

SSH-8

**USER'S GUIDE**

# **SSH-8 User's Guide**

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# Preface

The *SSH-8 User's Guide* describes the installation and operation of the SSH-8 simultaneous sample-and-hold board and is intended for system designers and installation technicians. The organization of this manual is as follows:

- **Chapter 1: Overview** - provides an introduction to the SSH-8 and includes sections on software support and SSH-8 accessories.
- **Chapter 2: Functional Description** - describes SSH-8 capabilities and concepts, providing the information you need to understand before planning your SSH-8 installation.
- **Chapter 3: Hardware Installation** - provides a quick reference section on SSH-8 controls, interfaces, and cabling, as well as detailed, step-by-step installation instructions.
- **Chapter 4: The SSH-8 Calibration Utility** - tells how to use the SSH-8 calibration utility to perform zero calibration.
- **Chapter 5: Troubleshooting** - suggests solutions for problems in SSH-8 operation.
- **Appendix A: Specifications** - provides detailed specifications for the SSH-8.
- **Appendix B: SSH-8 Filter Modules** - describes the low-pass filter modules available for use with the SSH-8.

An index completes this manual.

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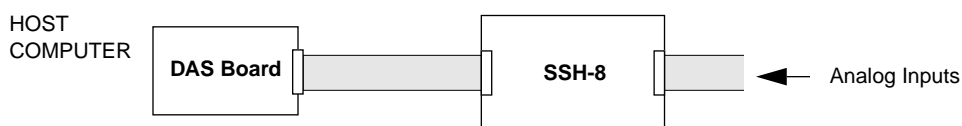
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# 1

## Overview

This chapter describes general features of the SSH-8.

The SSH-8 is an accessory board that provides eight channels of simultaneous sample-and-hold analog inputs to DAS-1200, DAS-1400, DAS-1600, and DAS-1800 Series data acquisition boards. Figure 1-1 shows a diagram of a typical measurement system using an SSH-8.



**Figure 1-1. A Typical SSH-8 Application**

The SSH-8 is available in a selectable-gain version (SSH-8/SG) and a fixed-gain version (SSH-8/FG). The SSH-8/SG provides switch-selectable gains of 0.5, 5.0, 50, and 250. The SSH-8/FG provides a fixed-gain setting of 0.5.

The SSH-8 accepts analog input signals in the range of  $\pm 10$  V and provides  $\pm 5$  V outputs. Optional plug-in, low-pass filters minimize noise and aliasing effects.

To obtain additional simultaneous sample-and-hold channels, you can add additional SSH-8 accessories. You can add a second SSH-8 to a DAS-1200/1400/1600 Series board or a DAS-1800AO/HR/ST Series board for a total of 16 channels, or you can add up to eight SSH-8s to a DAS-1800HC Series board for a total of 64 channels. At minimum gain (0.5), the SSH-8 samples input signals within 2 ns across all channels.

The SSH-8 is mounted in a metal enclosure to provide shielding.

## Software Support

---

This section provides a brief description of the SSH-8 calibration utility that comes with the SSH-8, as well as a description of DAS board support for simultaneous sample-and-hold applications.

### SSH-8 Calibration Utility

The SSH-8 calibration utility zero-calibrates the aggregate system (DAS board plus SSH-8) for each channel. The calibration utility runs under MS-DOS® on the computer in which the DAS board is installed and communicates with the SSH-8 through the DAS board.

You normally run the SSH-8 calibration utility when you are installing the SSH-8 and at periodic intervals thereafter to maintain zero offset.

### DAS Board Software

DAS board software includes drivers with functions to control the SSH feature and a configuration utility that includes the setup. If you plan to connect your SSH-8 to a DAS board that you purchased at an earlier time, contact the Keithley MetraByte Hardware Application Engineering Department to verify that your DAS board software is up-to-date. Chapter 5 tells how to contact Hardware Application Engineering.

If you are using the Keithley MetraByte Function Call Driver to write application programs for your measurement system, you must use the **K\_SetSSH** function to turn on SSH mode for operations that acquire data through the SSH-8. You can use **K\_GetSSH** to read a frame's SSH mode status.

## Accessories

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This section describes the accessories available for use with the SSH-8.

### STC-SSH-8 Screw Terminal Connector

The optional STC-SSH-8 screw terminal connector board plugs directly into the SSH-8 analog input connector. This accessory provides labeled screw terminals for signals, power, and an external pacer clock. The STC-SSH-8 must be ordered separately.

The alternative to using the STC-SSH-8 is designing your own custom cable.

### Signal-Shorting Connector

The SSH-8 comes with a signal-shorting connector for use during the zero calibration procedure. This connector grounds all the analog inputs to provide a ground input reference for the zero calibration software.

### Expansion Cable

You can order the following cables for special SSH-8 applications:

- SSH-8-DC cable - connects two SSH-8 accessories together using their expansion connectors. You need this cable for systems containing a DAS-1200/1400/1600 Series board or a DAS-1800AO/HR/ST Series board and two SSH-8 accessories or for systems containing a DAS-1800HC Series board and up to four pairs of SSH-8 accessories.
- C-1800 cable - connects a DAS-1200/1400/1600 Series board or STA accessories to SSH-8 accessories.
- S-1800 cable - connects a DAS-1200/1400/1600 Series board to SSH-8 accessories. This cable is a shielded version of the C-1800 cable.

# 2

## Functional Description

This chapter describes the functional and operational concepts you need to understand before attempting to install or configure an SSH-8 accessory.

For installation and configuration instructions, refer to Chapter 3.

This chapter includes the following sections:

- Functional Block Diagram
- Inputs and Outputs
- Gain
- Control Signals and Timing
- Filtering
- Digital I/O Communication

### Functional Block Diagram

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Figure 2-1 is a functional block diagram of the SSH-8 showing inputs, outputs, jumpers, and switches.

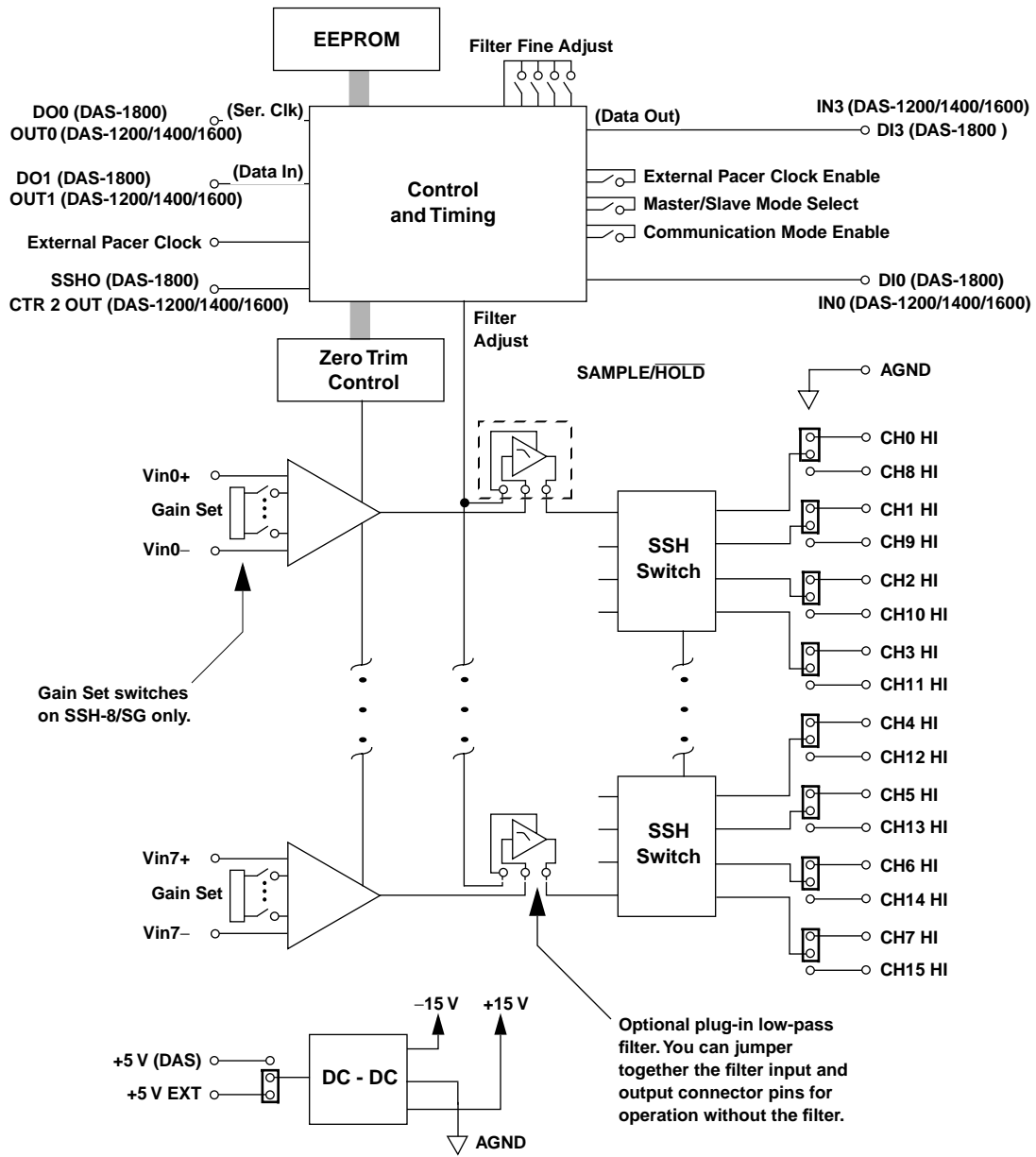


Figure 2-1. SSH-8 Functional Block Diagram

## Inputs and Outputs

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The SSH-8 has eight simultaneous sample-and-hold channels. Each channel accepts a  $\pm 10$  V input (including any common mode signals) and provides a  $\pm 5$  V output (DAS board input). The effective input channel bandwidth is dependent on the gain and the signal magnitude. Refer to the bandwidth and risetime specifications in Appendix A for more details.

## Gain

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The SSH-8/FG provides a fixed gain of  $\times 0.5$ . On the SSH-8/SG, you can set the gain for each channel to a value of  $\times 0.5$ ,  $\times 5$ ,  $\times 50$ , or  $\times 250$ . A set of DIP switches controls the gain for each channel. At minimum gain ( $\times 0.5$ ), the SSH-8 samples input signals within 2 ns across all channels.

## Zero Calibration

The SSH-8 calibration utility performs semi-automatic zero calibration for the data acquisition system (SSH-8 plus DAS board). An onboard microprocessor and EEPROM maintain the zero calibration, with or without power.

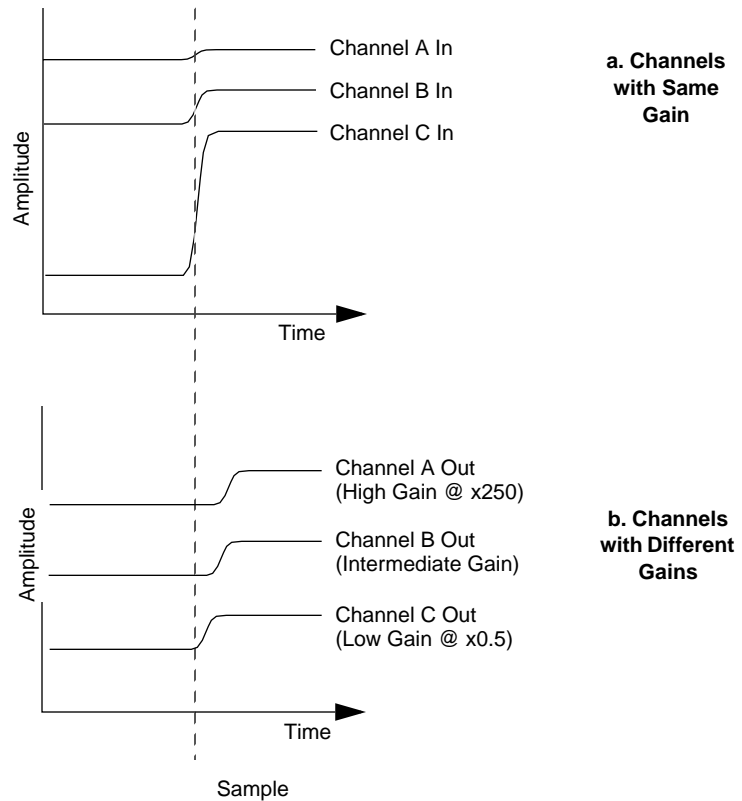
## Where to Set the Gain: SSH-8 or DAS Board

In addition to being able to set the gain on the SSH-8/SG, in many cases it is also possible to set the gain on the DAS board. There are several issues to consider when choosing where to apply gain in a system using simultaneous sample-and-hold.

Setting gain on the SSH-8 maximizes the signal-to-noise ratio at the ADC (analog-to-digital converter) as well as common mode rejection on the SSH-8. Setting gain at the DAS board is dynamically programmable, making it easier to fine tune the input analog signal range to the ADC range.



To make sampling across a set of channels as close to simultaneous as possible, those channels must have identical gain (as well as filter type and cutoff frequency, see “Filtering” on page 2-9) on the SSH-8 accessory. These requirements apply because the SSH-8 applies gain to signals before sampling them. If different channels have different gain settings, the signals experience different gain-related delays before sampling, as shown in Figure 2-2. This effect increases with increasing signal frequency.



**Figure 2-2. Effect of Varying Gain Before Sampling (not drawn to scale)**

If you want to be as close as possible to simultaneous sampling across a set of channels and you also want different gains among those channels, you should vary the gains on the DAS board, if possible. The DAS-1800 Series boards allow gains to be changed, and the DAS-1802 Series boards, with their small steps between gains, work well with different channel gains in burst mode.

## Timing and Control Signals

The SSH-8 and the DAS board exchange control signals in order to coordinate their operations. This section describes timing of control signals, using an external pacer clock and master and slave control modes.

### *Timing*

There are two timing arrangements: one is for the DAS-1200, DAS-1400, and DAS-1600 Series boards, the other is for the DAS-1800 Series boards.

#### **Timing for DAS-1200, DAS-1400, and DAS-1600 Series Boards**

DAS-1200, DAS-1400, and DAS-1600 Series boards use an external source or the onboard clock (CTR 2 OUT signal) as the pacer clock source. On the SSH-8, a pacer clock pulse causes a hold operation. After inserting a delay to allow the held signal to settle, the SSH-8 uses the IP0/XCLCK signal to tell the DAS board to perform the A/D conversion.

Use the following formula to determine the minimum pacer clock period:

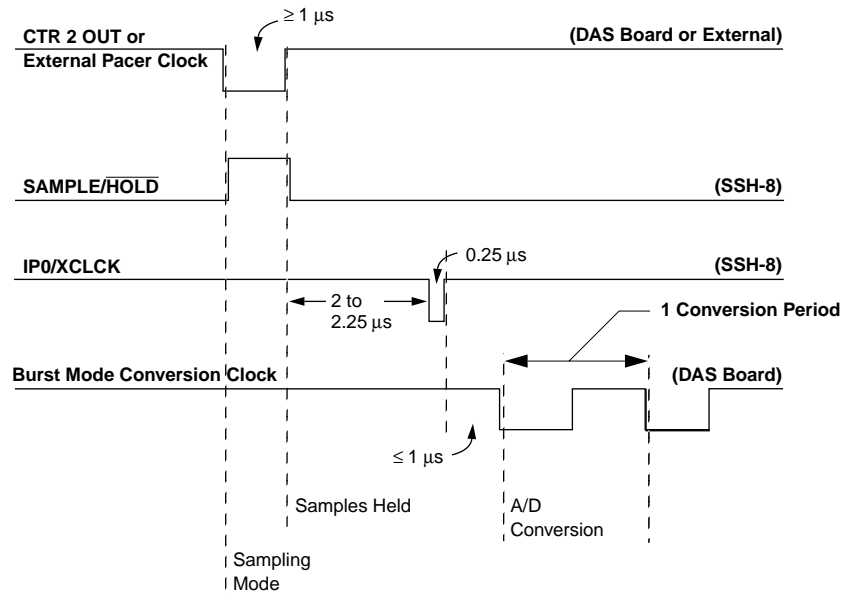
$$\text{MPCP} = (\# \text{ Chans}) \infty \text{ CP} + 2.5 \mu\text{s} + \text{CTR2OUT Low Pulse Width}$$

where MPCP is *Minimum Pacer Clock Period*, Chans is *Channels*, and CP is *Conversion Period*.

In addition, the CTR2OUT Low Pulse Width is 1  $\mu\text{s}$ , as shown in Figure 2-3.

Refer to the appropriate DAS board user's guide for information on programming the burst mode conversion rate and onboard counter/timer.

Figure 2-3 shows the timing diagram for the DAS-1200/1400/1600 Series and SSH-8 control signals.



**Figure 2-3. SSH-8 Control Signal Timing (DAS-1200, 1400, and 1600 Series Boards)**

The negative edge of the pacer clock pulse causes  $\overline{\text{SAMPLE/HOLD}}$  to go high, which causes sampling to occur on the SSH-8. After a pause of at least 1 μs, the positive edge of the pacer clock pulse causes  $\overline{\text{SAMPLE/HOLD}}$  to go low, causing the sampled values to be held. After a delay of 2 to 2.25 μs, the SSH-8 pulls IP0/XCLCK low. The rising edge of IP0/XCLCK initiates an A/D conversion on the DAS-1200/1400/1600 Series board. The conversion is synchronized with the DAS-1200/1400/1600 Series board's internal clock. Because the DAS-1200/1400/1600 Series board and SSH-8 clocks are not synchronized, a delay of up to 1 μs can occur between the rising edge of IP0/XCLCK and the actual conversion.

### Timing for DAS-1800 Series Boards

DAS-1800 Series boards use an external source or the user-programmable DAS-1800 Series board counter/timer as the pacer clock source. The SSHO signal controls sample-and-hold on the SSH-8. After signaling the SSH-8 to hold a sample, the DAS-1800 Series board waits one burst clock period before beginning conversion. This allows the held signal levels to settle.

Use the following formula to determine the minimum pacer clock period:

$$\text{MPCP} = (\# \text{ Chans} + 1) \infty \text{ CP}$$

where MPCP is *Minimum Pacer Clock Period*, Chans is *Channels*, and CP is *Conversion Period*.

Refer to the appropriate DAS-1800 Series register-level programming user's guide for information on programming the burst mode conversion rate and onboard clock.

Figure 2-4 shows the timing diagram for the DAS-1800 Series board and SSH-8 control signals.

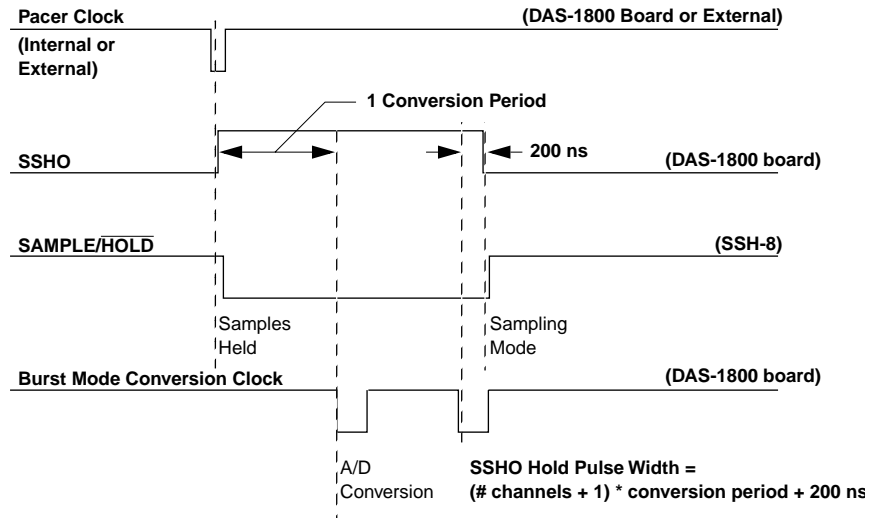


Figure 2-4. SSH-8 Control Signal Timing (DAS-1800 Series Boards)

The negative edge of the pacer clock pulse causes the SSHO signal on the DAS-1800 Series board to go high. On the SSH-8, this causes  $\overline{\text{SAMPLE/HOLD}}$  to go low, which causes the SSH-8 to hold sampled signal levels. The DAS-1800 Series board begins the A/D conversion one burst mode conversion period after SSHO goes high.

The SSHO signal remains high until 200 ns after the DAS-1800 Series board has started conversion of the last channel in the burst. When SSHO goes low,  $\overline{\text{SAMPLE/HOLD}}$  goes high, causing the SSH-8 to return to sampling mode.

## External Pacer Clock

You can use any TTL-compatible source to provide an external pacer clock signal. For DAS-1200, DAS-1400, and DAS-1600 Series boards, the external pacer clock connects to the board through a pin on the SSH-8 analog input connector. For DAS-1800 Series boards, the external pacer clock connects to the DI0 screw terminal on the STA-1800HC or STA-1800U screw terminal accessory board (note that the DAS-1800HC uses the STA-1800HC; all other DAS-1800 Series boards use the STA-1800U). Refer to your DAS-1800 Series user's guide for screw terminal information.

## Master and Slave Modes

You can configure an SSH-8 accessory as a master or a slave. An SSH-8 in master mode provides the A/D conversion timing signal back to the DAS board. A board in slave mode does not provide this signal. A DIP switch controls whether the SSH-8 is in master mode or slave mode.

When one SSH-8 is connected to a DAS-1200, DAS-1400, or DAS-1600 Series board, configure that SSH-8 as a master. When two SSH-8 accessories are connected to a DAS-1200, DAS-1400, or DAS-1600 Series board, configure the first SSH-8 as a master and the second as a slave.

When connecting to a DAS-1800 Series board, configure all SSH-8 accessories as slaves.

## Filtering

---

Each channel on the SSH-8 has a connector for an optional, plug-in, signal-conditioning filter module. Filters attenuate or block undesirable input-signal components such as noise. Refer to Appendix B for a description of the filter modules.

For some applications, you do not need to filter the input signal. The SSH-8 is shipped ready-to-use for such applications. Factory-installed jumpers connect each filter connector's input pin to its output pin. These jumpers enable board operation without any filters installed.

The following sections provide an overview of the issues involved in filtering signals on measurement systems using the SSH-8.

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**Note:** Contact your sales representative or the Keithley MetraByte Hardware Application Engineering Department if you need assistance in determining whether or not your application requires filters.

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### About SSH-8 Filtering

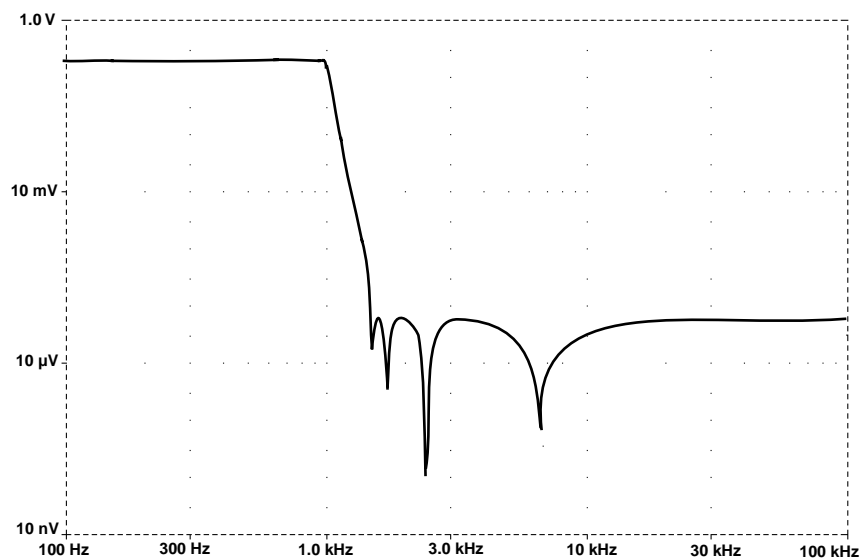
The optional low-pass filter modules available for the SSH-8 suppress high-frequency signal components that can cause aliasing. Aliasing can occur in sampled waveforms and introduce errors.

Signal components with frequencies that exceed one-half the sampling rate can cause aliasing. The sampling rate is the frequency at which one channel is sampled. For example, if you are acquiring data from eight channels at 100 kHz, the sampling rate for one channel is about  $100 \div 8$  kHz, or 12.5 kHz. In this case, any signal component with a frequency above 6.25 kHz causes aliasing.

Keep in mind that using filters can cause a slight increase in sample skew. Since the SSH-8 filters signals before it samples them, any variation in signal delay introduced by filtering appears in the sampled data. Even well-matched filters introduce a variation in signal delay that exceeds sample skew specifications for the SSH-8 accessories.

## Cutoff Frequency

A filter's cutoff frequency is the frequency at which the amplitude of an input signal is attenuated by 3 dB. Figure 2-5 shows the frequency response of an 8<sup>th</sup> order Cauer low-pass filter with a cutoff frequency of 1 kHz. Notice that the filter attenuates the signal at frequencies above the cutoff frequency, but has minimal effect on the signal at lower frequencies. Maximum attenuation occurs in the stopband, and begins at the stopband frequency.



**Figure 2-5. Amplitude versus Normalized Frequency for an SSH-8 Cauer Filter**

On the SSH-8, the cutoff frequency of installed filters is controlled by two configurable values: a wide adjustment and a fine adjustment. The wide adjustment is controlled by a jumper on the filter module. The fine adjustment is controlled by DIP switches on the SSH-8. Appendix B tells which wide adjustment and fine adjustment values to use to obtain a desired cutoff frequency.

In general, you should select a cutoff frequency that fully attenuates all signal components having potential for aliasing. This selection means setting the cutoff frequency ( $f_c$ ) such that the stopband frequency ( $f_s$ ) is less than or equal to one-half the sampling frequency. You can determine the stopband frequency from the filter's transition ratio specification. This is the ratio of stopband frequency to cutoff frequency.

For example, if you are acquiring data from eight channels at 100 kHz, the sampling frequency for one channel is  $100 \div 8$  kHz, or 12.5 kHz. One-half the sampling frequency is 6.25 kHz. Suppose you are using a filter with a transition ratio of 1.5. You then solve for the cutoff frequency as follows:  $f_c = f_s \div (\text{transition ratio})$ . In this example,  $f_c = 6.25 \text{ kHz} \div 1.5$ , or 4.17 kHz.

## Digital I/O Communication

---

The SSH-8 calibration utility uses the DAS board's digital I/O lines to perform several functions, including SSH-8 address modification and zero calibration. On DAS-1200, DAS-1400, and DAS-1600 Series boards, these signals are named OP1, OP2, and IN3. On DAS-1800 Series boards, these signals are named DO1, DO2, and DI3. A DIP switch on the SSH-8 enables and disables communication on the digital I/O lines.

Typically, you run the SSH-8 calibration utility only during initial setup and periodic recalibration. When you are not calibrating the SSH-8, you can use the digital I/O lines for other purposes and should leave the communication bit disabled.



# 3

## Hardware Installation

This chapter uses the following sections to tell how to install and configure the SSH-8 hardware:

- How to Use this Chapter
- Quick Reference
- Installation Procedures

---

**Note:** Before you install the SSH-8, install the DAS board according to the instructions in the user's guide for your DAS board.

---

### How to Use this Chapter

---

If you have experience setting up data acquisition systems and want to get started quickly, use the quick reference section at the beginning of this chapter. If you prefer ordered, step-by-step procedures, go to "Installation Procedures" on page 3-12.

### Quick Reference

---

This section consists of figures and tables that contain information on SSH-8 jumpers, DIP switches, connectors, and cabling.

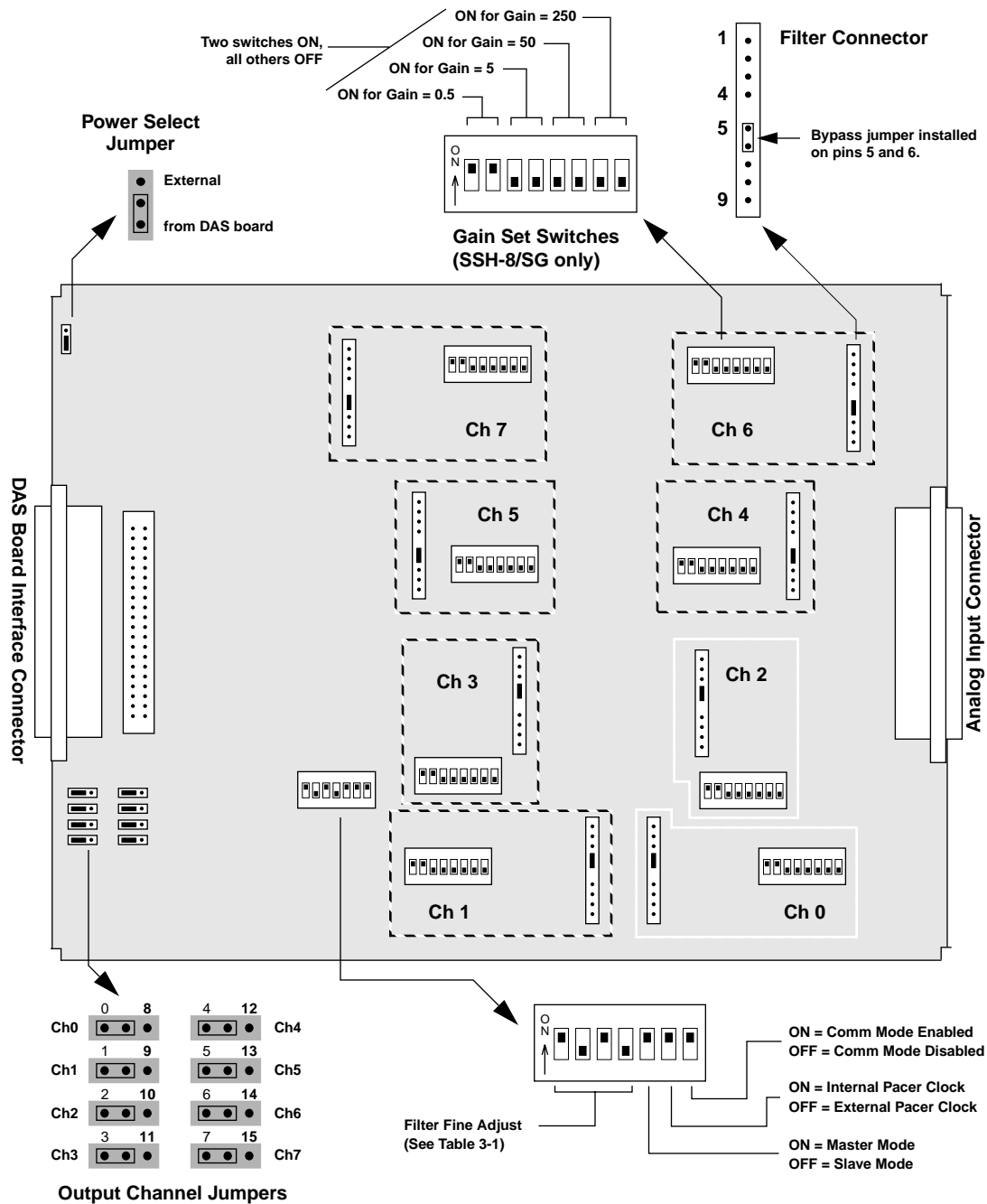
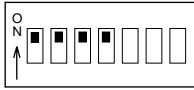
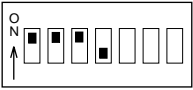
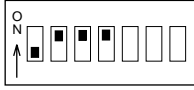
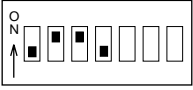






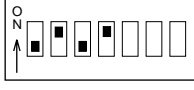







Figure 3-1. SSH-8 Jumpers and Switches

**Table 3-1. Filter Fine Adjustment DIP Switch Settings**

DIP Switches	Fine Adjustment Value	DIP Switches	Fine Adjustment Value
	Not Used		9
	Not Used		10 (Default)
	Not Used		11
	4		12
	5		13
	6		14
	7		15
	8		16

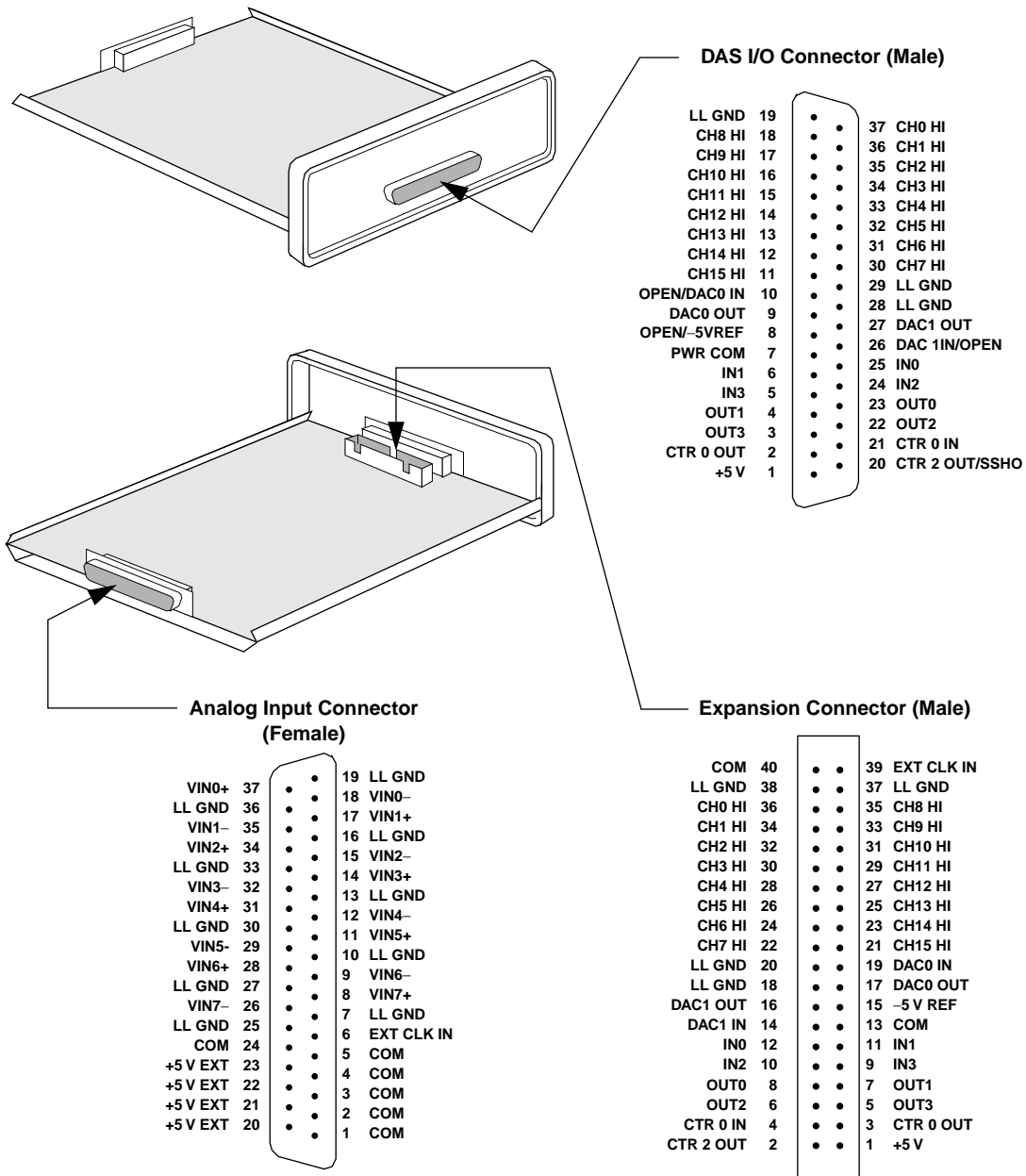
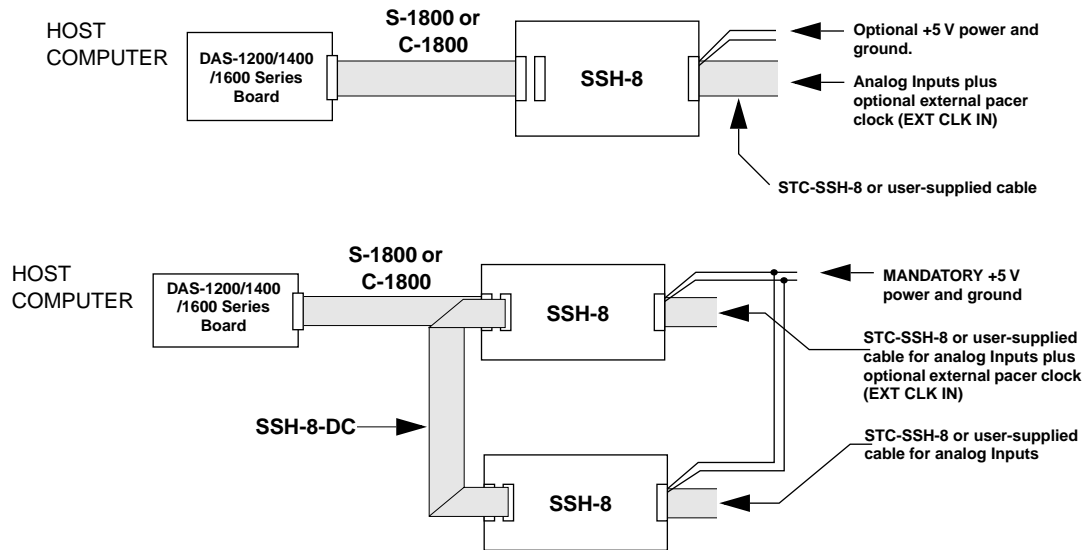


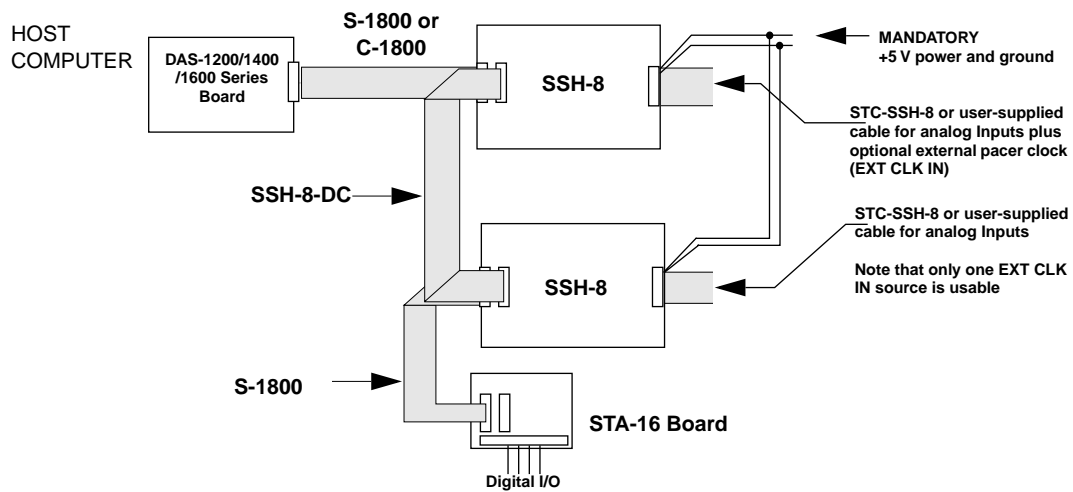
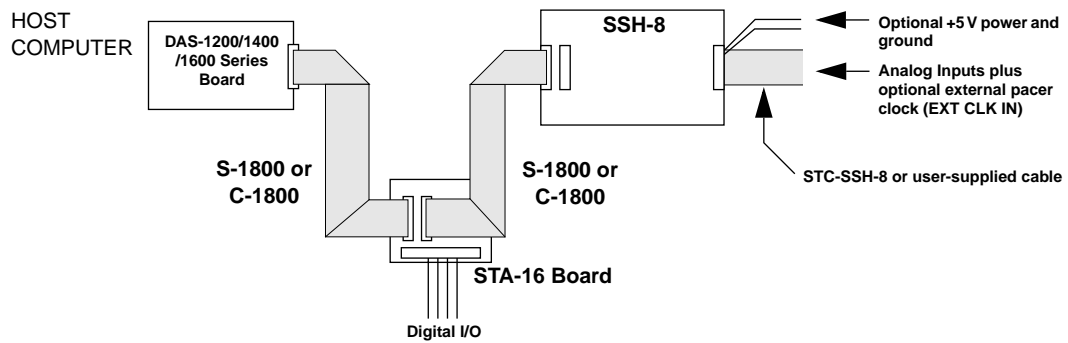
Figure 3-2. Connector Pin Assignments



**Figure 3-3. Common Cabling Arrangements for DAS-1200, DAS-1400, and DAS-1600 Series Boards**

When you use the cabling of Figure 3-3, 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 8 feet maximum of #18 AWG wire (or heavier) for optional external power and ground.
- When daisy-chaining two SSH-8 accessories to a DAS-1200/1400/1600 Series board, put the first in master mode and the other in slave mode.
- Optional channel jumpers are 0 to 7 for the first SSH-8 accessory and 8 to 15 for the second.
- Where the S-1800 cable is called out, other options include C-1800, S-1801, and C-1801. Crosstalk, shielding, and cost tradeoffs are factors in the selection of these options.



**Figure 3-4. Using an Accessory Board with DAS-1200, DAS-1400, and DAS-1600 Series Boards**

---

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

---

When making the connections shown in Figure 3-4, observe the following rules:

- When using digital I/O, disable the communication mode on the SSH-8.
- When using an external clock, connect an external clock cable to both SSH-8 accessories using leads of equal length and gauge to minimize sample skew.
- 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 8 feet maximum of #18 AWG wire (or heavier) for optional external power and ground.
- When daisy-chaining two SSH-8 accessories to a DAS-1200/1400/1600 Series board, put the first in master mode and the other in slave mode.
- Optional channel jumpers are 0 to 7 for the first SSH-8 accessory and 8 to 15 for the second accessory.
- Where the S-1800 cable is called out, other options include C-1800, S-1801, and C-1801. Crosstalk, shielding, and cost tradeoffs are factors in the selection of these options.

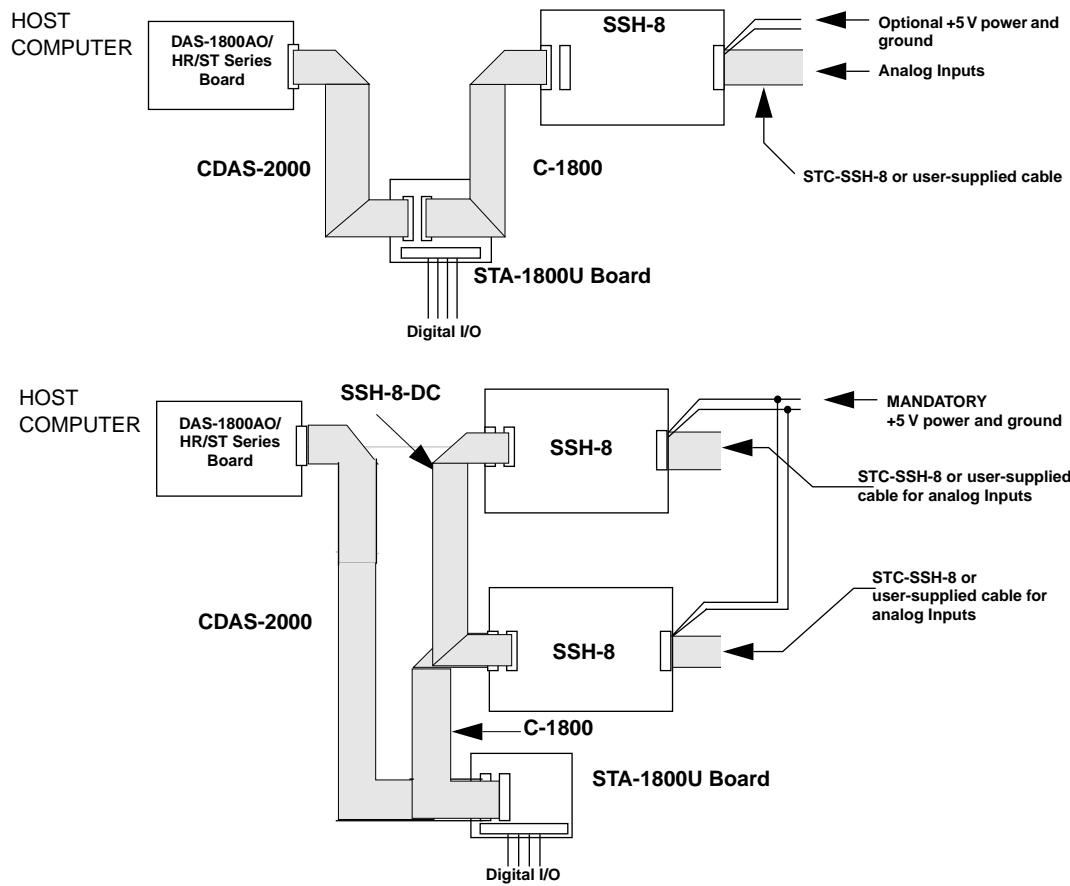


Figure 3-5. Common Cabling Arrangements for DAS-1800AO/HR/ST Series Boards



When making the connections shown in Figure 3-5, observe the following rules:

- You can connect a maximum of two SSH-8 accessories to a DAS-1800AO/HR/ST Series board using the STA-1800U.
- Optional channel jumpers are 0 to 7 for the first SSH-8 accessory and 8 to 15 for the second accessory.
- All SSH-8 accessories connected to a DAS-1800 Series board must be in slave mode.
- 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 8 feet maximum of #18 AWG wire (or heavier) for optional external power and ground.

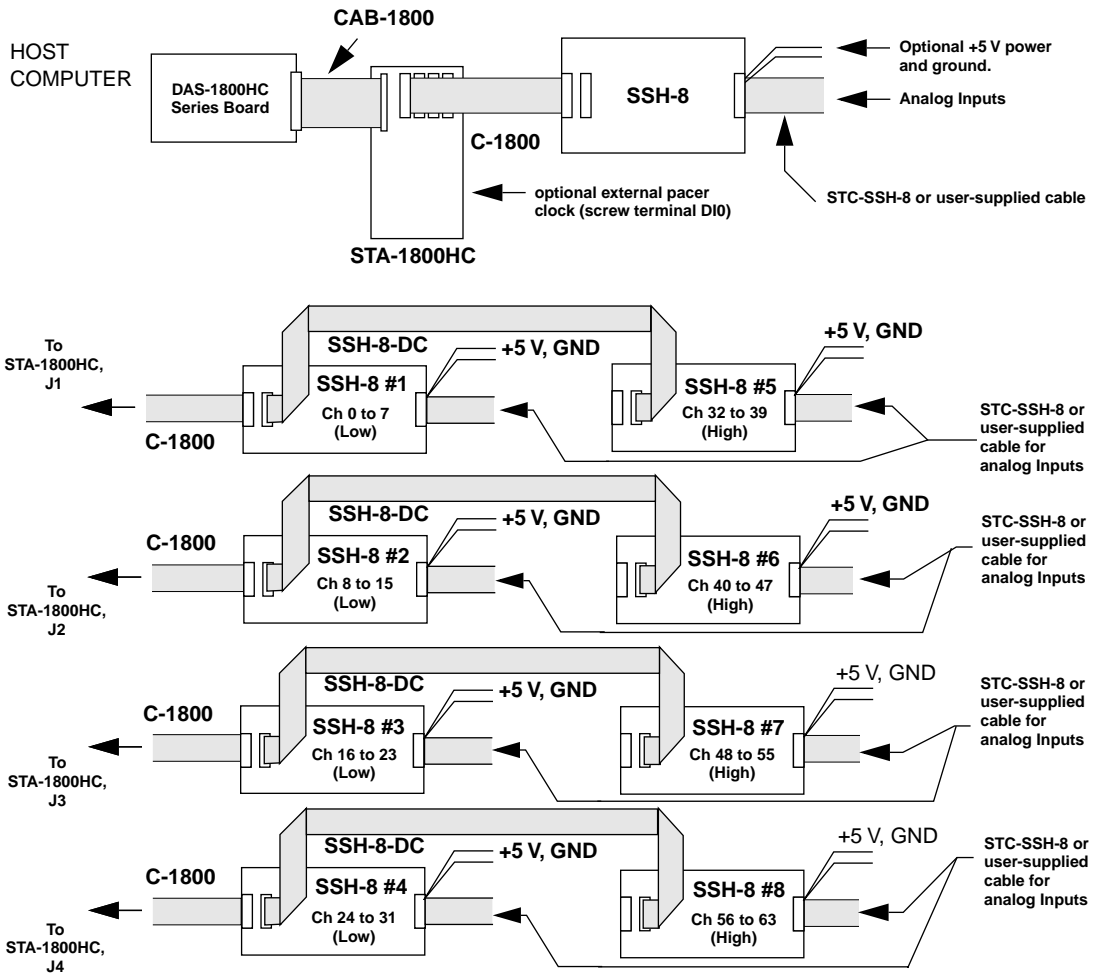


Figure 3-6. Common Cabling Arrangements for DAS-1800HC Series Boards

When making the connections shown in Figure 3-6, observe the following rules:

- All SSH-8 accessories connected to a DAS-1800 Series board must be in slave mode.
- For each of the STA-1800HC connectors J1 to J4, optional channel jumpers are 0 to 7 for the first SSH-8 accessory and 8 to 15 for the second accessory. When you connect more than two SSH-8 accessories, the channels represented in the configuration file by these optional channel jumpers are as shown in Figure 3-5.
- You can calibrate up to two SSH-8 accessories at a time if one SSH-8 is attached to STA-1800HC connector J1 and the other attached to STA-1800HC connector J2. If you have more than two SSH-8 accessories to be calibrated, you must calibrate them individually or in twos on STA-1800HC connectors J1 and J2.
- 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 8 feet maximum of #18 AWG wire (or heavier) for optional external power and ground.

## Installation Procedures

---

This section contains step-by-step procedures to guide you through installing and configuring an SSH-8. Before you begin, be sure you understand the concepts and product options described in Chapters 1 and 2.

Start with the next section and perform the rest of the procedures in this chapter in order.

---

**Caution:** If you are using two SSH-8 accessories in one system, first perform all procedures for the first SSH-8. When you are done, repeat the procedures for the second SSH-8. If you don't perform the procedures in this order, configuration settings will conflict, preventing proper operation. Follow any special instructions that appear for dual SSH-8 systems.

---

### Unpacking and Inspecting the SSH-8

Unpack the SSH-8 and inspect the enclosure for signs of damage. If any damage is apparent, contact Keithley MetraByte's Applications Engineering Department for instructions. Chapter 5 tells how to obtain technical support.

Check the remaining contents of your package against the packing list to be sure that your order is complete. Report any missing items to your sales representative immediately.

### Selecting a Site

You can install the SSH-8 in any location suitable for general-purpose electronic equipment. The temperature in this location must be between 0°C and +45°C for rated performance. If the environment is harsh or unfavorable, make sure that the enclosure cover is installed during operation.

## Installing the DAS Board

Install the Keithley MetraByte DAS board in your computer according to the instructions in the user's guide for your DAS board. Make sure you run the DAS board's configuration utility and specify that an SSH-8 accessory is attached.

DAS board software includes drivers with functions to control the SSH feature and a configuration utility that includes the setup. If you plan to connect your SSH-8 to a DAS board that you purchased at an earlier time, contact Keithley MetraByte's Hardware Application Engineering Department to verify that your DAS board software is up-to-date. Chapter 5 tells how to obtain technical support.

## Removing the SSH-8 Enclosure Cover

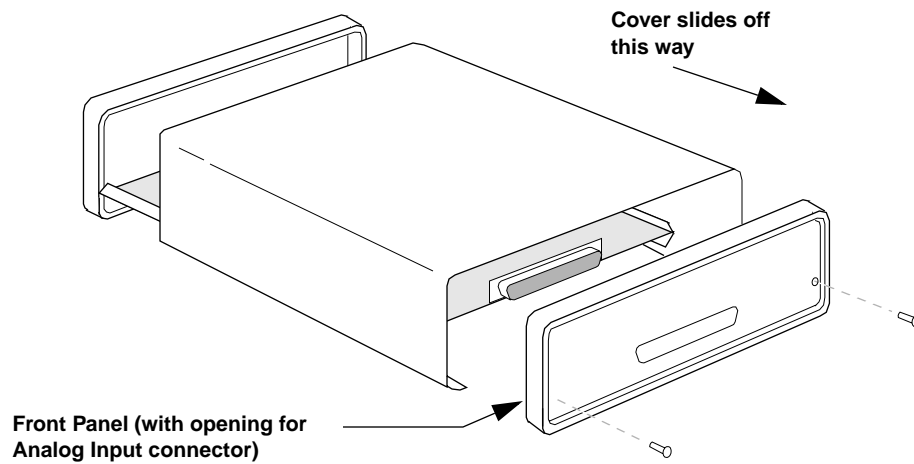
You must remove the SSH-8 enclosure cover in order to reach jumpers, switches, and the expansion connector. To remove the cover, perform the following steps. Refer to Figure 3-7 on page 3-14 for an illustration.

---

**Caution:** To prevent component damage caused by static discharge, wear a grounded wrist strap or similar device whenever handling the board itself.

---

1. Remove the two screws that hold the front panel (Analog Input connector end) in place. Note that this connector is not screwed to the front panel.
2. Remove the front panel.
3. Slide off the cover.



**Figure 3-7. Removing the Enclosure Cover**

## Cabling

The following sections tell how to cable the SSH-8 to a DAS board, to accessory boards, and to another SSH-8.

### ***Connecting the SSH-8 to the DAS Board***

Cabling is the same for DAS-1200, DAS-1400, and DAS-1600 Series boards, but differs for DAS-1800 Series boards. The following sections describe how to cable the SSH-8 to the different types of DAS boards.

---

**Caution:** To avoid accidental damage to the SSH-8, turn the computer off until you install the SSH-8 Configuration Utility as described in “Setting the Channel Gain (SSH-8-SG Only)” on page 3-31.

---

### DAS-1200, DAS-1400, and DAS-1600 Series Boards

In the simplest arrangement, you cable the SSH-8 directly to the DAS-1200, DAS-1400, or DAS-1600 Series board with an S-1800 or C-1800 cable as shown in Figure 3-8. If supply your own cable, make sure it is shielded and as short as practical. In any case, the cable length should not exceed 30 inches.

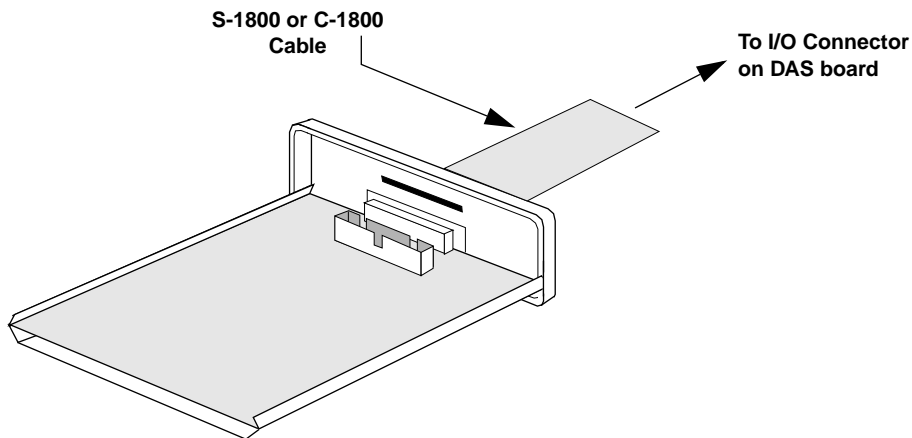


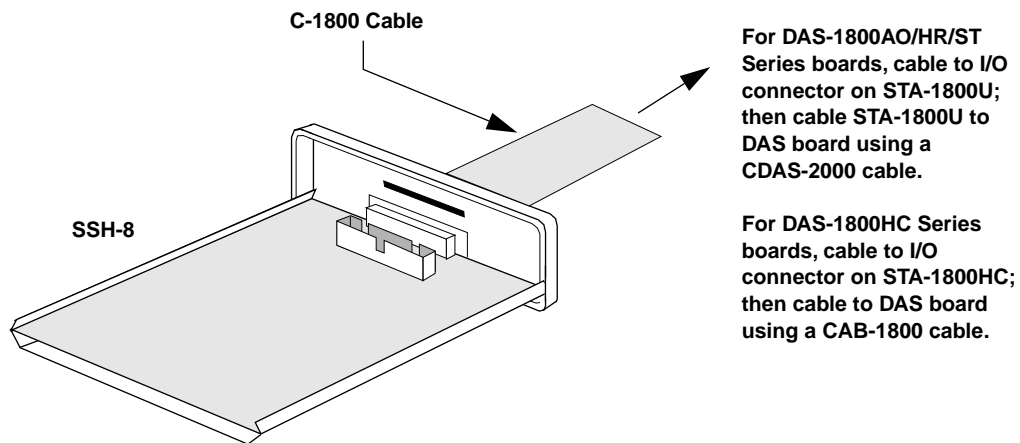
Figure 3-8. Cabling the SSH-8 to a DAS-1200, DAS-1400, or DAS-1600 Series Board

### DAS-1800 Series Boards

In the simplest arrangement, you use the C-1800 cable to connect the SSH-8 to connector J1 on the STA-1800U (for DAS-1800AO/HR/ST Series boards) or to the STA-1800HC (for DAS-1800HC Series boards only), as shown in Figure 3-9.

You then connect as follows:

- **STA-1800U** - cable to DAS-1800AO/HR/ST Series board using a CDAS-2000 cable. See your DAS-1800 Series user's guide for more information.
- **STA-1800HC** - cable to DAS-1800HC Series board using a CAB-1800 cable. See your *DAS-1800HC Series User's Guide* for more information.



**Figure 3-9. Cabling the SSH-8 to a DAS-1800 Series Board**

## **Adding a Screw Terminal Accessory Board (DAS-1200/1400/1600 Series Only)**

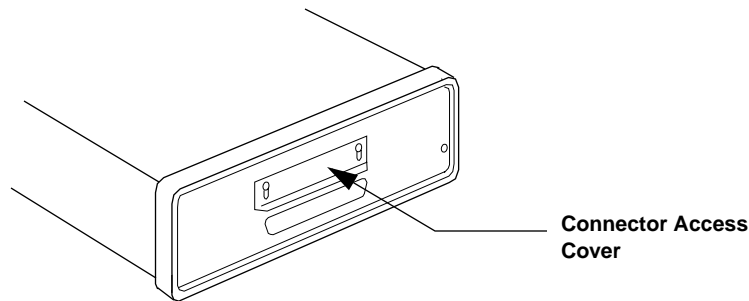
Your application may require DAS I/O lines to system components other than the SSH-8. One way to access to these I/O lines is to add an STA-16 (Screw Terminal Accessory) board to the system. The STA-16 board brings all of the DAS I/O lines out to screw terminals. You can wire the desired DAS outputs from these terminals.

In systems using a DAS-1200, DAS-1400, or DAS-1600 Series board and single or dual SSH-8 accessories, connect the STA-16 board as shown in Figure 3-4 on page 3-6.

Perform the following steps to connect an S-1800, C-1800, and/or SSH-8-DC cable to an SSH-8:

1. On the SSH-8 enclosure, loosen the retaining screws on the connector access cover (shown in Figure 3-10) so that the cover slides up.
2. Run the S-1800, C-1800, or SSH-8-DC cable through the expansion-connector opening and connect it to the appropriate connector.





**Figure 3-10. Connector Access Cover**

3. Slide the connector access cover all the way down and tighten the retaining screws so that the cable is held firmly in place.

In systems using a DAS-1800 Series board, you are already connected to an STA-1800HC or STA-1800U.

---

**Note:** If you use an STA board, use care not to make connections to lines already in use by the SSH-8 (such as analog inputs).

---

## Selecting DAS or External Power

You can configure the SSH-8 to use power supplied either through the DAS board or from an external power supply. You can use DAS board power if all of the following conditions apply:

- Your system uses one SSH-8.
- Filters are not installed on the SSH-8.

If your system does not meet the above conditions, you must use an external power supply.

## **Using DAS Board Power**

The SSH-8 is factory-configured to use DAS board power. If you plan to use DAS board power, skip ahead to “Configuring the SSH-8 to Use an External Pacer Clock” on page 3-19.

## **Using External Power**

This section tells how to select and install a power supply and configure the SSH-8 to use external power.

### **Selecting a Power Supply**

Select a +5 V supply with sufficient capacity for your system. Table 3-2 shows the power requirements for single and dual SSH-8 systems with and without filters. Under rated load conditions, the power supply must deliver +5 V  $\pm$ 5% with a maximum of 50 mV ripple and noise.

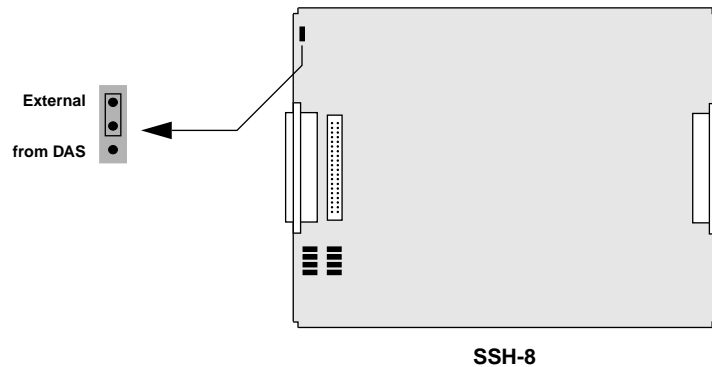
**Table 3-2. SSH-8 Power Requirements**

	<b>Single SSH-8 System</b>	<b>Dual SSH-8 System</b>
<b>No Filters</b>	600 mA	1200 mA
<b>All Filters Installed</b>	1100 mA	2200 mA

### Configuring the SSH-8 to Use External Power

If you are using an external power supply, you must change the Power Select jumper setting as described in the following steps:

1. Refer to Figure 3-11 to locate the Power Select jumper.



**Figure 3-11. Power Select Jumper**

2. Move the Power Select jumper to select external power. On the SSH-8, this position is labeled "EXT."

### Configuring the SSH-8 to Use an External Pacer Clock

If you plan to use an external pacer clock in place of the DAS board pacer clock, read this section and perform the procedure. Otherwise, skip ahead to “Connecting Signals and Power” on page 3-21.

If you are using an external pacer clock, you configure the SSH-8 one way for DAS-1800 Series boards and another way for DAS-1200, DAS-1400, and DAS-1600 Series boards. Refer to the section below that applies to your DAS board.

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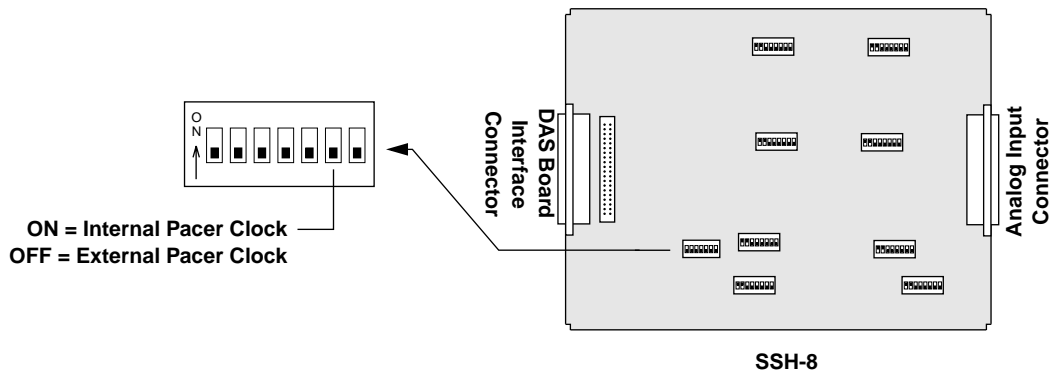
**Note:** The external pacer clock signal must meet the requirements described in Chapter 2.

---

### ***DAS-1200, DAS-1400, and DAS-1600 Series Boards***

If you are using an external pacer clock in a system using a DAS-1200, DAS-1400, or DAS-1600 Series board, you must change the Pacer Clock Select DIP switch setting as described in the following steps:

1. Refer to Figure 3-12 to locate the Pacer Clock Select DIP switch.



**Figure 3-12. Pacer Clock Select DIP Switch**

2. Move the Pacer Clock Select DIP switch to the OFF position.

### ***DAS-1800 Series Boards***

In systems using a DAS-1800 Series board and a pacer clock signal from an outside source, the pacer clock signal can be supplied through a screw terminal of the STA-1800HC/STA-1800U or through the analog input connector of the SSH-8. You set the pacer clock switch on the SSH-8 (shown in Figure 3-12) according to the SSH-8 interface connector that is receiving the signal. If the pacer clock signal is supplied through the DAS board connector (from the STA-1800HC/STA-1800-U), set the pacer clock switch to *internal* (ON). If the pacer clock signal is supplied through the analog input connector, set the pacer clock switch to *external* (OFF).

## Connecting Signals and Power

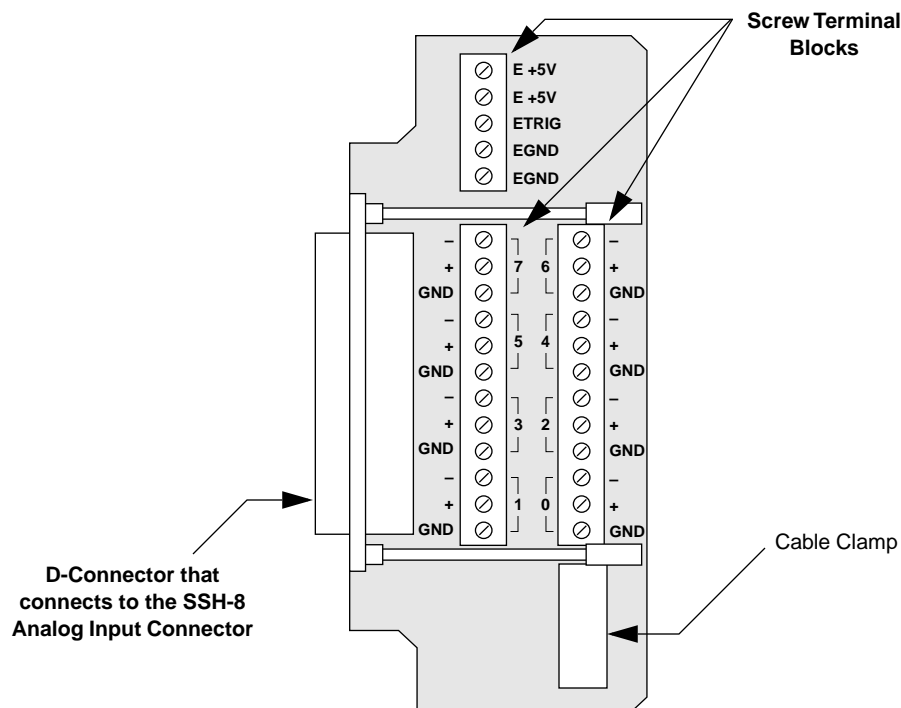
The SSH-8's analog input connector accepts eight differential analog signal inputs, an external pacer clock input (optional) for DAS-1200, DAS-1400, and DAS-1600 Series boards, and external power (optional). This section tells how to physically connect these inputs to the SSH-8.

You can make connections to the analog interface either through the optional STC-SSH-8 screw terminal connector board or through your own cable. The STC-SSH-8 is flexible and easy-to-use, whereas using a cable generally results in cleaner connection. This section describes both of these options.

### Using the STC-SSH-8

The STC-SSH-8 plugs directly into the analog input connector on the SSH-8. It provides labeled screw terminals for signals, power, and an external pacer clock (labeled "ETRIG"). Figure 3-13 shows the layout of the STC-SSH-8.

**Figure 3-13. STC-SSH-8 Layout**



To wire and install the STC-SSH-8, bring wires in through the cable clamp and then connect them to the appropriate screw terminals.

### ***Using a Custom Cable***

Instead of using the STC-SSH-8, you can build a custom cable to attach directly to the analog input connector. For best results, use one shielded twisted pair for each input signal and one twisted pair (shielded or unshielded) for the optional external pacer clock (DAS-1200, DAS-1400, and DAS-1600 Series boards).

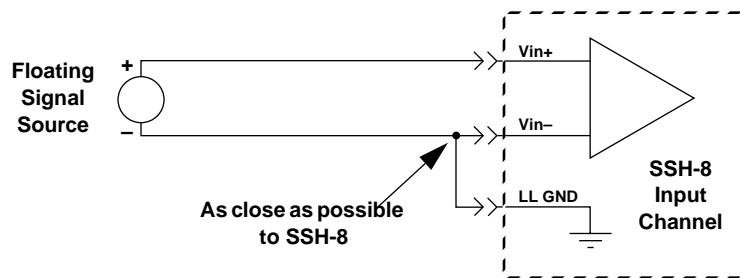
### ***Connecting Analog Signals***

This section describes the differences in wiring floating and grounded signal sources, as well as the use of shielded twisted pair wire. Connect analog signals according to the guidelines in this section.

#### **Floating and Grounded Signal Sources**

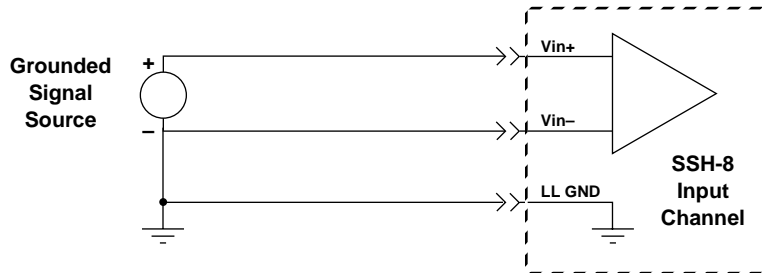
The SSH-8 provides a differential input configuration for analog signals. This configuration consists of two inputs relative to ground.

The way you wire a signal to a differential input depends on whether the signal is floating or grounded. A floating signal source is not connected to system ground at the source. For example, a battery-powered signal source typically has no connection to system ground. Figure 3-14 shows how to wire a floating signal source to the SSH-8.



**Figure 3-14. Wiring a Floating Signal Source**

Figure 3-15 shows how to wire a grounded signal source to the SSH-8.

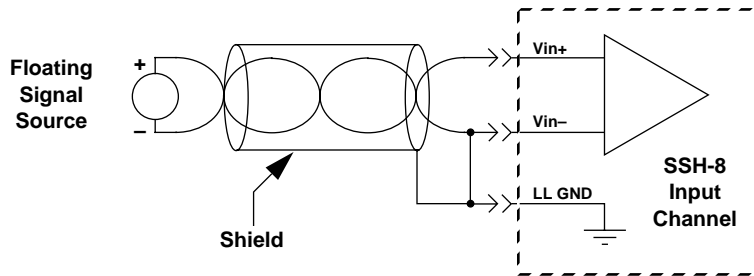


**Figure 3-15. Wiring a Grounded Signal Source**

### Using Shielded Twisted Pair Wire

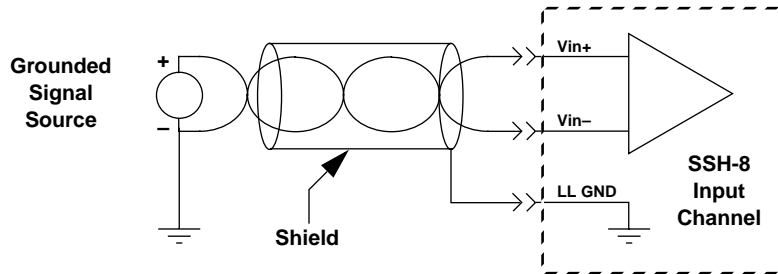
Using shielded twisted pair wire to connect analog signals to the SSH-8 produces the best results. Shielded twisted pair contains three conductors: two for the signal and a third "shield" conductor.

Figure 3-16 shows how to use shielded twisted pair to connect a floating signal to the SSH-8. Note that the shield is not connected at the source.



**Figure 3-16. Using Shielded Twisted Pair Wire to Connect a Floating Input**

Figure 3-17 shows how to use shielded twisted pair to connect a grounded signal to the SSH-8.



**Figure 3-17. Using Shielded Twisted Pair Wire to Connect a Grounded Input**

### ***Connecting an External Pacer Clock***

The external pacer clock input is wired one way for DAS-1800 Series boards and another way for the DAS-1200, DAS-1400, and DAS-1600 Series boards. Refer to the section that applies to your DAS board.

#### **DAS-1200, DAS-1400, and DAS-1600 Series Boards**

The external pacer clock connects to two pins (ETRIG IN and COM) on the analog input connector. The actual physical connection to these pins depends on whether you bring signals into the analog input connector through the STC-SSH-8 screw terminal connector or through a custom cable. You can use twisted pair or shielded twisted pair wire.

---

**Note:** For dual SSH-8 systems, use parallel leads of equal length and gauge to connect the pacer clock to both boards.

---



To wire the external pacer clock to the SSH-8, do the following:

1. Connect the pacer clock signal wire to the ETRG screw terminal on the STC-SSH-8 or the EXT CLK IN pin (pin 6) on the analog input connector.
2. Connect the pacer clock return wire to the EGND screw terminal on the STC-SSH-8 or the COM pin (pin 1, 2, 3, 4, 5, and 24) on the analog input connector.

### **DAS-1800 Series Boards**

For a DAS-1800 Series board, connect the external pacer clock and the pacer clock return to the STA-1800HC or STA-1800U screw terminal accessory board. The pacer clock signal connects to the DIO screw terminal and the pacer clock return connects to the D GND screw terminal. Refer to your DAS-1800 Series user's guide for screw terminal information.

## ***Connecting External Power***

External power connects to two pins on the analog input connector. The actual physical connection to these pins depends on whether you bring signals into the analog input connector through the STC-SSH-8 screw terminal connector or through a custom cable.

Make sure you use power wire that can handle the expected current (refer to Table 3-2 on page 3-18 for current specifications). #18 AWG wire should be heavy enough for any installation provided you keep the length under eight feet (four feet in each lead).

### **Wiring Power**

To wire power to the SSH-8, do the following:

1. Make sure the power supply is turned off.
2. Connect the +5 V power supply terminal to the E+5V screw terminal on the STC-SSH-8 or the +5 V EXT pin (pin 20, 21, 22, and 23) on the analog input connector.
3. Connect the grounded power supply terminal to the EGND screw terminal on the STC-SSH-8 or the COM pin (pin 1, 2, 3, 4, 5, and 24) on the analog input connector.

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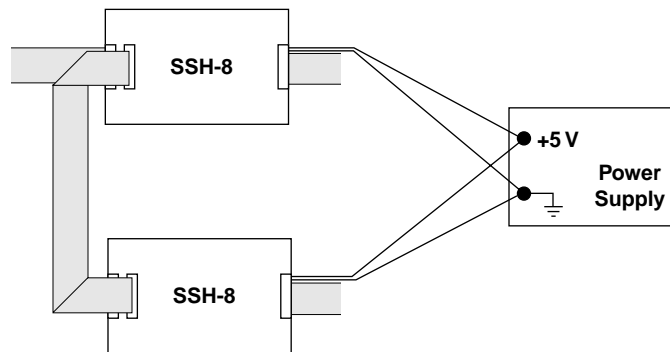
**Caution:** To avoid damage to the board, do not turn on power yet.

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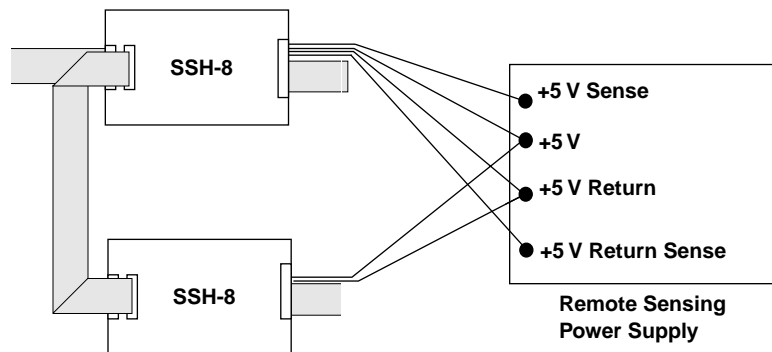
### Wiring Power to Multiple SSH-8 Systems

If you have completed installation of the first SSH-8 and are installing additional SSH-8s, you can now wire power to the other SSH-8s.

Figure 3-18 and Figure 3-19 show the most efficient way to power two or more SSH-8s. This method uses a separate set of power wires between each additional SSH-8 and the power supply to minimize current flow through the wires.



**Figure 3-18. Connecting External Power to Two SSH-8s**



**Figure 3-19. Connecting Remote Sensing Power Supply**

## Installing and Configuring Channel Filters (Optional)

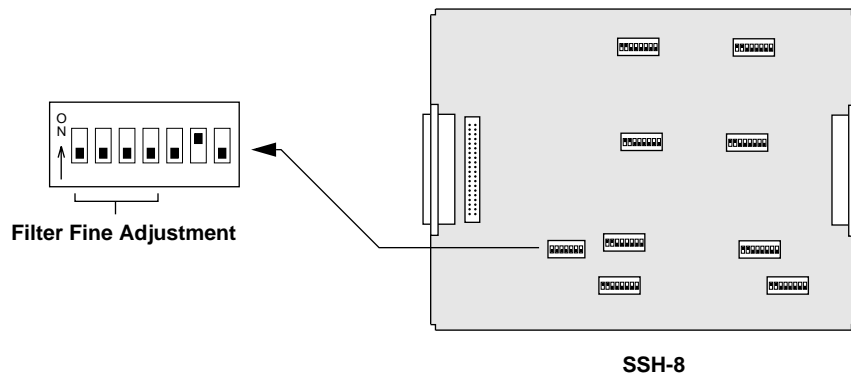
If you are using channel filters, install them now as described in this section. Otherwise, skip ahead to “Assigning SSH-8 Outputs to DAS Input Channels” on page 3-28.

### ***Setting the Filter Cutoff Frequency***

The filter cutoff frequency is controlled by a jumper setting on the filter module and DIP switch settings on the SSH-8. This section tells how to set the DIP switches on the SSH-8.

To set the filter cutoff frequency, do the following:

1. Follow the instructions in Appendix B to set up the filter module and determine the fine adjustment value required to produce the desired cutoff frequency.
2. Refer to Figure 3-20 to locate the Filter Fine Adjustment DIP switches.



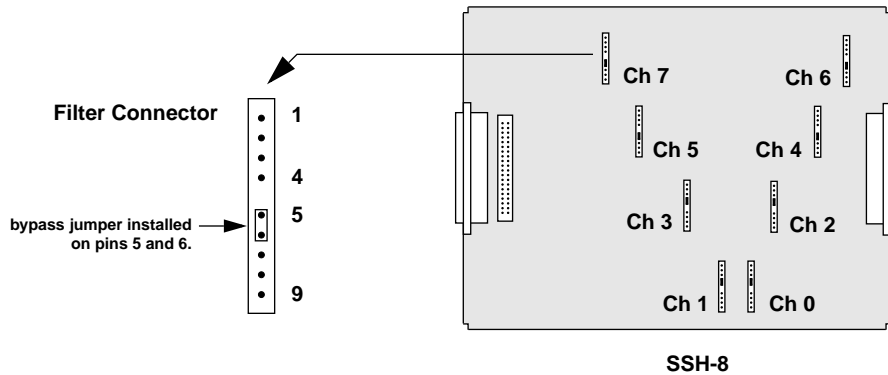
**Figure 3-20. Filter Fine Adjustment DIP Switches**

3. Referring to Table 3-1 on page 3-3, set the Filter Fine Adjustment DIP switches to the desired fine adjustment value.

## Installing the Filters

Perform the following procedure for each channel on which you want to install a filter.

1. Refer to Figure 3-21 to locate the filter connector for the desired channel.



**Figure 3-21. Filter Connector Locations**

2. Remove the bypass jumper.
3. Insert the filter. The filter connector is keyed to ensure correct positioning.
4. Repeat this procedure for each channel on which you want to install a filter.

## Assigning SSH-8 Outputs to DAS Input Channels

For connections to DAS-1200/1400/1600 Series boards or to DAS-1800AO/HR/ST Series boards, you can direct SSH-8 channel outputs to one of two analog input channel ranges: the channel 0 to 7 range or the channel 8 to 15 range. For connections to DAS-1800HC Series boards, you can direct SSH-8 outputs to one of eight analog input channel ranges; these ranges are as shown in Figure 3-6 on page 3-10.

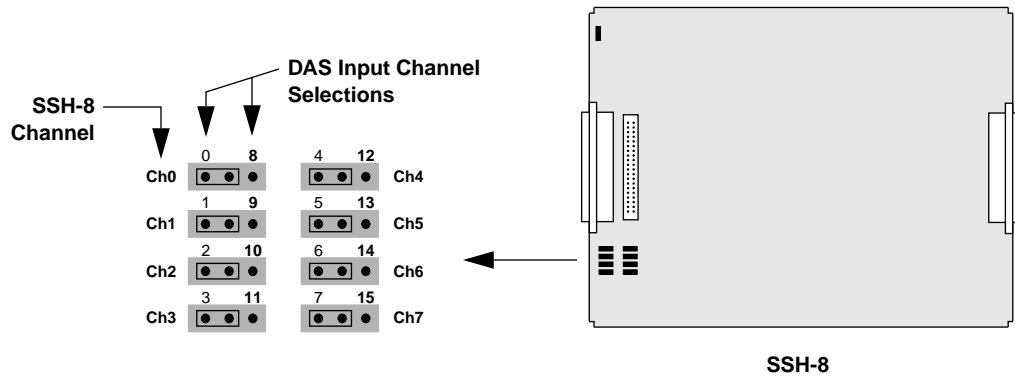
For each SSH-8 output channel, an output channel jumper on the SSH-8 selects the DAS input channel. The default settings of these eight jumpers are SSH-8 channels 0 to 7, the low range.

This capability lets you resolve a DAS input channel conflict. For example, you may be adding SSH channels to a system in which the low DAS channels (0 to 7) are already in use. In this case, you can set the Output Channel jumpers so that SSH channels use DAS channels 8 to 15.

For a multiple SSH-8 system, you must change the output channel jumper settings on one of each SSH-8 accessories attached to a DAS-1200/1400/1600 Series board or to a DAS-1800AO/HR/ST Series board or on one of each pair of SSH-8 accessories attached to an STA-1800HC accessory. Typically you use DAS channels 0 to 7 (the low range) for the first SSH-8 and 8 to 15 (the high range) for the second SSH-8.

To redirect SSH-8 channel outputs, do the following:

1. Refer to Figure 3-22 to locate the output channel jumpers. This figure shows channels 0 to 7 selected.



**Figure 3-22. Output Channel Jumpers**

2. Change jumper settings as required.

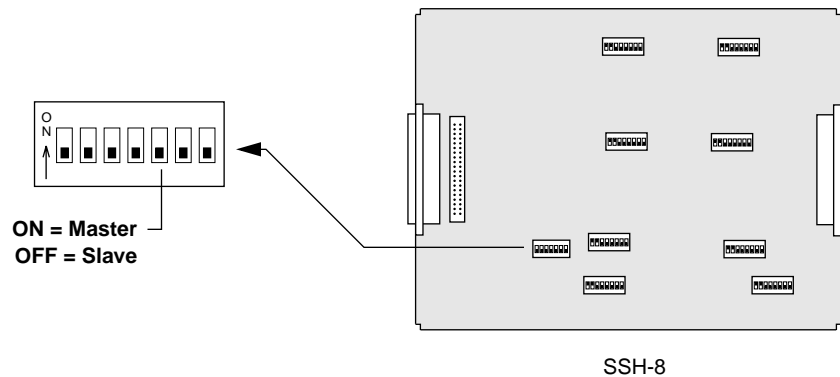
## Changing the Master/Slave Mode

An SSH-8 in master mode sends a data conversion control signal to the attached DAS board. Two cases call for changing the factory setting of master mode:

- If you are using the SSH-8 with a DAS-1800 Series board, you must set all SSH-8 accessories to slave mode.
- If you have a dual SSH-8 system with a DAS-1200, DAS-1400, or DAS-1600 Series board, you must set the first SSH-8 to slave mode.

To select slave mode on the SSH-8, do the following:

1. Refer to Figure 3-23 to locate the master/slave DIP switch.



**Figure 3-23. Master/Slave DIP Switch**

2. Move the master/slave DIP switch to the OFF position.

## Setting the Channel Gain (SSH-8-SG Only)

The factory setting for channel gain is x0.5. To change channel gain to a different value, do the following:

1. Refer to Figure 3-24 to locate the Gain Set DIP switches for the desired channels.

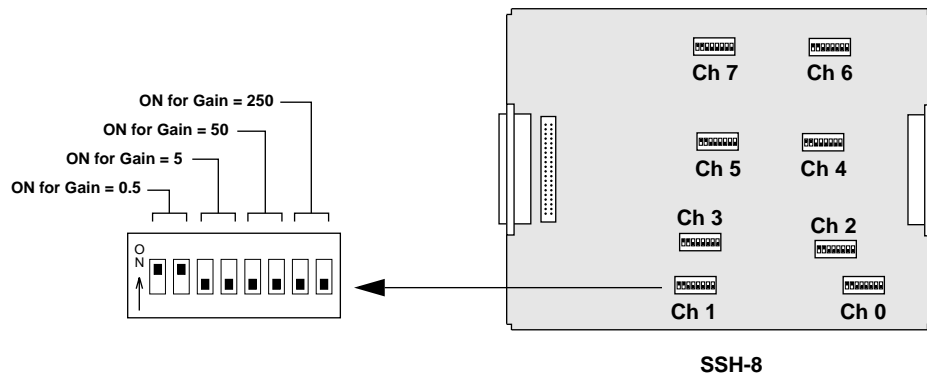


Figure 3-24. Gain Set DIP Switches

2. Adjust the switches to the desired gain settings. Notice that for any gain setting, two switches are ON and the rest are OFF.

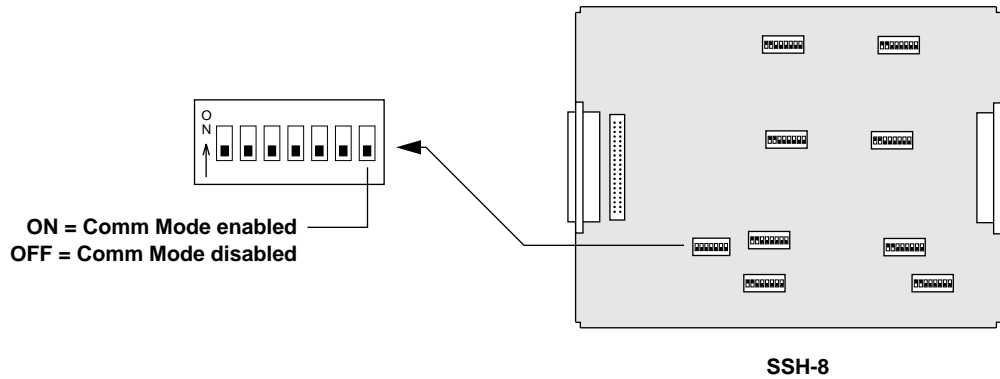
## Disabling Communication Mode

The SSH-8 calibration utility, which runs on the PC, uses the DAS digital outputs to communicate with the SSH-8. You run this utility only during installation and during periodic system maintenance. Therefore, during normal SSH-8 operation, the DAS digital outputs are available for other purposes.

If you plan to use any of the DAS board digital outputs, you must disable communication mode on the SSH-8 when the SSH-8 calibration utility is not in use. This section tells how to enable and disable communication mode.

The factory setting for communication mode is enabled. To disable communication mode, change the communication mode DIP switch setting as described in the following steps:

1. Refer to Figure 3-25 to locate the communication mode DIP switch.



**Figure 3-25. Communication Mode DIP Switch**

2. Move the communication mode DIP switch to the OFF position.

---

**Note:** You must re-enable communication mode whenever you run the SSH-8 calibration utility.

---

## Connecting a Second SSH-8

Once you have performed all of the preceding installation procedures for the first SSH-8, you can install the second SSH-8. Go back to the beginning of this chapter and repeat the procedures, in order, to install the second SSH-8.



## Running the SSH-8 Calibration Utility

The SSH-8 calibration utility calibrates the aggregate system (DAS board plus SSH-8).

---

**Note:** The calibration utility requires a fully calibrated DAS board. If you are unsure of the DAS board's calibration status, recalibrate the board according to the calibration procedure described in the DAS board user's guide.

---

You should calibrate the system at this time. Power on the computer and external power supply (if used) and refer to the instructions in Chapter 4 to run the SSH-8 calibration utility.

## Replacing the Enclosure Cover

Before you replace the SSH-8 enclosure cover, perform your own tests on the system to make sure it works as expected.

Then replace the cover by doing the following:

1. Disconnect the STC-SSH-8 or analog input cable.
2. Slide the enclosure cover and rear panel back on.
3. Replace and tighten the retaining screws that hold the rear panel in place.
4. Reconnect the STC-SSH-8 or analog input cable.

# 4

## SSH-8 Calibration Utility

The SSH-8 calibration utility (CALSSH8.EXE) is a DOS program for calibrating one or two SSH-8 accessories at a time. The program requires the SSH-8 accessories to be attached to a system and ready to run. The calibration utility communicates with the SSH-8 accessories through the DAS board.

You connect an SSH-8 to the DAS board for calibration as follows:

- In a system using DAS-1200/1400/1600 Series boards, you attach a single SSH-8 or a daisy-chained pair of SSH-8s directly to the DAS board, as shown in Figure 3-3.
- In a system using a DAS-1800AO/HR/ST Series board, you attach a single SSH-8 to connector J1 of the STA-1800U and a second SSH-8 (if needed) to connector J2 of the STA-1800U, as shown in Figure 3-5.
- In a system using a DAS-1800HC Series board, you attach a single SSH-8 to connector J1 of the STA-1800HC and a second SSH-8 (if needed) to connector J2 of the STA-1800HC, as shown in Figure 3-6. If you have more than two SSH-8 accessories to calibrate with a DAS-1800HC Series board, you must calibrate each SSH-8 individually or in pairs through connectors J1 and J2 of the STA-1800HC.

---

**Note:** The calibration utility also requires a fully calibrated DAS board. If you are unsure of the DAS board's calibration status, recalibrate the board according to the calibration procedure described in the DAS board user's guide.

---

Normally, you run the SSH-8 calibration utility immediately after installing the SSH-8 and then as often as necessary to maintain required accuracy. This chapter tells how to install, activate, and use the SSH-8 calibration utility.

## Installing the SSH-8 Calibration Utility

---

The SSH-8 calibration utility is available on both 3 1/2-inch and 5 1/4-inch diskettes. To install the calibration utility, perform the following steps:

1. Create a directory on the computer hard drive for the SSH-8 software. For example, enter the following at the C:\ prompt:  

```
mkdir ssh8
```
2. Insert the SSH-8 software diskette in the computer's diskette drive and copy the contents to the directory created in Step 1. An example follows:  

```
CD SSH8  
copy A:*.*
```

## Using the Configuration File

---

The SSH-8 calibration utility requires one configuration file for the DAS board and another for the SSH-8 accessories. The configuration file for the DAS board must be a product of that board's configuration utility (CFG1600.EXE or CFG1800.EXE). For purposes of the SSH-8 calibration utility, the DAS board configuration file must be set for single-ended, bipolar inputs and for the proper number of SSH-8 accessories.

---

**Note:** If you are using a DAS-1200/1400/1600 Series board, the board's configuration file must be from Version 3.00 or later of the DAS-1600 Series software package. Only Version 3.00 or later includes SSH software support.

---

A default configuration file (SSH8.CFG) is included in the SSH-8 software package. This file contains the default address that is factory-programmed into an EEPROM on the SSH-8 accessory (for calibration purposes only). If you are calibrating a single SSH-8, you need only the default version of SSH8.CFG and do not need to run the configuration utility. If you are calibrating two SSH-8 accessories, you must initially run the calibration utility to program a new address to the second SSH-8. The calibration utility allows you to save the changed configuration file for later calibration of the same two SSH-8 accessories.

## Using the SSH-8 Calibration Utility

---

This section contains instructions for starting and running the SSH-8 calibration utility. The utility works with keyboard or mouse.

### Starting the SSH-8 Calibration Utility

You start the SSH-8 calibration utility for one of two purposes: to program a new EEPROM address for a second board or to calibrate an SSH-8 accessory. To start the calibration utility for the purpose of programming a new EEPROM address for the second board, change to the directory containing the SSH-8 software and enter the following statement:

```
CALSSH8 das_config_filename
```

where *das\_config\_filename* is the name of the DAS board configuration file. For example, make the following entry for a DAS-1601 board:

```
CALSSH8 DAS1600.CFG
```

To start the SSH-8 calibration utility for the purpose of calibration, change to the directory containing the SSH-8 software and enter the following statement:

```
CALSSH8 das_config_filename ssh8_config_filename
```

where *das\_config\_filename* is the name of the DAS board configuration file and *ssh8\_config\_filename* is the name of the SSH-8 accessory configuration file.

For example, make the following entry for a DAS-1802HC board:

```
CALSSH8 DAS1800.CFG SSH8.CFG
```

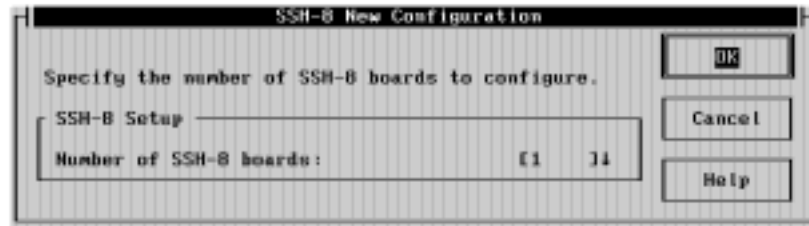
---

**Note:** Although both configuration filenames are indicated as optional command-line arguments, you must enter a DAS board configuration filename to start the calibration utility.

---

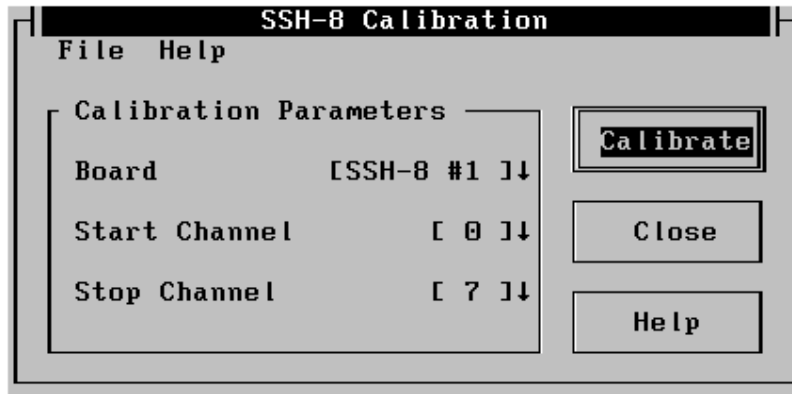
## Running the SSH-8 Calibration Utility

If you start the SSH-8 calibration utility for the purpose of programming an EEPROM address for a second SSH-8 accessory, you are asked if you are creating a new configuration file. Answering *Yes* switches the calibration utility to the screen shown in Figure 4-1.



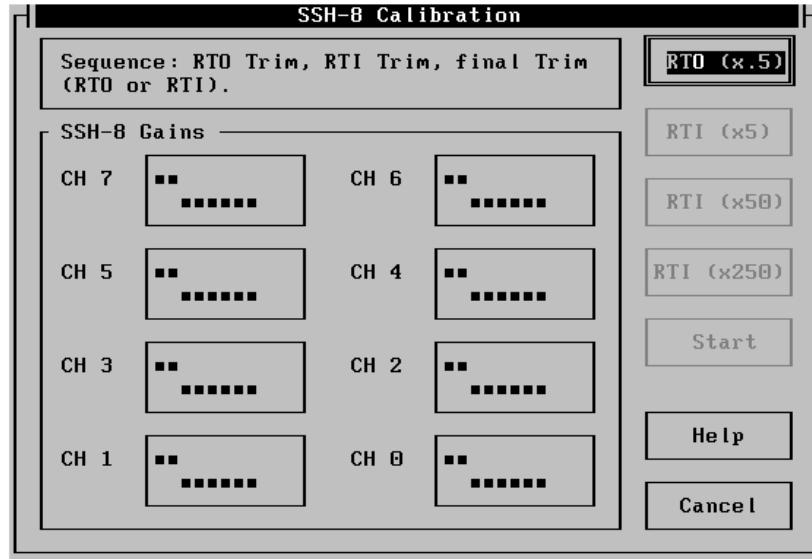
**Figure 4-1. New Configuration Screen**

Select the correct number of boards, then choose **OK**. After you follow instructions for programming the new base addresses, the screen shown in Figure 4-2 appears.



**Figure 4-2. Startup Screen for Calibration**

Figure 4-2 is the startup screen if you activate the SSH-8 calibration utility for the purpose of calibration. Select the appropriate options for the **Calibration Parameters**. If you are unsure of what or how to select, choose **Help**. When you complete the selections, choose **Calibrate**. If you are calibrating an SSH-8FG, the calibration utility completes the calibration process. If you are calibrating an SSH-8SG, the calibration utility displays the screen shown in Figure 4-3.



**Figure 4-3. Calibration Screen for SSH-8SG**

When you see the calibration screen, you perform RTO Trim, RTI Trim, and Final Trim to complete the calibration process. RTO (Referred To Output) Trim describes a relatively coarse offset adjustment made beyond the input amplifier gain stages to compensate for such effects as DAS board offset, sample switching effects, and any filter module offsets. RTI (Referred To Input) Trim describes an adjustment made before the input amplifier gain stages to trim such values from the instrumentation amplifier as relative input offsets and signal source effects. Final Trim is a final adjustment of the gain to be used (RTO or RTI gains, as shown in the boxes of the calibration screen).

A zero calibration is necessary to adjust the RTO Trim to correct value at minimum gain. This adjustment must be followed by a fine adjustment of the RTI Trim at high gain and then a Final Trim of the gain to be used.

To complete the calibration process, perform the three steps of gain trimming, as follows:

1. **RTO Trim:** select the **RTO (x.5)** box of the calibration screen to see the settings for the channel/gain switches. Setting the channel/gain switches (refer to Figure 3-1 on page 3-2 for the switch locations) to the positions indicated in the calibration screen and choosing **Start** performs the RTO Trim.
2. **RTI Trim:** select the **RTI (x50)** box of the calibration screen to see the settings for the channel/gain switches. Setting the channel/gain switches to the positions indicated in the calibration screen and choosing **Start** performs the RTI Trim.
3. **Final Trim:** select the gain box (RTO x.5, RTI x5, RTI x50, or RTI x250) of the calibration screen for the gain to be used to see the settings for the channel/gain switches. Setting the channel/gain switches to the positions indicated in the calibration screen and choosing **Start** performs the Final Trim.

After each step of calibration, the calibration utility notifies you of good or bad data, which is based on calibration statistics contained by the utility program. If calibration is successful, you are asked whether to save the calibration data.

If calibration fails, the corresponding calibration statistics are saved to a text file. A failure at any stage requires you to repeat the RTO Trim stage.

---

**Note:** In the event a calibration fails, the calibration utility generates a text file (SSH8ERR.TXT) containing calibration statistics. If you are trying to determine the cause of a calibration failure, look in this file for a channel whose statistics differ widely from those of the other channels. Also check jumpers for proper position. When no cause is apparent, call for technical support as described in Chapter 5.

---



## Maintaining Calibration

---

Calibrate your system at regular intervals to maintain accuracy. The length of a calibration interval depends on gain settings, temperature variations in the operating environment, frequency of system power cycling, and system accuracy requirements.

High-gain systems require more frequent calibration than low-gain systems. The higher the gain, the more often calibration is required. Systems subject to wide fluctuations in operating environment temperatures and frequent power cycling also tend to need more frequent calibration.

At first, plan on calibrating your system every one to three months. Experience with your system will indicate whether this interval is sufficient. If system accuracy is critical, consider performing regular benchmark tests to determine whether your system needs more frequent calibration.

# 5

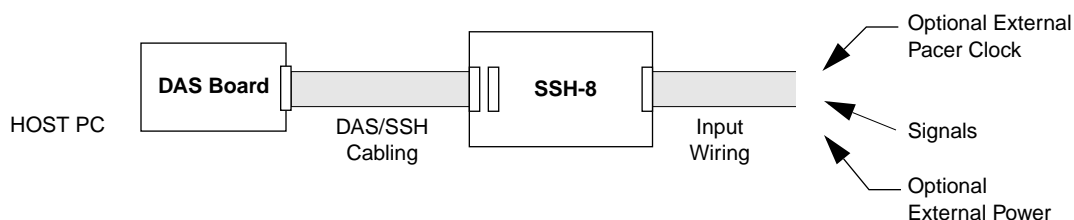
## Troubleshooting

This chapter guides you in resolving problems with measurement systems using the SSH-8.

### Problem Isolation

---

If you suspect a problem with faulty hardware or with cabling and wiring, try to isolate the problem to a major system component. Figure 5-1 shows the components in a simple measurement system using an SSH-8.



**Figure 5-1. SSH-8 System Components**

Measurement systems that use the SSH-8 vary in configuration and complexity, so it is not possible to provide one problem isolation procedure that applies to all systems. Two general techniques you can use to isolate a system problem are as follows:

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

An example of this kind of test is checking the signal path through an SSH-8 by applying known input signals at the input connector and observing the outputs at the output connector. Another example is

using an ohm meter to test the continuity of wiring or cable conductors.

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

## Common Problems and Solutions

---

Table 5-1 lists symptoms and suggested solutions for problems with measurement systems using the SSH-8. If you cannot solve the problem with this table, refer to “Technical Support” on page 5-6.

**Table 5-1. Problems and Suggested Solutions**

Symptom	Possible Cause	Suggestions
No response from SSH-8 during data acquisition	Bad physical connection or cable	Check the DAS/SSH-8 cabling. Make sure all the connectors are firmly tightened. To verify that the problem is not with the cable itself, remove the cable and try a different one.
	Wrong cable	For DAS-1200/1400/1600 Series boards, use the S-1800 cable to connect the SSH-8 to the DAS board. For DAS-1800 Series boards, use the C-1800 to attach the SSH-8 to the STA-1800U or STA-1800HC.
	No power or inadequate power	Make sure the SSH-8 is configured to use the power from the correct source (DAS or external). If the configuration is correct, make sure the power supply rating is sufficient to handle the current demand. Make sure the wires or cable are not too long. Refer to Chapter 3.

**Table 5-1. Problems and Suggested Solutions (cont.)**

<b>Symptom</b>	<b>Possible Cause</b>	<b>Suggestions</b>
No response from SSH-8 during data acquisition (cont.)	Problem with DAS board or PC	Refer to the DAS board user's guide for assistance.
	Master/Slave setting incorrect	The Master/Slave DIP switch must be set correctly. Refer to information on Master/Slave setting in Chapters 2 and 3.
	Pacer Clock selection incorrect	The pacer clock can be internal or external. A DIP switch selects which is used. Refer to information on the pacer clock in Chapter 3.
No response from SSH-8 during calibration	Communication mode disabled	Make sure the Comm Mode DIP switch is in the ON position. Refer to Chapter 3 for information on setting DIP switches.
	IRQ/DMA channel conflict or incorrect	Check IRQ/DMA levels of DAS board for possible conflict
	See other causes above for "No response from SSH-8 during data acquisition."	—
Intermittent operation	Vibrations or loose connections	Cushion source of vibration and tighten connections.
	Overheating	Check for external heat sources and try to position the SSH-8 away from them.
	Electrical noise	For DAS-1200/1400/1600 Series boards, make sure you are using the S-1800 shielded cable to connect to the SSH-8. If the enclosure cover is removed, try replacing it. Make sure the PC cover is installed. Re-route the cable away from likely sources of emissions, such as video monitors.

**Table 5-1. Problems and Suggested Solutions (cont.)**

<b>Symptom</b>	<b>Possible Cause</b>	<b>Suggestions</b>
Intermittent operation (cont.)	Inadequate power	Make sure the power supply rating is sufficient to handle the current demand. Make sure the wires or cable are not too long. Refer to Chapter 3.
Unexpected data	Bad input connections	Check cabling or wiring from sensors to SSH-8 inputs.
	Electrical noise	Use shielded input wiring. Make sure the PC cover is installed. Re-route the wiring away from likely sources of emissions, such as video monitors.
	Swapped channels	Trace all signals from the sensors to the DAS board to make sure they connect to the correct DAS inputs. Check the Output Channel jumpers on the SSH-8.
	Gain too high or too low	Check gain calculations. Check gain settings on SSH-8 and DAS board. Measure signal levels at SSH-8 and DAS inputs.
	Different gain values for different channels	If different gain values for different channels are set on the SSH-8, sample skew increases. If possible, use identical channel gains, or if using the DAS-1802, set different channel gains on the DAS board instead of the SSH-8. Refer to the section on varying gain in Chapter 2.
	Calibration required	Run the DAS calibration and SSH-8 zero calibration procedures.

**Table 5-1. Problems and Suggested Solutions (cont.)**

<b>Symptom</b>	<b>Possible Cause</b>	<b>Suggestions</b>
Unexpected data (cont.)	Filter cutoff frequency too high or low	If using optional filters, make sure the cutoff frequency is set correctly. Refer to the sections on filtering in Chapter 3 and Appendix B.
	Different cutoff frequencies	Using different filter cutoff frequencies on a set of inputs increases sample skew as well as causing other unexpected effects. Make sure all filters are configured for the same cutoff frequency.
	Communication mode enabled	If you are using the digital I/O lines on the DAS board, you must disable communication mode on the SSH-8. Refer to Chapter 3.
	Inadequate power	Make sure the power supply rating is sufficient to handle the current demand. Make sure the wires or cable are not too long. Refer to Chapter 3.
	Problem with DAS board or PC	Refer to the DAS board user's guide for assistance.
Miscellaneous	Master/Slave setting	Make sure the Master/Slave DIP switch is set correctly. Refer to information on Master/Slave setting in Chapters 2 and 3.
	Pacer Clock	Make sure the External Pacer Clock DIP switch is set correctly. If you are using an external pacer clock, make sure it is operational, conforms to TTL specifications, and meets timing requirements as described in Chapter 2. Refer to Chapters 2 and 3 for more information.

**Table 5-1. Problems and Suggested Solutions (cont.)**

<b>Symptom</b>	<b>Possible Cause</b>	<b>Suggestions</b>
Miscellaneous (cont.)	Timing problem	Verify that you are observing the timing protocol described in Chapter 2.
	Damaged SSH-8	Contact the Keithley MetraByte Hardware Application Engineering Department. Refer to the following section.

## **Technical Support**

---

To obtain technical support, please call the Keithley MetraByte Hardware Application Engineering Department at (508) 880-3000 at the following times:

**Monday through Friday, 8:00 A.M. to 6:00 P.M. Eastern Time**

An applications engineer will help you try to diagnose and resolve your board problem over the telephone.

To save time, be ready to furnish the following information:

<b>Software package</b>	Name	_____
	Serial #	_____
	Version	_____
	Invoice/Order #	_____
<b>Compiler (if applicable)</b>	Language	_____
	Manufacturer	_____
	Version	_____
<b>Operating System</b>	DOS version	_____
	Windows version	_____
	Windows mode	_____
<b>Computer</b>	Manufacturer	_____
	CPU type	_____
	Clock speed (MHz)	_____
	KB of RAM	_____
	Video system	_____
	BIOS type	_____



**DAS Board  
Configuration**

Model \_\_\_\_\_  
Serial # \_\_\_\_\_  
Revision code \_\_\_\_\_  
Base address setting \_\_\_\_\_  
Interrupt level setting \_\_\_\_\_  
Number of channels \_\_\_\_\_  
Input (S.E. or Diff.) \_\_\_\_\_  
Mode (uni. or bip.) \_\_\_\_\_  
DMA channel(s) \_\_\_\_\_  
Number of SSH-8 brds. \_\_\_\_\_  
\_\_\_\_\_

**Accessories**

Type \_\_\_\_\_  
Type \_\_\_\_\_  
Type \_\_\_\_\_  
Type \_\_\_\_\_  
Type \_\_\_\_\_  
Type \_\_\_\_\_  
Type \_\_\_\_\_  
Type \_\_\_\_\_  
\_\_\_\_\_

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

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

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

---

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

---

Repackage the equipment. Use its original anti-static wrapping, if possible. Ship the equipment to

**Attn RMA #** \_\_\_\_\_  
**Repair Department**  
**Keithley MetraByte**  
**440 Myles Standish Boulevard**  
**Taunton, Massachusetts 02780**

**Telephone 508/880-3000**  
**Telex 503989**  
**FAX 508/880-0179**



# A

## Specifications

Table A-1 provides specifications for the SSH-8.

**Table A-1. SSH-8 Specifications**

<b>Feature</b>	<b>Specification</b>
Inputs	
Channels	8
Voltage Range	$\pm 10$ V nominal, $\pm 11$ V max (differential + common mode signals)
Temperature Coefficient of Offset	6 $\mu\text{V}/^\circ\text{C}$ typical
Offset Drift	0.08 $\mu\text{V}/\text{month}$
Offset Current	2 pA typical, 1000 pA maximum
Bias Current	4 pA typical, 3 nA maximum
Gain	x0.5 (SSH-8FG)
Gain Sets	x0.5, x5.0, x50, x250 (SSH-8SG)
Gain Accuracy	0.025%
Small Signal Bandwidth ( $\pm 0.5$ V input)	
x0.5	180 kHz
x5.0	135 kHz
x50	18 kHz
x250	3.6 kHz
Large Signal Bandwidth ( $\pm 5$ V input)	
x0.5	90 kHz
x5.0	135 kHz
x50	18 kHz
x250	3.6 kHz

**Table A-1. SSH-8 Specifications (cont.)**

<b>Feature</b>	<b>Specification</b>
Small Signal 10-90% Risetime (±0.5 V input) x0.5 x5.0 x50 x250	1.9 μs 2.2 μs 19 μs 83 μs
Large Signal 10-90% Risetime (±5 V input) x0.5 x5.0 x50 x250	5 μs 2.7 μs 19 μs 83 μs
Common Mode Rejection x0.5 x5.0 x50 x250	80 dB 90 dB 100 dB 100 dB
Outputs Channels Range Impedance Drive Current Additive Noise	8 ±5 V nominal, ±6 V maximum 0.3 Ω typical, 0.5 Ω maximum ±5 mA 150 μV <sub>rms</sub> typical
Sample Skew at x0.5 gain Channels 0 to 3 Channels 4 to 7 Channels 0 to 7 Two SSH-8 accessories daisy-chained	1 ns 1 ns 2 ns 5 ns
Hold Droop	1 μV/μs maximum
Power Supply Voltage	+5 V ±5%

**Table A-1. SSH-8 Specifications (cont.)**

<b>Feature</b>	<b>Specification</b>
Current Draw No filters installed All filters installed	600 mA 1100 mA
Environment Temperature Range, Rated Performance Temperature Range, Operating Temperature Range, Storage Relative Humidity	0°C to +45°C 0°C to +45°C -25°C to +75°C 0 to 95% @ 60°C noncondensing

# B

## SSH-8 Filter Modules

The optional SSH-8 filter modules (SSH-FLT and SSH-FLT/8-5K) are single-channel, low-pass Cauer filters. The small printed circuit board mounts directly on the SSH-8 accessory. The cutoff frequency of the filter modules is adjustable.

This appendix uses the following sections to describe the SSH-8 filter modules:

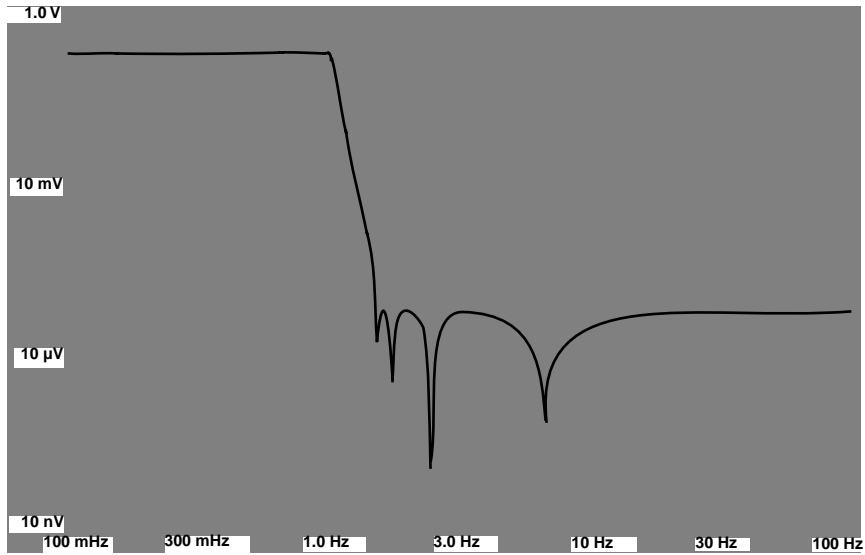
- Electrical Characteristics
- Determining the Cutoff Frequency
- Setting the Cutoff Frequency
- Mounting the Filter
- Other Filter Configurations

### Electrical Characteristics

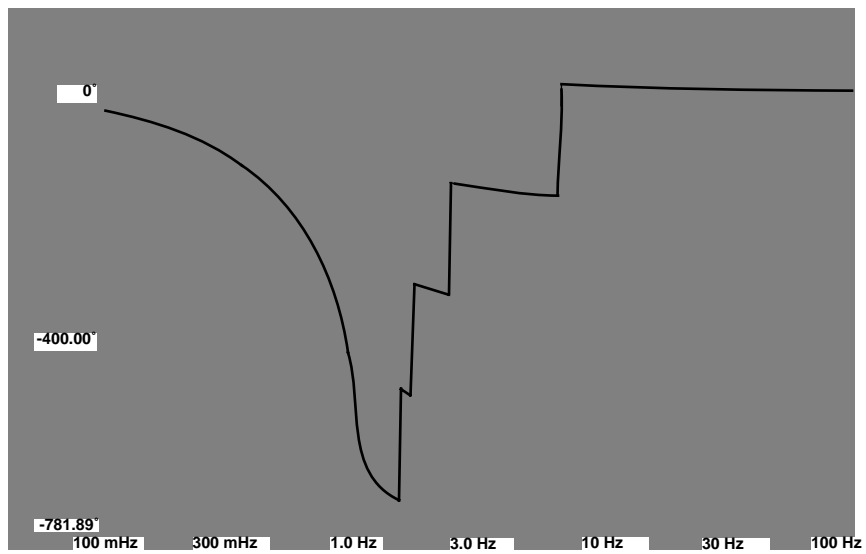
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The SSH-8 filter modules are 8<sup>th</sup> order Cauer (or Elliptic) filters. This section describes general characteristics of Cauer filters and specific characteristics of the SSH-8 filter modules.

Figure B-1 describes the amplitude response of these filters. Figures B-2 and B-3 describe corresponding phase and delay characteristics. These figures are normalized: when a cutoff frequency is known, you multiply indicated frequencies by that cutoff frequency, and divide indicated times by the same cutoff frequency, to obtain characteristics for any given filter.

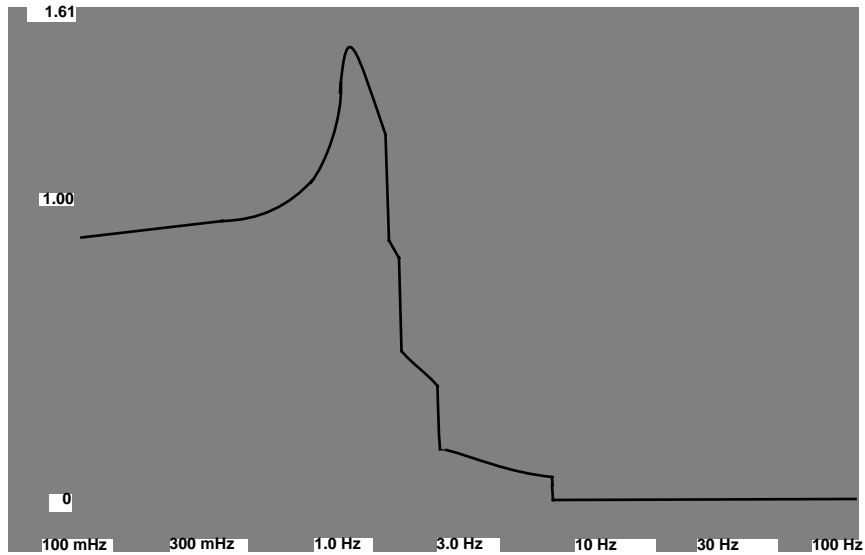


**Figure B-1. Amplitude versus Normalized Frequency for the SSH-8 Cauer Filter**



**Figure B-2. Phase versus Normalized Frequency for the SSH-8 Cauer Filter**

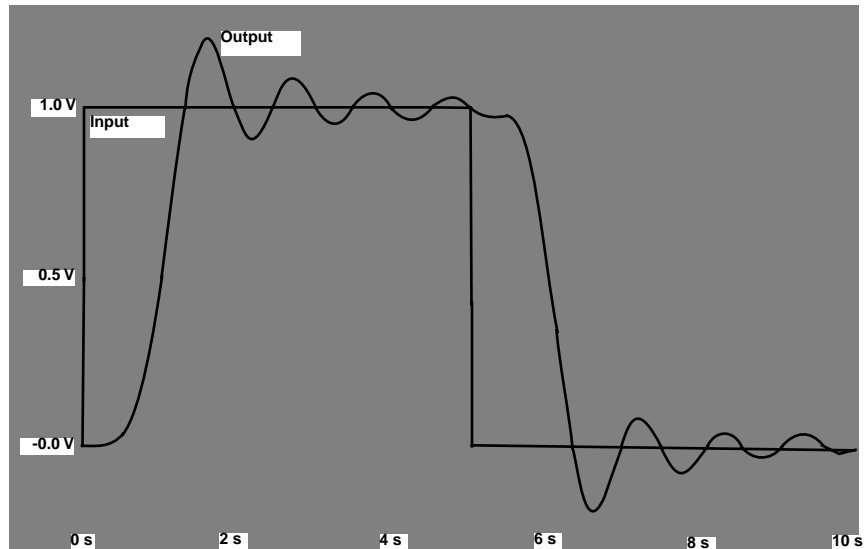




**Figure B-3. Delay versus Normalized Frequency for the SSH-8 Cauer Filter Modules**

## General

Ideally, an SSH-8 filter would not pass any signal or noise component higher than the cutoff frequency. An ideal filter would also allow the ringing time for an induced transient to approach infinity. Actually, the low-pass characteristics of the SSH-8 filter modules come moderately close to ideal in that the filters exhibit considerable ringing following square-wave inputs. The SSH-8 filter modules' response to a square wave input is shown in Figure B-4.



**Figure B-4. Normalized Response of SSH-8 Cauer Filter Module to a Square-Wave Input in Voltage versus Time**

The SSH-8 filter modules belong to the clocked, switched-capacitor class of filters. This class includes the Cauer and two other choices of filters, as follows:

- Butterworth (or maximally flat)
- Bessel (or constant delay)

Performance of the Butterworth and Bessel filters grows progressively worse in the frequency domain while transient performance improves.

Switched-capacitor filters are characterized by a significant amount of clock-noise feedthrough, typically at 50 times the cutoff frequency. These filters also exhibit unacceptable amounts of DC offset voltage. The SSH-8 filter modules use an output buffer in the form of a Butterworth filter to attenuate the clock noise to a level suitable for 12-bit conversion. The module uses a DC bypass circuit to take care of the DC offset voltage.

You can set switched-capacitor filters to operate over a wide range of frequencies by changing the clock frequency. On the SSH-8 filter

modules, a clock divider allows you to make coarse filter-cutoff settings by dividing the input clock by powers of two. The common clock is derived from a 20 MHz source and can be divided by numbers between four and 16 for fine control of the cutoff frequency. Since the divider on a SSH-8 filter module divides by at least two, the module can be provided with clock frequencies ranging from a few hundred hertz to 2.5 MHz.

The Butterworth filter on the SSH-8 filter modules is not as flexible as the Cauer filter. To prevent the Butterworth filter from adversely affecting performance of a SSH-8 filter module, you must set the Butterworth at least a factor of three above the highest cutoff frequency to be used. At the same time, to properly attenuate clock feedthrough, you must set the Butterworth at least a factor of three below the lowest clock frequency to be used. Thus, a single setting of the Butterworth filter operates well over about a 5:1 range of cutoff frequencies.

Similarly, you must adjust a capacitor used in the DC bypass circuit and a low-pass filter used at the input to match the frequency to be set. Typically, one set of these components must be valid for about a 5:1 range of cutoff frequencies.

The input low-pass filter serves to prevent interaction between broad-band sources and the filter clock, which if present can cause aliased output frequencies anywhere in the range of DC to one-half the clock frequency. If adjustment of the low-pass filter cutoff frequency is too high and cutoff frequency is too low, the aliasing effect can cause excess errors; if this adjustment is too high, it allows excess attenuation and phase delay at the clocked filter cutoff frequency.

A DC bypass capacitor that is too small can cause increased overshoot following transient waveforms. If too large, this capacitor can cause excessive time for attaining DC values and can lead to a ringing at very low frequencies. The manner of selecting and installing capacitors to cover a given frequency range is discussed in the section of this appendix on setting filter cutoff frequency.

A DC-DC converter on the SSH-8 accessory supplies  $\pm 15$  V to all analog circuits and a filter module. The clocked filter operates at low voltage, requiring current from a nominal  $\pm 5$  V. The input and output buffers use current at the higher voltage.

## Special Cases

If signal characteristics are such that there is no significant aliased energy (the signal is low-passed either at a very low frequency or with a high-order low pass) and some extra aliased noise is tolerable, you may not require any kind of filter.

If you have a small number of channels requiring significant bandwidth but you have other channels requiring negligible bandwidth, you may wish to set up a sampling queue in a DAS-1800 Series board (or equivalent) that allows faster channels to be sampled frequently enough to be reproduced while allowing slower channels to be sampled at slower rates. In this situation, using a more expensive board, such as a DAS-1800 Series board, can result in overall cost savings; otherwise you would require several boards of the DAS-1600 Series to achieve the same result.

## Determining the Required Cutoff Frequency

---

Considerations for determining the required filter cutoff frequency must include the following information:

- the number of channels
- the conversion rate
- the nature of the signal source
- the requirements for signal frequency content in the digitized output signal

Knowing the nature of the signal source enables you to determine the sort of filter to be used. Then, knowing the requirements for signal frequency content in the digitized output signal allows you to select an appropriate sampling rate (an often-cited first-order approximation calls for slightly more than two samples-per-cycle in order to see the highest frequency in the digitized data).

Thus, final determination of the required cutoff frequency calls for taking into account the nature of the signal source and using one of the following two methods:

- Method 1 - If there is a system specification for the required frequency response in each channel and the number of channels to be digitized, you can set the filter cutoff frequency to include the specified response. Then, using the nature of the signal source to determine the required types of transient response and using an assumption about allowable aliasing level to determine required attenuation at the Nyquist frequency, you can determine the sampling frequency (two times the Nyquist frequency) for a given cutoff frequency. (With an effective cutoff ratio for a filter, the clocked filter exhibits a cutoff at less than one-half the channel-sampling frequency; that cutoff determines the highest practical frequency for reconstruction from the digital data.) After you determine the channel-sampling frequency, you can multiply your result by the number of channels to determine the A/D conversion rate. If you obtain an A/D conversion rate higher than the capabilities of your DAS board, you have the following options:
  - Reevaluate of the needed signal bandwidth, allowable aliased data, and ability to use a filter with sharper cutoff (and poorer transient response)
  - Reduce of the number of channels sampled by the DAS board
  - Use of a DAS board with faster sampling capability
- Method 2 - Start by assuming a DAS board sampling rate and then determining a channel-sampling rate by simple division. Divide the channel-sampling rate by 2 to obtain a Nyquist rate. Determine the filter cutoff frequency, taking into account the allowable transient characteristics and the allowable aliased energy. The filter cutoff is then the effective bandwidth of available signals reconstructed from the digital data. If the filter cutoff is inadequate, you have the following options:
  - Reevaluate of the needed signal bandwidth, allowable aliased data, and ability to use a filter with sharper cutoff (and poorer transient response)
  - Reduce of the number of channels sampled by the DAS board
  - Use a DAS board with faster sampling capability

## Setting the Cutoff Frequency

---

After determining the cutoff frequency, you must proceed through the following three steps to set the cutoff frequency:

1. Set passive components for the correct range.
2. Set the onboard jumper for the correct clock range.
3. Set the clock frequency DIP switch on the SSH-8 accessory.

This section describes each of these steps.

## Setting the Range on the SSH-FLT Filter Module

If you are using the SSH-FLT/8-5K filter module, skip ahead to page B-10.

The SSH-FLT filter module is typically set to cover a frequency range of 2 kHz to 10 kHz. If the cutoff frequency you wish to use is within this range, proceed to the next section (“Set the Onboard Jumper for the Correct Clock Range”). Otherwise, refer to the package of auxiliary components supplied with your SSH-8 accessory.

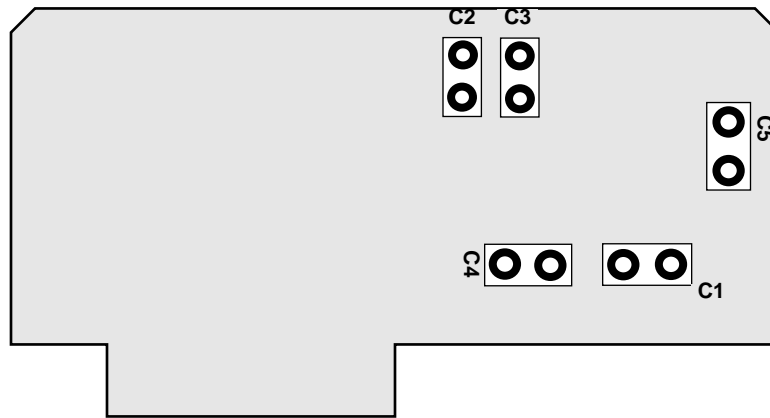
For the SSH-FLT filter module, the package of auxiliary components contains three sets of capacitors that correspond to ranges of frequency within 80 Hz to 50 kHz. An additional set of capacitors that selects the 2 kHz to 10 kHz frequency range is installed on the board. Each of the four capacitor sets contains five capacitors (C1 through C5). The values of C1 through C5 for each of the four frequency ranges are shown in Table B-1.

**Table B-1. Capacitor Choices for Cutoff Frequency Ranges**

Frequency Range	C1	C2	C3	C4	C5
10 kHz to 50 kHz	180 pF	0.047 $\mu$ F	---	100 pF	100 pF
2 kHz to 10 kHz <sup>1</sup>	1000 pF	0.22 $\mu$ F	---	470 pF	470 pF
400 Hz to 2 kHz	4700 pF	1.0 $\mu$ F	---	2200 pF	2200 pF
80 Hz to 400 Hz	0.022 $\mu$ F	4.7 $\mu$ F	0.22 $\mu$ F	0.01 $\mu$ F	0.01 $\mu$ F

**Notes**  
<sup>1</sup>Default range.

Choose the capacitor set whose corresponding frequency range includes the cutoff frequency you wish to use. Use the capacitors from the selected set to replace capacitors C1 through C5 on a filter module. The receptacles for capacitors C1 through C5 are located on the filter module as shown in Figure B-5.



**Figure B-5. Receptacles for Cutoff Frequency Capacitors on the SSH-8 Filter Modules**

When handling the capacitors, avoid overstressing the point at which the leads join the body. If you need to bend or cut the leads, grip the lead between the bend or cut and the capacitor body using pliers or tweezers.

When inserting a capacitor into a receptacle on a filter module, make sure the leads are straight and spaced to match the sockets of the receptacle. Apply only enough force to secure the capacitor leads in the receptacle; the leads do not have to bottom out in the receptacle to be secure.

If you require a cutoff frequency just beyond the range of an installed set of capacitors, you may not have to switch to another set of capacitors. You can exceed the specified frequency range limit of a capacitor set by up to 25%. However, in exceeding a frequency range limit, you must also expect to experience a departure from specified performance. Therefore, you have to determine whether exceeding a frequency range limit is worth any departure from specified performance.

Before installing a capacitor set, make sure the values of the individual capacitors match the values listed in Table B-1. The individual capacitors are marked with a 3-digit code indicating capacitance in picofarads. The first two digits of the code indicate capacitance to two significant figures, while the third digit is a power of ten. For example, a 0.0047  $\mu\text{F}$  capacitor is marked 473 for 4700 pF.

## Setting the Range on the SSH-FLT/8-5K Filter Module

The SSH-FLT/8-5K filter module is typically set to cover a frequency range of 8 Hz to 40 Hz. If the cutoff frequency you wish to use is within this range, proceed to the next section (“Set the Onboard Jumper for the Correct Clock Range”). Otherwise, refer to the package of auxiliary components supplied with your SSH-8 accessory.

For the SSH-FLT/8-5K filter module, the package of auxiliary components contains three sets of capacitors that correspond to the ranges of frequency within 40 Hz to 5 kHz. An additional set of capacitors that selects the 8 Hz to 40 Hz frequency range is installed on the board. Each of the four capacitor sets contains five capacitors (C1 through C5). The values of C1 through C5 for each of the four frequency ranges are shown in Table B-2.



**Table B-2. Capacitor Choices for Cutoff Frequency Ranges**

<b>Frequency Range</b>	<b>C1</b>	<b>C2</b>	<b>C3</b>	<b>C4</b>	<b>C5</b>
1 kHz to 5 kHz	1500 pF	0.047 $\mu$ F	---	1000 pF	1000 pF
200 Hz to 1 kHz	0.01 $\mu$ F	0.22 $\mu$ F	---	4700 pF	4700 pF
40 Hz to 200 Hz	0.047 $\mu$ F	1.0 $\mu$ F	---	0.022 $\mu$ F	0.022 $\mu$ F
8 Hz to 40 Hz <sup>1</sup>	0.22 $\mu$ F	4.7 $\mu$ F	0.22 $\mu$ F	0.1 $\mu$ F	0.1 $\mu$ F

**Notes**

<sup>1</sup>Default range.

Choose the capacitor set whose corresponding frequency range includes the cutoff frequency you wish to use. Use the capacitors from the selected set to replace capacitors C1 through C5 on a filter module. The receptacles for capacitors C1 through C5 are located on the filter module as shown in Figure B-5.

When handling the capacitors, avoid overstressing the point at which the leads join the body. If you need to bend or cut the leads, grip the lead between the bend or cut and the capacitor body using pliers or tweezers.

When inserting a capacitor into a receptacle on a filter module, make sure the leads are straight and spaced to match the sockets of the receptacle. Apply only enough force to secure the capacitor leads in the receptacle; the leads do not have to bottom out in the receptacle to be secure.

If you require a cutoff frequency just beyond the range of an installed set of capacitors, you may not have to switch to another set of capacitors. You can exceed the specified frequency range limit of a capacitor set by up to 25%. However, in exceeding a frequency range limit, you must also expect to experience a departure from specified performance. Therefore, you have to determine whether exceeding a frequency range limit is worth any departure from specified performance.

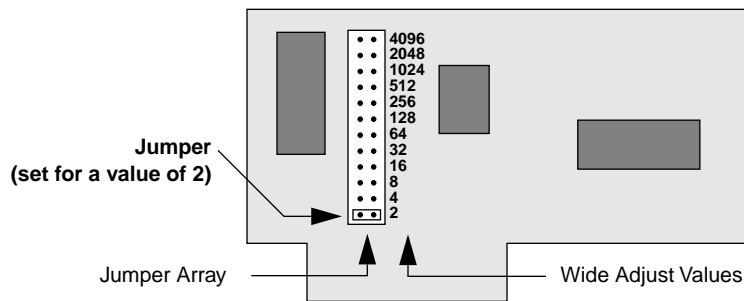
Before installing a capacitor set, make sure the values of the individual capacitors match the values listed in Table B-2. The individual capacitors are marked with a 3-digit code indicating capacitance in picofarads. The first two digits of the code indicate capacitance to two significant figures, while the third digit is a power of ten. For example, a 0.0047  $\mu\text{F}$  capacitor is marked 473 for 4700 pF.

## Set the Onboard Jumper for the Correct Clock Range

The cutoff frequency is controlled by two configurable values: a wide adjustment and a fine adjustment. You make the wide adjustment by setting a jumper on the filter module. You make the fine adjustment by setting DIP switches on the SSH-8.

To adjust the cutoff frequency, do the following:

1. Refer to the tables in this section to determine the wide adjustment and fine adjustment values for the desired cutoff frequency. Refer to Figure B-6 for the layout of the jumper array.



**Figure B-6. Wide Adjust Jumper Array**

Notice that the cutoff frequency ranges for wide adjustment values overlap. If you can, choose a value that has the desired cutoff frequency close to the middle of its range. Then if significant tuning is required, there is less chance you will have to change the wide adjustment value.

**Table B-3. Cutoff Frequencies for Wide Adjust = 2 to 256**

Fine	Wide							
	2	4	8	16	32	64	128	256
4	50 kHz	25 kHz	12.5 kHz	6.25 kHz	3.13 kHz	1.56 kHz	781 Hz	391 Hz
5	40 kHz	20 kHz	10 kHz	5 kHz	2.5 kHz	1.25 kHz	625 Hz	313 Hz
6	33.3 kHz	16.7 kHz	8.33 kHz	4.16 kHz	2.09 kHz	1.04 kHz	521 Hz	260 Hz
7	28.5 kHz	14.3 kHz	7.13 kHz	3.56 kHz	1.78 kHz	893 Hz	446 Hz	223 Hz
8	25 kHz	12.5 kHz	6.25 kHz	3.13 kHz	1.56 kHz	781 Hz	391 Hz	195 Hz
9	22.2 kHz	11.1 kHz	5.55 kHz	2.77 kHz	1.38 kHz	694 Hz	347 Hz	174 Hz
10	20 kHz	10 kHz	5 kHz	2.5 kHz	1.25 kHz	625 Hz	312 Hz	156 Hz
11	18.2 kHz	9.09 kHz	4.55 kHz	2.27 kHz	1.14 kHz	568 Hz	284 Hz	142 Hz
12	16.7 kHz	8.33 kHz	4.16 kHz	2.09 kHz	1.04 kHz	521 Hz	260 Hz	130 Hz
13	15.4 kHz	7.69 kHz	3.87 kHz	1.92 kHz	962 Hz	481 Hz	240 Hz	120 Hz
14	14.3 kHz	7.13 kHz	3.56 kHz	1.78 kHz	893 Hz	446 Hz	223 Hz	112 Hz
15	13.3 kHz	6.67 kHz	3.33 kHz	1.67 kHz	833 Hz	417 Hz	208 Hz	104 Hz
16	12.5 kHz	6.25 kHz	3.13 kHz	1.56 kHz	781 Hz	391 Hz	195 Hz	98 Hz

**Table B-4. Cutoff Frequencies for Wide Adjust = 512 to 4096**

Fine	Wide			
	512	1024	2048	4096
4	195 Hz	98 Hz	49 Hz	24 Hz
5	156 Hz	78 Hz	39 Hz	20 Hz
6	130 Hz	65 Hz	33 Hz	16 Hz
7	112 Hz	56 Hz	28 Hz	14 Hz
8	98 Hz	49 Hz	24 Hz	12 Hz
9	87 Hz	43 Hz	22 Hz	11 Hz
10	78 Hz	39 Hz	20 Hz	10 Hz
11	71 Hz	36 Hz	18 Hz	9 Hz
12	65 Hz	33 Hz	16 Hz	8 Hz
13	60 Hz	30 Hz	15 Hz	7.5 Hz
14	56 Hz	28 Hz	14 Hz	7 Hz
15	52 Hz	26 Hz	13 Hz	6.5 Hz
16	49 Hz	24 Hz	12 Hz	6 Hz

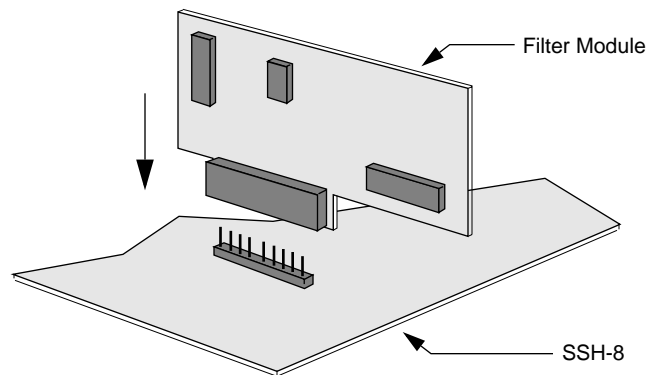
For example, the cutoff frequency ranges for wide adjustment values 4 and 8 both include 10 kHz. In this case, 4 is the better choice because 10 kHz is near the middle of its range, while 10 kHz is near the high end of the range for 8.

2. Move the Wide Adjust jumper to the desired setting on the filter module. Figure B-6 shows the Wide Adjust jumper array on the filter module.
3. Refer to Chapter 3 for instructions on making the fine adjustment on the SSH-8 accessory.

## Mounting the Filter

---

Each filter module has a keyed female connector that mounts on a 9-pin connector on the SSH-8. Figure B-7 shows how a filter module mounts on the SSH-8.



**Figure B-7. Filter Module Mounting**

---

**Note:** Filters for channels 0 to 3 mount with components facing the input connector. Filters for channels 4 to 7 mount in the opposite direction.

---

## Other Filter Configurations

---

The theory of classic filters includes four principal filter types. Three of these filter types are readily available as ladder implementations in switched (clocked) ladder filter chips using CMOS technology and are thus attractive for use in boards external to DAS boards. In order of increasing signal selectivity, these three filters are the Bessel (or constant delay), the Butterworth (or maximally flat), and the Cauer (or elliptic). These filters compare in the frequency domain as shown in Figure B-8 and in the time domain as shown in Figure B-9.

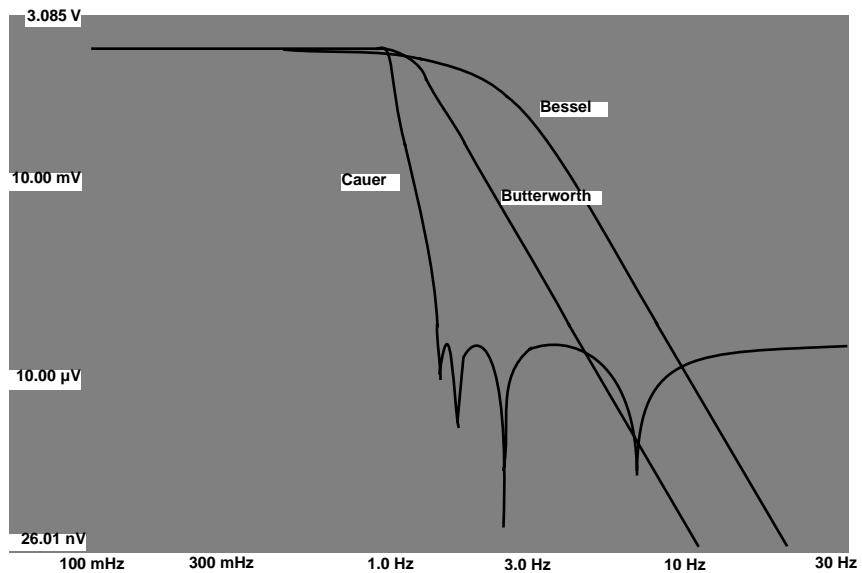
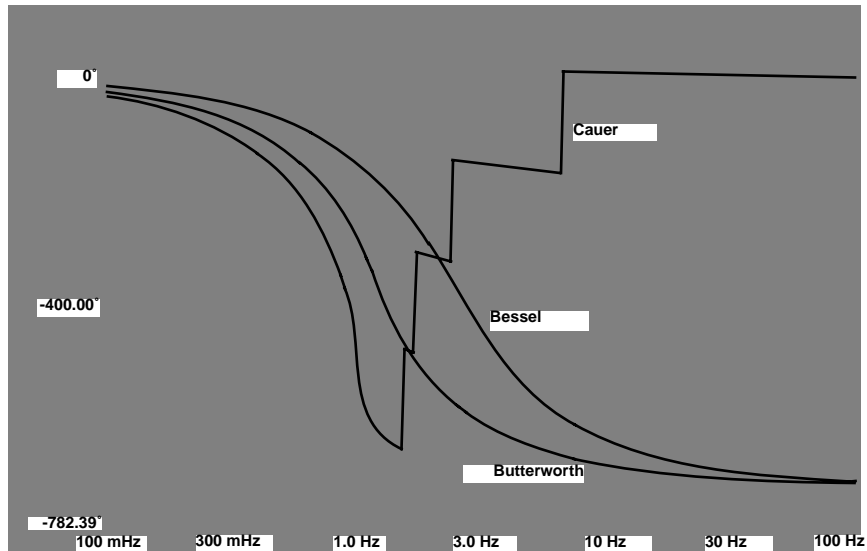


Figure B-8. Normalized Filter Frequency Response

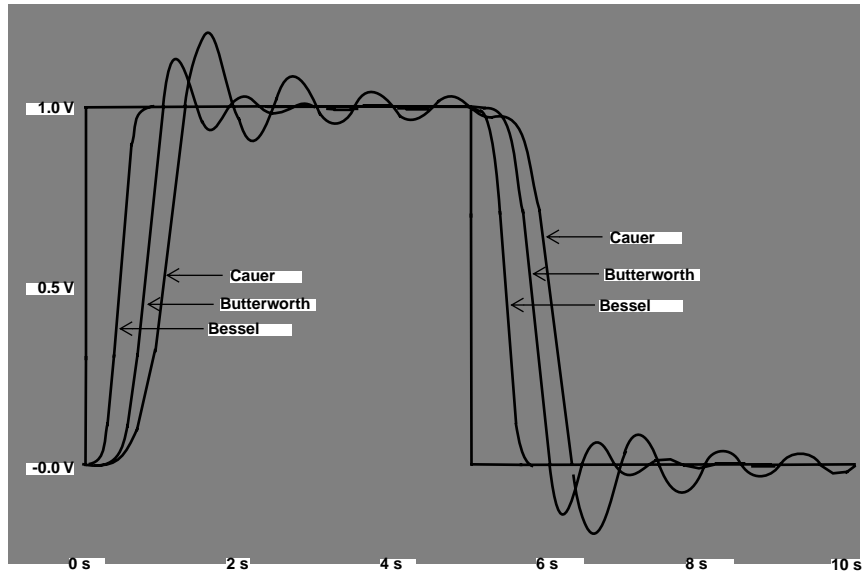


**Figure B-9. Normalized Filter Phase Response**

As mentioned earlier, the Sampling Theorem states that frequencies up to “slightly less than” the Nyquist rate can be completely reconstructed from a sampled waveform. When considering presampling analog filtering and post-DAC analog filtering, the term *slightly less than* can be quantified.

If a filter is to introduce negligible aliasable energy and if the “negligible” term is defined in LSBs of acceptable noise, the dB level below the passband can be defined. Then for each usable filter type, there is a well-defined ratio of Nyquist-to-filter cutoff frequency.

When a filter type is determined, a distinct trade-off between transient fidelity and usable bandwidth eventually traces directly to system cost. If a high degree of transient fidelity is needed at a given signal bandwidth and with a stated amount of aliasable energy, a Nyquist rate is effectively established. This rate times the number of channels yields the required sample rate. The sample rate divided by 100,000 for DAS-1600 Series boards or 330,000 for DAS-1800 Series boards indicates the required number of DAS boards. Transient response of the three filter types is shown in Figure B-10.



**Figure B-10. Transient Response of Three Filter Types**

When the computed scanning rate exceeds the maximum scanning rate of a given DAS board, you must use either multiple DAS boards of the same kind or a faster (more expensive) DAS board. Another choice is to use a filter with better frequency-domain characteristics, allowing the Nyquist rate to drop without affecting data performance and permitting higher channel-sampling rates or more channels from the given DAS board. However, signal fidelity is affected very noticeably if the signal source has significant transient energy.

## Example Cases

Consider a situation calling for some signal channels to be amplified with a signal bandwidth of 5 kHz and an accuracy of roughly 1 LSB. When the different filters are applied, results are as shown in Table B-5.

**Table B-5. Results for 5 kHz Bandwidth and 1 LSB Accuracy**

Filter Type	Bessel	Butterworth	Cauer
F(Nyquist)/F(Corner)	5.6	2.75	1.5
F(Nyquist)	28 kHz	13.75 kHz	7.5 kHz
Channel Sample Rate	56 kHz	27.5 kHz	15 kHz
Maximum Channels DAS-1600 Series	1	3	6
Maximum Channels DAS-1800HC Series	5	12	22
Maximum Channels DAS-1800AO/HR/ST Series	5	12	16

Under the same conditions, except for an accuracy of 10 LSBs, aliased energy (at the Nyquist frequency) can be down 52 dB, rather than 72 dB. In this case, results are as shown in Table B-6.

**Table B-6. Results for 5 kHz Bandwidth and 10 LSB Accuracy**

Filter Type	Bessel	Butterworth	Cauer
F(Nyquist)/F(Corner)	4.0	2.1	1.5
F(Nyquist)	20 kHz	10.5 kHz	7.5 kHz
Channel Sample Rate	40 kHz	21 kHz	15 kHz
Maximum Channels DAS-1600 Series	2	4	6



**Table B-6. Results for 5 kHz Bandwidth and 10 LSB Accuracy (cont.)**

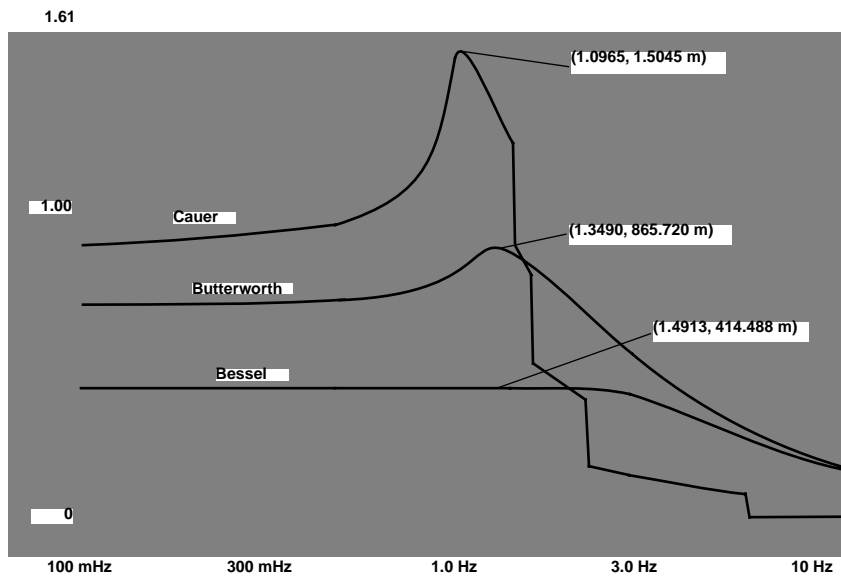
<b>Filter Type</b>	Bessel	Butterworth	Cauer
Maximum Channels DAS-1800HC Series	8	15	22
Maximum Channels DAS-1800AO/HR/ST Series	8	15	16

Rolloff for the Cauer filter is so sharp that the change in accuracy has little effect on the required corner frequency. However, keeping the transient responses of Figure B-10 in mind, the peak overshoot of a Bessel filter following a step function is negligible, while a Butterworth filter can show about 10% peak overshoot and a Cauer filter about 20%. A full-scale step and 12-bit converter translate to 410 LSBs and 819 LSBs respectively (well beyond most acceptable error limits).

## **Delay Characteristics**

When using filters with simultaneous sample-and-hold switches, delay characteristics of those filters become important. Although sampling may occur at a fixed point, the effect of a filter introducing variable delays into the signal ahead of the switches is the same as introducing a corresponding time lead into the sampling signal. Some filters, most notably the Cauer filter, are characterized by delays that are a function of signal frequency.

Given the phase characteristics of a filter versus frequency, delay can be calculated as that phase for any frequency divided by phase delay in a complete cycle ( $360^\circ$ ) and multiplied by the time required for a single cycle, or  $1/\text{frequency}$ . Figure B-11 shows the delay effects of the three filters; rolloff is normalized to 1 Hz.



**Figure B-11. Delays for Normalized Cauer, Butterworth, and Bessel Filters**

The delays for the three filters can be compared for any rolloff frequency by dividing delays by the selected rolloff frequency. The same delays can be compared with the sort of delays (nanoseconds) inherent in the sampling switches to see the importance of the filter delays to the sampling process.

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