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DAS-1600/1400 Series
User's Guide

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DAS-1600/1400 Series
User's Guide

Revision A - June 1994
Part Number: 81490

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Preface

This guide is for persons needing to understand the installation, interface requirements, functions, and operation of the following products:

- The DAS-1601 and DAS-1602 boards, which are referred to collectively as DAS-1600 Series boards.
- The DAS-1401 and DAS-1402 boards, which are referred to collectively as DAS-1400 Series boards.

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

To follow the information and instructions contained in this manual, you must be familiar with the operation of an IBM™ PC/XT or compatible in the MS-DOS® or Windows™ 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-1600/1400 Series boards	Chapter 1
What software is available for the boards	Chapter 1

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Table 1. Finding Information

To learn more about	See
What accessories are available for the boards	Chapter 1
Functionality of DAS-1600/1400 Series boards	Chapter 2
Installing the DAS-1600/1400 Series standard software package	Chapter 3
Installing the ASO-1600 and ASO-1400 software package	Chapter 3
How to create a configuration file	Chapter 3
Setting up switch-selectable options	Chapter 3
Installing your boards	Chapter 3
Attaching accessories	Chapter 4
Precautions to observe when connecting signals	Chapter 4
Using the Control Panel software for test and data acquisition	Chapter 5
Calibrating the board	Chapter 6
Troubleshooting and obtaining technical support	Chapter 7
DAS-1600/1400 Series specifications	Appendix A
I/O connector pin assignments	Appendix B
Using the DAS-1600 External Driver with application packages	Appendix C
Installing and setting up the Keithley Memory Manager	Appendix D
The register level I/O map	Appendix E

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Related Documents

You can find more information on DAS-1600/1400 Series software and accessories in the related documents listed in Table 2.

Table 2. Related Documents

Document
DAS-1600/1400/1200 Series Function Call Driver User's Guide
VisualDAS for the DAS-1600/1400/1200/800 Series User's Guide
EXP-16 & EXP-16/A Expansion Multiplexer/Amplifier System User's Guide
EXP-GP Signal Conditioning Multiplexer User's Guide
MB Series User's Guide
SSH-4/A Simultaneous Sample & Hold Module User's Guide
SSH-8 User's Guide
ISO-4 User's Guide

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1

Overview

The DAS-1600/1400 Series is a family of high-performance analog and digital I/O boards for IBM PC/XT, PC AT, and compatible computers. The DAS-1601 and DAS-1401 are high-gain boards, while the DAS-1602 and DAS-1402 are low-gain boards.

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

Features

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

- Boards are switch-configurable for 16 single-ended or eight differential analog input channels.
- Analog inputs are switch-configurable for either unipolar (0-10 V) or bipolar (±10 V) signals.
- Analog input channels are individually programmed for gain. The DAS-1601/1401 have programmable gains of 1, 10, 100, and 500. The DAS-1602/1402 have programmable gains of 1, 2, 4, and 8.
- Analog inputs are sampled at a maximum of 100 ksamples/s with 12-bit resolution.
- The base I/O address and Direct Memory Address (DMA) channel are switch-configurable; interrupt levels are software-configurable.

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- 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 to 1 pulse/hour to 100 kHz. The 82C54 counter/timer can also be used to measure frequency, period, and pulse width.
- The boards have four unidirectional digital inputs and four unidirectional digital outputs.
- The boards are backward compatible with the DAS-16G1 and DAS-16G2 boards.

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

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DAS-1600 Series boards provide the following additional features:

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

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

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

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

Supporting Software

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

- **DAS-1600/1400 Series standard software package** - This package, which comes with the board, is provided on 3.5-inch and 5.25-inch diskettes. The package includes function libraries for writing application programs under DOS using Microsoft® QuickBasic™, Microsoft® Professional Basic, or Microsoft® Visual Basic™ for DOS. The package also includes support files, example programs, and the following utility programs:

  – *Configuration Utility* - The configuration utility (CFG1600.EXE) is a DOS-based program for creating or modifying a DAS-1600/1400 Series configuration file.

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A configuration file contains the settings used by the DAS-1600/1400/1200 Series Function Call Driver and other driver software for configuring a board. For more information on the configuration utility, refer to "Creating a Configuration File" on page 3-6.

- *Calibration Utility* - The calibration utility (CAL1600.EXE or CAL1400.EXE) is a DOS-based program for calibrating the analog I/O circuitry of DAS-1600/1400 Series boards. For more information on the calibration utility, refer to Chapter 6.

- *Control Panel* - The Control Panel (CTL1600.EXE) is a DOS-based stand-alone program. This tool provides access to all DAS-1600/1400 Series board operations without programming.

  The Control Panel provides a means of testing the board and your application; it is also a means of performing simple applications and saving data to a disk file. Refer to Chapter 5 for more information about the Control Panel.

- *DAS-1600 External Driver* - The External Driver (DAS1600.EXE) for DAS-1600, DAS-1400, and DAS-1200 Series boards provides control and communication between data acquisition and analysis packages and the boards.

  DAS1600.EXE executes as a terminate-and-stay-resident (TSR) program that occupies a small amount of memory in the host.

- **ASO-1600 and ASO-1400** - Advanced Software Option. This option includes both Windows and DOS versions; both versions are supplied on 3.5-inch and 5.25-inch diskettes. The ASO-1600 and ASO-1400 include function libraries for application programs that you write for MS-DOS and Windows environments in the following languages:

  - Microsoft and Borland® C/C++
  - Borland Turbo Pascal®
  - Microsoft Visual Basic for Windows
  - Microsoft QuickC®
  - Microsoft Visual C++™

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Refer to the *DAS-1600/1400/1200 Series Function Call Driver User's Guide* for more information.

The ASO-1600 and ASO-1400 software package also contains miscellaneous support files, example programs, and the following:

- *Configuration Utility* - The configuration utility (CFG1600.EXE) is a program for creating or modifying a DAS-1600/1400 Series configuration file.

  A configuration file contains the settings used by the DAS-1600/1400/1200 Series Function Call Driver and other driver software for configuring a board. For more information on the configuration utility, refer to "Creating a Configuration File" on page 3-6.

- *Calibration Utility* - The calibration utility (CAL1600.EXE or CAL1400.EXE) is a DOS-based program for calibrating the analog I/O circuitry of the DAS-1600/1400 Series boards. For more information on the calibration utility, refer to Chapter 6.

- *Control Panel* - The Control Panel is a stand-alone program supplied in a DOS version (CTL1600.EXE) and a Windows version (CTL1600W.EXE). This program provides access to all DAS-1600/1400 Series operations without programming.

  Control Panel operations include acquiring analog inputs, controlling analog outputs, and controlling digital I/O. The control panel provides a means of testing the board and your application; it is also a means of performing simple applications and saving data to a disk file.

  The Windows version allows you to graphically represent up to eight analog inputs and transfer acquired data to other Windows applications through the Windows Dynamic Data Exchange (DDE) feature. Refer to Chapter 5 for more information on the Control Panel.

- *Port I/O software* - If you are programming in the Windows environment, you can use the Port I/O (PIO) software to program DAS-1600/1400 Series boards at the register level using I/O instructions. Refer to the PORTIO.TXT file for more information.

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- **VDAS-1600** - VisualDAS™ Custom Controls for Visual Basic for Windows. VisualDAS simplifies the setup of data acquisition operations. The package includes a comprehensive user's guide, offers extensive online help, and furnishes software on 3.5-inch and 5.25-inch diskettes.

- **Data acquisition and analysis application software** - VIEWDAC®, EASYEST LX®, and EASYEST AG™ are integrated software packages available for DAS-1600/1400 Series boards. Programming tools, such as ASYST® scientific and engineering programming language, are also available to help you in writing your application programs.

Note: If you use VIEWDAC, EASYEST LX, EASYEST AG, or ASYST to program your DAS-1600/1400 Series board, you must use the DAS-1600 External Driver. This driver is included in the DAS-1600/1400 Series standard software package and is described in Appendix C.

Other data acquisition and analysis packages include the following:

- **SNAP-MASTER** - Data acquisition and analysis package from H.E.M. Data Corporation (only available for Windows).

- **NOTEBOOK/NOTEBOOK*pro*** - Menu-driven data acquisition and analysis from Laboratory Technologies Corporation (available for both DOS and Windows).

- **STREAMER** - Menu-driven data acquisition software for high-speed transfers of DAS-1600/1400 Series data to a hard disk (only available for DOS).

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Accessories

The following accessories are available for use with the DAS-1600/1400 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 signals from the PIO cable connector (J2) to screw terminals.
- **STC-37** - Direct DAS-1600/1400 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 boards; requires the S-1600 cable and the PG-408A option.
- **EXP-GP** - 8-channel signal conditioning board with Wheatstone bridge and RTD interface; requires the S-1600 cable.

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2

Functional Description

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

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

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

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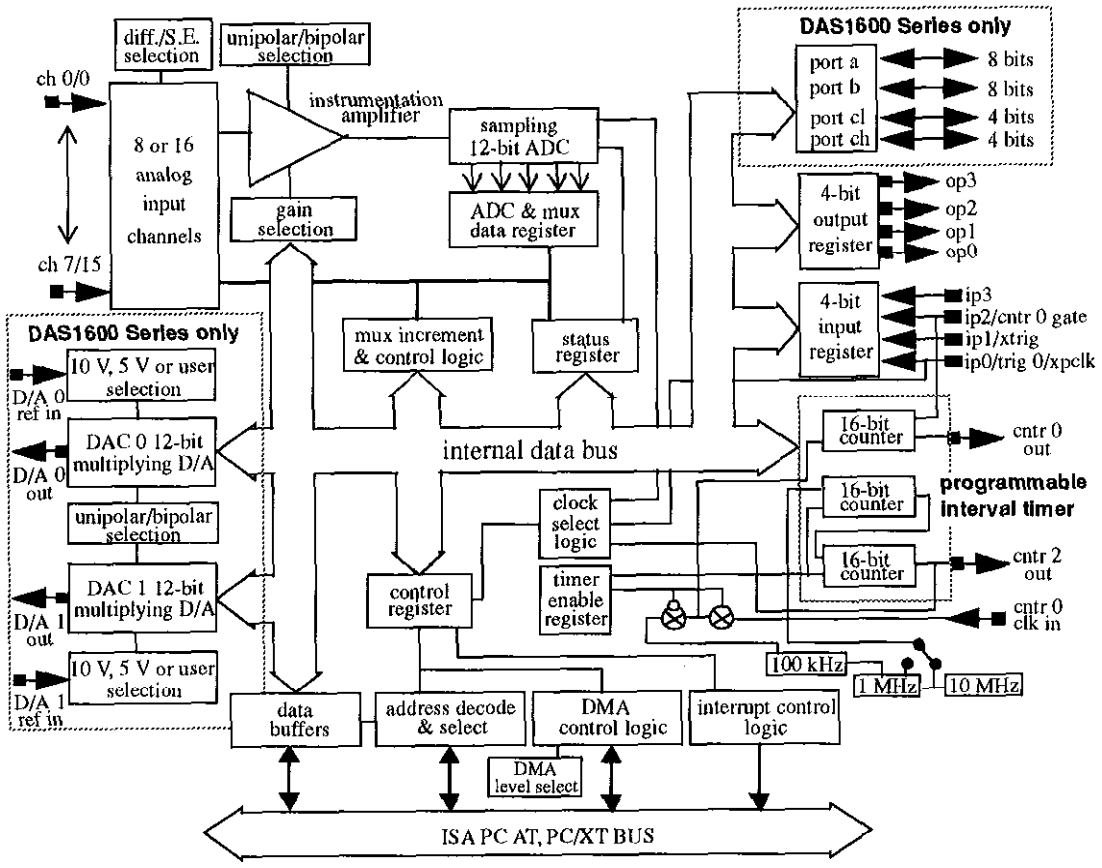


Figure 2-1. Functional Block Diagram

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Analog Input Features

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

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

Unipolar/Bipolar Selection

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

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

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Channel Selection in Expanded Configurations

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

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

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-1600/1400 Series boards.

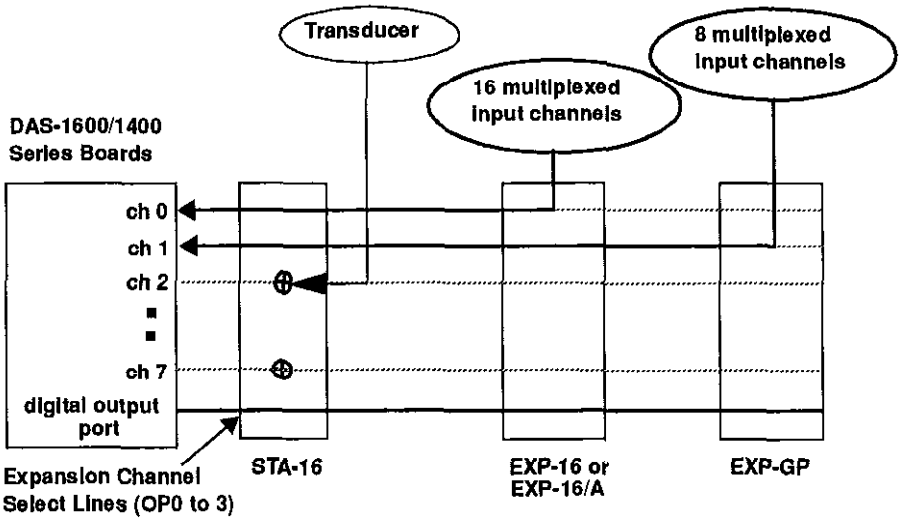


Figure 2-2. Expanding the Analog Inputs of DAS-1600/1400 Series Boards

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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 Chapter 4.

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

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

Gain Selection

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

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

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

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

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

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

Conversion Modes

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

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

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

  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.

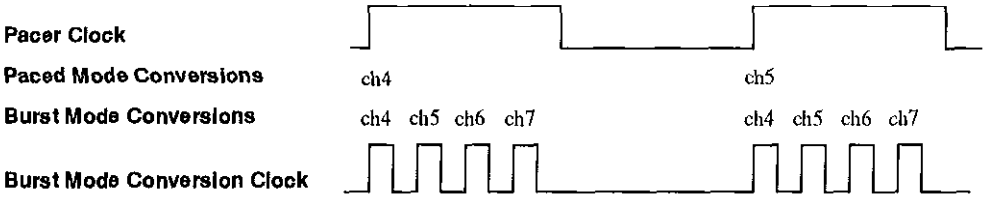


Figure 2-3. Timing Relationships of Conversion Modes

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Clock Sources

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

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

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

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

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

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

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

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Notes: The ADC acquires samples at a maximum of 100 ksamples/s (one sample every 10.0 µs). If you are using an external clock, make sure 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.

Triggers

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

- **Internal** - When you enable the analog input operation, conversions begin immediately.
- **External Analog** - While an analog trigger is not a hardware feature of the DAS-1600/1400 Series boards, you can program an analog trigger using one of the analog input channels as the trigger channel. The DAS-1600/1400/1200 Series Function Call Driver provides functions for an analog trigger; refer to the *DAS-1600/1400/1200 Series Function Call Driver User's Guide* for more information.
- **External Digital** - While a digital trigger is not a hardware feature of the DAS-1600/1400 Series boards, you can program a digital trigger using one of the digital input channels as the trigger channel. The DAS-1600/1400/1200 Series Function Call Driver provides functions for a digital trigger; refer to the *DAS-1600/1400/1200 Series Function Call Driver User's Guide* for more information.

  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.

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

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

Data Transfer Modes

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

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

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

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

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

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

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

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

Analog Output Features (DAS-1600 Series Only)

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

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

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

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

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

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Digital I/O Features

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

Logic 1 on an I/O line indicates that the input/output is high; logic 0 on an I/O line indicates that the input/output is low (see Table A-3 on page A-5 for logic levels). The digital inputs are compatible with TTL-level signals. These inputs are provided with 10 kΩ pull-up resistors to +5 V; therefore, the inputs appear high (logic 1) with no signal connected.

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

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

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

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

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

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

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Counter/Timer Features

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

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

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Wait State Selection

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

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

Power

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

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3

Setup and Installation

This chapter describes inspection, software installation, configuration, and hardware installation for DAS-1600/1400 Series boards.

Read this chapter before you attempt to install and use your DAS-1600/1400 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-1600/1400 Series board:

1. Factory packaging of the DAS-1600/1400 Series boards includes a final wrap of protective, anti-static material. Remove the board from its anti-static wrapping material. You may wish to 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).

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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 Chapter 6 for instructions.

Installing the Software Package

This section provides installation procedures for the DAS-1600/1400 Series standard software package and the ASO-1600 and ASO-1400 software package. Before you work with the software from any package, make a copy of all diskettes in the package. Use the copies as your working diskettes, and store the originals as backup diskettes.

Installing the DAS-1600/1400 Series Standard Software

The DAS-1600/1400 Series standard software package is for the DOS environment only. Use the following procedure to install this package:

1. Insert diskette #1 into an appropriate floppy-disk drive of your computer.

2. Change to the drive containing the diskette and enter the following at the DOS prompt:

```
INSTALL
```

3. Respond to the installation program prompts.

4. When the installation program requests a designation for the drive that is to receive your software, enter a designation of your choosing or defer to the default designation of *C*.

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5. When the installation program requests a name for the directory that is to receive the software, enter a name of your choosing or accept the default name.

   The installation program automatically creates a hierarchical directory tree on the specified drive and then copies all files, expanding any compressed files, to the new directory.

6. Insert any additional disks, as required by the installation program.

The installation program notifies you when it completes the installation. After the installation, you may want to review the following files:

- **README.TXT** - An ASCII text file containing information available after the publication of this manual.
- **EXAMPLES.TXT** - An ASCII text file containing notes and tips on how to successfully compile and execute the supplied example programs.
- **FILES.TXT** - An ASCII text file that lists and describes all the files that can be installed.

Installing the ASO-1600 and ASO-1400 Advanced Software Option

The ASO-1600 and ASO-1400 advanced software option contains software for both the DOS and Windows environments. This section contains procedures for installing both versions.

DOS Installation

Use the following procedure to install the DOS version of the ASO-1600 and ASO-1400 software package:

1. Insert diskette #1 into an appropriate floppy-disk drive of your computer.

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2. Change to the drive containing the diskette and enter the following at the DOS prompt:

   ```
   INSTALL
   ```

3. Respond to the installation program prompts.

4. When the installation program requests a designation for the drive that is to receive your software, enter a designation of your choosing or defer to the default designation of *C*.

5. When the installation program requests a name for the directory that is to receive the software, enter a name of your choosing or accept the default name.

   The installation program automatically creates a hierarchical directory tree on the specified drive and then copies all files, expanding any compressed files, to the new directory.

6. Insert any additional disks, as required by the installation program.

The installation program notifies you when it completes the installation. After the installation, you may want to review the following files:

- **README.TXT** - An ASCII text file containing information available after the publication of this manual.
- **EXAMPLES.TXT** - An ASCII text file containing notes and tips on how to successfully compile and execute the supplied example programs.
- **FILES.TXT** - An ASCII text file that lists and describes all the files that can be installed.

Windows Installation

Use the following procedure to install the Windows portion of the ASO-1600 and ASO-1400 software package:

1. Insert diskette #1 into an appropriate floppy-disk drive of your computer.

2. Enter the Windows environment.

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3. From the Program Manager File menu, select Run.

4. In the Command Line text box, type the letter of the drive containing your Windows diskette and follow with **SETUP**. For example, if your diskette is in drive B, type the following:

```
B:SETUP
```

5. Select OK.

6. Respond to the installation program prompts.

7. When the installation program requests a designation for the drive that is to receive your software, enter a designation of your choosing or defer to the default designation of *C*.

8. When the installation program requests a name for the directory that is to receive the software, enter a name of your choosing or accept the default name.

   The installation program automatically creates a hierarchical directory tree on the specified drive and then copies all files, expanding any compressed files, to the new directory.

   The installation program also creates a DAS-1600 program manager group containing icons for all DAS-1600 programs and information files.

9. Insert any additional disks, as required by the installation program.

The installation program notifies you when it completes the installation. After the installation, you may want to review the following files:

- **README.TXT** - An ASCII text file containing information available after the publication of this manual.

- **EXAMPLES.TXT** - An ASCII text file containing notes and tips on how to successfully compile and execute the supplied example programs.

- **FILES.TXT** - An ASCII text file that lists and describes all the files that can be installed.

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Creating a Configuration File

The configuration file contains a list of the configuration options and a setting for each. The file is used by application packages such as VIEWDAC and EASYEST LX as well as programs written using the Function Call Driver. When you set up software to operate your DAS-1600/1400 Series board, you specify the name of the configuration file.

The switch-configurable options that you enter into the configuration file are also used to create a graphic representation that you can use as a reference when you set up switches on your board. Setting switch-configurable options is discussed under "Setting Switch-Configurable Options" on page 3-14.

The configuration file you specify can be either the default configuration file for the board you are installing or a file you create with the configuration utility. The following sections describe the default configuration file and the configuration utility.

Default Configuration File

A default configuration file called DAS1600.CFG is provided in both the DAS-1600/1400 Series standard software package and the ASO-1600 and ASO-1400 software package. The default configuration file contains an ASCII list of the configuration options that apply to a DAS-1602 board.

Table 3-1 lists the configuration options and their default settings.

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Table 3-1. Default Configuration File Settings

Options	Default settings
Board number	0
Board name	*DAS1602*
Address	&H300
Clock timebase	10 MHz
Wait state	No
A/D mode	Bipolar
A/D configuration	Differential
DAC0 mode	Bipolar
DAC1 mode	Bipolar
DAC0 ref	*–5.0 (C0A00000)*
DAC1 ref	–5.0 (C0A00000)
DMA channel	3
Interrupt level	7
Port A	*Input*
Port B	Input
Port CL	Input
Port CH	Input
Number of EXP-16s	*0*
Number of EXP-GPs	0
Number of SSHs	0

If the default settings meet the needs of your application, refer to Figure 3-1 on page 3-14 to visually verify the default switch-configurable options and then go on to "Installing the Board" on page 3-18. If you have to change the default configuration file settings, refer to the next subsection.

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Configuration Utility

The configuration utility, CFG1600.EXE, is furnished in both the DAS-1600/1400 Series standard software package and the ASO-1600 and ASO-1400 software package. This utility enables you to modify an existing configuration file or to create a new configuration file for up to two boards. To modify or create a configuration file, use the following procedure:

1. Start the configuration utility from DOS or Windows as follows:

   – From *DOS*, change to the directory containing CFG1600.EXE and enter the following at the DOS prompt:

   ```
   CFG1600 <filename>
   ```

   where the optional <*filename*> is the name of the configuration file you want to modify or create. If the file is not located in your default directory, include its full pathname.

   – From *Windows*, select Run from the Program Manager File menu. Enter the following in the Command Line dialog box, and select OK.

   ```
   path CFG1600 <filename>
   ```

   where *path* is the complete path to CFG1600.EXE and the optional <*filename*> is the name of the configuration file you wish to modify or create. If the file is not located in your default directory, include its full pathname.

   Whether *filename* is an existing file in the directory containing CFG1600.EXE or a file to be created, it is the name displayed by the configuration utility's opening screen. However, the settings displayed for *filename* may differ as follows:

   – If *filename* is an existing file, the configuration utility displays the settings contained in this existing file.

   – If *filename* is a file to be created, the configuration utility displays the default configuration settings.

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– If no entry was made for *filename*, the configuration utility displays the default configuration file DAS1600.CFG.

Note: If you alter the default configuration file, you should rename it and then create a new default configuration file by starting the configuration utility with no *filename* and saving the results without change.

---

2. In the opening screen, enter the number of boards you plan to configure (**1** or **2**).

   After you make this entry, the utility program displays the configuration window for the first board (board 0, which is shown in the upper-left corner of the window). The window contains the following configuration options:

   – *Board name* - This option identifies the board you are installing. You can select one of the following:

DAS-1601	DAS-1401	DAS-1201
DAS-1602	DAS-1402	DAS-1202

   – *Base address* - This option requires selection of a 3-digit hexadecimal address. The addresses you can select range from 200h to 3F0h. Base addresses presented for selection begin on even boundaries that increment by 16 (00Fh).

     When selecting a base address, do not select an address that conflicts with those already in use. Table 3-2 lists standard address assignments and their corresponding devices.

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Table 3-2. Standard Address Assignments

Addresses	Device	Address	Device
000 - 0FF	Internal I/O	378 - 37F	Printer
100 - 1FF	Undecoded	380 - 389[1]	Binary comm. 2
200 - 20F	Joy stick port	380 - 38C[1]	SDLC comm.
210 - 217	Expansion unit	390 - 39F	Available
218 - 21F	Available	3A0 - 3A9[1]	Binary comm. 1
220 - 24F	Reserved	3AA - 3AF	Available
250 - 277	Available	3B0 - 3BF	Mono disp./printer
278 - 27F	Reserved	3CO - 3CF	Reserved
280 - 2EF	Available	3D0 - 3DF	Color/graphics
2F0 - 2F7	Reserved	3E0 - 3E7	Reserved
2F8 - 2FF	Com2:	3E8 - 3EF	Available
300 - 31F	Available	3F0 - 3F7	Floppy disk
320 - 32F	PC/XT fixed disk	3F8 - 3FF	Com1:
330 - 377	Available		

Notes

[1] These addresses are slightly different in the IBM PC AT.

- *Clock Select* - This option is a choice between a 1 MHz or 10 MHz clock.
- *Wait State* - This option is a choice between yes and no.
- *A/D mode* - This option is a choice between bipolar and unipolar.
- *A/D config* - This option is a choice between differential and single-ended.
- *D/A 0 Mode* - This option applies to DAS-1600 Series boards only. This option is a choice between bipolar and unipolar.

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– *D/A 1 Mode* - This option applies to DAS-1600 Series boards only. This option is a choice between bipolar and unipolar.

– *DMA channel* - This option is a choice between DMA channels 3 and 1.

– *IRQ level* - This option selects an interrupt level from 2 through 7. Table 3-3 lists the standard interrupt request assignments.

Table 3-3. Standard Interrupt Request (IRQ) Assignments

Interrupt Level	
IRQ2	Reserved (XT), IRQ 8 to 15 (AT)
IRQ3	COM2 or SDLC
IRQ4	COM1 or SDLC
IRQ5	Hard disk (XT), LPT (AT)
IRQ6	Floppy disk
IRQ7	LPT

– *Digital CFG* - This option applies to DAS-1600 Series boards only. The option displays a menu that allows you to select either input or output for the digital ports A, B, CL, and CH.

– *Number EXP-16s* - This option specifies the number of EXP-16 and EXP-16/A expansion multiplexer/amplifiers that you are going to install. You can select from 0 to 8 EXP-16s. When a value other than 0 is selected, the *EXP-16 Gains* option is applicable.

– *EXP-16 Gains* - This option specifies the switch-configurable gain that you set for each channel of the EXP-16s you are installing in your system.

Refer to the *EXP-16 & EXP-16/A Expansion Multiplexer/Amplifier System User's Guide* for more information.

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- *Number EXP-GPs* - This option specifies the number of EXP-GP general-purpose multiplexer and signal conditioning modules that you are going to install. You can select from 0 to 8 EXP-GPs. When a value other than 0 is selected, the *EXP-GP Gains* option is applicable.

- *EXP-GP Gains* - This option displays two menus. The first menu selects the switch-configurable gain multiplier that you set up for all EXP-GP channels. The factors you can choose from are X1 or X2.5.

  The second level menu selects the switch-configurable gain factor you are setting for each individual channel of the EXP-GP boards you are installing in your system.

  Refer to the *EXP-GP Signal Conditioning Multiplexer User's Guide* for more information.

- *CJR Channel* - If your application uses thermocouples, it is suggested that you use the cold-junction compensation (CJC) circuit of the EXP-GP; this option selects the channel that you are connecting the CJC sensor to.

- *Number of SSHs* - This option specifies the number of simultaneous sample-and-hold boards that you are installing in your system. You can select a maximum of four when you are installing SSH-4/A boards and a maximum of two when installing SSH-8 boards.

- *SSH Type* - This option is a choice between SSH-4/A and SSH-8 simultaneous sample-and-hold boards.

Warning: When you select SSH-8 as an *SSH Type*, you must select a 10 MHz clock (in the *Clock Select* option). Selecting a 1 MHz clock for use with an SSH-8 causes the Function Call Driver and the DAS-1600 External Driver to report an error (28714) and terminate.

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- *SSH Gains* - This option specifies the switch-configurable gains that you set up for each channel of your SSH-4/A or SSH-8.
- *SSH 4/A Mode* - This option is a choice between master and slave modes.
- *SSH Timing* - This option is a choice between internal and external.

  Refer to the *SSH-4A User's Guide* or *SSH-8 User's Guide* for more information.
- *A/D Gain* - Not applicable to DAS-1600/1400 Series boards.

3. To change the setting for a configuration option, use the arrow keys to highlight the option and press **[Enter]** to display a list of option settings. Use the arrow keys to highlight the required setting and then press **[Enter]** to select the setting. These instructions are summarized in the Commands/Status box at the bottom of the screen.
4. When you complete your selections for a board, you can view a graphic representation of the switch positions that correspond to the options you have selected by pressing **[S]** for "Show Switches".

   You can use this graphic representation to set up and verify the switch-configurable options that you have selected. If you have any questions or require additional information, refer to "Setting Switch-Configurable Options" on page 3-14.
5. If you are configuring more than one board, press **[N]** for "Next Board" to display the menu box for the next board.
6. When you complete the changes for all boards, press **[Esc]**.
7. The configuration utility asks whether to save the changes. Press **[Y]** for *yes* or **[N]** for *no*.

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Setting Switch-Configurable Options

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

If you are using a board configuration other than the default, you must generate a configuration file with the configuration utility. You can use the utility's **[Show Switches]** command to generate a graphic representation of switch positions for the options you have selected.

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

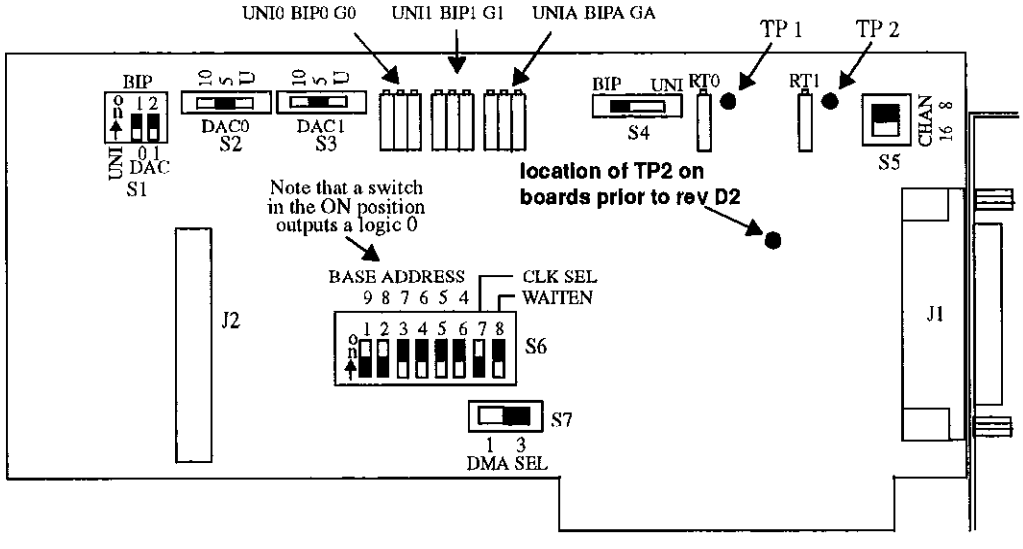


Figure 3-1. Default Switch Configuration for DAS-1600 Series Boards

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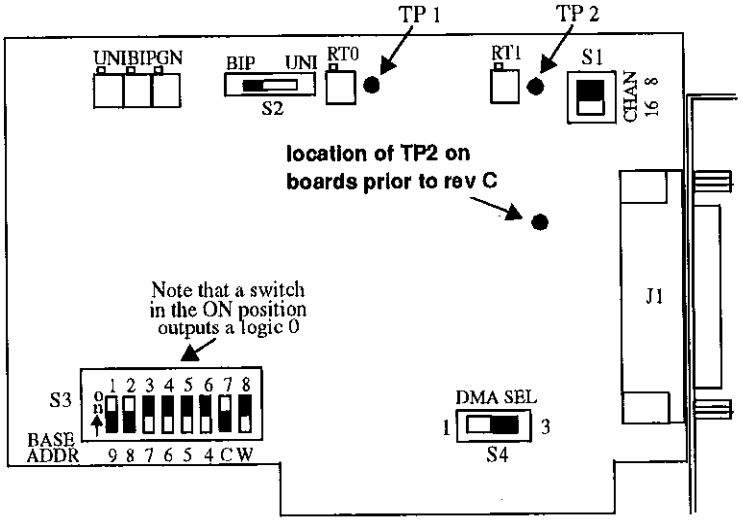


Figure 3-2. Default Switch Configuration for DAS-1400 Series Boards

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

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

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

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

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

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

Setting the ADC Bipolar/Unipolar Switch

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

Setting the Chan 8/16 Switch

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

Setting an Alternate Base Address

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

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

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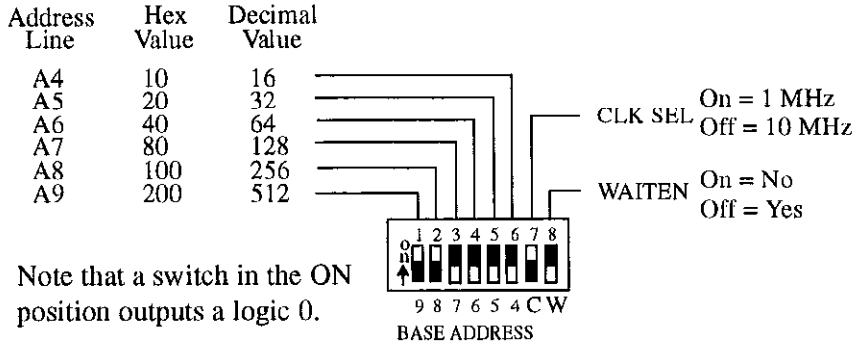


Figure 3-3. Base Address, Clock Select, and Wait State Enable Switch

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

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

1. Select an alternate address that does not conflict with another installed device. See Table 3-2 on page 3-10.

2. Use the configuration utility to create a new configuration file and view the corresponding switch settings in the menu-box diagram (see "Creating a Configuration File" on page 3-6).

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.

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Setting the Clock Select Switch

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

Setting the Wait State Enable Switch

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

Setting the DMA Channel Select Switch

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

Installing the Board

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

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

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

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

2. Remove the computer chassis cover.

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

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

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

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

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

8. Replace the computer cover.

9. Turn on power to the computer.

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

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

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4

Cabling and Wiring

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

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

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

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

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Attaching Screw Terminal Connectors and Accessories

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

- STC-37 Screw Terminal Connector; when using a DAS-1600 Series board, your application may require two connectors
- STP-37 Screw Terminal Panel; when using a DAS-1600 Series board, your application may require two panels
- STA-16 Screw Terminal Accessory
- STA-U Universal Screw Terminal Accessory

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

Attaching an STC-37

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

To connect an STC-37 to the main I/O connector (J1) of a DAS-1600/1400 Series board, 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-1400 Series board.

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

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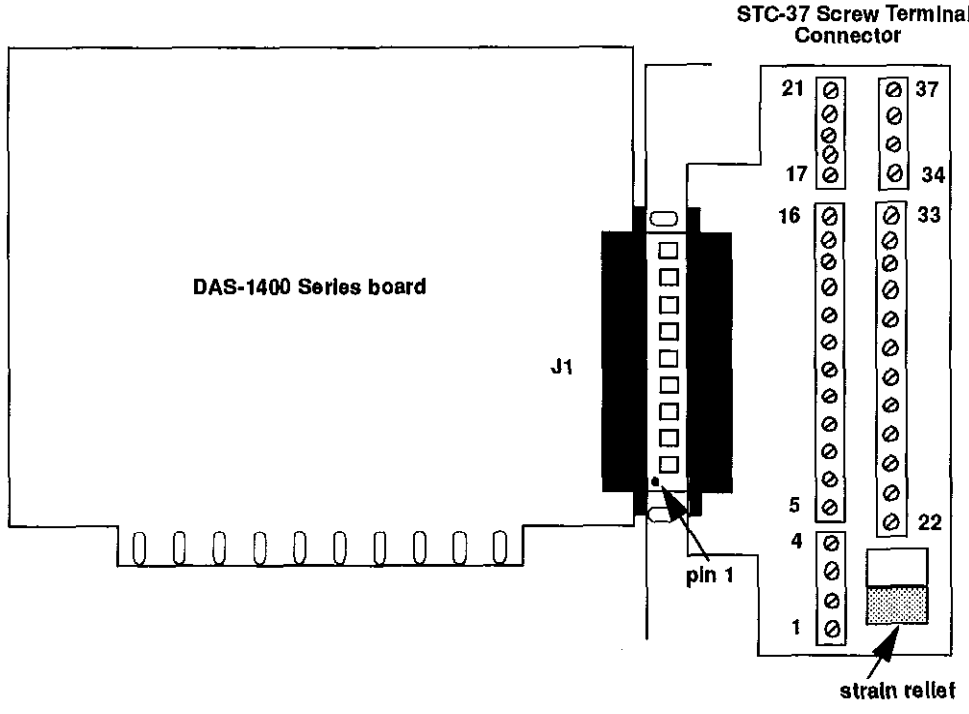


Figure 4-1. Attaching an STC-37 Screw Terminal Connector

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.

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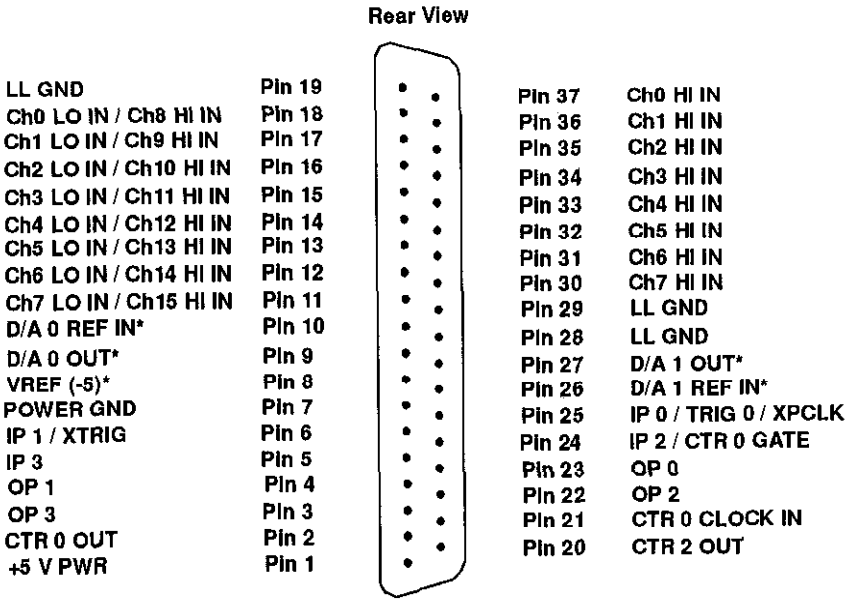


Figure 4-2. Pin Assignments of the Main I/O Connector (J1)

When using an STC-37 to make connections to the bidirectional digital I/O, first attach the board end of the PIO cable to the PIO cable connector (J2) on the DAS-1600/1400 board, then install the 37-pin D-type connector of the PIO cable in the connector panel next to the main I/O connector (J1) of the DAS-1600/1400 Series board, and finally attach the second STC-37 to the 37-pin D-type connector of the PIO cable. For more information about making field connections, see "Connecting Analog Signals" on page 4-24.

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Attaching an STP-37

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

- A 37-pin male connector for cabling to the main I/O connector of a DAS-1600/1400 Series board.
- Labeled screw terminals for connecting sensor outputs and test equipment. These terminals accept wire sizes 12-22 AWG.

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

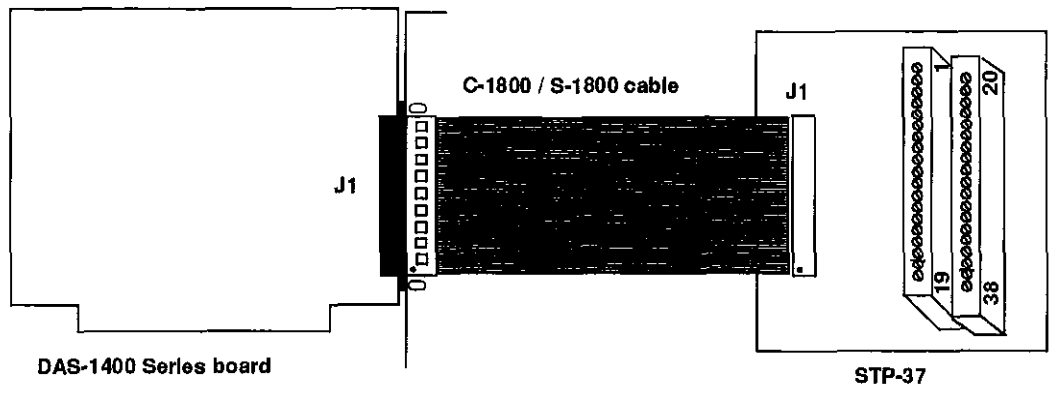


Figure 4-3. Attaching an STP-37 to the Main I/O Connector

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

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

Attaching an STA-16

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

- Two 37-pin male connectors. One for cabling to the main I/O connector of a DAS-1600/1400 Series board and a second for daisy-chaining additional accessories.
- Labeled screw terminals for connecting sensor outputs and test equipment. These terminals accept wire sizes 12-22 AWG.
- A breadboard area for user-installed circuitry.

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

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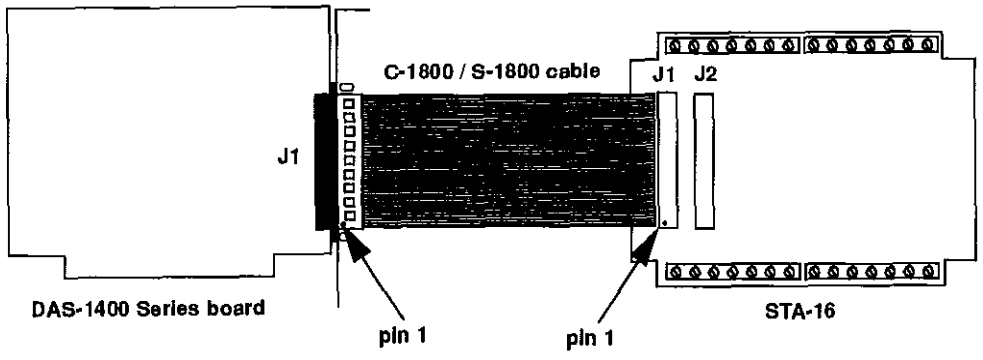


Figure 4-4. Attaching an STA-16

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

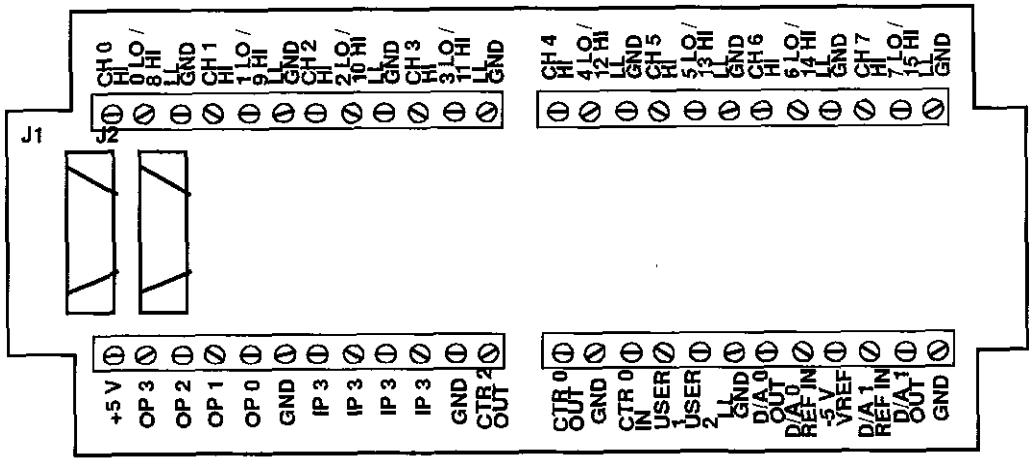


Figure 4-5. STA-16 Terminal Names

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Attaching an STA-U

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

- A 37-pin male connector for cabling to the PIO cable connector (J2) on a DAS-1600 Series board.
- Labeled screw terminals for connecting digital inputs and outputs. These terminals accept wire sizes 12-22 AWG.
- A breadboard area for user-installed circuitry.

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

Figure 4-6 shows how to attach an STA-U to a DAS-1600 Series board.

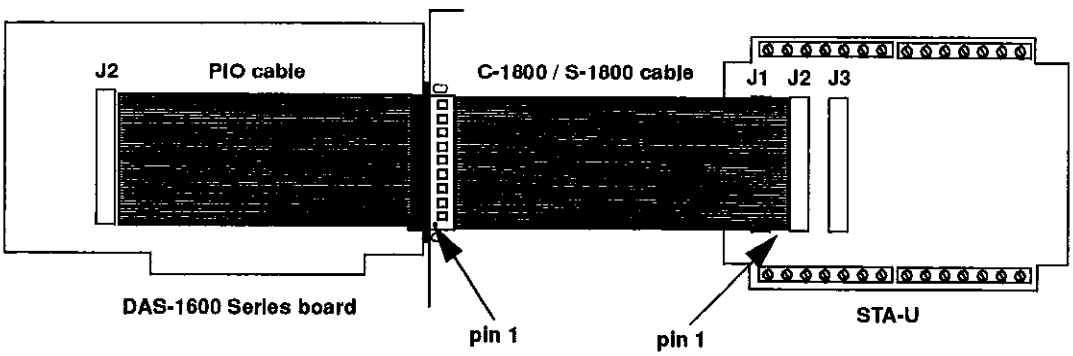


Figure 4-6. Cabling and Connections for Attaching an STA-U

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

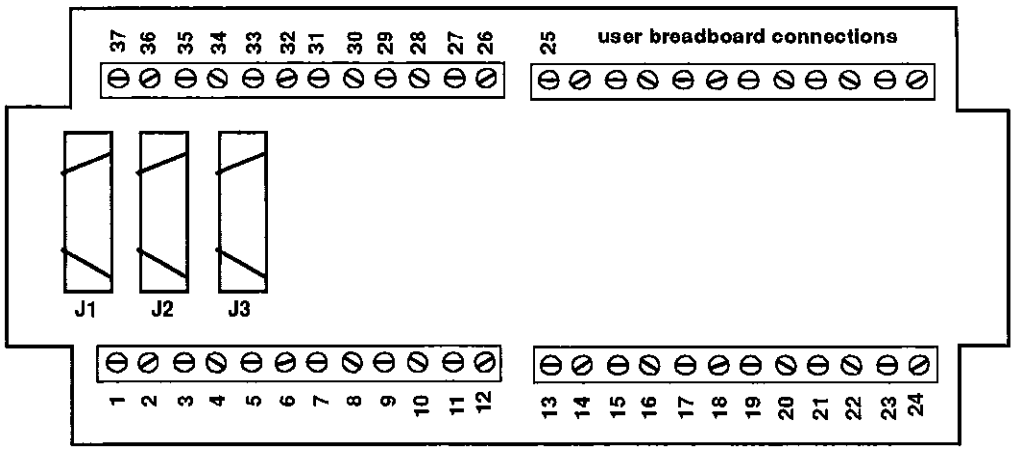


Figure 4-7. STA-U Terminal Names

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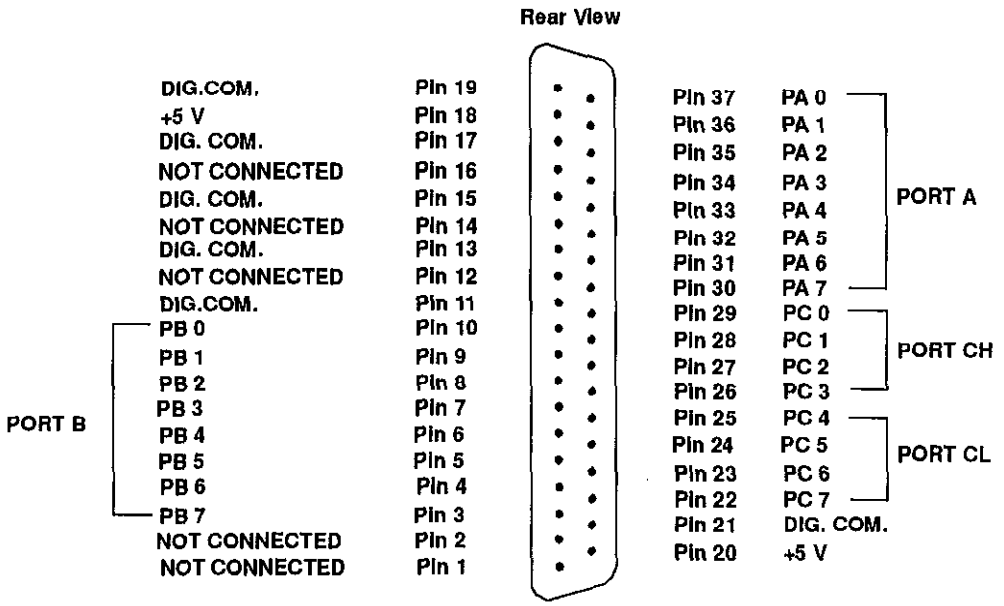


Figure 4-8. Pin Assignments of PIO Cable Connector (J2)

Attaching Expansion Accessories

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

- EXP-16
- EXP-16/A
- EXP-GP

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

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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-1600/1400 Series board, attach one end of an S-1600 cable to the DAS-1600/1400 Series main I/O connector (J1) and the other end of the cable to the J1 connector on the EXP-16 or EXP-16/A. Figure 4-9 illustrates the connection of an EXP-16 to a DAS-1400 Series board.

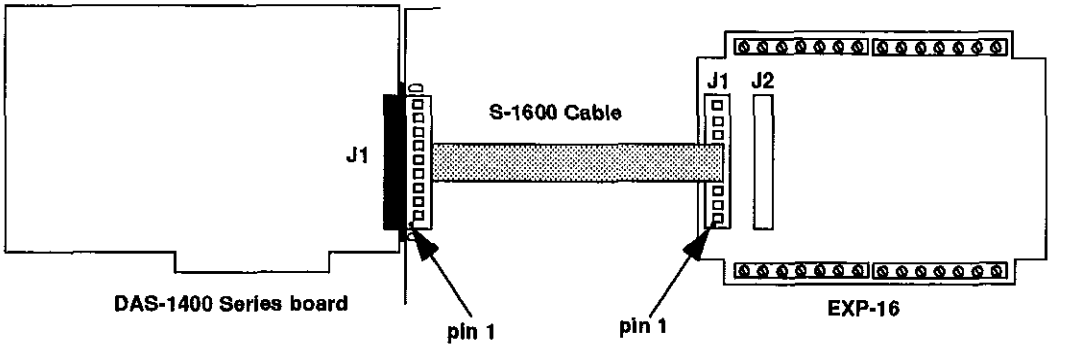


Figure 4-9. Attaching an EXP-16 or EXP-16/A Expansion Accessory

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Note: The S-1600 cable must be used to connect the first EXP to the DAS-1600/1400 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 (J2) on the DAS-1600 Series board.

Attaching an EXP-GP Expansion Accessory

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

Table 4-2. EXP-GP Terminal Names

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

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

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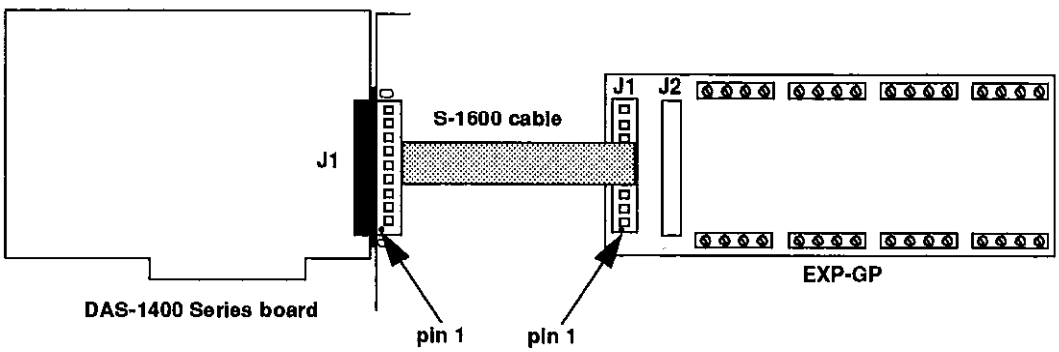


Figure 4-10. Attaching an EXP-GP Expansion Accessory

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-1600/1400 Series board by attaching one end of an S-1600 cable to the main I/O connector (J1) on the DAS-1600/1400 Series board and the other end of the cable to the J1 connector on the expansion accessory.

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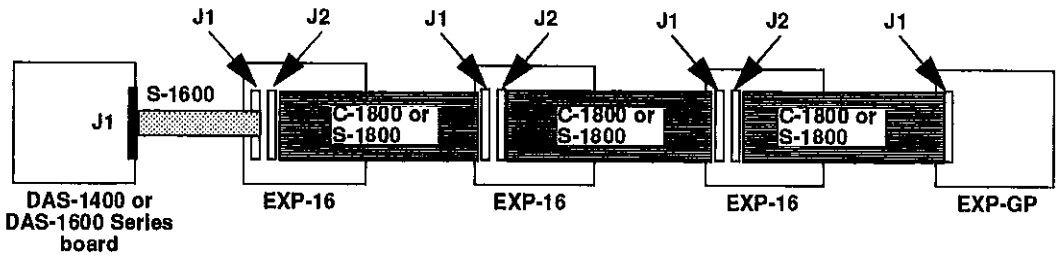


Figure 4-11. Attaching Multiple Expansion Accessories

To connect additional expansion accessories, attach one end of a C-1800 cable or S-1800 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-1600/1400 Series boards. You specify the associated DAS-1600/1400 input channel by setting a jumper on each expansion board. Make sure that you use a unique jumper setting for each expansion board you are using. Refer to your expansion board documentation for more information.

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

You can access the remaining functions of the DAS-1600/1400 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-1400 Series board.

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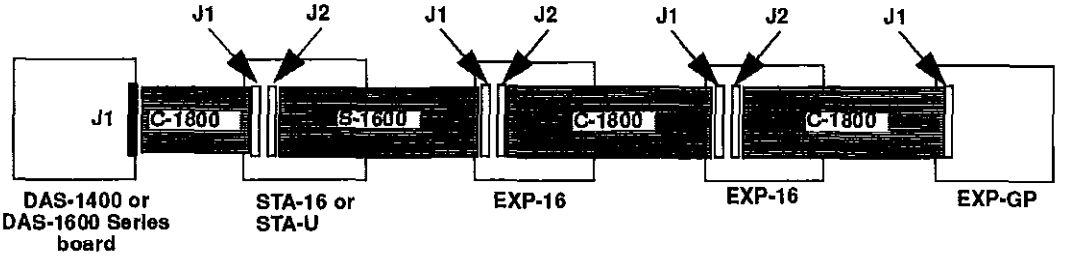


Figure 4-12. Attaching Multiple Expansion Accessories with an STA-16 or STA-U

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 accessory to a DAS-1600/1400 Series board, attach one end of an S-1600 cable to the DAS-1600/1400 Series main I/O connector (J1) and the other end of the cable to the J1 connector on the ISO-4 accessory. Figure 4-13 illustrates the connection of an ISO-4 accessory to a DAS-1400 Series board.

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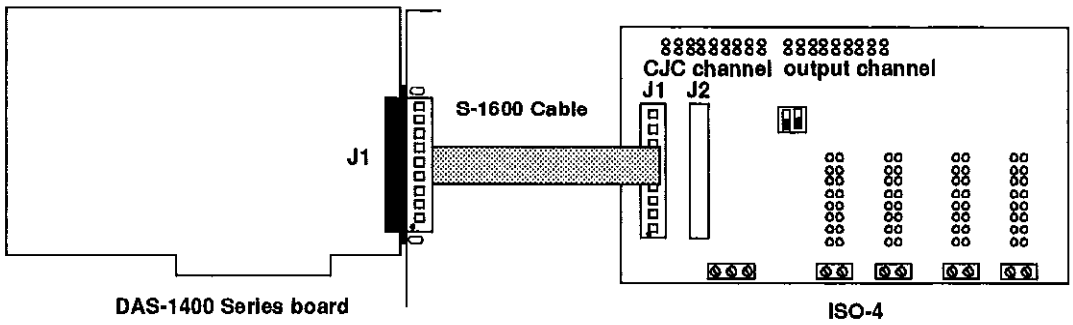


Figure 4-13. Attaching an ISO-4 Accessory

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-1600/1400 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.

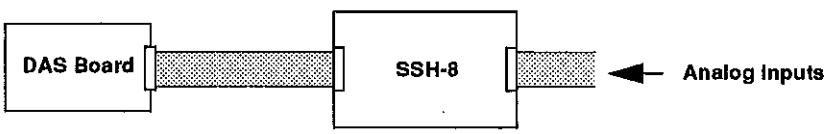


Figure 4-14. A Typical SSH-8 Application

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

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Attaching an SSH-4/A

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

Figure 4-15 shows how to attach the SSH-4/A to a DAS-1400 Series board.

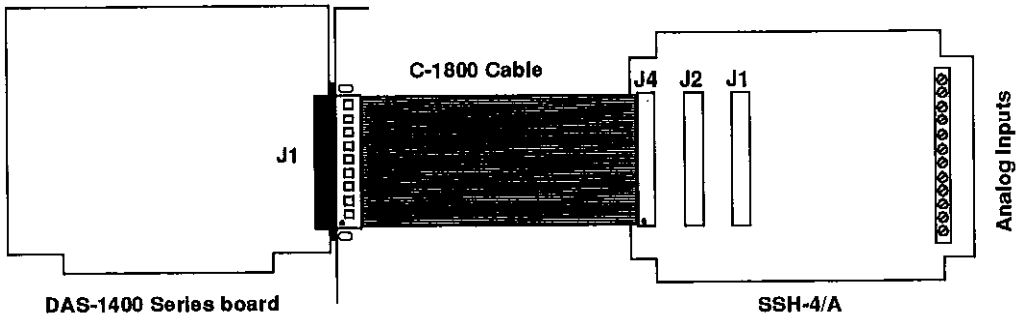


Figure 4-15. Attaching an SSH-4/A Accessory

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-1600/1400 Series boards.

Figure 4-16 and Figure 4-17 show how to attach SSH-8 boards to a DAS-1600/1400 Series board.

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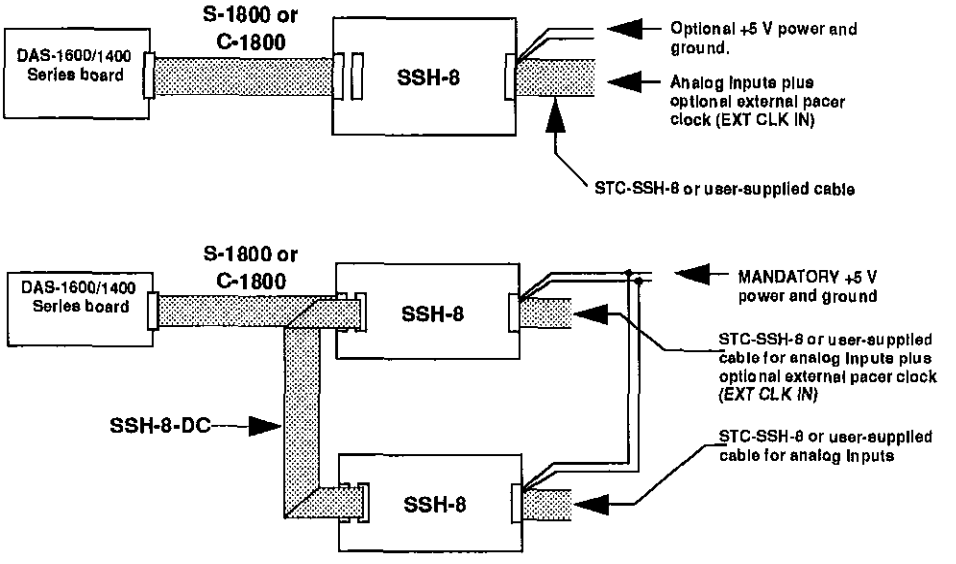


Figure 4-16. Attaching SSH-8 Accessories

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-1600/1400 Series board, put the first in master mode and the second in slave mode.
- Optional channel jumpers are 0 to 7 for the first SSH-8 accessory and 8 to 15 for the second.

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- Where the S-1800 cable is called out, other options include C-1800, S-1801, and C-1801. Crosstalk, shielding, and cost trade-offs are factors in the selection of these options.

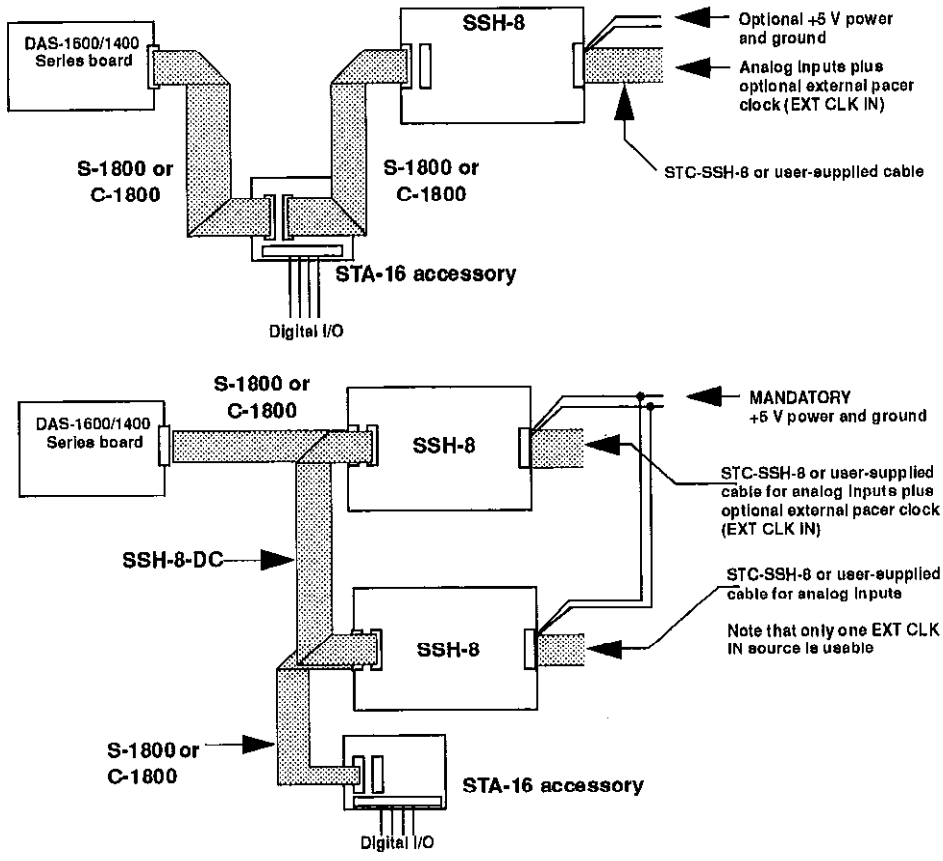


Figure 4-17. Attaching SSH-8 and STA-16 Accessories

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.

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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.

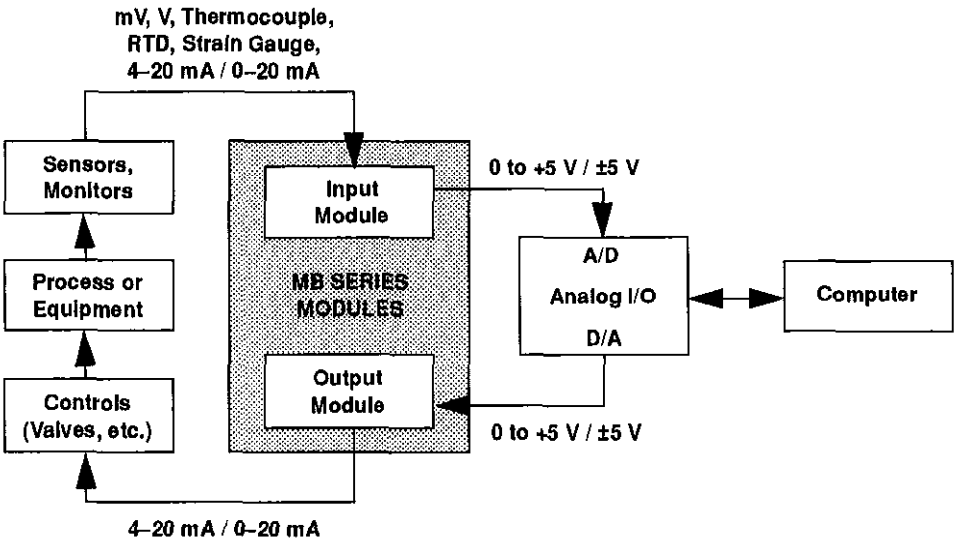


Figure 4-18. Typical Measurement and Control Application

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

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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 an a DAS-1600/1400 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 DAS1600/1400 Series board.

Attaching an MB01 Backplane

Use the C16-MB1 cable to connect a DAS-1600/1400 Series board to an MB01 backplane. This cable connects MB01 channels 0 through 15 to analog input channels 0 through 15 on the DAS-1600/1400 Series board. Refer to Figure 4-19 for a cabling diagram.

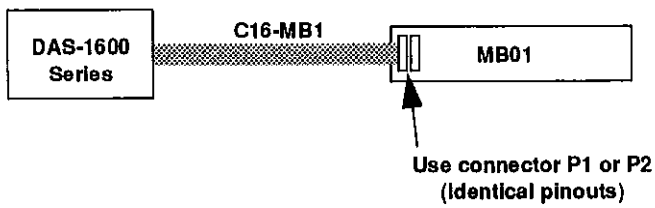


Figure 4-19. Attaching an MB01 Backplane

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

Attaching an MB02 Backplane

Figure 4-20 shows how to connect a DAS-1600/1400 Series board to up to four MB02 backplanes. The STA-SCM16 interface connects one MB02 board to one analog input channel of the DAS-1600/1400 Series board. One C-2600 cable connects each MB02 to the STA-SCM16, and the C-1800 cable connects the STA-SCM16 to the DAS-1600/1400 Series board.

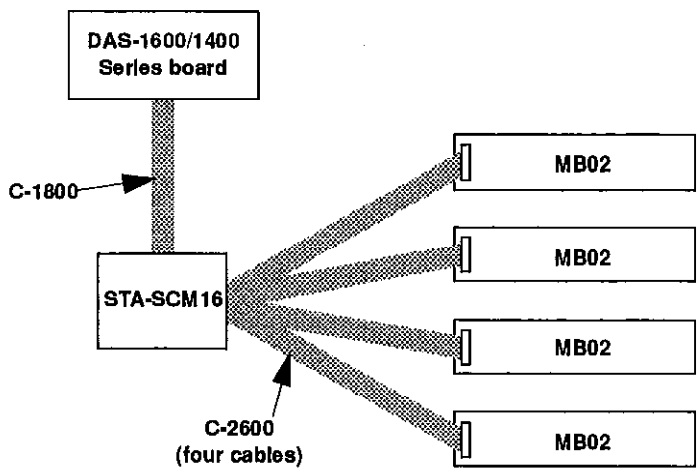


Figure 4-20. Attaching Multiple MB02 Backplanes

Figure 4-21 shows how the STA-SCM16 connects DAS-1600/1400 Series boards with MB02 backplanes.

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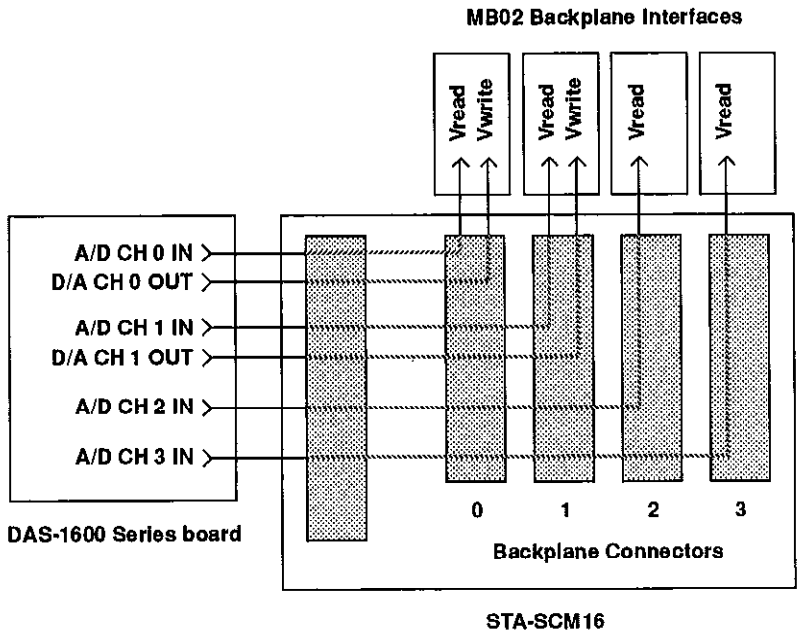


Figure 4-21. MB02 I/O Connections

The four digital output lines on the DAS-1600/1400 Series boards select one of the 16 MB02 channels. For example, if you set the digital output lines to 1000 (8 decimal), MB02 channel 8 is selected on all four backplanes. Analog input channels 0 to 3 on the DAS-1600/1400 Series board map directly to the connectors labeled 0 to 3 on the STA-SCM16.

In this arrangement, the channel connections are single-ended. Make sure that the DAS-1600/1400 Series board is set for single-ended, 16-channel operation.

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

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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-1600/1400 Series boards.

While the circuit diagrams show direct connections to channel input pins of the main I/O connector, you must make actual connections through corresponding inputs of an accessory.

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-1601 or DAS-1401 boards at high gain, read the precautionary information in the following section. Other considerations for I/O connections are offered under "Additional Precautions" on page 4-25.

Precautions for Using DAS-1601/1401Boards at High Gains

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

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

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- Minimize noise from crosstalk and induced-voltage pickup in the flat cables and screw terminal accessories by using shielded cable. Connect the shield to LL GND and the inner conductors to Channel LO and HI. Channel LO and LL GND should have a DC return (or connection) at some point; this return should be as close to the signal source as possible. Induced noise from RF and magnetic fields can easily exceed tens of microvolts, even on one- or two-foot cables; shielded cable eliminates this problem.

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

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

Additional Precautions

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

- Avoid direct connections to the AC line.

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

- Use isolation amplifiers and transformers where necessary.

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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-1600/1400 Series board configured for single-ended input mode.

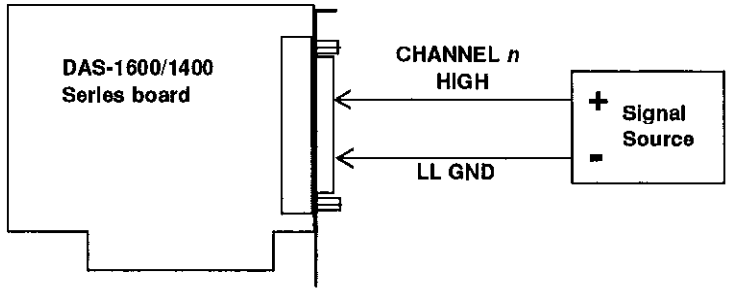


Figure 4-22. Connections for Wiring a Signal Source to a DAS-1600/1400 Series Board Configured for Single-Ended Inputs

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

- POWER GND is the noisy or "*dirty*" ground that carries all digital signal and power supply currents.
- LL GND or low level ground is the ground reference for all analog input functions and it only carries signal currents that are less than a few mA.

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.

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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-1600/1400 Series board configured for differential input mode.

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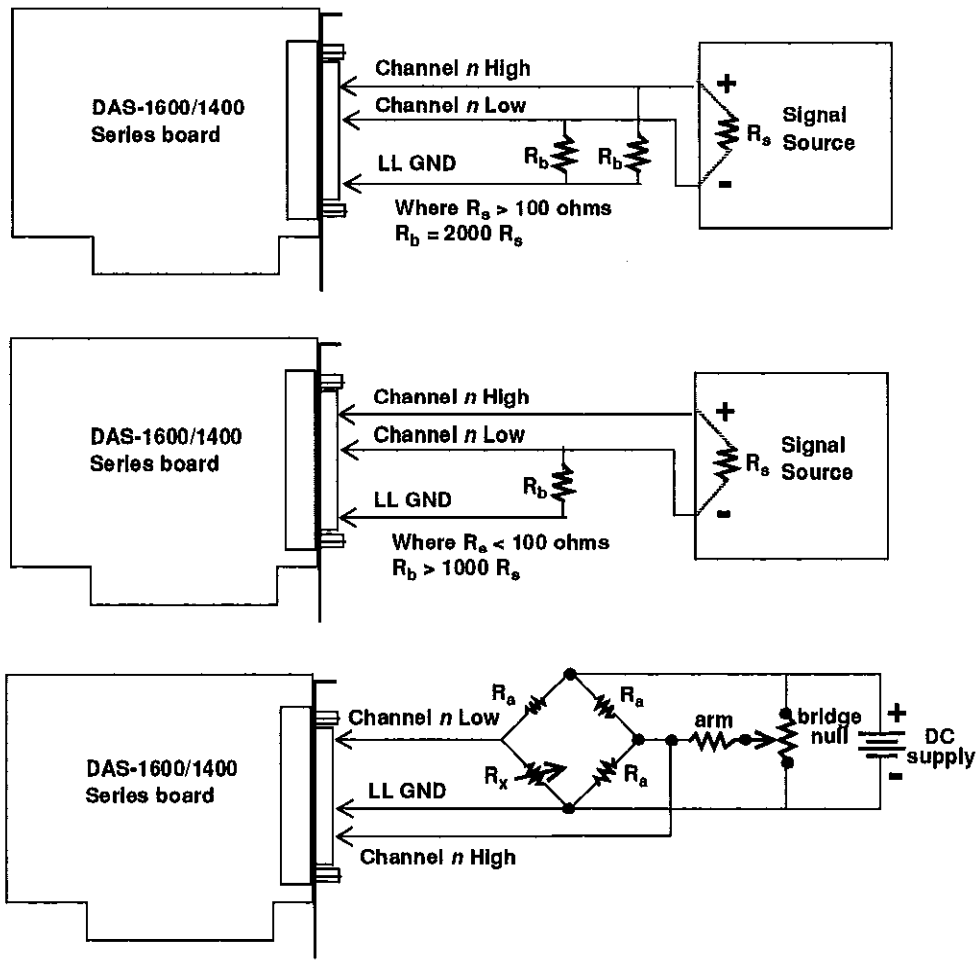


Figure 4-23. Three Methods of Wiring Differential Inputs

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

- When R_s is greater than 100 Ω, use the connections in the upper circuit. The resistance of each of the two bias return resistors must equal 2000 R_s.
- When R_s is less than 100 Ω, use the connections in the middle circuit. The resistance of the bias return resistor must be greater than 1000 R_s.

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

Avoiding Ground Loops with Differential Inputs

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

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.*

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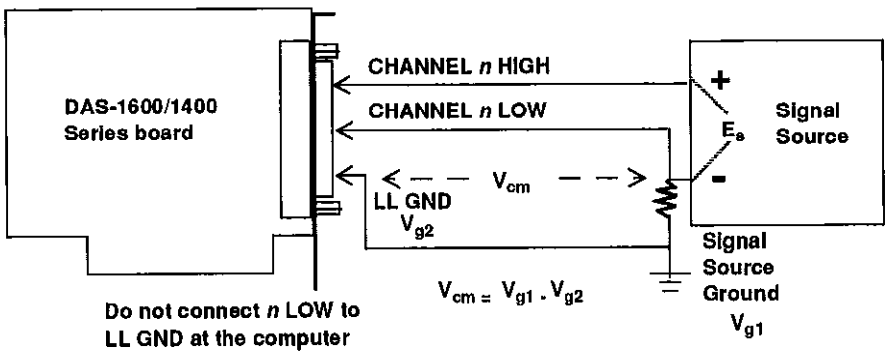


Figure 4-24. A Differential Input Configuration that Avoids a Ground Loop

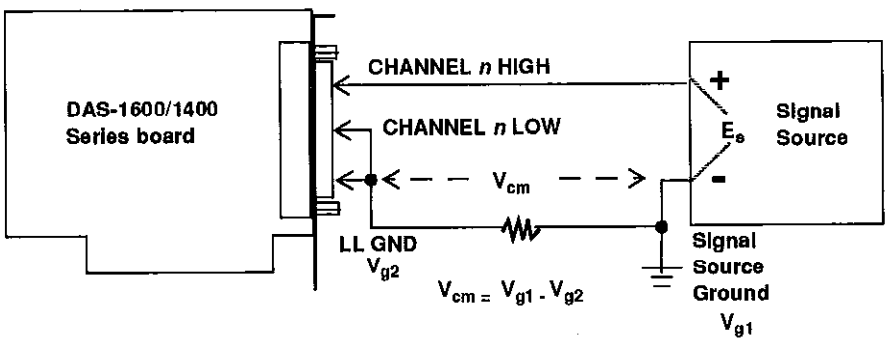


Figure 4-25. Differential Input Configuration with a Ground Loop

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Connecting Analog Output Signals

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

Table 4-4. DAC Input and Output Connections

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

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5

The Control Panel

The Control Panel is a utility program for testing the functions of your DAS-1600/1400 Series boards; it is available in a DOS version (CTL1600.EXE) and a Windows version (CTL1600W.EXE). The DOS version is part of both the DAS-1600/1400 Series standard software package and the ASO-1600 and ASO-1400 software package. The Windows version is a part of the ASO-1600 and ASO-1400 software package only.

Note: Before using the Windows version of the Control Panel, you are advised to install the Keithley Memory Manager (VDMAD.386) to ensure the allocation of a memory buffer large enough for Control Panel needs. Refer to Appendix D for details of the Keithley Memory Manager.

To use the Control Panel, perform the following steps:

1. Start the Control Panel from the DOS or Windows environments as follows:

   – *If you are in the DOS environment*, change to the directory containing the CTL1600.EXE program and enter the following at the DOS prompt:

   ```
   CTL1600
   ```

   – *If you are in the Windows environment*, double click on the Control Panel icon in the DAS-1600 Group window, which is within the Program Manager window.

   After the Control Panel starts, it asks you for the name of a configuration file.

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2. To use the settings from the default configuration file, select OK. If you prefer to use the settings from another configuration file, enter the name of that file and select OK.

   After the Control Panel accepts the name of a configuration file, it displays the DAS-1600 TEST & CONTROL panel. This panel contains the controls that allow you to acquire, read, and transfer data and to set up and display parameters.

3. To set up and perform an operation, select the appropriate buttons. To obtain information on the setup and performance of an operation, use the Help option in the Control Panel menu. To obtain information on DAS-1600/1400 Series board functions and parameters, refer to Chapter 2.

4. To set up and perform a digital I/O operation, select Digital I/O from the Control Panel menu; to set up and perform a D/A operation, select D/A from the Control Panel menu. When the Control Panel displays the DIGITAL I/O & D/A panel, you can select appropriate buttons to proceed with your operation.

5. *If you are working in the Windows environment*, you can use the Control Panel's Dynamic Data Exchange (DDE) to transfer data to another Windows program by selecting DDE from the Control Panel menu and use the Display options/Graphics panel to graph up to eight channels.

6. Use the File menu to open, close, or save a file.

7. When you finish using the Control Panel, select the Exit option from the File menu to terminate the program.

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6

Calibration

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

Equipment Requirements

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

- A digital voltmeter accurate to a minimum of 5 1/2 digits
- An adjustable ±10 V power source

Potentiometers and Test Points

Figure 3-1 on page 3-14 and Figure 3-2 on page 3-15 show the locations of the potentiometers and test points that are used during the calibration of a DAS-1600 Series or DAS-1400 Series board.

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

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Calibration Utility

To calibrate a DAS-1600 Series board, use the DOS-based CAL1600.EXE calibration utility. To calibrate a DAS-1400 Series board, use the DOS-based CAL1400.EXE calibration utility. These utilities are included in both the DAS-1600/1400 Series standard software package and the ASO-1600 and ASO-1400 software package.

Start the calibration utility by changing to its directory and entering the following at the DOS prompt:

```
CAL1600
```

or

```
CAL1400
```

Follow the utility-program prompts as they appear; the program guides you through the calibration process.

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7

Troubleshooting

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

Problem Isolation

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

Identifying Symptoms and Possible Causes

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

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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 3-16 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 factory; see page 7-6.
Intermittent operation	The most common cause of this problem is that the I/O bus speed is in excess of 8 MHz.	Reduce I/O bus speed to a maximum of 8 MHz (to change the I/O bus speed, run BIOS setup). See the documentation for your computer for instructions on running BIOS setup.
	Vibrations or loose connections exist.	Cushion source of vibration and tighten connections.
	The board is overheating.	Check environmental and ambient temperature. See the documentation for your computer.
	Electrical noise exists.	Provide better shielding or reroute wiring.
	Bus cycles require wait state.	Enable wait states on the DAS-1600/1400 Series board.

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Table 7-1. Troubleshooting Information (cont.)

Symptom	Possible Cause	Possible Solution
Data appears to be invalid	The most common cause of this problem is that the I/O bus speed is in excess of 8 MHz.	Reduce I/O bus speed to a maximum of 8 MHz (to change the I/O bus speed, run BIOS setup). See the documentation for your computer for instructions on running BIOS setup.
	An open connection exists.	Check wiring to screw terminal.
	Another device is using the specified base address.	Reconfigure the base address of the DAS-1600/1400 Series board; refer to page 3-16 for more information. Check the I/O assignments of other system devices and reconfigure, if necessary.
Computer does not boot	Board not seated properly.	Check that the board is properly installed.
	The base address setting of the DAS-1600/1400 Series board conflicts with that of another device.	Verify that the base address setting of your DAS-1600/1400 Series board is unique.
	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.

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Testing the Board and Host Computer

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

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

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

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

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

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

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

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Testing the Accessory Slot and I/O Connections

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

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

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

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

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

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

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

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Technical Support

Before returning any equipment for repair, call the factory. Please make sure that you have the following information available before you call:

DAS-1600/1400 Series Board Configuration	Model	_____
	Serial #	_____
	Revision code	_____
	Base address setting	_____
	Interrupt level setting	_____
	Number of channels	_____
	Input (S.E. or Diff.)	_____
	Mode (uni. or bip.)	_____
	DMA chan(s)	_____
	Number of SSH-8 brds.	_____
	Number of EXP brds.	_____
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	_____
	Type	_____

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A

Specifications

Tables A-1 to A-7 list specifications for the DAS-1600/1400 Series boards.

Table A-1. Analog Input Specifications

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

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

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

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

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

Notes

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

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

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Table A-2. Analog Output Specifications

Attribute	DAS-1600 Series Boards
DAC Channels	2
Resolution	12-bit (one part in 4096 or 224 ppm)
Data format	Left-justified, offset binary
Range	User input ±10.00 volts in multiplying DAC mode
	0.000 to +5.000 V
	0.000 to +10.000 V
	±5.000 V
	±10.000 V
Linearity	Integral: ±½ LSB typical; ±1 LSB max.
	Differential: ±1 LSB
	Monotonicity: guaranteed over operating range
Maximum output current	±5 mA maximum
Settling time	4 µs to 0.01% typical
Output impedance	< 0.1 ohm
Gain accuracy	Adjustable to ±1 LSB
Offset accuracy	Adjustable to 0
Power up	DACs power up to 0.0 V at reset
Reference output voltage	Accuracy: −5.0 V ±50 mV
	Temperature coefficient: ±30 ppm/ °C
	Load current: ±5.0 mA maximum

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

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

Notes

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

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

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

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Table A-5. Programmable Counter/Timer Specifications

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

Table A-6. Power Supply Requirements

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

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Table A-7. Environmental Specifications

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

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B

Connector Pin Assignments

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

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Main I/O Connector (J1)

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

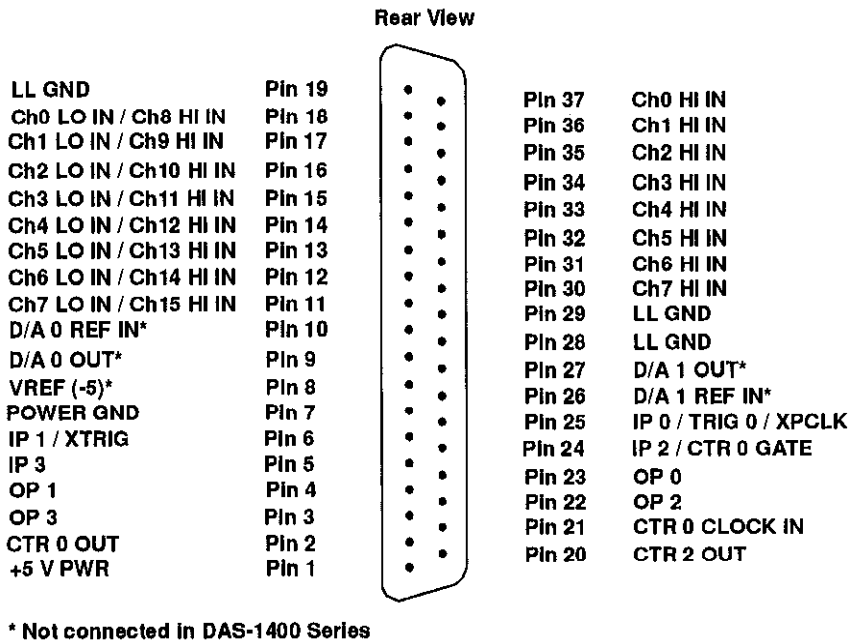


Figure B-1. Pin Assignments of Main I/O Connector (J1) on DAS-1600/1400 Series

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

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

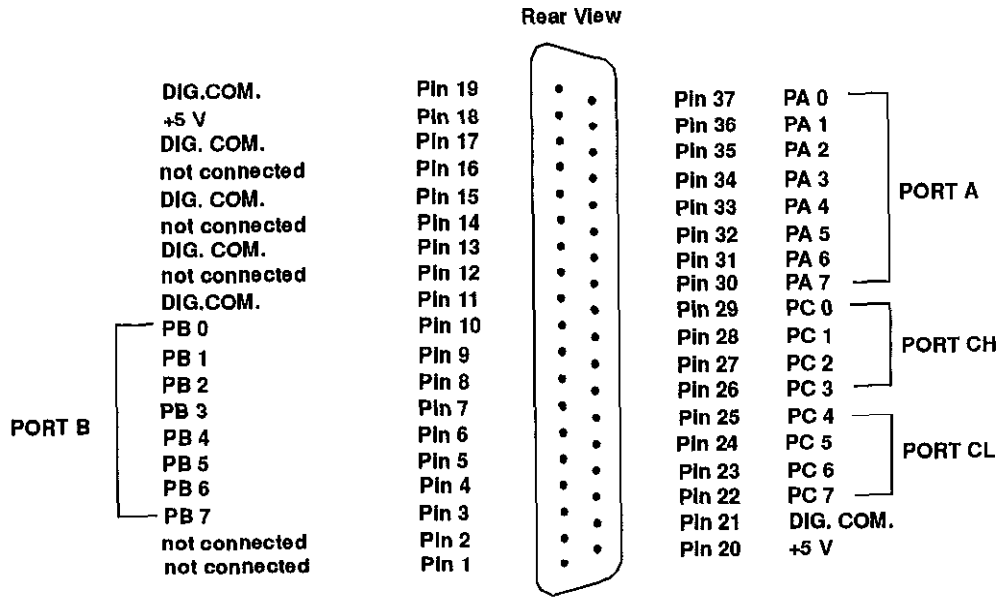


Figure B-2. Pin Assignments of PIO Cable Connector (J2)

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C

Using the DAS-1600 External Driver

The DAS-1600 External Driver (DAS1600.EXE) allows the following data acquisition and analysis packages to exchange data with DAS-1600/1400/1200 Series boards:

- VIEWDAC
- EASYEST LX
- EASYEST AG
- ASYST

You use the external driver characteristics described in this appendix by selecting menu items and entering text in dialog boxes of the software package in use.

Options Supported

The DAS-1600 External Driver supports the following options:

- Analog input operations, including interrupt and Direct Memory Access (DMA)
  - 16 single-ended or eight differential 12-bit analog input channels
  - Up to 136 channels through EXP-16 and EXP-GP support
- Two 12-bit digital-to-analog output channels (DAS-1600 Series only)
- 32 digital I/O bits on DAS-1600 Series and DAS-1200 Series boards, and eight digital I/O bits on DAS-1400 Series boards

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- Analog triggering
- Simultaneous sample-and-hold through the SSH-4A
- Event counting
- Pulse output

Quick Start

The following sections describe how to install and access the DAS-1600 External Driver.

Setting Up the Board

Prior to starting the external driver, perform the following steps:

1. Install the DAS-1600/1400/1200 standard software package. See "Installing the Software Package" on page 3-2 for installation instructions.
2. Verify that the switch-configuration of your board matches the options set in your configuration file. See "Creating a Configuration File" on page 3-6 for instructions on using and creating configuration files. For information on setting up the board, see "Setting Switch-Configurable Options" on page 3-14.
3. Install the board in your computer. See "Installing the Board" on page 3-18 for installation procedures.
4. Connect the appropriate signals to your DAS-1600/1400/1200 Series board, keeping the following in mind:
   - **External digital trigger** - Connect the external digital trigger to the IP1/XTRIG pin (6) on the main I/O connector.
   - **External clock** - Connect the external clock signal to the IP0/TRIG 0/XPCLK pin (25) on the main I/O connector.
   - **Event counting** - Connect the event signal to the CTR 0 CLOCK IN pin (21) on the main I/O connector.
   - **Pulse output** - Connect the pulse output signal to the CTR 2 OUT pin (20) on the main I/O connector.

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Loading the DAS-1600 External Driver

You must load the DAS-1600 External Driver, DAS1600.EXE, each time you start up your computer in order for your application program to recognize it. The DAS-1600 External Driver remains in memory until you turn off or reboot your computer.

To load the DAS-1600 External Driver, access the directory containing DAS1600.EXE and enter the following at the DOS prompt:

```
das1600 <filename>
```

where the optional *<filename>* is the name of the configuration file you are using. If you do not specify a configuration file, the driver searches for the default configuration file, DAS1600.CFG, in the current directory.

Note: You can also load the DAS-1600 External Driver automatically whenever you start the computer by modifying your AUTOEXEC.BAT file.

Loading the External Driver in Multiple Board Configurations

The number of DAS-1600/1400/1200 Series boards that you can install in your system is limited by the available slots in your computer. Each memory-resident external driver can support two DAS-1600/1400/1200 Series boards. The number of external drivers that you can load is limited only by the amount of available memory in your computer.

Note: Some operations may not be available when using multiple DAS boards depending on the system resources that the operations require and how system resources are allocated.

To access more than two boards, load the DAS-1600 External Driver as many times as you have configuration files. For example, to access three boards, you can create two configuration files called D1600_1.CFG and D1600_2.CFG.

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In this example, D1600_1.CFG contains the configuration data for two boards at addresses 300h and 310h and D1600_2.CFG contains the configuration data for a single board at address 340h. To load the DAS-1600 External Drivers, use the following syntax:

```
DAS1600 D1600_1.CFG
DAS1600 D1600_2.CFG
```

Using the External Driver with Application Software Packages

This section describes how to access the DAS-1600 External Driver when using VIEWDAC, EASYEST LX, EASYEST AG, and ASYST. For additional information, refer to your VIEWDAC, EASYEST LX / AG, or ASYST documentation.

VIEWDAC

All DAS tasks within VIEWDAC have an associated dialog box. Select the DAS Device pop-up menu in this dialog box and click on the DAS1600 entry.

Note: If the DAS-1600 External Driver is the only driver installed in your system, VIEWDAC DAS tasks automatically select the driver.

EASYEST LX / AG

If the DAS-1600 External Driver is the only driver installed in your system, your EASYEST LX / AG application programs access the DAS-1600 External Driver automatically.

If more than one driver is installed, you must perform the following steps to access the DAS-1600 External Driver:

1. Select *Devices* from the EASYEST LX / AG menu bar.
2. From the *DAS Configuration* screen, select option 1, *DAS Board Selection.*
3. Select the appropriate external driver (board name) from the displayed list.

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ASYST

If you are using ASYST, always perform the following steps to access the DAS-1600 External Driver:

1. After loading the DAS-1600 External Driver, start up ASYST version 2.10 or greater and permanently load the *Data Acq Master* and the *Ext DAS Driver Support* system overlays from the Data Acquisition menu. ASYST automatically searches for and creates a DAS device called DAS1600.
2. Enter the following at the OK prompt to make the DAS-1600/1400/1200 Series board the current device:

```
DAS1600
```

DAS-1600 External Driver Characteristics

The following sections describe special attributes and operating characteristics of the DAS-1600 External Driver.

Channels and Gains

The external driver supports channel-gain queues of 128 channels for DAS-1600 Series and DAS-1400 Series boards. Channel-gain queues are not supported for DAS-1200 Series boards. Table C-1 lists the gains and corresponding gain codes supported by DAS-1600/1400/1200 Series boards.

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Table C-1. Supported Gains and Gain Codes

Board	Gain	Gain Code
DAS-1601 DAS-1401 DAS-1201[1]	1	0
	10	1
	100	2
	500	3
DAS-1602 DAS-1402 DAS-1202[1]	1	0
	2	1
	4	2
	8	3

Notes

[1] Gains on DAS-1200 Series boards are not software programmable. They are displayed here for use in altering the burst mode conversion rate only.

Cascading Multiple Expansion Accessories

A physical channel is the analog input channel on the DAS-1600/1400/1200 Series board that the EXP accessory is attached to.

The logical channel is the channel that the application software uses to access channels on the DAS-1600/1400/1200 Series board and any EXP accessories.

The logical and physical channel assignments are displayed by the configuration utility (CFG1600.EXE) when you select *Show Switches*.

You can cascade multiple EXP-16, EXP-16/A and EXP-GP accessories by assigning each EXP accessory a distinct analog input channel on a DAS-1600/1400/1200 Series board. You can also connect an STA-16 to the system to use the remaining analog input channels on the DAS-1600/1400/1200 Series board.

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Note: If you are using an STA-16 with expansion accessories, the accessory channels are still accessible on the STA-16. However, make sure that you do not connect any signals to these inputs.

Digital output bits OP0 to OP3 are used to select the current channel on the EXP accessories. The DAS-1600 External Driver does not allow you to use these output bits if any EXP accessories are configured.

Table C-2 shows the relationship between the logical and physical channels on a DAS-1602 when using two EXP-GPs and two EXP-16s.

Table C-2. Logical and Physical Channels

Logical Channels	Physical Channel	EXP-GP / EXP-16 Jumper J4
0 to 15	EXP-16: 0	0
16 to 31	EXP-16: 1	1
32 to 39	EXP-GP: 2	2
40 to 47	EXP-GP: 3	3
48 to 59	DAS-1602: 4 to 15	Not applicable

Setting Expansion Accessory Gains

VIEWDAC uses the EXP-16 and EXP-GP gains specified in the configuration file. For EASYEST LX and AG, you must set the gain of channel 0 only (channel 0 is on the first EXP-16 or on the first EXP-GP if no EXP-16s are configured).

In the configuration utility, select *Show Switches* to display the EXP logical-to-physical-channel mapping table. In this case, the gain of all channels is relative to the setting of the A/D range type (unipolar or bipolar) and the gain of channel 0. You must compensate for gains other than the gain of channel 0 if the gain for other channels differs.

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Note: When using a gain of 0.5 on the EXP-16, the maximum input range is ±12 V, not ±20 V.

Conversion Modes

The following sections describe how the DAS-1600 External Driver supports the burst and SSH conversion modes.

Using Pseudo-Digital Output Channels

Burst mode and SSH mode are not standard features of the software. To access these features, the DAS-1600 External Driver uses pseudo-digital output channels.

Pseudo-digital output channels are digital output channels supported by the software; these channels are used by DAS-1600/1400/1200 Series boards for control only, not for output.

Note: Only values written to digital output channel 0 affect the digital output lines on the DAS-1600/1400/1200 Series board. Values written to the pseudo-digital output channels are intercepted by the DAS-1600 External Driver and are used to set up the non-standard features.

Table C-6 lists the pseudo-digital channels used by the DAS-1600 External Driver for burst mode and SSH mode operations.

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Table C-3. Pseudo-Digital Output Channels (Burst / SSH Mode)

Digital Output Channel	Function	Description
41	Acquisition mode	SSH mode or paced mode. The value written to this channel can be one of the following: **0** = paced mode **1** = SSH mode. An SSH-4A or SSH-8 must be connected to select SSH mode.
42	Burst mode enable/disable	Burst mode is supported for DMA operations only. The value written to this channel can be one of the following: **1** = enables the burst mode feature **0** = disables the burst mode feature
43	Set burst mode conversion rate for gain code 0	Using a count value, alters the burst mode conversion rate associated with a gain code of 0. The value written to this channel depends on a number of factors. Refer to Table C-1 for more information about gain codes.
44	Set burst mode conversion rate for gain code 1	Using a count value, alters the burst mode conversion rate associated with a gain code of 1. The value written to this channel depends on a number of factors. Refer to Table C-1 for more information about gain codes.
45	Set burst mode conversion rate for gain code 2	Using a count value, alters the burst mode conversion rate associated with a gain code of 2. The value written to this channel depends on a number of factors. Refer to Table C-1 for more information about gain codes.
46	Set burst mode conversion rate for gain code 3	Using a count value, alters the burst mode conversion rate associated with a gain code of 3. The value written to this channel depends on a number of factors. Refer to Table C-1 for more information about gain codes.

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Burst Mode and SSH Mode

Burst mode is a software simulated simultaneous sample-and-hold feature in which successive analog input channels are sampled as quickly as possible.

Note: When using the DAS-1600 External Driver, burst mode is supported for DMA operations only.

The burst mode conversion rate defaults to a gain-dependent value that you can alter. Refer to page C-11 for information on altering the burst mode conversion rate.

SSH (simultaneous sample-and-hold) mode is a hardware feature that requires use of an SSH-4A or SSH-8. The requested channels are sampled nearly instantaneously and held until read. The rate between scans is set by the sample frequency.

Warning: When you select SSH-8 as an *SSH Type* in the configuration utility, you must select a 10 MHz clock (in the *Clock Select* option). Selecting a 1 MHz clock for use with an SSH-8, causes the Function Call Driver and the DAS-1600 External Driver to report an error (28714) and terminate.

Note that in burst mode, the data is skewed slightly; in SSH mode, the data is not skewed.

When using VIEWDAC or EASYEST LX / AG, you specify the sampling frequency as the per channel rate. For example, specifying a frequency of 1 kHz when acquiring from two channels in paced (normal) mode results in an aggregate board rate of 2 kHz.

When using burst or SSH mode, the specified sampling frequency is also a per channel rate. For example, if you specify a frequency of 1 kHz when acquiring from two channels in burst or SSH mode, the two channels are sampled nearly instantaneously and are sampled again after 1 ms (1 kHz).

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When using ASYST, you specify the conversion delay rather than the per channel rate. The conversion delay is the time between conversions, which translates to a sampling rate that is dependent on the number of channels to scan.

For example, specifying a conversion delay of 1 ms when acquiring from one channel equates to a 1 kHz sampling rate. Adding a second channel drops the per channel rate to 500 Hz.

When using burst or SSH mode, the conversion delay is interpreted the same way even though the time between channels is nearly instantaneous. For example, to sample two channels at a 1 kHz sampling rate, you would specify a conversion delay of 0.5 ms for each channel, even though the time between scans is actually 1 ms. This interpretation allows you to calculate sampling rates that apply with or without burst or SSH mode.

The scan sequence in ASYST is as follows:

Paced (normal) mode:

0 [cd] 1 [cd] 2 [cd] ... (n-1) [cd] 0 [cd] 1 [cd] ...

Burst or SSH mode:

0 1 2 3 ... (n-1) [cd*n] 0 1 2 3 .. (n-1) [cd*n] 0 1 2 3

where

cd = conversion delay specified; n = number of channels

0 = start channel; [ ] = actual time delay

Altering the Burst Mode Conversion Rate

When a DAS-1600/1400/1200 Series board operates in DMA burst mode, it acquires data in a burst from the channels specified by the start/stop parameters. The burst is programmed to run at the maximum possible rate, which is determined by the gain setting. The higher the gain, the more settling time is required and the slower the burst mode conversion rate.

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In some computers, the built-in memory cache can slow the maximum burst mode conversion rate because caching takes precedence over DMA operations and causes data loss. In this event, you can adjust the burst mode conversion rate (settling time) to slow the acquisition rate.

Table C-4 contains the default settling times for each DAS-1600/1400/1200 Series board gain and the corresponding count value.

Table C-4. Default Settling Times

Board	Gain	Settling Time	Count
DAS-1601 DAS-1401	1	10 µs	2
	10	10 µs	2
	100	14 µs	3
	500	34 µs	8
DAS-1602 DAS-1402 DAS-1202	1	10 µs	2
	2	10 µs	2
	4	10 µs	2
	8	10 µs	2
DAS-1201	1	22 µs	5
	10	22 µs	5
	100	22 µs	5
	500	102 µs	25

If you wish to use a settling time other than the default, you can specify a count value to alter the burst mode conversion rate. Use the following formula to determine the appropriate count value:

$$\text{Count} = \frac{\text{Settling Time (in µs)} - 2}{4}$$

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The relationship between the settling time and the burst mode conversion rate is shown in the following equation:

$$\text{Settling Time (in } \mu\text{s)} = \frac{1 \text{ MHz}}{\text{Burst Mode Conversion Rate}}$$

For reference, Table C-5 lists some of the most common settling times, along with their corresponding burst mode conversion rates and counts. However, you can use any count value between 2 and 255.

Table C-5. Common Settling Times

Settling Time (μs)	Burst Mode Conversion Rate (kHz)	Count
10	100	2
14	71.428	3
18	55.55	4
22	45.45	5
26	38.46	6
30	33.33	7
34	29.4	8
38	26.3	9
42	23.8	10

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Clock Sources

The DAS-1600 External Driver supports an internal and external clock source, as follows:

- **Internal clock source** - A conversion begins without waiting for an external clock signal and proceeds at the specified rate until finished. With the jumper in the 1 MHz position, the clock resolution is 1 µs. With the jumper in the 10 MHz position, the clock resolution is 0.1 µs.
- **External clock source** - The software waits for a rising edge at the IP0/TRIG 0/XPCLK pin (25) input before starting each conversion. Acquisition proceeds and is paced by the external clock until the requested amount of data is acquired.

Triggers

The following sections describe how the DAS-1600 External Driver supports an external analog and external digital trigger.

Note: When using external analog and external digital triggering, make sure that you provide a valid trigger to the DAS-1600 External Driver. If no trigger is found, the computer will appear to be hung as the DAS-1600 External Driver waits indefinitely for the trigger.

Using Pseudo-Digital Output Channels

External analog and external digital triggers are not standard features of the software. To access these features, the DAS-1600 External Driver uses pseudo-digital output channels.

Pseudo-digital output channels are digital output channels supported by the software; these channels are used by DAS-1600/1400/1200 Series boards for control only, not for output.

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Note: Only values written to digital output channel 0 affect the digital output lines on the DAS-1600/1400/1200 Series board. Values written to the pseudo-digital output channels are intercepted by the DAS-1600 External Driver and are used to set up the non-standard features.

Table C-6 lists the pseudo-digital channels used by the DAS-1600 External Driver when performing external analog and external digital triggering.

Table C-6. Pseudo-Digital Output Channels (Analog Trigger)

Digital Output Channel	Function	Description
32	Analog trigger channel	The analog input channel on which an external analog trigger event occurs. The value written to this channel can be any valid logical analog input channel except an SSH channel.
33	Trigger signal source	The type of external trigger you want to use to begin conversions. The value written to this channel can be one of the following: **0** = an external digital trigger using the IP1/XTRIG pin (6). Refer to page 2-9 for more information about external digital triggers. **1** = an analog trigger. An analog trigger event occurs when the conditions specified by pseudo-digital output channels 34, 35, 38, and 39 are met by the analog input signal on the channel specified by pseudo-digital output channel 32.

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Table C-6. Pseudo-Digital Output Channels (Analog Trigger) (cont.)

Digital Output Channel	Function	Description
34	Trigger sensitivity	Edge triggering or level triggering. The value written to this channel can be one of the following: **0** = edge triggering. **1** = level triggering. Refer to page 2-9 for more information about edge and level triggering for external digital triggers. Refer to page C-17 for more information about edge and level triggering for external analog triggers.
35	Trigger polarity	Positive triggering or negative triggering. The value written to this channel can be one of the following: **0** = positive triggering. **1** = negative triggering. Refer to page 2-9 for more information about positive and negative triggering for external digital triggers. Refer to page C-17 for more information about positive and negative triggering for external analog triggers.
38	Analog voltage level	The voltage level at which an external analog trigger event occurs. The value written to this channel is a raw count value between 0 and 4095. Refer to page C-17 for more information about external analog triggers.
39	Hysteresis value	The amount of hysteresis applied to an analog trigger signal. The value written to this channel is a raw count value between 0 and 4095. A hysteresis value of 0 disables the option. Refer to page C-18 for more information about using a hysteresis value with an external analog trigger.

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Types of Analog Triggers

DAS-1600/1400/1200 Series boards support the following types of analog triggers:

- **Positive, edge-sensitive trigger** - The trigger event occurs at the instant that the signal (on the analog input channel determined by pseudo-digital output channel 32) rises above a specified voltage level (determined by pseudo-digital output channel 38, using the hysteresis value specified by pseudo-digital output channel 39, if applicable).
- **Negative, edge-sensitive trigger** - The trigger event occurs at the instant that the signal (on the analog input channel determined by pseudo-digital output channel 32) falls below a specified voltage level (determined by pseudo-digital output channel 38, using the hysteresis value specified by pseudo-digital output channel 39, if applicable).
- **Positive, level-sensitive trigger** - The trigger event occurs at any time that the signal (on the analog input channel determined by pseudo-digital output channel 32) is above a specified voltage level (determined by pseudo-digital output channel 38, using the hysteresis value specified by pseudo-digital output channel 39, if applicable).
- **Negative, level-sensitive trigger** - The trigger event occurs at any time that the signal (on the analog input channel determined by pseudo-digital output channel 32) is below a specified voltage level (determined by pseudo-digital output channel 38, using the hysteresis value specified by pseudo-digital output channel 39, if applicable).

You specify the voltage level as a raw count value between 0 and 4095, using pseudo-digital output channel 38. The voltage equivalent of the raw count value depends on the input range type (unipolar or bipolar). For example, a level of 0 is interpreted as 0 V if the analog input range is 0 to 10 V, but it is interpreted as –5 V if the analog input range is ±5 V.

Figure C-1 illustrates these analog trigger conditions, where the specified voltage level is +5 V.

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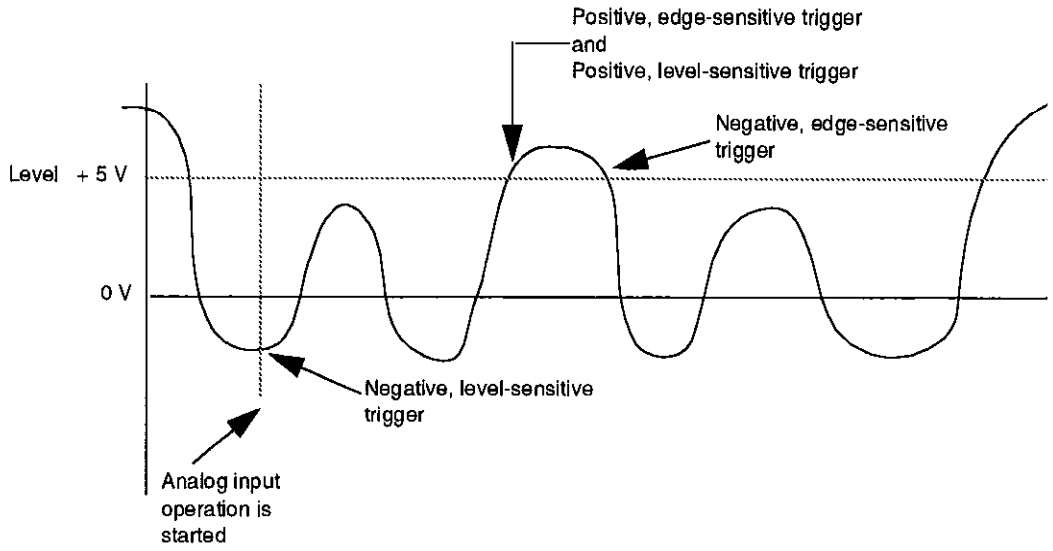


Figure C-1. Analog Trigger Conditions

Using a Hysteresis Value

You can specify a hysteresis value to prevent noise from triggering an operation. For positive triggering, the analog signal must fall below the specified voltage level by at least the amount of the hysteresis value before the trigger event can occur.

For negative triggering, the analog signal must rise above the specified voltage level by at least the amount of the hysteresis value before the trigger event can occur.

The hysteresis value is an absolute number, which you specify as a raw count value between 0 and 4095, using pseudo-digital output channel 39.

In Figure C-2, the specified voltage level is +5 V and the hysteresis value is 0.1 V. The analog signal must fall below +4.9 V and then rise above +5 V before a positive trigger event occurs; the analog signal must rise above +5.1 V and then fall below +5 V before a negative trigger event occurs.

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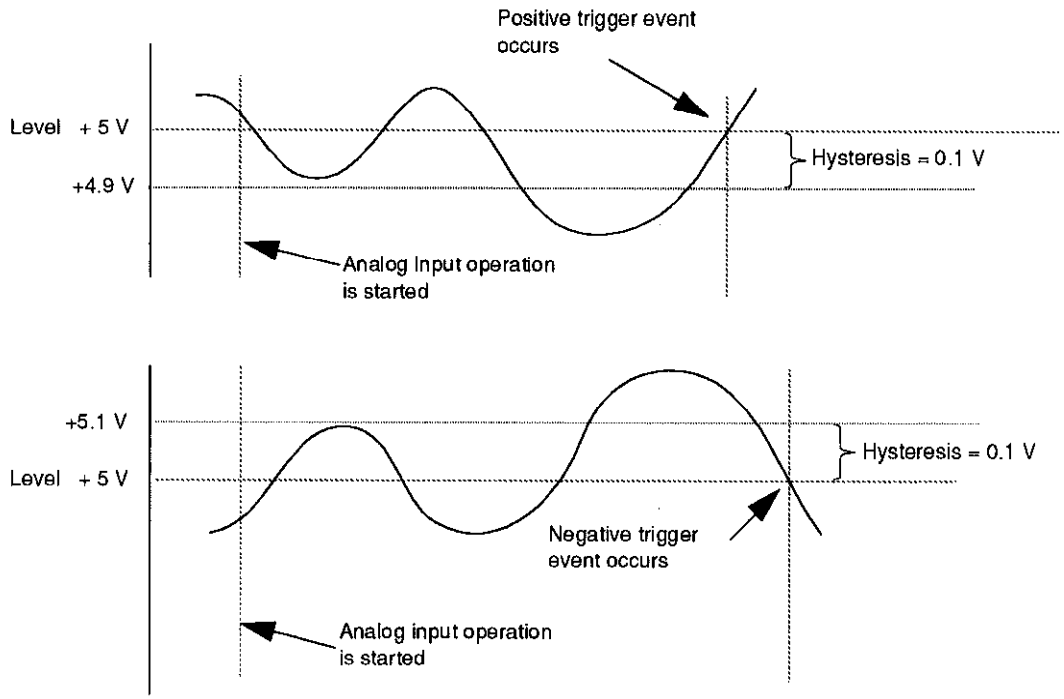


Figure C-2. Using a Hysteresis Value

Synchronous, DMA, and Interrupt Operations

Keep the following in mind when performing a synchronous, DMA, or interrupt operation:

- Only one operation can be active on a board at one time.
- Burst mode and continuous acquisition are not supported for synchronous operations.
- DMA mode is allowed only for analog input operations. DMA supports burst mode acquisition. The use of channel-gain queues is not allowed for DMA mode. DMA cannot be performed on EXP-16, EXP-16/A, and EXP-GP channels. Only non-cyclic (single cycle) and cyclic (continuous) single buffering are supported for DMA operations; double buffering is not supported.

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- Interrupt mode is supported for analog input, analog output, and digital I/O operations. Burst mode is not supported for interrupt operations. Only non-cyclic (single cycle) and cyclic (continuous) single buffering are supported for interrupt operations; double buffering is not supported.

Note: Because the DAS-1600 External Driver cannot detect all interrupt overrun conditions, ensure that interrupt operation speeds are valid for your system.

Digital I/O Characteristics

Note: Since the extended digital ports (32 to 46) require 12 output bits, the software always shows a minimum of 12 available bits, no matter how a digital output port is configured. If a digital output port is configured for 8, 4, or 0 output bits, you can disregard the extra bits. The following subsections describe the digital I/O support for the DAS boards.

DAS-1600/1200 Series Boards

The DAS-1600/1200 Series boards have four unidirectional digital input bits and four unidirectional digital output bits. In addition, an Intel 8255 provides 24 bits of bidirectional digital I/O. These 24 bits are organized into four ports (ports A, B, CL, and CH); you can configure each port for either input or output.

Note: When an EXP accessory is configured, the four unidirectional digital output bits are dedicated to EXP accessory control and are not available for digital output.

The external driver supports one digital input channel and one digital output channel on each board (if any bits are available). The number of bits used in each channel depends on the port configuration and whether an EXP accessory is configured.

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Starting from the least significant bit, Port A uses the first eight bits available, Port B uses the next eight bits available, Port CL uses the next four bits available, Port CH uses the next four bits available, and the unidirectional bits use the next four bits available.

If a particular port is configured for input, it does not use any bits in the output channel; if a particular port is configured for output, it does not use any bits in the input channel.

Note: The digital channel requires DP.INTEGER output if more than 16 bits are configured.

For example, a DAS-1600/1200 Series board is configured with no EXPs and with Port A, Port B, Port CL, and Port CH all configured for output. Table C-7 illustrates how the bits in the digital I/O channels are used.

Table C-7. Digital I/O Channel Usage; No EXPs, All Ports Output

Bits	Output Channel Use	Input Channel Use
0 to 3	Port A	4 unidirectional input bits
4 to 7		
8 to 11	Port B	
12 to 15		
16 to 19	Port CL	
20 to 23	Port CH	
24 to 27	4 fixed output bits	

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As another example, a DAS-1600/1200 Series board is configured with one or more EXPs and with Port A, Port B, Port CL, and Port CH configured for output. Table C-8 illustrates how the bits in the digital I/O channels are used. Note that the four unidirectional output bits are dedicated to EXP board control and are not available.

Table C-8. Digital I/O Channel Usage; EXPs Used, All Ports Output

Bits	Output Channel Use	Input Channel Use
0 to 3	Port A	4 unidirectional input bits
4 to 7		
8 to 11	Port B	
12 to 15		
16 to 19	Port CL	
20 to 23	Port CH	
24 to 27		

As another example, a DAS-1600/1200 Series board is configured with no EXPs, with Port A and Port B configured for output, and with Port CL and Port CH configured for input. Table C-9 illustrates how the bits in the digital I/O channels are used.

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Table C-9. Digital I/O Channel Usage; No EXPs, A and B Output, CL and CH Input

Bits	Output Channel Use	Input Channel Use
0 to 3	Port A	Port CL
4 to 7		Port CH
8 to 11	Port B	4 unidirectional input bits
12 to 15		
16 to 19	4 unidirectional output bits	
20 to 23		
24 to 27		

As a final example, a DAS-1600/1200 Series board is configured with no EXPs, with Port B and Port CH configured for output, and with Port A and Port CL configured for input. Table C-10 illustrates how the bits in the digital I/O channels are used.

Table C-10. Digital I/O Channel Usage; No EXPs, B and CH Output, A and CL Input

Bits	Output Channel Use	Input Channel Use
0 to 3	Port B	Port A
4 to 7		
8 to 11	Port CH	Port CL
12 to 15	4 unidirectional output bits	4 unidirectional input bits
16 to 19		
20 to 23		
24 to 27		

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DAS-1400 Series Boards

DAS-1400 Series boards have four unidirectional digital input bits and four unidirectional digital output bits.

Note: When an EXP accessory is configured, the four unidirectional digital output bits are dedicated to EXP accessory control and are not available for digital output.

Table C-11 illustrates how the bits in the digital I/O channels are used if a DAS-1400 Series board is configured with no EXPs.

Table C-11. Digital I/O Channel Usage; No EXPs

Bits	Output Channel Use	Input Channel Use
0 to 3	4 unidirectional output bits	4 unidirectional input bits

Table C-12 illustrates how the bits in the digital I/O channels are used if a DAS-1400 Series board is configured with one or more EXPs. Note that the four unidirectional output bits are dedicated to EXP board control and are not available.

Table C-12. Digital I/O Channel Usage; EXPs Used

Bits	Output Channel Use	Input Channel Use
0 to 3		4 unidirectional input bits

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Counter/Timer Functions

Table C-13 shows the counter/timer functions supported by the external driver. The supported functions are described in the following subsections.

Table C-13. Counter/Timer Functions

Function	Supported
Timer Interrupt Generation	No
Frequency Measurement	No
Event Counting	Yes
Pulse Output	Yes
One-Shot Pulse Output	No
Time Interval Measurement	No

Event Counting

To perform event counting, connect the signal to be counted to CTR 0 CLOCK IN pin (21). The maximum count is 65,535; any count greater than 65,535 causes driver error 32791, "Event counter overflow."

Note that if the signal being counted starts high, with events driving it temporarily low, each event is counted correctly. However, if the signal being counted starts low, with events driving it temporarily high, the first event is skipped and subsequent counts return one less than the actual number of events.

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Pulse Output

A pulse output generates a pulse train on the CTR 2 OUT pin (20). The duty cycle of the pulse train is fixed at 50% due to the nature of the 8254 counter/timer circuitry.

Software Interrupt Vectors

The DAS-1600 External Driver uses two software interrupt vectors for communicating with the application package. The interrupt vectors used are two of the user vectors (60h to 67h) that are set aside by DOS.

When conflicts with other devices or programs occur, you can set each of the interrupt vectors to use a location that is different from the default.

You can change the interrupt vectors by using the DOS SET command to change the environment variables read by the DAS-1600 External Driver. Table C-14 lists the environment variables used.

Table C-14. Interrupt Vectors

Interrupt	Default Interrupt Vector	Environment Variable[1]
Device linking vector	66h	'DAS DS=xx'
Critical error vector	65h	'DAS CE=xx'

Notes
[1] where xx ranges from 60h to 67h.

Note: Do not confuse these software interrupt vectors with the hardware interrupt levels used by DAS-1600/1400/1200 Series boards.

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DAS-1600 External Driver Error Messages

Table C-15 lists the error messages that may occur during operation of the DAS-1600 External Driver.

Table C-15. Error Messages

Error Number	Error Message	Description
0	No error	No errors were encountered.
28698	Bad Rev. Number	An invalid DAS Specification version was passed to the driver.
28699	Resource Busy	An attempt was made to execute interrupt and DMA operations simultaneously. Only one of these operations is allowed at one time.
28700	Unknown Error Number	A request for an undefined message string was made.
28701	Channel Gain Array Not Supported	A DMA operation was attempted with a channel-gain queue. This is an illegal operation.
28702	DMA not supported on EXP Channels	A DMA operation was attempted on an EXP board. This is an illegal operation.
28703	Incorrect A/D Uni/Bip Switch Setting	The Unipolar/ Bipolar switch on the board does not match the setting that you configured in the driver.
28704	Counter Not Active	The counter/timer circuitry has not been activated.
28705	Incorrect A/D 16/8 Channel Switch Setting	The single-ended/ differential switch on the board does not match the setting that you configured in the driver.
28706	Illegal Settling Time	An invalid burst mode conversion rate count is set.
28707	BadNumofSSH	An illegal number of SSH accessories was specified; check configuration file, value should be 1 to 4
28708	BadSSHChan	An illegal number of channels was specified; check configuration file, number of channels should be 0 to 3
28709	BadSSHGain	Illegal gain selection; check configuration file

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Table C-15. Error Messages (cont.)

Error Number	Error Message	Description
28710	BadSSH4Mode	Illegal ssh4 mode; check configuration file, mode should be master or slave
28711	BadSSHTiming	Illegal SSH timing selection; check configuration file, timing should be internal or external
28713	BadSSHType	Illegal SSH type; check configuration file, type must be SSH4A or SSH8
28714	BadSSHPacer	Illegal clock selection; check configuration file, clock must be 10 Mhz
32769	Function Not Supported	A function was requested that is not supported by the DAS driver.
32770	Function Out Of Bounds	A function number not defined by the DAS Driver Specification was requested.
32771	Non-valid Board Number	A board number that is out of range of configured boards was requested. This driver can support a maximum of two boards.
32772	Non-valid Error Number	An invalid error number was requested by the DAS driver function Report Error Message. A request was made for an error message string that is not defined.
32773	Board Not Found At Configured Address	The board was not found at the configured address. The address select switches on the board must match the settings you configured for the driver.
32774	A/D Not Initialized	An A/D conversion was requested before the A/D circuitry was initialized.
32775	D/A Not Initialized	A D/A operation was requested before the D/A circuitry was initialized.
32776	Digital Input Not Initialized	A digital input operation was requested before the digital input ports were initialized.
32777	Digital Output Not Initialized	A digital output operation was requested before the digital output ports were initialized.
32778	Timer Not Initialized	The counter/timer circuitry has not been initialized.
32779	Conversion Overrun	A software-detected conversion overrun occurred.

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Table C-15. Error Messages (cont.)

Error Number	Error Message	Description
32780	Conversion Delay Is Too Small	The conversion delay value passed to the driver was too small.
32782	Pulse Output Period Is Too Small	The pulse period value passed to the driver was too small.
32783	Pulse Output Duty Cycle Is Too Small	The pulse duty cycle was too small for the number of period ticks.
32785	Conversion Delay Is Too Large	The conversion delay value passed to the driver was greater than a software set limit.
32787	Pulse Output Period Is Too Large	The pulse period value passed to the driver was too large.
32788	Pulse Output Duty Cycle Is Too Large	The pulse duty cycle was too large for the number of period ticks.
32790	Interrupt Overrun	An interrupt was generated before the program was ready to handle it. This usually occurs when the interrupt generator is running too fast.
32791	Event Counter Overflow	The count exceeded 65535 during an event counting operation.
32794	Interrupts Already Active	An interrupt function was called while another interrupt function was in use. Do not use more than one function that uses the interrupt channel concurrently.
32795	DMA Already Active	A DMA function was called while DMA was being used by another function. An interrupt function was called while another interrupt function was in use. Do not use more than one function that uses the interrupt channel concurrently.
32797	Event counting not active	The counter/timer circuitry has not been activated.

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D

Keithley Memory Manager

The process that Windows uses to allocate memory can limit the amount of memory available to DAS boards operating in Windows Enhanced mode. To reserve a memory heap large enough for the needs of your application, use the Keithley Memory Manager (KMM), included in the ASO software package.

The reserved memory heap is part of the total physical memory available in your system. When you start up Windows, the KMM reserves the memory heap. Then, whenever your application program requests memory, the memory buffer is allocated from the reserved memory heap instead of from the Windows global heap. The KMM is DAS board independent and can be used by multiple DAS Windows application programs simultaneously.

Note: The memory allocated with the KMM can be used by any DMA controller, if applicable.

The following are supplied with the KMM:

- **VDMAD.386** - Customized version of Microsoft's Virtual DMA Driver. This file consists of a copy of Microsoft's Virtual DMA Driver and a group of functions that are added to perform the KMM functions. When you use the KMM to reserve a memory heap, Microsoft's Virtual DMA Driver is replaced by the VDMAD.386 file.

  Note: If you have multiple versions of VDMAD.386, it is recommended that you install the latest version; to determine which version is the latest version, refer to the time stamp of the file.

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- **KMMSETUP.EXE** - Windows program that helps you set up the VDMAD.386 parameters and then modifies your SYSTEM.INI file accordingly.

Installing and Setting Up the KMM

To install and set up the KMM whenever you start up Windows, you must modify the SYSTEM.INI file. You can modify the SYSTEM.INI file using either the KMMSETUP.EXE program or a text editor.

Using KMMSETUP.EXE

Using the KMMSETUP.EXE program, you can modify your Windows SYSTEM.INI file as follows:

1. Invoke KMMSETUP.EXE in one of the following ways:
   - From the Program Manager menu, choose File and then Run, and then type the complete path and program name for KMMSETUP.
   - Select the KMMSETUP icon, if installed.
2. In the New VDMAD.386 box, enter the path and name of the VDMAD.386 file, as follows:

   ```
   C:\WINDOWS\VDMAD.386
   ```

   The string you enter replaces `*vdmad` in the `device=*vdmad` line in your SYSTEM.INI file.

   Note: Normally, the VDMAD.386 file is stored in the WINDOWS directory. If it is stored elsewhere, enter the correct path and name or use the Browse button to find the file.

3. Notice the Current Setting box. The value specified reflects the current size of the reserved memory heap in KBytes.

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4. In the Desired Setting box, enter the desired size of the reserved memory heap in KBytes.

   The value you enter replaces the `KEIDMAHEAPSIZE=` line in the [386Enh] section of your SYSTEM.INI file.

Notes: The memory size you specify is no longer available to Windows. For example, if your computer has 8 MBytes of memory installed and you specify `KEIDMAHEAPSIZE=1000` (1 MByte), Windows can only see and use 7 MBytes.

If you specify a value less than 128, a 128 KByte minimum heap size is assumed. The maximum heap size is limited only by the physical memory installed in your system and by Windows itself.

---

5. Select the Update button to update the SYSTEM.INI file with the changes you have made.

6. Restart Windows to ensure that the system changes take effect.

Using a Text Editor

Using a text editor, you can modify your Windows SYSTEM.INI file in the [386Enh] section, as follows:

1. Replace the line `device=*vdmad` with the following:

   ```
   device=c:\windows\vdmad.386
   ```

Note: Normally, the VDMAD.386 file is stored in the WINDOWS directory. If it is stored elsewhere, enter the correct path and name.

---

2. Add the following line:

   ```
   KEIDMAHEAPSIZE=<size>
   ```

   where *size* indicates the desired size of the reserved memory heap in KBytes.

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Notes: The memory size you specify is no longer available to Windows. For example, if your computer has 8 MBytes of memory installed and you specify `KEIDMAHEAPSIZE=1000` (1 MByte), Windows can only see and use 7 MBytes.

If you do not add the `KEIDMAHEAPSIZE` keyword or if the size you specify is less than 128, a 128 KByte minimum heap size is assumed. The maximum heap size is limited only by the physical memory installed in your system and by Windows itself.

3. Restart Windows to ensure that the system changes take effect.

Removing the KMM

If you make changes to the SYSTEM.INI file, you can always remove the updated information from the SYSTEM.INI file and return all previously reserved memory to Windows.

If you are using KMMSETUP.EXE, select the Remove button to remove the updated information. If you are using a text editor, modify and/or delete the appropriate lines in SYSTEM.INI. In both cases, make sure that you restart Windows to ensure that the system changes take effect.

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E

Register-Level Address Map

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

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

Register Functions

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

- Analog-to-Digital converter (ADC) registers
- MUX scan register
- Digital input and output registers
- Digital-to-Analog converter (DAC) output registers (DAS-1600 Series only)
- Status registers
- Control register
- Programmable gain selection and burst rate register
- Counter enable and burst length register

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- 82C54 programmable interval counter/timer registers
- 8255 programmable I/O registers (DAS-1600 only)
- 1600 mode and burst mode enable registers

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

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

Table E-1. Register-Level Address Map

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

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

Location	Function	Type	Name
Base Address +Dh	Counter 1 register	Read/Write	TIMER1
Base Address +Eh	Counter 2 register	Read/Write	TIMER2
Base Address +Fh	82C54 Counter Control	Write	TIMERCTL
Bidirectional digital ports A,B, CL, and CH (8255 Programmable I/O) (DAS-1600 Series only)			
Base Address +400h	Digital port A	Read/Write	PIOPA
Base Address +401h	Digital port B	Read/Write	PIOPB
Base Address +402h	Digital port CL and CH	Read/Write	PIOPC
Base Address +403h	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	1600/1400 mode enable register	Write	1600MDEN 1400MDEN
Base Address +407h	Status register B	Read	STATUSB

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

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

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

- A/D conversion data
- MUX channel number from which data is converted
- Start a software controlled A/D conversion

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

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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).

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

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

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

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

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

The bit names are defined and used as follows:

- **AL0 to AL3** = Start of scan address.
- **AH0 to AH3** = End of scan address.

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

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

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

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

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

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

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

The bit names are defined and used as follows:

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

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

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

The bit names are defined and used as follows:

- **IP0 to IP3** = Bits 0 to 3 of the digital input port.
- **Bits 7 to 4** = Board ID; these bits have a fixed value of 1100 for DAS-1600 Series boards and 1110 for DAS-1400 Series boards.

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

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

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

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

DAC0

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

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

The bit names are defined and used as follows:

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

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

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

The bit names are defined and used as follows:

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

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DAC1

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

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

The bit names are defined and used as follows:

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

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

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

The bit names are defined and used as follows:

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

DAC Controller Modes

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

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

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

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Table E-2. DAC Bipolar Output Modes

DAC Input Code			Vout IN ±5.0 Mode (2.44 mV/CNT)	Vout IN ±10.0 Mode (4.88 mV/CNT)
Binary	Decimal	Analog Output[1]		
1111 1111 1111	4095	−(Vin) (2047/2048)	+4.998V	+9.995V
1000 0000 0001	2049	−(Vin) (1/2048)	+2.44mV	+4.88mV
1000 0000 0000	2048	0	0 V	0 V
0000 0000 0001	1	+(Vin) (2047/2048)	−4.99756 mV	−9.99512 mV
0000 0000 0000	0	+(Vin) (2048/2048)	−5.00V	−10.00V

Notes

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

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

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

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

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Table E-3. DAC Unipolar Output Modes

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

Notes

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

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

Vout = (−Vin x code) / 4096

Status Register A (Base Address +8h)

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

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

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

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The bit names are defined and used as follows:

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

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

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

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

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

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

- **U/B** = Unipolar/bipolar. This bit can be useful in scaling routines. The U/B bit indicates whether the ADC input is operating in unipolar or bipolar mode (as set by UNI/BIP switch). See Figure 3-1 on page 3-14. Table E-4 defines the logic states of the U/B bit.

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

Mode Selection	State
unipolar	logic 1
bipolar	logic 0

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

Control Register (Base Address +9h)

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

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

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

The bit names are defined and used as follows:

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

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

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

Notes

[1] X = data insensitive.

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

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

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

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

- **IL0 to IL2** = Interrupt level select. Selects the interrupt level 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 E-7 lists the interrupt levels selected by the states of IL0 through IL2.

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

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

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

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

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

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

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

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

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

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

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

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

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

Bit assignments of base address +Ah are as follows:

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

The bit names are defined and used as follows:

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

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

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

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

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

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

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

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

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

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

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

Bit assignments of base address +Bh are as follows:

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

The bit names are defined and used as follows:

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

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

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

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

BURST RATE = 1 MHz / (4 x BURST RATE VALUE) + 2

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

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

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

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

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

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

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

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

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

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

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

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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, presettable down counters and a control register. Table E-9 maps counter/timer registers to their addresses.

Table E-9. Counter/Timer Address Map

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

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

- A programmable timer for generating interrupts and clocking for periodic A/D conversions.
- A variable-frequency square-wave generator for testing and frequency synthesis.
- An event counter of external input pulses.

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- A time-delay generator.

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

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

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

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

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

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

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

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

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- **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.

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The DAS-1600/1400 Series 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 x 2) with a 10 MHz clock providing a 2.5 MHz output at one extreme, and a division ratio of 2^{32} (65,535 x 65,535) with a 1 MHz clock providing an output of about 1 pulse/hour at the other extreme.

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

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

Measuring Frequency and Period

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

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

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

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

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

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

Using Counter 0 for Generating Programmable Time Delays

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

- **[Configuration 0: Pulse On Terminal Count]** - After loading the counter the output goes low. Counting is enabled when the gate input is high and continues until the count reaches zero when the output goes high. The output remains high until the counter is reloaded by program command. Taking the gate input low during the count down disables counting as long as it is low.

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

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- **[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 a programmed duration after loading the counter.

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

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

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

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

Bit assignments of base address +Fh are as follows:

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

The bit names are defined and used as follows:

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

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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 E-10.

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

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

Notes

[1] X = data insensitive.

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

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

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

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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).

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

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

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

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

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

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

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

The format of the readback command byte is as follows:

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

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The bit names are defined and used as follows:

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

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

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

Notes

[1] X = data insensitive.

- **STA** = When set to 0, STA returns the Status Byte of the counter selected by C0 to C2.
- **CNT** = When set to 0, CNT latches the counter selected by C0 to C2. See Table E-13 for counter selected by C0 to C2.
- **SC0 and SC1** = The readback command occurs when SC1 and SC0 are both set to 1.

Status Byte Format (Returned if STA =0)

The format of the status byte is as follows:

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

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

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

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

Table E-14. PPI Register Address Map

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

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

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

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

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

Port descriptions are as follows:

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

Control Register (Base Address +403h)

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

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

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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 E-15 for definitions of operating mode selected.
- **PCH** = Selects the transfer direction of port CH (upper nibble of port C). When you set the bit to logic 1, the port is an input. When the bit is set to 0, the port is an output.
- **PA** = Selects the transfer direction of port A. When you set the bit to logic 1, the port is an input. When the bit is set to 0, the port is an output.
- **PA/PCH0 - PA/PCH1** = Selects operating mode for PA and PCH (upper nibble of port C). See Table E-15 for definitions of operating mode selected.

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

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

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

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

Table E-16. PIO Control Word

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

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Conversion Disable Register (Base Address +404h)

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

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

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

A write of 40h to the conversion disable register (base address +404h) allows the DAS-1600/1400 Series to ignore all conversion clock sources and disable 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-1600/1400 Series receives the terminal count signal from the computer's DMA controller, the conversion disable register becomes set (1), preventing further conversions and DMA transfers. To allow conversions to take place again, you must reset this register by writing a value of 00h to base address +404h.

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

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Burst Mode Enable Register (Base Address +405h)

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

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

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

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

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

This register allows the following functions:

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

Status Register B (Base Address +407h)

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

- 1 MHz/10 MHz clock select switch
- wait state enable switch
- 1600/1400 mode enable setting
- conversion disable setting
- burst mode enable setting

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

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

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

The bit names are defined and used as follows:

- **CLKSL** = 0 indicates the 1 MHz clock is selected and 1 indicates the 10 MHz clock is selected.
- **WSEN** = 0 indicates that wait states are not selected and 1 indicates that wait states are selected.
- **DARM** = 0 indicates that the conversion disable register is set; conversions disabled. 1 indicates that the conversion disable register is reset; conversions allowed.
- **AMDE** = 0 indicates that the 1600/1400 mode enable register is reset; conversions cannot be disabled and burst mode cannot be enabled. 1 indicates that the 1600/1400 mode enable register is set; conversions can be disabled and burst mode can be enabled.
- **BMDE** = 0 indicates that the burst mode enable register is reset; burst mode is disabled. 1 indicates that the burst mode enable register is set; burst mode is enabled.

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