to 177H	Hard disk controller #1
1F0H to 1F8H	Hard disk controller #2
1F0H to 1FFH	Hard disk controller (AT)
200H to 2FFH	Game / control
210H to 21FH	Expansion unit (XT)
238H to 23BH	Bus mouse
23CH to 23FH	Alternate bus mouse
278H to 27FH	Parallel printer
2B0H to 2DFH	EGA
2E0H to 2EFH	GPIB (AT)
2E8H to 2EFH	Serial port
2F8H to 2FFH	Serial port
300H to 31FH	Prototype card
320H to 32FH	Hard disk (XT)
370H to 377H	Floppy disk controller #2
378H to 37FH	Parallel printer
380H to 38FH	SDLC
3A0H to 3AFH	SDLC
3B0H to 3BBH	MDA
3BCH to 3BFH	Parallel printer
3C0H to 3CFH	VGA EGA
3D0H to 3DFH	CGA
3E8H to 3EFH	Serial port
3F0H to 3F7H	Floppy disk controller #1
3F8H to 3FFH	Serial port

The Expansion Board Configuration for Keithley DAS-1200 Series dialog in DriverLINX allows you to record the settings of your analog input multiplexers and enable the expansion channels. Make sure that the switch settings match the settings you define in DriverLINX. Refer to the *DriverLINX Appendix F: Configuration and Implementation Notes—Keithley DAS-16/1600 manual*.

After you have successfully installed the DAS-1200 Series board in your computer, start Windows.

Run “Learn DriverLINX” (**LearnDL.exe**) from the DriverLINX program group to tell DriverLINX how you configured your DAS-1200 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 the *Run...* option. <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-1200 Series 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-1200 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 all your selections, save the configuration parameters by clicking on the *OK* button. This will create or update the configuration file, <device>.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-1200, select *Device/Initialize* from the main menu in Learn DriverLINX.
2. The first time the DAS-1200 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-1200 Series boards.

4

Cabling and Wiring

In most applications, you use accessories to connect external I/O devices to the DAS-1200 Series boards. Keithley accessories extend signals from the main I/O connector (J1) to corresponding screw terminals of the accessory.

You access the 24 bits of parallel bidirectional digital I/O by using a flat ribbon cable known as the PIO cable. The board end of the PIO cable attaches to the PIO cable connector (J4) on the DAS-1200 Series 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-1200 Series boards.

This chapter describes the cabling and accessories required for attaching field wiring to your DAS-1200 Series boards.

Caution: To avoid electrical damage, turn off power to the computer and any attached accessories before making connections to DAS-1200 Series boards.

Attaching Screw Terminal Connectors and Accessories

You can use the following screw terminal connectors and accessories to simplify connection of field wiring to DAS-1200 Series boards:

- STC-37 Screw Terminal Connector; your application may require two connectors
- STP-37 Screw Terminal Panel; your application may require two connectors
- STA-16 Screw Terminal Accessory
- STA-U Universal Screw Terminal Accessory

The following sections describe how to attach these accessories to the DAS-1200 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-1200 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-1200 Series board, directly attach the 37-pin connector on the STC-37 to the main I/O connector (J1). Figure 4-1 illustrates the connection of an STC-37 to a DAS-1200 Series board.

Note: Your application may require connections to the main I/O connector (J1) and connections to the PIO cable connector (J4). 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.

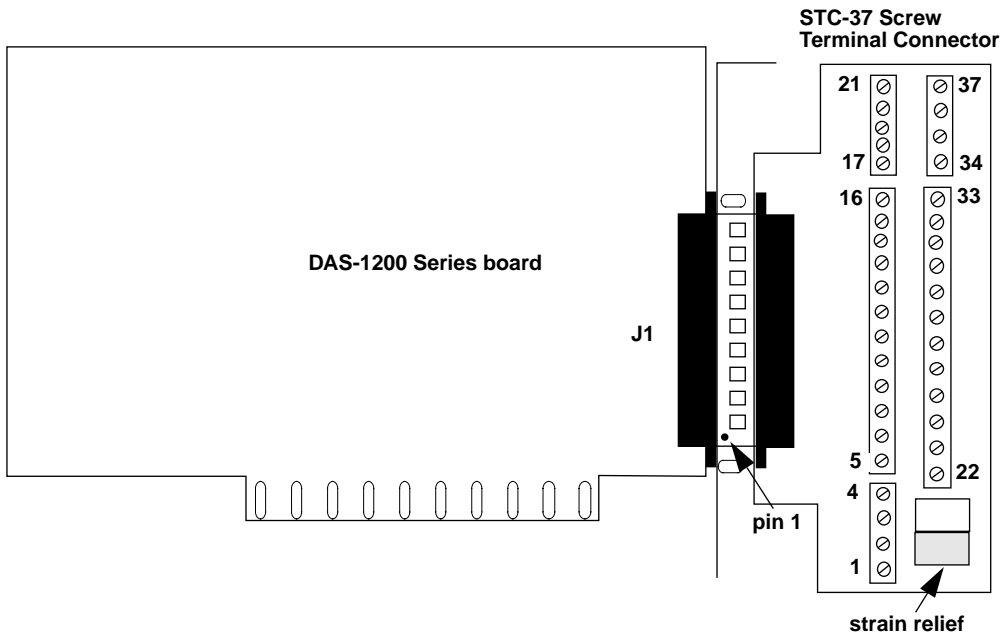


Figure 4-1. Attaching an STC-37 Screw Terminal Connector

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.

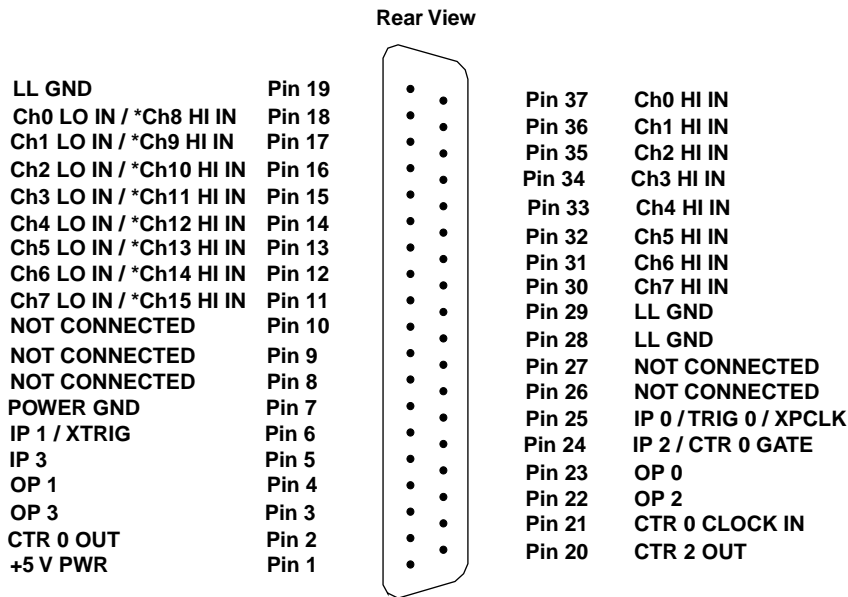


Figure 4-2. Pin Assignments of the Main I/O Connector (J1)

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 (J4) on the DAS-1200 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-1200 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 Signals.”

Attaching an STP-37

The screw terminals on the STP-37 screw terminal panel allow you to connect field wiring to DAS-1200 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-1200 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-1200 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-1200 Series board.

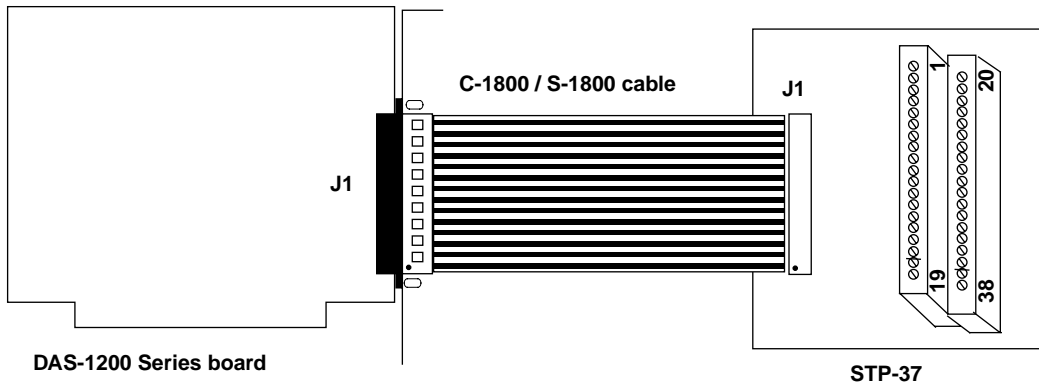


Figure 4-3. Attaching an STP-37

The screw terminals are labeled 1 to 38 and correspond directly to the functions of the board 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 (J4) on the DAS-1200 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-1200 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 PIO cable.

Attaching an STA-16

The screw terminals on the STA-16 screw terminal accessory allow you to connect field wiring to DAS-1200 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-1200 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.

You attach an STA-16 screw terminal accessory to the main I/O connector (J1) on the DAS-1200 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-1200 Series board.

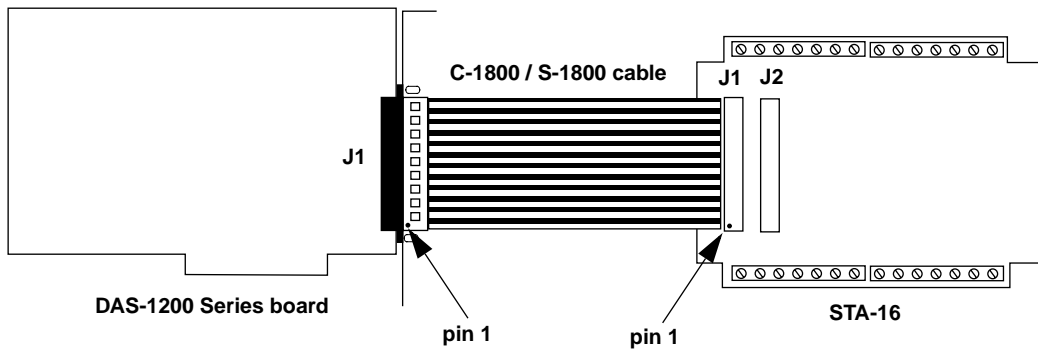


Figure 4-4. Cabling and Connections for Attaching an STA-16

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

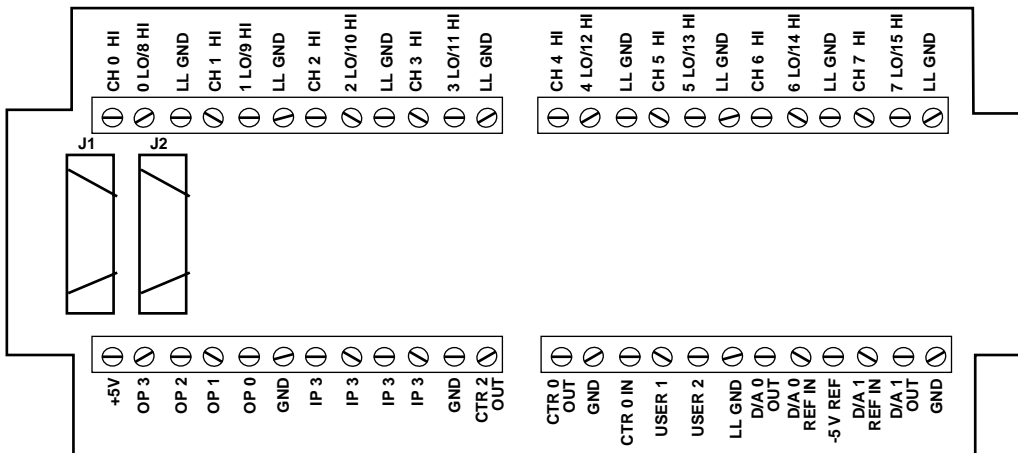


Figure 4-5. STA-16 Terminal Names

Attaching an STA-U

The screw terminals on the STA-U universal screw terminal accessory allow you to connect field wiring to the DAS-1200 Series board PIO cable connector (J4). The STA-U contains the following components:

- A 37-pin male connector for cabling to the PIO cable connector (J4).
- 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 (J4) on the DAS-1200 Series 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-1200 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-1200 Series board.

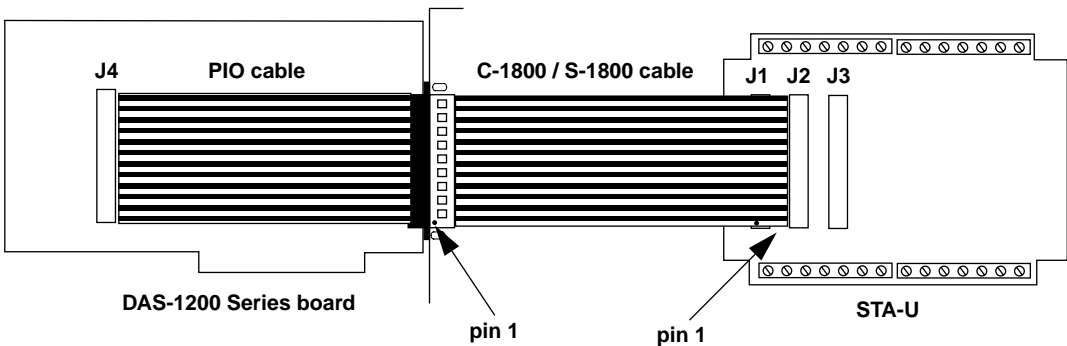


Figure 4-6. Cabling and Connections for Attaching an STA-U

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 (J4) shown in Figure 4-8.

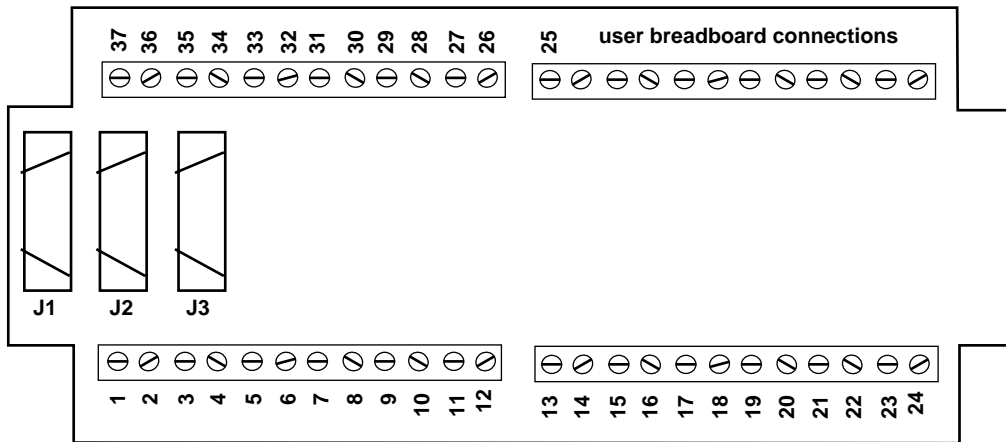


Figure 4-7. STA-U Terminal Names

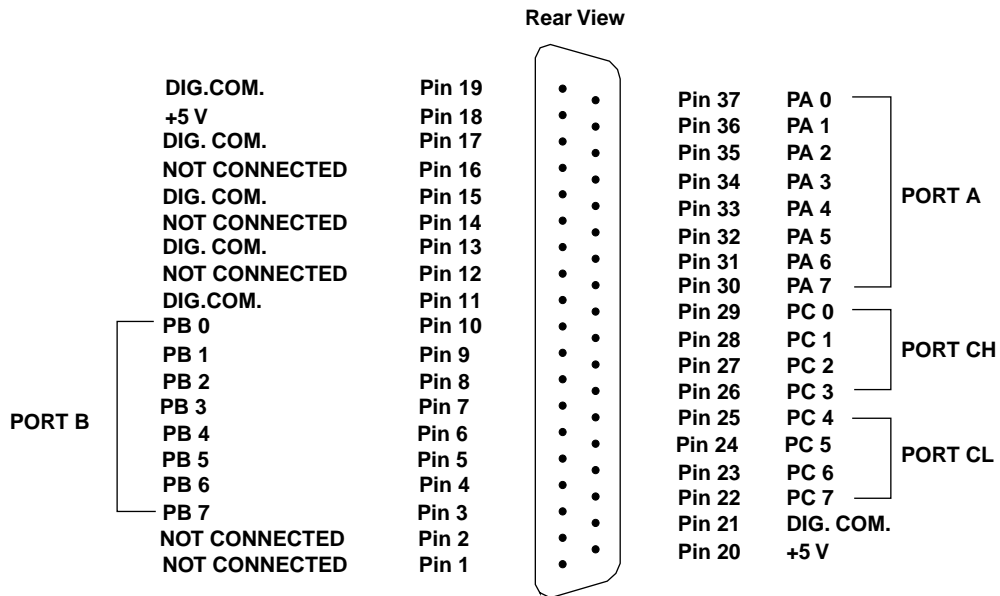


Figure 4-8. Pin Assignments of PIO Cable Connector (J4)

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

The following sections describe how to attach these expansion accessories to DAS-1200 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
CH n HI	positive input; where n indicates the channel number
CH n LO	negative input; where n indicates the channel number

To connect an EXP-16 or EXP-16/A to a DAS-1200 Series board, attach one end of an S-1600 cable to the DAS-1200 Series main I/O connector (J1) and the other end of the cable to the J1 connector on the EXP-16 or EXP-16/A. Figure 4-9 illustrates the connection of an EXP-16 to a DAS-1200 Series board.

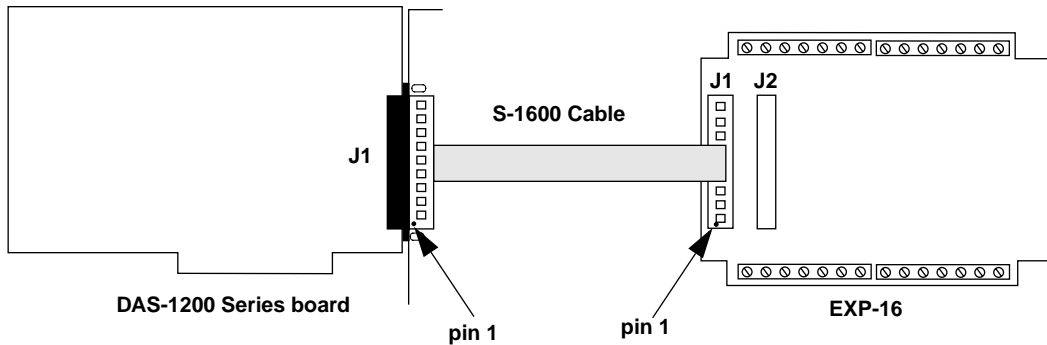


Figure 4-9. Attaching an EXP-16 or EXP-16/A Expansion Accessory

Note: The S-1600 cable must be used to connect the first EXP to the DAS-1200 Series board.

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 (J4).

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-1200 Series board, attach one end of an S-1600 cable to the DAS-1200 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-1200 Series board.

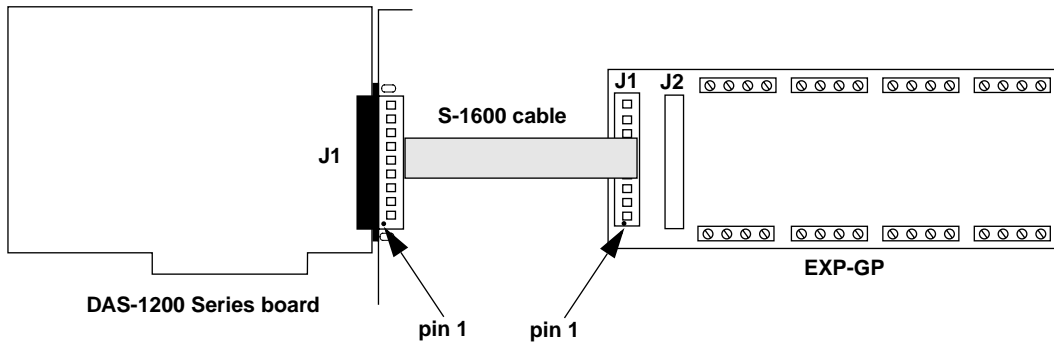


Figure 4-10. Attaching an EXP-GP Expansion Accessory

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

Attaching Multiple Expansion Accessories

You can daisy-chain up to eight EXP-16, EXP-16/A, and/or EXP-GP expansion accessories to provide up to 128 analog input channels.

As shown in Figure 4-11, you connect the first expansion accessory to the DAS-1200 Series board by attaching one end of an S-1600 cable to the main I/O connector (J1) on the DAS-1200 Series board and the other end of the cable to the J1 connector on the expansion accessory.

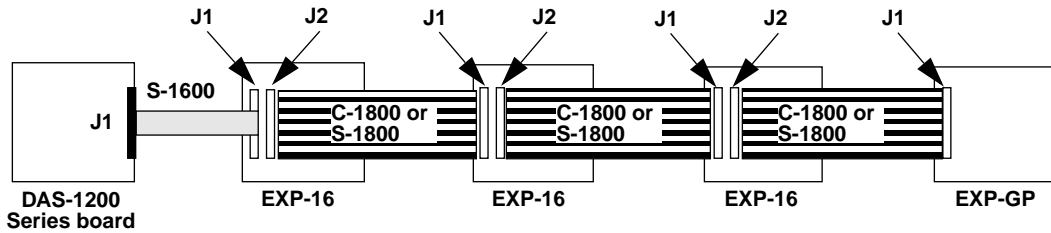


Figure 4-11. Attaching Multiple Expansion Accessories

To connect additional expansion boards, attach one end of a C-1800 or S-1800 cable to the J2 connector on the previous expansion board and the other end of the cable to the J1 connector on the next expansion board in the chain.

Notes: Each EXP-16, EXP-16/A, or EXP-GP expansion accessory is associated with an analog input channel on the DAS-1200 Series board. You specify the associated DAS-1200 input channel by setting a jumper on each expansion accessory. Make sure that you use a unique jumper setting for each expansion accessory you are using. Refer to your expansion accessory documentation for more information.

Make sure that you attach EXP-16 and EXP-16/A expansion accessories before EXP-GP expansion accessories.

You can access the remaining functions of the DAS-1200 Series board by including an STA-16 or STA-U screw terminal accessory in the daisy chain. Figure 4-12 illustrates how to connect two EXP-16 expansion accessories, one EXP-GP expansion accessory, and an STA-16 (or STA-U) screw terminal accessory to a DAS-1200 Series board.

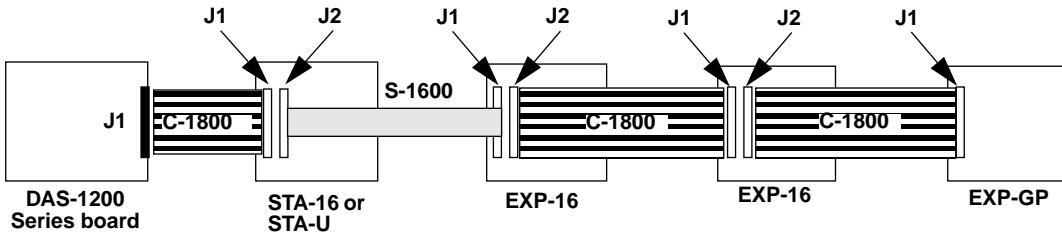


Figure 4-12. Attaching Multiple Expansion Accessories with an STA-16 or STA-U

Note: As shown in Figure 4-12, when you use an STA-16 (or STA-U) to access unused signals, you must attach the STA-16 (or STA-U) first with a C-1800 or S-1800 cable.

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 to a DAS-1200 Series board, attach one end of an S-1600 cable to the DAS-1200 Series main I/O connector (J1) and the other end of the cable to the J1 connector on the ISO-4 accessory. Figure 4-13 illustrates the connection of an ISO-4 accessory to a DAS-1200 Series board.

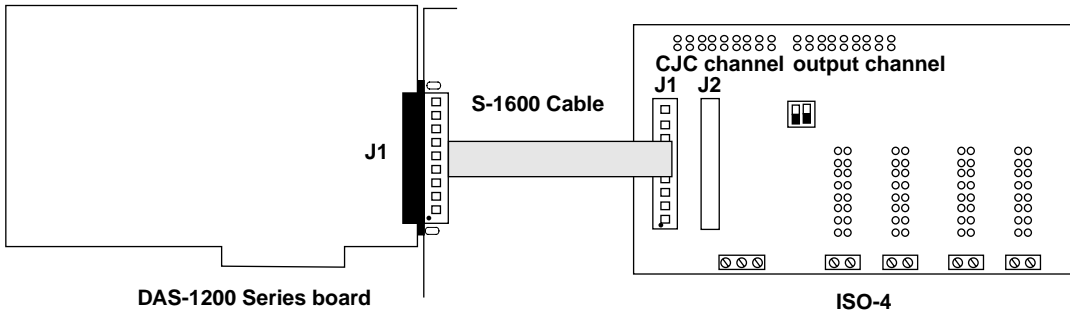


Figure 4-13. Attaching an ISO-4 Accessory

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-1200 Series boards are the SSH-4/A and the SSH-8.

Figure 4-14 shows a diagram of a typical measurement system using an SSH-8.



Figure 4-14. A Typical SSH-8 Application

The following subsections describe how to attach SSH-4/A and SSH-8 boards to DAS-1200 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-1200 Series boards.

Figure 4-15 shows how to attach the SSH-4/A to a DAS-1200 Series board.

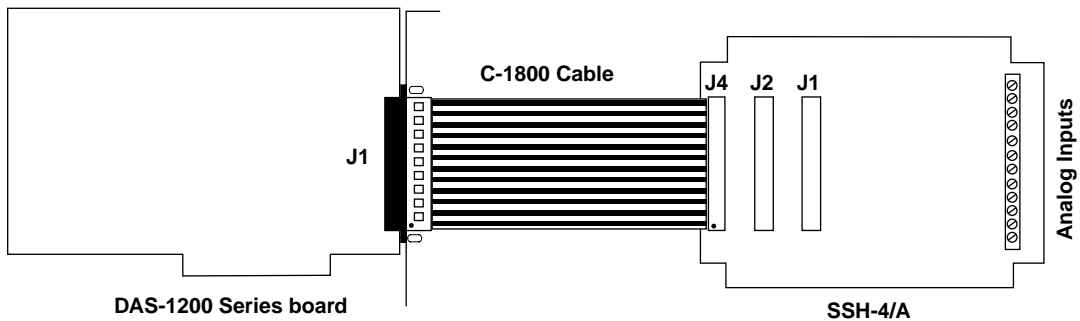


Figure 4-15. Attaching an SSH-4/A Accessory

Additional SSH-4/A accessories are attached in daisy-chain fashion with a 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-1200 Series boards.

Figure 4-16 and Figure 4-17 show how to attach SSH-8 boards to a DAS-1200 Series board.

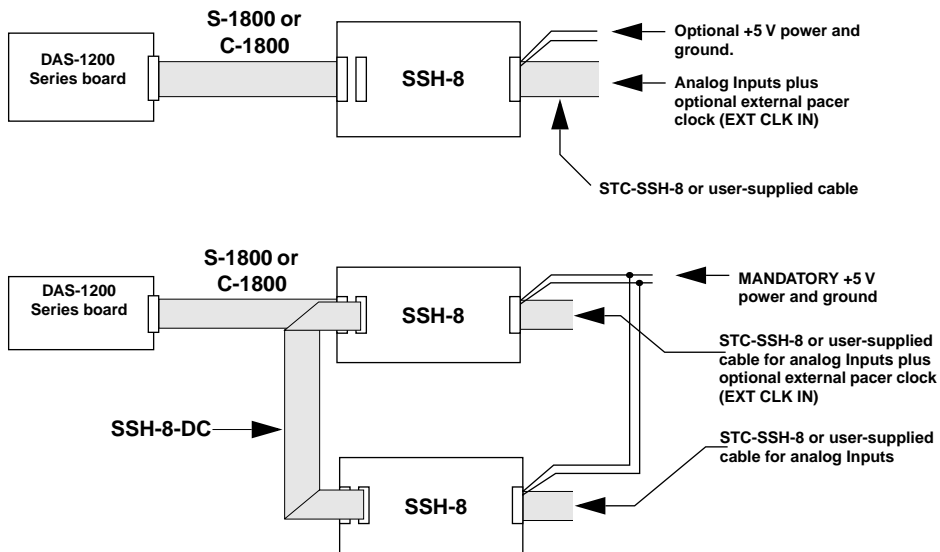


Figure 4-16. Attaching SSH-8 Accessories

When you use the cabling shown in Figure 4-16, 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-1200 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 tradeoffs are factors in the selection of these options.

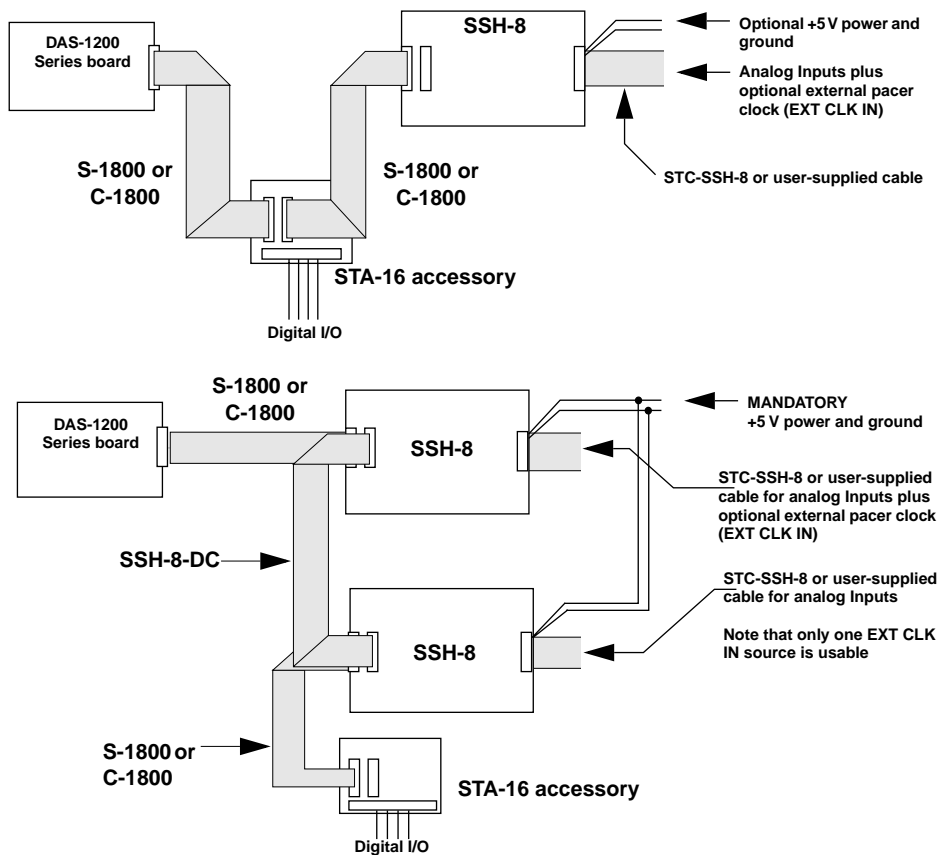


Figure 4-17. Attaching SSH-8 and STA-16 Accessories

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 4-18 shows a block diagram of a typical MB Series measurement and control application.

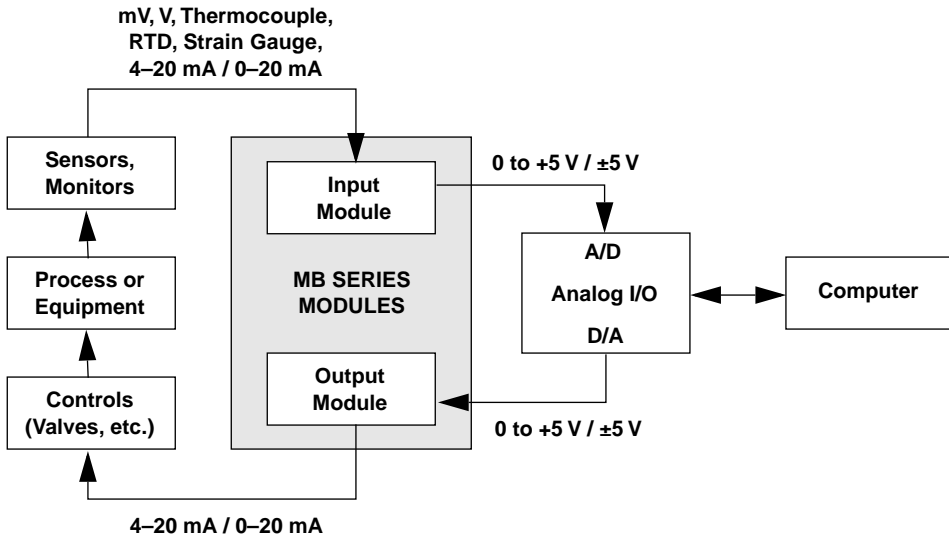


Figure 4-18. Typical Measurement and Control Application

Table 4-3 provides a brief summary of 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-1200 Series board making it suitable for high-speed, high-resolution applications.
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.
STA-MB	Holds up to four modules and provides general-purpose screw terminal connections for all other signals on the DAS-1200 Series board.

Attaching an MB01 Backplane

Use the C16-MB1 cable to connect a DAS-1200 Series board to an MB01 backplane. This cable connects MB01 channels 0 through 15 to analog input channels 0 through 15 on the DAS-1200 Series board. Refer to Figure 4-19 for a cabling diagram.

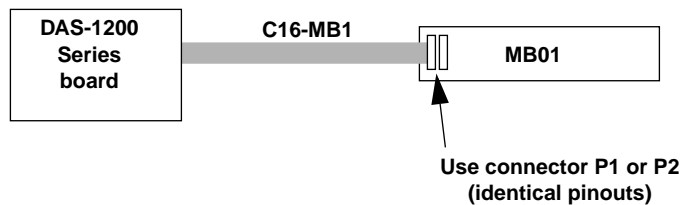


Figure 4-19. Attaching an MB01 Backplane

Note: The channel connections are single-ended. Make sure that the DAS-1200 Series board is set for 16-channel, single-ended operation.

Attaching an MB02 Backplane

Figure 4-20 shows how to connect the DAS-1200 Series to up to four MB02 backplanes. The STA-SCM16 interface connects one MB02 board to one analog input channel of the DAS-1200 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-1200 Series board.

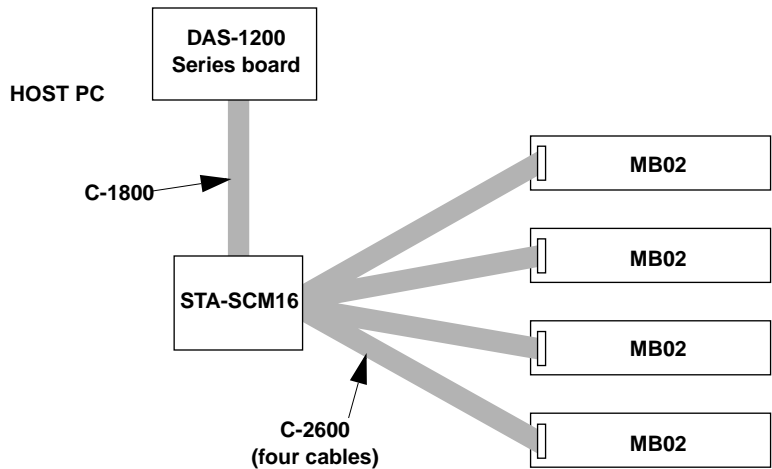


Figure 4-20. Attaching Multiple MB02 Backplanes

Figure 4-21 shows how the STA-SCM16 connects DAS-1200 Series boards with MB02 backplanes.

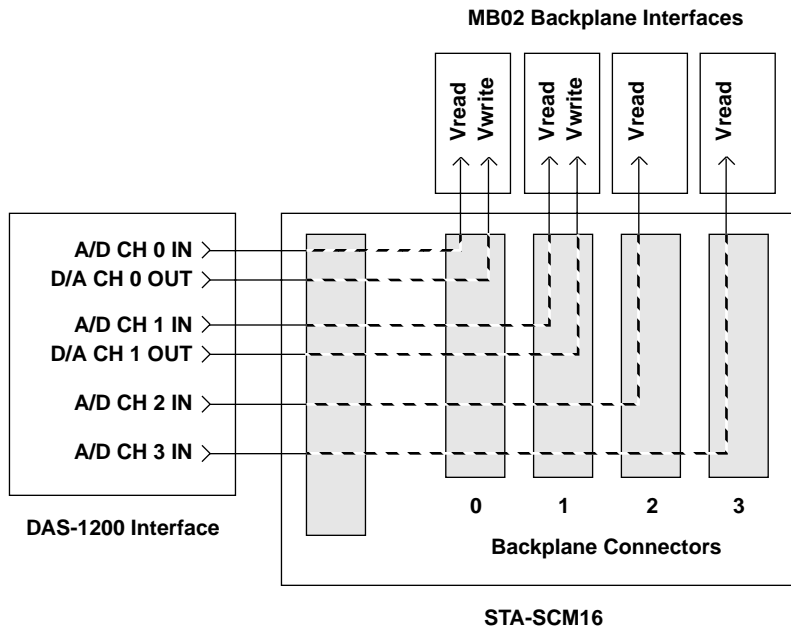


Figure 4-21. MB02 I/O Connections

The four digital output lines on the DAS-1200 Series board 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-1200 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-1200 Series board is set for single-ended, 16-channel operation.

Refer to the *MB Series User's Guide* for more information.

Connecting Analog Signals

This section contains precautionary advice to consider before making analog input connections. The section also shows some circuits for wiring signal sources to input channels of DAS-1200 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.

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 DAS-1201 boards at high gains, read the precautionary information in the following section. Other considerations for I/O connections are offered under “Additional Precautions” on page 4-24.

Precautions for Using the DAS-1201 Board at High Gains

Operating DAS-1201 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 -5.0 V to $+5.0$ V, each bit of A/D output corresponds to 4.88 μ V 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-1201 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 $40 \mu\text{V}/^\circ\text{C}$. 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.

Connecting a Signal to a Single-Ended Analog Input

Figure 4-22 shows the connections between a signal source and a channel of a DAS-1200 Series board configured for single-ended input mode.

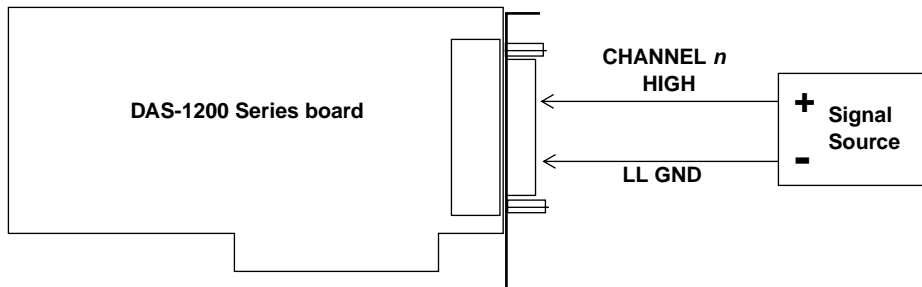


Figure 4-22. Connections for Wiring a Signal Source to a DAS-1200 Series Board Configured for Single-Ended Inputs

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.

Due to connector contact resistance and cable resistance, there may be many millivolts difference 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

This section describes common connection schemes for differential inputs. The section also discusses the principles for avoiding ground loops.

Common Connection Schemes for Differential Inputs

Figure 4-23 shows three methods of wiring a signal source to a channel of a DAS-1200 Series board configured for differential input mode.

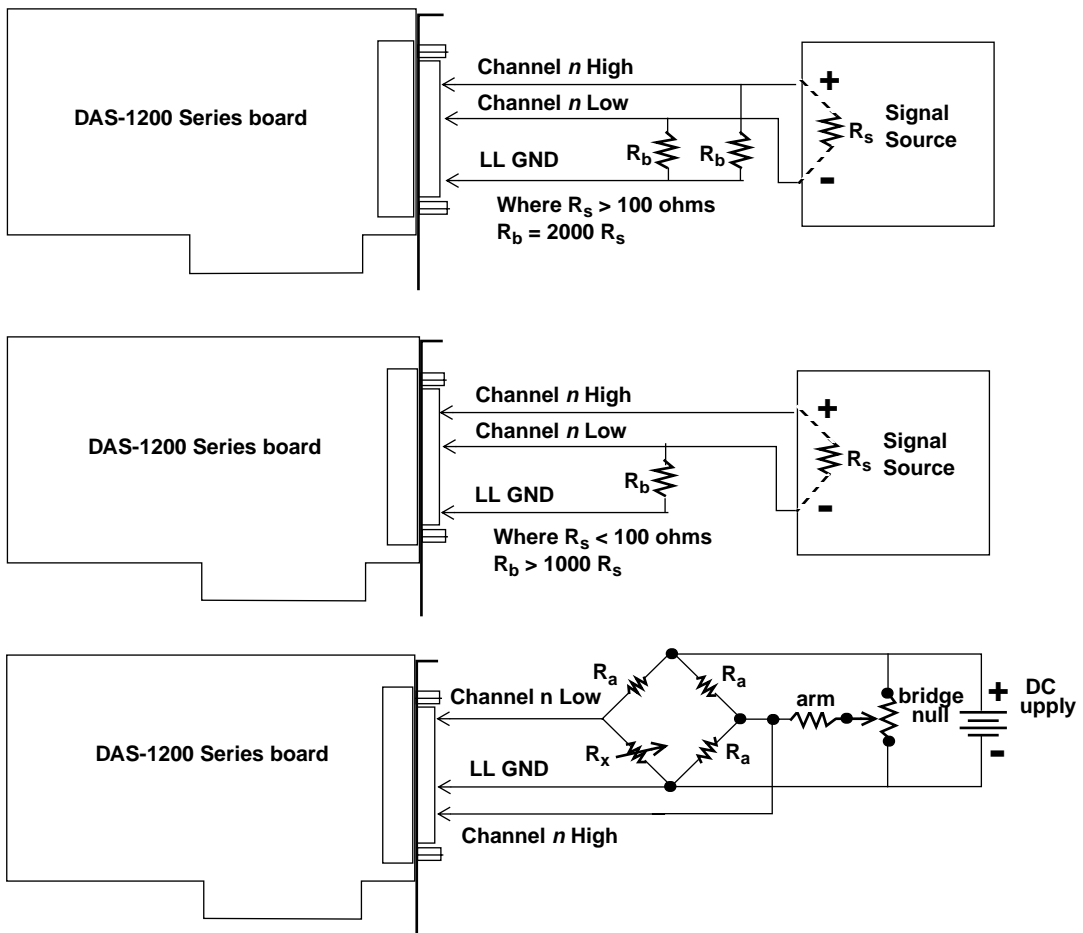


Figure 4-23. Three Methods for Wiring Differential Inputs

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 100Ω , 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 100Ω , 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 Ground Loops with Differential Inputs

Very often, the signal-source ground and the DAS-1200 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* (V_{cm}) because it is normally common to both sides of a differential input (it appears between each side and ground).

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 the sum of the signal-source and common-mode voltages. Figure 4-24 shows the proper way to connect a differential input while Figure 4-25 illustrates the effect of a ground loop.

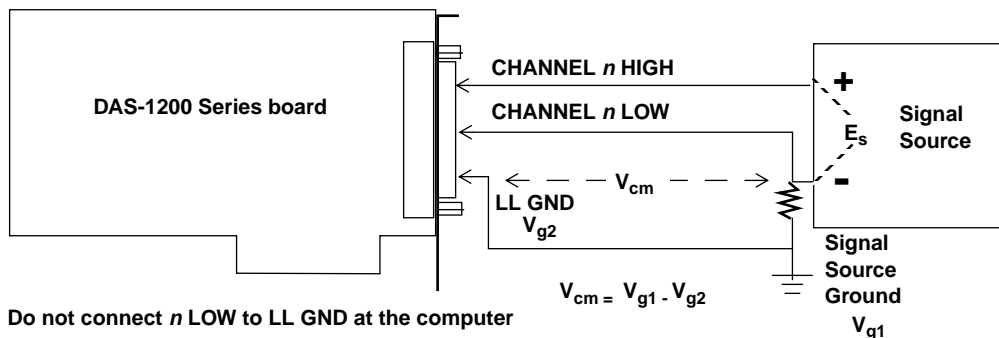


Figure 4-24. A Differential Input Configuration that Avoids a Ground Loop

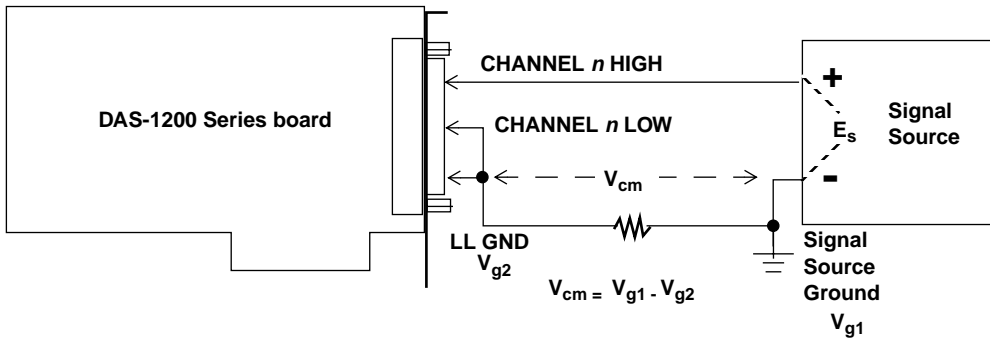


Figure 4-25. Differential Input Configuration with a Ground Loop

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 two-channel Oscilloscope.
- Measure analog voltages using the 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-1200 DriverLINX installation and configuration.
- Verifying signal inputs to your DAS-1200 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-1200 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-1200 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-1200 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 section provides the information you need to calibrate a DAS-1200 Series board.

Equipment Requirements

The equipment requirements for calibrating a DAS-1200 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 3-3 shows the locations of the potentiometers and test points that are used during the calibration of a DAS-1200 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.

Troubleshooting

If your DAS-1200 Series board is not operating properly, use the information in this section 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 contact an applications engineer.

Problem Isolation

If you encounter a problem with a DAS-1200 Series board, use the instructions in this section to isolate the cause of the problem before calling Keithley for technical support.

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-1200 Series boards.

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 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 the DAS-1200 Series board 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.

Table 7-1. Troubleshooting Information

Symptom	Possible Cause	Possible Solution
Board does not respond	Base address is incorrect.	Ensure that 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, ensure that no other computer device is using any of the I/O locations beginning at the specified base address. See Table 3-2 for a list of standard address assignments. If necessary, reconfigure the base address. Refer to page 3-5 for instructions on setting the base address.
	The interrupt level is incorrect.	Ensure that 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 the Keithley Hardware Applications Engineering Department; 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 DAS-1200 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-1200 Series board; refer to page 3-5 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-1200 Series board conflicts with that of another device.	Verify that the base address setting of your DAS-1200 Series board is unique.
	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.
System lockup	A timing error occurred.	Press [Ctrl] + [Break] .

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-1200 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-1200 Series board(s).
3. Remove the DAS-1200 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-1200 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-1200 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 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-1200 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-1200 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-1200 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-1200 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. - 5:00 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-1200 Series Board Configuration	Model	_____
	Serial #	_____
	Revision code	_____
	Base address setting	_____
	Interrupt level setting	_____
	Number of channels	_____
	Input (S.E. or Diff.)	_____
	DMA chan(s)	_____
	Number of SSH-8 brds.	_____
	Number of EXP brds.	_____
Gain selection setting	_____	
Computer	Manufacturer	_____
	CPU type	_____
	Clock speed (MHz)	_____
	KB of RAM	_____
	Video system	_____
	BIOS type	_____

Operating System	DOS version	_____
	Windows version	_____
	Windows mode	_____
Software package	Name	_____
	Serial #	_____
	Version	_____
	Invoice/Order #	_____
Compiler (if applicable)	Language	_____
	Manufacturer	_____
	Version	_____
Accessories	Type	_____
	Type	_____
	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. Ship the equipment to:

ATTN.: RMA# _____
Repair Department
Keithley Instruments, Inc.
28775 Aurora Road
Cleveland, Ohio 44139-1891

Telephone 1-888-KEITHLEY
FAX (440) 248-6168

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

Tables A-1 to A-6 list specifications for the DAS-1200 Series boards.

Table A-1. Analog Input Specifications

Attribute	DAS-1201 Boards	DAS-1202 Boards
Number of channels	Switch-configurable as eight differential or 16 single-ended	
Input mode	bipolar	
Resolution	12-bits (1 part in 4096 or 244 ppm)	
Gain (range)	1 (± 5.0 V)	1 (± 5.0 V)
	10 (± 0.5 V)	2 (± 2.5 V)
	100 (± 0.05 V)	4 (± 1.25 V)
	500 (± 0.01 V)	8 (± 0.625 V)
Gain (settling time)	1 (22 μ s)	1 (10 μ s)
	10 (22 μ s)	2 (10 μ s)
	100 (22 μ s)	4 (10 μ s)
	500 (102 μ s)	8 (10 μ s)
Throughput ¹	50 kHz maximum for gains less than 500	100 kHz maximum for all gains
	10 kHz maximum for a gain of 500	
Absolute accuracy	Typical: 0.01% of reading ± 1 LSB, typical for all ranges after calibrating gain and offset for that range	
	Maximum unadjusted error: For gain < 500: 0.7% of reading ± 1 LSB maximum @ 25°C For gain = 500: 0.8% of reading ± 1 LSB maximum @ 25°C	

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

Attribute	DAS-1201 Boards	DAS-1202 Boards
Temperature coefficient of accuracy (includes ADC)	Gain: ±100 ppm/ °C maximum	Gain: ±150 ppm/ °C maximum
	Offset (referred to input): (1 + 115/gain) μV/ °C maximum	Offset (referred to input): (10 + 200/gain) μV/ °C maximum
Dynamic parameters	Acquisition time: 1.4 μs	
	Aperture delay: 20.0 ns	
	Aperture uncertainty: 300 ps rms	
	Conversion time: 8.5 μs maximum	
Non-linearity	±1 LSB	
Input impedance	Greater than 25 megohms	
Input current	250 nA maximum (125nA typ.) @ 25° C	
Input bias current	±2.0 nA maximum @ 25° C	±0.002 nA maximum @ 25° C
	±2.5 nA maximum over operating range	±0.02 nA maximum over operating range
Input overvoltage	±35.0 V continuous powered	
Common mode rejection ratio	73 dB for gain = 1	73 dB for gain = 1
	93 dB for gain = 10	79 dB for gain = 2
	110 dB for gain = 100	84 dB for gain = 4
	110 dB for gain = 500	88 dB for gain = 8
Noise ²	Bipolar electrical noise (in counts) <ul style="list-style-type: none"> • 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 = 4; rms = 0.5 	Bipolar electrical noise (in counts) <ul style="list-style-type: none"> • 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 = 2; rms = 0.2
DMA channels	1 and 3	
Interrupt levels	2, 3, 4, 5, 6, and 7	

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

Attribute	DAS-1201 Boards	DAS-1202 Boards
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. Digital I/O Specifications (8-bits on Main I/O Connector)

Attributes	DAS-1200 Series Boards
Outputs (standard LSTTL)	Output bits: 4 bits latched
	Low Voltage: 0.5 V maximum @ Isink= 8.0 mA
	High voltage: 2.4 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 μ A maximum

Notes

- ¹ IP0/TRIG 0/XPCLK minimum pulse width = 10.0 ns.

Table A-3. Digital I/O Specifications (24-bits on PIO Cable Connector)

Attributes	DAS-1200 Series Boards
Device type	NMOS 8255A-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 μ A maximum
	High voltage: 2.0 V minimum
	High current: 10 μ A maximum

Table A-4. Programmable Counter/Timer Specifications

Attributes	DAS-1200 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 = 25.0 mA
	High voltage: 2.0 V minimum @ Isource = -15.0 mA
Inputs (buffered)	Low voltage: 0.8 V maximum
	Low current: -0.2 mA maximum
	High voltage: 2.0 V minimum
	High current: 20 μ A 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-5. Power Supply Requirements

Attribute	DAS-1200 Series Boards
+5 VDC supply	235 mA typical
+12 VDC supply	4 mA typical
-12 VDC supply	4 mA typical

Table A-6. Environmental Specifications

Attribute	DAS-1200 Series Boards
Operating temperature	0 to 70°C
Storage temperature	-20 to 70°C
Humidity	0 to 95% noncondensing
Dimensions	7 in. L × 4.25 in. H × 0.90 in. D (17.8 cm × 10.8 cm × 2.3 cm)

B

Connector Pin Assignments

This appendix contains pin assignments for the I/O connectors of the DAS-1200 Series boards. See Figure 3-1 for the locations of connectors discussed in this section.

Main I/O Connector (J1)

The pin assignments of the main I/O connector (J1) on the DAS-1200 Series boards are shown in Figure B-1.

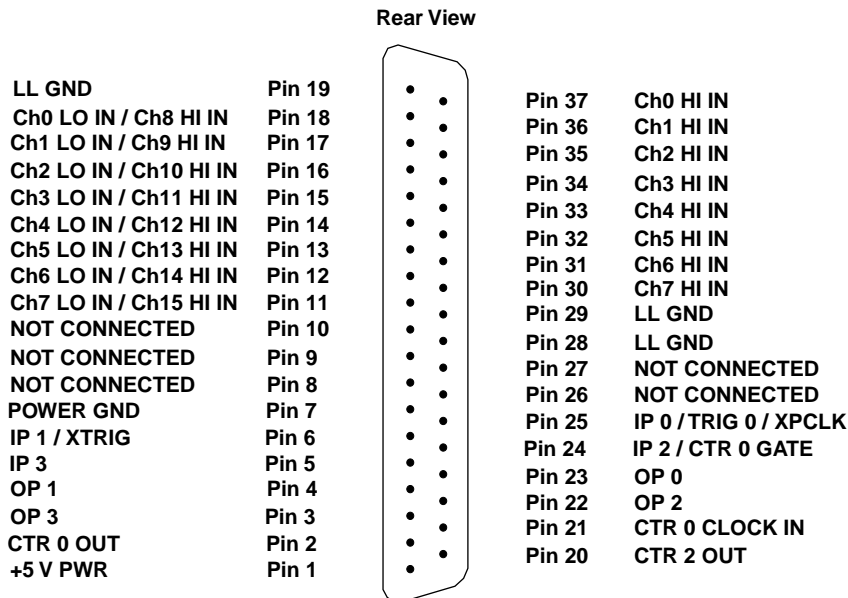


Figure B-1. Pin Assignments of Main I/O Connector (J1) on DAS-1200 Series

PIO Cable Connector (J4)

The pin assignments of PIO cable connector (J4) are shown in Figure B-2.

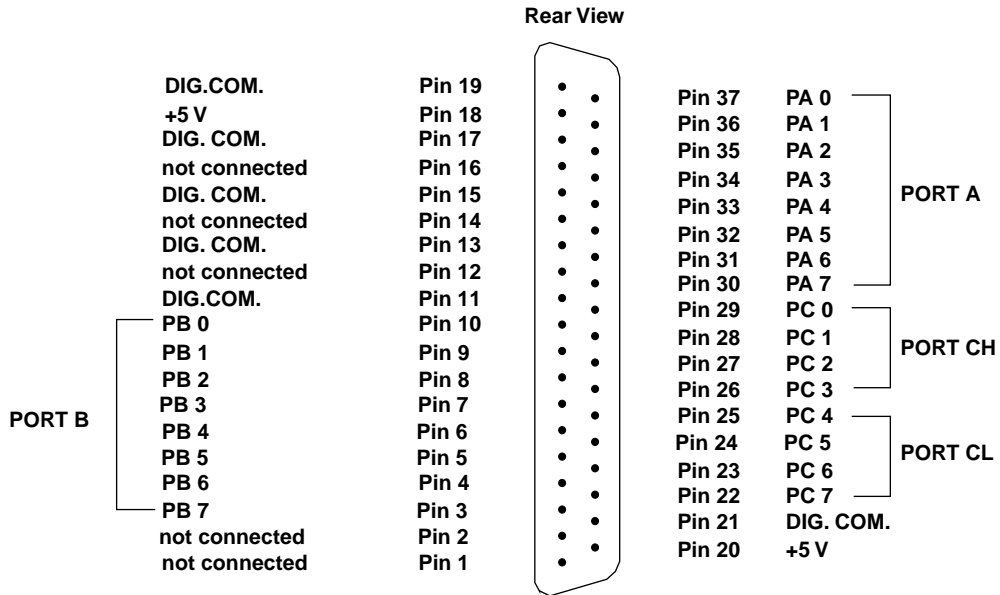


Figure B-2. Pin Assignments of PIO Cable Connector (J4)

Register-Level Address Map

DAS-1200 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 section describes each I/O register in terms of function, address, bit structure, and bit functions. The section does not describe how to program at the register-level.

Register Functions

DAS-1200 Series register functions are categorized as follows:

- Analog-to-Digital converter (ADC) registers
- MUX scan register
- Digital input and output registers
- Status registers
- Control register
- Burst rate register
- Counter enable and burst length register
- 82C54 programmable interval counter/timer registers

- 8255 programmable I/O registers
- 1600 mode and burst mode enable registers

DAS-1200 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	
Base Address +4h	NOT USED		
Base Address +5h	NOT USED		
Base Address +6h	NOT USED		
Base Address +7h	NOT USED		
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	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 (8255 Programmable I/O)			
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	8255 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 mode enable register	Write	1600MDEN
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 +0h 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-1200 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-1200 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
0	0	1	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 0010.

Status Register A (Base Address +8h)

Status register A is read only and provides information on the operation and configuration of the DAS-1200 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	X	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-1200 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 3-5).

Table C-2 defines the logic states of MUX bit.

Table C-2. Logic State of Status Register A: MUX Bit 5

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

- **X** = Data insensitive.
- **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-1200 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-3 lists pacer clock sources selected by the states of S0 and S1.

Table C-3. 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

¹X = 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-1200 Series board.

- **X** = Data insensitive.
- **IL0 to IL2** = Interrupt level select. Selects the interrupt level that you want interrupts processed on. 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-4 lists the interrupt levels selected by the states of IL0 through IL2.

**Table C-4. Control Register:
Interrupt Level Selection Bits 4, 5, & 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-1200 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/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 CTR0 CLOCK IN, CTR0 GATE, and CTR0 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/XPCLK, this bit enables and disables counters 1 and 2 to provide a means of holding off clock pulses from the counter/timer to the A/D 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/XPCLK is logic 0, the counter/timers are enabled.

When CEN0 is a logic 1 and IP0/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.

Burst Rate Register (Base Addresses +Bh)

The burst rate register is an 8-bit read/write register that selects 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	X	X

The bit names are defined and used as follows:

- **X**= Data insensitive.
- **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:

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

Burst mode allows DAS-1200 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 mode by writing a value of 40h to the 1600 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 burst rate register (base address +Bh) is programmable for 100 kHz to 3.94 kHz (10 μ s to 254 μ s).

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.

82C54 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, presetable down counters and a control register. Table C-5 maps counter/timer registers to their addresses.

Table C-5. 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-1200 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-1600/1400/1200 Function Call Driver always set 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 (2×2) with a 10 MHz clock providing a 2.5 MHz output at one extreme, and a division ratio of 2^{32} ($65,535 \times 65,535$) 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-1200 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 $65,535 \times 10 = 655$ 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 retriggerable).

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 timeout and producing a negative going strobe pulse.

Like configuration 1, the time out is retriggerable (a new cycle commences if the gate input is taken high before a current cycle has timed out).

Counter 0 can produce 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 “82C54 Counter/Timer Control Register (Base Address +Fh)” on page C-19), 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-6.

Table C-6. 82C54 Counter/Timer Control Register: Selecting Functionality

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

Notes

¹X = data insensitive.

- **RL0 to RL1** = Control the type of read/load operations performed on counters, as shown in Table C-7.

Table C-7. 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 to SC1** = These bits control counter selection, as shown in Table C-8.

Table C-8. 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 & 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-9 lists the bit conditions that select each counter.

Table C-9. Counter Status Byte Selection: Bits 0, 1, & 2

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

Notes

¹X = 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-9 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 Programmable Peripheral Interface (Base Address +400h to +403h)

The DAS-1200 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-10. 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 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 IO (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-11 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-11 for definitions of operating mode selected.

Table C-11. 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. This Table C-12 summarizes information from the Intel Peripheral Data book on control words and their port directions for mode 0.

Table C-12. 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
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 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-1200 Series to ignore all conversion clock sources and disable any 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-1200 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 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 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-1200 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 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 mode enable register is reset; conversions cannot be disabled and burst mode cannot be enabled. 1 indicates that the 1600 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.

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