Errata

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HP References in this Manual

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HP 3852 Data Acquistion/Control Unit

HP 44705, 44706, 44708 Relay Multiplexer Accessories

Programming and Configuration Manual

HEWLETT PACKARD

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SAFETY SUMMARY

The following general safety precautions must be observed during all phases of operation, service, and repair of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended use of the instrument. Hewlett-Packard Company assumes no liability for the customer's failure to comply with these requirements.

GROUND THE INSTRUMENT

To minimize shock hazard, the instrument chassis and cabinet must be connected to an electrical ground.

DO NOT OPERATE IN AN EXPLOSIVE ATMOSPHERE

Do not operate the instrument in the presence of flammable gases or fumes. Operation of any electrical instrument in such an environment constitutes a definite safety hazard.

KEEP AWAY FROM LIVE CIRCUITS

Operating personnel must not remove instrument covers. Component replacement and internal adjustments must be made by qualified maintenance personnel. Under certain conditions, dangerous voltages may exist even with the instrument switched off. To avoid injuries, always disconnect input voltages and discharge circuits before touching them.

DO NOT SERVICE OR ADJUST ALONE

Do not attempt internal service or adjustment unless another person, capable of rendering first aid and resuscitation, is present.

DO NOT SUBSTITUTE PARTS OR MODIFY INSTRUMENT

Because of the danger of introducing additional hazards, do not install substitute parts or perform any unauthorized modification to the instrument. Return the instrument to a Hewlett-Packard Sales and Service Office for service and repair to ensure that safety features are maintained.

DO NOT OPERATE A DAMAGED INSTRUMENT

Whenever it is possible that the safety protection features built into this instrument have been impaired, either through physical damage, excessive moisture, or any other reason, REMOVE POWER and do not use the instrument until safe operation can be verified by service-trained personnel. If necessary, return the instrument to a Hewlett-Packard Sales and Service Office for service and repair to ensure that safety features are maintained.

C

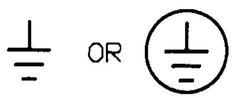
Operating and Safety Symbols

Symbols Used On Products And In Manuals

~ LINE — AC line voltage input receptacle.

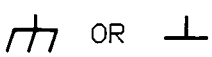
Instruction manual symbol affixed to product. Warns and cautions the user to refer to respective instruction manual procedures to avoid personal injury or possible damage to the product.

Indicates dangerous voltage – terminals connected to interior voltage exceeding 1000 volts.



Protective conductor terminal. Indicates the field wiring terminal that must be connected to earth ground before operating equipment – protects against electrical shock in case of fault.

Clean ground (low-noise). Indicates terminal that must be connected to earth ground before operating equipment – for single common connections and protection against electrical shock in case of fault.



Frame or chassis ground. Indicates equipment chassis ground terminal – normally connects to equipment frame and all metal parts.

Affixed to product containing static sensitive devices – use anti-static handling procedures to prevent electrostatic discharge damage to components.

NOTE

NOTE

Calls attention to a procedure, practice, or condition that requires special attention by the reader.

CAUTION

CAUTION

Calls attention to a procedure, practice, or condition that could possibly cause damage to equipment or permanent loss of data.

WARNING

WARNING

Calls attention to a procedure, practice, or condition that could possibly cause bodily injury or death.

WARNING, CAUTION, and NOTE Symbols

Some labels on the HP 3852A, HP 3853A, and plug-in accessories include an international warning symbol (triangle with subscripted number) which refers the reader to the manuals for further information. This table shows the warning symbols used for the HP 3852A/3853A and plug-in accessories. Refer to the manual set for specific information on WARNINGS, CAUTIONS, or NOTES referenced with a warning symbol.

HP 3852A WARNING, CAUTION, and NOTE Symbols

Symbol	Meaning	Location
⚠ 1	Shock hazard originating outside the instrument (field wiring)	. Analog Extender Connector on Power Supply Modules . Terminal modules on plug-in accessories . Component module covers on plug-in accessories
⚠ 2	Treat all channels as "one circuit" for safety purposes.	. Inside terminal modules on plug-in accessories . Metal cover on component modules of plug-in accessories
⚠ 3	Maximum number of certain plug-in accessories to be installed into an HP 3852A or HP 3853A.	. HP 44701A, HP 44702A/B, HP 44727A/B/C plug-in accessories
⚠ 4	If High-Speed FET multiplexers are used with the HP 44702A/B, ribbon cable may be connected.	. HP 44711A, 44712A, 44713A (referenced on HP 44702A and HP 44702B)

Contents

Chapter 1
Introduction

Chapter 1

Introduction

Manual Contents

This manual shows how to configure and program seven HP 3852A accessory relay multiplexers:

- HP 44705A 20-Channel Relay Multiplexer
- HP 44705F 20-Channel Solid-State Relay Multiplexer
- HP 44705H 20-Channel High-Voltage Relay Multiplexer
- HP 44706A 60-Channel Single-Ended Relay Multiplexer
- HP 44708A 20-Channel Relay Multiplexer/Thermocouple Compensation
- HP 44708F 20-Channel Solid-State Relay Multiplexer/ Thermocouple Compensation
- HP 44708H 20-Channel High-Voltage Relay Multiplexer/ Thermocouple Compensation.

In this manual, each multiplexer is referred to by its model number or model number family (the HP 44705A, HP 44705F, and HP 44705H are referred to as the HP 44705 and the HP 44708A, HP 44708F and HP 44708H are referred to as the HP 44708 when features are common among the multiplexers). Refer to the HP 3852A Mainframe Configuration and Programming Manual for additional information on the accessories. The manual has five chapters: Introduction, Configuring the HP 44705, Configuring the HP 44706A, Configuring the HP 44708, and Programming the Multiplexers.

- **Introduction** contains a manual overview, summarizes multiplexer descriptions and functions, and shows suggested steps to get started.

- **Configuring the HP 44705** contains a block diagram description of the HP 44705A, HP 44705F and HP 44705H multiplexers, shows how to hardware configure terminal modules, and shows how to connect field wiring to the terminal modules.

- **Configuring the HP 44706A** contains a block diagram description of the HP 44706A multiplexer and shows how to connect field wiring to the terminal module.

- **Configuring the HP 44708** contains a block diagram description of the HP 44708A, 44705F and HP 44708H multiplexers, shows how to hardware configure terminal modules, and shows how to connect field wiring to the terminal modules.

- **Programming the Multiplexers** shows how to program the accessories for voltage, current, resistance, and temperature measurements, as applicable to the accessory.

Multiplexer Descriptions

The multiplexer accessories are used to switch (multiplex) signals from up to 20 inputs (HP 44705 and HP 44708) or up to 60 inputs (HP 44706A only) to the analog backplane bus for measurements by HP 3852A voltmeter accessories or by external voltmeters. A description of each multiplexer follows.

HP 44705A 20-Channel Relay Multiplexer

The HP 44705A is an analog signal multiplexer used to switch (multiplex) signals from up to 20 inputs for measurement by HP 3852A voltmeter accessories or by external voltmeters. This accessory provides switching capability for up to 20 inputs at scanning speeds up to 450 channels/second using HP 3852A voltmeters. The accessory can switch signals up to 120 V dc or 120 V ac rms (170 V peak).

The HP 44705A consists of a component module and a 20-channel terminal module. Field wiring from user sources (such as voltage sources) is connected to the terminal module and signals are sent to the switches on the component module. Each channel on the HP 44705A can be independently configured to allow multiple functions to be measured using the same accessory.

HP 44705F 20-Channel Solid-State Relay Multiplexer

The HP 44705F is a solid-state analog signal multiplexer used to switch (multiplex) signals from up to 20 inputs for measurement by HP 3852A voltmeter accessories or by external voltmeters. This accessory provides switching capability for up to 20 inputs at scanning speeds up to 450 channels/second using HP 3852A voltmeters. The accessory can switch signals up to 100 V dc or 70 V ac rms (100 V peak).

The HP 44705F consists of a component module (similar to the HP the same as the HP 44705A component module but with solid-state relays) and a 20-channel terminal module (similar to the HP 44705A terminal module). Field wiring from user sources (such as voltage sources) is connected to the terminal module and signals are sent to the switches on the component module. Each channel on the HP 44705F can be independently configured to allow multiple functions to be measured using the same accessory.

HP 44705H 20-Channel High Voltage Relay Multiplexer

The HP 44705H is an analog signal multiplexer used to switch (multiplex) signals from up to 20 inputs for measurement by HP 3852A voltmeter accessories or by external voltmeters. This accessory provides switching capability for up to 20 inputs at scanning speeds up to 250 channels/second using HP 3852A voltmeters. The accessory can switch signals up to 200 V dc or 250 V ac rms (354 V peak).

The HP 44705H consists of a component module (the same as the HP 44705A component module but with high-voltage relays added) and a 20-channel terminal module (the same as the HP 44705A terminal module). Field wiring from user sources (such as voltage sources) is connected to the terminal module and signals are sent to the switches on the component module. Each channel on the HP 44705H can be independently configured to allow multiple functions to be measured using the same accessory.

HP 44706A 60-Channel Relay Multiplexer

The HP 44706A is an analog signal multiplexer used to switch (multiplex) signals from up to 60 single-ended inputs for measurement by HP 3852A voltmeter accessories or by external voltmeters. This accessory provides switching capability for up to 60 single-ended inputs at scanning speeds up to 450 channels/second using HP 3852A voltmeters. The accessory can switch signals up to 30 V dc or 30 V ac rms (42V peak).

The HP 44706A consists of a component module and a 60-channel terminal module. Field wiring from user sources (such as voltage sources) is connected to the terminal module and signals are sent to the switches on the component module. Each channel on the HP 44706A can be independently configured to allow multiple functions to be measured using the same accessory.

HP 44708A 20-Channel Relay Multiplexer/TC

The HP 44708A is an analog signal multiplexer used to switch (multiplex) signals from up to 20 inputs for measurement by HP 3852A voltmeter accessories or by external voltmeters. This accessory provides switching capability for up to 20 inputs at scanning speeds up to 450 channels/second using HP 3852A voltmeters. The accessory can switch signals up to 120 V dc or 120 V ac rms (170 V peak).

The HP 44708A consists of a component module and a 20-channel terminal module. The HP 44708A uses the same component module as the HP 44705A. A special isothermal connector block on the terminal module provides the reference junction for thermocouple measurements. A thermistor mounted on the isothermal connector block is used to measure the isothermal block reference temperature. The HP 3852A uses software compensation to automatically compensate for the reference temperature when making thermocouple measurements.

Field wiring from user sources (such as voltage sources) is connected to the terminal module and signals are sent to the switches on the component module. Each channel on the HP 44708A can be independently configured to allow multiple functions to be measured using the same accessory.

HP 44708F 20-Channel Solid-State Relay Multiplexer/TC

The HP 44708F is an analog signal multiplexer used to switch (multiplex) signals from up to 20 inputs for measurement by HP 3852A voltmeter accessories or by external voltmeters. This accessory provides switching capability for up to 20 inputs at scanning speeds up to 450 channels/second using HP 3852A voltmeters. The accessory can switch signals up to 100 V dc or 70 V ac rms (100 V peak).

The HP 44708F consists of a component module and a 20-channel terminal module. The HP 44708F uses the same component module as the HP 44705F. A special isothermal connector block on the terminal module provides the reference junction for thermocouple measurements. A thermistor mounted on the isothermal connector block is used to measure the isothermal block reference temperature. The HP 3852A uses software compensation to automatically compensate for the reference temperature when making thermocouple measurements.

Field wiring from user sources (such as voltage sources) is connected to the terminal module and signals are sent to the switches on the component module. Each channel on the HP 44708F can be independently configured to allow multiple functions to be measured using the same accessory.

HP 44708H 20-Channel High-Voltage Relay Multiplexer/TC

The HP 44708H is an analog signal multiplexer used to switch (multiplex) signals from up to 20 inputs for measurement by HP 3852A voltmeter accessories or by external voltmeters. This accessory provides switching capability for up to 20 inputs at scanning speeds up to 250 channels/second using HP 3852A voltmeters. The accessory can switch signals up to 200 V dc or 250 V ac rms (354 V peak).

The HP 44708H consists of a component module and a 20-channel terminal module. The HP 44708H uses the same component module as the HP 44705H. A special isothermal connector block on the terminal module provides the reference junction for thermocouple measurements. A thermistor mounted on the isothermal connector block is used to measure the isothermal block reference temperature. The HP 3852A uses software compensation to automatically compensate for the reference temperature when making thermocouple measurements.

Field wiring from user sources (such as voltage sources) is connected to the terminal module and signals are sent to the switches on the component module. Each channel on the HP 44708H can be independently configured to allow multiple functions to be measured using the same accessory.

Multiplexer Functions

The multiplexer accessories can be used to switch signals for four measurement functions: voltage, current, resistance, or temperature. Each channel can be independently configured to allow multiple functions to be measured using the same accessory.

Table 1-1 summarizes recommended measurement functions for the five multiplexers. Note that 2-wire RTD and thermistor measurements can be made with the HP 44708A and HP 44708H but they are not recommended for the HP 44708F or the HP 44705F. The HP 44705F and the HP 44708F have an additional 100 Ohms of series resistance plus several hundred ohms of On resistance in the measurement path which reduces their usefulness for 2-wire ohms measurements.

Table 1-1. Primary Multiplexer Measurements/Applications

Multiplexer	Recommended Measurements	Primary Features
HP 44705A	. AC/DC Voltage [1] . AC/DC Current [2] . 2 and 4-Wire Ohms . RTDs [3] . Thermistors [4]	. Guarded measurements . Up to 20 inputs . Max input 120 V dc or 120 V ac rms (170 V peak) . Up to 450 channels/s
HP 44705F	. AC/DC Voltage [1] . AC/DC Current [2] . 4-Wire Ohms . RTDs [3] . Thermistors [4]	. Guarded measurements . Up to 20 inputs . Max input 100 V dc or 70 V ac rms (100 V peak) . Up to 450 channels/s
HP 44705H	. AC/DC Voltage [1] . AC/DC Current [2] . 2 and 4-Wire Ohms . RTDs [3] . Thermistors [4]	. Guarded measurements . Up to 20 inputs . Max input 200 V dc or 250 V ac rms (354 V peak) . Up to 250 channels/s
HP 44706A	. AC/DC Voltage [1] . 2-Wire Ohms [5]	. Single-ended measurements . Up to 60 inputs . Up to 450 channels/sec . Max input 30 V dc or 30 V ac rms (42 V peak)
HP 44708A	. AC/DC Voltage [1] . AC/DC Current [2] . 2-Wire Ohms [5] . Thermocouples [6]	. Thermocouple measurements . Up to 20 inputs . Up to 450 channels/sec . Max input 120 V dc or 120 V ac rms (170 V peak)

Table 1-1. Primary Multiplexer Measurements/Applications (continued)

Multiplexer	Recommended Measurements	Primary Features
HP 44708F	. AC/DC Voltage [1] . AC/DC Current [2] . Thermocouples [6]	. Thermocouple measurements . Up to 20 inputs . Max input 100 V dc or 70 V ac rms (100 V peak) . Up to 450 channels/s
HP 44708H	. AC/DC Voltage [1] . AC/DC Current [2] . 2-Wire Ohms [5] . Thermocouples [6]	. Thermocouple measurements . Up to 20 inputs . Up to 250 channels/sec . Max input 200 V dc or 250 V ac rms (354 V peak)

Notes:

[1] = With HP 44702A/B High-Speed Voltmeter, can only make DC voltage measurements.

[2] = Requires installation of resistor on terminal module. With HP 44702A/B High-Speed Voltmeter, can only make DC current measurements.

[3] = 4-wire ohms measurement method recommended. HP 3852A supports Type 85 (a = 0.00385 ohms/ohms/deg C) and Type 92 (a = 0.003916 ohms/ohms/deg C) RTDs.

[4] = 4-wire ohms measurement method recommended. HP 3852A supports Type 2252 (2252 ohms), 5K (5000 ohms), and 10K (10,000 ohm) thermistors.

[5] = Due to potential temperature measurement errors with 2-wire ohms measurements, RTD measurements should be made using the 4-wire technique.

[6] = HP 3852A conversion program applicable only to B, E, J, K, N14 (AWG 14), N28 (AWG 28), R, S, and T types. Other thermocouples can be measured with user supplied temperature conversion program.

NOTE

The maximum voltage specification refers to the maximum voltage between any two points including chassis.

Getting Started

To use a multiplexer accessory for your application, you will need to do three things:

- Define your application.
- Configure multiplexer.
- Program the multiplexer.

Define Your Application

The first step is to define your application and select the multiplexer for the requirements of your application. When selecting devices to be connected, refer to the Specifications appendix in the HP 3852A Mainframe Configuration and Programming Manual to ensure that the voltage and current requirements of your application are within the specifications for the accessory.

Configure the Multiplexer

The next step is to configure the multiplexer for your application. Refer to Table 1-1 for a list of recommended measurements for the accessories.

If you selected the HP 44705 multiplexer, refer to Chapter 2 - Configuring the HP 44705 for information on hardware configuration and connecting field wiring to the terminal module for voltage, current, resistance, and temperature measurements.

If you selected the HP 44706A multiplexer, refer to Chapter 3 - Configuring the HP 44706A for information on connecting field wiring to the terminal module for voltage, current, and resistance measurements.

If you selected the HP 44708 multiplexer, refer to Chapter 4 - Configuring the HP 44708 for information on hardware configuration and connecting field wiring to the terminal module for voltage, current, resistance, and temperature measurements.

Program the Multiplexer

When the multiplexer has been configured for your measurement, the third step is to program the accessory for your application. Refer to Chapter 5 - Programming the Multiplexers to program the accessory for voltage, current, resistance, and thermocouple measurements.

Contents

Chapter 2
Configuring the HP 44705

Chapter 2
Configuring the HP 44705

Configuration Overview

This chapter shows how to configure the HP 44705 multiplexer accessories. The chapter contains a block diagram description of the HP 44705A, 44705F, and 44705H accessories, shows how to hardware configure the terminal modules, and shows how to connect field wiring to the terminal modules.

When you have configured the multiplexer for your application, refer to Chapter 5 - Programming the Multiplexers to program the accessories for voltage, current, resistance, and temperature measurements.

Warnings and Cautions

This section summarizes the WARNINGS and CAUTIONS which apply to the HP 44705A, 44705F and 44705H multiplexers. You should review the WARNINGS and CAUTIONS shown before configuring the multiplexers.

WARNING

⚠ 1 *SHOCK HAZARD. Only qualified, service-trained personnel who are aware of the hazards involved should install, remove, or configure any accessory. Before touching any installed accessory, turn off all power to the mainframe, extenders, and to all external devices connected to the mainframe, extenders, or accessories.*

⚠ 1 *SHOCK HAZARD. All channels that have a common connection (multplexer or matrix), or are configured by the user to have a common connection (general purpose relay switch), must be insulated so that the user is protected from electrical shock in the event that two or more channels are connected together. This means wiring for all channels must be insulated as though each channel carries the voltage of the highest voltage channel.*

⚠ 2 *POSSIBLE OPERATOR INJURY. For safety, consider all accessory channels to be at the highest potential applied to any channel. Under most conditions of failure, the relays on the relay multiplexers will remain in whatever state the program sets them. However, for some equipment failures, the relays may not remain in their programmed state. If the relays settle in the closed state, the relay contacts may weld together and the highest voltage present on any one channel may be present on all channels. This condition may cause operator injury if the terminals are touched or equipment damage may result.*

⚠ 2 *MAXIMUM VOLTAGE LIMITATIONS. The HP 3852A and the HP 3853A internal analog buses interconnect the multiplexer and voltmeter accessories to form one circuit. To protect against possible personal injury due to equipment failure or programming error, limitations are placed on the potentials that can appear between any two points on the circuit (or between the circuit and chassis).*

These limitations are listed for the HP 3852A, HP 3853A, and all plug-in accessories. For any given set of accessories installed in the mainframe or extender, the maximum potential between any two points is determined by the accessory with the LOWEST peak voltage limitation, as follows. (If the analog extender cable is NOT connected between the mainframe and the extenders, each instrument is *considered as a separate circuit.)*

The maximum nondestructive voltage which can be applied to the HP 44705A is 120 V dc or 120 V ac rms (170 V peak). The maximum nondestructive voltage which can be applied to the HP 44705F is 100 V dc or 70 V ac rms (100 V peak). The maximum nondestructive voltage which can be applied to the HP 44705H is 200 V dc or 250 V ac rms (354 V peak).

Instrument/Accessory	Peak Voltage
HP 3852A Mainframe	350 V
HP 3853A Extender	350 V
HP 44701A Integrating Voltmeter	350 V
HP 44702A/B High-Speed Voltmeter	42 V
HP 44705A/08A/17A/18A 20-Channel Relay Multiplexers	170 V
HP 44705F/08F 20-Channel Solid-State Relay Multiplexer	100 V
HP 44705H/08H 20-Channel High-Voltage Relay Multiplexers	354 V
HP 44706A 60-Channel Relay Multiplexer	42 V
HP 44709A/10A/11A/12A/13A FET Multiplexers	42 V

CAUTION

POSSIBLE EQUIPMENT DAMAGE. When making high-voltage measurements with the HP 44705, the HP 3852A analog backplane becomes charged to the voltage on the last channel connected to it. Thus, the next channel that is closed may have to absorb all of the stored energy on the backplane.

If the backplane is not discharged after making a high-voltage measurement, the voltage present on the backplane must be added to the voltage being switched on the next channel to determine the total relay contact voltage.

STATIC SENSITIVE. Use clean-handling techniques when handling the accessory. Do not install an accessory without the metal covers attached.

The HP 44705F solid-state switches exhibit much greater switching life than electromechanical relays, but they are more static sensitive. Avoid exposing the terminals to electostatic discharge during operation as well as during handling and installation.

Block Diagram Description

The HP 44705 accessories consist of a 20-channel terminal module and a component module as shown in Figure 2-1. Field wiring from your application sensors (such as voltage sources) is connected to the terminal module and the signals are sent to the switches located on the component module.

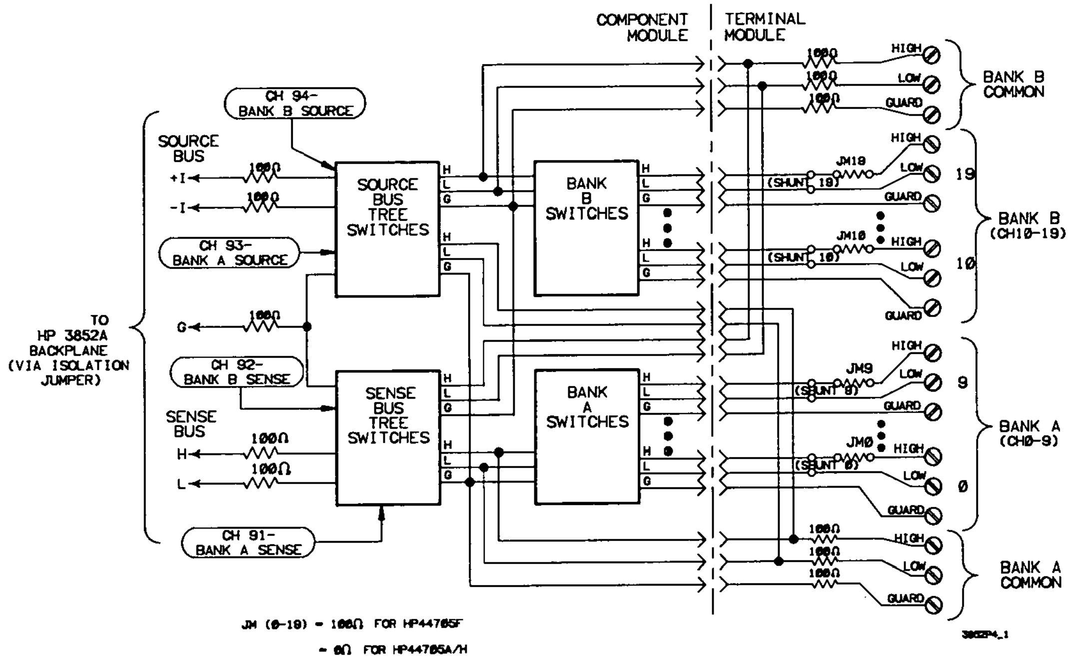


Figure 2-1. HP 44705 Block Diagram

Component Module

The component module consists of 24 switches which are divided into two categories: bank switches and tree switches. Each of the 24 switches consists of three relays (reed-actuated in the HP 44705A and HP 44705H and solid-state in the HP 44705F), one each for HIGH, LOW, and GUARD lines. There are 20 bank switches which are divided into two groups of 10 channels each: Bank A and Bank B. The channels in Bank A are numbered 0 through 9 and the channels in Bank B are numbered 10 through 19.

NOTE

Only one channel per bank can be closed at a time. Closing a second channel in a bank will open any previously closed channel in that bank.

The component module contains two types of tree switches: Source Bus and Sense Bus. Each of the two banks has one Source Bus tree switch and one Sense Bus tree switch. The tree switches control signal flow to and from the HP 3852A backplane and also isolate the bank switches from the backplane when they are not in use.

The Sense Bus tree switches provide connections to the backplane to make voltage measurements. The Source Bus tree switches provide backplane connections to the HP 44701A or HP 44702A/B voltmeter current sources (+I and -I) to make resistance measurements.

Five resistors on the component module connect the tree switches to the HP 3852A backplane to provide current limiting protection for the component module relays. The resistors do not affect resistance measurements (2-wire ohms error due to contact and trace resistance is <2 Ω for the HP 44705A and <1300 Ω for the HP 44705F). These resistors can be shorted out, but this will seriously shorten relay life if high voltages or currents are switched.

The component module also includes an Isolation Jumper which allows you to disconnect the tree switches from the HP 3852A backplane for special signal routing applications. Refer to "Setting the Isolation Jumper" for details on setting the Isolation Jumper.

Terminal Module

The terminal module consists of 20 channels of terminal connectors to connect field wiring and a Bank A COMMON and Bank B COMMON connection. The Bank A COMMON and Bank B COMMON terminals on the terminal module can be used to connect an external voltmeter or for diagnostic procedures.

As factory configured, there are three current limiting resistors in series with the Bank A COMMON terminal and three current limiting resistors in series with the Bank B COMMON terminal.

Channel Definitions

Table 2-1 shows the channel definitions for the HP 44705 accessories. Channels 0 through 19 control the bank switches, channels 91 and 92 control the Sense Bus tree switches, and channels 93 and 94 control the Source Bus tree switches. When using high-level commands (such as CONFMEAS or MEAS), the appropriate tree switches and bank switches are automatically closed along with the measurement channel by the command. However, when using low-level commands such as OPEN and CLOSE, the appropriate bank and tree switch channels (as defined in Table 2-1) must be specified as well as the measurement channel.

For example, to make voltage measurements on channel 0 using CLOSE, you will need to close the Bank A Sense Bus tree switch (channel 91) and the measurement channel (channel 0). Or, to make voltage measurements on channel 19, close Bank B Sense Bus tree switch (channel 92) and the measurement channel (channel 19).

To make resistance measurements with CLOSE, you will need to close both the Sense Bus and Source Bus tree switches and the measurement channel. For example, to make 2-wire ohms resistance measurements on channel 0, close the Bank A Sense Bus tree switch (channel 91), the Bank A Source Bus tree switch (channel 93) and the measurement channel (channel 0).

Table 2-1. HP 44705 Channel Definitions

Channel	Definitions
0 - 9	Bank A Switches
10 - 19	Bank B Switches
91	Sense Bus Tree Switch (Bank A)
92	Sense Bus Tree Switch (Bank B)
93	Source Bus Tree Switch (Bank A)
94	Source Bus Tree Switch (Bank B)

Programming Notes

This page is provided for special comments or notes.

Setting the Isolation Jumper

The tree switches on the HP 44705 multiplexers can be connected or disconnected from the HP 3852A backplane using the Isolation Jumper. Figure 2-2 shows the location of the Isolation Jumper (J1) on the component module.

The jumper has an EN (enable) and DIS (disable) position. For normal operation, the jumper should be in the EN position to connect the tree switches to the backplane. For special applications which require tree switch isolation from the backplane, move the jumper to the DIS position. Factory setting is the EN position.

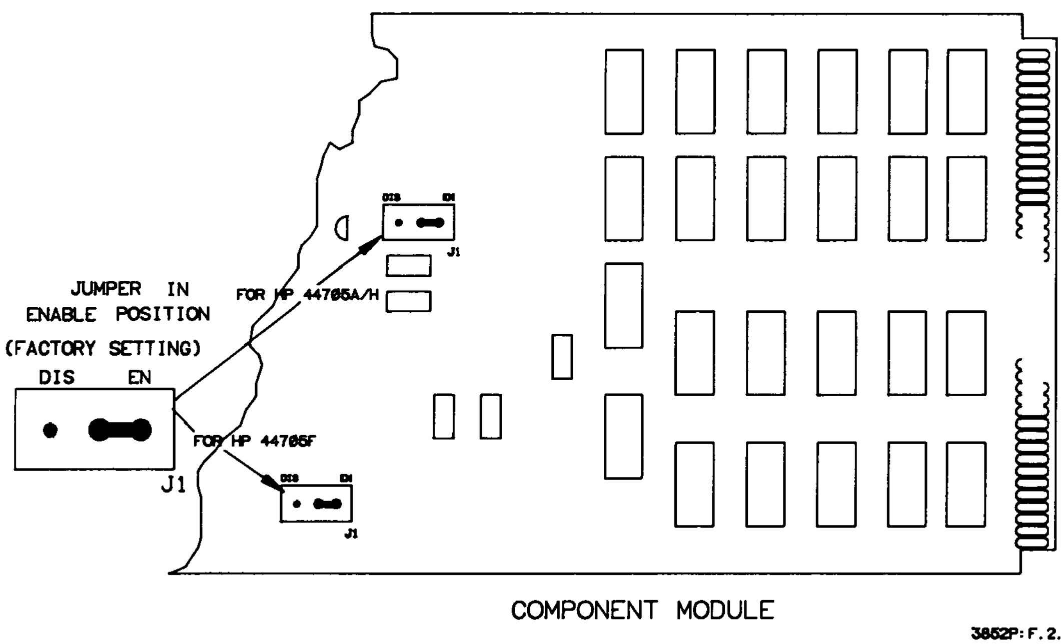


Figure 2-2. HP 44705 Isolation Jumper Configuration

Terminal Module Configuration

This section shows how to hardware configure the HP 44705 terminal modules. It shows how to install low-pass filters and attenuators on the terminal module for input signal conditioning and how to install resistors on the terminal module for current sensing applications.

Low-Pass Filters

Space has been provided on the terminal module for you to install low-pass filters for input signal conditioning on each channel. Figure 2-3 shows normal channel configuration and shows how to install a low-pass filter on channel 10 of the terminal module. To install the low-pass filter, remove the jumper (SERIES JM 10) and install your resistor in its place. Then, install your capacitor in the SHUNT 10 position as shown.

NOTE

The 44705F has 100 Ω resistors installed in the series positions (for electrostatic discharge (ESD) protection). Reducing this resistance value will worsen sensitivity to ESD.

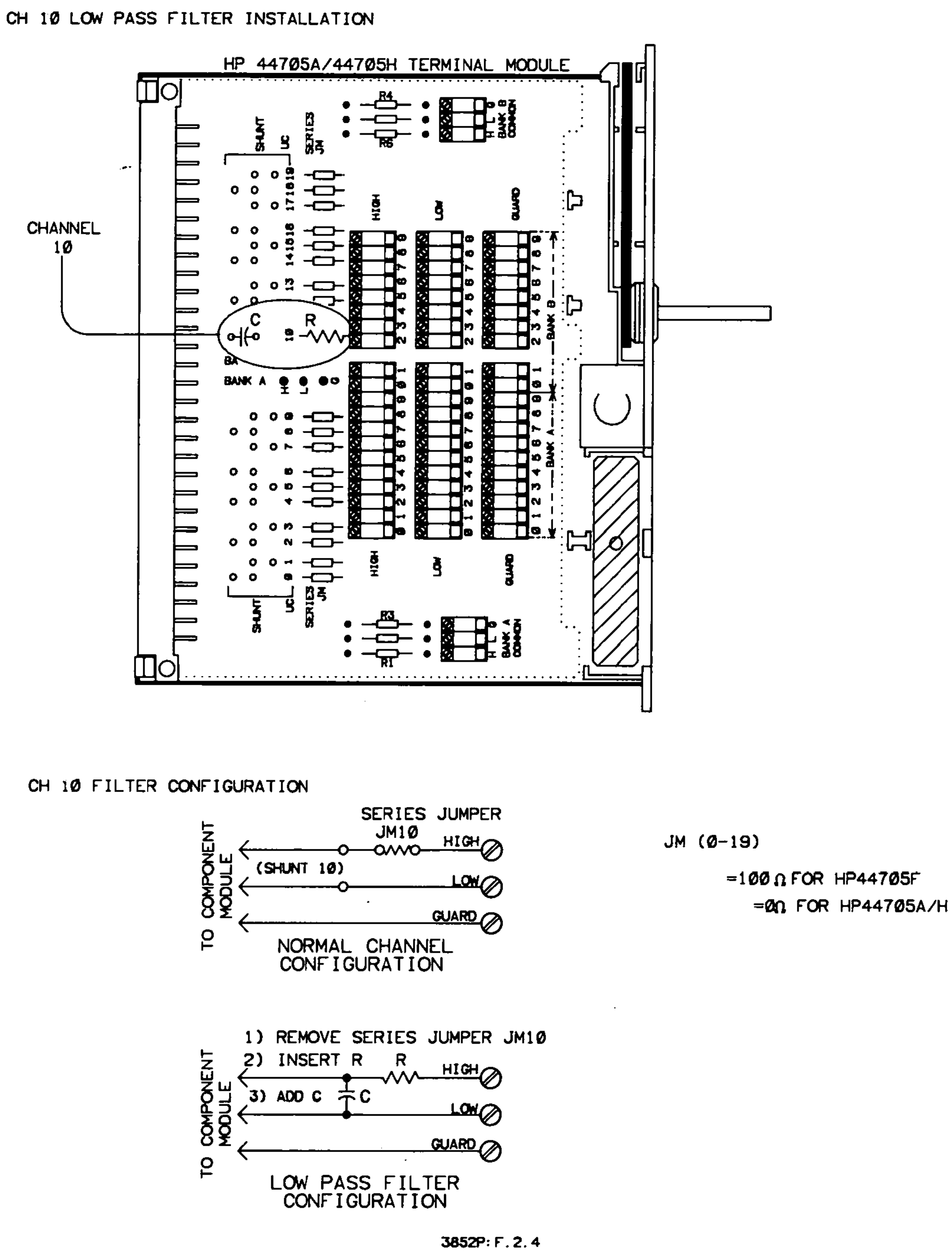


Figure 2-3. HP 44705 Low-Pass Filter Channel Configuration

Attenuators

The space for low-pass filters on the terminal module can also be used to install attenuators to reduce input signals to a usable level for the HP 44705. Figure 2-4 shows normal channel configuration and shows how to install an attenuator on channel 0 of the terminal module. To install the attenuator, remove the jumper (SERIES JM 0) and install resistor R1 in its place. Then, install resistor R2 in the SHUNT 0 position as shown. Precision components should be used to maintain accuracy.

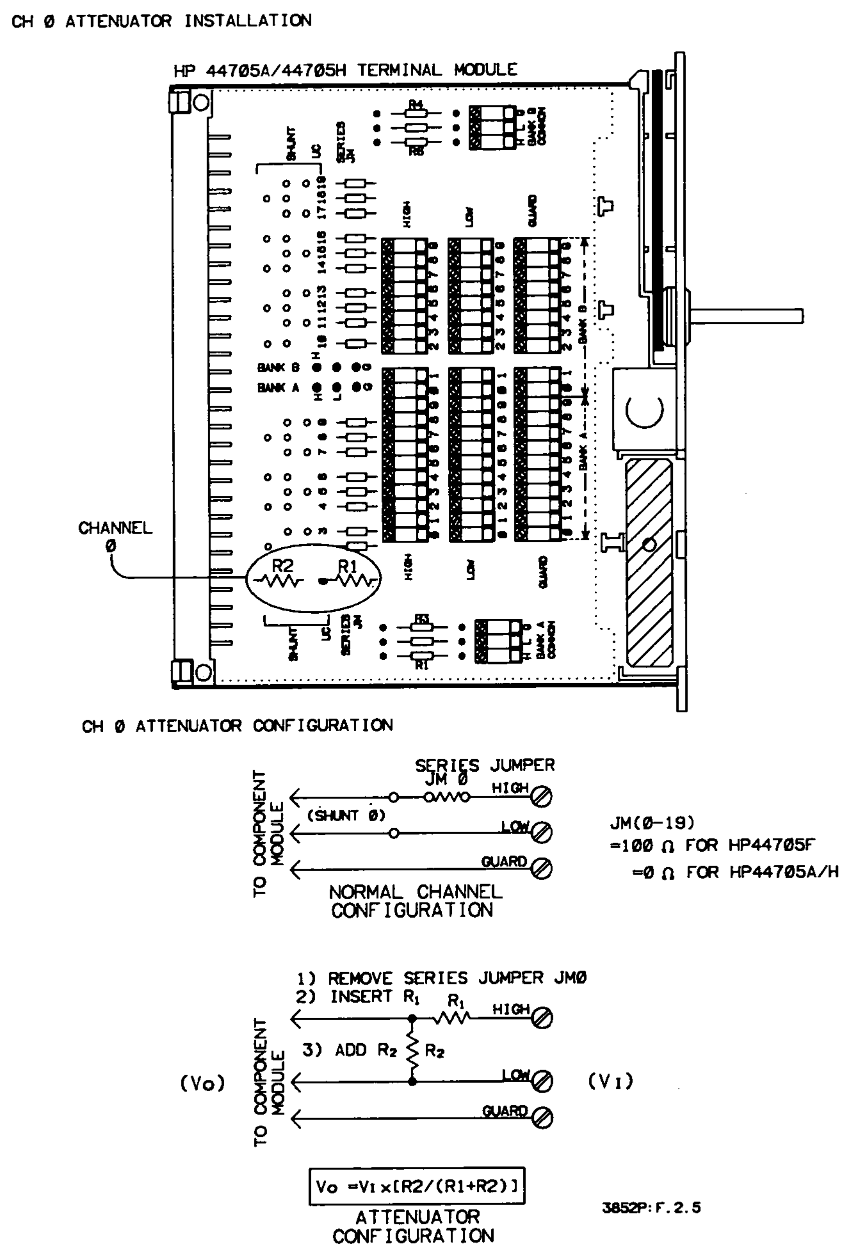


Figure 2-4. HP 44705 Attenuator Channel Configuration

Current Sensing

The HP 44705 multiplexers use current sensing to make current measurements. When making a current sensing measurement, the voltage across a shunt resistor is measured and the current is calculated by the controller using the measured voltage and the resistance value of the shunt. Presision resistors should be used to maintain accuracy.

Figure 2-5 shows normal channel configuration and shows how to configure channel 0 for current sensing measurements. In Figure 2-6, a 250 Ω shunt resistor (R0) is installed in the shunt position (Bank A SHUNT 0) for channel 0 on the terminal module. Note that the SERIES JM0 jumper MUST be in place on the terminal module for each channel being used for current measurements.

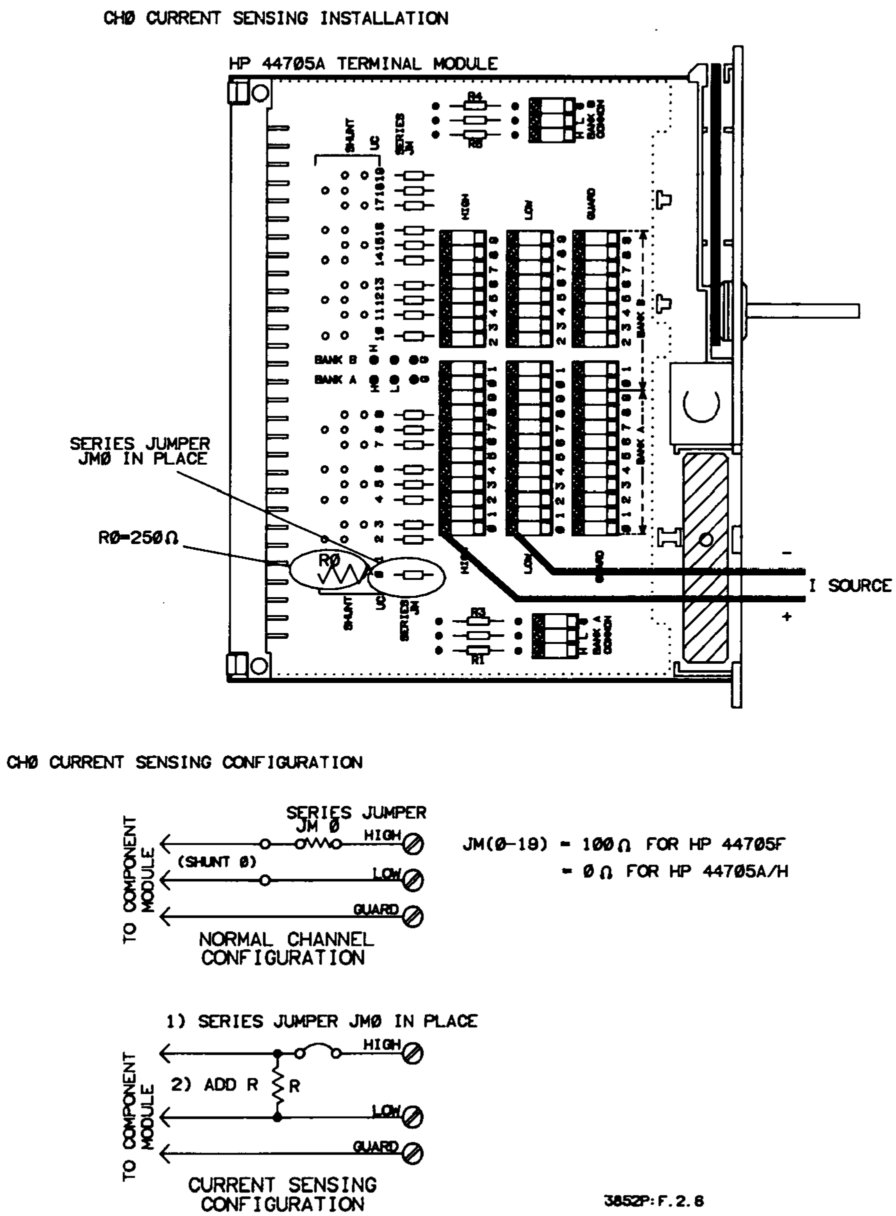


Figure 2-5. HP 44705 Current Sensing Configuration

Field Wiring Connections

When the terminal module is configured as required, the next step is to connect field wiring from your application to the terminals on the terminal module. This section contains example field wiring connections to the HP 44705 terminal module for voltage, resistance, and temperature measurements.

NOTE

For measurements using the HP 44702A/B High-Speed Voltmeter shielded, twisted-pair cable is required for connections to the terminal module. Shielded, twisted-pair cable suitable for connections to the HP 44705 multiplexer can be ordered from your nearest Hewlett-Packard Sales and Support Office. Order HP part number 03498-61602 which is a 2 metre shielded, twisted-pair cable with crimped and heat-shrunk wires attached to the braided shield at both ends.

The 44705F has 100 Ω resistors installed in the series positions (for electrostatic discharge (ESD) protection). Reducing this resistance value will worsen sensitivity to ESD.

Terminal Module Connections

Figure 2-6 shows the HP 44705 terminal module with the cover removed. Each of the 20 channels has a HIGH, LOW, and GUARD terminal. Terminals 0 through 9 in Bank A are for channels 0 through 9, respectively. Terminals 0 through 9 in Bank B are for channels 10 through 19, respectively.

When connecting field wiring to the terminal module, route the wires under the strain relief clamp and tighten the clamp screw to reduce the chance of wires being pulled out of the terminal connectors. If the clamp screw is loosened far enough, the strain relief clamp can be rotated to make it easier to route the wiring.

When connecting components such as resistors, the lead length may be too short to route through the strain relief clamp. In this case, the components will have to be stored inside the terminal module. When connecting these components, make sure that no leads are shorted together and bend the leads to allow the terminal module cover to be replaced.

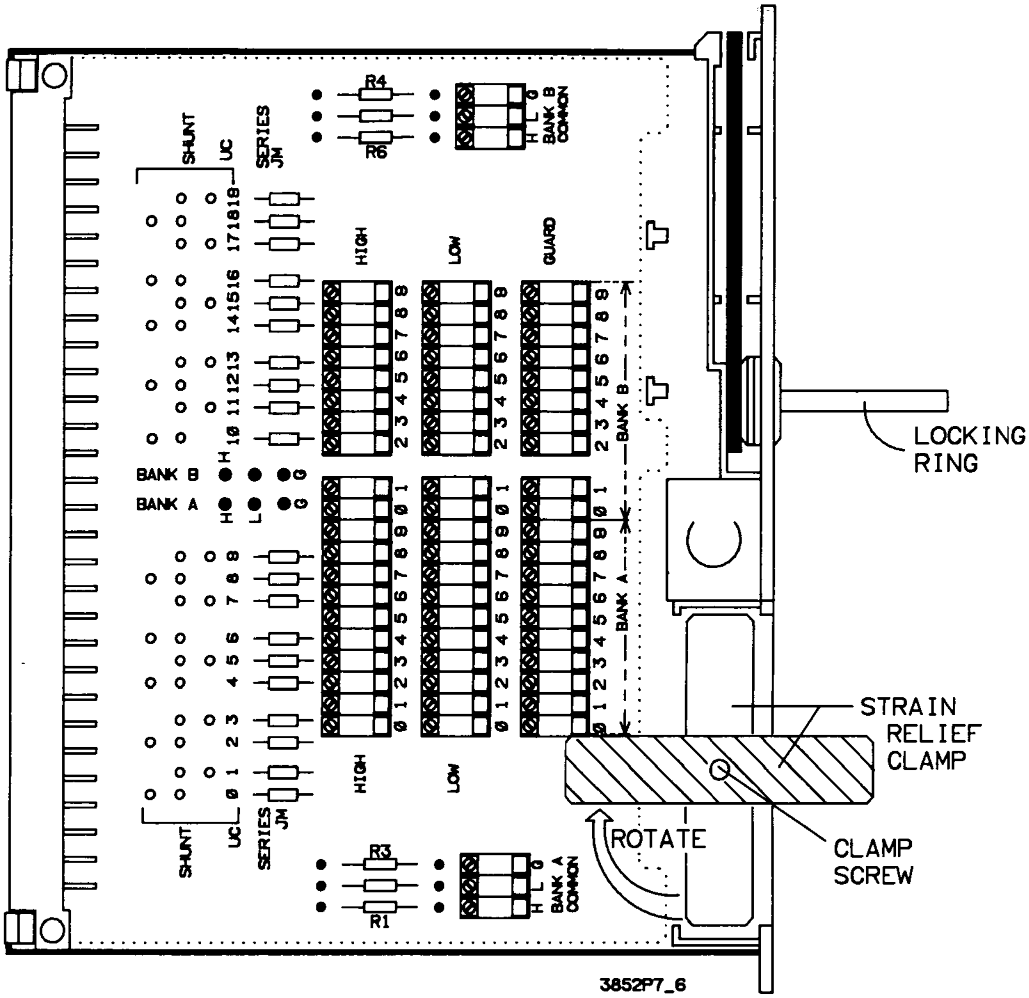


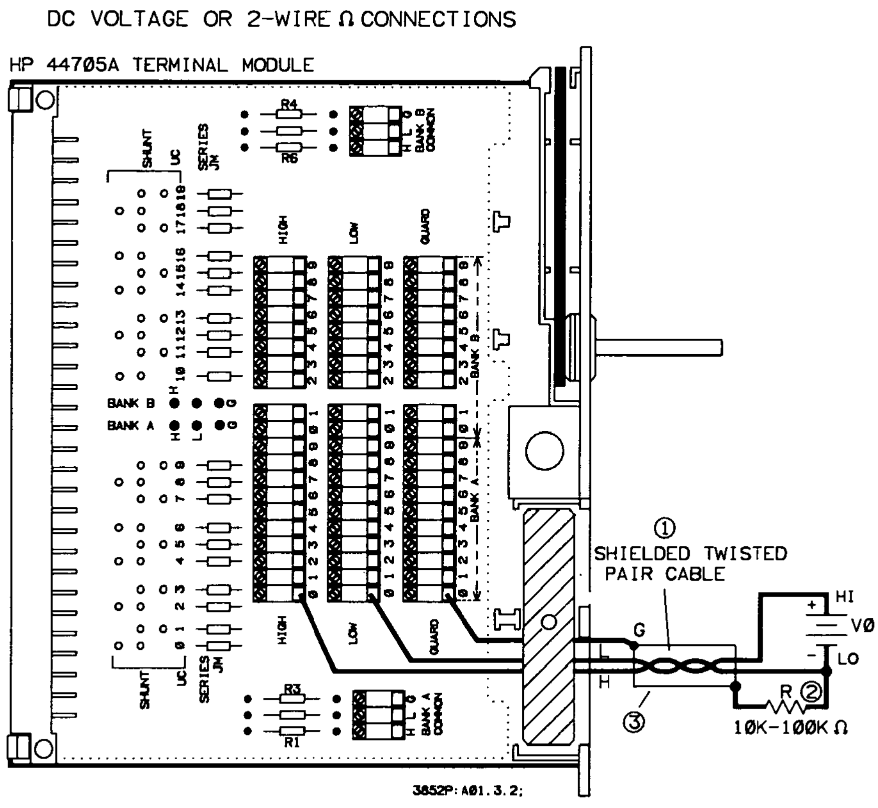
Figure 2-6. HP 44705 Terminal Module

Voltage Measurements Connections

The HP 44705 can switch signals for up to 20 guarded (3-wire) DC or AC voltage measurements (DC voltage measurements only for inputs to the HP 44702A/B High-Speed Voltmeter). For guarded voltage measurements, HIGH, LOW, and GUARD lines are switched on each selected channel for maximum common mode noise rejection.

Figure 2-7 shows typical voltage measurement connections to channel 0 on the terminal module. Connect the HI (+) lead from the voltage source to channel 0 HIGH terminal and the LO (-) lead from the voltage source to the channel 0 LOW terminal. If a guarded (3-wire) voltage measurement is being made, connect the shield from the shielded twisted-pair cable to the channel 0 GUARD terminal.

Since shielded, twisted-pair cable reduces measurement noise, shielded cable is required for measurements with the HP 44702A/B voltmeter and is recommended for measurements with the HP 44701A voltmeter. Also, for the HP 44702A/B voltmeter, an external resistor (R) should be connected between the source voltage LO and the shield, as shown in Figure 2-7. Select R so that the combination of signal voltage + common mode voltage (CMV) $\leq \pm$ 10.24V.



Notes:

[1] = Shielded cable and external resistor R are required for measurements with the HP 44702A/B High-Speed Voltmeter. Shielded cable is highly recommended for measurements with the HP 44701A Integrating Voltmeter.

[2] = For measurements with the HP 44702A/B High-Speed Voltmeter, use R = 10 kΩ to 100 kΩ. For measurements with the HP 44701A Integrating Voltmeter, make a direct connection from V0 LO to the shield (e.g., R = 0).

[3] = For the HP 44701A Integrating Voltmeter ONLY, if shielded cable is not used connect a lead from V0 HI (+) to channel 0 HIGH, a lead from V0 LO (−) to channel 0 LOW, and a lead from V0 LO to channel 0 GUARD.

Figure 2-7. HP 44705 Voltage Connections

Resistance Measurements Connections

The HP 44705 accessory can also be used to switch signals for resistance measurements using 2-wire and 4-wire ohms measurement techniques.

2-Wire Ohms Connections

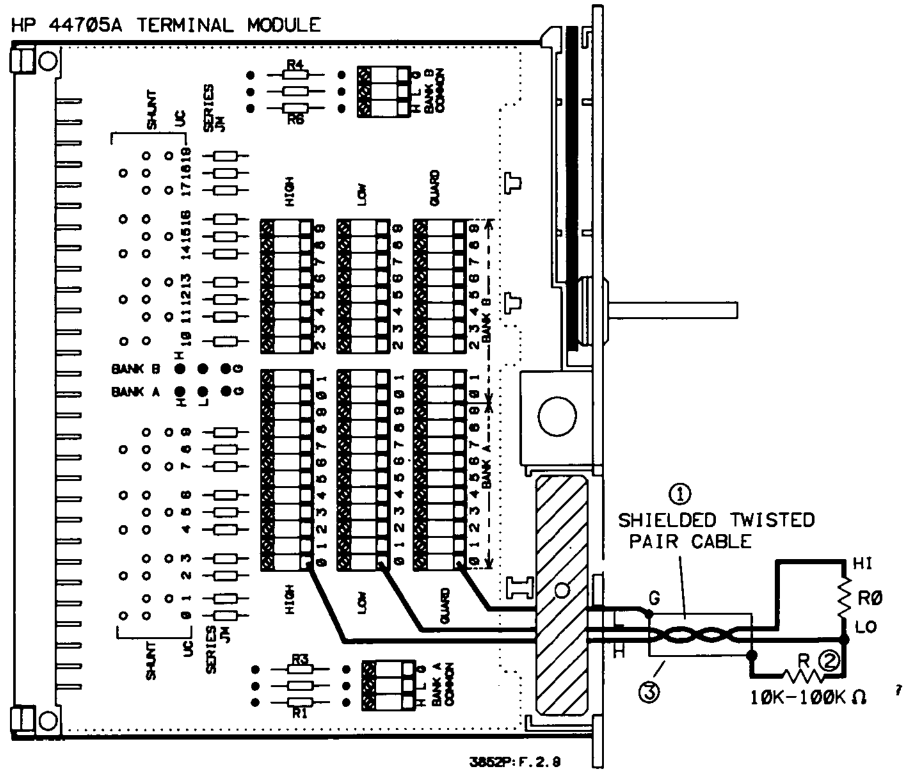
In applications where the resistance of the test leads is not critical, the 2-wire ohms function can be used with the HP 44705A and the HP 44705H. Generally, the larger the resistance being measured, the less you have to be concerned about test lead resistances. Since the HP 44705F uses solid-state relays to switch signals, the resistance when the signal is connected (the On resistance) is a nominal few hundred ohms. This adds directly to the series resistance during a 2-wire ohm measurement, so that the total resistance in the high and low leads is less than or equal to 1300 Ω. The 2-wire ohms function can be used to switch up to 20 resistances for measurement per HP 44705 accessory.

Figure 2-8 shows typical 2-wire ohms measurement connections for a resistor (R0) connected to channel 0 on the terminal module with shielded, twisted-pair cable. Shielded cable and an external resistor R are required for inputs to the HP 44702A/B voltmeter. Shielded cable is highly recommended for inputs to the HP 44701A voltmeter. In Figure 2-8, note that one end of the shield lead is connected to the LO side of the resistor and the other end of the shield lead is connected to channel 0 GUARD.

For measurements with the HP 44702A/B High-Speed Voltmeter, select R so that the combination of common mode voltage + signal voltage is $\leq \pm 10.24$V. For measurements with the HP 44701A Integrating Voltmeter, make a direct connection from R0 LO to the shield (e.g., R = 0).

For measurements with the HP 44701A Integrating Voltmeter ONLY, if shielded cable is not used, connect one lead of the resistor to channel 0 HIGH terminal and the other lead of the resistor to channel 0 LOW terminal. If high common mode noise rejection is required, also connect a separate lead from resistor R0 LO to the channel 0 GUARD terminal.

2-WIRE Ω MEASUREMENTS



Notes:

[1] = Shielded cable and external resistor R are required for measurements with the HP 44702A/B High-Speed Voltmeter. Shielded cable is highly recommended for measurements with the HP 44701A Integrating Voltmeter.

[2] = For measurements with the HP 44702A/B High-Speed Voltmeter, use R = 10 kΩ to 100 kΩ. For measurements with the HP 44701A Integrating Voltmeter, make a direct connection from R0 LO to the shield (e.g., R = 0).

[3] = For the HP 44701A Integrating Voltmeter ONLY, if shielded cable is not used connect a separate lead from the channel 0 GUARD terminal to R0 LO.

Figure 2-8. HP 44705 2-Wire Ohms Connections

4-Wire Ohms Connections

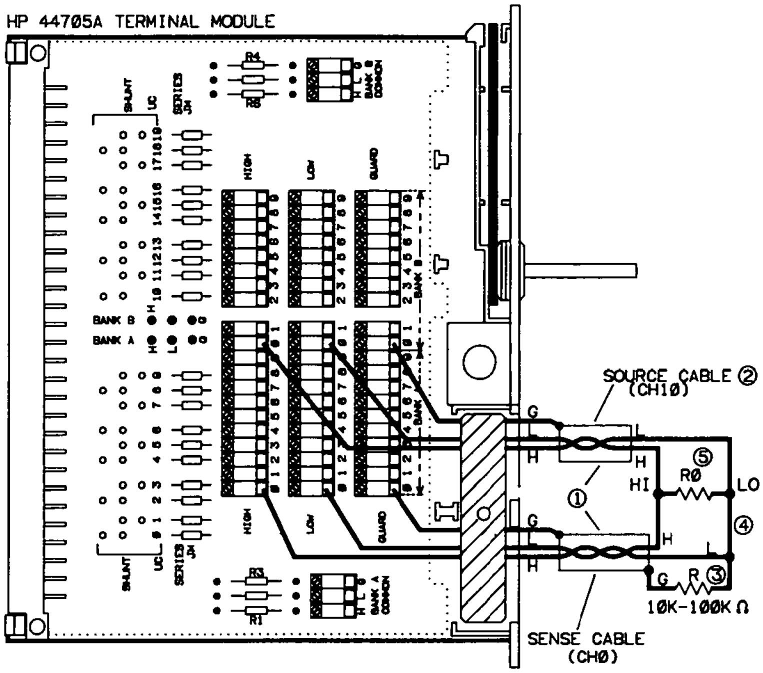
Using 4-wire ohms measurements virtually eliminates the error caused by field wiring lead resistances. With 4-wire ohms, the current through the unknown resistance remains the same regardless of field wiring lead resistance and the voltmeter measures only the voltage across the resistance.

The 4-wire ohms function is essential when highest accuracy is required. However, since each 4-wire ohms measurement requires two channels, a maximum of ten resistance measurements can be made per HP 44705 accessory.

Each 4-wire ohms measurement requires two channels, one from Bank A and one from Bank B. When connecting a resistor to the terminal module for a 4-wire ohms measurement, use two channels that are separated by one decade (e.g., channels 0 and 10, channels 1 and 11, etc.).

See Figure 2-9 for 4-wire ohms connections of a resistance (R0) connected to channel 0 and channel 10 using shielded, twisted-pair cable. (Shielded cable is required for inputs to the HP 44702A/B voltmeter and is highly recommended for inputs to the HP 44701A voltmeter.) Channel 0 is used as the voltage sense channel and channel 10 as the current source channel for the measurement.

4-WIRE Ω MEASUREMENTS



Notes:

[1] = Shielded cable and external resistor R are required for measurements with the HP 44702A/B High-Speed Voltmeter. Shielded cable is highly recommended for measurements with the HP 44701A Integrating Voltmeter.

[2] = For measurements with the HP 44702A/B High-Speed Voltmeter, use R = 10 kΩ to 100 kΩ. For measurements with the HP 44701A Integrating Voltmeter, make a direct connection from R0 LO to the shield (e.g., R = 0).

[3] = For the HP 44701A Integrating Voltmeter ONLY, if shielded cable is not used, connect a separate lead from the Sense channel GUARD terminal to R0 LO.

[4] = R0 can be a resistor, an RTD, or a thermistor. The HP 3852A supports Type 85 and 92 RTDS and Type 2252, 5k, and 10k thermistors.

Figure 2-9. HP 44705 4-Wire Ohms Connections

In Figure 2-9, note that one end of the Sense cable (channel 0) shield lead is connected to the channel 0 GUARD terminal and the other end of the shield lead is connected to R0 LO. However, although one end of the Source cable (channel 10) shield lead is connected to channel 10, the other end of the shield lead is NOT connected to R0 LO.

If you do not use shielded cable, connect channel 0 HIGH and LOW and channel 10 HIGH and LOW terminals to the resistor as shown in Figure 2-9 and connect a separate lead from the Sense channel (channel 0) GUARD terminal to the resistor LO. However, measurement accuracy with unshielded leads will not be as high as when shielded cable is used, since unshielded leads do not provide any noise immunity.

Temperature Measurements Connections

One of the functions of the HP 44705 multiplexer is to switch signals for temperature measurements. This section shows how to connect RTDs and thermistors to the terminal module for temperature measurements.

RTD Connections

The resistance temperature detector (RTD) is a temperature-sensitive resistor that is typically stable, accurate, and linear. Since each 4-wire measurement requires two channels, up to ten RTD measurements can be made per HP 44705A/F/H accessory. The HP 3852A resistance-to-temperature conversions support Type 85 and Type 92 RTDs (temperature coefficients (α) of 0.00385 $\Omega/\Omega/^\circ C$ and 0.003916 $\Omega/\Omega/^\circ C$, respectively, and resistance values of 100Ω at $0^\circ C$).

Each 4-wire RTD measurement requires two channels, one from Bank A and one from Bank B. When connecting an RTD to the terminal module for a 4-wire measurement, use two channels that are separated by one decade (e.g., channels 0 and 10, channels 1 and 11, etc.). See Figure 2-9 in "Resistance Measurements Connections" for a typical connection diagram.

Thermistor Connections

Thermistors are capable of detecting small changes in temperature and are used in applications where the temperature extremes are not too high. Thermistors are highly dependent upon variables such as thermistor composition and size. Most thermistors have negative temperature coefficients which means that their resistance values decrease with increasing temperature.

Since each 4-wire measurement requires two channels, up to ten temperature measurements can be made per accessory. The HP 3852A resistance-to-temperature conversions support Type 2252, 5K, and 10K thermistors (resistance values at $25^\circ C$ of 2252Ω, 5 kΩ, and 10 kΩ, respectively).

Each 4-wire thermistor measurement requires two channels, one from Bank A and one from Bank B. When connecting a thermistor to the terminal module for a 4-wire measurement, use two channels that are separated by one decade (e.g., channels 0 and 10, channels 1 and 11, etc.). See Figure 2-9 in "Resistance Measurements Connections" for a typical connection diagram.

Installation/Checkout

This section shows how to check the accessory identity, how to verify the field wiring connections, and how to read the state of the channels for an HP 44705 multiplexer.

NOTE

The example programs in this manual use "709" as the HP-IB address for the HP 3852A. Specific slot and channel numbers are also used. Program syntax and data return formats apply to HP Series 200/300 Controllers. Modify slot and channel numbers as required.

Check Accessory ID

After you have connected field wiring from your application to the terminal module, replace the terminal module cover and install the accessory in the desired mainframe or extender slot. Refer to the HP 3852A Mainframe Configuration and Programming Manual to connect the terminal module to the component module and to install the accessory.

When the accessory is installed, use the ID? command to check the accessory ID. At power-on, an HP 44705 returns 44705. An HP 44705 component module only (no terminal module attached) returns 447XXX. (Note that if the terminal module is removed after power-on, the accessory still returns 44705.)

For example, the following program determines the identity of an accessory in slot 2 of the mainframe. An HP 44705 multiplexer in this slot returns 44705.

```
10 OUTPUT 709;"ID? 200"        !Query ID in mainframe slot 4
20 ENTER 709;A$                !Enter ID
30 PRINT A$                    !Display ID
40 END
```

If the multiplexer does not return 44705 be sure you have addressed the correct slot and the terminal module is installed. If these are correct but the correct ID code is not returned, refer to the HP 3852A Assembly Level Service Manual for service procedures.

Verify Wiring Connections

To verify that your field wiring has been properly connected to the terminal module, send the MONMEAS (Monitor/Measure) command from the HP 3852A front panel keyboard or from a controller. This command can be used to check DC or AC voltage and 2-wire ohms connections. An example follows.

This program segment uses the MONMEAS command to verify DC voltage connections on channels 200 through 219 of an HP 44705 multiplexer in slot 2 of the mainframe. The CONF command configures the voltmeter in slot 0 of the mainframe for DC voltage measurements.

The 20 channels are to be scanned and measured one at a time starting with channel 200. Press the SADV KEY key on the HP 3852A front panel to advance the scanning to the next channel. When the scan is advanced past the last channel (channel 219 in this example), scanning will stop and the last measurement will remain on the display.

```
10 OUTPUT 709;"USE 0"                    !Use voltmeter in mainframe slot 0
20 OUTPUT 709;"CONF DCV"                 !Set DC volts function on voltmeter
30 OUTPUT 709;"MONMEAS DCV,200-219"      !Monitor/measure ch 200 through 219
            .                            !(Press SADV KEY to advance ch)
            .
```

Read Channel State

The CLOSE? command can be used to determine the state of HP 44705 channels. This command returns one of five numbers as shown in Table 2-2 for each channel queried. The number returned indicates if a channel is open or closed and to which bus (Sense, Source, or both) the channel is connected.

NOTE

The CLOSE? command will return 2, 3, or 4 only to indicate the state of channels 0 through 19 (i.e., these values will not be returned for the tree switches.)

Table 2-2. Values Returned by CLOSE?

Data Returned	Channel State
0	Channel Open
1	Channel Closed - not connected to Bus
2	Channel Closed - connected to Sense Bus
3	Channel Closed - connected to Source Bus
4	Channel Closed - connected to Both Buses

Example: Reading Channel State

This program uses the CLOSE? command to check the state of channels 200 through 204 on an HP 44705 in slot 2 of the mainframe. The RST (reset) command resets the multiplexer to its power-on state with all channels open. The CLOSE command closes channel 203 and the Bank A Sense Bus tree switch (channel 291). The OPEN command opens the channel and disconnects it from the backplane.

```
10  OUTPUT 709;"RST 200"          !Open all chs
20  INTEGER State(0:4)            !Define controller array
30  OUTPUT 709;"CLOSE 203,291"    !Close ch 203 and Sense Bus tree sw
40  OUTPUT 709;"CLOSE? 200-204"   !Query state of chs 200 through 204
50  ENTER 709;State(*)            !Enter state
60  PRINT State(*)                !Display state
70  OUTPUT 709;"OPEN 203,291"     !Open ch 203 and Sense Bus tree sw
80  END
```

For this example, since channel 203 was the only channel closed and was connected to the Sense Bus tree switch, a typical return is:

```
 0   0   0   2   0
```

Contents

Chapter 3
Configuring the HP 44706A

Chapter 3
Configuring the HP 44706A

Configuration Overview

This chapter shows how to configure the HP 44706A multiplexer accessory. It contains a block diagram description of the HP 44706A accessory, information on hardware configuring the terminal module, and information on connecting field wiring to the terminal module.

When you have configured the accessory for your application, refer to Chapter 5 - Programming the Multiplexers to program the accessory for voltage, current, resistance, and temperature measurements.

Warnings and Cautions

This section contains WARNINGS and CAUTIONS applicable to the HP 44706A multiplexer. You should review the WARNINGS and CAUTIONS shown before configuring the multiplexer.

WARNING

⚠ 1 *SHOCK HAZARD. Only qualified, service-trained personnel who are aware of the hazards involved should install, remove, or configure any accessory. Before touching any installed accessory, turn off all power to the mainframe, extenders, and to all external devices connected to the mainframe, extenders, or accessories.*

⚠ 1 *SHOCK HAZARD. All channels that have a common connection (multiplexer or matrix), or are configured by the user to have a common connection (general purpose relay switch), must be insulated so that the user is protected from electical shock in the event that two or more channels are connected together. This means wiring for all channels must be insulated as though each channel carries the voltage of the highest voltage channel.*

⚠ 2 *POSSIBLE OPERATOR INJURY. For safety, consider all accessory channels to be at the highest potential applied to any channel. Under most conditions of failure, the relays on the relay multiplexers will remain in whatever state the program sets them.*

However, for some equipment failures, the relays may not remain in their programmed state. If the relays settle in the closed state, the relay contacts may weld together and the highest voltage present on any one channel may be present on all channels. This condition may cause operator injury if the terminals are touched or equipment damage may result.

⚠ 2 *MAXIMUM VOLTAGE LIMITATIONS. The HP 3852A and the HP 3853A internal analog buses interconnect the multiplexer and voltmeter accessories to form one circuit. To protect against possible personal injury due to equipment failure or programming error, limitations are placed on the potentials that can appear between any two points on the circuit (or between the circuit and chassis).*

These limitations are listed for the HP 3852A, HP 3853A, and all plug-in accessories. For any given set of accessories installed in the mainframe or extender, the maximum potential between any two points is determined by the accessory with the

LOWEST peak voltage limitation, as shown. (If the analog extender cable is NOT connected between the mainframe and the extenders, each instrument is considered as a separate circuit.)

The maximum nondestructive voltage which can be applied to the HP 44706A is 42 V dc or 30 V ac rms (42 V peak).

Instrument/Accessory	Peak Voltage
HP 3852A Mainframe	350 V
HP 3853A Extender	350 V
HP 44701A Integrating Voltmeter	350 V
HP 44702A/B High-Speed Voltmeter	42 V
HP 44705A/08A/17A/18A 20-Channel Relay Multiplexers	170 V
HP 44705F/08F 20-Channel Solid-State Relay Multiplexer	100 V
HP 44705H/08H 20-Channel High-Voltage Relay Multiplexers	354 V
HP 44706A 60-Channel Relay Multiplexer	42 V
HP 44709A/10A/11A/12A/13A FET Multiplexers	42 V

CAUTION

STATIC SENSITIVE. Use clean-handling techniques when handling the accessory. Do not install an accessory without the metal covers attached.

Block Diagram Description

The HP 44706A accessory consists of a 60-channel terminal module and a component module as shown in Figure 3-1. Field wiring from your application sensors (such as voltage sources) is connected to the terminal module and the signals are sent to the switches located on the component module.

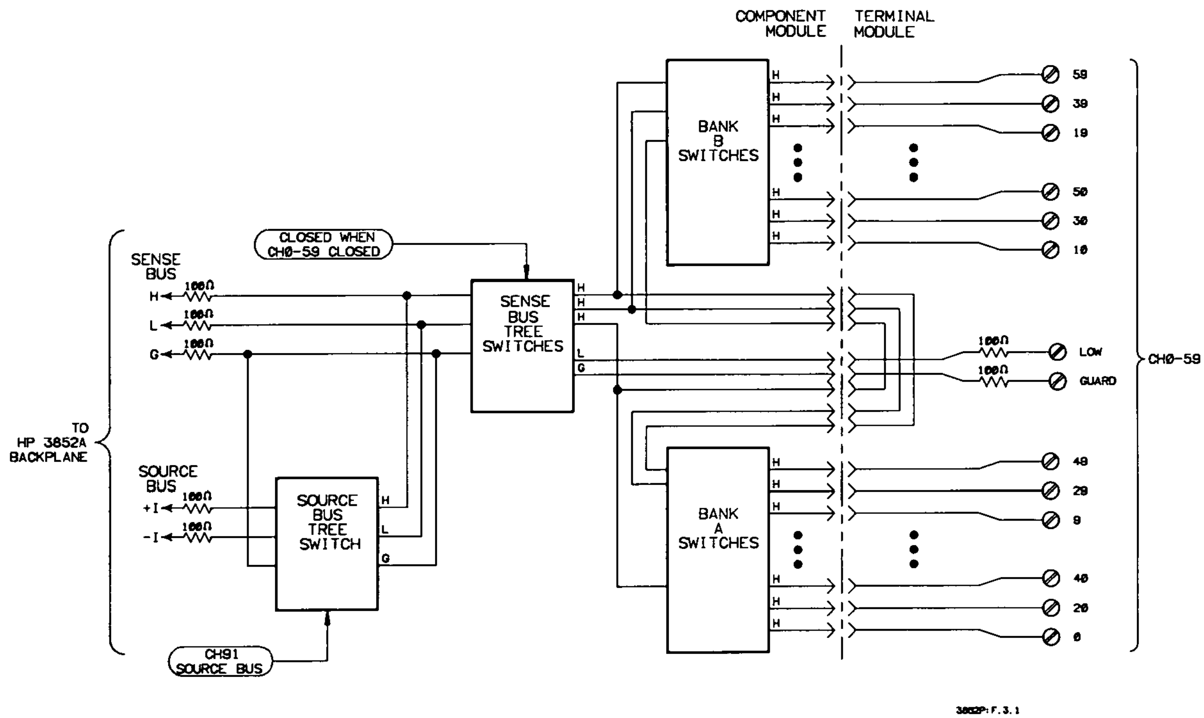


Figure 3-1. HP 44706A Block Diagram

Component Module

The component module consists of two types of switches: bank switches and tree switches. There are 60 bank switches divided into two groups of 30 channels each: Bank A and Bank B. Unlike the guarded multiplexer accessories, the HP 44706A switches the HIGH line only. LOW and GUARD are common to all channels, but are not switched.

NOTE

Only one bank switch can be closed at a time. Closing a second bank switch will open any previously closed bank switch.

The component module contains two types of tree switches: Source Bus and Sense Bus. There are three Sense Bus tree switches and one Source Bus tree switch. The tree switches control signal flow to and from the HP 3852A backplane and also isolate the bank switches from the backplane when they are not in use.

The Sense Bus tree switches provide connections to the backplane to make voltage measurements. The Source Bus tree switches provide backplane connections to the HP 44701A or HP 44702A/B voltmeter current sources (+I and -I) to make resistance measurements.

Terminal Module

The terminal module contains 60 terminals to connect field wiring. As factory configured, there is a 100 Ω resistor in series with the LOW terminal and with the GUARD terminal on the terminal module. Five 100 Ω resistors on the component module connect the tree switches to the HP 3852A backplane.

Channel Definitions

Table 3-1 shows the channel definitions for the HP 44706A accessory. Channels 0 through 59 control the bank switches. When a command is executed to close a channel, the appropriate Sense Bus tree switches are also automatically closed. Channel 91 controls the Source Bus tree switch for all 60 channels.

If you use high-level commands (such as CONFMEAS and MEAS) to program the accessory, you need to specify only the measurement channels since CONFMEAS or MEAS automatically closes the proper channels and switches for the measurement selected.

However, if you use low-level commands such as CLOSE and OPEN for measurements, you will need to specify the switches which are to be closed. For example, to make voltage measurements on channel 0, you will need to close the measurement channel (channel 0) which also closes the Sense Bus tree switch.

To make resistance measurements (2-wire ohms), you will need to close both the Sense Bus and Source Bus tree switches and the measurement channel. For example, to make resistance measurements on channel 0, close the measurement channel (channel 0) (which also closes the Sense Bus tree switch) and the Source Bus tree switch (channel 91).

Table 3-1. HP 44706A Channel Definitions

Channel	Definitions
0 - 59	Bank Switches/Sense Bus Tree Switch
91	Source Bus Tree Switch

Field Wiring Connections

This section contains example field wiring connections to the HP 44706A terminal module for voltage, resistance (2-wire ohms), and temperature (RTD and thermistor) measurements.

NOTE

For measurements using the HP 44702A/B High-Speed Voltmeter shielded, twisted-pair cable is required for connection to the terminal module. Shielded, twisted-pair cable suitable for connections to the HP 44705 multiplexer can be ordered from your nearest Hewlett-Packard Sales and Support Office. Order HP part number 03498-61602 which is a 2 metre shielded, twisted-pair cable with crimped and heat-shrunk wires attached to the braided shield at both ends.

Terminal Module Connections

Figure 3-2 shows the HP 44706A terminal module with the cover removed. Each of the 60 channels has a HIGH terminal (numbered 0 through 59), a common LOW terminal, and a common GUARD terminal.

When connecting field wiring to the terminal module, route the wires under the strain relief clamp and tighten the clamp screw to reduce the chance of wires being pulled out of the terminal connectors. If the clamp screw is loosened far enough, the strain relief clamp can be rotated to make it easier to route the wiring.

When connecting components such as resistors, the lead length may be too short to route through the strain relief clamp. In this case, the components will have to be stored inside the terminal module. When connecting these components, make sure that no leads are shorted together and bend the leads to allow the terminal module cover to be replaced.

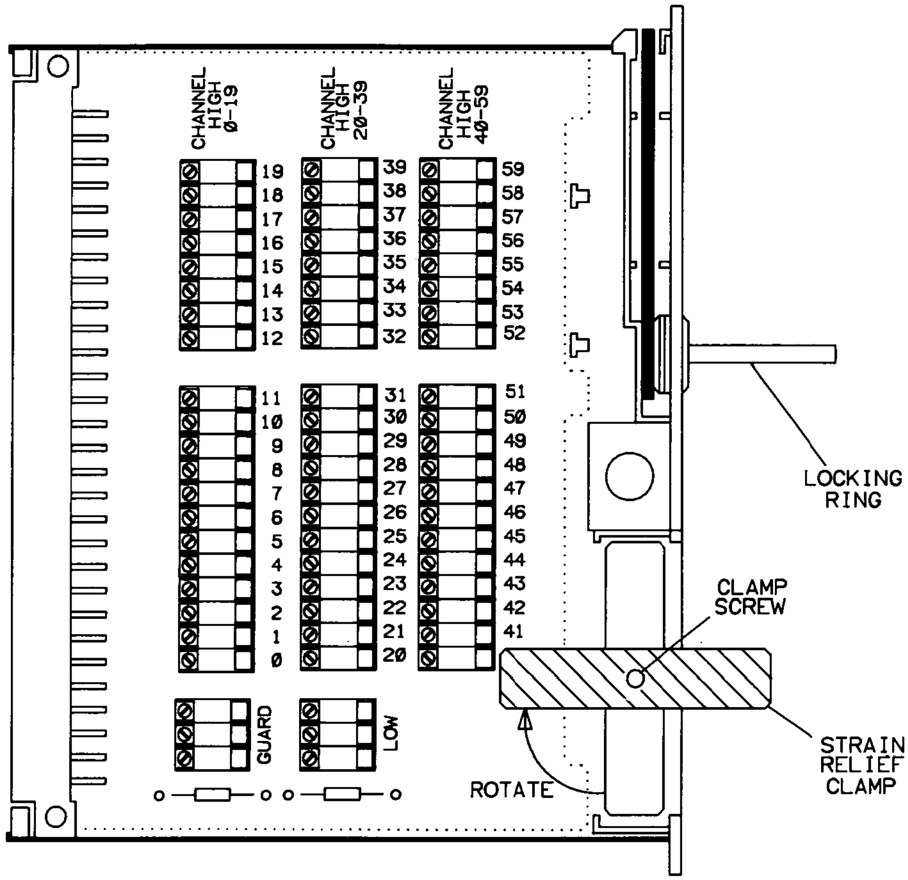


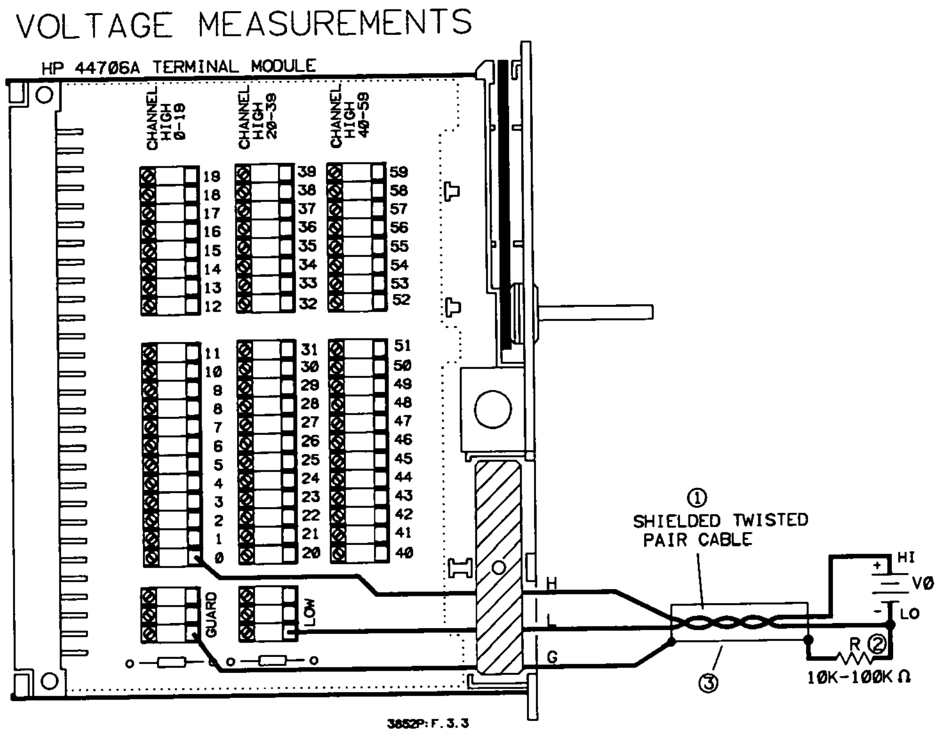
Figure 3-2. HP 44706A Terminal Module

Voltage Measurements Connections

The HP 44706A multiplexer can switch signals for up to 60 single-ended DC or AC voltage measurements (DC voltage measurements only for inputs to the HP 44702A/B High-Speed Voltmeter). When making single-ended voltage measurements, only the HIGH line is switched. LOW, and GUARD are common to each channel but are not switched.

Figure 3-3 shows typical voltage measurement connections to channel 0 on the terminal module. Connect the HI (+) lead from the voltage source to channel 0 HIGH terminal and the LO (-) lead from the voltage source to the common LOW terminal. If a guarded (3-wire) voltage measurement is being made, connect the shield from the shielded, twisted-pair cable to the common GUARD terminal.

Since shielded, twisted-pair cable reduces measurement noise, shielded cable is required for measurements with the HP 44702A/B voltmeter and is recommended for measurements with the HP 44701A voltmeter. Also, for the HP 44702A/B voltmeter, an external resistor (R) should be connected between the source voltage LO and the shield, as shown in Figure 3-3. Select R so that the combination of signal voltage + common mode voltage (CMV) $\leq \pm$ 10.24V.



Notes

[1] = Shielded cable and external resistor R are required for measurements with the HP 44702A/B High-Speed Voltmeter. Shielded cable is highly recommended for measurements with the HP 44701A Integrating Voltmeter.

[2] = For measurements with the HP 44702A/B High-Speed Voltmeter, use R = 10 kΩ to 100 kΩ. For measurements with the HP 44701A Integrating Voltmeter, make a direct connection from V0 LO to the shield (e.g., R = 0).

[3] = For the HP 44701A Integrating Voltmeter ONLY, if shielded cable is not used connect a lead from V0 HI (+) to channel 0 HIGH, a lead from V0 LO (−) to the common LOW, and a lead from V0 LO to the common GUARD.

Figure 3-3. HP 44706A Voltage Connections

Resistance Measurements Connections

The HP 44706A accessory can also be used to switch signals for resistance measurements using 2-wire ohms measurement techniques. In applications where the resistance of the test leads is not critical, the 2-wire ohms function can be used. Generally, the larger the resistance being measured, the less you have to be concerned about test lead resistances.

Use the 2-wire ohms function to switch signals for up to 60 resistance measurements per HP 44706A accessory. Figure 3-4 shows typical 2-wire ohms measurement connections for a resistor (R0) connected to channel 0 on the terminal module with shielded, twisted-pair cable.

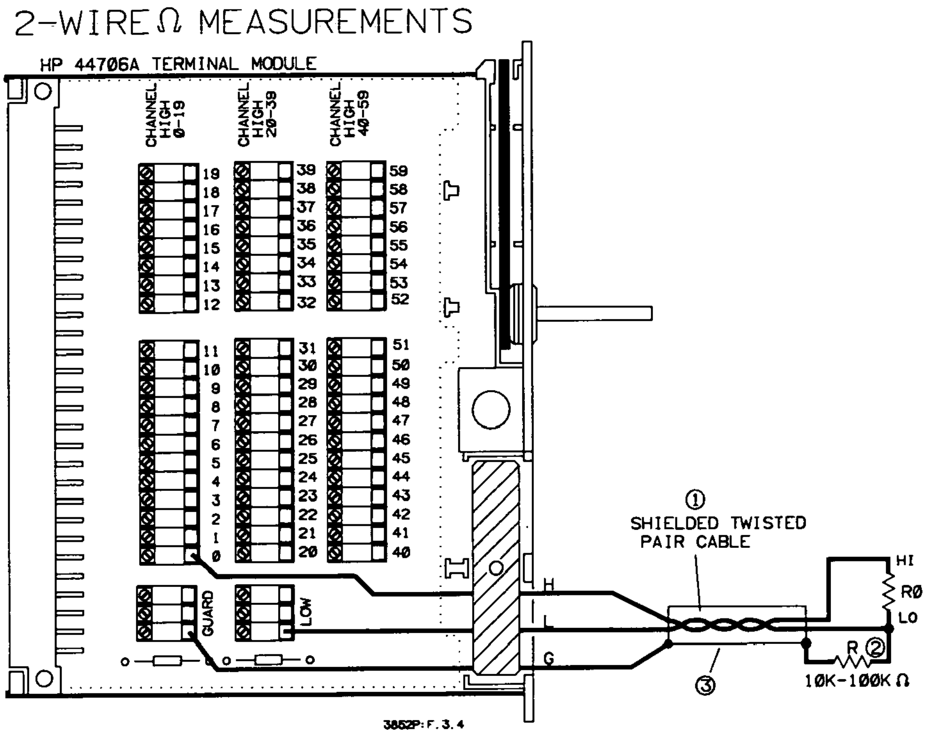
(Shielded cable is required for inputs to the HP 44702A/B voltmeter and is highly recommended for inputs to the HP 44701A voltmeter.) In Figure 3-4, note that one end of the shield lead is connected to the LO side of the resistor and the other end of the shield lead is connected to channel 0 GUARD.

For measurements with the HP 44702A High-Speed Voltmeter, select an external resistor R so that the combination of common mode voltage + signal voltage is $\leq \pm 10.24V$. For measurements with the HP 44701A Integrating Voltmeter, make a direct connection from R0 LO to the shield (e.g., R = 0).

For measurements with the HP 44701A Integrating Voltmeter ONLY, if shielded cable is not used, connect one lead of the resistor to channel 0 HIGH terminal and the other lead of the resistor to common LOW terminal. If high common mode noise rejection is required, also connect a separate lead from resistor R0 LO to the common GUARD terminal.

NOTE

Due to the 100 Ω protection resistor in series with the LOW terminal on the terminal module, there is a 100 Ω offset error when making 2-wire ohms measurements with the HP 44706A. This resistor can be shorted out, but this will seriously shorten relay life if high voltages or currents are switched.



Notes:

[1] = Shielded cable and external resistor R are required for measurements with the HP 44702A/B High-Speed Voltmeter. Shielded cable is highly recommended for measurements with the HP 44701A Integrating Voltmeter.

[2] = For measurements with the HP 44702A/B High-Speed Voltmeter, use R = 10 kΩ to 100 kΩ. For measurements with the HP 44701A Integrating Voltmeter, make a direct connection from R0 LO to the shield (e.g., R = 0).

[3] = For the HP 44701A Integrating Voltmeter ONLY, if shielded cable is not used connect a separate lead from the channel 0 GUARD terminal to R0 LO.

Figure 3-4. HP 44706A 2-Wire Ohms Connections

Temperature Measurements Connections

One of the functions of the HP 44706A accessory is to switch signals for temperature measurements. This section shows how to connect RTDs and thermistors to the terminal module for temperature measurements.

NOTE

Due to the 100 Ω resistor in series with the LOW terminal on the terminal module, there is a 100 Ω offset error when making 2-wire temperature measurements. This resistor can be shorted out, but this will seriously shorten relay life if high voltages or currents are switched.

RTD Connections

The resistance temperature detector (RTD) is a temperature-sensitive resistor that is typically stable, accurate, and linear. The HP 3852A resistance-to-temperature conversions support Type 85 and Type 92 RTDs (temperature coefficients (α) of 0.00385 Ω/Ω°C and 0.003916 Ω/Ω°C, respectively, and resistance values of 100Ω at 0°C). See Figure 3-4 in "Resistance Measurements Connections" for a typical connection diagram.

Thermistor Connections

Thermistors are capable of detecting small changes in temperature and are used in applications where the temperature extremes are not too high. Thermistors are highly dependent upon variables such as thermistor composition and size. Most thermistors have negative temperature coefficients which means that their resistance values decrease with increasing temperature.

The HP 3852A resistance-to-temperature conversions support Type 2252, 5K, and 10K thermistors (resistance values at 25°C of 2252Ω, 5 kΩ, and 10 kΩ, respectively). See Figure 3-4 in "Resistance Measurements Connections" for a typical connection diagram.

Installation/Checkout

This section shows how to check the accessory identity, how to verify the field wiring connections, and how to read the state of the channels for an HP 44706A multiplexer.

NOTE

The example programs in this manual use "709" as the HP-IB address for the HP 3852A. Specific slot and channel numbers are also used. Program syntax and data return formats apply to HP Series 200/300 Controllers. Modify slot and channel numbers as required.

Check Accessory ID

After you have connected field wiring from your application to the terminal module, replace the terminal module cover and install the accessory in the desired mainframe or extender slot. Refer to the HP 3852A Mainframe Configuration and Programming Manual to connect the terminal module to the component module and to install the accessory.

When the accessory is installed, use the ID? command to check the accessory ID. At power-on, an HP 44706A returns 44706A. An HP 44706A component module only (no terminal module attached) returns 447XXX. (Note that if the terminal module is removed after power-on, the accessory still returns 44706A.)

For example, the following program determines the identity of an accessory in slot 2 of the mainframe. An HP 44706A multiplexer in this slot returns 44706A.

```
10 OUTPUT 709;"ID? 200"        !Query ID in mainframe slot 4
20 ENTER 709;A$                !Enter ID
30 PRINT A$                    !Display ID
40 END
```

If the multiplexer does not return 44706A be sure you have addressed the correct slot and the terminal module is installed. If these are correct but the correct ID code is not returned, refer to the HP 3852A Assembly Level Service Manual for service procedures.

Verify Wiring Connections

To verify that your field wiring has been properly connected to the terminal module, send the MONMEAS (Monitor/Measure) command from the HP 3852A front panel keyboard or from a controller. This command can be used to check DC or AC voltage and 2-wire ohms connections. An example follows.

This program segment uses the MONMEAS command to verify DC voltage connections on channels 200 through 204 of an HP 44706A multiplexer in slot 2 of the mainframe. The CONF command configures the voltmeter in slot 0 of the mainframe for DC voltage measurements.

The 5 channels are to be scanned and measured one at a time starting with channel 200. Press the SADV KEY key on the HP 3852A front panel to advance the scanning to the next channel. When the scan is advanced past the last channel (channel 204 in this example), scanning will stop and the last measurement will remain on the display.

```
10 OUTPUT 709;"USE 0"                  !Use voltmeter in mainframe slot 0
20 OUTPUT 709;"CONF DCV"               !Set DC volts function on voltmeter
30 OUTPUT 709;"MONMEAS DCV,200-204"    !Monitor/measure ch 200 through 204
              .                        !(Press SADV KEY to advance ch)
              .
```

Read Channel State

The CLOSE? command can be used to determine the state of the HP 44706A channels. This command returns one of five numbers as shown in Table 3-2 for each channel queried. The number returned indicates if a channel is open or closed and to which bus (Sense, Source, or both) the channel is connected.

NOTE

The CLOSE? command will return 2 or 4 only to indicate the state of channels 0 through 59 (i.e., these values will not be returned for the tree switches).

Table 3-2. Values Returned by CLOSE?

Data Returned	Channel State
0	Channel Open
1	Channel Closed (Valid only for Source Bus tree switch - channel 91)
2	Channel Closed - connected to Sense Bus
4	Channel Closed - connected to Sense Bus and Source Bus

Example: Reading Channel State

This program uses the CLOSE? command to check the state of channels 200 through 204 of an HP 44706A in slot 2 of the mainframe. The RST (reset) command resets the multiplexer to its power-on state with all channels open. The CLOSE command closes channel 203 and the Sense Bus tree switch. The OPEN command opens the channel and disconnects it from the backplane.

```
need 15
10  OUTPUT 709;"RST 200"           !Open all channels
20  INTEGER State(0:4)             !Define controller array
30  OUTPUT 709;"CLOSE 203"         !Close ch 203 and Sense Bus tree sw
40  OUTPUT 709;"CLOSE? 200-204"    !Query state of chs 200 through 204
50  ENTER 709;State(*)             !Enter state
60  PRINT State(*)                 !Display state
70  OUTPUT 709;"OPEN 203"          !Open ch 203 and Sense Bus tree sw
80  END
```

For this example, since channel 203 was the only channel closed, a typical return is:

```
0  0  0  2  0
```

Contents

Chapter 4
Configuring the HP 44708

Chapter 4
Configuring the HP 44708

Configuration Overview

This chapter shows how to configure the HP 44708 multiplexer accessories. It contains a block diagram description of the accessories, information on hardware configuring the terminal modules, and information on connecting field wiring to the terminal modules.

When you have configured the accessory for your application, refer to Chapter 5 - Programming the Multiplexers to program the accessories for voltage, current, resistance, and thermocouple measurements.

Warnings and Cautions

This section contains WARNINGS and CAUTIONS applicable to the HP 44708 multiplexers. You should review the WARNINGS and CAUTIONS shown before configuring the accessories.

WARNING

⚠1 *SHOCK HAZARD. Only qualified, service-trained personnel who are aware of the hazards involved should install, remove, or configure any accessory. Before touching any installed accessory, turn off all power to the mainframe, extenders, and to all external devices connected to the mainframe, extenders, or accessories.*

⚠1 *SHOCK HAZARD. All channels that have a common connection (multiplexer or matix), or are configured by the user to have a common connection (general purpose relay switch), must be installed so that the user is protected from electical shock in the event that two or more channels are connected together. This means wiring for all channels must be insulated as though each channel carries the voltage of the highest voltage channel.*

⚠2 *POSSIBLE OPERATOR INJURY. For safety, consider all accessory channels to be at the highest potential applied to any channel. Under most conditions of failure, the relays on the relay multiplexers will remain in whatever state the program sets them. However, for some equipment failures, the relays may not remain in their programmed state. If the relays settle in the closed state, the relay contacts may weld together and the highest voltage present on any one channel may be present on all channels. This condition may cause operator injury if the terminals are touched or equipment damage may result.*

⚠2 *MAXIMUM VOLTAGE LIMITATIONS. The HP 3852A and the HP 3853A internal analog buses interconnect the multiplexer and voltmeter accessories to form one circuit. To protect against possible personal injury due to equipment failure or programming error, limitations are placed on the potentials that can appear between any two points on the circuit (or between the circuit and chassis).*

These limitations are listed for the HP 3852A, HP 3853A, and all plug-in accessories. For any given set of accessories installed in the mainframe or extender, the maximum potential between any two points is determined by the accessory with the LOWEST peak voltage limitation, as follows. (If the analog extender cable is NOT connected between the mainframe and the extenders, each instrument is *considered as a separate circuit.)*

The maximum nondestructive voltage which can be applied to the HP 44708A is 170 V dc or 120 V ac rms (170 V peak). The maximum nondestructive voltage which can be applied tothe HP 44708F is 100 V dc and 70 V ac rms (100 V peak). The maximum nondestructive voltage which can be applied to the HP 44708H is 200 V dc or 250 V ac rms (354 V peak).

Instrument/Accessory	Peak Voltage
HP 3852A Mainframe	350 V
HP 3853A Extender	350 V
HP 44701A Integrating Voltmeter	350 V
HP 44702A/B High-Speed Voltmeter	42 V
HP 44705A/08A/17A/18A 20-Channel Relay Multiplexers	170 V
HP 44705F/08F 20-Channel Solid-State MRelay Multiplexer	100 V
HP 44705H/08H 20-Channel High-Voltage Relay Multiplexers	354 V
HP 44706A 60-Channel Relay Multiplexer	42 V
HP 44709A/10A/11A/12A/13A FET Multiplexers	42 V

CAUTION

POSSIBLE EQUIPMENT DAMAGE. When making high-voltage measurements with the HP 44708, the HP 3852A analog backplane becomes charged to the voltage on the last channel connected to it. Thus, the next channel that is closed may have to absorb all of the stored energy on the backplane.

If the backplane is not discharged after making a high-voltage measurement, the voltage present on the backplane must be added to the voltage being switched on the next channel to determine the total relay contact voltage.

CAUTION

STATIC SENSITIVE. Use clean-handling techniques when handling the accessory. Do not install an accessory without the metal covers attached.

The HP 44708F solid-state switches exhibit much greater switching life than electromechanical relays, but they are more static sensitive. Avoid exposing the terminals to electrostatic discharge during operation as well as during handling and installation.

Block Diagram Description

The HP 44708 accessories consist of a 20-channel terminal module and a component module as shown in Figure 4-1. Field wiring from application sensors (such as thermocouples) is connected to the terminal module and the input signal is sent to the Bank A switches or Bank B switches located on the component module.

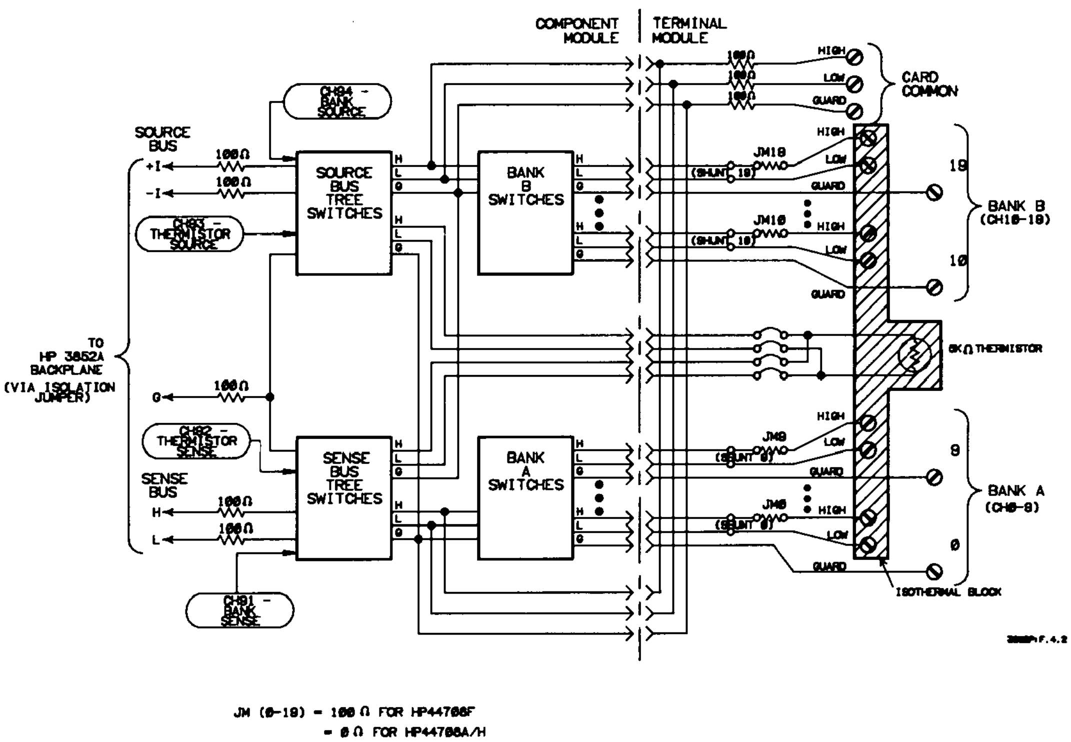


Figure 4-1. HP 44708 Block Diagram

A special isothermal connector block on the terminal module provides the reference junction for thermocouple measurements. A thermistor mounted on the isothermal connector block is used to measure the isothermal block reference temperature. The HP 3852A uses software compensation to automatically compensate for the reference temperature when making thermocouple measurements.

Component Module

The component module consists of 24 switches which are divided into two categories: bank switches and tree switches. Each of the 24 switches consists of three relays (solid-state in the HP 44708F and reed-actuated in the HP 44708A and HP 44708H), on each for HIGH, LOW, and GUARD lines. There are 20 bank switches divided into two groups of 10 channels each: Bank A and Bank B. The channels in Bank A are numbered 0 through 9 and the channels in Bank B are numbered 10 through 19.

NOTE

Only one channel per bank can be closed at a time. Closing a second channel in a bank will open any previously closed channel in that bank.

The component module contains four tree switches which are of two types: Source Bus tree switches and Sense Bus tree switches. The 20 bank switches share a Source Bus tree switch and a Sense Bus tree switch. The other Source Bus and Sense Bus tree switches are used to measure the reference temperature when making thermocouple measurements.

The tree switches control signal flow to and from the HP 3852A backplane and also isolate the bank switches from the backplane when they are not in use. The Sense Bus tree switches provide connections to the backplane for making voltage measurements. The Source Bus tree switches provide backplane connections to the HP 44701A or HP 44702A/B voltmeter current source connections (+I and -I) for making resistance measurements.

NOTE

Two tree switches of the same type cannot be closed simultaneously (e.g., only one of the two Sense Bus tree switches can be closed at a time). Closing a second tree switch will open any previously closed tree switch of the same type.

For the HP 44708A and HP 44708H, five resistors on the component module connect the tree switches to the HP 3852A backplane which provide current limiting protection for the relays on the component module. The resistors do not affect resistance measurements (2-wire ohms error due to contact and trace resistance is <2 Ω) for the HP 44708A/H and <1300 Ω for the HP 44708F). resistors can be shorted out, but this will seriously shorten relay life if high voltages or currents are switched.

For the HP 44708F, a 100 Ω resistor is placed in series in each common bus lead (Hi,Lo, and Guard) and in each Hi of the channel input. In addition, since the HP 44708 uses solid-state relays, the intrinsic On resistance of several hundred ohms adds to the uncertainty in total offset resistance. Therefore, the HP 44708F is not recommended for measuring resistances. However, the 2-wire ohms function can still be useful for checking channel continuity between Hi and Lo. The component module also includes an Isolation Jumper which allows you to disconnect the tree switches from the HP 3852A backplane for special signal routing applications. Refer to "Setting the Isolation Jumper" for information on setting the Isolation Jumper.

Terminal Module

The terminal module contains 20 channels of terminal connectors for field wiring, a CARD COMMON terminal, and an isothermal block with a 5 kΩ thermistor. Note that the HIGH and LOW terminals for each channel are mounted on the isothermal block, but the GUARD terminals are not. The 5 kΩ thermistor is used to measure the isothermal block temperature to arrive at the reference temperature.

The bank switch terminals are connected together on the terminal module to form the CARD COMMON terminal. As factory configured, there is a current limiting resistor in series with the CARD COMMON HIGH, LOW, and GUARD terminals.

Channel Definitions

Table 4-1 shows the channel definitions for the HP 44708 accessories. Channels 0 through 19 control the bank switches, channels 91 and 94 control the tree switches for the measurement channels, and channels 92 and 93 control the tree switches for thermistor measurements on the isothermal block. Because of this configuration, the HP 44708 cannot be used for 4-wire ohms measurements.

If you use high-level commands (such as CONFMEAS or MEAS) to close channels, the high-level command automatically closes the proper channels and switches for the measurement selected. However, if you use low-level commands such as CLOSE and OPEN for measurements, you will need to specify the switches which are to be closed.

For example, to make voltage measurements on channel 0, you will need to close the Sense Bus tree switch (channel 91) and the measurement channel (channel 0). Or, to make voltage measurements on channel 19, close the Sense Bus tree switch (channel 91) and the measurement channel (channel 19).

To make resistance measurements, you will need to close both the Sense Bus and Source Bus tree switches and the measurement channel. For example, to make resistance measurements on channel 0, close the Sense Bus tree switch (channel 91), the Source Bus tree switch (channel 94), and the measurement channel (channel 0).

To measure the reference temperature (by measuring the thermistor on the isothermal block), close the Sense Bus tree switch (channel 92) and the Source Bus tree switch (channel 93).

Table 4-1. HP 44708 Channel Definitions

Channel	Definitions
0 - 9	Bank A Switches
10 - 19	Bank B Switches
91	Sense Bus Tree Switch (Bank sense)
92	Sense Bus Tree Switch (thermistor sense)
93	Source Bus Tree Switch (thermistor source)
94	Source Bus Tree (Bank source)

Setting the Isolation Jumper

The tree switches on the HP 44708 multiplexers can be connected or disconnected from the HP 3852A backplane using the Isolation Jumper. Figure 4-2 shows the location of the Isolation Jumper (J1) on the component module.

The jumper has an EN (enable) and DIS (disable) position. For normal operation, the jumper should be in the EN position to connect the tree switches to the backplane. For special applications which require tree switch isolation from the backplane, move the jumper to the DIS position. Factory setting is the EN position.

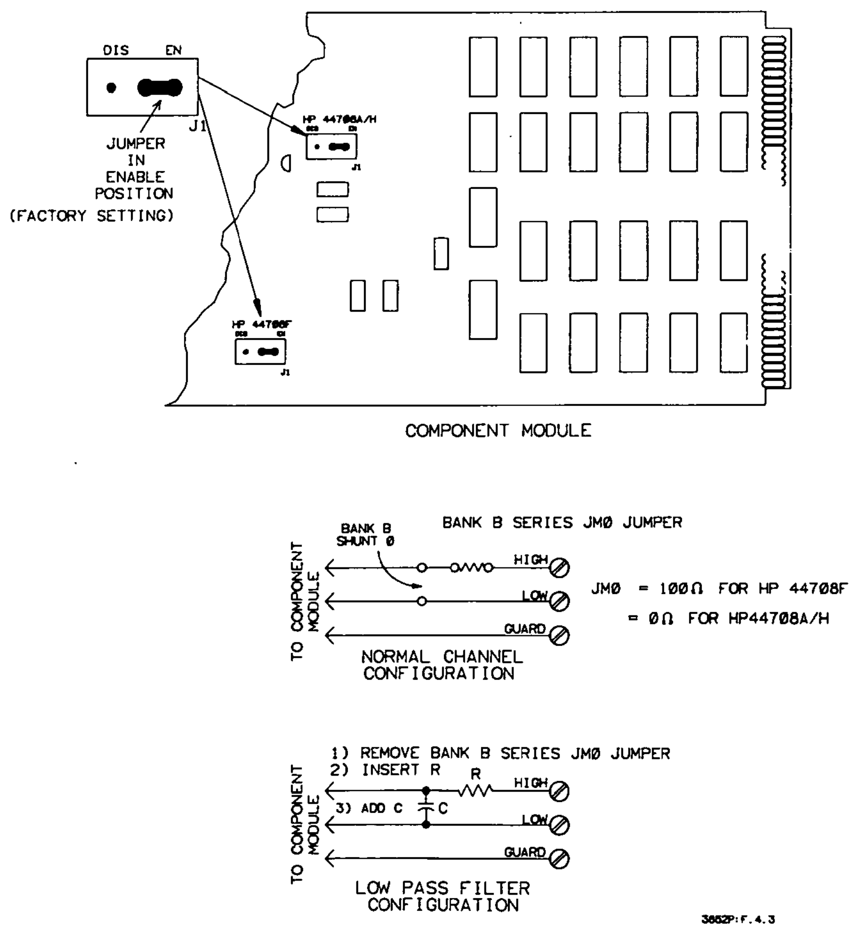


Figure 4-2. HP 44708 Isolation Jumper Configuration

Terminal Module Configuration

This section shows how to hardware configure the HP 44708 terminal modules. It shows how to configure the terminal modules for low-pass filtering and signal attenuation, and how to install resistors on the terminal module to configure the multiplexers for current sensing applications.

Low-Pass Filters

Space is provided on the terminal module for you to install low-pass filters for input signal conditioning on each channel. Figure 4-3 shows the normal channel configuration and shows how to install a low-pass filter for channel 10 on the terminal module.

To install the low-pass filter, remove the jumper Bank B SERIES JM0 jumper (the HP 44708F is loaded with 100 Ω in this position) and install your resistor in its place. Then, install your capacitor in the Bank B SHUNT 0 position as shown.

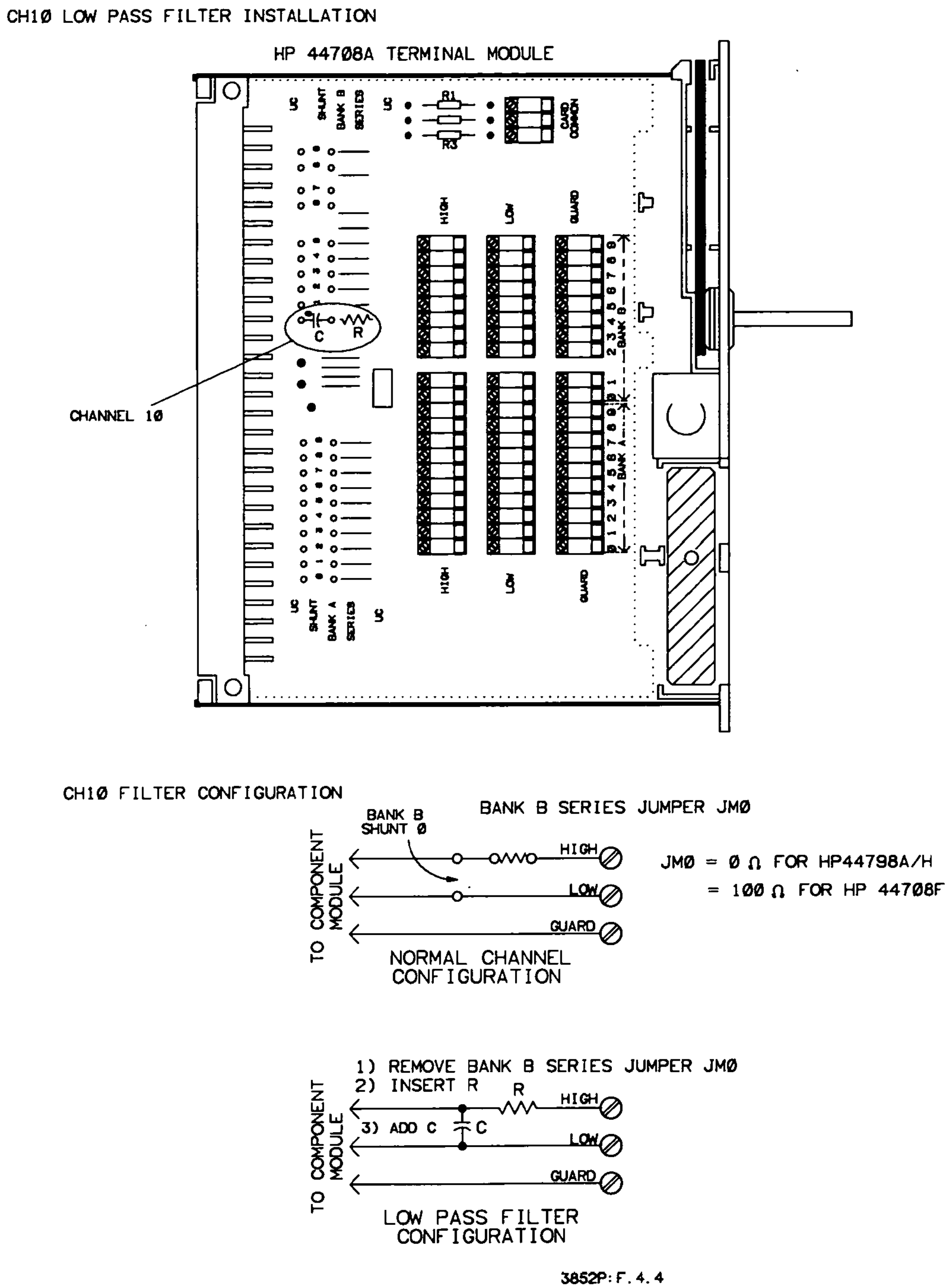


Figure 4-3. HP 44708 Low-Pass Filter Channel Configuration

Attenuators

The space for low-pass filters on the terminal module can also be used to install attenuators to reduce input signals to a usable level for the HP 44708. Figure 4-4 shows normal channel configuration and shows how to install an attenuator for channel 0 on the terminal module. To install the attenuator, remove the Bank A SERIES JM0 jumper (the HP 44708F has a 10 Ω resistor in this position) and install resistor R1 in its place. Then, install resistor R2 in the Bank A SHUNT 0 position as shown. Precision components should be used to maintain accuracy.

NOTE

The power dissipated in the attenuator will upset the isothermal characteristics of the terminal module and introduce errors in measurements. Low-pass filtering, the primary purpose of the series and shunt elements, neither dissipates power nor introduces these errors.

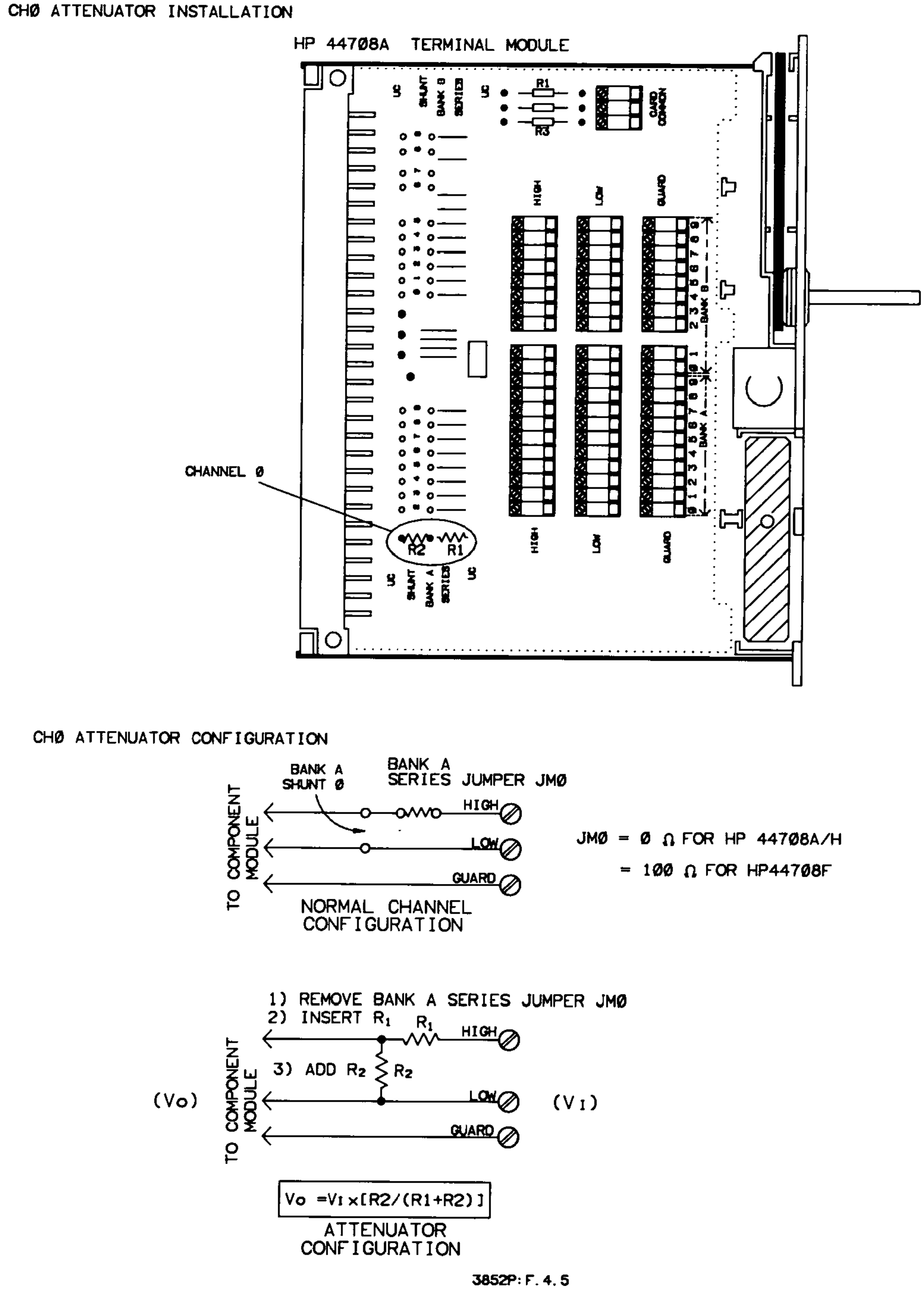


Figure 4-4. HP 44708 Attenuator Channel Configuration

Current Sensing

The HP 44708 multiplexers use current sensing to make current measurements. When making a current sensing measurement, the voltage across a shunt resistor is measured and the current is calculated using the measured voltage and the resistance value of the shunt. Precision resistors should be used to maintain accuracy.

Figure 4-5 shows normal channel configuration and shows how to configure channel 0 for current sensing measurements. In Figure 4-5, a 250 Ω shunt resistor (R0) is installed in the shunt position (Bank A SHUNT 0) for channel 0 on the terminal module. Note that the Bank A SERIES JM0 jumper (the HP 44708F has 100 Ω resistor in this position) MUST be in place on the terminal module for each channel being used for current measurements.

NOTE

Current sensing measurements are not recommended when making temperature measurements on the same terminal module. The heat produced by the shunt resistor may affect the accuracy of the temperature measurements.

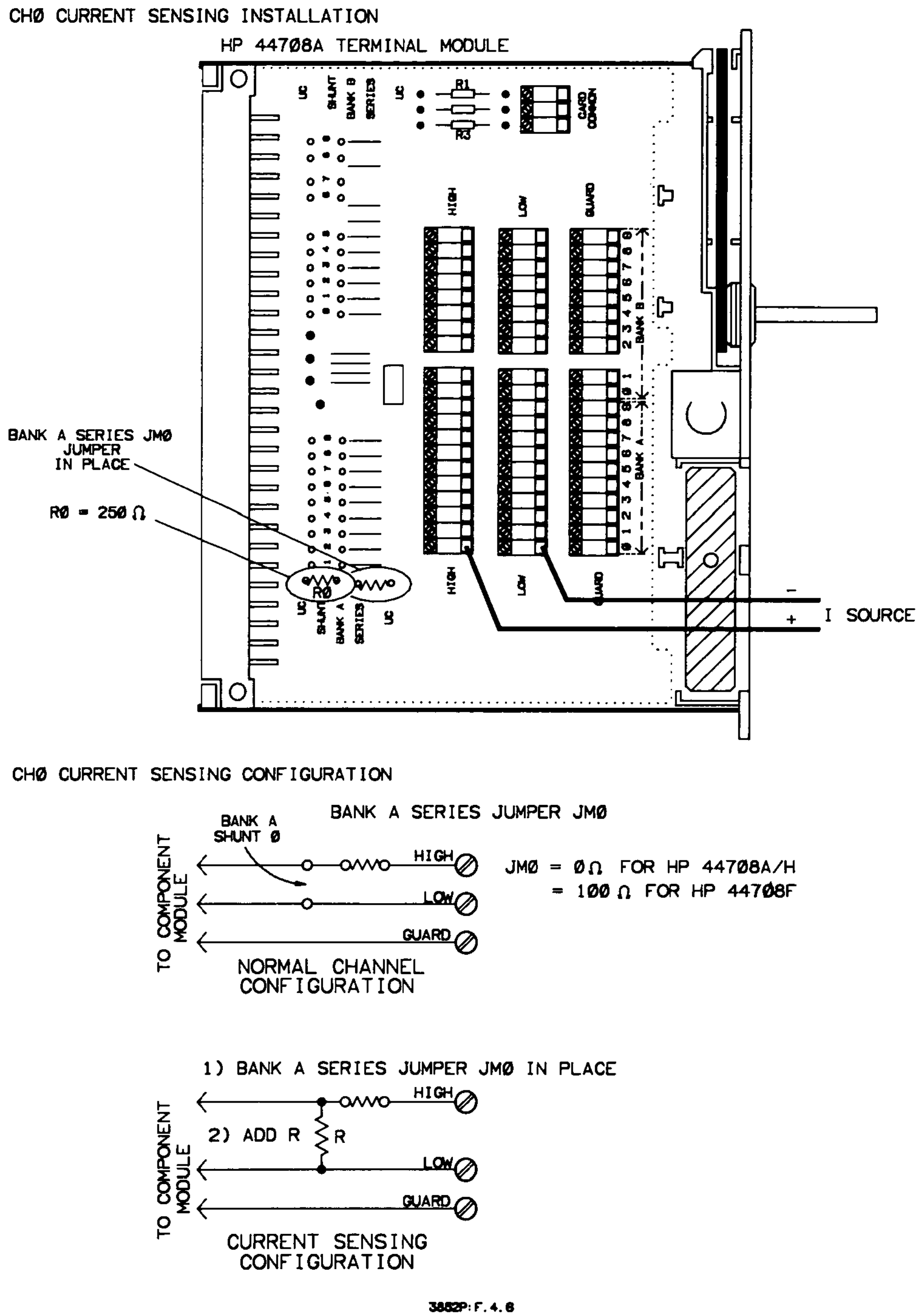


Figure 4-5. HP 44708 Current Sensing Configuration

Field Wiring Connections

When the terminal module is configured as required, the next step is to connect field wiring from your application to the terminals on the terminal module. This section contains example field wiring connections to the terminal module for voltage, resistance (2-wire ohms), and thermocouple measurements.

NOTE

For measurements using the HP 44702A/B High-Speed Voltmeter shielded, twisted-pair cable is required for connections to the terminal module. Shielded, twisted-pair cable suitable for connections to the HP 44708 multiplexer can be ordered from your nearest Hewlett-Packard Sales and Support Office. Order HP part number 03498-61602 which is a 2 metre shielded, twisted-pair cable with crimped and heat-shrunk wires attached to the braided shield at both ends.

Terminal Module Connections

Figure 4-6 shows the HP 44708 terminal module with the cover removed. Each of the 20 channels has a HIGH, LOW, and GUARD terminal. Terminals 0 through 9 in Bank A are for channels 0 through 9, respectively. Terminals 0 through 9 in Bank B are for channels 10 through 19, respectively.

When connecting field wiring to the terminal module, route the wires under the strain relief clamp and tighten the clamp screw to reduce the chance of wires being pulled out of the terminal connectors. If the clamp screw is loosened far enough, the strain relief clamp can be rotated to make it easier to route the wiring.

When connecting components such as resistors, the lead length may be too short to route through the strain relief clamp. In this case, the components will have to be stored inside the terminal module. When connecting these components, make sure that no leads are shorted together and bend the leads to allow the terminal module cover to be replaced.

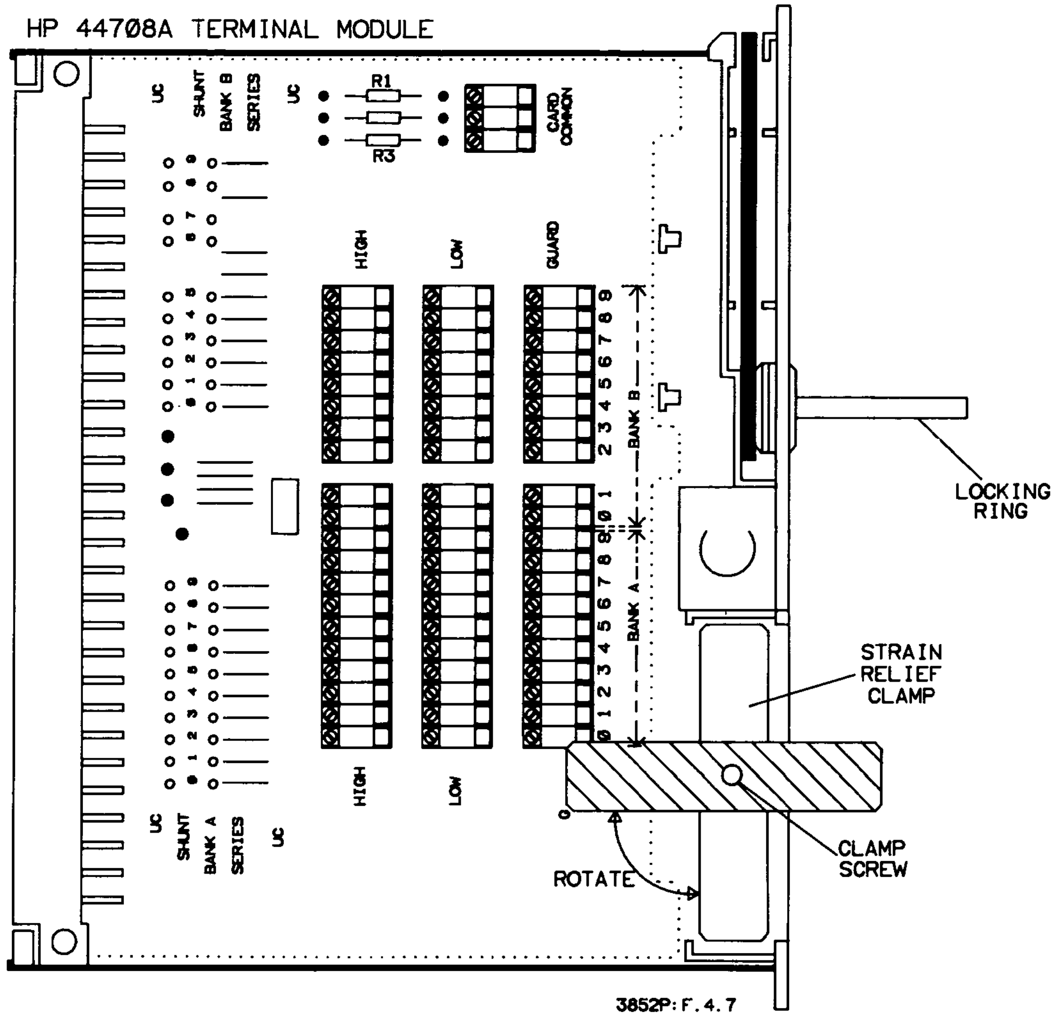


Figure 4-6. HP 44708 Terminal Module

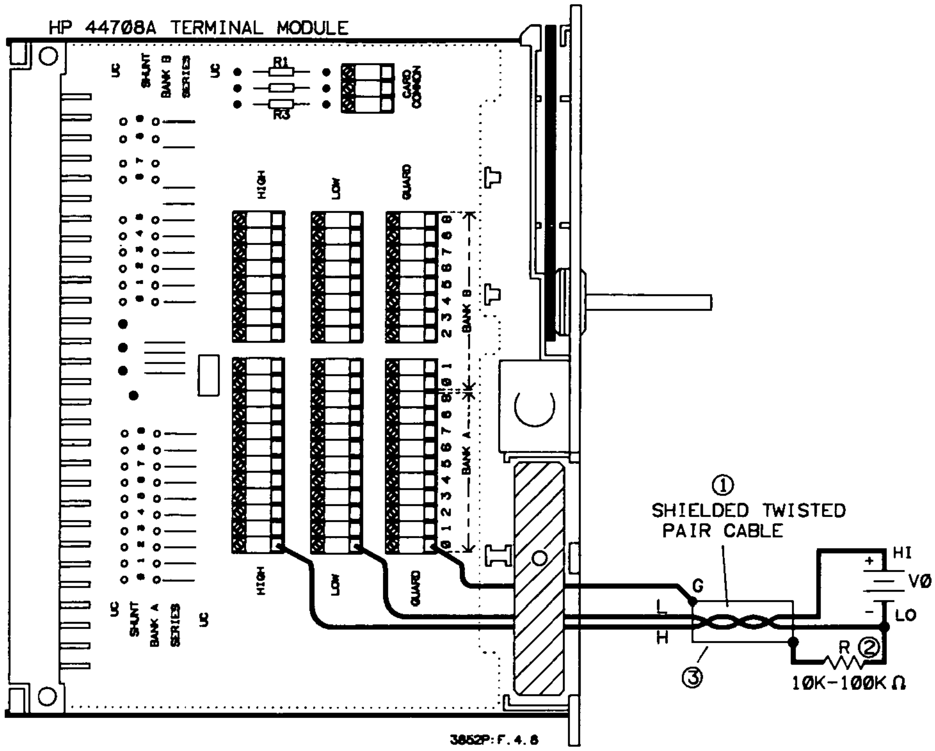
Voltage Measurements Connections

The HP 44708 multiplexer can switch signals for up to 20 guarded (3-wire) DC or AC voltage measurements (DC voltage measurements only for the HP 44702A/B High-Speed Voltmeter). With guarded voltage measurements, HIGH, LOW, and GUARD lines are switched on each selected channel for maximum common mode noise rejection.

Figure 4-7 shows typical voltage measurement connections to channel 0 on the terminal module. Connect the HI (+) lead from the voltage source to channel 0 HIGH terminal and the LO (-) lead from the voltage source to the channel 0 LOW terminal. If a guarded (3-wire) voltage measurement is being made, connect the shield from the shielded twisted-pair cable to the channel 0 GUARD terminal.

Since the shielded, twisted-pair cable reduces measurement noise. Shielded cable is required for measurements with the HP 44702A/B voltmeter and is recommended for measurements with the HP 44701A voltmeter. Also, for the HP 44702A/B voltmeter, an external resistor (R) should be connected between the source voltage LO and the shield, as shown in Figure 4-7. Select R so that the combination of signal voltage + common mode voltage (CMV) is $\leq \pm$ 10.24V.

VOLTAGE MEASUREMENTS



Notes:

[1] = Shielded cable and external resistor R are required for measurements with the HP 44702A/B High-Speed Voltmeter. Shielded cable is highly recommended for measurements with the HP 44701A Integrating Voltmeter.

[2] = For measurements with the HP 44702A/B High-Speed Voltmeter, use R = 10 kΩ to 100 kΩ. For measurements with the HP 44701A Integrating Voltmeter, make a direct connection from V0 LO to the shield (e.g., R = 0).

[3] = For the HP 44701A Integrating Voltmeter ONLY, if shielded cable is not used connect a lead from V0 HI (+) to channel 0 HIGH, a lead from V0 LO (−) to channel 0 LOW, and a lead from V0 LO to channel O GUARD.

Figure 4-7. HP 44708 Voltage Connections

Resistance Measurements Connections

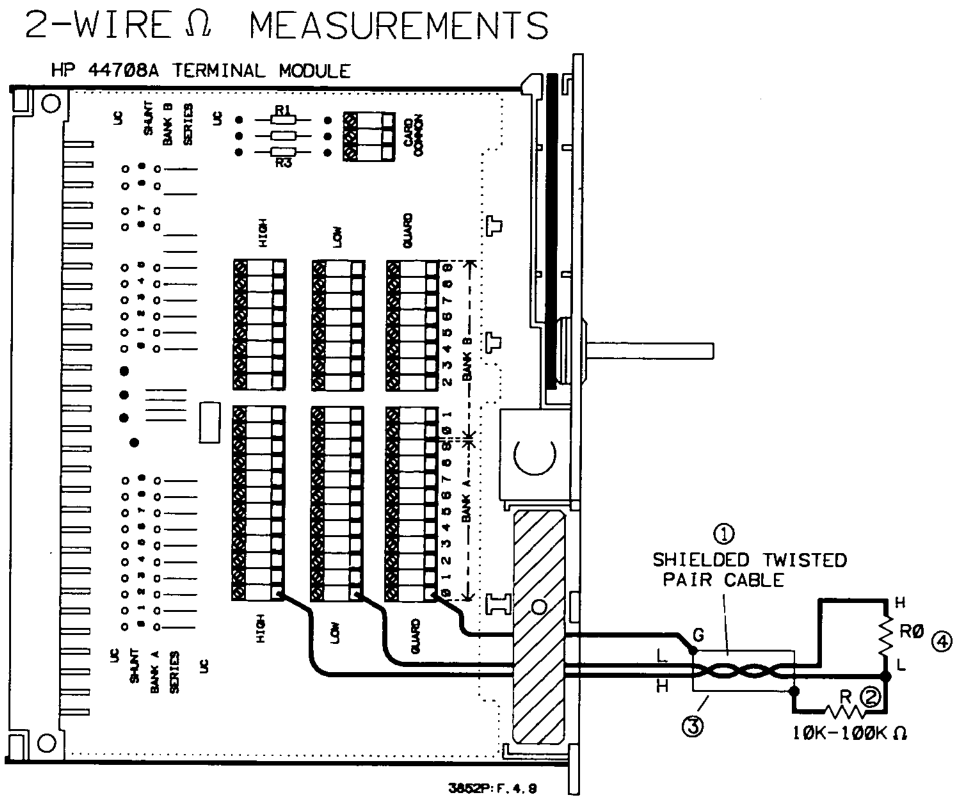
The HP 44708 can also be used to switch signals for resistance measurements using 2-wire ohms measurement techniques. The HP 44708F Solid-State Relay Multiplexer has several hundred ohms series resistance in each lead; therefore, it should be used as continuity tester and not for resistance measurements. (Note that these multiplexers cannot be used for 4-wire ohms measurements.)

In applications where the resistance of the test leads is not critical, the 2-wire ohms function can be used. Generally, the larger the resistance being measured, the less you have to be concerned about test lead resistances. Use the 2-wire ohms function to switch signals for up to 20 resistance measurements per HP 44708 accessory.

Figure 4-8 shows typical 2-wire ohms measurement connections for a resistor (R0) connected to channel 0 on the terminal module with shielded, twisted-pair cable. (Shielded cable is required for inputs to the HP 44702A/B voltmeter and is highly recommended for inputs to the HP 44701A voltmeter.) In Figure 4-8, note that one end of the shield lead is connected to the LO side of the resistor and the other end of the shield lead is connected to the channel 0 GUARD terminal.

For measurements with the HP 44702A High-Speed Voltmeter, select an external resistor R so that the combination of common mode voltage + signal voltage is $\leq \pm 10.24$V. For measurements with the HP 44701A Integrating Voltmeter, make a direct connection from R0 LO to the shield (e.g., R = 0).

For measurements with the HP 44701A Integrating Voltmeter ONLY, if shielded cable is not used, connect one lead of the resistor to channel 0 HIGH terminal and the other lead of the resistor to channel 0 LOW terminal. If high common mode noise rejection is required, also connect a separate lead from the resistor LO to the channel 0 GUARD terminal.



Notes:

[1] = Shielded cable and external resistor R are required for measurements with the HP 44702A/B High-Speed Voltmeter. Shielded cable is highly recommended fro measurements with the HP 44701A Integrating Voltmeter.

[2] = For measurements with the HP 44702A/B High-Speed Voltmeter, use R = 10 kΩ to 100 kΩ. For measurements with the HP 44701A Integrating Voltmeter, make a direct connection from R0 LO to the shield (e.g., R = 0).

[3] = For the HP 44701A Integrating Voltmeter ONLY, if shielded cable is not used connect a lead from R0 HI to channel 0 HIGH, a lead from R0 LO to channel 0 LOW, and a lead from R0 LO to channel 0 GUARD.

Figure 4-8. HP 44708 2-Wire Ohms Connections

Temperature Measurements Connections

One of the functions of the HP 44708 multiplexer is to switch signals for temperature measurements. This section shows how to connect thermistors and thermocouples to the terminal modules for temperature measurements.

Thermistor Connections

Thermistors are capable of detecting small changes in temperature and are used in applications where the temperature extremes are not too high. Thermistors are highly dependent upon variables such as thermistor composition and size. Most thermistors have negative temperature coefficients which means that their resistance values decrease with increasing temperature.

Since only 2-wire ohms measurements can be made with the HP 44708, up to 20 thermistor measurements can be made per accessory. The HP 3852A resistance-to-temperature conversions support Type 2252, 5K, and 10K thermistors (resistance values at 25 °C of 2252Ω, 5 kΩ, and 10 kΩ, respectively). See Figure 4-8 in "Resistance Measurements Connections" for a typical connection diagram.

Thermocouple Measurements Connections

A primary function of the HP 44708 is to make temperature measurements using thermocouples. Thermocouples provide a simple, durable, inexpensive, and relatively accurate temperature sensor for a wide variety of applications and environmental conditions. The thermocouple is a junction of two dissimilar metals that produces a voltage related to the junction temperature. Up to 20 thermocouple measurements can be made per HP 44708 accessory.

Since the channels on the HP 44708 can be independently configured and software compensation is used, any mixture of thermocouple types can be measured using the multiplexers. Although any thermocouple can be used with the HP 44708, the HP 3852A temperature conversions support only B, E, J, K, N14, N28, R, S, and T type thermocouples. Before connecting thermocouples to the terminal module, refer to Table 4-2 for connection guidelines.

Table 4-2. Thermocouple Connection Guidelines

1. Use the largest thermocouple wire possible that will not shunt significant heat away from the thermocouple area.
2. Use thermocouple wire that is well within its rating.
3. Avoid mechanical stress and vibration that could strain the wires.
4. For long runs, use a shielded, twisted-pair thermocouple extension cable and connect the shield to the GUARD terminal on the terminal module.
5. Avoid steep temperature gradients.
6. In hostile environments, use proper sheathing material to reduce adverse effects on thermocouple wires.

See Figure 4-9 for example thermocouple (TC0) connections to channel 0 on the terminal module. Connect the negative metal lead (red lead) to the LOW terminal on channel 0 and connect the positive metal lead to the HIGH terminal on channel 0. If high common mode noise rejection is required, connect the shield lead from the thermocouple to the GUARD terminal on channel 0. Figure 4-9 also shows three alternate thermocouple wiring configurations.

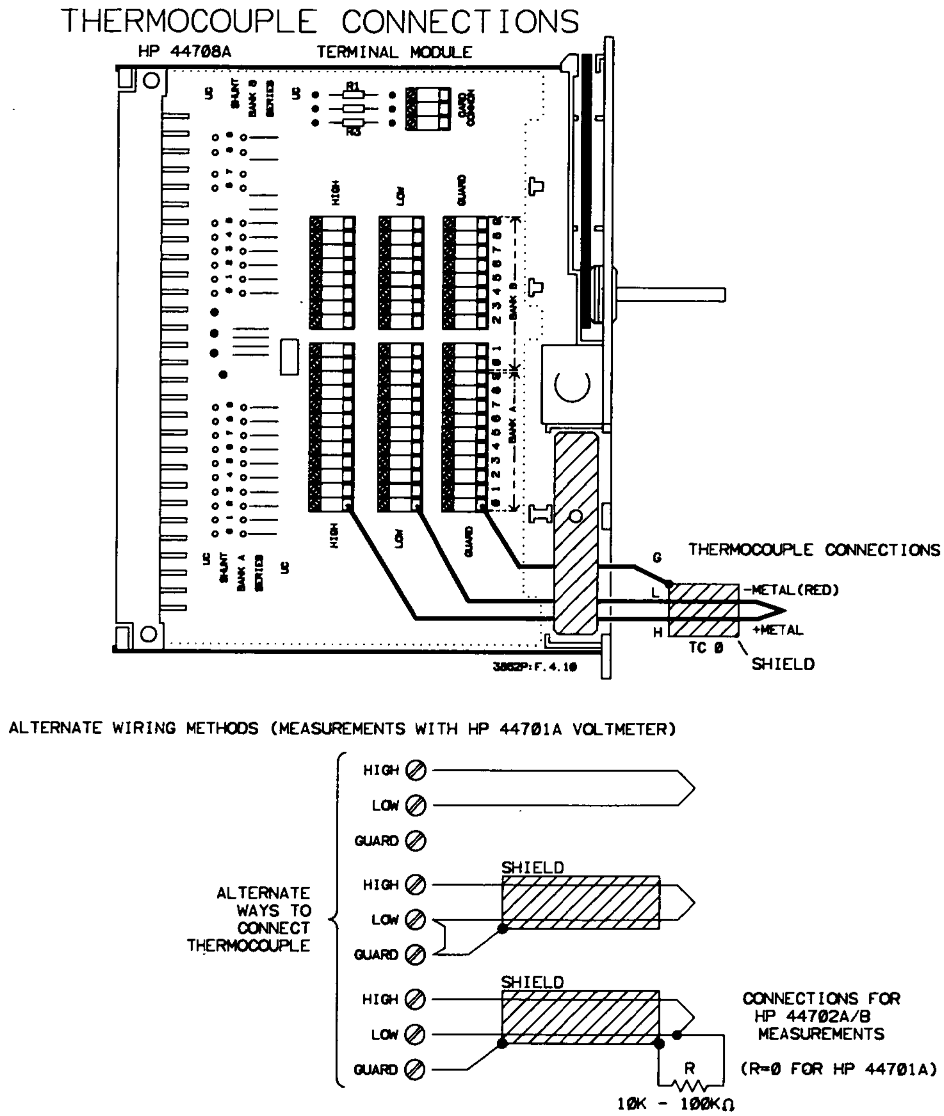


Figure 4-9. HP 44708 Thermocouple Connections

Installation/Checkout

This section shows how to check the accessory identity, how to verify the field wiring connections, and how to read the state of the channels for the HP 44708.

NOTE

The example programs in this manual use "709" as the HP-IB address for the HP 3852A. Specific slot and channel numbers are also used. Program syntax and data return formats apply to HP Series 200/300 Controllers. Modify slot and channel numbers as required.

Check Accessory ID

After you have connected field wiring from your application to the terminal module, replace the terminal module cover and install the accessory in the desired mainframe or extender slot. Refer to the HP 3852A Mainframe Configuration and Programming Manual to connect the terminal module to the component module and to install the accessory.

When the accessory is installed, use the ID? command to check the accessory ID. At power-on, an HP 44708 returns 44708A, while a component module only (no terminal module attached) returns 447XXX. (Note that if the terminal module is removed after power-on, the accessory still returns 44708A.)

For example, the following program determines the identity of an accessory in slot 2 of the mainframe. An HP 44708 multiplexer in this slot returns 44708A.

```
10 OUTPUT 709;"ID? 200"        !Query ID in mainframe slot 4
20 ENTER 709;A$                !Enter ID
30 PRINT A$                    !Display ID
40 END
```

If the multiplexer does not return 44708A, be sure you have addressed the correct slot and the terminal module is installed. If these are correct but the correct ID code is not returned, refer to the HP 3852A Assembly Level Service Manual for service procedures.

Verify Wiring Connections

To verify that your field wiring has been properly connected to the terminal module, send the MONMEAS (Monitor/Measure) command from the HP 3852A front panel keyboard or from a controller. This command can be used to check DC or AC voltage and 2-wire ohms connections. An example follows.

This program segment uses the MONMEAS command to verify DC voltage connections on channels 200 through 219 of an HP 44708 multiplexer in slot 2 of the mainframe. The CONF command configures a voltmeter for DC voltage measurements. The voltmeter is installed in slot 0 of the mainframe.

The 20 channels are to be scanned and measured one at a time starting with channel 200. Press the SADV KEY key on the HP 3852A front panel to advance the scanning to the next channel. When the scan is advanced past the last channel (channel 219 in this example), scanning will stop and the last measurement will remain on the display.

```
10 OUTPUT 709;"USE 0"                      !Use voltmeter in mainframe slot 0
20 OUTPUT 709;"CONF DCV"                   !Set DC volts function on voltmeter
30 OUTPUT 709;"MONMEAS DCV,200-219"        !Monitor/measure ch 200 through 219
             .                             !(Press SADV KEY to advance ch)
             .
```

Read Channel State

The CLOSE? command can be used to determine the state of the multiplexer channels. This command returns one of five numbers as shown in Table 4-3 for each channel queried. The numbers returned indicate if a channel is open or closed and to which bus (Sense, Source, or both) channel is connected.

NOTE

The CLOSE? command will return 2, 3, or 4 only to indicate the state of channels 0 through 19 (i.e., these values will not be returned for the tree switches).

Table 4-3. Values Returned by CLOSE?

Data Returned	Channel State
0	Channel Open
1	Channel Closed - not connected to Bus
2	Channel Closed - connected to Sense Bus
3	Channel Closed - connected to Source Bus
4	Channel Closed - connected to Both Buses

Example: Reading Channel State

This program uses the CLOSE? command to check the state of channels 200 through 204 of an HP 44708 in slot 2 of the mainframe. The RST (reset) command resets the multiplexer to its power-on state with all channels open. The CLOSE command closes channel 203 and the Sense Bus tree switch (channel 291). The OPEN command opens the channel and disconnects it from the backplane.

```
10  OUTPUT 709;"RST 200"           !Open all chs and isolation relays
20  INTEGER State(0:4)             !Define controller array
30  OUTPUT 709;"CLOSE 203,291"     !Close ch 203, Sense Bus tree switch
40  OUTPUT 709;"CLOSE? 200-204"    !Query state of chs 200 through 204
50  ENTER 709;State(*)             !Enter state
60  PRINT State(*)                 !Display state
70  OUTPUT 709;"OPEN 203,291"      !Open ch 203, Sense Bus tree switch.
80  END
```

For this example, since channel 203 was the only channel closed and was connected to the Sense Bus tree switch, a typical return is:

```
0   0   0   2   0
```

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Chapter 5

Programming the Multiplexers

Programming Overview

As noted, the five multiplexers described in this manual have four primary measurement functions: voltage, current, resistance, and temperature. This chapter shows how to program the multiplexers for each measurement function.

Chapter Contents

This chapter includes a description of each measurement function, applicable commands for the function, and programming examples. Each example includes a sample program and typical data returns for assumed conditions.

The chapter also summarizes the programming commands used with the multiplexers (refer to "Command Summary") and lists the titles of the example programs (refer to "Program Titles").

The example programs show how to make typical measurements using the multiplexers with the HP 44701A Integrating Voltmeter or with the HP 44702A/B High-Speed Voltmeter when System Mode multiplexer measurements are used. Refer to the HP 3852A Mainframe Configuration and Programming Manual for information on making measurements using an external voltmeter. Refer to the HP 44701A or HP 44702A/B configuration and programming manual for details on programming the voltmeter.

NOTE

The example programs in this manual use "709" as the HP-IB address for the HP 3852A. Specific slot and channel numbers are also used. Program syntax and data return formats apply to HP Series 200/300 Controllers. Modify slot and channel numbers as required.

Command Summary

Table 5-1 is an alphabetical listing of commands which apply to the multiplexer accessories. Refer to the HP 3852A Command Reference Manual for a complete description of these commands.

Table 5-1. Multiplexer Commands

CLOSE *ch_list*

Closes a single multiplexer channel or a list of channels specified by *ch_list*. This command is intended for individual switch control in special signal-routing applications. It is not the easiest way to do routine measurements since the tree switches are not automatically configured as with high-level commands.

CLOSE? *ch_list* [INTO *name*] or [*fmt*]

Queries the state of channels specified by *ch_list*.

CONF *function* [USE *ch*]

Configure the voltmeter for the function specified by *function*.

CONFMEAS *function ch_list* [USE *ch*] [INTO *name*] or [*fmt*]

Configures the voltmeter accessory and measures a function specified by *function* on the channels specified by *ch_list*. This command automatically configures the voltmeter accessory and the tree switches on the multiplexer specified for the measurement.

ID? [*slot*]

Reads the identity of the accessory in the slot specified by *slot*.

MEAS *function ch_list* [USE *ch*] [INTO *name*] or [*fmt*]

Scans and measures a function specified by *function* on the channels specified by *ch_list*. This command does not fully configure the voltmeter, but does configure the tree switches on the multiplexer for the measurement.

MONMEAS *function ch_list* [USE *ch*]

Monitors and measures a function specified by *function* on the channels specified by *ch_list*. This command is useful to check wiring connections to the terminal module.

OPEN *ch_list*

Opens a single multiplexer channel or a list of channels specified by *ch_list*. This command is used to open channels and place them in a safe state after the measurements have been made.

RST [*slot*]

Resets the accessory in the slot specified by *slot* to its power-on state.

Program Titles

Table 5-2 lists the titles of the example programs in this chapter. Note that all examples do not apply to all multiplexers, but show only typical or recommended measurements for the multiplexers (refer to Table 1-1).

Table 5-2. Example Program Titles

Title	Description	Multiplexer(s)
	Voltage Measurements	
Guarded Voltage Measurements	Measure the output from 20 voltage sources.	HP 44705A, HP 44705F, HP 44705H
Single-Ended Voltage Measurements	Measure the output from 60 voltage sources.	HP 44706A
Guarded Voltage Measurements Using CLOSE	Measure the output from a voltage source. Use CLOSE and OPEN to control tree and bank switches.	HP 44705A, HP 44705F, HP 44705H
	Current Measurements	
AC/DC Current Measurements	Make a current sensing measurement using a shunt resistor installed on the terminal module.	HP 44705A, HP 44705F, HP 44705H
	Resistance Measurements	
Resistance Measurements (2-Wire Ohms)	Measure 20 resistances using 2-wire ohms measurements.	HP 44705A, HP 44705F, HP 44705H, HP 44706A
Resistance Measurements (2-Wire Ohms) Using CLOSE	Measure a single resistance using 2-wire ohms measurements. Use CLOSE and OPEN to control tree and bank switches.	HP 44705A, HP 44705F, HP 44705H
Resistance Measurements (4-Wire Ohms)	Measure single resistance using 4-wire ohms measurements.	HP 44705A, HP 44705F, HP 44705H

Table 5-2. Example Program Titles (continued)

Title	Description	Multiplexer(s)
	Temperature Measurements	
RTD Measurements	Measure temperature using an RTD and 4-wire ohms measurements.	HP 44705A, HP 44705F, HP 44705H
Thermistor Measurements	Measure temperature using a thermistor and 4-wire ohms measurements.	HP 44705A, HP 44705F, HP 44705H
Thermocouple Measurements	Make 20 temperature measurements using J-type thermocouples.	HP 44708A, HP 44708F, HP 44708H
Isothermal Block Reference Temperature	Measure the isothermal block (reference) temperature.	HP 44708A, HP 44708F, HP 44708H

Voltage Measurements

One of the functions of the multiplexer accessories is to switch signals for voltage measurements. This section shows how to program the HP 44705 to make guarded (3-wire) and DC and AC voltage measurements using the CONFMEAS and the OPEN, CLOSE commands. It also shows how to use CONFMEAS to make single-ended voltage measurements with the HP 44706A.

Three example programs follow to illustrate DC voltage measurements. The first example uses an HP 44705 multiplexer and the CONFMEAS command. The second example uses an HP 44706A multiplexer and the CONFMEAS command. The third example uses an HP 44705 multiplexer and the OPEN and CLOSE commands.

NOTE

The AC voltage function is considerably slower than the DC voltage function. It takes approximately two seconds for the HP 44701A Integrating Voltmeter to configure for AC voltage measurements and approximately 1.5 seconds per reading. Note that the HP 44702A/B High-Speed Voltmeter cannot be used to make AC voltage measurements.

Example: Guarded Voltage Measurements

This example uses the CONFMEAS command to measure the outputs from 20 voltage sources connected to an HP 44705 multiplexer. See Figure 2-7 to connect voltage sources to the HP 44705A/F/H terminal module.

This program measures 20 DC voltage sources connected to channels 200 through 219 of the multiplexer installed in slot 2 of the mainframe using a voltmeter installed in slot 0 of the mainframe. The CONFMEAS command configures the voltmeter accessory for DC voltage measurements and measures the 20 channels once.

NOTE

To use the program to make AC voltage measurements with the HP 44701A Integrating Voltmeter Accessory, substitute the following line for the existing line 30:

```
30 OUTPUT 709;"CONFMEAS ACV,200-219"
```

```
10 DIM Volts(0:19)                    !Define controller array
20 OUTPUT 709;"USE 0"                 !Use voltmeter in mainframe slot 0
30 OUTPUT 709;"CONFMEAS DCV,200-219"  !Set DC volts, meas ch 200-219
40 ENTER 709;Volts(*)                 !Enter 20 readings
50 PRINT USING "K,/";Volts(*)         !Display 20 readings
60 END
```

For a set of 5V 5% inputs, a typical return is:

```
4.993
4.9935
   .     20 readings
   .
4.9947
```

Example: Single-Ended Voltage Measurements

This example uses the CONFMEAS command to measure the outputs from 60 single-ended voltage sources connected to an HP 44706A multiplexer. See Figure 3-3 to connect voltage sources to the HP 44706A terminal module.

This program uses the CONFMEAS command to measure 60 DC voltage sources connected to channels 200 through 259 of the multiplexer installed in slot 2 of the mainframe using a voltmeter installed in slot 0 of the mainframe. The CONFMEAS command configures the voltmeter accessory for DC voltage measurements and measures the 60 channels once.

NOTE

To use the program to make AC voltage measurements with the HP 44701A Integrating Voltmeter Accessory, substitute the following line for the existing line 30:

```
30 OUTPUT 709;"CONFMEAS ACV,200-259"
```

```
10 DIM Volts(0:59)                          !Dimension controller array
20 OUTPUT 709;"USE 0"                       !Use voltmeter in mainframe slot 0
30 OUTPUT 709;"CONFMEAS DCV,200-259"        !Set DC volts, meas ch 200-259
40 ENTER 709;Volts(*)                       !Enter 60 readings
50 PRINT USING "K,/";Volts(*)               !Display 60 readings
60 END
```

For a set of 5V 5% inputs, a typical return is:

```
4.93
4.995
  .       60 readings
  .
4.974
```

Example: Guarded Voltage Measurements Using CLOSE

This example uses the CLOSE command to measure the output from a voltage source connected to channel 200 of an HP 44705 in slot 2 of the mainframe. See Figure 2-7 to connect voltage sources to the HP 44705 terminal module.

CAUTION

The CLOSE command does not close channels in a break-before-make fashion. Therefore, the command can and will cause damage to the multiplexer accessory (relay or FET) and external system if it is used to force one channel open by closing another. This applies to channels in the same bank, in separate banks tied together by the tree relays, and to the tree relays themselves.

Before a channel is closed with the CLOSE command, use the OPEN command to open the channel that is currently closed. This prevents any two channels from being closed at the same time and reduces the risk of damaging your equipment.

NOTE

The CLOSE command is a low-level command intended for individual switch control in special signal-routing applications. It is not the easiest way to do routine measurements since the tree switches and the isolation relays are not automatically configured as with the high-level commands.

In the following program, CLOSE closes the measurement channel (channel 200) and the Bank A Sense Bus tree switch (channel 291) for the multiplexer, CONF configures the voltmeter for DC voltage measurements, TRIG triggers the voltmeter to take a single measurement, and CHREAD sends the reading from the voltmeter to the output buffer. OPEN opens the channel and disconnects it from the backplane after the measurement has been taken.

NOTE

To use the following program to make an AC voltage measurement with the HP 44701A Integrating Voltmeter, substitute the following line for the existing line 30:

```
30 OUTPUT 709;"CONF ACV"
```

```
10 OUTPUT 709;"USE 0"             !Use voltmeter in mainframe slot 0
20 OUTPUT 709;"CLOSE 200,291"     !Close ch 200, Sense Bus tree switch
30 OUTPUT 709;"CONF DCV"          !Set DC volts
40 OUTPUT 709;"TRIG SGL"          !Trigger voltmeter
50 OUTPUT 709;"CHREAD 0"          !Transfer reading to output buffer
60 ENTER 709;A                    !Enter reading
70 PRINT A                        !Display reading
80 OUTPUT 709;"OPEN 200,291"      !Open ch 200, Sense Bus tree switch
90 END
```

A typical return from a 5 volt 5% input is:

```
4.987
```

Current Measurements

The HP 44705 and HP 44708 multiplexers use current sensing to make current measurements. When making a current sensing measurement, the voltage across the shunt resistor is measured and the current is calculated using the measured voltage and the resistance of the shunt. This section shows how to program the HP 44705 to make DC and AC current measurements.

NOTE

Current sensing measurements are not recommended when making temperature measurements on the same HP 44708 terminal module since the heat produced by the shunt resistor may affect the accuracy of the temperature measurements.

NOTE

The AC voltage function (used for AC current sensing) is considerably slower than the DC voltage function. It takes approximately two seconds for the HP 44701A Integrating Voltmeter to configure for AC voltage measurements and approximately 1.5 seconds per reading. Note that the HP 44702A/B High-Speed Voltmeter cannot be used to make AC current measurements.

An example follows to show how to make DC current measurements on channel

200 of an HP 44705 in slot 2 of the mainframe when a 250 Ω shunt resistor is installed on the channel.

Example: AC/DC Current Measurements

The following program uses the CONFMEAS command to measure DC voltage across a 250Ω shunt resistor installed on channel 200 of an HP 44705 in slot 2 of the mainframe. The CONFMEAS command configures the voltmeter for DC voltage measurements and measures the channel once. The equivalent DC current value is computed in the controller by using Current = Volts/250 (see line 40). See Figure 2-5 to install a shunt resistor on the HP 44705 terminal module for current measurements.

NOTE

To use the following program to make AC current measurements with the HP 44701A Integrating Voltmeter, substitute the following line for the existing line 20:

```
20 OUTPUT 709;"CONFMEAS ACV,200"
```

```
10 OUTPUT 709;"USE 0"                !Use voltmeter in mainframe slot 0
20 OUTPUT 709;"CONFMEAS DCV,200"     !Set DC volts, measure ch 200
30 ENTER 709;Volts                   !Enter DC voltage value
40 PRINT Volts/250                   !Display DC current value = Volts/250
50 END
```

If a a 250 Ω 5% resistor is used, a typical return from a 4-20 mA current loop which is outputting 10 mA (value in Amps) is:

```
.01004
```

Resistance Measurements

This section shows how to make 2-wire ohms resistance measurements using the CONFMEAS and OPEN, CLOSE commands and shows how to make 4-wire ohms resistance measurements using the CONFMEAS command with the HP 44705 multiplexer. (Recall that the HP 44706A and HP 44708 cannot be used for 4-wire ohms measurements.)

2-Wire Ohms Measurements

This section shows how to program the HP 44705 for 2-wire ohms resistance measurements. For applications where the resistance of the test leads is not critical, the 2-wire ohms function can be used. Generally, the larger the resistance being measured, the less you have to be concerned about test lead resistances. Use the 2-wire ohms function to make up to 20 resistance measurements per HP 44705 accessory.

Example: Resistance Measurements (2-Wire Ohms)

This example uses the CONFMEAS command to measure 20 resistors connected to an HP 44705 in slot 3 of the mainframe using the 2-wire ohms function. See

Figure 2-8 to connect resistors to the terminal module.

The following program uses the CONFMEAS command to measure 20 resistors connected to Channels 300 through 319 of an HP 44705 multiplexer in slot 3 of the mainframe. The CONFMEAS command configures the voltmeter accessory for 2-wire ohms measurements and measures each of the 20 channels once.

```
10 DIM Ohms(0:19)                        !Dimension controller array
20 OUTPUT 709;"USE 0"                    !Use voltmeter in mainframe slot 0
30 OUTPUT 709;"CONFMEAS OHM,300-319"     !Set 2-wire ohms, meas ch 300-319
40 ENTER 709;Ohms(*)                     !Enter 20 readings
50 PRINT USING "K,/";Ohms(*)             !Display 20 readings
60 END
```

For a set of 5 kΩ 5% resistors, a typical return (values in Ohms) is:

```
4928.34
5024.9
    .       20 readings
    .
5008.38
```

Example: Resistance Measurements (2-Wire Ohms) Using CLOSE

This example uses the CLOSE command to make a 2-wire ohms measurement of a resistor connected to channel 300 of an HP 44705 multiplexer in slot 3 of the mainframe using the 2-wire ohms function. See Figure 2-8 to connect resistors to the terminal module.

CAUTION

The CLOSE command does not close channels in a break-before-make fashion. Therefore, the command can and will cause damage to the multiplexer accessory (relay or FET) and external system if it is used to force one channel open by closing another. This applies to channels in the same bank, in separate banks tied together by the tree relays, and to the tree relays themselves.

Before a channel is closed with the CLOSE command, use the OPEN command to open the channel that is currently closed. This prevents any two channels from being closed at the same time and reduces the risk of damaging your equipment.

NOTE

The CLOSE command is a low-level command intended for individual switch control in special signal-routing applications. It is not the easiest way to do routine measurements since the tree switches and the isolation relays are not automatically configured as with the high-level commands.

In the program, CLOSE is used to close the measurement channel (channel 300), the Bank A Sense Bus tree switch (channel 391), and the Bank A Source Bus tree switch (channel 393) for an HP 44705. CONF configures the voltmeter accessory for 2-wire ohms measurements, TRIG triggers the voltmeter to take a single measurement, and CHREAD transfers the resistance value from the voltmeter to the output buffer. OPEN is used to open the channel and disconnect it from the backplane after the measurements have been taken.

```
10 OUTPUT 709;"USE 0"                  !Use voltmeter in mainframe slot 0
20 OUTPUT 709;"CLOSE 300,391,393"      !Close ch and tree switches
30 OUTPUT 709;"CONF OHM"               !Configure for 2-wire ohms
40 OUTPUT 709;"TRIG SGL"               !Trigger the voltmeter
50 OUTPUT 709;"CHREAD 0"               !Transfer reading to output buffer
60 ENTER 709;A                         !Enter reading
70 PRINT A                             !Display reading
80 OUTPUT 709;"OPEN 300,391,393"       !Open ch and tree switches
90 END
```

4-Wire Ohms Measurements

Using 4-wire ohms measurements virtually eliminates the error caused by the test lead resistances. The current through the unknown resistance is the same regardless of the lead resistance, but the voltmeter measures only the voltage across the resistance, not across the combined test lead resistance and the unknown resistance.

The 4-wire ohms function is essential when highest accuracy is required. Since each 4-wire ohms measurement requires two channels, up to ten resistance measurements can be made per HP 44705 accessory. (Note that 4-wire ohms measurements cannot be made with the HP 44706A and HP 44708.) An example follows.

Example: Resistance Measurements (4-Wire Ohms)

This example uses the CONFMEAS command to measure the resistance of a resistor connected to channel 300 of an HP 44705 in slot 3 of the mainframe using the 4-wire ohms function. See Figure 2-9 to connect the resistor to the terminal module for 4-wire ohms measurements.

The program uses the CONFMEAS command to measure a resistor using the 4-wire ohms function. Channel 300 is used as the voltage Sense channel and channel 310 as the current Source channel.

Note that the channel specified by the CONFMEAS *ch_list* parameter (channel 300) is designated as the Sense channel. The mainframe then automatically configures the channel one decade away from the Sense channel as the Source channel. The Sense channel is scanned once by the voltmeter and the result (in Ohms) is returned to the controller.

```
10 OUTPUT 709;"USE 0"                    !Use voltmeter in mainframe slot 0
20 OUTPUT 709;"CONFMEAS OHMF,300"        !Config for 4-wire ohms, meas ch 300
30 ENTER 709;A                           !Enter resistance value
40 PRINT A                               !Display resistance value
50 END
```

For a 5 kΩ 5% resistor connected to the channel, a typical return (value in Ohms) is:

```
4982.4
```

Temperature Measurements

One of the primary functions of the multiplexer accessories is to switch signals for temperature measurements. This section shows how to program the HP 44705 for RTD and thermistor measurements and shows how to program the HP 44708A or HP 44708H multiplexers for thermocouple and isothermal block (reference temperature) measurements.

RTD Measurements

The resistance temperature detector (RTD) is a temperature-sensitive resistor that is typically stable, accurate, and linear. The HP 3852A resistance-to-temperature conversions support Type 85 and Type 92 RTDs (temperature coefficients (α) of 0.00385 Ω/Ω°C and 0.003916 Ω/Ω°C, respectively, and resistance values of 100Ω at 0°C).

Most RTDs have small resistance values (typically less than 300 Ω) which makes the test lead resistance a significant factor when making resistance measurements. Thus, the only usable RTD measurement method with the HP 44705 accessory is the 4-wire ohms measurement function. Since each 4-wire ohms measurement requires two channels, a single HP 44705 accessory can be used to make up to ten RTD measurements. An example program follows.

Example: RTD Measurements

This example uses the CONFMEAS command to make a temperature measurement using a Type 92 RTD and the 4-wire function. See Figure 2-9 to connect an RTD to the terminal module for 4-wire temperature measurements.

The following program uses the CONFMEAS command to scan and measure a Type 92 RTD (α = 0.003916 Ω/Ω°C) connected to channel 200 of an HP 44705 in slot 2 of the mainframe using the 4-wire ohms function. Channel 200 is used as the voltage Sense channel and channel 210 as the current Source channel.

Note that the channel specified by the CONFMEAS *ch_list* parameter (channel 200) is designated as the Sense channel. The mainframe then automatically configures the channel one decade away from the Sense channel as the Source channel. The Sense channel is scanned once by the voltmeter and the result (in °C) is returned to the controller.

```
10 OUTPUT 709;"USE 0"                    !Use voltmeter in mainframe slot 0
20 OUTPUT 709;"CONFMEAS RTDF92,200"      !Conf for type 92 RTD, meas ch 200
30 ENTER 709;Temp                        !Enter temperature
40 PRINT Temp                            !Display temperature
50 END
```

A typical return (value in °C) for an RTD at room temperature is:

```
24.54297
```

Thermistor Measurements

Thermistors are capable of detecting small changes in temperature and are used in applications where temperature extremes are not too high. They are highly dependent upon variables such as thermistor composition and size. Most thermistors have negative temperature coefficients which means that their resistance values decrease with increasing temperature.

The HP 3852A allows thermistors to be measured using the 4-wire function. Since each 4-wire measurement requires two channels, up to ten thermistors can be measured per HP 44705 accessory. The HP 3852A resistance-to-temperature conversions support Type 2252, 5K, and 10K thermistors (resistance values at 25°C of 2252Ω, 5 kΩ, and 10 kΩ, respectively). An example program follows.

Example: Thermistor Measurements

This example uses the CONFMEAS command to make a 4-wire temperature measurement using a Type 2252 thermistor connected to channel 200 of an HP 44705 in slot 2 of the mainframe. See Figure 2-9 to connect a thermistor to the terminal module for a 4-wire temperature measurement.

The following program uses CONFMEAS to scan and measure a Type 2252 thermistor using the 4-wire ohms function. Channel 200 is used as the voltage Sense channel and channel 210 as the current Source channel.

Note that the channel specified by the CONFMEAS *ch_list* parameter (channel 200) is designated as the Sense channel. The HP 3852A automatically configures the channel that is one decade away from the Sense channel as the Source channel. The Sense channel is scanned once by the voltmeter and the result (in °C) is returned to the controller.

```
10 OUTPUT 709;"USE 0"                    !Use voltmeter in mainframe slot 0
20 OUTPUT 709;"CONFMEAS THMF2252,200"    !Conf for thermistor, meas ch 200
30 ENTER 709;Temp                        !Enter temperature
40 PRINT Temp                            !Display temperature
50 END
```

For a thermistor at room temperature, a typical return (value in °C) is:

```
24.69674
```

Thermocouple Measurements

Thermocouples provide a simple, durable, inexpensive, and relatively accurate temperature sensor for a wide variety of applications and environmental conditions. The thermocouple is a junction of two dissimilar metals which produces a voltage related to the junction temperature. Up to 20 thermocouple measurements can be made per HP 44708 accessory. The HP 3852A temperature conversions support B, E, J, K, N14, N28, R, S, and T type thermocouples.

The HP 3852A does not directly measure the temperature of thermocouples, but measures the voltages generated by the thermocouples. The measured voltage is a function of the actual temperature of the thermocouples.

The problem with this approach is that the voltage measured by the HP 3852A is different from the actual thermocouple voltage (due to junction voltages on the terminal module) unless some compensating technique is used. The HP 3852A uses a technique called software compensation. In performing software compensated thermocouple measurements, the steps shown in Table 5-3 occur.

Table 5-3. Thermocouple Software Compensation Steps

1. Measure the resistance of the thermistor mounted on the isothermal connector block and compute the isothermal block reference temperature (T_{ref}).
2. Measure the voltage produced by the thermocouple system (V_t).
3. Convert the isothermal block reference temperature (T_{ref}) to a thermocouple reference voltage (V_{ref}). Since the thermocouple reference voltage depends upon the type of thermocouple being compensated, the value returned for V_{ref} will be different for each type of thermocouple. Thus, different thermocouple types can be used on the same accessory.
4. Compute the absolute value of V_t (step 2) - V_{ref} (step 3). That is, $V = |V_t - V_{ref}|$.
5. Convert V computed in step 4 to an equivalent temperature in °C.

NOTE

1. When used with high-level commands (CONFMEAS for example), the HP 3852A automatically performs the compensation steps when making thermocouple measurements. However, when low-level commands such as CLOSE and OPEN are used, the compensation steps are not performed automatically.

2. Since channels on the HP 44708 can be independently configured and software compensation is used, any mixture of thermocouple types can be measured. However, separate commands must be executed for each type of thermocouple.

Example: Thermocouple Measurements

This example uses the CONFMEAS command to make 20 temperature measurements using J-type thermocouples connected to channels 200 through 219 of an HP 44708 in slot 2 of the mainframe. See Figure 4-9 to connect thermocouples to the terminal module for temperature measurements.

The following program uses the CONFMEAS command to measure 20 J-type thermocouples connected to channels 200 through 219 of an HP 44708 in slot 2 of the mainframe. The program scans the 20 channels once and returns the results (in °C) to the controller.

```
10 DIM Temp(0:19)                        !Define controller array
20 OUTPUT 709;"USE 0"                    !Use voltmeter in mainframe slot 0
30 OUTPUT 709;"CONFMEAS TEMPJ,200-219"   !Conf for J-type t-couple, meas ch
40 ENTER 709;Temp(*)                     !Enter 20 temperature readings
50 PRINT USING "K,/";Temp(*)             !Print readings
60 END
```

For thermocouples at room temperature, a typical return (values in °C) is:

```
24.542
24.5415
  .        20 readings
  .
25.856
```

Example: Isothermal Block Reference Temperature

The HP 3852A linearization program supports B, E, J, K, N14, N28, R, S, and T type thermocouples. However, if you want to use a different type of thermocouple for temperature measurements, you will need to measure the reference temperature (isothermal block temperature) to use in your own linearization program. The following example shows how to measure the reference temperature of an HP 44708 in slot 2 of the mainframe.

This example measures the temperature (the reference temperature) of the thermistor mounted on the isothermal connector block using the CONFMEAS command.

```
10 OUTPUT 709;"USE 0"                !Use voltmeter in mainframe slot 0
20 OUTPUT 709;"CONFMEAS REFT,200"    !Meas ref temp in mainframe slot 2
30 ENTER 709;Reftemp                 !Enter ref temp
40 PRINT Reftemp                     !Display ref temp
50 END
```

For an HP 44708 at room temperature, a typical return (value in°C) is:

```
24.438
```

HP 3852A Data Acquisition/Control Unit

High-Speed FET Multiplexer Accessories

HP 44711A/B, HP 44712A, and HP 44713A/B

Configuration and Programming Manual

HEWLETT PACKARD

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The following general safety precautions must be observed during all phases of operation, service, and repair of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended use of the instrument. Hewlett-Packard Company assumes no liability for the customer's failure to comply with these requirements.

GROUND THE INSTRUMENT

To minimize shock hazard, the instrument chassis and cabinet must be connected to an electrical ground.

DO NOT OPERATE IN AN EXPLOSIVE ATMOSPHERE

Do not operate the instrument in the presence of flammable gases or fumes. Operation of any electrical instrument in such an environment constitutes a definite safety hazard.

KEEP AWAY FROM LIVE CIRCUITS

Operating personnel must not remove instrument covers. Component replacement and internal adjustments must be made by qualified maintenance personnel. Under certain conditions, dangerous voltages may exist even with the instrument switched off. To avoid injuries, always disconnect input voltages and discharge circuits before touching them.

DO NOT SERVICE OR ADJUST ALONE

Do not attempt internal service or adjustment unless another person, capable of rendering first aid and resuscitation, is present.

DO NOT SUBSTITUTE PARTS OR MODIFY INSTRUMENT

Because of the danger of introducing additional hazards, do not install substitute parts or perform any unauthorized modification to the instrument. Return the instrument to a Hewlett-Packard Sales and Service Office for service and repair to ensure that safety features are maintained.

DO NOT OPERATE A DAMAGED INSTRUMENT

Whenever it is possible that the safety protection features built into this instrument have been impaired, either through physical damage, excessive moisture, or any other reason, REMOVE POWER and do not use the instrument until safe operation can be verified by service-trained personnel. If necessary, return the instrument to a Hewlett-Packard Sales and Service Office for service and repair to ensure that safety features are maintained.

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Operating and Safety Symbols

Symbols Used On Products And In Manuals

~ LINE — AC line voltage input receptacle.

Instruction manual symbol affixed to product. Cautions the user to refer to respective instruction manual procedures to avoid possible damage to the product.

Indicates dangerous voltage – terminals connected to interior voltage exceeding 1000 volts.

 OR 

Protective conductor terminal. Indicates the field wiring terminal that must be connected to earth ground before operating equipment – protects against electrical shock in case of fault.

Clean ground (low-noise). Indicates terminal that must be connected to earth ground before operating equipment – for single common connections and protection against electrical shock in case of fault.

 OR 

Frame or chassis ground. Indicates equipment chassis ground terminal – normally connects to equipment frame and all metal parts.

Affixed to product containing static sensitive devices – use anti-static handling procedures to prevent electrostatic discharge damage to components.

NOTE

NOTE
Calls attention to a procedure, practice, or condition that requires special attention by the reader.

CAUTION

CAUTION
Calls attention to a procedure, practice, or condition that could possibly cause damage to equipment or permanent loss of data.

WARNING

WARNING
Calls attention to a procedure, practice, or condition that could possibly cause bodily injury or death.

WARNING, CAUTION, and NOTE Symbols

Some labels on the HP 3852A, HP 3853A, and plug-in accessories include an international warning symbol (triangle with subscripted number) which refers the reader to the manuals for further information. This table shows the warning symbols used for the HP 3852A/3853A and plug-in accessories. Refer to the manual set for specific information on WARNINGS, CAUTIONS, or NOTES referenced with a warning symbol.

HP 3852A WARNING, CAUTION, and NOTE Symbols

Symbol	Meaning	Location
⚠ 1	Shock hazard originating outside the instrument (field wiring)	. Analog Extender Connector on Power Supply Modules . Terminal modules on plug-in accessories . Component module covers on plug-in accessories
⚠ 2	Treat all channels as "one circuit" for safety purposes.	. Inside terminal modules on plug-in accessories . Metal cover on component modules of plug-in accessories
⚠ 3	Maximum number of certain plug-in accessories to be installed into an HP 3852A or HP 3853A.	. HP 44701A, HP 44702A/B, HP 44727A/B/C plug-in accessories
⚠ 4	If High-Speed FET multiplexers are used with the HP 44702A/B, ribbon cable may be connected.	. HP 44711A, 44712A, 44713A (referenced on HP 44702A and HP 44702B)

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Introduction

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Introduction

Manual Contents

This manual shows how to configure and program five HP 3852A high-speed FET multiplexer accessories:

- HP 44711A 24-Channel High-Speed FET Multiplexer
- HP 44711B 24-Channel High-Speed FET Multiplexer
- HP 44712A 48-Channel High-Speed Single-Ended FET Multiplexer
- HP 44713A 24-Channel High-Speed FET Multiplexer with Thermocouple Compensation.
- HP 44713B 24-Channel High-Speed FET Multiplexer with Thermocouple Compensation.

The B version of both the HP 44711 and HP 44713 have been developed to provide reduced settling time for use with the HP 44704A High-Speed Voltmeter's high resolution modes. Configuring and programming are the same for A and B versions.

In this manual, each multiplexer is referred to by its product number (HP 44711A/B, HP 44712A, or HP 44713A/B). Refer to the HP 3852A Mainframe Configuration and Programming Manual for additional information on the accessories. The manual has five chapters:

- **Introduction** contains a manual overview, summarizes multiplexer descriptions, lists WARNINGS, CAUTIONS, and NOTES which apply to the multiplexers, and shows suggested steps to get started.

- **Configuring the HP 44711A/B** contains a block diagram description of the HP 44711A/B and shows how to configure and connect field wiring to the terminal module.

- **Configuring the HP 44712A** contains a block diagram description of the HP 44712A and shows how to connect field wiring to the terminal module.

- **Configuring the HP 44713A/B** contains a block diagram description of the HP 44713A/B and shows how to configure and connect field wiring to the terminal module.

- **Programming the Multiplexers** shows how to program the multiplexers for voltage, current, resistance, and temperature measurements.

Multiplexer Descriptions

The high-speed FET multiplexers switch (multiplex) signals from up to 24 two-wire inputs (HP 44711A/B and HP 44713A/B) or up to 48 single-ended inputs (HP 44712A). Measurements are made by the HP 44701A Integrating Voltmeter, the HP 44702A/B or HP 44704A High-Speed Voltmeters, or by external voltmeters.

Modes of Operation

Each high-speed FET multiplexer has two modes of operation: backplane and ribbon cable. With backplane operation, the mainframe controls multiplexer operation. With ribbon cable operation (applicable to the HP 44702A/B and HP 44704A in Scanner Mode only), the HP 44702A/B or 44704A operates independently of the mainframe to control the multiplexers and make measurements.

HP 44711A/B 24-Channel High-Speed FET Multiplexer

The HP 44711A/B consists of a component module and a 24-channel terminal module. User field wiring connects to the terminal module and signals are sent to switches on the component module. Each channel on an HP 44711A/B can be independently configured so multiple functions can be measured on the same accessory.

As noted, the HP 44711A/B has two modes of operation: backplane and ribbon cable. With backplane operation, the multiplexer is controlled by the mainframe with measurements made by an HP 44701A Integrating Voltmeter, by an HP 44702A/B or 44704A High-Speed Voltmeter, or by an external voltmeter. Maximum switching rate for backplane operation is 5500 channels/second (with mainframe ROM revision 2.0 or greater).

With ribbon cable operation, the HP 44711A/B is connected to an HP High-Speed Voltmeter (HP 44702A/B or 44704A) by a dedicated interface bus (ribbon cable). In ribbon cable operation, the HP High-Speed voltmeter operates independently of the mainframe and maximum switching rate is 100,000 channels/second.

HP 44712A 48-Channel High-Speed Single-Ended FET Multiplexer

The HP 44712A uses the same component module as the HP 44711A but uses a 48-channel terminal module. Since only the HIGH terminal is switched, measurements with the HP 44712A are called single-ended measurements. Modes of operation and switching speeds for the HP 44712A are the same as for the HP 44711A.

HP 44713A/B 24-Channel High-Speed FET Multiplexer

The HP 44713A uses the same component module as the HP 44711A. The HP 44713B uses the same component module as the HP 44711B. The HP 44713A/B adds an isothermal block on the terminal module for thermocouple measurement compensation. A thermistor mounted on the isothermal block measures the reference temperature and the mainframe uses "software compensation" to normalize measured temperature to a 0°C reference. Modes of operation for the HP 44713A/B are the same as for the HP 44711A/B. The HP 44713B provides reduced settling time compatible with the HP 44704A High-Speed Voltmeter's high resolution modes.

Primary Applications

Table 1-1 shows recommended measurements and primary applications for the HP 44711A/B, HP 44712A, and HP 44713A/B.

Table 1-1. Primary Applications

Multiplexer	Recommended Measurements		Primary Applications
HP 44711A/B	- AC/DC Voltage		- Differential measurements
	- AC/DC Current	[1]	- Up to 24 inputs
	- 4-Wire Ohms	[2]	- Up to 100,000 channels/sec
	- RTDs	[3]	- Max input 10.24V peak.
	- Thermistors	[4]	
HP 44712A	- AC/DC Voltage		- Single-ended measurements
			- Up to 48 inputs
			- Up to 100,000 channels/sec
			- Max input 10.24V peak.
HP 44713A/B	- AC/DC Voltage		- Thermocouple measurements
	- AC/DC Current	[1]	- Up to 24 inputs
	- 2-Wire Ohms	[5]	- Up to 100,000 channels/sec
	- Thermocouple	[6]	- Max input 10.24V peak.

Notes:

[1] = Requires installation of resistor on terminal module.

[2] = 2-wire ohms measurements are NOT recommended for the HP 44711A/B, 44712A, and 44713A/B due to high ON resistance (about 3.2 kΩ).

[3] = 4-wire ohms measurement method recommended. HP 3852A supports Type 85 (α = 0.00385 Ω/Ω/°C and Type 92 (α = 0.003916 Ω/Ω/°C) RTDs.

[4] = 4-wire ohms measurement method recommended. HP 3852A supports Type 2252 (2252 Ω), 5K (5000 Ω), and 10K (10,000 Ω) thermistors.

[5] = 2-wire ohms measurements intended for open thermocouple detection only.

[6] = HP 3852A conversion program applicable only to B, E, J, K, N14 (AWG 14), N28 (AWG 28), R, S, and T types. Other thermocouples can be measured with user-supplied temperature conversion programs.

Measurement Guidelines

Guidelines to make voltage, current, resistance, or temperature measurements with the HP 44711A/B, HP 44712A, or HP 44713A/B follow.

Voltage Measurements

The HP 44711A/B, HP 44712A, and HP 44713A/B can be used for AC or DC voltage measurements. However, the HP 44711A/B and HP 44713A/B have differential capability while the HP 44712A has only single-ended measurement capability.

For higher accuracy voltage measurements, use the HP 44711A/B or HP 44713A/B to measure up to 24 channels per multiplexer. For measurements which do not require highest accuracy, use the HP 44712A to measure up to 48 channels per multiplexer.

Current Measurements

The HP 44711A/B and HP 44713A/B use current sensing to make current measurements. When making a current sensing measurement, the voltage across a user-supplied shunt resistor is measured and the current is calculated (in the controller) using the measured voltage and the shunt resistance value.

NOTE

Current sensing measurements are not recommended when making temperature measurements on the same HP 44713A/B terminal module since the heat produced by the shunt resistor may affect the accuracy of the temperature measurements.

Resistance Measurements

The HP 44711A/B can be used for 2-wire ohms and 4-wire ohms measurements. The HP 44712A and HP 44713A/B can be used for 2-wire ohms measurements only.

- 2-Wire Ohms Measurements:

You CAN use 2-wire ohms to make up to 24 resistance measurements per HP 44711A/B or HP 44713A/B or up to 48 resistance measurements per HP 44712A. However, since each FET has up to 1.6 kΩ of ON resistance (3.2 kΩ total/channel), 2-wire ohms measurements are NOT recommended.

• 4-Wire Ohms Measurements:

Using 4-wire ohms measurements virtually eliminates the error caused by the field wiring resistances. The current through the unknown resistance is the same regardless of the wiring resistance, but the voltmeter measures only the voltage across the unknown resistance, not across the combined field wiring resistance and the unknown resistance.

The 4-wire ohms function is essential when highest accuracy is required. Since each 4-wire ohms measurement requires two channels, up to 12 resistance measurements can be made per HP 44711A/B accessory.

Temperature Measurements

The HP 44711A/B can be used to make 4-wire ohms temperature measurements of resistance temperature detectors (RTDs) and thermistors. The HP 44713A/B can be used to measure thermocouple temperatures. Although the HP 44712A and HP 44713A/B CAN be used for 2-wire ohms temperature measurements, this is not recommended due to high ON resistance of the FETs (about 3 kΩ) which causes errors in 2-wire ohms measurements.

• RTD Measurements:

The resistance temperature detector (RTD) is a temperature sensitive resistor that is typically stable, accurate, and linear. The HP 3852A resistance-to-temperature conversions support Type 85 and Type 92 RTDs (temperature coefficients (α) of 0.00385 Ω/Ω/°C and 0.003916 Ω/Ω/°C, respectively, and resistance values of 100 Ω at 0°C).

Most RTDs have small resistance values (typically less than 300 Ω) which makes RTDs unusable with 2-wire ohms measurements. Thus, the most accurate RTD measurement method is the 4-wire ohms measurement function. Since each 4-wire ohms measurement requires two channels, a single HP 44711A/B can be used to make up to 12 RTD measurements.

• Thermistor Measurements:

Thermistors are capable of detecting small changes in temperature and are used in applications where temperature extremes are not too high. Most thermistors have negative temperature coefficients so their resistance value decreases with increasing temperature.

The HP 3852A allows thermistors to be measured using 4-wire ohms. Since each 4-wire ohms measurement requires two channels, up to 12 thermistors can be measured per HP 44711A/B. The HP 3852A resistance-to-temperature conversions support Type 2252, 5K, and 10K thermistors (resistance values at 25°C of 2252 Ω, 5 kΩ, and 10 kΩ, respectively).

- Thermocouple Measurements:

Thermocouples provide simple, durable, inexpensive, and relatively accurate temperature sensors for a wide variety of applications and environmental conditions. The thermocouple is a junction of two dissimilar metals which produces a voltage related to the junction temperature.

The HP 44713A/B is primarily used for thermocouple measurements. Up to 24 thermocouple measurements can be made per HP 44713A/B multiplexer. The HP 3852A temperature conversions support B, E, J, K, N14, N28, R, S, and T type thermocouples.

Since channels on the HP 44713A/B can be independently configured and software compensation is used, any mixture of thermocouple types can be measured. However, separate commands must be executed for each type of thermocouple.

The HP 3852A does not directly measure the temperature of thermocouples, but measures the voltages generated by the thermocouples. The measured voltage is a function of the actual temperature of the thermocouples.

The problem with this is that the voltage measured by the HP 3852A is different from the actual thermocouple voltage (due to junction voltages on the terminal module) unless some compensating technique is used. The HP 3852A uses a technique called software compensation. Refer to Table 1-2 for the steps used for software compensated thermocouple measurements.

Table 1-2. Thermocouple Software Compensation Steps

1. Measure the resistance of the thermistor mounted on the isothermal connector block and compute the isothermal block reference temperature (T_{ref}).
2. Measure the voltage produced by the thermocouple system (V_t).
3. Convert the isothermal block reference temperature (T_{ref}) to a thermocouple reference voltage (V_{ref}). Since the thermocouple reference voltage depends upon the type of thermocouple being compensated, the value returned for V_{ref} will be different for each type of thermocouple.
4. Compute the absolute value of V_t (step 2) - Vref (step 3). That is, $V = \lvert V_t - V_{ref} \rvert$
5. Convert V computed in step 4 to an equivalent temperature in °C.

Warnings, Cautions, and Notes

This section summarizes WARNINGS, CAUTIONS, and NOTES which apply to the HP 44711A/B, HP 44712A, and HP 44713A/B. You should review the WARNINGS and CAUTIONS before handling or configuring any multiplexer.

WARNING

SHOCK HAZARD. Only qualified, service-trained personnel who are aware of the hazards involved should install, remove, or configure any accessory. Before touching any installed accessory, turn off all power to the mainframe, extenders, and to all external devices connected to the mainframe, extenders, or accessories.

WARNING

POSSIBLE OPERATOR INJURY. For safety, consider all accessory channels to be at the highest potential applied to any channel. Under most conditions of failure, the relays on the relay multiplexers will remain in the position programmed before the failure.

However, for some equipment failures, the relays may not remain in their programmed state. If the relays settle in the closed state, the relay contacts may weld together and the highest voltage present on any one channel may be present on all channels. This condition may cause operator injury if the terminals are touched, or further equipment damage may result.

WARNING

MAXIMUM VOLTAGE LIMITATIONS. The HP 3852A and the HP 3853A internal analog buses interconnect the multiplexer and voltmeter accessories to form one circuit. To protect against possible personal injury due to equipment failure or programming error, limitations are placed on the potentials that can appear between any two points in the circuit (or between the circuit and chassis).

These limitations are listed for the HP 3852A, HP 3853A, and all plug-in accessories. For any given set of accessories installed in the mainframe or extender, the maximum potential between any two points is determined by the accessory with the LOWEST peak voltage limitations, as follows. (If the analog extender cable in NOT connected between the mainframe and the extenders, each instrument is considered as a separate circuit.)

Instrument/Accessory	Peak Voltage
HP 3852A Mainframe	354 V
HP 3853A	354 V
HP 44701A Integrating Voltmeter	354 V
HP 44702A/B or HP 44704A High-Speed Voltmeter	42 V
HP 44705A/08A/17A/18A 20-Channel Relay Multiplexers	170 V
HP 44705H/08H 20-Channel High-Voltage Relay Multiplexers	354 V
HP 44706A 60-Channel Relay Multiplexer	42 V
HP 44709A/10A/11A/12A/13A FET Multiplexers	42 V

NOTE

SHIELDED CABLE REQUIRED. For measurements with the HP 44702A/B or HP 44704A High-Speed Voltmeter, shielded twisted-pair cable is required for connections to the HP 44711A/B, 44712A, or 44713A/B terminal module. shielded twisted-pair cable is highly recommended for measurements with the HP 44701A Integrating Voltmeter.

You can order the appropriate cable from your nearest Hewlett-Packard Sales and Support Office. Order HP part number 03498-61602 which is a 2 meter cable with crimped and heat-shrunk wires attached to the braided shield at both ends.

NOTE

HP-IB ADDRESS. The example programs in this manual use "709" as the HP-IB address for the HP 3852A. Specific slot and channel numbers are also used. Program syntax and data return formats apply to the HP Series 200/300 controllers. Modify slot and channel numbers and program syntax as required.

Getting Started

To use an HP 44711A/B, HP 44712A, or HP 44713A/B for your application, you will need to do three things:

- Define your application.
- Configure the multiplexer.
- Program the multiplexer.

Define Your Application

The first step is to define your application and select the multiplexer for the requirements of your application. When selecting devices to be connected, refer to the Specifications appendix in the HP 3852A Mainframe Configuration and Programming Manual to ensure that the voltage and current requirements of your application are within multiplexer specifications.

Configure the Multiplexer

The next step is to configure the multiplexer for your application. If you use the HP 44711A/B, refer to Chapter 2 - Configuring the HP 44711A/B for terminal module configuration and field wiring connections.

If you use the HP 44712A, refer to Chapter 3 - Configuring the HP 44712A to connect field wiring to the terminal module. If you use the HP 44713A/B, refer to Chapter 4 - Configuring the HP 44713A/B for terminal module configuration and field wiring connections.

Program the Multiplexer

When the multiplexer has been configured, the third step is to program the accessory for your application. Refer to Chapter 5 - Programming the Multiplexers to program the multiplexer for voltage, current, resistance, or temperature measurements, as applicable.

Chapter 2
Configuring the HP 44711A/B

Contents

Configuring the HP 44711A/B

Chapter Contents

This chapter shows how to configure the HP 44711A and HP 44711B multiplexers. The HP 44711B provides reduced settling time for use with the HP 44704A High-Speed Voltmeter's high resolution modes. Otherwise, the A and B versions of the HP 44711 are identical. The chapter contains a block diagram description of the HP 44711A/B, shows how to hardware configure the terminal module, and shows how to connect field wiring to the terminal module.

When you have configured the HP 44711A/B for your application, refer to Chapter 5 - Programming the Multiplexers to program the HP 44711A/B for voltage, current, resistance, or temperature measurements.

Block Diagram Description

The HP 44711A/B consists of a 24-channel terminal module and a component module as shown in Figure 2-1. Field wiring from your application sensors connects to the terminal module and the signals are sent to switches on the component module.

Component Module

The component module consists of 28 switches divided into two categories: bank switches and tree switches. Each switch consists of two Field Effect Transistors (FETs), one each for HIGH and LOW lines. There are 24 bank switches divided into two groups of 12 channels each: Bank A (channels 0 through 11) and Bank B (channels 12 through 23).

NOTE

Only one channel per bank can be closed at a time. Closing a second channel in a bank will open any previously closed channel in that bank.

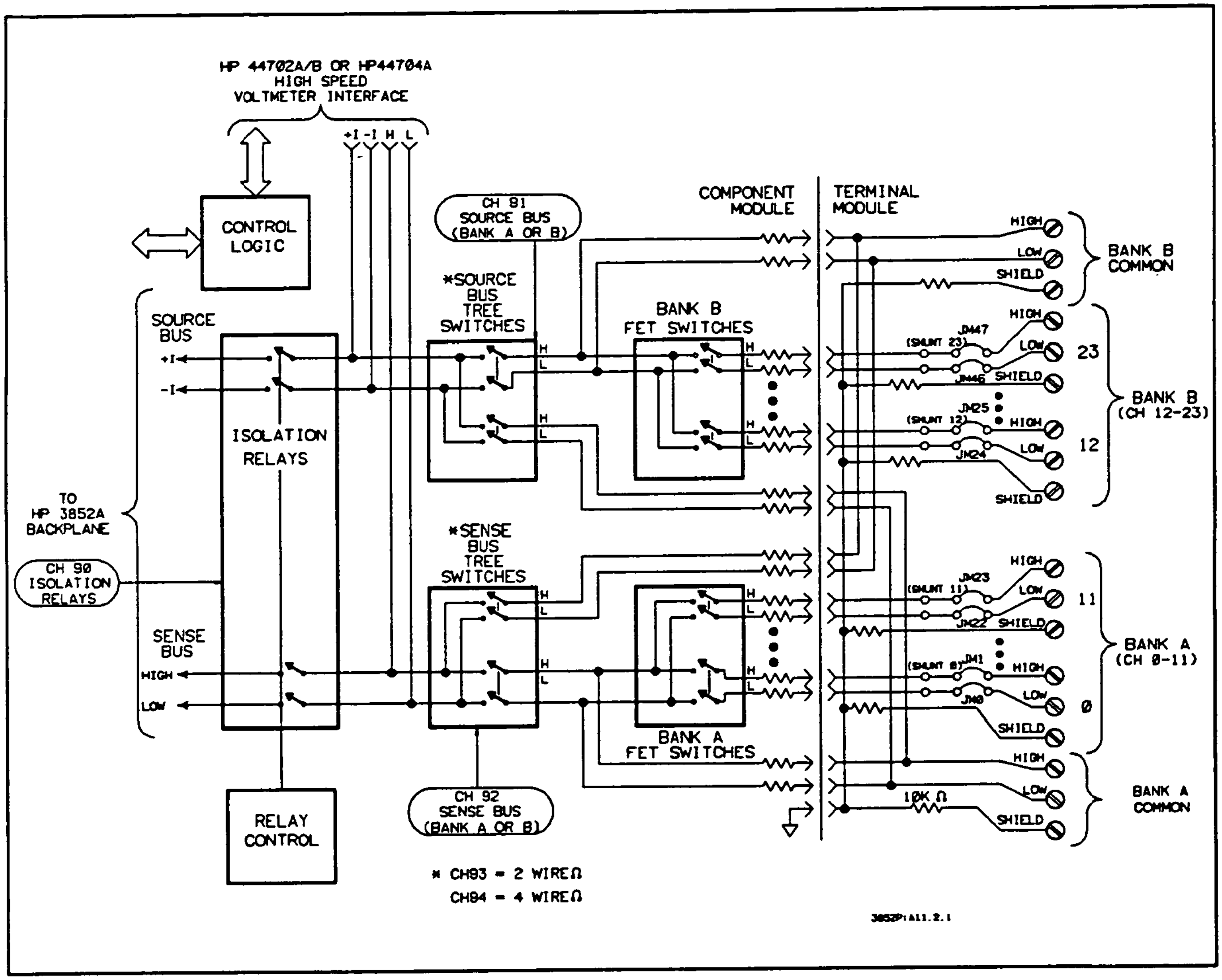


Figure 2-1. HP 44711A/B Block Diagram

The component module contains two types of tree switches: Source Bus and Sense Bus. Each bank has a Source Bus tree switch and a Sense Bus tree switch. The tree switches determine signal flow to and from the mainframe backplane or to an HP 44702A/B or HP 44704A High-Speed Voltmeter interface bus. Tree switches also isolate unused bank switches from the backplane and from the high speed interface bus.

Sense Bus tree switches provide connections to the backplane or to the HP High-Speed Voltmeter interface bus for voltage measurements. Source Bus tree switches provide backplane connections to the HP 44701A or HP High-Speed Voltmeters (HP 44702A/B or HP 44704A) current sources (+I and −I) for resistance measurements. Source Bus tree switches also provide connections to the HP High-Speed Voltmeter current sources (+I and −I) via the high speed voltmeter interface bus for resistance measurements.

The component module has two isolation relays which allow the HP 44711A/B to be isolated from the mainframe backplane. Isolation relays can be used to reduce leakage currents on the backplane or when using the backplane at voltages greater than the ±10.24 V peak limitation of the HP 44711A/B.

Isolation relays are automatically opened when voltages greater than ±12 volts peak are detected on the backplane or when the HP 44711A/B is used with an HP High-Speed Voltmeter in ribbon cable mode.

Terminal Module

The terminal module has 24 channels of terminal connectors to connect field wiring and a BANK A COMMON and BANK B COMMON connection. The BANK A COMMON and BANK B COMMON terminals can be used to connect an external voltmeter or for diagnostic procedures.

As factory configured, there is a 10 kΩ current limiting resistor in series with each input channel SHIELD terminal and with the BANK A and BANK B COMMON SHIELD terminals.

Channel Definitions

Table 2-1 defines channel numbers for the HP 44711A/B. When using high-level commands (such as CONFMEAS or MEAS), the appropriate tree switches and bank switches are automatically closed along with the measurement channel by the command. However, when using low-level commands such as CLOSE, the appropriate bank and tree switch channels (as defined in Table 2-1) must be specified as well as the measurement channel.

For example, to make voltage measurements on channel 0 using CLOSE, you will need to close the Sense Bus tree switch (channel 92), the isolation relay (channel 90), and the measurement channel (channel 0).

To make 2-wire ohms measurements with CLOSE, the easiest way is to close channel 93 (2-wire ohms), the isolation relay (channel 90), and the measurement channel. Or, to make 4-wire ohms measurements, close channel 94 (4-wire ohms), the isolation relay (channel 90), and the measurement channel.

Table 2-1. HP 44711A/B Channel Definitions

Channel	Definitions
0 - 11	Bank A Switches
12 - 23	Bank B Switches
90	Isolation Relays
91	Source Bus Tree Switch (Bank A or Bank B)*
92	Sense Bus Tree Switch (Bank A or Bank B)*
93	2-Wire Ohms Configuration
94	4-Wire Ohms Configuration

Notes:
* = The Source or Sense Bus is connected to Bank A if a channel from 0 through 11 is selected. The Source or Sense Bus is connected to Bank B if a channel from 12 through 23 is selected.

Terminal Module Configuration

This section shows how to install attenuators and low-pass filters on the HP 44711A/B terminal module for input signal conditioning and shows how to install resistors on the terminal module for current sensing applications. Figure 2-2 shows typical configurations for attenuators, low-pass filters, and current sensing.

Installing Attenuators

As required, you can install attenuators in each channel to reduce input signals to a usable level. Figure 2-2 shows how to install an attenuator on channel 20 of the terminal module. To install the attenuator, remove the SERIES JM40 and SERIES JM41 jumpers and install resistors R1 and R3 in their places. Then, install resistor R2 in the SHUNT UC20 position. To maintain the best common mode noise rejection, use R1 = R3. Attenuation is:

$$V_{out} = V_{in}\left[\frac{R2}{(R1 + R2 + R3)}\right]$$

Installing Low-Pass Filters

As required, you can also install low-pass filters for input signal conditioning on each channel. Figure 2-2 shows how to install a low-pass filter on channel 11 of the terminal module. To install the low-pass filter, remove the SERIES JM22 and SERIES JM23 jumpers and install resistors R1 and R2 in their places. Then, install capacitor C in the SHUNT UC11 position. To maintain best common mode noise rejection, use R1 = R2. The filter time constant is:

$$T_f = C(R1 + R2)$$

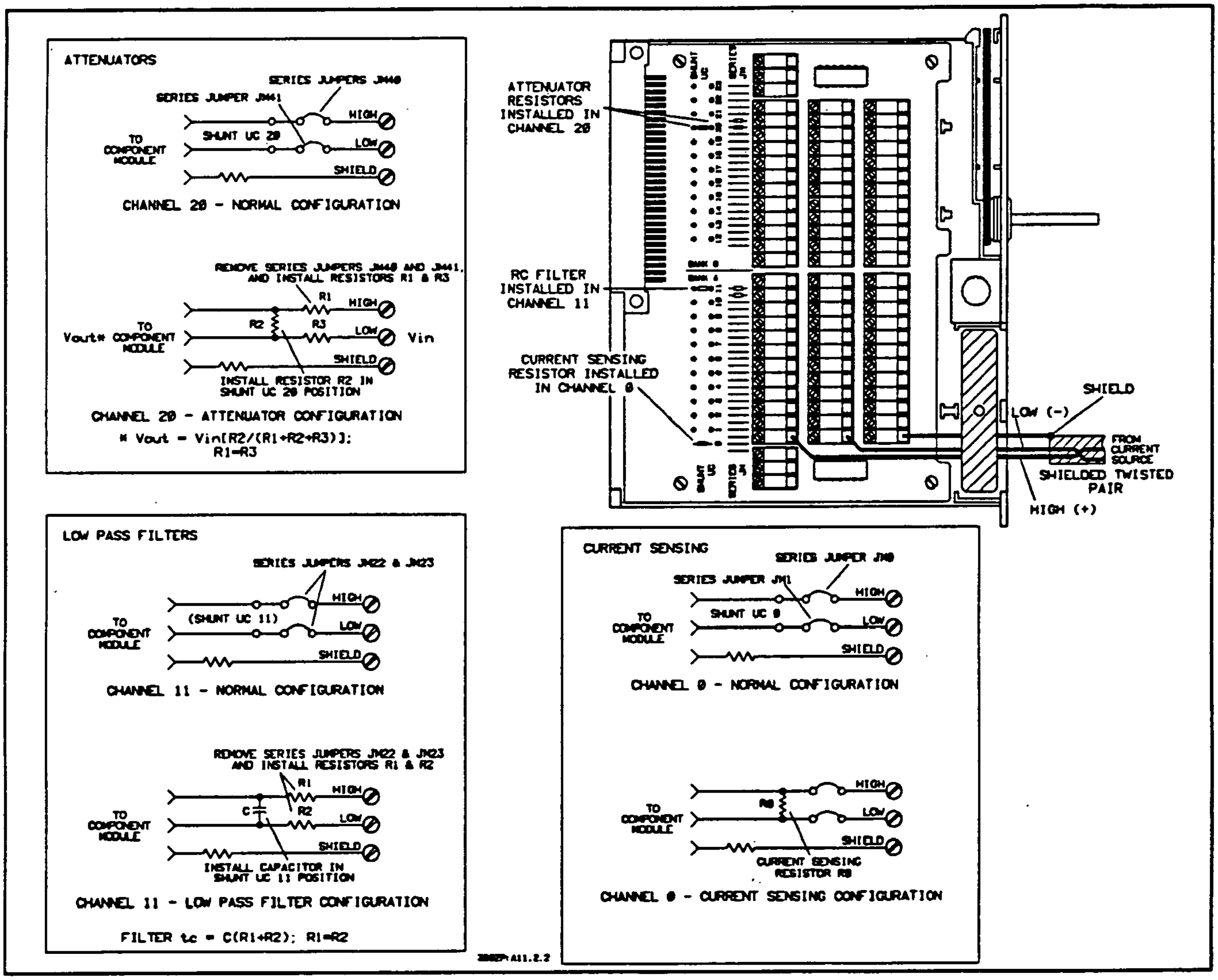


Figure 2-2. HP 44711A/B Terminal Module Configuration

Current Sensing

The HP 44711A/B uses current sensing to make current measurements. When making a current sensing measurement, the voltage across a shunt resistor is measured and the current is calculated by the controller using the measured voltage and the shunt resistance value.

Figure 2-2 shows how to configure channel 0 for current sensing measurements. In Figure 2-2, a 250 Ω shunt resistor (R0) is installed in the shunt position (SHUNT UC0) for channel 0 on the terminal module. Note that the SERIES JM jumper (JM0 in this example) MUST be in place on each channel used for current measurements.

Field Wiring Connections

When the terminal module is configured, the next step is to connect field wiring from your application to the terminal module. This section shows example field wiring connections to the HP 44711A/B terminal module for voltage, resistance, or temperature measurements.

Terminal Module Connections

Figure 2-3 shows the HP 44711A/B terminal module with the cover removed. Each of the 24 channels has a HIGH, LOW, and SHIELD terminal. Terminals 0 through 11 in Bank A are for channels 0 through 11 respectively. Terminals 12 through 23 in Bank B are for channels 12 through 23 respectively.

When connecting field wiring to the terminal module, route the wires under the strain relief clamp and tighten the clamp screw to reduce the chance of wires being pulled out of the terminal connectors. If the clamp screw is loosened far enough, the strain relief clamp can be rotated to make it easier to route the wiring.

When connecting components such as resistors, the lead length may be too short to route through the strain relief clamp. In this case, the components will have to be stored inside the terminal module. When connecting these components, make sure that no leads are shorted together and bend the leads to allow the terminal module cover to be replaced.

Voltage Measurements Connections

The HP 44711A/B can switch signals for up to 24 differential DC or AC voltage measurements. HIGH and LOW are switched on each selected channel. A SHIELD line is provided on each channel for maximum common mode noise rejection but is not switched.

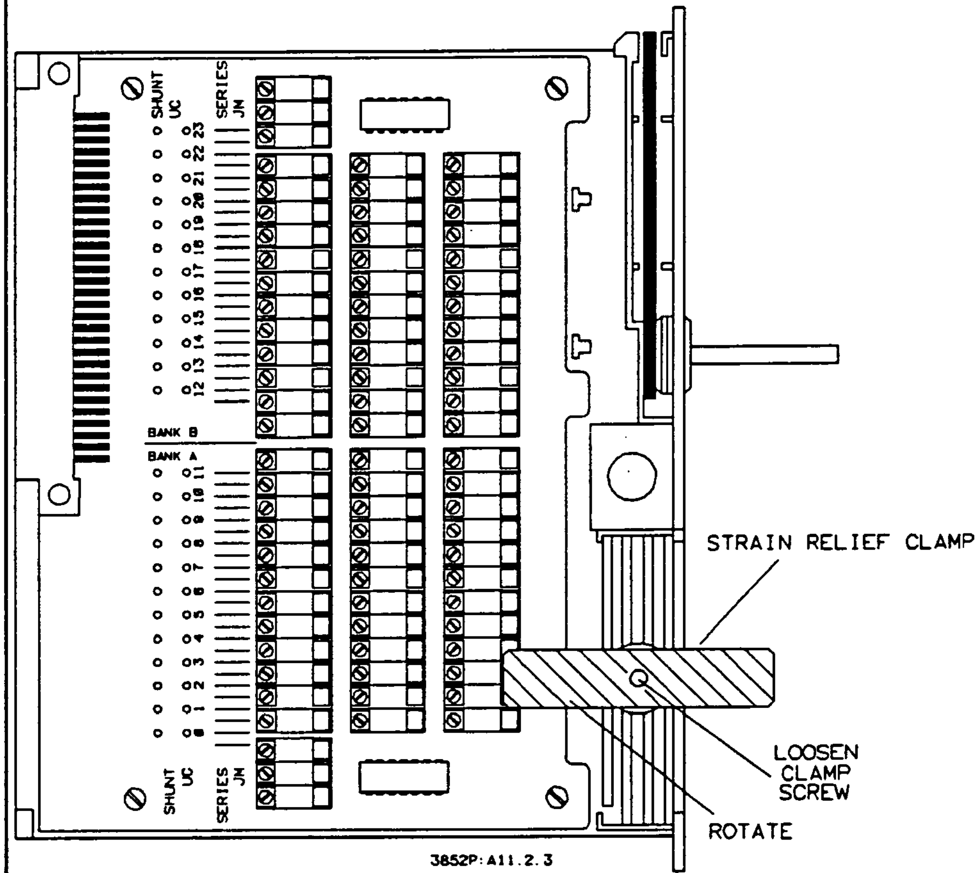


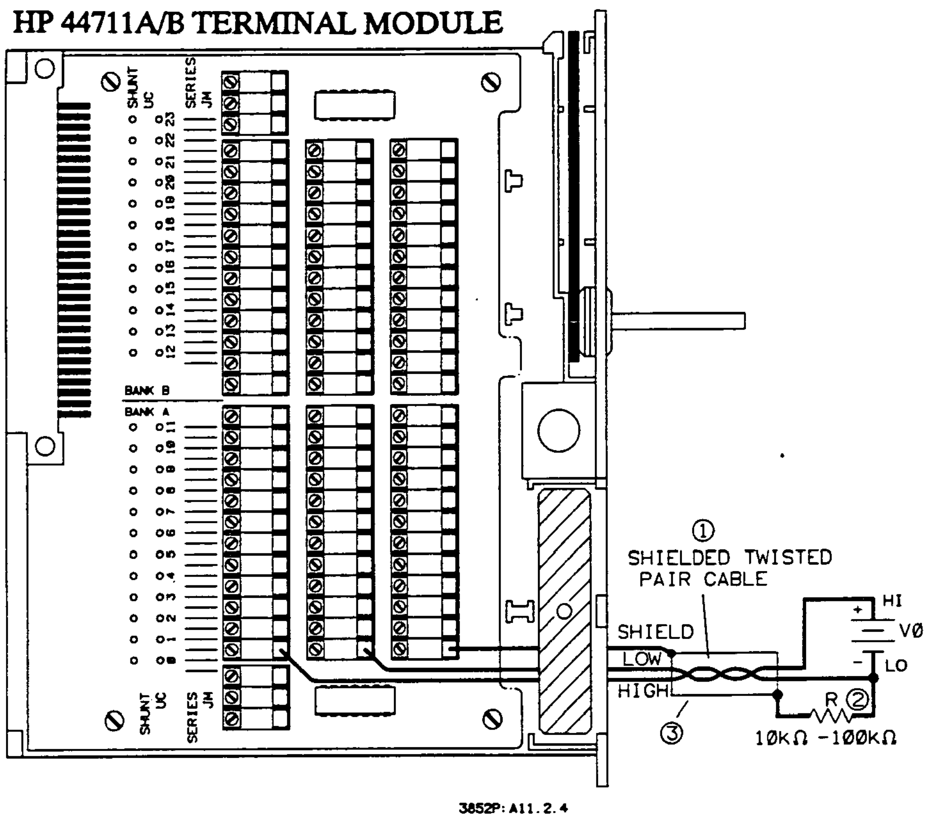
Figure 2-3. HP 44711A/B Terminal Module

Figure 2-4 shows typical voltage measurement connections to channel 0 on the terminal module. Note that shielded cable is required for measurements with the HP 44702A/B and HP 44704A voltmeter and is highly recommended for measurements with the HP 44701A voltmeter. For the HP 44702A/B voltmeter, connect an external resistor (R) between V0 LO and the shield, as shown in Figure 2-4.

Resistance Measurements Connections

Because of the high ON resistance (about 3.2 kΩ per channel), only 4-wire ohms are recommended for HP 44711A/B resistance measurements. Figure 2-5 shows typical 4-wire ohms connections of a resistance (R0) connected to channels 0 and 12 using shielded, twisted-pair cable. Channel 0 is the voltage Sense channel and channel 12 is the current Source channel for the measurement.

VOLTAGE MEASUREMENTS



Notes:

[1] = Shielded cable is required for HP 44702A/B and HP 44704A measurements and is highly recommended for HP 44701A measurements.

[2] = For HP 44701A measurements, make a direct connection from the shield to VO LO.

[3] = If shield cable is not used (HP 44701A measurements only), connect separate lead from channel 0 SHIELD to VO LO.

Figure 2-4. HP 44711A/B Voltage Connections

Each 4-wire ohms measurement requires two channels, one from Bank A and one from Bank B. When connecting a resistor to the terminal module for 4-wire ohms measurements, use two channels separated by 12 (such as channels 0 and 12, channels 1 and 13, etc.).

In Figure 2-5, one end of the Sense cable (channel 0) shield lead connects to the channel 0 SHIELD and the other end connects to R0 LO. However, although one end of the Source cable (channel 12) shield lead connects to channel 12 SHIELD , the other end of the shield lead does not connect to R0 LO. Do NOT connect the Source cable shield lead to R0 LO, as this will reduce the effective compliance voltage.

If you do not use shielded cable, connect channel 0 HIGH and LOW and channel 12 HIGH and LOW terminals to the resistor and connect a separate lead from the Sense channel (channel 0) SHIELD terminal to R0 LO. However, measurement accuracy with unshielded leads will not be as high as with shielded cable, since unshielded leads do not provide noise immunity.

Temperature Measurements Connections

This subsection shows how to connect RTDs and thermistors to the HP 44711A/B terminal module for temperature measurements using 4-wire ohms. Each 4-wire RTD or thermistor measurement requires two channels, one from Bank A and one from Bank B. When connecting an RTD or thermistor to the terminal module for a 4-wire measurement, use two channels that are separated by 12 (such as channels 0 and 12, channels 1 and 13, etc.). See Figure 2-5 in "Resistance Measurements Connections" for a typical connection diagram.

Installation and Checkout

This section shows how to check identity, verify field wiring connections, and read channel states of an HP 44711A/B.

NOTE

For ribbon cable operation, the cable must be connected between the HP 44711A/B and the HP 44702A/B or HP 44704A voltmeter. For backplane operation, the ribbon cable must NOT be connected. Refer to the HP 3852A Mainframe Configuration and Programming Manual to connect or disconnect the ribbon cable

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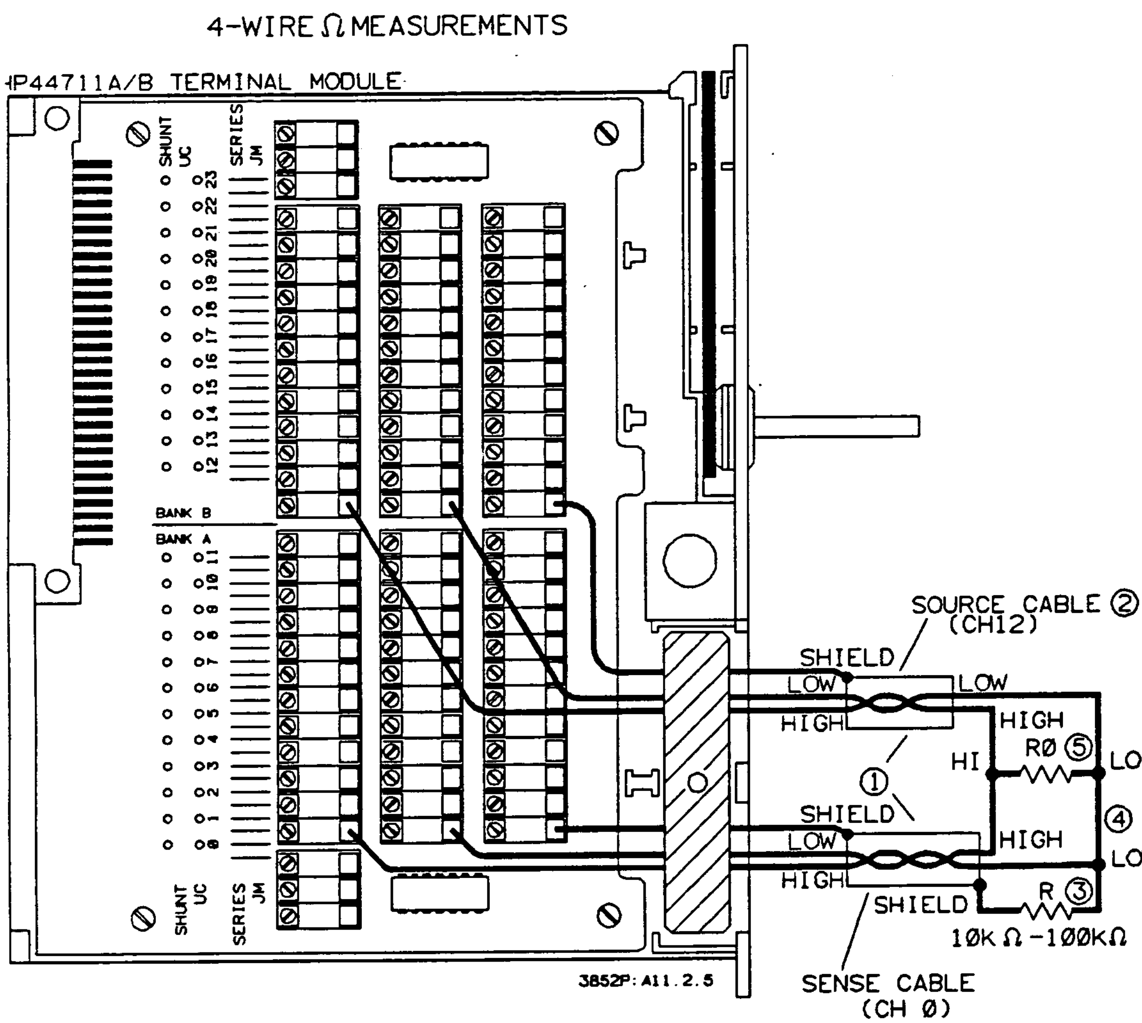


Notes:

[1] = Shielded cable is required for HP 44702A/B and HP 44704A measurements and is highly recommended for HP 44701A measurements.

[2] = Do NOT connect the Source channel shield to RO LO as this will reduce effective compliance voltage.

[3] = For HP 44701A measurements, make a direct connection from the shield to RO LO.

[4] = If shielded cable is not used (HP 44701 measurements only), connect a separate lead from channel 0 SHIELD to RO LO.

[5] = RO can be a resistor, an RTD, or a thermistor. The HP 3852A supports Type 85 and 92 RTDs and Type 2252, 5K, and 10K thermistors.

Figure 2-5. HP 44711A/B 4-Wire Ohms Connections

Check HP 44711A/B ID

When you have connected field wiring to the terminal module, replace the terminal module cover and install the HP 44711A/B in the desired mainframe or extender slot. Refer to the HP 3852A Mainframe Configuration and Programming Manual to connect the terminal module to the component module and to install the HP 44711A/B.

Then, use ID? to check the HP 44711A/B ID. At power-on, an HP 44711A/B returns 44711. An HP 44711A/B component module only (no terminal module attached) returns 447XXX. (If the terminal module is removed after power-on, the accessory still returns 44711.)

If the multiplexer does not return 44711 be sure you have addressed the correct slot and the terminal module is installed. If these are correct but the correct ID code is not returned, refer to the HP 3852A Assembly Level Service Manual for service procedures.

Example: Checking Accessory ID

This program queries the identity of an accessory in slot 5 of the mainframe. An HP 44711A in this slot returns 44711A.

```
10 OUTPUT 709;"ID? 500"           ! Query ID in mainframe slot 5
20 ENTER 709;A$                   ! Enter ID
30 PRINT A$                       ! Display ID
40 END
```

Verify Wiring Connections

To verify that field wiring has been properly connected to the terminal module, you can send MONMEAS (Monitor/Measure) from the mainframe front panel or from a controller. MONMEAS can be used to check DC voltage or resistance connections.

Example: Checking Wiring Connections

This program uses MONMEAS to verify wiring connections to channels 500 through 523 of an HP 44711A. CONF configures the voltmeter in slot 6 for DC voltage measurements.

The 24 channels are scanned and measured one at a time starting with channel 500. Press the SADV KEY key on the mainframe front panel to advance the scan to the next channel. When the scan is advanced past the last channel (channel 523), the scan stops and the last measurement remains on the display.

```
10 OUTPUT 709;"USE 600"                 ! Use voltmeter in mainframe slot 6
20 OUTPUT 709;"CONF DCV"                ! Set DC volts function on voltmeter
30 OUTPUT 709;"MONMEAS DCV,500-523"     ! Monitor/measure ch 500 through 523
40 END
```

Read Channel State

CLOSE? can be used to determine the state of HP 44711A/B channels. This command returns 0, 1, 2, 3, or 4 as shown in Table 2-2 for each channel queried. (CLOSE? returns only 0 (open) or 1 (closed) for the state of the isolation relays and the tree switches.)

Table 2-2. Values Returned by CLOSE?

Value Returned*	Channel State
0	Channel Open
1	Channel Closed - not connected to a bus
2	Channel Closed - connected to Sense Bus
3	Channel Closed - connected to Source Bus
4	Channel Closed - connected to both buses

Note:
* = Only 0 (open) or 1 (closed) is returned for isolation relays (channel 90) and tree switches (channel 91 or 92).

Example: Reading Channel State

This program uses CLOSE? to check the state of channels 500 through 504 on an HP 44711A. RST (reset) resets the multiplexer to its power-on state with all channels open. CLOSE closes channel 503 , the isolation relay (channel 590), and the Sense Bus tree switch (channel 592). OPEN opens the channel, the isolation relay, and the tree switch.

```
10 OUTPUT 709;"RST 500"                  ! Open all chs
20 INTEGER State(O:4)                    ! Define controller array
30 OUTPUT 709;"CLOSE 503,590,592"        ! Close ch 503, iso relay, tree switch
40 OUTPUT 709;"CLOSE? 500-504"           ! Query state of chs 500 through 504
50 ENTER 709;State(*)                    ! Enter channel states
60 PRINT State(*)                        ! Display channel states
70 OUTPUT 709;"OPEN 503,590,592"         ! Open ch 503,iso relay, tree switch
80 END
```

Since channel 503 was the only channel closed and was connected to the Sense Bus tree switch, a typical return is:

0 0 0 2 0

Chapter 3
Configuring the HP 44712A

Contents

Configuring the HP 44712A

Chapter Contents

This chapter shows how to configure the HP 44712A multiplexer. It contains a block diagram description of the HP 44712A and shows how to connect field wiring to the terminal module.

When you have configured the HP 44712A, refer to Chapter 5 - Programming the Multiplexers to program the HP 44712A for voltage measurements.

Block Diagram Description

The HP 44712A consists of a 48-channel terminal module and a component module as shown in Figure 3-1. Field wiring from your application sensors connects to the terminal module and the signals are sent to switches on the component module.

Component Module

The component module consists of two types of switches: bank switches and tree switches. There are 48 bank switches divided into two groups of 24 channels each: Bank A and Bank B. The HP 44712A switches the HIGH line only. LOW is common to all channels and to chassis but is not switched.

NOTE

Only one channel per bank can be closed at a time. Closing a second channel in a bank will open any previously closed channel in that bank.

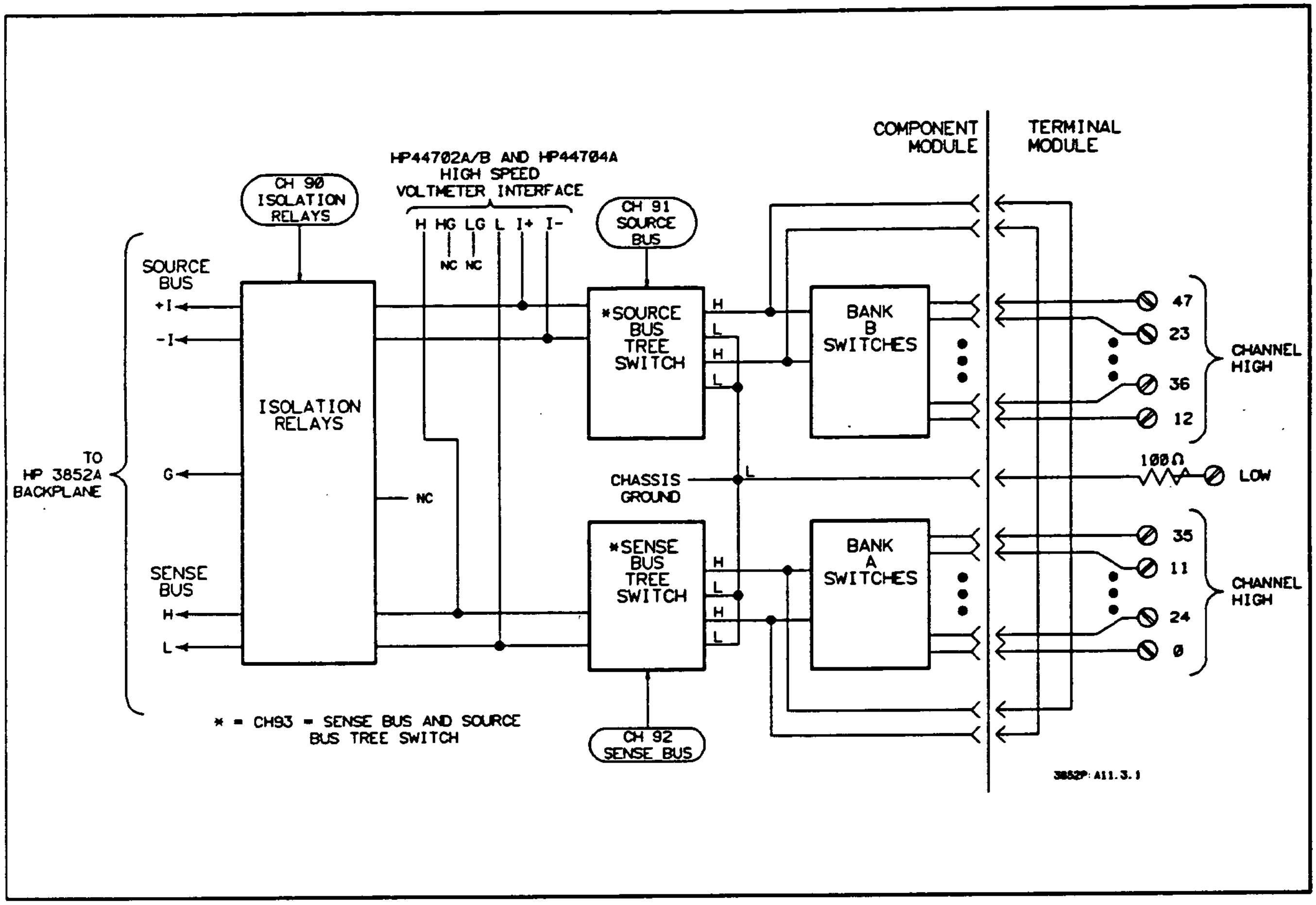


Figure 3-1. HP 44712A Block Diagram

The component module has two types of tree switches: two Source Bus and two Sense Bus. Tree switches control signal flow to and from the mainframe backplane and isolate the bank switches from the backplane when they are not in use.

Sense Bus tree switches provide connections to the mainframe backplane and to the HP High-Speed Voltmeter interface (ribbon cable) for voltage measurements. Source Bus tree switches provide backplane connections to the HP 44701A or HP High-Speed voltmeter (HP 44702A/B or HP 44704A) current sources (+I and −I) for 2-wire ohms measurements. Source Bus tree switches also provide ribbon cable interface connections (I+ and I−) for 2-wire ohms measurements.

The component module includes isolation relays which allow the HP 44712A to be isolated from the backplane. Isolation relays can be used to reduce the leakage current on the backplane or to use the backplane at voltages greater than the HP 44712A voltage specifications.

The HP 44712A has overvoltage protection circuitry which opens the isolation relays when voltages greater than ±12 V peak are detected on the backplane. The isolation relays are also opened when ribbon cable operation is used.

Terminal Module

The terminal module contains 48 terminals to connect field wiring. As factory configured, there is a protection resistor in series with the common LOW terminals.

Channel Definitions

Table 3-1 shows the channel definitions for the HP 44712A. If you use high-level commands (such as CONFMEAS and MEAS) to program the HP 44712A, you need to specify only the measurement channels since CONFMEAS or MEAS automatically closes the proper channels and switches for the measurement selected.

However, if you use low-level commands such as CLOSE, you will need to specify the switches to be closed. For example, to make voltage measurements on channel 0, you will need to close the measurement channel (channel 0), the isolation relay (channel 90), and the Sense Bus tree switch (channel 92). Or, to make 2-wire ohms measurements on channel 0, close the Sense Bus and Source Bus tree switches (channel 93) and the measurement channel (channel 0).

Table 3-1. HP 44712A Channel Definitions

Channel	Definitions
0 - 11	Bank A Switches
12 - 23	Bank B Switches
90	Isolation Relays
91	Source Bus Tree Switch (Bank A or Bank B)*
92	Sense Bus Tree Switch (Bank A or Bank B)*
93	2-Wire Ohms Configuration
94	4-Wire Ohms Configuration

Notes:
* = The Source or Sense Bus is connected to Bank A if a channel from 0 through 11 is selected. The Source or Sense Bus is connected to Bank B if a channel from 12 through 23 is selected.

Field Wiring Connections

This section shows typical field wiring connections to the HP 44712A terminal module for voltage measurements.

Terminal Module Connections

Figure 3-2 shows the HP 44712A terminal module with the cover removed. Each of the 48 channels has a HIGH terminal (numbered 0 through 47). There are 24 LOW terminals. All LOW channels are common to one another and to chassis ground.

When connecting field wiring to the terminal module, route the wires under the strain relief clamp and tighten the clamp screw to reduce the chance of wires being pulled out of the terminal connectors. If the clamp screw is loosened far enough, the strain relief clamp can be rotated to make it easier to route the wiring.

When connecting components such as resistors, the lead length may be too short to route through the strain relief clamp. In this case, the components will have to be stored inside the terminal module. When connecting these components, make sure that no leads are shorted together and bend the leads to allow the terminal module cover to be replaced.

Voltage Measurement Connections

The HP 44712A can switch signals for up to 48 single-ended DC or AC voltage measurements. Figure 3-3 shows typical voltage measurement connections to channel 0.

NOTE

Because the high ON resistance of the FET switches (approximately 3 kΩ) limits the accuracy of 2-wire ohms measurements, resistance measurements are not recommended for the HP 44712A.

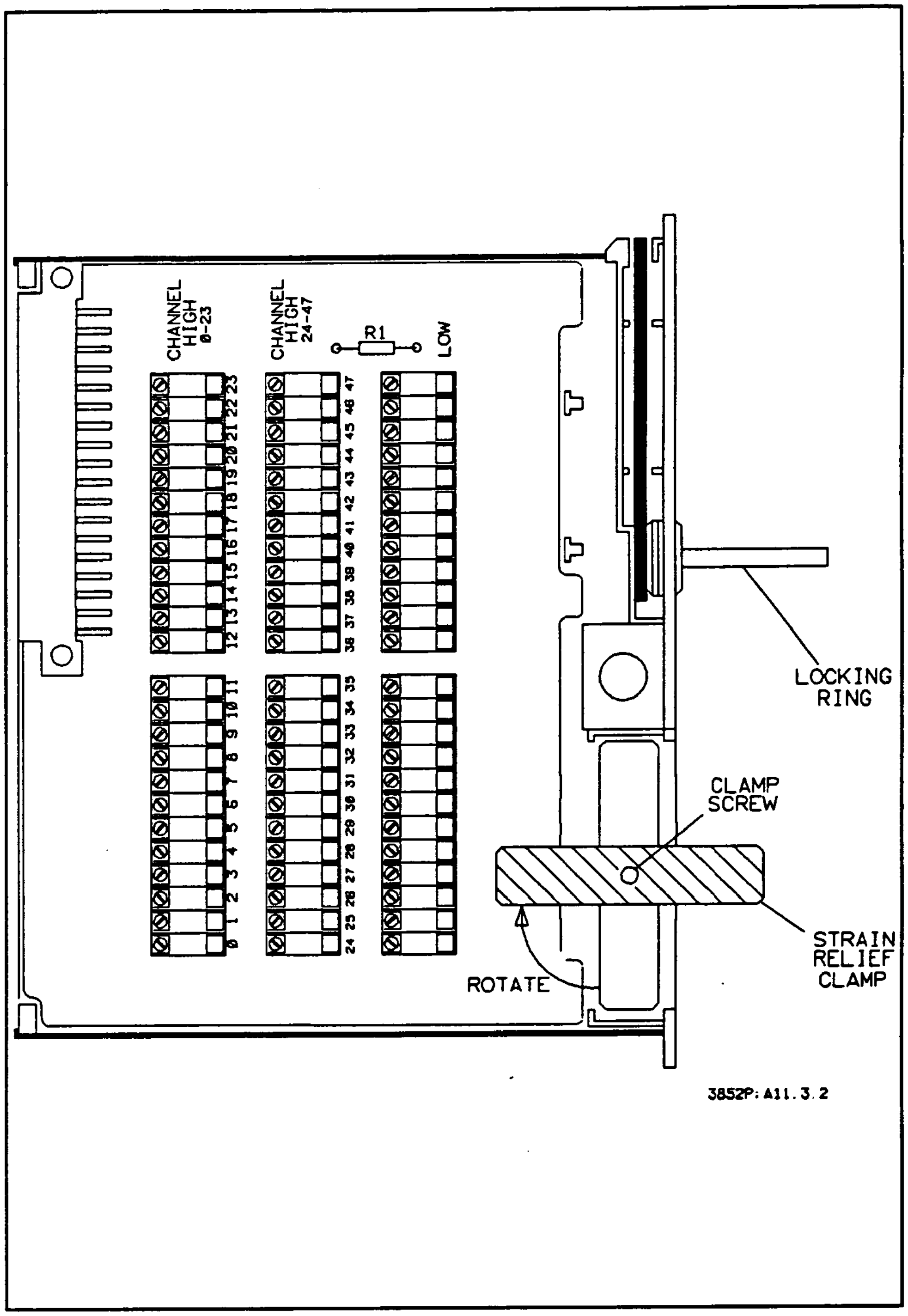
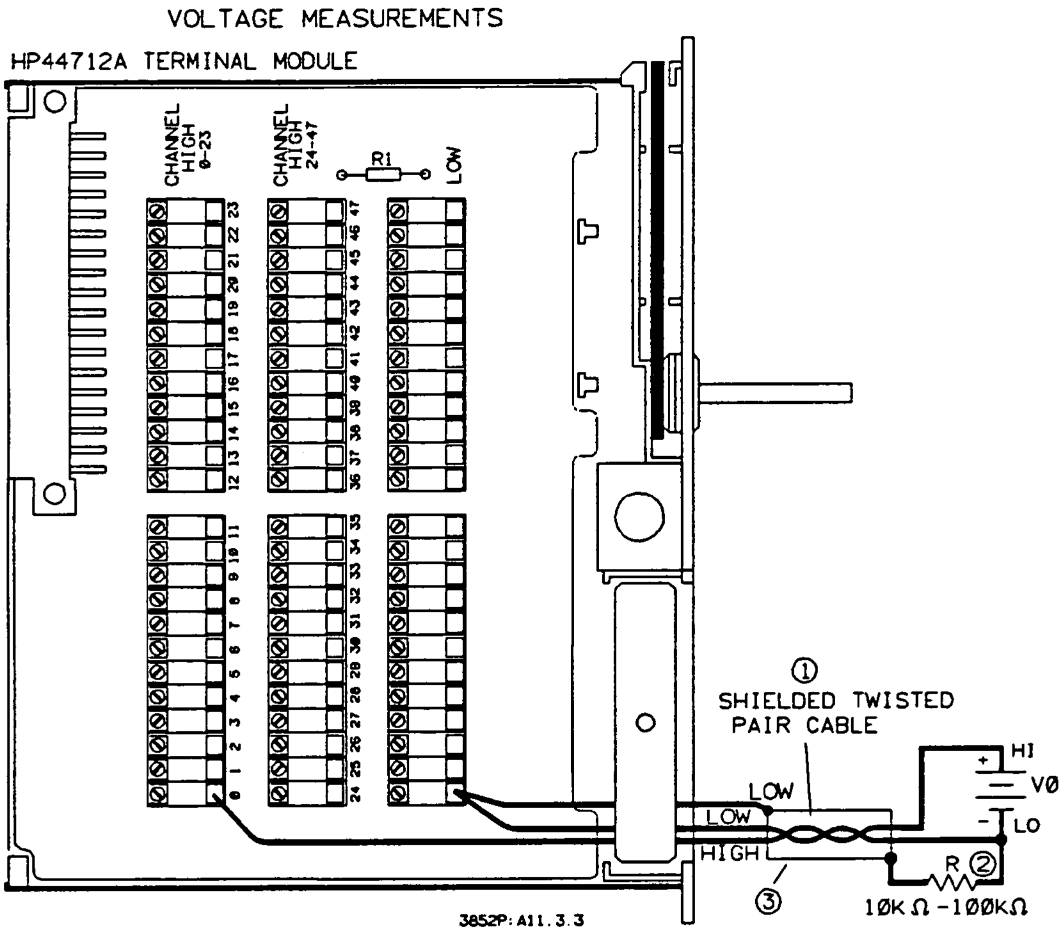


Figure 3-2. HP 44712A Terminal Module

Since shielded, twisted-pair Cable reduces measurement noise, shielded cable is required for measurements with an HP 44702A/B and HP 44704A voltmeter and is highly recommended for measurements with the HP 44701A voltmeter. For the HP 44702A/B or HP 44704A voltmeter connect an external resistor (R) between V0 LO and the shield, as shown in Figure 3-3.



Notes:

[1] = Shielded cable is required for HP 44702A/B and HP 44704A measurements and is highly recommended for HP 44701A measurements.

[2] = For Hp 44701a measurement, make a direct connection from the sheild to V0 LO.

Figure 3–3. HP 44712A Voltage Connections

Installation and Checkout

This section shows how to check identity, verify field wiring connections, and read channel states of an HP 44712A.

NOTE

For ribbon cable operation, the cable must be connected between the HP 44712A and the HP 44702A/B or HP 44704A voltmeter. For backplane operation, the ribbon cable must NOT be connected. Refer to the HP 3852A Mainframe Configuration and Programming Manual to connect or disconnect the ribbon cable.

Check HP 44712A ID

When you have connected field wiring to the terminal module, replace the terminal module cover and install the HP 44712A in the desired mainframe or extender slot. Refer to the HP 3852A Mainframe Configuration and Programming Manual to connect the terminal module to the component module and to install the HP 44712A.

Then, use ID? to check the HP 44712A ID. At power-on, an HP 44712A returns 44712. An HP 44712A component module only (no terminal module attached) returns 447XXX. (If the terminal module is removed after power-on, the accessory still returns 44712.)

If the multiplexer does not return 44712 be sure you have addressed the correct slot and the terminal module is installed. If these are correct but the correct ID code is not returned, refer to the HP 3852A Assembly Level Service Manual for service procedures.

Example: Checking Accessory ID

This program queries the identity of an accessory in slot 5 of the mainframe. An HP 44712A in this slot returns 44712A.

```
10 OUTPUT 709;"ID? 500"          ! Query ID in mainframe slot 5
20 ENTER 709;A$                  ! Enter ID
30 PRINT A$                      ! Display ID
40 END
```

Verify Wiring Connections

To verify that field wiring has been properly connected to the terminal module, you can send MONMEAS (Monitor/Measure) from the mainframe front panel or from a controller. MONMEAS can be used to check DC voltage or resistance connections.

Example: Checking Wiring Connections

This program uses MONMEAS to verify wiring connections to channels 500 through 547 of an HP 44712A. CONF configures the voltmeter in slot 6 for DC voltage measurements.

The 48 channels are scanned and measured one at a time starting with channel 500. Press the SADV KEY key on the mainframe front panel to advance the scan to the next channel. When the scan is advanced past the last channel (channel 547), the scan stops and the last measurement remains on the display.

```
10 OUTPUT 709;"USE 600"                    ! Use voltmeter in mainframe slot 6
20 OUTPUT 709;"CONF DCV"                   ! Set DC volts function on voltmeter
30 OUTPUT 709;"MONMEAS DCV,500-547"        ! Monitor/measure ch 500 through 523
40 END
```

Read Channel State

CLOSE? can be used to determine the state of HP 44712A channels. This command returns a 0, 1, 2, 3, or 4 as shown in Table 3-2 for each channel queried. (CLOSE? returns only 0 (open) or 1 (closed) for the state of the isolation relays and the tree switches.)

Table 3-2. Values Returned by CLOSE?

Value Returned*	Channel State
0	Channel Open
1	Channel Closed - not connected to a bus
2	Channel Closed - connected to Sense Bus
3	Channel Closed - connected to Source Bus
4	Channel Closed - connected to both buses

Note:
* = Only 0 (open) or 1 (closed) is returned for isolation relays (channel 90) and tree switches (channel 91 or 92).

Example: Reading Channel State

This program uses CLOSE? to check the state of channels 500 through 504 on an HP 44712A. RST (reset) resets the multiplexer to its power-on state with all channels open. CLOSE closes channel 503 , the isolation relays (channel 590), and the Sense Bus tree switch (channel 592). OPEN opens the channel, the isolation relay, and the tree switch.

```
10 OUTPUT 709;"RST 500"                  ! Open all chs
20 INTEGER State(0:4)                    ! Define controller array
30 OUTPUT 709;"CLOSE 503,590,592"        ! Close ch 503, iso relay, tree switch
40 OUTPUT 709;"CLOSE? 500-504"           ! Query state of chs 500 through 504
50 ENTER 709;State(*)                    ! Enter channel states
60 PRINT State(*)                        ! Display channel states
70 OUTPUT 709;"OPEN 503,590,592"         ! Open ch 503,iso relay, tree switch
80 END
```

Since channel 503 was the only channel closed and was connected to the Sense Bus tree switch, a typical return is:

0 0 0 2 0

Chapter 4
Configuring the HP 44713A/B

Contents

Configuring the HP 44713A/B

Chapter Contents

This chapter shows how to configure the HP 44713A and HP 44713B multiplexer. The HP 44713B provides reduced settling time for use with the HP 44704A High-Speed Voltmeter's high resolution modes. Otherwise, the A and B versions of the HP 44713 are identical. The chapter contains a block diagram description of the HP 44713A/B, shows how to configure the terminal module, and shows how to connect field wiring to the terminal module.

When you have configured the HP 44713A/B, refer to Chapter 5 - Programming the Multiplexers to program the multiplexer for voltage, current, or thermocouple measurements.

Block Diagram Description

The HP 44713A/B consists of a 24-channel terminal module and a component module as shown in Figure 4-1. Field wiring from application sensors connects to the terminal module and signals are sent to switches on the component module.

An isothermal connector block on the terminal module provides the reference junction for thermocouple measurements. A thermistor on the block is used to measure the reference temperature. The HP 3852A uses software compensation to compensate for the reference temperature when making thermocouple measurements.

Component Module

The component module consists of 28 switches divided into two categories: tree switches and bank switches. Each switch consists of two Field Effect Transistors (FET), one each for HIGH and LOW input lines. There are 24 bank switches, divided into two banks: Bank A (channels 0 through 11) and Bank B (channels 12 through 23).

NOTE

Only one channel per bank can be closed at a time. Closing a second channel in a bank will open any previously closed channel in that bank.

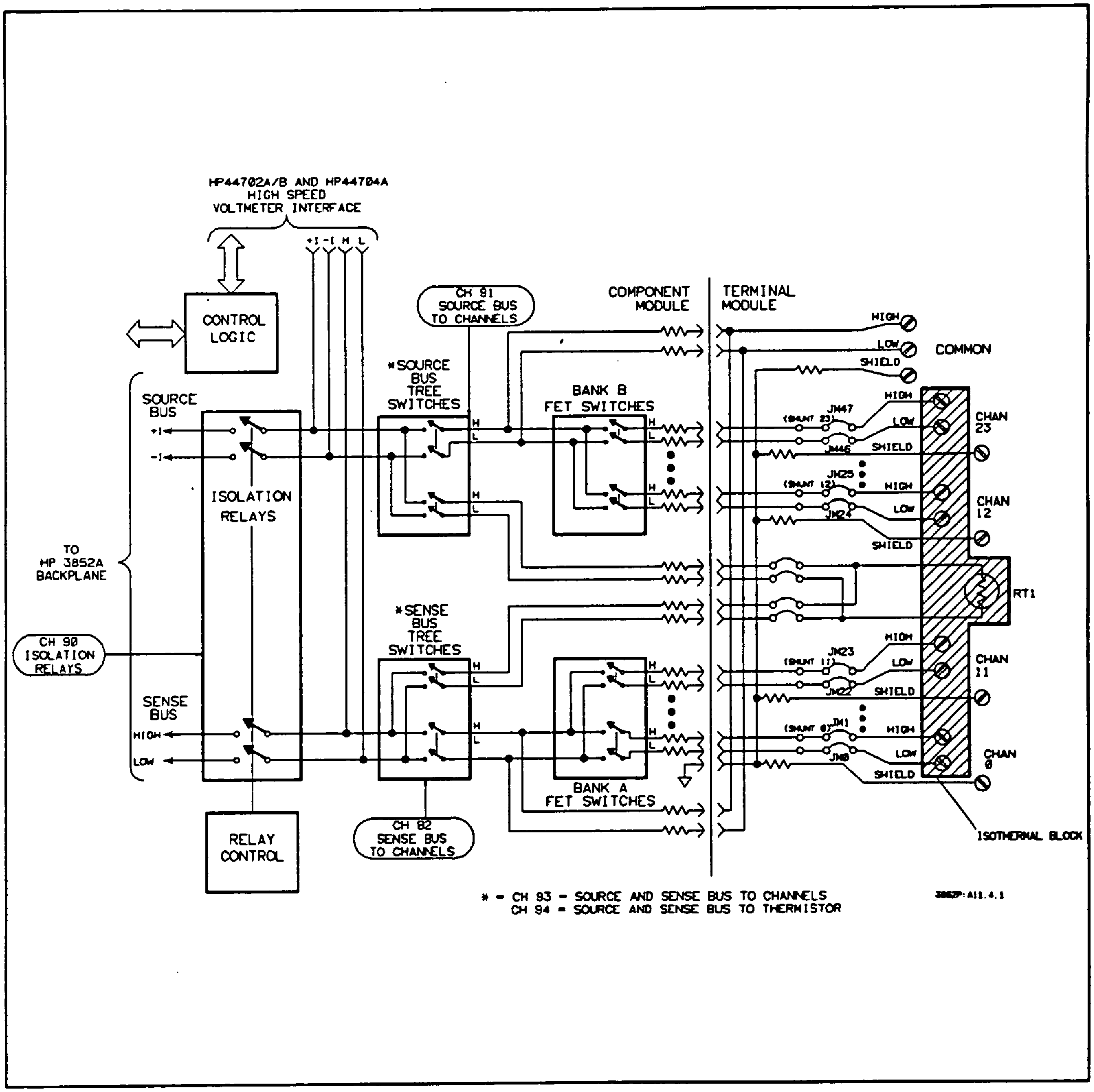


Figure 4-1. HP 44713A/B Block Diagram

The component module contains two types of tree switches: Source Bus and Sense Bus. Each bank has a Source Bus tree switch and a Sense Bus tree switch. The tree switches determine signal flow to and from the mainframe backplane or to the HP 44702A/B and HP 44704A High-Speed Voltmeter interface bus. Tree switches also isolate unused bank switches from the backplane and from the high speed interface bus.

Sense Bus tree switches provide connections to the backplane or to the HP 44702A/B and HP 44704A interface bus for voltage measurements. Source Bus tree switches provide backplane connections to the HP 44701A, HP 44702A/B, or HP 44704A voltmeter current sources (+I and −I) for resistance measurements. Source Bus tree switches also provide connections to the HP 44702A/B and HP 44704A current sources (+I and −I) via the high speed voltmeter interface bus for resistance measurements.

NOTE

Two tree switches of the same type cannot be used simultaneously (e.g., only one of the two Sense Bus tree switches can be closed at a time). Closing a second tree switch will open any previously closed tree switch of the same type.

The component module has two isolation relays which allow the HP 44713A/B to be isolated from the mainframe backplane. Isolation relays can be used to reduce leakage currents on the backplane or when using the backplane at voltages greater than the ±10.24 V peak limitation of the HP 44713A/B.

Isolation relays are automatically opened when voltages greater than ±12 volts peak are detected on the backplane or when the HP 44713A/B is used with an HP High-Speed Voltmeter (HP 44702A/B or HP 44704A) in ribbon cable mode.

Terminal Module

The terminal module contains 24 channels of terminal connectors for field wiring, a COMMON terminal and an isothermal block with a 5 kΩ thermistor (RT1) which is used to measure the isothermal temperature (the reference temperature).

The bank switch terminals are connected together on the terminal to form the COMMON terminal. The COMMON terminals can be used to connect an external monitoring device for diagnostic purposes. As factory configured, there are 10 kΩ current limiting resistors in series with the channel input lines and with the COMMON output lines.

Channel Definitions

Table 4-1 shows channel definitions for the HP 44713A/B. If you use high-level commands (such as CONFMEAS or MEAS) to close channels, the high-level command automatically closes the proper channels and switches for the measurement selected. However, if you use low-level commands such as CLOSE for measurements, you will need to specify the switches to be closed.

For example, to make voltage measurements on channel 0, you will need to close the Sense Bus tree switch (channel 92), the isolation relay (channel 90), and the measurement channel (channel 0).

To make 2-wire ohms resistance measurements, you can close the Sense Bus and Source Bus tree switches, the isolation relay, and the measurement channel or you can close the isolation relays, channel 93, and the measurement channel.

NOTE

Due to high ON resistance of the FETs (about 3 kΩ), 2-wire ohms measurements are recommended ONLY for open thermocouple detection.

For example, to make 2-wire ohms measurements on channel 0, you can close the Source Bus tree switch (channel 91), the Sense Bus tree switch (channel 92), the isolation relays (channel 90), and the measurement channel (channel 0). Or, you can close the isolation relay (channel 90), the Source and Sense Bus Tree Switch to Channels (channel 94), and the measurement channel (channel 0).

To measure the reference temperature (by measuring the thermistor on the isothermal block), close the isolation relays (channel 90) and the Source and Sense Bus tree switches to the thermistor (channel 94).

Table 4-1. HP 44713A/B Channel Definitions

Channel	Definitions
0 - 11	Bank A Switches
12 - 23	Bank B Switches
90	Isolation Relays
91	Source Bus Tree Switch (Bank A or Bank B)*
92	Sense Bus Tree Switch (Bank A or Bank B)*
93	2-Wire Ohms Configuration
94	4-Wire Ohms Configuration

Notes:
* = The Source or Sense Bus is connected to Bank A if a channel from 0 through 11 is selected. The Source or Sense Bus is connected to Bank B if a channel from 12 through 23 is selected.

Terminal Module Configuration

This section shows how to install attenuators and low-pass filters on the HP 44713A/B terminal module for input signal conditioning and shows how to install resistors on the terminal module for current sensing applications. Figure 4-2 shows typical configurations for attenuators, low-pass filters, and current sensing.

Installing Attenuators

As required, you can install attenuators in each channel to reduce input signals to a usable level. Figure 4-2 shows how to install an attenuator on channel 20 of the terminal module. To install the attenuator, remove the SERIES JM40 and SERIES JM41 jumpers and install resistors R1 and R3 in their places. Then, install resistor R2 in the SHUNT UC20 position. To maintain the best common mode noise rejection, use R1 = R3. Attenuation is:

$$V_{out} = V_{in}\left[\frac{R2}{(R1 + R2 + R3)}\right]$$

Installing Low-Pass Filters

As required, you can also install low-pass filters for input signal conditioning on each channel. Figure 4-2 shows how to install a low-pass filter on channel 11 of the terminal module. To install the low-pass filter, remove the SERIES JM22 and SERIES JM23 jumpers and install resistors R1 and R2 in their places. Then, install capacitor C in the SHUNT UC11 position. To maintain best common mode noise rejection, use R1 = R2. The filter time constant is:

$$T_f = C(R1 + R2)$$

Current Sensing

The HP 44713A/B uses current sensing to make current measurements. When making a current sensing measurement, the voltage across a shunt resistor is measured and the current is calculated by the controller using the measured voltage and the shunt resistance value.

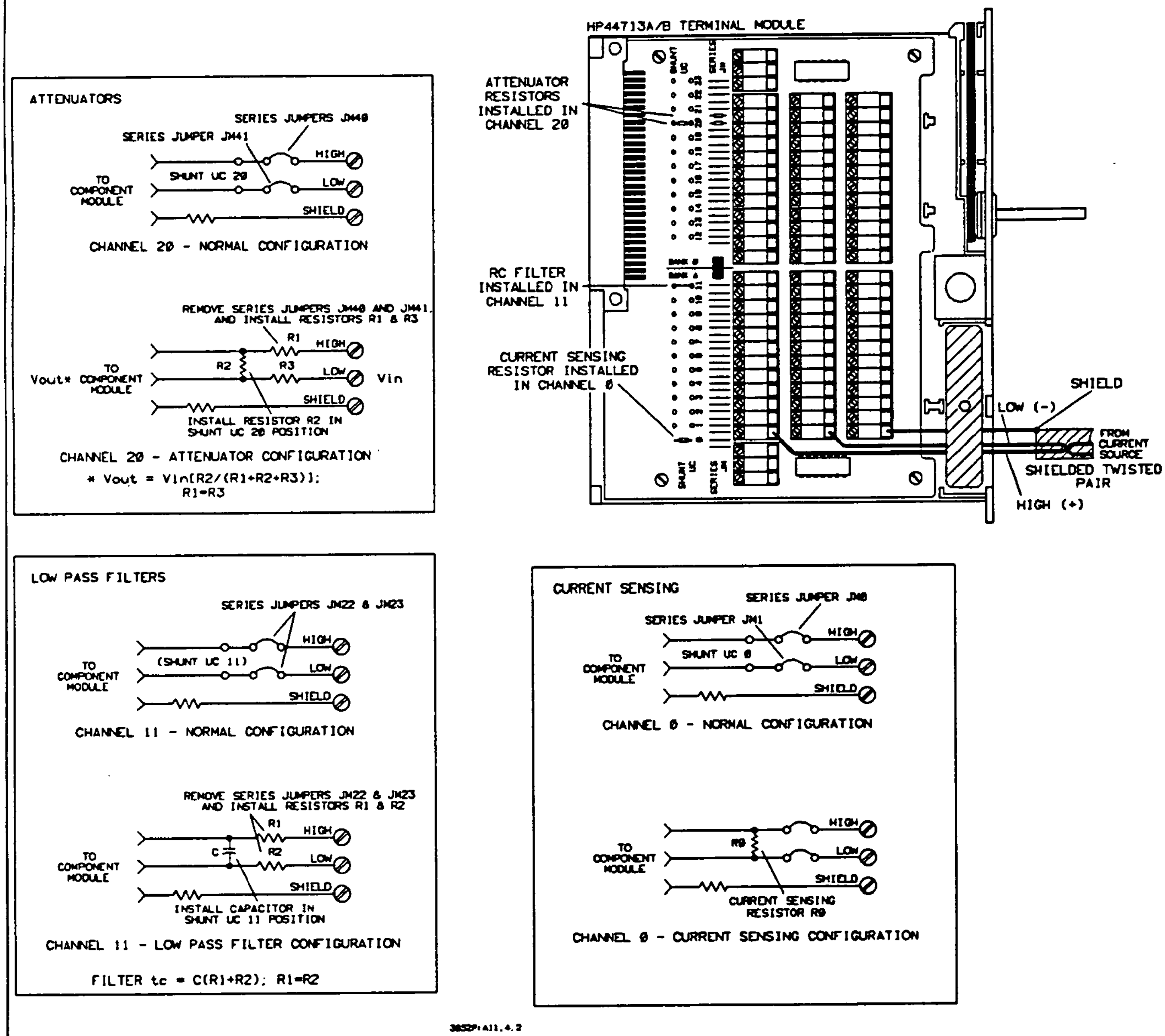


Figure 4-2. HP 44713A/B Terminal Module Configuration

Figure 4-2 shows how to configure channel 0 for current sensing measurements. In Figure 4-2, a 250 Ω shunt resistor (R0) is installed in the shunt position (SHUNT UC0) for channel 0 on the terminal module. Note that the SERIES JM jumper (JM0 in this example) MUST be in place on each channel used for current measurements.

Field Wiring Connections

When the terminal module is configured, the next step is to connect field wiring from your application to the terminal module. This section shows example field wiring connections to the HP 44713A/B terminal module for voltage, resistance, or temperature measurements.

Terminal Module Connections

Figure 4-3 shows the HP 44713A/B terminal module with the cover removed. Each of the 24 channels has a HIGH, LOW, and SHIELD terminal. Terminals 0 through 11 in Bank A are for channels 0 through 11 respectively. Terminals 12 through 23 in Bank B are for channels 12 through 23 respectively.

When connecting field wiring to the terminal module, route the wires under the strain relief clamp and tighten the clamp screw to reduce the chance of wires being pulled out of the terminal connectors. If the clamp screw is loosened far enough, the strain relief clamp can be rotated to make it easier to route the wiring.

When connecting components such as resistors, the lead length may be too short to route through the strain relief clamp. In this case, the components will have to be stored inside the terminal module. When connecting these components, make sure that no leads are shorted together and bend the leads to allow the terminal module cover to be replaced.

Voltage Measurements Connections

Figure 4-4 shows typical voltage measurement connections to channel 0 on the terminal module. Note that shielded cable is required for measurements with the HP 44702A/B and HP 44704A voltmeters and is highly recommended for measurements with the HP 44701A voltmeter. For the HP 44702A/B or HP 44704A voltmeter, connect an external resistor (R) between V0 LO and the shield, as shown in Figure 4-4.

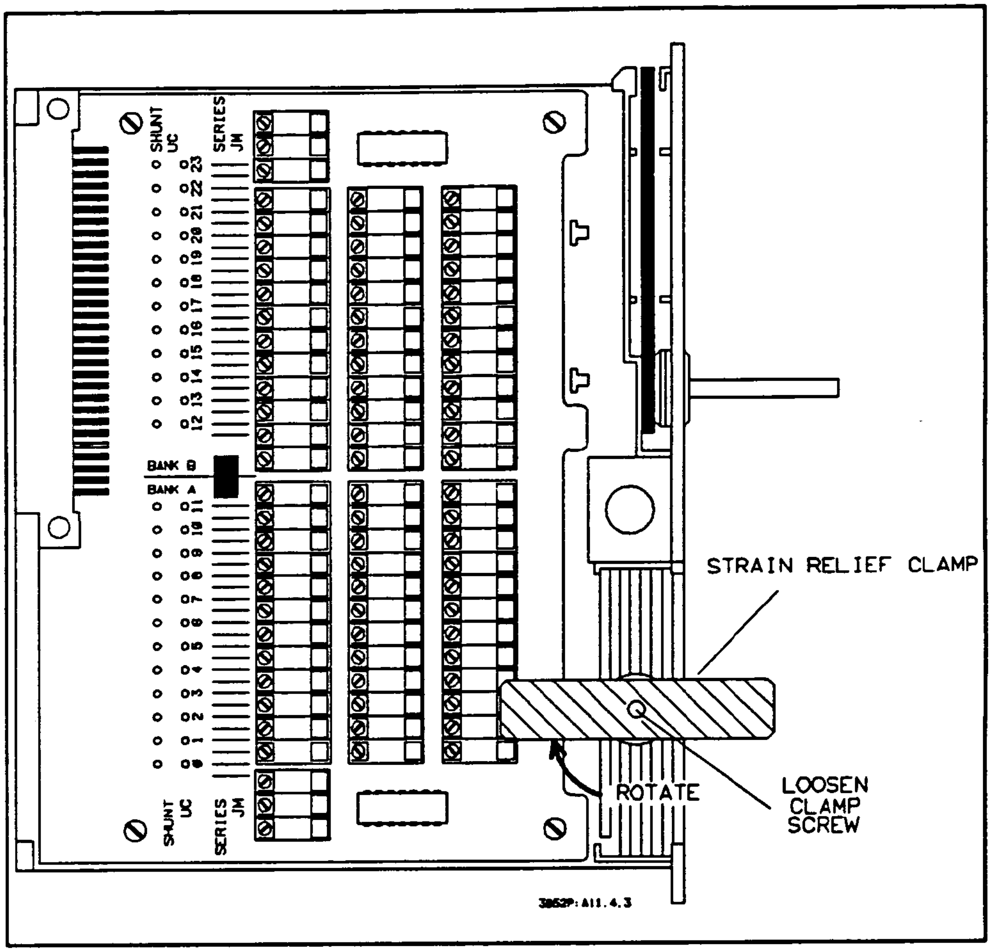


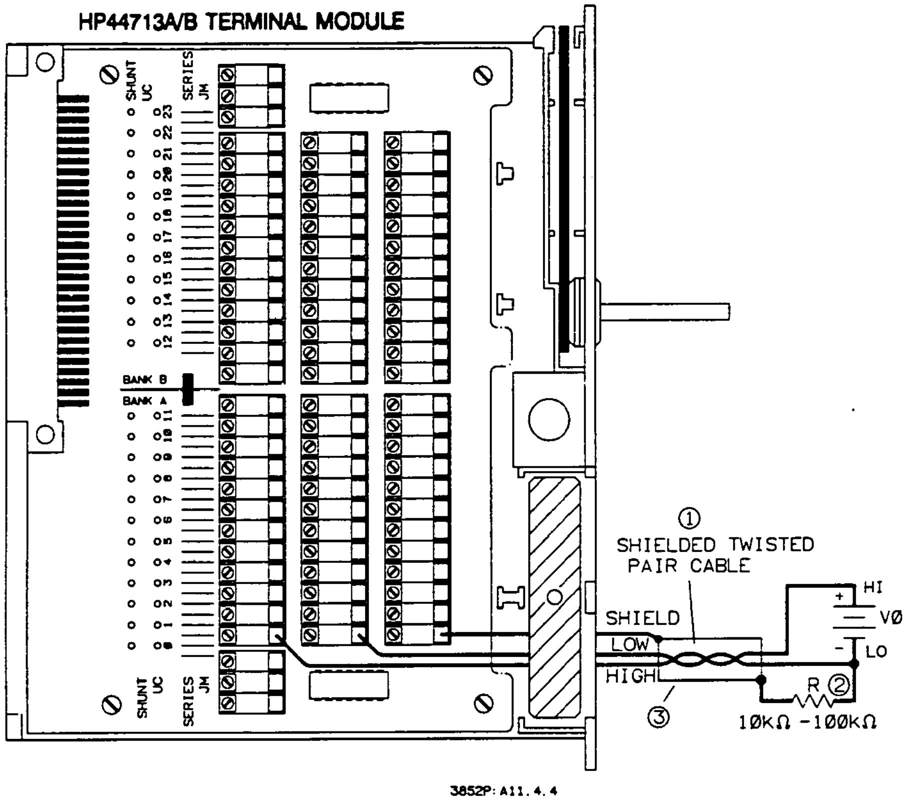
Figure 4-3. HP 44713A/B Terminal Module

Thermocouple Measurement Connections

A primary function of the HP 44713A/B is to make temperature measurements using thermocouples. Since the channels on the HP 44713A/B can be independently configured and software compensation is used, any mixture of thermocouple types can be measured using the HP 44713A/B.

Although the HP 3852A temperature conversions support only B, E, J, K, N14, N28, R, S, and T type thermocouples, you can measure other thermocouples by using your own temperature linearization program. Before connecting thermocouples to the terminal module, refer to Table 4-2 for connection guidelines.

Voltage Measurements



Notes:

[1] = Shielded cable is required for HP 44702A/B and HP 44704A measurements and is highly recommended for HP 44701A measurements.

[2] = For HP 44701A measurements, make a direct connection from the shield to VO LO.

[3] = If shield cable is not used (HP 44701A measurements only), connect separate lead from channel 0 SHIELD to VO LO.

Figure 4-4. HP 44713A/B Voltage Connections

Table 4-2. Thermocouple Connection Guidelines

1. Use the largest thermocouple wire possible that will not shunt significant heat away from the measurement area.
2. Use thermocouple wire that is well within its rating.
3. Avoid mechanical stress and vibration that could strain the thermocouple wires.
4. For long runs, use a shielded, twisted-pair thermocouple extension cable and connect the shield to the SHIELD terminal on the terminal module.
5. Avoid steep temperature gradients.
6. In hostile environments, use proper sheathing material to reduce adverse effects on thermocouple wires.

See Figure 4-5 for example thermocouple (TC0) connections to channel 0. Connect the negative metal lead (red lead) to channel 0 LOW and connect the positive metal lead to channel 0 HIGH. If high common mode noise rejection is required, connect the shield lead from the thermocouple to channel 0 SHIELD.

Installation/Checkout

This section shows how to check identity, verify field wiring connections, and read channel states of an HP 44713A/B.

NOTE

For ribbon cable operation, the cable must be connected between the HP 44713A/B and the HP 44702A/B or HP 44704A voltmeter. For backplane operation, the ribbon cable must NOT be connected. Refer to the HP 3852A Mainframe Configuration and Programming Manual to connect or disconnect the ribbon cable

---

Check HP 44713A/B ID

When you have connected field wiring to the terminal module, replace the terminal module cover and install the HP 44713A/B in the desired mainframe or extender slot. Refer to the HP 3852A Mainframe Configuration and Programming Manual to connect the terminal module to the component module and to install the HP 44713A/B.

Then, use ID? to check the HP 44713A/B ID. At power-on, an HP 44713A/B returns 44713. An HP 44713A/B component module only (no terminal module attached) returns 447XXX. (If the terminal module is removed after power-on, the accessory still returns 44713.)

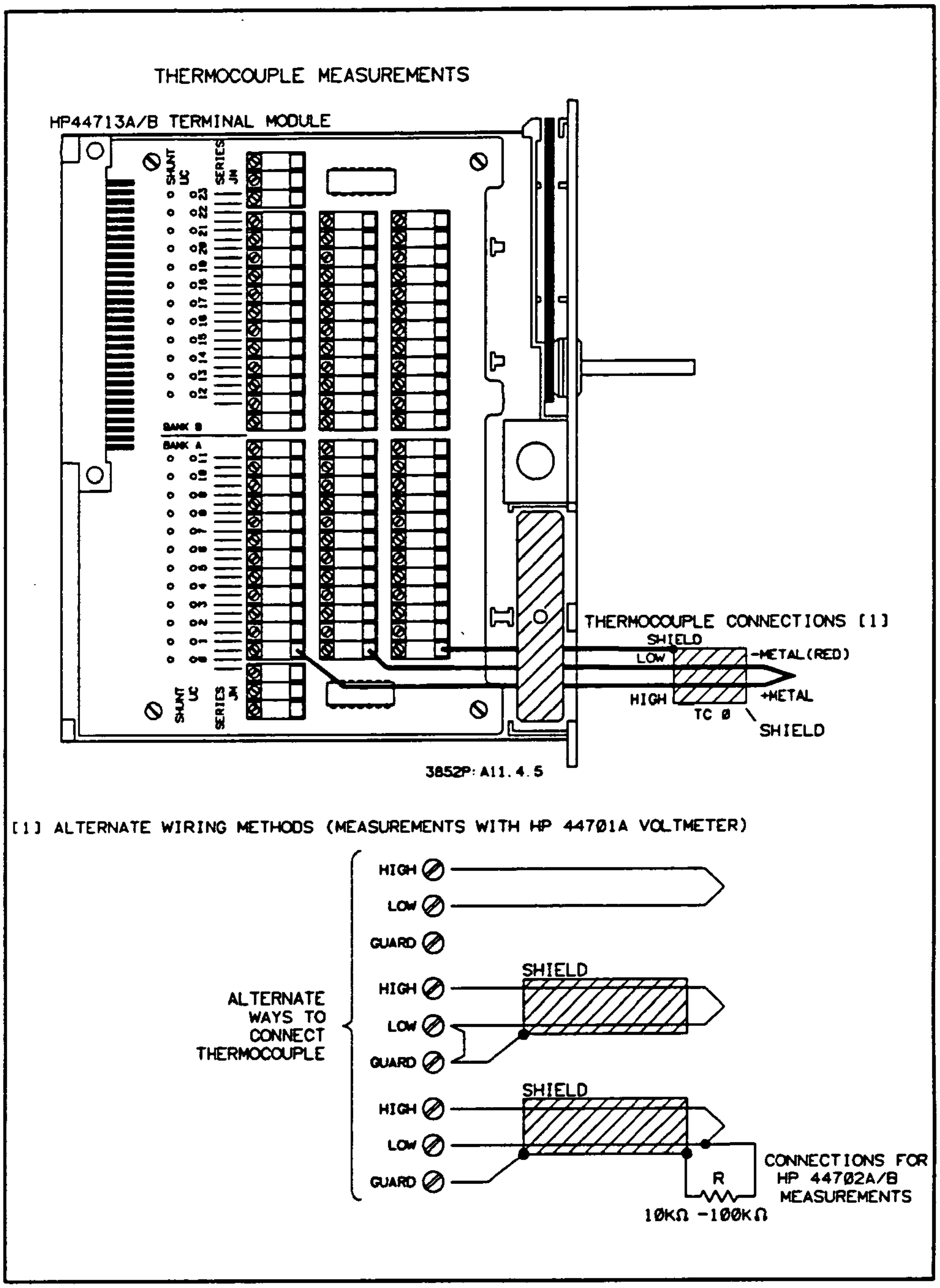


Figure 4-5. HP 44713A/B Thermocouple Connections

If the multiplexer does not return 44713 be sure you have addressed the correct slot and the terminal module is installed. If these are correct but the correct ID code is not returned, refer to the HP 3852A Assembly Level Service Manual for service procedures.

Example: Checking Accessory ID

This program queries the identity of an accessory in slot 5 of the mainframe. An HP 44713A/B in this slot returns 44713A.

```
10 OUTPUT 709;"ID? 500"                  ! Query ID in mainframe slot 5
20 ENTER 709;A$                          ! Enter ID
30 PRINT A$                              ! Display ID
40 END
```

Verify Wiring Connections

To verify that field wiring has been properly connected to the terminal module, you can send MONMEAS (Monitor/Measure) from the mainframe front panel or from a controller. MONMEAS can be used to check DC voltage or resistance connections.

Example: Checking Wiring Connections

This program uses MONMEAS to verify wiring connections to channels 500 through 523 of an HP 44713A. CONF configures the voltmeter in slot 6 for DC voltage measurements.

The 24 channels are scanned and measured one at a time starting with channel 500. Press the SADV KEY key on the mainframe front panel to advance the scan to the next channel. When the scan is advanced past the last channel (channel 523), the scan stops and the last measurement remains on the display.

```
10 OUTPUT 709;"USE 600"                  ! Use voltmeter in mainframe slot 6
20 OUTPUT 709;"CONF DCV"                 ! Set DC volts function on voltmeter
30 OUTPUT 709;"MONMEAS DCV,500-523"      ! Monitor/measure ch 500 through 523
40 END
```

Read Channel State

CLOSE? can be used to determine the state of HP 44713A/B channels. This command returns a 0, 1, 2, 3, or 4 as shown in Table 4-3 for each channel queried. (CLOSE? returns only 0 (open) or 1 (closed) for the state of the isolation relays and the tree switches.)

Table 4-3. Values Returned by CLOSE?

Value Returned*	Channel State
0	Channel Open
1	Channel Closed - not connected to a bus
2	Channel Closed - connected to Sense Bus
3	Channel Closed - connected to Source Bus
4	Channel Closed - connected to both buses

Note:
* = Only 0 (open) or 1 (closed) is returned for isolation relays (channel 90) and tree switches (channel 91 or 92).

Example: Reading Channel State

This program uses CLOSE? to check the state of channels 500 through 504 on an HP 44713A. RST (reset) resets the multiplexer to its power-on state with all channels open. CLOSE closes channel 503 , the isolation relays (channel 590), and the Sense Bus tree switch (channel 592). OPEN opens the channel, the isolation relay, and the tree switch.

```
10 OUTPUT 709;"RST 500"                   ! Open all chs
20 INTEGER State(0:4)                     ! Define controller array
30 OUTPUT 709;"CLOSE 503,590,592"         ! Close ch 503, iso relay, tree switch
40 OUTPUT 709;"CLOSE? 500-504"            ! Query state of chs 500 through 504
50 ENTER 709;State(*)                     ! Enter channel states
60 PRINT State(*)                         ! Display channel states
70 OUTPUT 709;"OPEN 503,590,592"          ! Open ch 503,iso relay, tree switch
80 END
```

Since channel 503 was the only channel closed and was connected to the Sense Bus tree switch, a typical return is:

0 0 0 2 0

HP 44713A/B Option 003

Option 003 to the HP 44713A or 44713B is a special terminal module that adds an anti-noise filter to each of the 24 channels. The addition of this terminal module does not alter the basic operation of the High Speed FET Multiplexer. The terminal block is designed to make DC Volts and Thermocouple measurements.

This page describes the differences and use of the Option 003 Terminal Module. Add this page to your *Configuration and Programming Manual* at the end of Chapter 4.

Terminal Module Description

The Option 003 Terminal Module contains a low-pass filter on each of the 24 channels. Figure 4-6 shows the terminal module. The 24 channels are divided into two banks: Bank A and Bank B. On the terminal module the channels are numbered A0 through A11 and B0 through B11.

The terminal module also contains an isothermal block and thermistor to provide a reference temperature for thermocouple conversions.

Each channel in the terminal block has connections for High, Low and Shield. Figure 4-7 shows a simplified schematic of one channel.

Refer to Figure 4-4 in the *Configuration and Programming Manual* for details about connections for DC Voltage measurements. Figure 4-5 in the *Configuration and Programming Manual* shows thermocouple connections.

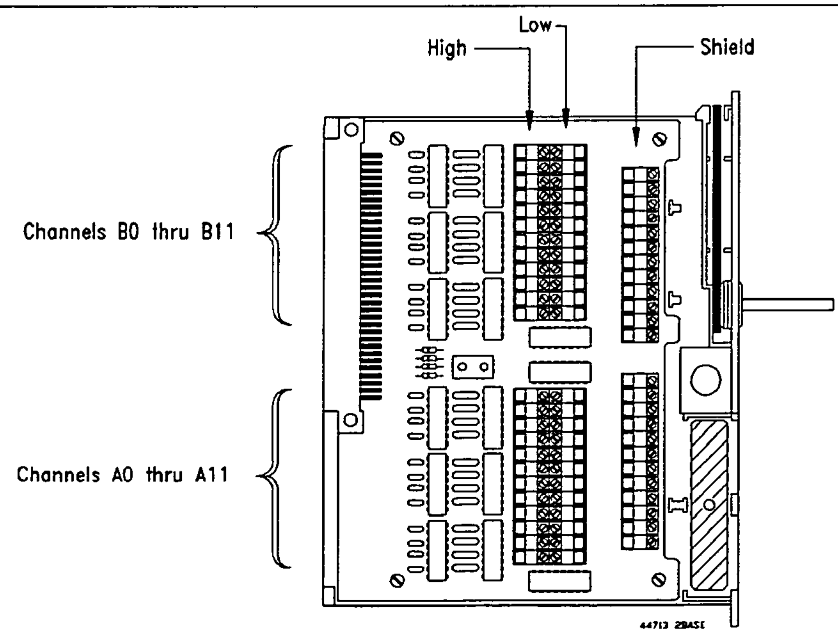


Figure 4-6. HP 44713A/B Option 003 Terminal Block

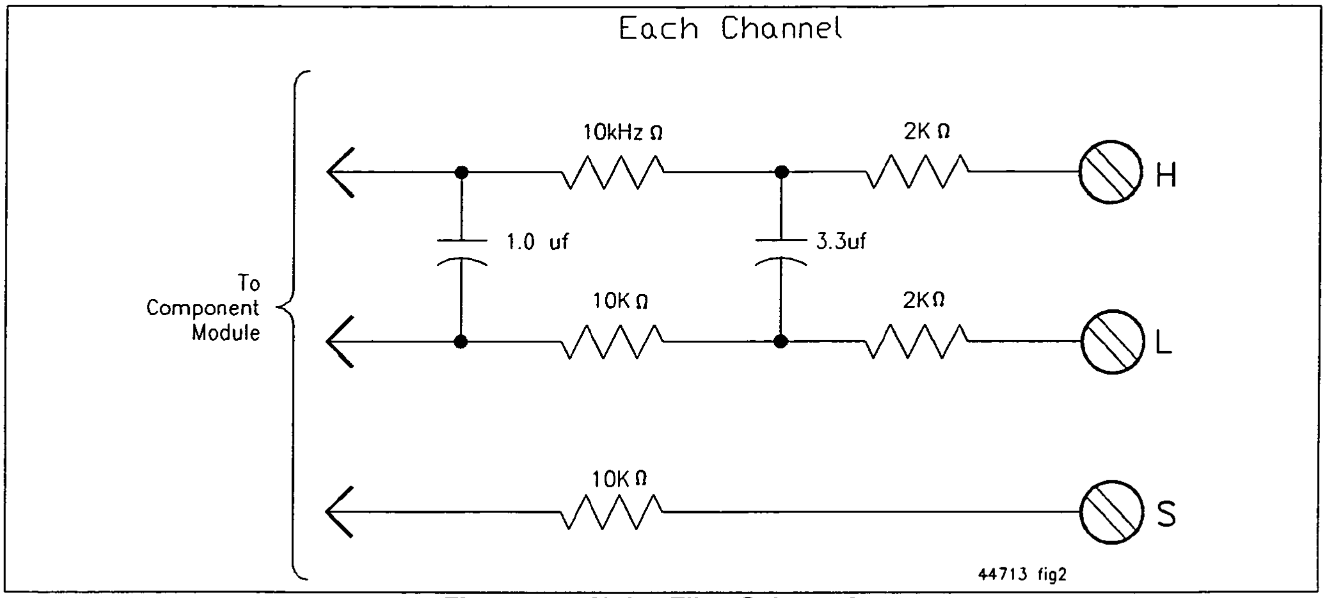
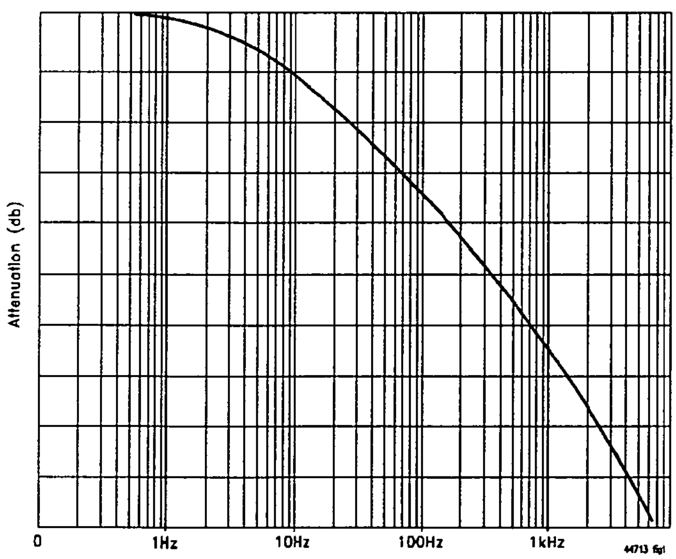


Figure 4-7. Noise Filter Schematic

Specifications

All Specifications are given at a nominal room temperature of 25°C.

HP 44713A/B Option 003 provides 24 two pole RC differential filters, each with poles at 5 Hz and 13 Hz.



Rolloff: 40 dB/decade

Attenuation: 60 Hz −25 dB
50 Hz −21 dB

Differential Offset Voltage: <3μV

Thermal tracking across terminal module:
better than 0.3° C

44713-90020

Chapter 5
Programming the Multiplexers

Contents

Programming the Multiplexers

Programming Overview

This chapter shows how to program the HP 44711A/B, HP 44712A, or HP 44713A/B multiplexer for voltage, current, resistance, or temperature measurements, as applicable. The chapter has two sections:

- **Programming Overview** includes an overview of the chapter contents, summarizes HP 44711A/B/44712A/44713A/B commands, and lists the titles of the example programs in the chapter.
- **Making Measurements** shows how to make voltage, current, resistance, or temperature measurements with an HP 44701A Integrating Voltmeter or with an HP 44702A/B or HP 44704A High-Speed Voltmeter.

Command Summary

Table 5-1 is an alphabetical listing of commands which apply to the HP 44711A/B, HP 44712A, and HP 44713A/B. Refer to the HP 3852A Command Reference Manual for a complete description of these commands.

Table 5-1. Command Summary

CLOSE *ch_list* Closes a single multiplexer channel or a list of channels specified by *ch_list*
CLOSE? *ch_list* **[INTO** *name***]** or **[***fmt***]** Queries the state of the channels specified by *ch_list*
CLWRITE **[***ribbon_bus***]** *ch_list* **[RANGE** *range_list***]** **[USE** *ch***]** Sets channel and range lists to be scanned and used by the High-Speed Voltmeter.
CONF *function* **[USE** *ch***]** Configure the voltmeter measurement function specified by *function*.
CONFMEAS *function ch_list* **[NSCAN** *number***][USE** *ch***]** **[INTO** *name***]** or **[***fmt***]** Configure the voltmeter and measures a function specified by *function* on the multiplexer channels specified by *ch_list*. (NSCAN is valid only for mainframe firmware revision 2.2 and greater.)
ID? **[***slot***]** Returns the identity of the accessory in the slot addressed by *slot*.
MEAS *function ch_list* **[NSCAN** *number***]** **[USE** *ch***]** **[INTO** *name***]** or **[***fmt***]**
MONMEAS *function ch_list* **[USE** *ch***]** Monitors and measures a function specified by *function* on the channels specified by *ch_list*. This command is useful to check wiring connections to the terminal module.
OPEN *ch_list* Opens a multiplexer channel or list of channels specified by *ch_list*. This command is used to open channels and place them is a safe state after measurements have been made.
RST **[***slot***]** Resets the accessory in the slot specified by *slot]* to its power-on state.

Example Program Titles

Table 5-2 lists the titles of the example programs in this chapter. Unless noted, all examples apply to either backplane operation or to ribbon cable operation.

When "ribbon cable only" is specified, the example applies ONLY to measurements with the HP 44702A/B or HP 44704A High-Speed Voltmeter in Scanner Mode with the ribbon cable connected. For ribbon cable measurements, the HP 44702A/B or HP 44704A must be set for Scanner Mode (SCANMODE ON), the ribbon cable between the multiplexer and the HP 44702A/B or HP 44704A must be connected, and TERM RIBBON must be set.

When "backplane only" is specified, the example applies to measurements with the HP 44701A Integrating Voltmeter, or the HP 44702A/B or HP 44704A High-Speed Voltmeter when the input is via the mainframe backplane. For backplane measurements with the HP 44702A/B or HP 44704A, the ribbon cable must NOT be connected.

Table 5-2. Example Program Titles

Title	Description	Multiplexers
	Voltage Measurements	
Voltage Measurements Using CONFMEAS	Measure 24 voltages using CONFMEAS.	HP 44711A/B, HP 44713A/B
Voltage Measurements Using CLWRITE	Measure 9 voltages using CLWRITE. (ribbon cable only)	HP 44711A/B, HP 44713A/B
Voltage Measurements Using CLOSE	Measure a voltage using CLOSE (backplane only).	HP 44711A/B, HP 44713A/B
Single-Ended Voltage Measurements	Measure 48 voltages using CONFMEAS.	HP 44712A
	Current Measurements	
DC Current Measurements	Make a DC current sensing measurement using CONFMEAS.	HP 44711A/B, HP 44713A/B
	Resistance Measurements	
4-Wire Ohms Measurements Using CONFMEAS	Measure 24 resistances using 4-wire ohms and CONFMEAS.	HP 44711A/B
4-Wire Ohms Measurements Using CLWRITE	Measure 9 resistances using 4-wire ohms and CLWRITE (ribbon cable only).	HP 44711A/B
4-Wire Ohms Measurements Using CLOSE	Measure a resistance using 4-wire ohms and CLOSE (backplane only).	HP 44711A/B
	Temperature Measurements	
RTD Measurements	Measure temperature using an RTD and CONFMEAS.	HP 44711A/B
Thermocouple Measurements	Make 20 temperature measurements using J-type thermocouples and CONFMEAS.	HP 44713A/B
Isothermal Block Reference Temperature	Measure the isothermal block (reference) temperature of an HP 44713A/B using CONFMEAS.	HP 44713A/B

Making Measurements

This section shows how to make voltage, current, resistance, or temperature measurements using an HP 44711A/B, HP 44712A, or HP 44713A/B multiplexer with an HP 44701A, an HP 44702A/B, or an HP 44704A voltmeter. Refer to Table 5-2 for a list of example program titles.

All example programs in this section use a multiplexer in slot 5 of the mainframe and an HP 44701A voltmeter in slot 6 or an HP 44702A/B or HP 44704A High-Speed Voltmeter in slots 6 and 7 (programming address 600) of the mainframe.

In general, program examples show how to make measurements with the HP 44702A/B or HP 44704A voltmeter in Scanner Mode (SCANMODE ON) with the ribbon cable connected from the HP 44702A/B or HP 44704A to the multiplexer.

NOTE

The HP 44704A High-Speed Voltmeter in its default 13 bit resolution mode (RESOL 13) can be substituted for the HP 44702A/B in all examples.

To modify the programs for measurements with the HP 44702A/B or HP 44704A in System Mode, change "SCANMODE ON" to "SCANMODE OFF" and disconnect the ribbon cable. To modify the programs for measurements with the HP 44701A voltmeter, delete the line containing "SCANMODE ON" and disconnect the ribbon cable.

NOTE

1. When a program example is labeled "ribbon cable only", the measurement can be done only with an HP High-Speed Voltmeter in the Scanner Mode with the ribbon cable connected and TERM RIBBON set. CLOSE, CLOSE?, and OPEN commands will not work for ribbon cable measurements.

2. When a program example is labeled "backplane only", the ribbon cable must NOT be connected and TERM BOTH (HP 44701A) or TERM INT (HP High-Speed Voltmeter) must be set. The CLWRITE command does not apply to backplane measurements.

Voltage Measurements

Four examples to measure DC voltages on an HP 44711A/B, HP 44712A, or HP 44713A/B follow. The first example uses CONFMEAS for 24 voltage measurements; the second uses CONF and CLWRITE (ribbon cable measurements only) to take 9 voltage measurements; the third uses CLOSE (backplane measurements only) to measure a single channel; and the fourth uses CONFMEAS for 48 single-ended voltage measurements.

Example: Voltage Measurements Using CONFMEAS

This program measures DC voltages connected to channels 500 through 523 of an HP 44711A or HP 44713A using an HP 44702A/B in Scanner Mode. See

Figure 2-4 for typical connections to the HP 44711A/B. See Figure 4-4 for typical connections to the HP 44713A/B.

In line 40, CONFMEAS DCV,500-523 configures the voltmeter for DC voltage measurements and measures each of the 24 channels once. Since Scanner Mode is set (SCANMODE ON in line 30), CONFMEAS also sets TERM RIBBON.

```
10 DIM Volts[0:23]                       ! Define controller array
20 OUTPUT 709;"USE 600"                  ! Use voltmeter in mainframe slot 6
30 OUTPUT 709;"SCANMODE ON"              ! Set Scanner Mode
40 OUTPUT 709;"CONFMEAS DCV,500-523"     ! Set DC volts, meas ch 500-523
50 ENTER 709;Volts(*)                    ! Enter 24 readings
60 PRINT USING "K,/";Volts(*)            ! Display 24 readings
70 END
```

For a set of 5 V 5% inputs, a typical return is:

```
4.993 ─┐
4.993  │
.      ├── 24 readings
.      │
4.994 ─┘
```

Example: Voltage Measurement Using CLWRITE

Ribbon Cable Only

This program measures DC voltages connected to channels 500-502 of an HP 44711A or HP 44713A using an HP 44702A/B. See Figure 2-4 for typical connections to the HP 44711A/B. See Figure 4-4 for typical connections to the HP 44713A/B.

In lines 60 - 90, RDGSMODE COMPLETE trims the data in the voltmeter buffer to that generated by two prescans plus one postscan (as set by PRESCAN 2 and POSTSCAN 1). CLWRITE SENSE,500-502 sets the ribbon cable interface for DC voltage measurements and specifies channels 500 through 502 as the channels in the channel list.

In lines 100 - 120, STTRIG EXT0 sets the Stop trigger source to the EXT0 port, STSLOPE HL sets the slope of the input to high-to-low, and SCTRIG INT sets the Scan trigger source to internal.

When SCTRIG INT is executed, the voltmeter makes continuous passes through channels 500 through 502 until a low-going pulse is input to the

EXT0 port and the Stop Trigger occurs. The voltmeter then makes one postscan pass and halts.

In line 130, XRDGS transfers 9 readings (2 prescans + 1 postscan pass of three channels). Since RDGSMODE COMPLETE is set, the readings transferred are from the last two prescans before the Stop Trigger occurs plus the readings from the single postscan. For example, if 8 prescans occurred before the Stop Trigger, the 3 readings from prescans #7 and #8 plus the 3 readings from postscan #1 are transferred by XRDGS.

```
10 DIM Volts(0:8)                          ! Dimension controller array
20 OUTPUT 709;"RST 600"                    ! Reset HP 44702A/B
30 OUTPUT 709;"USE 600"                    ! Use voltmeter in mainframe slot 6
40 OUTPUT 709;"SCANMODE ON"                ! Set Scanner Mode
50 OUTPUT 709;"CONF DCV"                   ! Set DC volts
60 OUTPUT 709;"RDGSMODE COMPLETE"          ! Trim to 2 prescans + 1 postscan
70 OUTPUT 709;"CLWRITE SENSE,500-502"      ! Set ribbon cable to DC volts
80 OUTPUT 709;"PRESCAN 2"                  ! Set 2 prescans
90 OUTPUT 709;"POSTSCAN 1"                 ! Set 1 postscan
100 OUTPUT 709;"STTRIG EXT0"               ! Set EXT0 port as Stop Trig source
110 OUTPUT 709;"STSLOPE HL"                ! Set Stop Trig slope for HL
120 OUTPUT 709;"SCTRIG INT"                ! Set Scan Trig source to internal
130 OUTPUT 709;"XRDGS 600"                 ! Transfer 9 readings
140 ENTER 709;Volts(*)                     ! Enter 9 readings
150 PRINT USING "K,/";Volts(*)             ! Display 9 readings
160 END
```

For a set of 9 V 5V% voltage sources connected to channels 500-502, a typical return (values in Volts) follows. The return assumes k prescan passes before the Stop Trigger (low-going pulse into EXT0) occurred.

```
8.993 ┐
9.001 ├── Prescan k-1
8.998 ┘
8.989 ┐
8.999 ├── Prescan k
9.002 ┘
9.001 ┐
8.998 ├── Postscan 1
9.002 ┘
```

Example: Voltage Measurements Using CLOSE

Backplane Only

This program uses CLOSE to measure the voltage connected to channel 500 of an HP 44711A or HP 44713A using an HP 44702A/B voltmeter in System

Mode (SCANMODE OFF). See Figure 2-4 for typical connections to the HP 44711A/B. See Figure 4-4 for typical connections to the HP 44713A/B.

CAUTION

The CLOSE command does not close channels in a break-before-make fashion. Therefore, the command can cause damage to the multiplexer accessory (relay or FET) and external system if it is used to force one channel open by closing another. This applies to channels in the same bank, in separate banks tied together by tree relays, and to the relays themselves.

Before a channel is closed with the CLOSE command, use the OPEN command to open the channel that is currently closed. This prevents any two channels from being closed at the same time and reduces the risk of damaging your equipment.

NOTE

CLOSE is a low-level command intended for individual switch control in special signal routing applications. It is not the easiest way to do routine measurements since the tree switches and the isolation relays are not automatically configured as with the high-level commands.

In the program, CLOSE closes the measurement channel (channel 500), the Sense Bus tree switch (channel 592), and the isolation relays (channel 590) on the HP 44711A or HP 44713A. CONF configures the voltmeter for DC voltage measurements, TRIG triggers the voltmeter to take a single measurement, and CHREAD sends the reading from the voltmeter to the output buffer. OPEN opens the channel, the isolation relays, and the Sense Bus tree switch after the measurement has been taken.

NOTE

To use the program for an AC voltage measurement with the HP 44701A voltmeter, substitute the following line for line 30:

```
30 OUTPUT 709;"CONF ACV"
```

```
10 OUTPUT 709;"USE 600"                  ! Use voltmeter in mainframe slot 6
20 OUTPUT 709;"CLOSE 500,590,592"        ! Close ch 500, iso relays, tree switch
30 OUTPUT 709;"CONF DCV"                 ! Set DC volts
40 OUTPUT 709;"TRIG SGL"                 ! Trigger voltmeter
50 OUTPUT 709;"CHREAD 600"               ! Transfer reading to output buffer
60 ENTER 709;A                           ! Enter reading
70 PRINT A                               ! Display reading
80 OUTPUT 709;"OPEN 500,590,592"         ! Open ch 500, iso relays, tree switch
90 END
```

A typical return from a 5V 5% input is:

```
4.987
```

Example: Single-Ended Voltage Measurements

This program uses CONFMEAS to measure DC voltages connected to channels 500 through 547 of an HP 44712A using an HP 44702A/B in Scanner Mode. See Figure 3-3 for typical connections to the HP 44712A.

In line 40, CONFMEAS DCV,500-547 configures the voltmeter for DC voltage measurements and measures each of the 48 channels once. Since Scanner Mode is set (SCANMODE ON in line 30), CONFMEAS also sets TERM RIBBON.

```
10 DIM Volts(0:47)                       ! Dimension controller array
20 OUTPUT 709;"USE 600"                  ! Use voltmeter in mainframe slot 6
30 OUTPUT 709;"SCANMODE ON"              ! Set Scanner Mode
40 OUTPUT 709;"CONFMEAS DCV,500-547"     ! Set DC volts, meas ch 500-547
50 ENTER 709;Volts(*)                    ! Enter 48 readings
60 PRINT USING "K,/";Volts(*)            ! Display 48 readings
70 END
```

For a set of 9 V 5V% inputs, a typical return is:

```
8.93  ┐
8.995 │
.     ├── 48 readings
.     │
8.974 ┘
```

Current Measurements

An example follows to show how to program the HP 44711A/B or HP 44713A/B for DC current measurements.

NOTE

Current sensing measurements are not recommended when making temperature measurements on the same HP 44713A/B terminal module since the heat produced by the shunt resistor may affect the accuracy of the temperature measurements.

Example: DC Current Measurements

This program uses CONFMEAS to measure DC voltage across a 250 Ω shunt resistor on channel 500 of an HP 44711A or HP 44713A using an HP 44702A/B in System Mode. CONFMEAS configures the voltmeter for DC voltage measurements and measures the channel once.

The equivalent current value is computed in the controller by using Current = Volts/250 (line 40). See Figure 2-2 to install a shunt resistor on the HP 44711A/B terminal module. See Figure 4-2 to install a shunt resistor on the HP 44713A/B terminal module.

```
10 OUTPUT 709;"USE 600"                  ! Use voltmeter in mainframe slot 6
20 OUTPUT 709;"CONFMEAS DCV,500"         ! Set DC volts, measure ch 500
30 ENTER 709;Volts                       ! Enter DC voltage value
40 PRINT Volts/250                       ! Display DC current value = Volts/250
50 END
```

If a 250 Ω 5% resistor is used, a typical return from a current source which is outputting 10 mA (value in Amps) is:

```
.01004
```

Resistance Measurements

Three examples follow to show how to make resistance measurements with an HP 44711A/B. The first example uses 4-wire ohms and CONFMEAS, the second uses 4-wire ohms and CLWRITE (ribbon cable measurement only), and the third uses 4-wire ohms and CLOSE (backplane measurements only).

Example: 4-Wire Ohms Measurements Using CONFMEAS

This program uses CONFMEAS to measure resistances connected to channels 500 through 523 of an HP 44711A using an HP 44702A/B in Scanner Mode. See Figure 2-5 for typical connections to the HP 44711A/B.

In line 40, CONFMEAS OHMF configures the voltmeter for 4-wire ohms measurements and measures each of the 24 channels once. Since Scanner Mode is set (SCANMODE ON in line 30), CONFMEAS also sets TERM RIBBON.

```
10 DIM Ohms(0:23)                            ! Dimension controller array
20 OUTPUT 709;"USE 600"                      ! Use voltmeter in mainframe slot 6
30 OUTPUT 709;"SCANMODE ON"                  ! Set Scanner Mode
40 OUTPUT 709;"CONFMEAS OHMF,500-523"        ! Set 4-wire ohms, meas ch 500-523
50 ENTER 709;Ohms(*)                         ! Enter 24 readings
60 PRINT USING "K,/";Ohms(*)                 ! Display 24 readings
70 END
```

For a set of 5 kΩ 5% resistors, a typical return (values in Ohms) is:

```
4928.34 ─┐
5024.9   │
.        ├──── 24 readings
.        │
5008.38 ─┘
```

Example: 4-Wire Ohms Measurements Using CLWRITE

Ribbon Cable Only

This program measures resistances connected to channels 500-502 of an HP 44711A using an HP 44702A/B in Scanner Mode. See Figure 2-5 for typical connections to the HP 44711A/B.

In lines 60 - 90, RDGSMODE COMPLETE trims the data in the voltmeter buffer to that generated by two prescans plus one postscan (as set by PRESCAN 2 and POSTSCAN 1). CLWRITE SEP, 500-502 sets the ribbon cable interface for 4-wire ohms measurements and specifies channels 500 through 502 as the channels in the channel list.

In lines 100 - 120, STTRIG EXT0 sets the Stop Trigger source to the EXT0 port, STSLOPE HL sets the slope of the input to high-to-low, and SCTRIG INT sets the Scan Trigger source to internal.

When SCTRIG INT is executed, the voltmeter makes continuous passes through channels 500 through 502 until a low-going pulse is input to the EXT0 port and the Stop Trigger occurs. The voltmeter then makes one postscan pass and halts.

In line 130, XRDGS transfers 9 readings (2 prescans + 1 postscan pass for three channels). Since RDGSMODE COMPLETE is set, the readings transferred are from the last two prescans before the Stop Trigger occurs plus the readings from the postscan pass. For example, if 8 prescans occurred before the Stop Trigger, the data from prescans #7 and #8 plus the data from postscan #1 are transferred by XRDGS.

```
10 DIM Ohms(0:8)                          ! Dimension controller array
20 OUTPUT 709;"RST 600"                   ! Reset HP 44702A/B
30 OUTPUT 709;"USE 600"                   ! Use voltmeter in mainframe slot 6
40 OUTPUT 709;"SCANMODE ON"               ! Set Scanner Mode
50 OUTPUT 709;"CONF OHMF"                 ! Set 4-wire ohms
60 OUTPUT 709;"RDGSMODE COMPLETE"         ! Trim to 2 prescans + 1 postscan
70 OUTPUT 709;"CLWRITE SEP,500-502"       ! Set ribbon cable to 4-wire ohms
80 OUTPUT 709;"PRESCAN 2"                 ! Set 2 prescans
90 OUTPUT 709;"POSTSCAN 1"                ! Set 1 postscan
100 OUTPUT 709;"STTRIG EXT0"              ! Set EXT0 port as Stop Trigger source
110 OUTPUT 709;"STSLOPE HL"               ! Set Stop Trig slope for HL
120 OUTPUT 709;"SCTRIG INT"               ! Set Scan Trig source to internal
130 OUTPUT 709;"XRDGS 600"                ! Transfer 9 readings
140 ENTER 709;Ohms(*)                     ! Enter 9 readings
150 PRINT USING "K,/";Ohms(*)             ! Display 9 readings
160 END
```

For a set of 10 kΩ 5% resistors connected to channels 500-502 , a typical return (values in Ohms) follows. The return assumes k prescan passes before the Stop Trigger (low-going pulse into EXT0) occurred.

```
9993   ┐
9993.3 ├── Prescan k-1
9993.5 ┘
9999.1 ┐
9999   ├── Prescan k 3
9999   ┘
9998.3 ┐
9998.5 ├── Postscan 1
9998.6 ┘
```

Example: 4-Wire Ohms Measurements Using CLOSE

Backplane Only

This program makes a 4-wire ohms measurement of channel 500 of an HP 44711A using CLOSE and an HP 44702A/B in System Mode. See Figure 2-5 for typical connections to the HP 44711A/B.

CAUTION

The CLOSE command does not close channels in a break-before-make fashion. Therefore, the command can cause damage to the multiplexer accessory (relay or FET) and external system if it is used to force one channel open by closing another. This applies to channels in the same bank, in separate banks tied together by tree relays, and to the relays themselves.

Before a channel is closed with the CLOSE command, use the OPEN command to open the channel that is currently closed. This prevents any two channels from being closed at the same time and reduces the risk of damaging your equipment.

NOTE

CLOSE is a low-level command intended for individual switch control in special signal routing applications. It is not the easiest way to do routine measurements since the tree switches and the isolation relays are not automatically configured as with the high-level commands.

In the program, CLOSE closes the measurement channel (channel 500) and configures the HP 44711A for 4-wire ohms measurements (channel 594). CONF configures the voltmeter for 4-wire ohms measurements; TRIG triggers the voltmeter to take a single measurement; and CHREAD transfers the resistance value from the voltmeter to the output buffer. OPEN opens the channel and disconnects it from the backplane after the measurement has been taken.

```
10 OUTPUT 709;"USE 600"                     ! Use voltmeter in mainframe slot 6
20 OUTPUT 709;"CLOSE 500,590,594"           ! Close ch 500, config for 4-wire ohms
30 OUTPUT 709;"CONF OHMF"                   ! Config voltmeter for 4-wire ohms meas
40 OUTPUT 709;"TRIG SGL"                    ! Trigger the voltmeter
50 OUTPUT 709;"CHREAD 600"                  ! Transfer reading to output buffer
60 ENTER 709;A                              ! Enter reading
70 PRINT A                                  ! Display reading
80 OUTPUT 709;"OPEN 500,590,594"            ! Open ch and tree switches
90 END                                      !
```

For a 10 kΩ 5V% resistor, a typical return (value in Ohms) is:

```
9999.98
```

Temperature Measurements

Three example programs to measure temperature follow. The first example shows how to program the HP 44711A/B for RTD measurements, the second example shows how to program the HP 44713A/B for thermocouple measurements, and the third example shows how to measure the isothermal block (reference temperature) on an HP 44713A/B.

Example: RTD Measurements

This program uses CONFMEAS to measure a Type 92 RTD connected to channel 500 of an HP 44711A using 4-wire ohms and an HP 44702A/B in Scanner Mode. See Figure 2-5 for typical connections to the HP 44711A/B.

In line 30, CONFMEAS RTD92,500 sets 4-wire ohms measurement of a Type 92 RTD and sets channel 500 as the Sense Channel. (The mainframe automatically configures channel 512 as the Source Channel.) Since Scanner Mode is set (SCANMODE ON in line 20), CONFMEAS also sets TERM RIBBON.

```
10 OUTPUT 709;"USE 600"                    ! Use voltmeter in mainframe slot 6
20 OUTPUT 709;"SCANMODE ON"                ! Set Scanner Mode
30 OUTPUT 709;"CONFMEAS RTD92,500"         ! Conf for type 92 RTD, meas ch 500
40 ENTER 709;A                             ! Enter temperature
50 PRINT A                                 ! Display temperature
60 END
```

A typical return value (in °C) for a Type 92 RTD at room temperature is:

```
24.54297
```

Example: Thermocouple Measurements

This program uses CONFMEAS to make temperature measurements of J-type thermocouples connected to channels 500 through 523 of an HP 44713A using an HP 44702A/B in Scanner Mode. See Figure 4-5 for typical connections to the HP 44713A/B.

In line 40, CONFMEAS TEMPj,500-523 sets measurement of a J-type thermocouple and sets channels 500 through 523 as the channels to be scanned. Since Scanner Mode is set (SCANMODE ON in line 30), CONFMEAS also sets TERM RIBBON.

```
10 DIM Temp(0:23)                          ! Define controller array
20 OUTPUT 709;"USE 600"                    ! Use voltmeter in mainframe slot 6
30 OUTPUT 709;"SCANMODE ON"                ! Set Scanner Mode
40 OUTPUT 709;"CONFMEAS TEMPJ,500-523"     ! Conf for J-type t-couple, meas ch
50 ENTER 709;Temp(*)                       ! Enter 24 temperature readings
60 PRINT USING "K,/";Temp(*)               ! Print readings
70 END
```

For J-Type thermocouples at room temperature, a typical return (values in °C) is:

```
24.542  ┐
24.5415 │
.       ├── 24 readings
.       │
25.856  ┘
```

Example: Isothermal Block Reference Temperature

The HP 3852A linearization program supports B, E, J, K, N14, N28, R, S, and T type thermocouples. However, to use a different type of thermocouple for temperature measurements, you will need to measure the reference temperature (isothermal block temperature) to use in your own linearization program. This program shows how to measure the reference temperature of an HP 44713A in slot 5 using CONFMEAS and an HP 44702A/B in Scanner Mode.

```
10 OUTPUT 709;"USE 600"                    ! Use voltmeter in mainframe slot 6
20 OUTPUT 709;"SCANMODE ON"                ! Set Scanner Mode
30 OUTPUT 709;"CONFMEAS REFT,500"          ! Meas ref temp in mainframe slot 5
40 ENTER 709;A                             ! Enter reference temperature
50 PRINT A                                 ! Display reference temperature
60 END                                     !
```

For an HP 44713A/B at room temperature, a typical return (value in °C) is:

```
24.438
```

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HP 3852A Data Acquisition/Control Unit

HP 44715A
5-Channel Counter Accessory

Configuration and Programming Manual

HEWLETT PACKARD

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HEWLETT PACKARD

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HEWLETT PACKARD

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F

HEWLETT PACKARD

SAFETY SUMMARY

The following general safety precautions must be observed during all phases of operation, service, and repair of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended use of the instrument. Hewlett-Packard Company assumes no liability for the customer's failure to comply with these requirements.

GROUND THE INSTRUMENT

To minimize shock hazard, the instrument chassis and cabinet must be connected to an electrical ground.

DO NOT OPERATE IN AN EXPLOSIVE ATMOSPHERE

Do not operate the instrument in the presence of flammable gases or fumes. Operation of any electrical instrument in such an environment constitutes a definite safety hazard.

KEEP AWAY FROM LIVE CIRCUITS

Operating personnel must not remove instrument covers. Component replacement and internal adjustments must be made by qualified maintenance personnel. Under certain conditions, dangerous voltages may exist even with the instrument switched off. To avoid injuries, always disconnect input voltages and discharge circuits before touching them.

DO NOT SERVICE OR ADJUST ALONE

Do not attempt internal service or adjustment unless another person, capable of rendering first aid and resuscitation, is present.

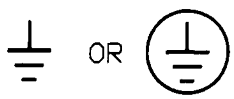
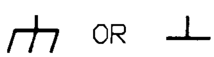
DO NOT SUBSTITUTE PARTS OR MODIFY INSTRUMENT

Because of the danger of introducing additional hazards, do not install substitute parts or perform any unauthorized modification to the instrument. Return the instrument to a Hewlett-Packard Sales and Service Office for service and repair to ensure that safety features are maintained.

C

Operating and Safety Symbols

Symbols Used On Products And In Manuals

~ LINE	AC line voltage input receptacle.
	Instruction manual symbol affixed to product. Warns and cautions the user to refer to respective instruction manual procedures to avoid personal injury or possible damage to the product.
	Indicates dangerous voltage – terminals connected to interior voltage exceeding 1000 volts.
	Protective conductor terminal. Indicates the field wiring terminal that must be connected to earth ground before operating equipment – protects against electrical shock in case of fault.
	Clean ground (low-noise). Indicates terminal that must be connected to earth ground before operating equipment – for single common connections and protection against electrical shock in case of fault.
	Frame or chassis ground. Indicates equipment chassis ground terminal – normally connects to equipment frame and all metal parts.
	Affixed to product containing static sensitive devices – use anti-static handling procedures to prevent electrostatic discharge damage to components.

NOTE

NOTE
Calls attention to a procedure, practice, or condition that requires special attention by the reader.

CAUTION

CAUTION
Calls attention to a procedure, practice, or condition that could possibly cause damage to equipment or permanent loss of data.

WARNING

WARNING
Calls attention to a procedure, practice, or condition that could possibly cause bodily injury or death.

WARNING, CAUTION, and NOTE Symbols

Some labels on the HP 3852A, HP 3853A, and plug-in accessories include an international warning symbol (triangle with subscripted number) which refers the reader to the manuals for further information. This table shows the warning symbols used for the HP 3852A/3853A and plug-in accessories. Refer to the manual set for specific information on WARNINGS, CAUTIONS, or NOTES referenced with a warning symbol.

HP 3852A WARNING, CAUTION, and NOTE Symbols

Symbol	Meaning	Location
⚠ 1	Shock hazard originating outside the instrument (field wiring)	. Analog Extender Connector on Power Supply Modules . Terminal modules on plug-in accessories . Component module covers on plug-in accessories
⚠ 2	Treat all channels as "one circuit" for safety purposes.	. Inside terminal modules on plug-in accessories . Metal cover on component modules of plug-in accessories
⚠ 3	Maximum number of certain plug-in accessories to be installed into an HP 3852A or HP 3853A.	. HP 44701A, HP 44702A/B, HP 44727A/B/C plug-in accessories
⚠ 4	If High-Speed FET multiplexers are used with the HP 44702A/B, ribbon cable may be connected.	. HP 44711A, 44712A, 44713A (referenced on HP 44702A and HP 44702B)

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Chapter 1

Introduction

Manual Contents

This manual shows how to configure and program the HP 44715A 5-Channel Counter/Totalizer (200 kHz) (counter). Refer to the HP 3852A Mainframe Configuration and Programming Manual for additional information on the counter. Manual chapters are:

- **Introduction** contains a manual overview, describes the counter, and shows suggested steps to get started.

- **Selecting Counter Functions** gives guidelines to define your measurement and to select the counter function required for the measurement.

- **Configuring the Counter** shows how to configure counter channels and how to install and initially check the accessory.

- **Programming the Counter** shows how to program the counter for counting and measurement functions and how to enable the counter for interrupts.

Counter Description

The HP 44715A 5-Channel Counter/Totalizer (200 kHz) (counter) consists of a counter component module and a terminal module. The counter has five channels which can be programmed for one of several functions. Each channel can be hardware configured to one of four operating modes.

Counter Functions

The counter can be programmed for counting or measurement functions, as shown in Table 1-1. (Quadrature Count also requires that jumper settings be changed on the component module.) The counting functions continuously repeat the count sequence, while the measurement functions perform a one-time measurement.

Inputs to the counter can be single input (A input) or double input (A input and B input). The B input is not used for single input functions. For double input functions, the A input is defined as the primary measurement input and the B input as an auxiliary input (usually a gate).

Some functions are defined as Modulo NPER, where the NPER value is set with the NPER *number* parameter and the range of NPER *number* = 1 to 65535. In Table 1-1, "transitions" refers to input state changes from low to high or high to low, as programmed.

Table 1-1. Counter Functions

Function	Description	Application
Totalize Counts		
Ungated Total Counts	Count number of A input transitions.	Total counts on single input.
Gated Total Counts	Count number of A input transitions, gate with B input.	Total counts on single input gated by second input.
Ungated Total Counts, Modulo NPER	Count number of A input transitions, modulo NPER.	Total counts on single input, modulo NPER.
Gated Total Counts, Modulo NPER	Count number of A input transitions, modulo NPER. Gate with B input.	Total counts on single input gated by second input, count modulo NPER.
Up/Down Counts		
Up/Down Counts	Count up on A input, count down on B input. Result is (A-B) counts.	Count difference between counts of two inputs.
Up/Down Counts, Modulo NPER	Count up on A input, count down on B input. Result is (A-B) counts, modulo NPER.	Count difference between counts of two inputs, Modulo NPER.
Count With Direction Control		
Count/ Direction	Count A input up or down. B input controls direction.	Count relative number of up counts and down counts.
Count/ Direction, Modulo NPER	Count A input up or down. B input controls direction. Count modulo NPER.	Count relative number of up counts and down counts, modulo NPER.
Quadrature Count	Count up on all A input transitions when B input leads A input. Count down on all A input transitions when A input leads B input.	Quadrature counts.
Quadrature Count, Modulo NPER	Same as Quadrature Count except count modulo NPER.	Quadrature counts, modulo NPER.
Ratio Measurements		
Ratio	Measure average number of A input counts per B input period.	Measure average number of counts per period of second input (A/B).
Period Measurements		
Period	Measure average of NPER periods of A input.	Measure average value of NPER periods of input.
Delayed Period	Measure NPERth gated period of A input, gate with B input.	Measure value of single period of input, delayed by NPER periods.
Frequency Measurements		
Frequency	Measure average frequency of A input.	Measure frequency of single input.

Input Signals

As shown in Figure 1-1, the counter consists of a component module and a terminal module. User signals are input to the terminal module to either Isolated (± 170 V to chassis maximum) or to Non Isolated (± 10 V to chassis maximum) channels. Each Isolated channel has a 5V/12V/24V signal level jumper which can be set as required. User-supplied passive (R, C) signal conditioning elements can also be added to each channel.

Non Isolated channels have AC/TTL jumpers for each channel. Use the AC jumper position to detect zero crossings or use the TTL position for TTL level signals. As required, user-supplied signal conditioning can be added to each Non Isolated channel. For otherwise floating inputs, such as relays or open collector outputs, the PULLUP resistor and SHIELD connections can be used.

The counter can also be used for quadrature measurements in 3 CH or 4 CH configuation when the quadrature jumpers on the component module are set to the Quadrature position.

Operating Modes

The counter must be hardware configured with the Card Configuration jumper on the terminal module to specify which function(s) shown in Table 1-1 can be performed on counter channels.

The Card Configuration jumper sets allowable counter measurement function(s) and defines the channels which can be used for the measurement. The jumper has four positions: TOTAL, FREQ, 4 CH, and 3 CH. See Figure 1-1 for counter functions and channel definitions for each position.

When the jumper is set for TOTAL, only Ungated Total Counts and Ungated Total Counts, Modulo NPER can be performed on each channel. When the jumper is set for FREQ, only Frequency Measurements can be performed on each channel. For the 4 CH or 3 CH positions, any function except Frequency Measurements can be performed on any channel.

Triggering

For either Isolated or Non Isolated channels, the counter can be triggered externally with an input to the XTRG terminals. Inputs to the XTRG terminals can be from an external (user) source or from the PACER OUT BNC port. In addition, the counter can be triggered internally from the mainframe or from the counter component module.

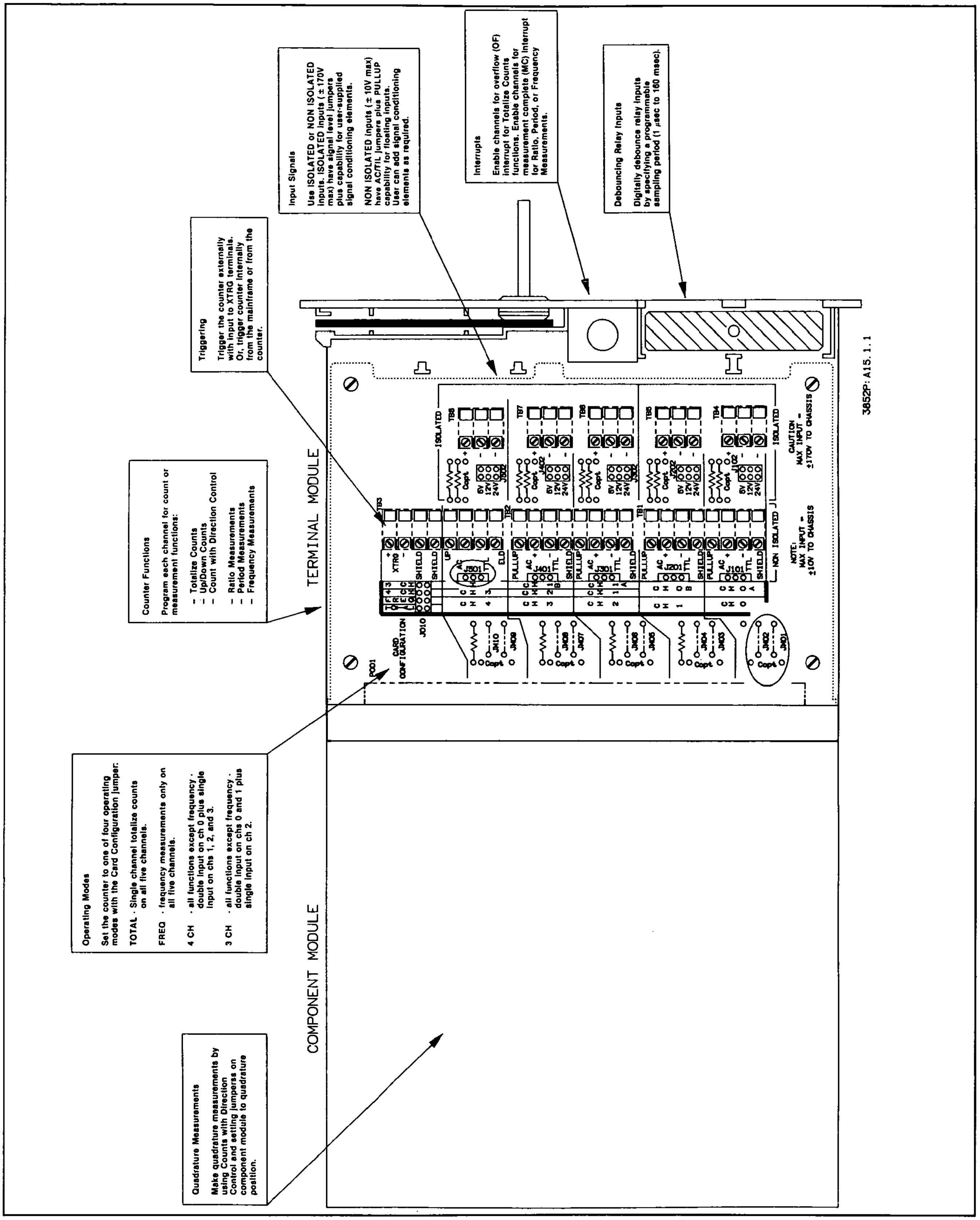

Figure 1-1. Counter Features

Interrupts

Each counter channel can be enabled for measurement complete (MC) or counter overflow (OVF) interrupts, depending on the function set on the channel. When the channel is enabled, Totalize Counts functions generate an OVF interrupt when the channel counter rolls over from −1 to 0.

Also, when the channel is enabled, the Ratio, Period, and Frequency Measurement functions generate a MC interrupt when the measurement is complete. The Up/Down Count and Count With Direction Control functions do not generate interrupts.

Debouncing Relay Inputs

Relay inputs can be digitally debounced by specifying a programmable sampling period from 1 μsec (default) to 160 msec.

Getting Started

There are three main steps to configure and program the counter for your measurement:

- Define Your Measurement
- Configure the Counter
- Program the Counter

Define Your Measurement

The first step is to define your measurement requirements and to select the counter function required for the measurement. Refer to Chapter 2 - Selecting Counter Functions for guidelines to define your measurement and to select the required counter function.

Configure the Counter

The next step is to hardware configure counter channels for your measurement. Refer to Chapter 3 - Configuring the Counter to hardware configure counter channels. When selecting devices to be connected to the counter, refer to the Specification appendix in the HP 3852A Mainframe Configuration and Programming Manual for details on voltage, current, and frequency limitations.

Program the Counter

When you have configured the channels and selected the channel function(s), the last step is to program each channel for your application. Refer to Chapter 4 - Programming the Counter for guidelines to select channel parameters and some example programs for counter functions.

Chapter 2
Selecting Counter Functions

Contents

Chapter 2

Selecting Counter Functions

Chapter Contents

This chapter gives guidelines to define your measurement and to select counter functions required for the measurement. Chapter sections are:

- **Chapter Contents** summarizes chapter contents.

- **Defining Your Measurement** gives guidelines to characterize your measurement application, including measurement parameters and data/interrupt handling requirements.

- **Counter Functions** includes an overview of counter functions and defines counting and measurement functions.

When you have defined your measurement and selected the counter function, refer to Chapter 3 - Configuring the Counter to hardware configure the counter and then to Chapter 4 - Programming the Counter to program the counter for your measurement.

Defining Your Measurement

Guidelines to help you characterize your measurement follow. The guidelines include a discussion of measurement parameters and data/interrupt requirements. You should also refer to the Specifications appendix in the HP 3852A Mainframe Configuration and Programming Manual for complete specifications when characterizing your measurement.

Measurement Parameters

Guidelines to select these measurement parameters follow.

- Type of Measurement
- Input Signal Frequency
- Input Signal Level
- Measurement Accuracy
- Number of Measurements
- Modulo (Range) Requirements
- Measurement Resolution

Type of Measurement

The first step is to select the type of measurement to be made. Table 1-1 in Chapter 1 summarizes the types of measurements which can be made with the counter.

Input Signal Frequency

The counter can measure inputs up to 200 kHz (minimum period of 5 μsec). Determine the frequency of the input signal for each channel to be used.

Input Signal Level

Next, determine the input signal level. If the signal level is >10 V, the Isolated input terminals must be used. For lower level signals, the Non Isolated terminals (TTL for TTL inputs or AC for zero crossing detection) can be used.

Measurement Accuracy

In general, measurement accuracy for the counter is $\pm$ 1 or 2 counts or $\pm$ 1/NPER counts for all functions except Period, Delayed Period, and Frequency. For these functions, accuracy is $\pm$ 0.01% of reading $\pm$ 1 count of resolution + trigger error where trigger error = maximum time for the input voltage to change from low to high or high to low.

Therefore, for Period, Delayed Period, or Frequency measurements determine the trigger error to ensure that resulting measurement accuracy will be acceptable.

Number of Measurements

The number of measurements required will determine other factors, such as resolution and measurement time. Determine the number of measurements required for your application.

Modulo (Range) Requirements

Normal counter range is from 2^{-31} to $2^{31} - 1$ (32 bits, 2s complement). However, for modulo NPER functions, the counter can be set to count modulo NPER where the range of NPER is from 1 to 65535 counts. Select the count range required for your measurement.

Measurement Resolution

For Period and Delayed Period Measurements, the resolution depends on the time base of the counter and the number of periods required to be measured. For Frequency Measurements, the range and resolution depend on the gate time. Determine required signal resolution for the function(s) selected.

Data/ Interrupt Requirements

When you have defined your measurement parameters, determine the data and interrupt requirements for the measurement. Two considerations are data transfer mode and interrupt handling.

Data Transfer Mode

When data is available, it can be transferred to the mainframe memory or to the output buffer and/or display with a CHREAD or XRDGS command. Select the data transfer mode required for your measurement. Refer to Chapter 6 in the HP 3852A Mainframe Configuration and Programming Manual for details on data transfer methods.

Interrupt Requirements

For the Totalize Counts functions, the counter can be enabled to interrupt on counter rollover (OVF interrupt). For Ratio, Period, or Frequency Measurements, the counter can be enabled to interrupt on measurement complete (MC interrupt). When enabled, interrupts can be handled in the mainframe or in the controller. Select the interrupt mode required for your application. Refer to Chapter 8 in the HP 3852A Mainframe Configuration and Programming Manual for guidelines on handling interrupts.

Counter Functions

When you have characterized your measurement, the next step is to select the counter function required for each channel to be used. This section describes the counter functions and shows counter operation for each function.

Function Overview

This subsection summarizes counter functions and describes the count sequence for the counting functions (Totalize Counts, Up/Down Counts, and Count With Direction Control).

Counter Functions Summary

Table 2-1 summarizes counter functions, shows the purpose of the A input and B input, and shows the conditions to generate interrupts on an enabled channel. Since channel functions are programmed with the CONF or FUNC command, the "function" column lists the CONF or FUNC *function* parameter which sets the channel to the function (FUNC does not apply to Frequency Measurements).

As noted, counter functions are defined for single input or double input channels. A single input channel has one user input (the A input), while a double input channel has two user inputs (the A input and the B input). Generally, the A input is the primary input to be measured and the B input is the auxiliary input - usually a gate.

In Table 2-1, an S in the "Ch" column = a single input channel and D = a double input channel. The Period (PER) function is an exception to the rule. Although the Period function is defined for a double input channel, the B "input" comes from the counter and the physical B input is not used.

Several functions count or measure "Modulo NPER", where NPER refers to the number of counts or periods used and the value is selected with the NPER *function* parameter. Some functions generate interrupts when the channel is enabled. In Table 2-1, OVF = a counter overflow interrupt when the counter rolls over from -1 to 0 and MC = a measurement complete interrupt when the measurement is complete. Refer to the next section "Counting Sequences" for a description of the counter sequences.

Table 2-1. Counter Function Summary

Function	function	Ch	Description	Inputs A	Inputs B	Interrupts Type	Interrupts When
Totalize Counts							
Ungated Total Counts	TOTAL	S	Count number of A input transitions.	Count	N/A	OVF	Rollover (−1 to 0)
Gated Total Counts	TOTAL	D	Count number of A input transitions, gate with B input.	Count	Gate	OVF	Rollover (−1 to 0)
Ungated Total Counts, Modulo NPER	TOTALM	S	Count number of A input transitions, modulo NPER.	Count	N/A	OVF	Rollover (NPER-1 to 0)
Gated Total Counts, Modulo NPER	TOTALM	D	Count number of A input transitions, modulo NPER. Gate with B input.	Count	Gate	OVF	Rollover (NPER-1 to 0)
Up/Down Counts							
Up/Down Counts	UDC	D	Count up on A input, count down on B input. Result is (A-B) counts.	Up Count	Down Count	——	None
Up/Down Counts, Mod NPER	UDCM	D	Count up on A input, count down on B input. Result is (A-B) counts, modulo NPER.	Up Count	Down Count	——	None
Count With Direction Control							
Count/ Direction	CD	D	Count A input up or down. B input controls direction.	Count	Dir	——	None
Count/ Direction, Mod NPER	CDM	D	Count A input up or down. B input controls direction. Count modulo NPER.	Count	Dir	——	None
Quadrature Count	CD	D	Count up on all A input transitions when B leads A. Count down on all A input transitions when A leads B.	Count	Dir	——	None
Quadrature Count, Modulo NPER	CDM	D	Same as Quadrature Count, except count modulo NPER.	Count	Dir	——	None
Ratio Measurements							
Ratio	RAT	D	Measure average number of A input counts per B input period.	Count	Count	MC	After NPER B Periods
Period Measurements							
Period	PER	D	Measure average of NPER periods of A input	Count	Not* Used	MC	After NPERth Period of A
Delayed Period	PERD	D	Measure NPERth gated period of A input, gate with B input.	Count	Gate	MC	After NPERth Gated Period of A
Frequency Measurements							
Frequency	FREQ**	S	Measure average frequency of A input.	Count	N/A	MC	After Gate Time

Notes:

* = Although B input is not used, function must be programmed on a double input channel.

** = FREQ parameter does not apply to FUNC command.

Counting Sequences

As noted, the counter has two types of functions: counting and measuring. The counting functions (Totalize Counts, Up/Down Counts, and Count With Direction Control) continuously repeat the count sequence, while the measurement functions perform a one-time measurement. Figure 2-1 summarizes the count sequence for the counting functions.

Example: Ungated Total Counts (TOTAL/TOTALM) Count Sequences

For example, with Ungated Total Counts (TOTAL), the counter sequence is from 0 (or from a preset value) to 2147483647 to −2147483648 to −1 and back to 0. When the counter rolls over from −1 to 0, if the channel is enabled the counter generates an overflow (OVF) interrupt.

With Ungated Total Counts, Modulo NPER (TOTALM), the count sequence is from 0 (presets do not apply) to NPER-1, where NPER = 2 to 65535 is selected with the NPER command. If the channel is enabled, the channel generates an overflow interrupt when the counter rolls over from NPER-1 to 0.

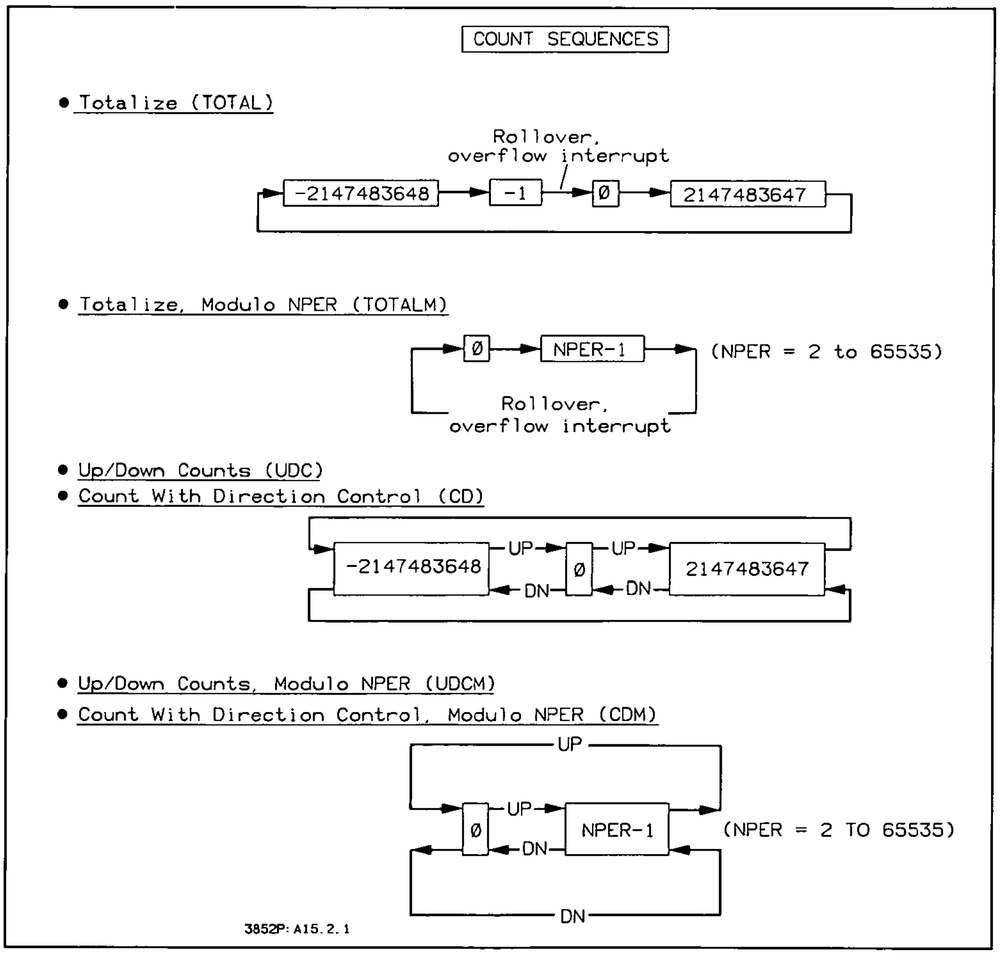

Figure 2-1. Counting Sequences

Counting Functions

This section describes the counting functions shown. For convenience, the CONF *function* parameter which sets the function is listed with each function. Refer to Table 2-1 for a summary of counting functions.

- Totalize Counts (TOTAL/TOTALM)
- Up/Down Counts (UDC/UDCM)
- Count With Direction Control (CD/CDM)

Totalize Counts (TOTAL/TOTALM)

There are four types of Totalize Counts functions:

- Ungated Total Counts (TOTAL)
- Gated Total Counts (TOTAL)
- Ungated Total Counts, Modulo NPER (TOTALM)
- Gated Total Counts, Modulo NPER (TOTALM)

Ungated Total Counts (TOTAL)

Ungated Total Counts (TOTAL) can be used to count and totalize single inputs, such as switch closures and, as desired, generate an overflow interrupt after a specified number of counts. For Ungated Total Counts only, the counter can be preset to any number between −2147483648 and +2147483647 with CNTSET. The preset number is used only once and the count then resumes the normal counting sequence. Measurement accuracy is ± 1 count.

For example, with CNTSET 1000000000, the count sequence is from 1000000000 to 2147483647 to −2147483648 and back to 0 (not to the preset). If enabled, the channel generates an overflow interrupt when the counter overflows from −1 to 0. Figure 2-2 shows an example sequence for Ungated Total Counts for LH transitions. Since this is a single input function, the B input is not used.

Gated Total Counts (TOTAL)

Use Gated Total Counts (TOTAL) to totalize an input when a second input (the gate) is high or low, as desired. For example, use this function to totalize switch closures when a second switch is open or closed, as required.

Gated Total Counts is similar to Ungated Total Counts except that the B input gates the A input count. You can set the B input so that A input transitions (LH or HL as programmed) are counted only when the B input is high or low (as programmed). The count sequence, presets, accuracy, and interrupt conditions are the same as for Ungated Total Counts. Figure 2-3 shows an example counter operation to count LH transitions of the A input when the B input is low.

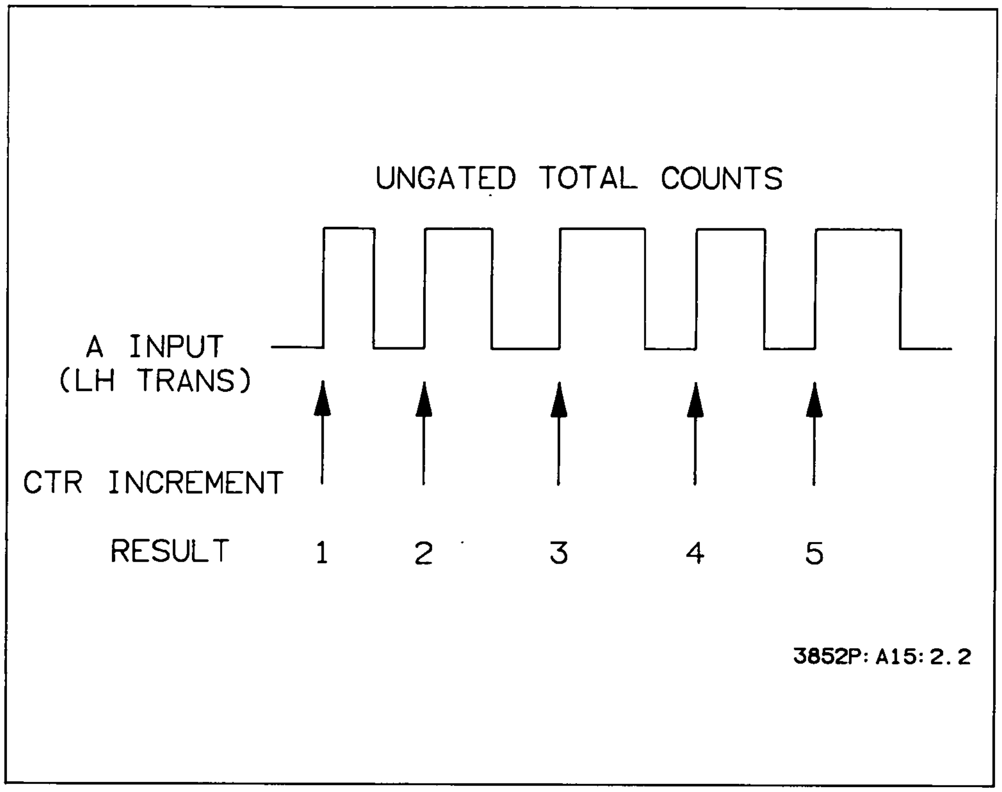

Figure 2-2. Example: Ungated Total Counts (TOTAL)

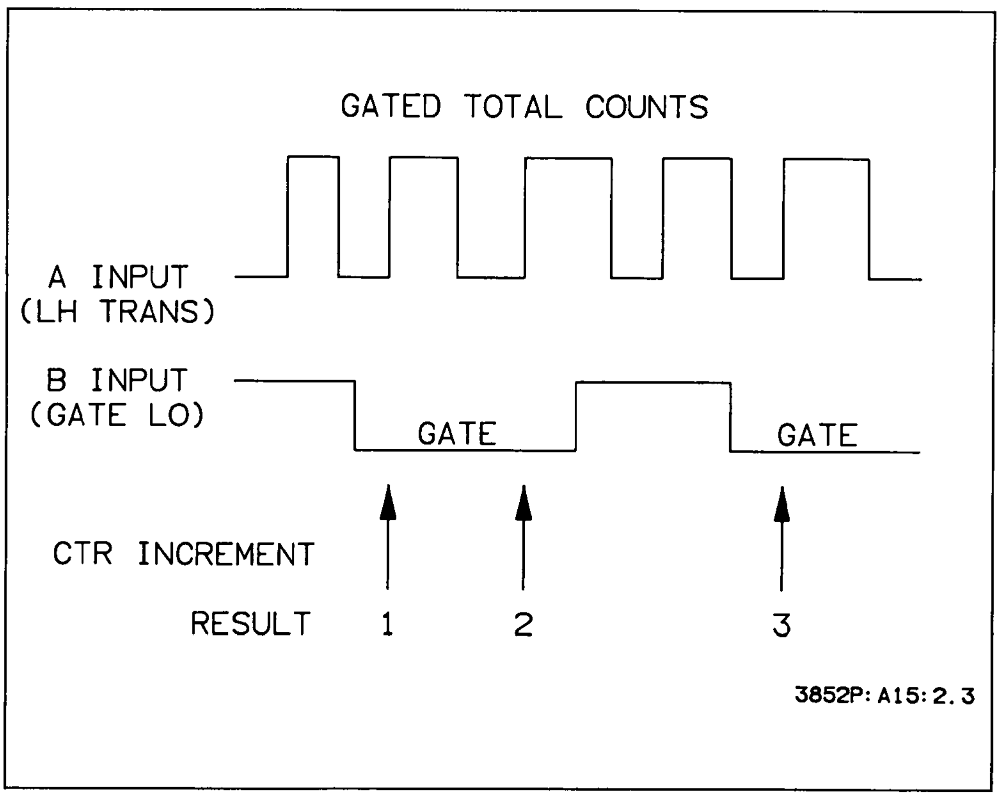

Figure 2-3. Example: Gated Total Counts (TOTAL)

Ungated Total Counts, Modulo NPER (TOTALM)

Use Ungated Total Counts, Modulo NPER (TOTALM) to totalize counts and restart the count after a desired number of counts. With this function, you can set a channel to count up from 0 to a value from 2 to 65534, roll over to 0, and begin counting up again.

For this function, the channel counts the A input LH or HL transitions (as programmed) starting at 0 up to NPER-1 where NPER = 2 to 65535 is set with the NPER command. (There is no preset value other than 0.) Since this is a single input function, the B input is not used. Accuracy is ± 1 count.

The count sequence continuously repeats as long as the channel is programmed for the TOTALM function. Each channel can be enabled for an overflow interrupt when the counter rolls over from NPER-1 to 0. Figure 2-4 shows an example count sequence for A input LH transitions and NPER 4.

Gated Total Counts, Modulo NPER (TOTALM)

Use Gated Total Counts, Modulo NPER (TOTALM) to totalize counts on one input (modulo NPER) as gated by a second input. An example would be to count the number of stepper motor steps when a control switch is open and reset the counter to zero with each complete revolution of the motor.

With this function, the counter counts programmed A input transitions (LH or HL) starting at 0 up to NPER-1 (NPER = 2 to 65535) as gated by the B input. (There is no preset value other than 0.) The count sequence, accuracy, and interrupt conditions are the same as for Ungated Total Counts, Modulo NPER. Figure 2-5 shows an example sequence to count A input LH transitions when the B input is low. For this example, NPER 4 is set.

Up/Down Counts (UDC/UDCM)

Up/Down Counts includes two types of functions:

- Up/Down Counts (UDC)
- Up/Down Counts, Modulo NPER (UDCM)

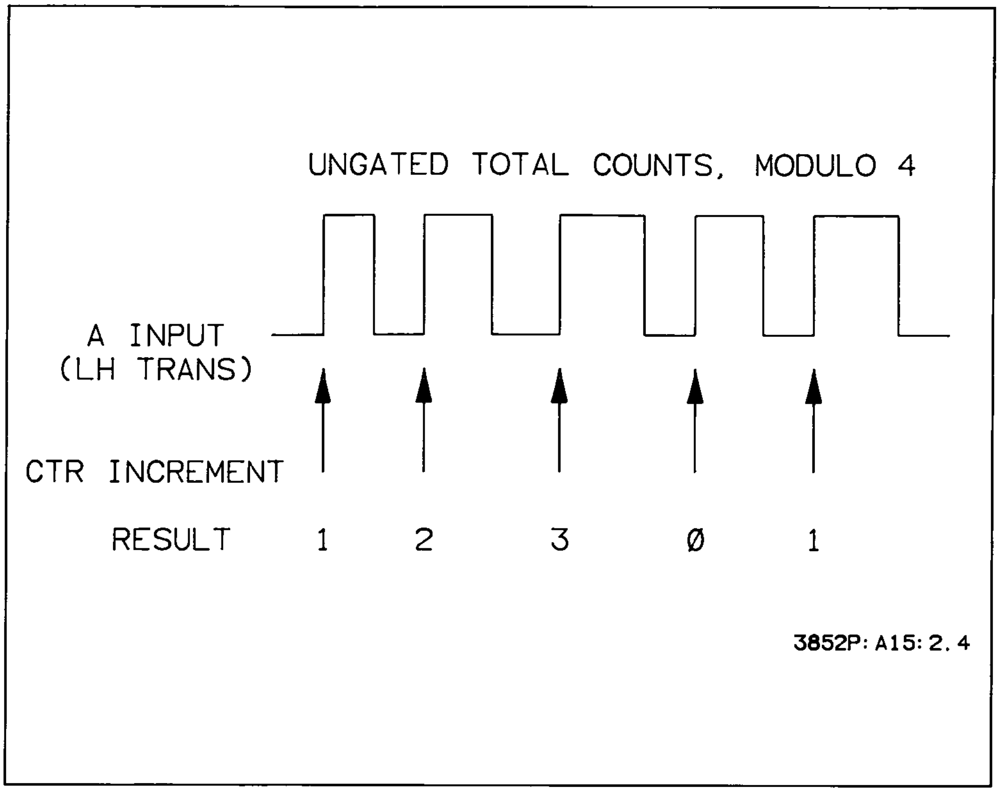

Figure 2-4. Example: Ungated Total Counts, Modulo NPER (TOTALM)

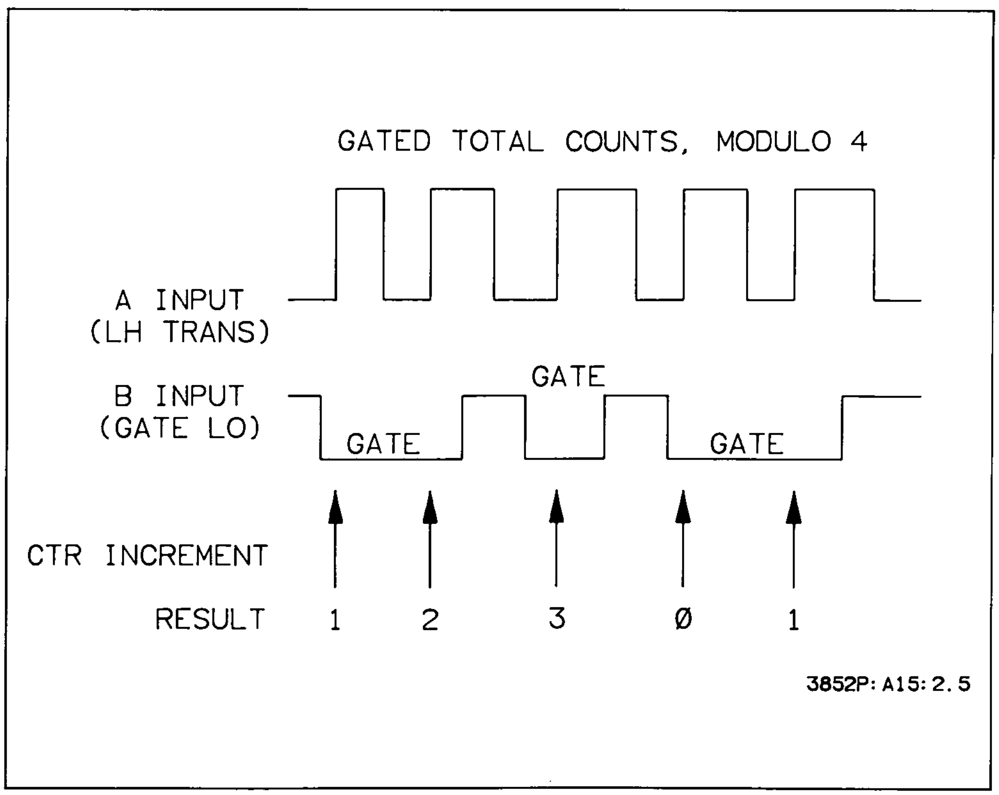

Figure 2-5. Example: Gated Total Counts, Modulo NPER (TOTALM)

Up/Down Counts (UDC)

Use Up/Down Counts (UDC) to measure the difference in counts between two inputs. With this function, programmed A input transitions (LH or HL) increase the count and programmed B input transitions (LH or HL) decrease the count. At any time, the count in the counter is the difference (A-B) between the the two input counts. The counter counts up on programmed A input transitions (LH or HL) starting from 0. The counter counts down on programmed B input transitions (LH or HL) starting at 0.

For up counts (A input), the count sequence is from 0 to 2147483647 to −2147483648 and back to 0. For down counts (B input), the count sequence is from 0 to −2147483648 to 2147483647 and back to 0. No interrupts are generated for Up/Down Counts. Measurement accuracy is ± 2 counts. Figure 2-6 shows an example sequence with LH transitions for both the A and B inputs.

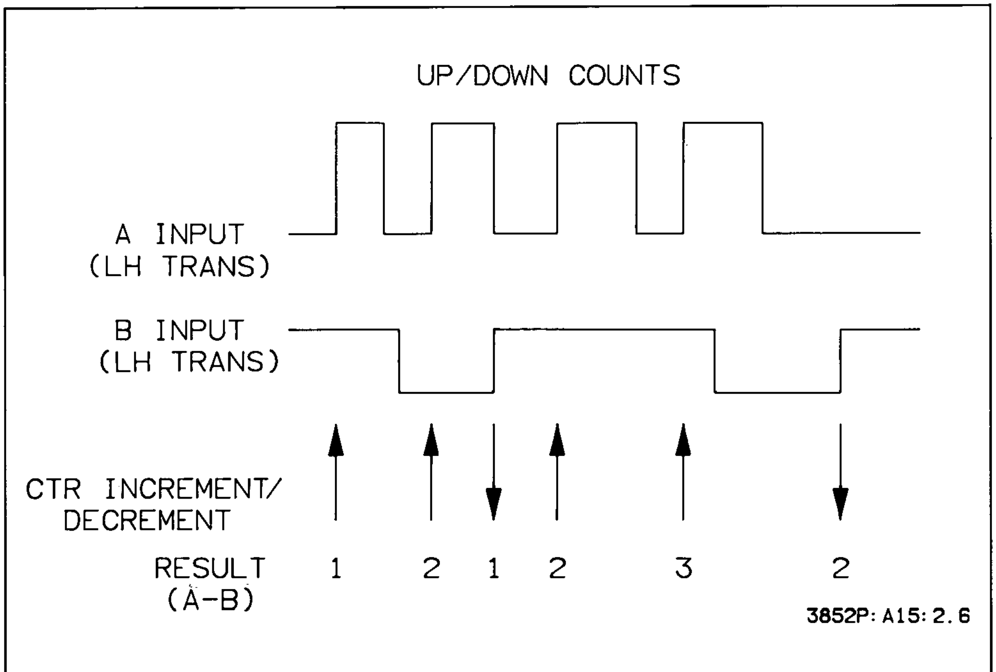

Figure 2-6. Example: Up/Down Counts (UDC)

Up/Down Counts, Modulo NPER (UDCM)

Use Up/Down Counts, Modulo NPER (UDCM) to measure the difference (A-B) between two inputs to a channel, modulo NPER. For this function, the counter counts up on programmed A input transitions (LH or HL) from 0 up to NPER-1, where NPER = 2 to 65535. The counter counts down from NPER-1 to 0 on programmed transitions (LH or HL) of the B input.

No interrupts are generated and measurement accuracy is ± 2 counts. Figure 2-7 shows an example sequence for NPER 3 with LH transitions for the A input and HL transitions for the B input.

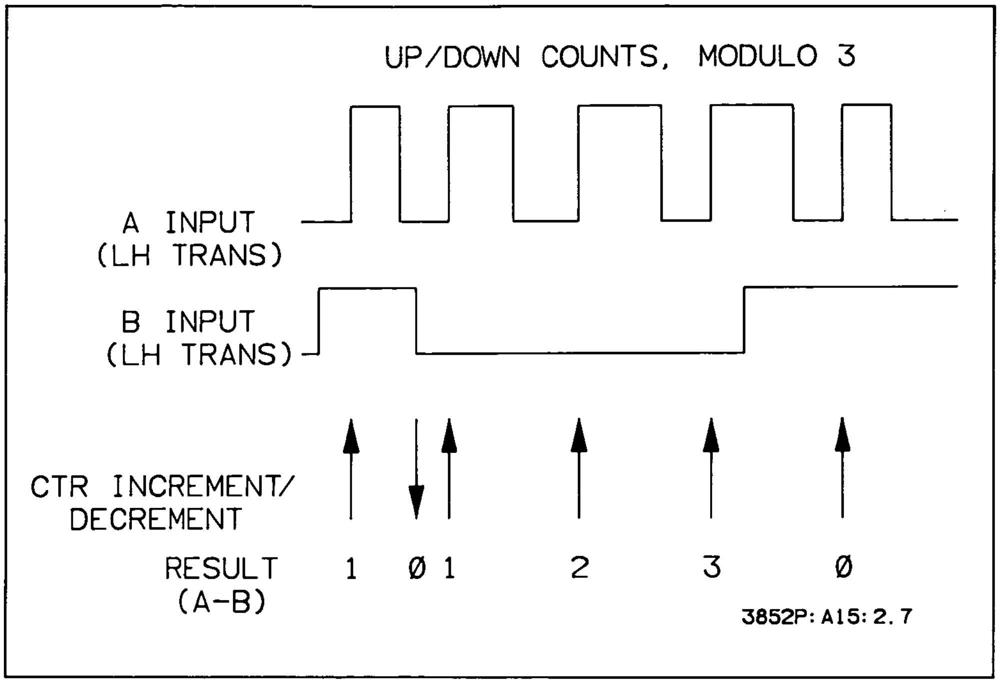

Figure 2-7. Example: Up/Down Counts, Modulo NPER (UDCM)

Count With Direction Control (CD/CDM)

Count With Direction Control includes four functions:

- Count/Direction (CD)
- Count/Direction, Modulo NPER (CDM)
- Quadrature Count (CD)
- Quadrature Count, Modulo NPER (CDM)

Count/Direction (CD)

Use the Count/Direction (CD) function to measure the net number of counts (up counts minus down counts) for an input as controlled by a second input. With this function, the counter counts A input programmed transitions (LH or HL) up or down, depending on the programmed B input gate level (LO or HI).

With the B input gate level set to HI, the counter counts up on programmed A input transitions when the B input is high and counts down when the B input is low. With the B input gate level set to LO, the counter counts up on programmed A input transitions when the B input is low and counts down when the B input is high.

The count sequence for Count/Direction is the same as for the Up/Down Counts (UDC). No interrupts are generated and measurement accuracy is ± 1 count + #reversals/2. Figure 2-8 shows an example sequence in which LH transitions of the A input are up counts when the B input is low and down counts when the B input is high (B input gate level is set for LO).

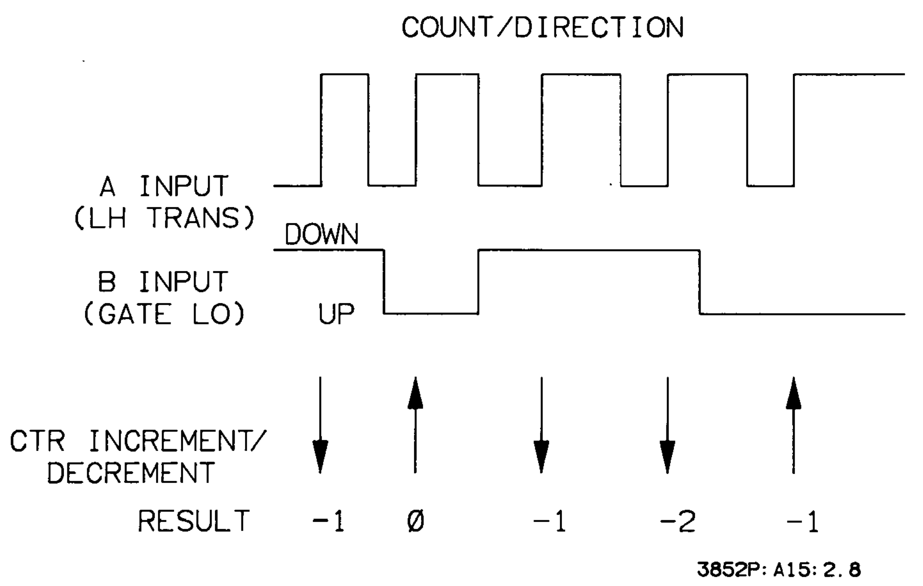

Figure 2-8. Example: Count/Direction (CD)

Count/Direction, Modulo NPER (CDM)

Use Count/Direction, Modulo NPER (CDM) to measure the difference between up counts and down counts, module NPER. As with the Count/Direction function, the counter counts programmed A input transitions (LH or HL) up or down, depending on the level of the B input.

The count sequence starts at 0. For up counts, the count sequence is from 0 to NPER-1 and back to 0. For down counts, the count sequence is from 0 to NPER-1 to 0 and back up to NPER-1 (see Figure 2-1). Measurement accuracy is ± 1 count + #reversals/2. Figure 2-9 shows an example sequence with NPER 3 in which LH transitions of the A input are up counts when the B input is high and down counts when the B input is low (B input level is set for HI).

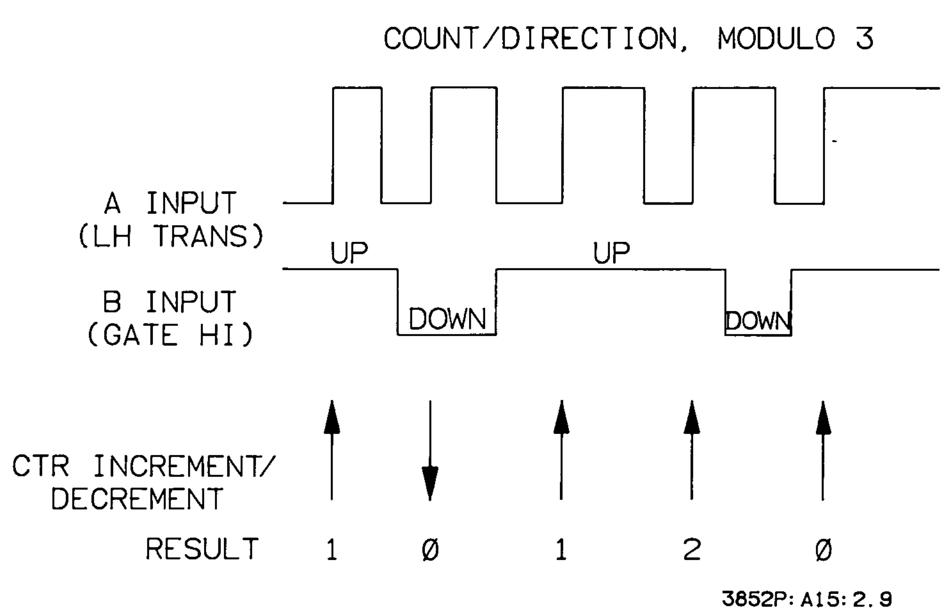

Figure 2-9. Example: Count/Direction, Modulo NPER (CDM)

Quadrature Count (CD)

Quadrature Count (CD) is similar to Count/Direction (CD) except that every transition (LH and HL) of the A input is counted. This function can be used for applications such as measuring the position of a shaft using the A input and determining the direction of motion (CW or CCW) using the B input.

However, a problem can occur if the shaft vibrates just enough to change the A input without changing the B input. If this happens, the count may increment but not decrement (or vice-versa) giving a false count. To overcome this, you can set jumpers on the counter component module so that all transitions of the A input are counted.

Note that Count/Direction (CD) counts programmed A input edges (LH or HL) up or down according to the programmed B input level (LO or HI). However, with Quadrature Count all edges of the A input are counted. The count is ALWAYS up when the B input signal leads the A input signal and ALWAYS down when the A input signal leads the B input signal (two signals 90° out of phase are assumed).

When configured for Quadrature Count, the counter counts double the number of counts for Count/Direction. Table 2-2 summarizes the differences between Count/Direction and Quadrature Count functions.

Table 2-2. Count/Direction vs. Quadrature Count

	Count/Direction	Quadrature Count
Jumpers:*	A: "Normal" (pins 2&3) B: "Normal" (pins 2&3)	A: "Quad" (pins 1&2) B: "Quad" (pins 1&2)
Application:	Non direction changing shaft or low accuracy	Direction changing shaft/high accuracy
Error in Count/Dir:	± 1 count plus #reversals/2	± 1 count
Result:	1 count/A input period	2 counts/A input period
EDGE cmd effect:	EDGE sets A input edge to count and sets B input gate level.	EDGE has no effect with Quadrature Count
Other functions	No effect	Will not work

* = Setting the A jumpers to "Quad" and the B jumpers to "Normal" causes the TOTAL, TOTALM, PER, and PERD functions to count double the normal counts and the B input to be ignored and is not recommended.

Figure 2-10 shows an example of Quadrature Count in which the A and B signals are 90° out of phase. When A leads B, each A input edge (LH and HL transitions) is a down count. When B leads A, each A input edge is an up count. The result is twice the number of (up - down) counts which would be returned with the Count/Direction (CD) function.

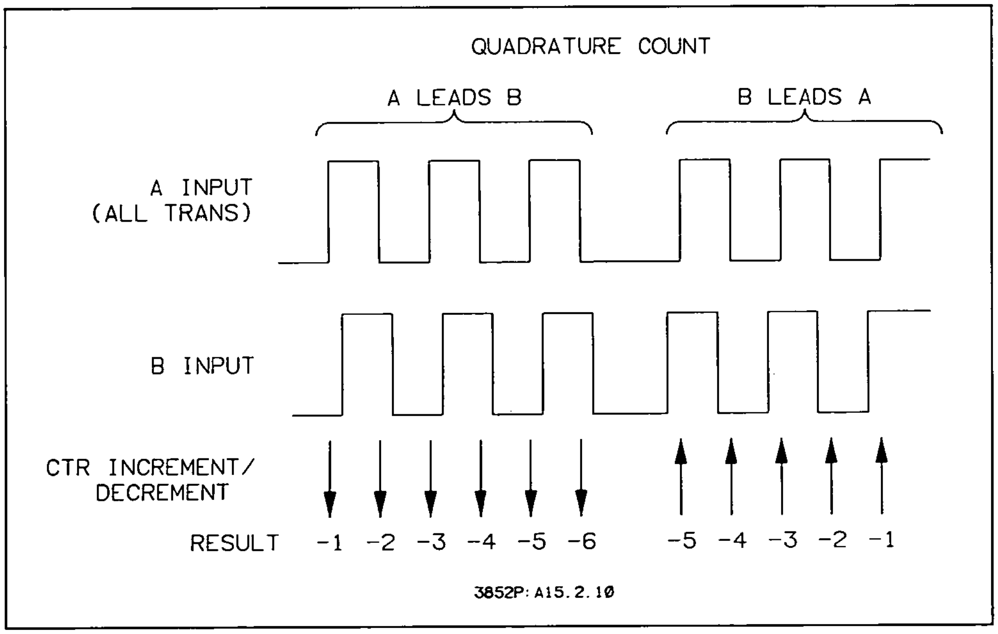

Figure 2-10. Example: Quadrature Count (CD)

Quadrature Count, Modulo NPER (CDM)

Quadrature Count, Modulo NPER (CDM) is similar to Quadrature Count (CD) except that the count sequence is from 0 to NPER-1 (NPER = 2 to 65535) and back to 0 (see Figure 2-1). Figure 2-11 shows an example of Quadrature Count, Modulo NPER with NPER 4.

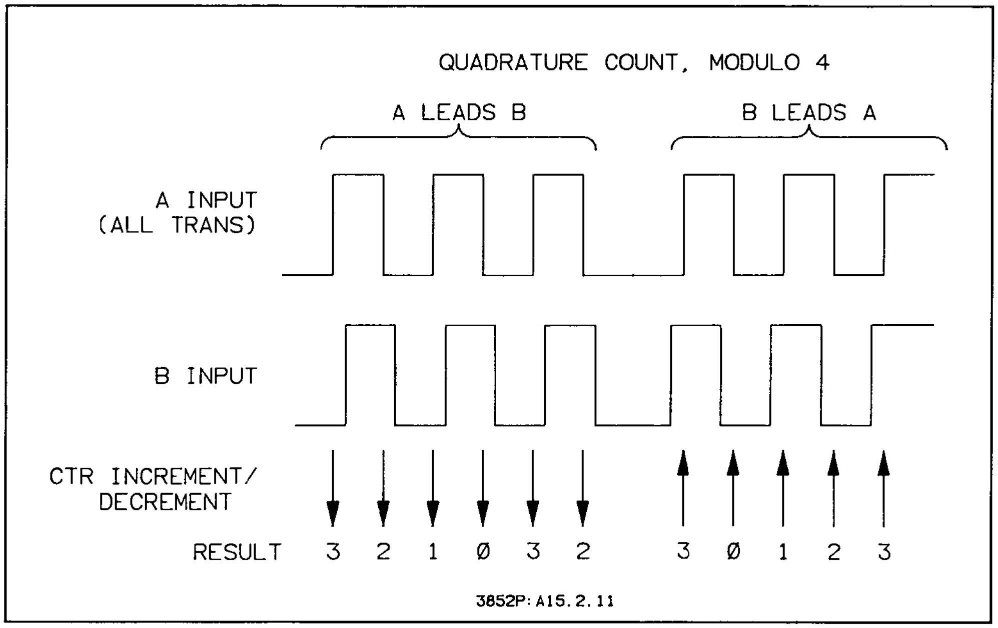

Figure 2-11. Example: Quadrature Count, Modulo NPER (CDM)

Measurement Functions

There are three types of measurement functions, as shown. In contrast to the counting functions in which the count sequence continuously repeats, measurement functions make a one time measurement and halt the sequence. Descriptions of the measurement functions follow. Refer to Table 2-1 for a summary of the measurement functions.

- Ratio Measurements (RAT)
- Period Measurements (PER/PERD)
- Frequency Measurements (FREQ)

Ratio Measurements (RAT)

Use Ratio Measurements (RAT) to count the number of programmed A input transitions (LH or HL) during NPER periods of the B input (NPER = 1 to 65535). The A input count is divided by NPER to get the average number of A input counts per B input period. The maximum number of counts on the A or B inputs is 65535 and measurement accuracy is ± 1/NPER counts.

The channel can be enabled to generate a measurement complete interrupt after NPER B periods. Figure 2-12 shows an example ratio measurement in which A input LH transitions are counted during 3 periods of the B input (NPER = 3). For this example, LH transitions also mark the B input period start and stop. The A/B ratio (average number of A input transitions per B period) = 5/3.

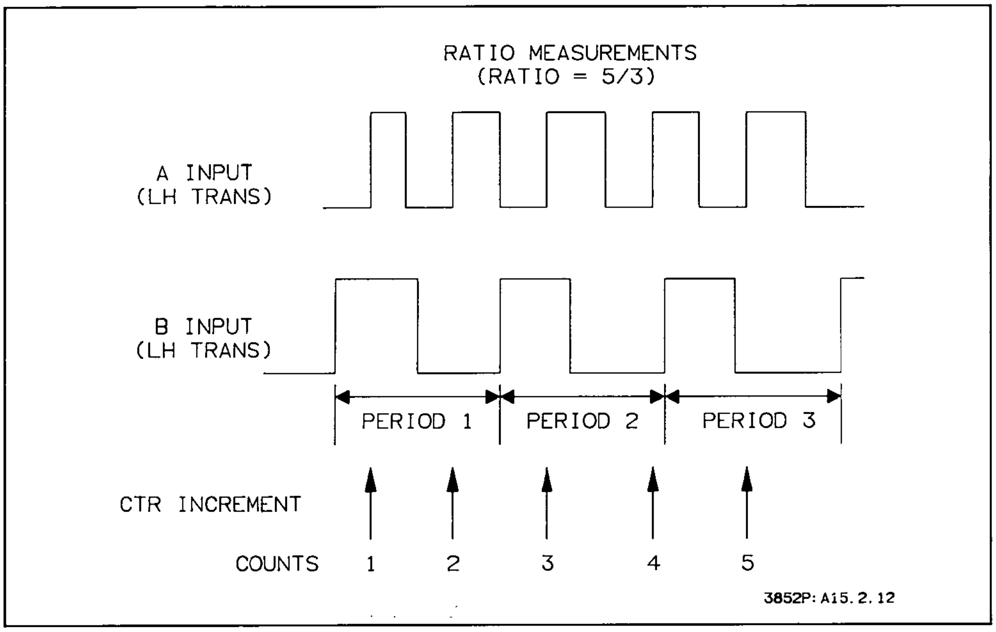

Figure 2-12. Example: Ratio Measurements (RAT)

Period Measurements (PER/PERD)

Period Measurements include the Period (PER) and Delayed Period (PERD) Measurements. Period Measurements measures the average of NPER periods of the A input while Delayed Period Measurements measures the NPERth gated period of the A input.

Period Measurements (PER)

With the Period Measurement (PER) function, the counter averages NPER periods of the A input, where NPER = 1 to 65535. This is a double input function even though the B input is not used directly. Minimum period for the A input is 5 μsec (maximum period is 655.35 seconds).

Data returned is the average value of NPER periods of the A input. If enabled, the channel generates a measurement complete interrupt after NPER periods of the A input have been received. Figure 2-13 shows an example measurement to average three periods of the A input with LH transitions marking the start of each period.

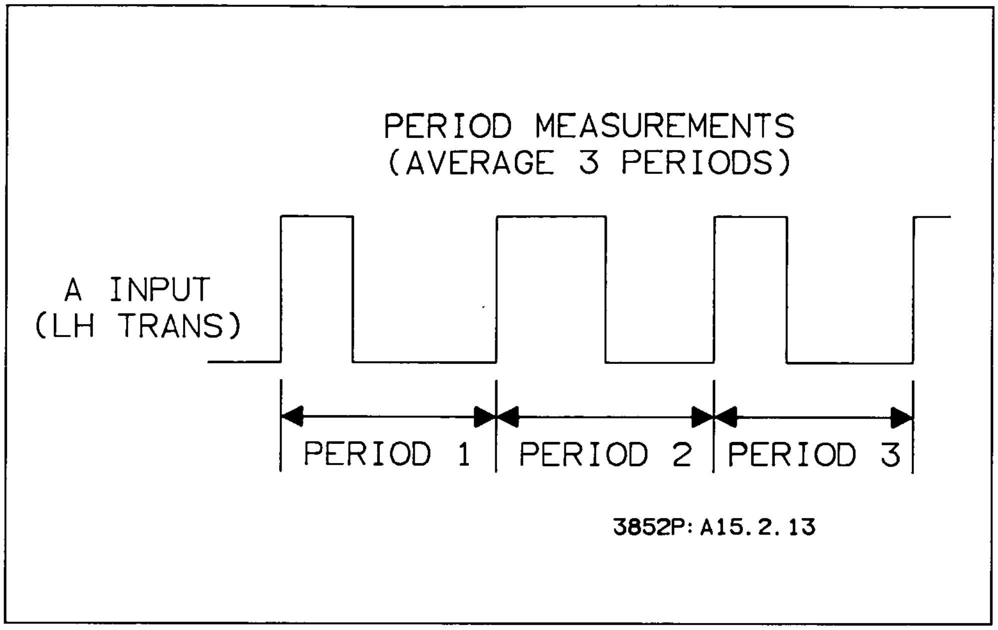

Figure 2-13. Example: Period Measurements (PER)

For this function, the counter uses a reciprocal counter technique. That is, a counter clock is used which has a time base faster than the period to be measured. With this technique, measurement accuracy is ± 0.01% to reading ± 1 count of resolution + trigger error where trigger error is the maximum time for the input voltage to change from low to high or high to low.

Measurement resolution can be increased by increasing NPER, as shown in Table 2-3. Refer to Chapter 4 - Programming the Counter for details.

Table 2-3. Period Measurements (PER) Resolution

Time Base	Resolution
1 μsec	1/NPER μsec
10 μsec	10/NPER μsec
100 μsec	100/NPER μsec
1 msec	1/NPER msec
10 msec	10/NPER msec

Delayed Period Measurements (PERD)

Use Delayed Period Measurements (PERD) to measure a single period of the A input as gated by the B input. With this function, the channel measures the NPERth gated period of the A input, where NPER = 1 to 65534. In contrast to the Period Measurement (PER) function, the B input is used as a gate.

The B input gate level can be set for LO or HI. When the gate level is set for HI, A input periods are counted when the B input is high. When the gate level is set for LO, A input periods are counted when the B input is low. If enabled, the channel generates a measurement complete interrupt after the NPERth gated period of the A input has been measured.

For this function (as with Period Measurements (PER)), measurement accuracy is ± 0.01% of reading ± 1 count of resolution + trigger error where trigger error is the maximum time for the input voltage to change from low to high or high to low. Table 2-4 shows resolution for the PERD function. For PERD, note that resolution = the Time Base used.

Table 2-4. Delayed Period Measurements (PERD) Resolution

Time Base	Resolution
1 μsec	1 μsec
10 μsec	10 μsec
100 μsec	100 μsec
1 msec	1 msec
10 msec	10 msec

Figure 2-14 shows an example measurement with the B input gate set for HI, A input LH transitions marking the start and end of periods, and NPER = 3. Note that the measurement starts at the beginning of the NPERth period.

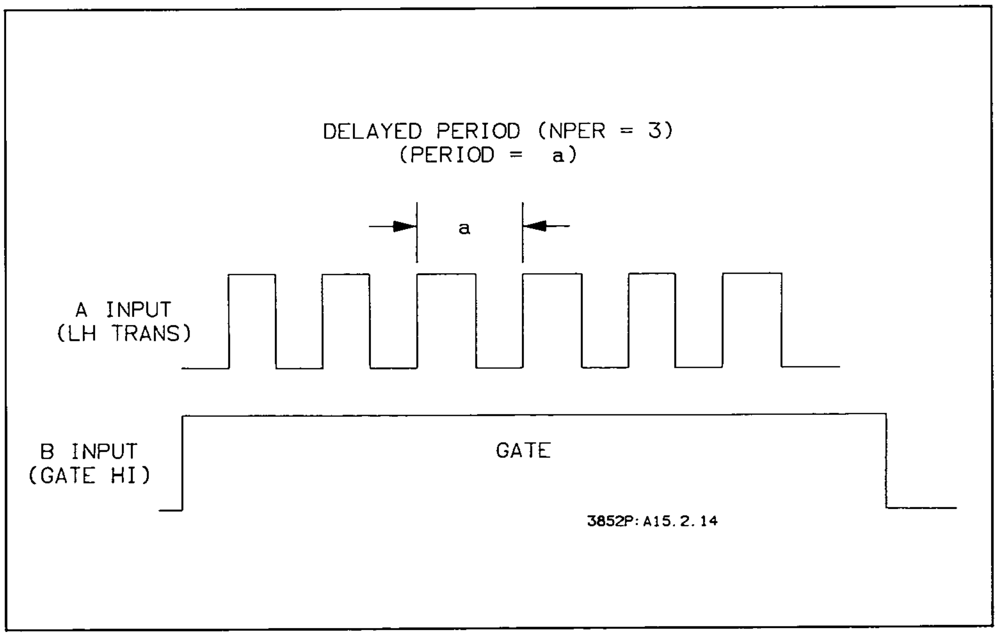

Figure 2-14. Example: Delayed Period Measurements (PERD)

Frequency Measurements (FREQ)

Use Frequency Measurements (FREQ) to measure the average frequency of inputs from >1 Hz up to 200 kHz. With this function all five channels simultaneously perform Frequency Measurements only (the Card Configuration jumper must be set to the FREQ position). If enabled, each channel generates a measurement complete interrupt when the frequency measurement is complete.

Frequency is measured by counting the number of programmed A input transitions (LH or HL) over a selected time base (10 msec to 1 sec). The time base is the same for all channels.

NOTE

You can also make Frequency Measurements by setting a channel to Period Measurements (PER) and taking the reciprocal of the period measured. Since the resolution is better for Period Measurements, this method offers a more accurate means to measure frequency than Frequency Measurements.

However, PER measurements require two channels while FREQ uses only a single channel. Also, FREQ takes the measurement for a fixed period of time while PER takes the measurement for a fixed number of periods.

Measurement accuracy for Frequency Measurements is ± 0.01% of reading ± 1 count of resolution + trigger error, where trigger error is the maximum time for the input voltage to change from low to high or high to low. Table 2-5 shows ranges and resolution for the three gate times. Refer to Chapter 4 - Programming the Counter for details.

Table 2-5. Frequency Measurements (FREQ) Ranges/Resolution

Gate Time	Range	Resolution
1 sec	1 Hz to 65.535 kHz	1 Hz
100 msec	10 Hz to 200 kHz	10 Hz
10 msec	100 Hz to 200 kHz	100 Hz

Figure 2-15 shows an example measurement with gate time (time base) of 1 sec and LH transitions of the A input used for counting. Since 5 transitions occurred during the 1 sec gate time, average frequency = 5/1 = 5 Hz.

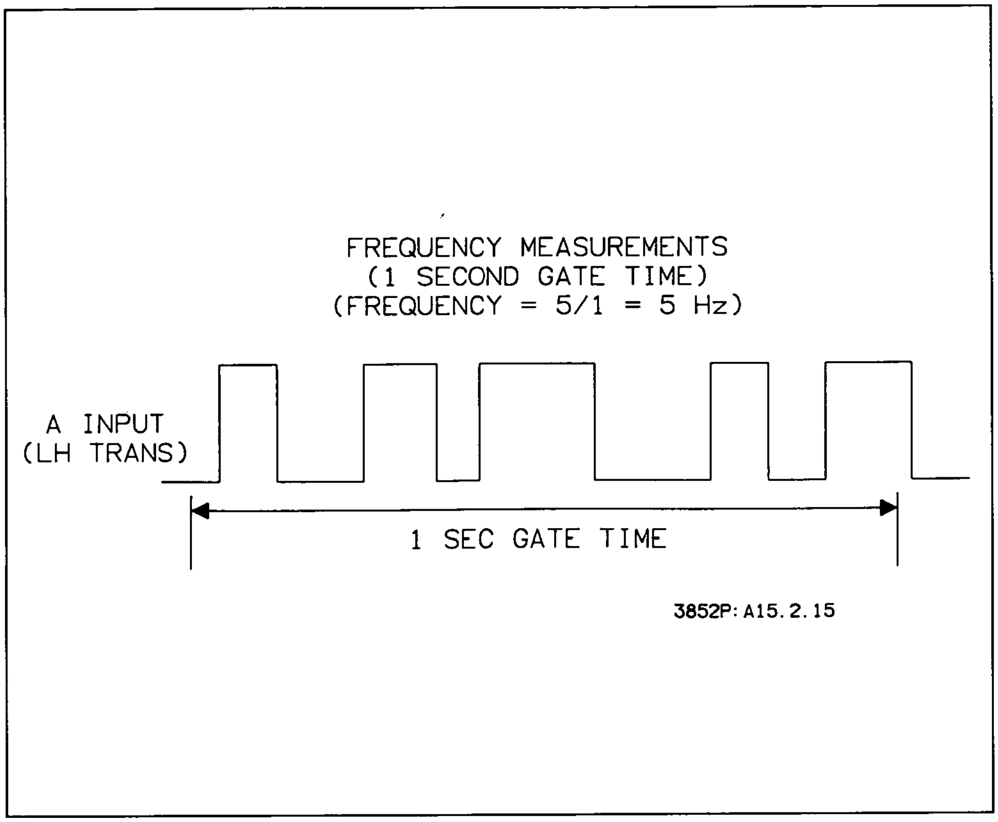

Figure 2-15. Example: Frequency Measurements (FREQ)

Chapter 3
Configuring The Counter

Contents

Chapter 3

Configuring the Counter

Introduction

This chapter shows how to hardware configure counter channels and how to check the counter ID.

Chapter Contents

Chapter sections are:

- **Introduction** summarizes chapter contents, lists WARNINGS, CAUTIONS, and NOTES which apply to the counter, and shows a suggested sequence to configure the counter channels.

- **Setting Counter Jumpers** shows how to set the Card Configuration jumper and the Quadrature jumpers (resetting required only for Quadrature Count).

- **Setting Counter Triggering** summarizes counter triggering sources and shows how to use the XTRG terminals for external trigger inputs.

- **Configuring Isolated Channels** shows how to configure Isolated input channels. It shows how to set the signal level jumpers, install user-supplied signal conditioning elements, and how to connect field wiring.

- **Configuring Non Isolated Channels** shows how to configure Non Isolated input channels. It includes setting AC/TTL jumpers, installing optional user supplied signal conditioning elements, using pullup resistors, and connecting field wiring.

Warnings, Cautions, and Notes

This section summarizes WARNINGS, CAUTIONS, and NOTES which apply to the counter. You should review the WARNINGS and CAUTIONS before handling or configuring any accessory.

WARNING

SHOCK HAZARD. Only qualified, service-trained personnel who are aware of the hazards involved should install, remove, or configure any
1 *accessory. Before touching any installed accessory, turn off all power to the mainframe, extenders, and to all external devices connected to the mainframe, extenders, or accessories.*

WARNING

POSSIBLE OPERATOR INJURY. For safety, consider all accessory
2 *channels to be at the highest potential applied to any channel.*

CAUTION

MAXIMUM INPUT VOLTAGE. Maximum input voltage to Isolated channels is ±170 V between any two terminals or between any terminal and chassis. Maximum input voltage to Non Isolated channels is ±10 V between any two terminals or between any terminal and chassis.

CAUTION

STATIC SENSITIVE. Use clean-handling techniques when handling the accessory. Do not install an accessory without the metal covers attached.

NOTE

HP-IB ADDRESS. The example programs in this manual use "709" as the HP-IB address for the HP 3852A. Specific slot and channel numbers are also used. Program syntax and data return formats apply to HP Series 200/300 controllers. Modify slot and channel numbers and program syntax as required.

Getting Started

To begin hardware configuration of counter channels, remove the terminal module cover. If the counter is installed in the mainframe or in an extender, refer to the HP 3852A Mainframe Configuration and Programming Manual to remove the terminal module.

There are three steps to configure the counter channel(s) to be used for your measurement:

- Set Counter Jumpers
- Select Counter Trigger Source
- Configure Counter Channels

Figure 3-1 shows the counter terminal module and summarizes steps to configure counter channels. To configure Isolated channels, refer to "Setting Counter Jumpers", then to "Setting Counter Triggering", then to "Configuring Isolated Channels". To configure Non Isolated channels, refer to "Setting Counter Jumpers", then to "Setting Counter Triggering", and then to "Configuring Non Isolated Channels".

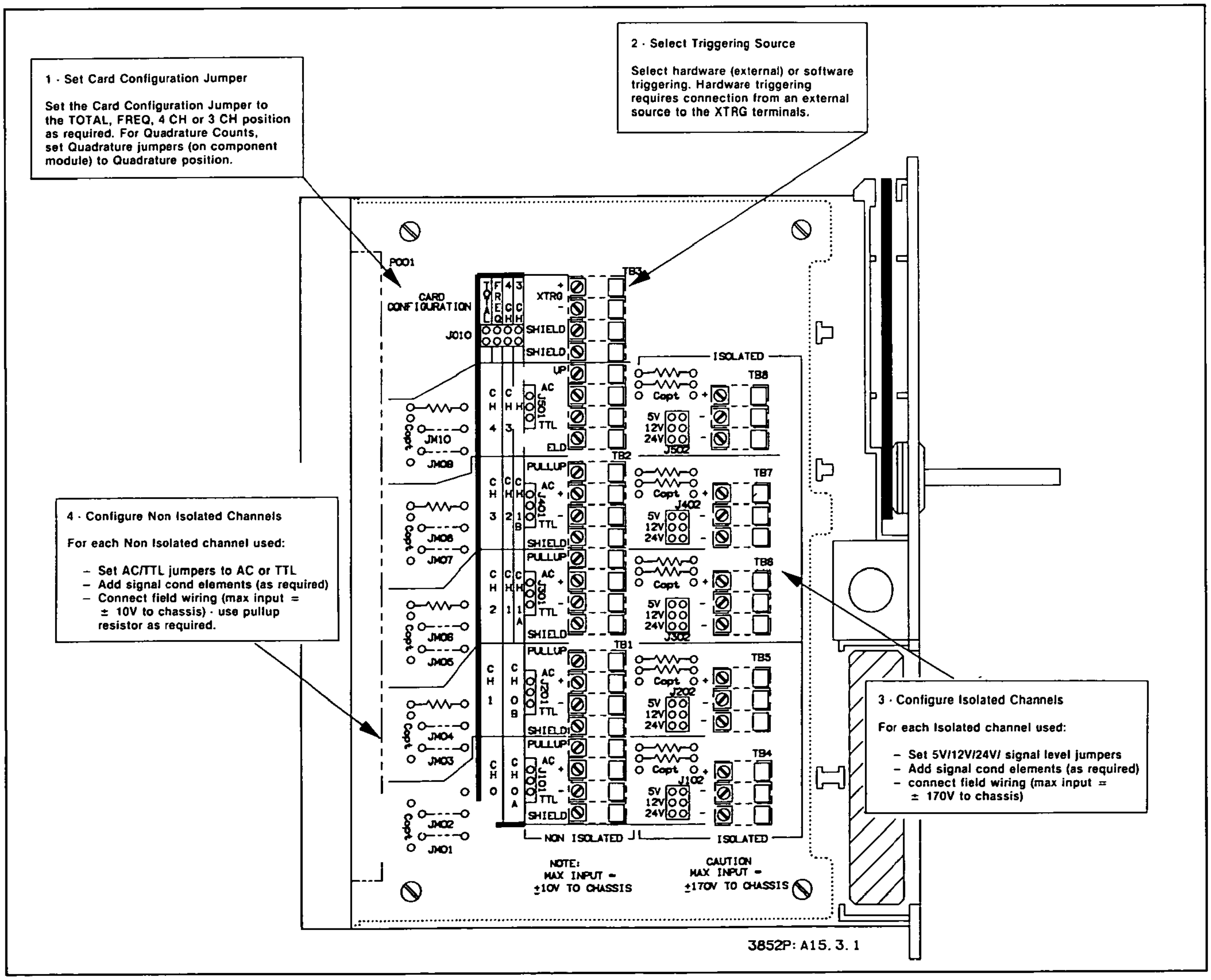

Figure 3-1. Terminal Module Configuration

Setting Counter Jumpers

When you have selected the counter function(s) required (refer to Chapter 2 - Selecting Counter Functions), the first step to configure the channels is to set the Card Configuration jumper. Also, for Quadrature Count or Quadrature Count, Modulo NPER, the Quadrature jumpers on the component module must be set to the Quadrature position (refer to "Setting Quadrature Jumpers").

Setting Card Configuration Jumper

Use the Card Configuration jumper (see Figure 3-1) to set each channel of the counter to one of four operating modes: TOTAL, FREQ, 4 CH, or 3 CH. Table 3-1 summarizes the four hardware settings and shows channel numbers and counter functions for each setting.

Channel numbers for each jumper setting are printed on the terminal module in the column under each setting. For example, with the 4 CH setting, the hardware channel numbers are CH0A, CH0B, CH1, CH2, and CH3.

Note that hardware channel numbers are not necessarily the same as the channel numbers used for programming. For example, with the FREQ or TOTAL setting, both hardware and software (programming) channel numbers are 0, 1, 2, 3, and 4. However, for the 4 CH setting, programming channel numbers are 0, 1, 2, and 3, but hardware channel numbers are 0A, 0B, 1, 2, and 3.

NOTE

The input path (Isolated or Non Isolated) is selected with the TERM command. Refer to Chapter 4 - Programming the Counter for a description of the TERM command.

Table 3-1. Card Configuration Jumper Settings

Setting	Description	Channel Numbers Hardware	Channel Numbers Programming
TOTAL	Single input Totalize Counts (TOTAL/TOTALM) only.	0,1,2,3,4	0,1,2,3,4
FREQ	Frequency Measurements (FREQ) only.	0,1,2,3,4	0,1,2,3,4
4 CH	All functions except Frequency on ch 0 plus TOTAL/TOTALM functions on chs 1, 2, and 3.	0A,0B,1,2,3	0,1,2,3
3 CH	All functions except Frequency on ch 0 and ch 1 plus TOTAL/ TOTALM functions on ch 2.	0A,0B,1A,1B,2	0,1,2

To set counter channels for your measurement, first determine the function to be used for each channel and the type of channel (single input or double input) required. To set all five channels for Frequency Measurements, set the Card Configuration jumper to the FREQ position. To set Ungated Total Counts (TOTAL) or Ungated Total Counts, Modulo NPER (TOTALM) on each channel, set the jumper to the TOTAL position. For other requirements set the jumper to the 4 CH or 3 CH position, as required.

Example: Setting Card Configuration Jumper

You want to make a Ratio Measurement (RAT), an Ungated Total Counts (TOTAL) measurement, and an Up/Down Counts (UDC) measurement on a counter. Since Ratio and Up/Down Counts each require a double input channel while Ungated Total Counts requires a single input channel, set the Card Configuration jumper to the 3 CH position.

Then, typical connections might be to connect the Ratio Measurement input to channels 0A and 0B (or 1A and 1B), connect the Up/Down Counts input to channels 1A and 1B (or 0A and 0B), and connect the Ungated Total Counts input to channel 2.

Setting Quadrature Jumpers

For Quadrature Count (CD or CDM), you will need to change the settings of the Quadrature jumpers on the counter component module and set the Card Configuration jumper to the 3 CH or 4 CH position.

When the Card Configuration jumper is set for 4 CH, only channel 0 (inputs 0A and 0B) can be used for Quadrature Count. For 4 CH configuration, set jumpers J602 and J603 to pins 1 and 2 which configures channel 0 for Quadrature Count.

When the Card Configuration jumper is set for 3 CH, both channels 0 and 1 can be used for Quadrature Count. For 3 CH configuration, set J602 and J603 to pins 1 and 2 to configure channel 0 and set J600 and J601 to pins 1 and 2 to configure channel 1. See Figure 3-2 for quadrature jumper locations and settings.

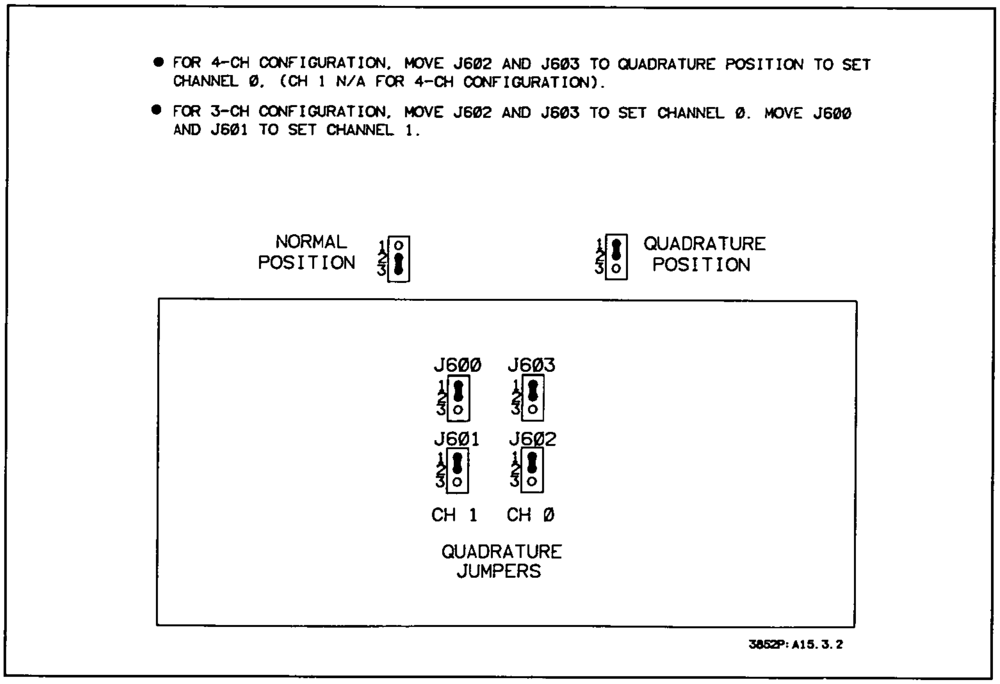

Figure 3-2. Setting Quadrature Jumpers

Setting Counter Triggering

This section shows counter triggering sources and gives guidelines to connect external trigger sources to the XTRG terminals on the terminal module.

Trigger Sources

The counter trigger source or mode is set with the TRIG *source* [USE *ch*] command. Trigger sources are AUTO, EXT, SGL, or SYS plus TRIG HOLD which disables the trigger. Figure 3-3 summarizes the trigger sources. Note that all sources except EXT are software triggers. Refer to Chapter 4 - Programming the Counter for a description of the TRIG command.

If you need to use an external trigger source, refer to the next section "Connecting External Triggering". If not, go to "Configuring Isolated Channels" or to "Configuring Non Isolated Channels" as required.

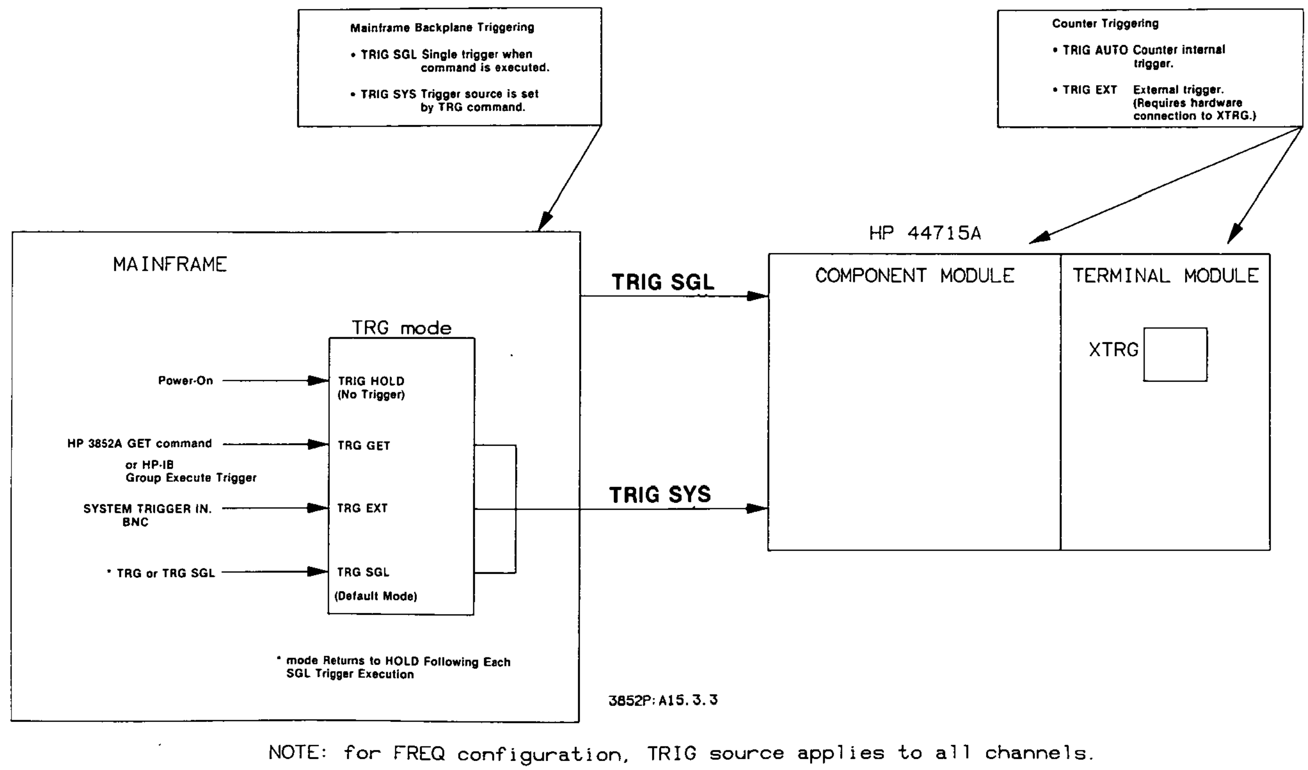

Figure 3-3. Counter Triggering Sources

Connecting External Triggering

To externally trigger the counter, connect a cable from an external (user) triggering source to the XTRG + and − terminals on the terminal module. If the cable has a shield, connect the shield to one of the SHIELD terminals. (The additional SHIELD terminal is provided for redundancy). Both SHIELD terminals are at chassis potential.

You can also provide external triggering by connecting a BNC connector from the PACER OUT BNC terminal on the mainframe to the XTRG +, XTRG −, and SHIELD terminals. Triggering is on the high-to-low transition and inputs must have high >4.0 volts and low <0.9 volts. Refer to the HP 3852A Mainframe Configuration and Programming Manual for details on the PACER OUT BNC terminal.

Configuring Isolated Channels

There are three steps to configure an Isolated input channel, as shown. Figure 3-4 shows the jumper and signal conditioning element locations for Isolated input channels.

- Set signal level jumpers.
- Install signal conditioning (as required).
- Connect field wiring.

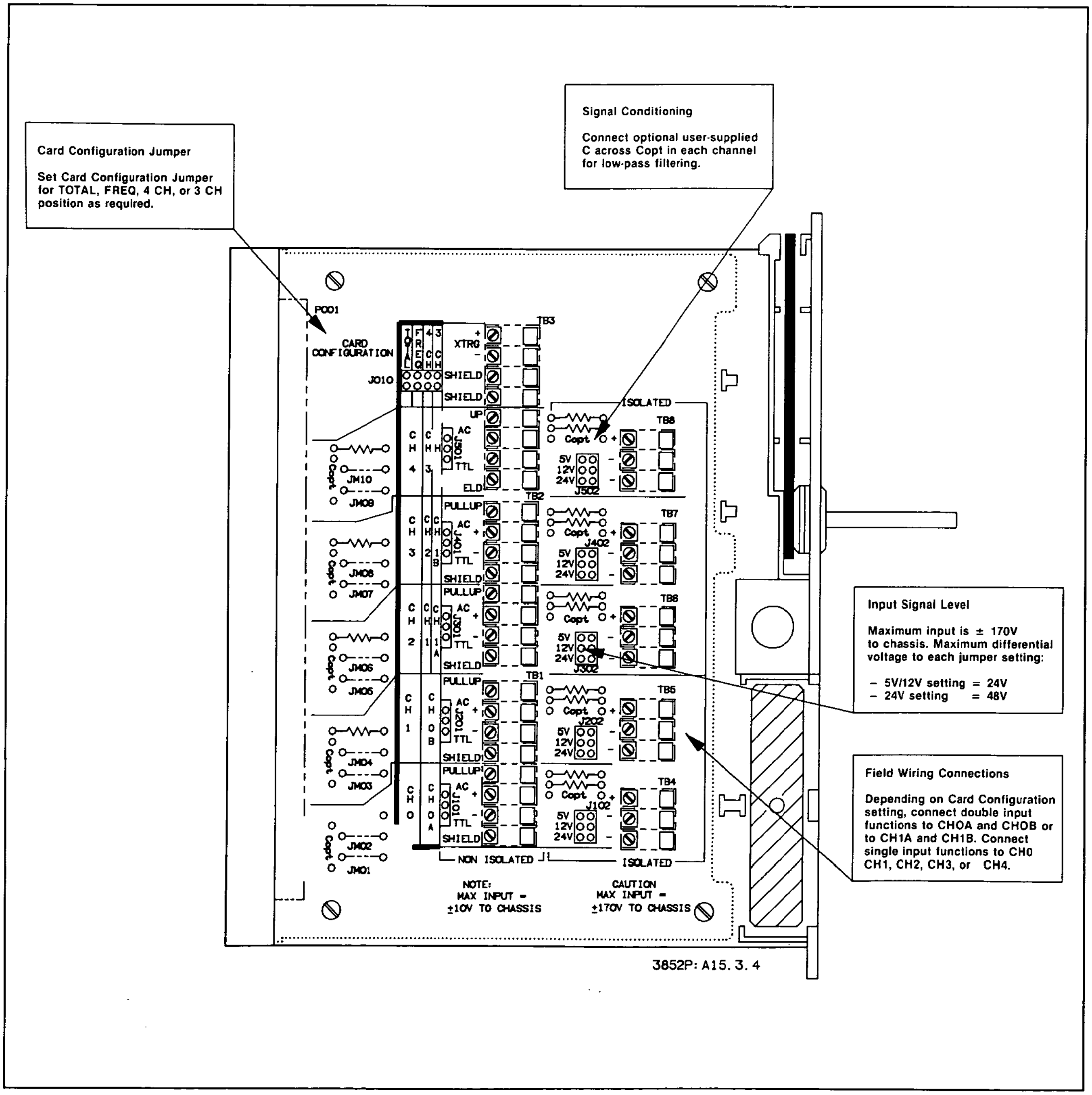

Figure 3-4. Isolated Channel Features

Setting Signal Level Jumpers

As shown in Figure 3-4, each Isolated input channel has a separate jumper which sets the channel input voltage level to 5V, 12V, or 24V, where the level refers to the voltage differential between Vhigh and Vlow. Maximum differential voltage for the 5V and 12V settings is 24 volts, while maximum differential voltage for the 24V setting is 42 volts. Set each jumper for the required input level.

Adding Signal Conditioning Elements

As required, you can install a user supplied capacitor in each Isolated input channel Copt connector to act as a low pass filter (see Figure 3-4 for Copt location).

When a capacitor is placed across Copt, input signal attenuation for the channel is as shown in the following equation, where C = capacitance (in Farads) to be placed across Copt, R (in Ω) depends on the range set by the 5V/12V/24V Signal Level Jumper, and f = frequency of the desired 3 dB point.

$$\text{Attenuation} = \frac{(1100 + R)}{(1100 + R) + 1100\,(2\pi f * R * C)}$$

where:

R = Rsource (5V range)
R = Rsource + 2700 Ω (12V range)
R = Rsource + 6600 Ω (24V range)
C = Copt value (Farads)
f = Frequency of 3 dB point

To determine the value of Copt for a specific frequency, let (1100 + R) = 1100[(2πf)(R)(Copt)]. Then, use the following equation to find Copt for a specified 3 dB point:

$$\text{Copt} = \frac{1100 + R}{6911.5\,(R)(f)} \qquad \text{(Copt in Farads)}$$

As required, determine the capacitance values needed for Copt and install the capacitors in the channels to be used.

Connecting Field Wiring

When the signal level jumpers have been set and signal conditioning elements installed (as required), connect field wiring from your devices to the + and − terminals on TB4, TB5, TB6, TB7, or TB8. When connecting the wiring, route the wires under the strain relief clamp and tighten the clamp screw to reduce the chance of the wires being pulled out of the terminals. (The additional - terminal is for redundancy).

Recall that hardware channel numbering depends on the setting of the Card Configuration jumper. When connecting field wiring, be sure the inputs match the desired channel numbers. For example, inputs connected to TB7 can be CH3, CH2, or CH1B inputs, depending on the Card Configuration jumper setting.

There are two types of functions for the counter: single input and double input. Single input functions require only one input (the A input), while double input functions require two inputs (A input and B input). Ungated Total Counts (TOTAL), Ungated Total Counts, Modulo NPER (TOTALM), and Frequency (FREQ) are the only single input functions. All other functions are double input.

NOTE

The Period Measurements (PER) function is a double input function. However, the B "input" comes from the counter and is NOT a user input. For Period Measurements, the A input must be connected to channel 0A or 1A and the Card Configuration jumper must be set for 4 CH or 3 CH.

Example: Field Wiring - Isolated Channels

Figure 3-5 shows example field wiring connections to Isolated input channels 0 and 1 and the Card Configuration jumper set to 4 CH. For this configuration, a double input function can be connected to channel 0A (TB4) and channel 0B (TB5). Also, a single input function (TOTAL or TOTALM) can be connected to channel 1 (TB6). For all inputs, maximum differential voltage is 24 V.

Configuring Non Isolated Channels

There are three steps to hardware configure Non Isolated input channels, as shown. Figure 3-6 summarizes Non Isolated input channel features and shows jumper locations.

- Set AC/TTL jumpers.
- Install signal conditioning (as required).
- Connect field wiring.

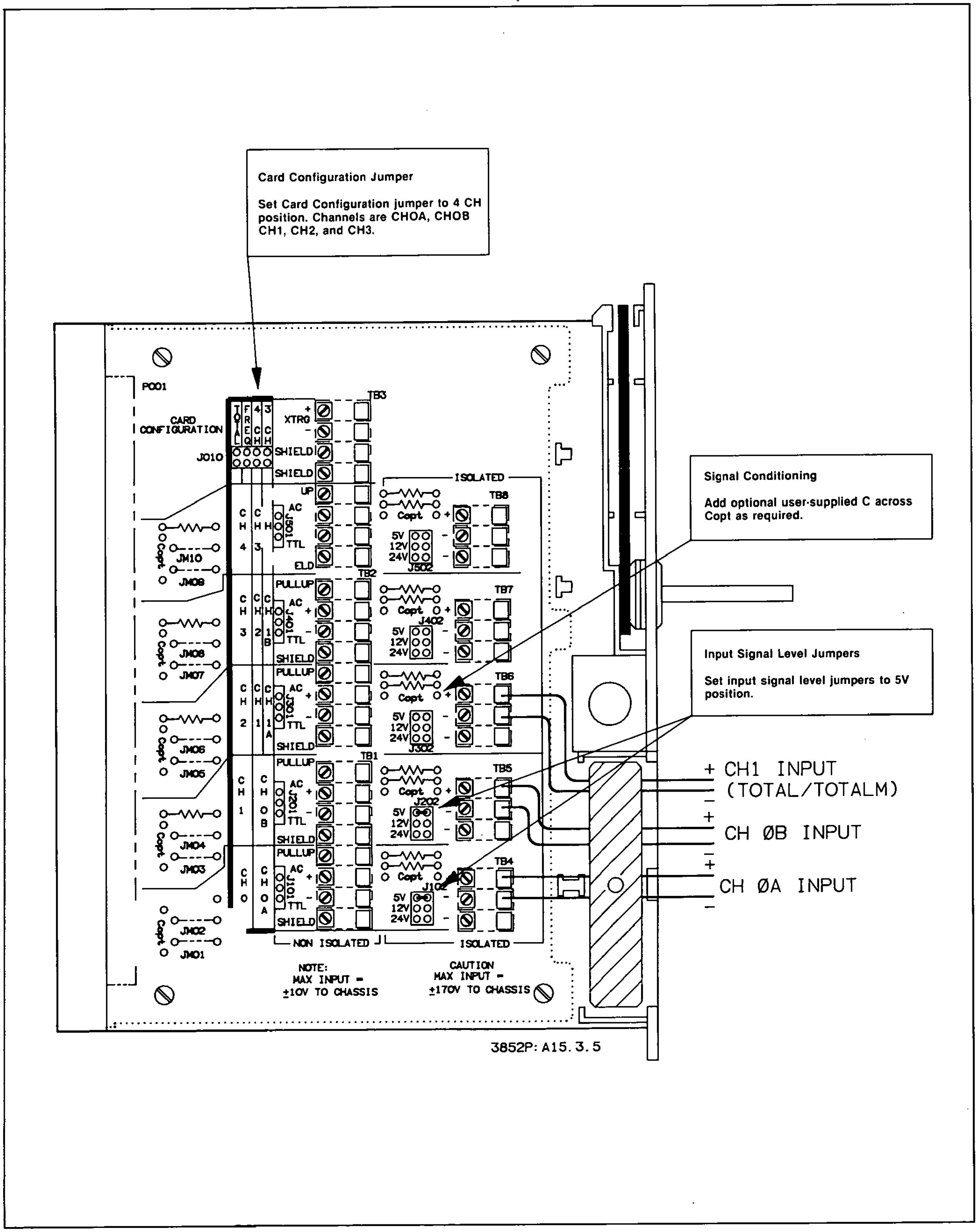

Figure 3-5. Example: Isolated Channels - Field Wiring

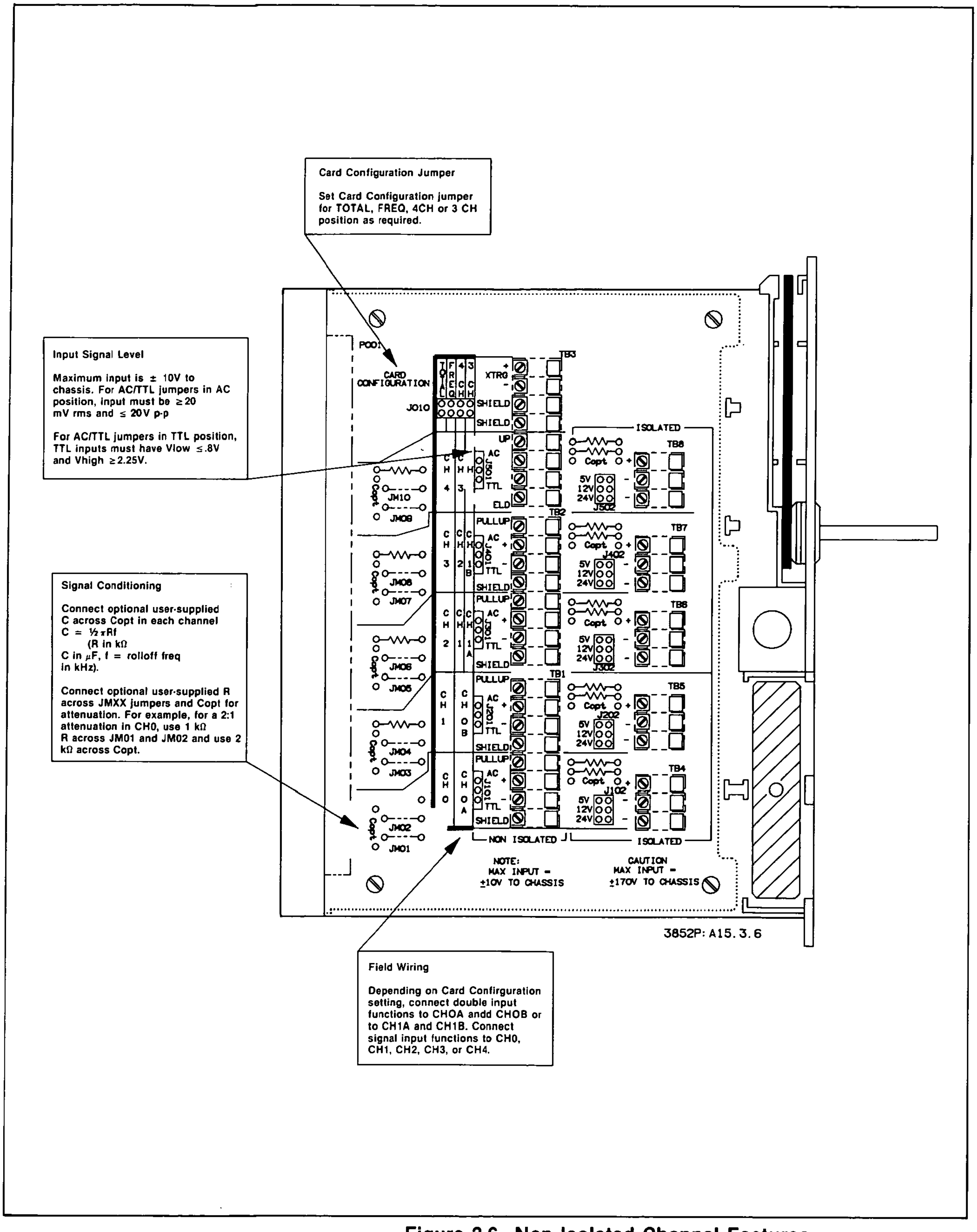

Figure 3-6. Non Isolated Channel Features

Setting AC/TTL Jumpers

As shown in Figure 3-6, each Non Isolated input channel has a separate jumper which sets the channel input voltage level to AC or TTL. AC inputs must be ≤ ± 10 VAC peak to chassis (20 VAC peak to peak input signal) and ≥ 25 mV rms. TTL inputs must have Vlow ≤0.8 volts and Vhigh ≥2.25 volts. Set each jumper to AC or TTL as required for your inputs.

Adding Signal Conditioning Elements

Each Non Isolated input channel has connections (JMXX) for optional, user-supplied resistors and a connector (Copt) for an optional, user-supplied capacitor. The JM jumpers can be replaced with resistors and Copt can be replaced with a resistor or a capacitor for DC attenuation or for a low-pass filter.

For 2:1 DC attenuation on a channel, place 1 kΩ resistors across each of the JM jumpers and a 2 kΩ resistor across Copt. For a low-pass filter, compute the capacitance value from Copt = $1/(2\pi f^*R)$, where R = resistor value in kΩ to be placed across each of the JM jumpers, f = desired rolloff frequency in kHz, and Copt = capacitor value in μF. Note that these elements attenuate only normal mode signals and will not help common mode noise rejection.

For example, for filter rolloff frequency = 1 kHz in channel 0, use R = 1 kΩ across JM01 and across JM02 and use Copt = 0.08 μF. For filter rolloff frequency = 10 kHz on this channel, use R = 1 kΩ across JM01 and across JM02, and use Copt = 0.008 μF.

Connecting Field Wiring

When the AC/TTL jumpers have been set and signal conditioning elements have been installed (as required), connect field wiring from your devices to terminals TB1, TB2, or TB3. When connecting the wiring, route the wires under the strain relief clamp and tighten the clamp screw to reduce the chance of the wires being pulled out of the terminals.

Using Pullup Resistors

A 3 kΩ pullup resistor to +5V is provided on each Non Isolated input channel. For inputs such as relays or open collector outputs, you can connect field wiring to the PULLUP, +, −, and SHIELD terminals. Connect PULLUP to +, SHIELD to −, and set the AC/TTL jumper to the TTL position. With these connections, relay closure causes a low input and relay opening causes a high input.

Figure 3-7 shows typical connections using the pullup resistor. The two wire connection (method A) is acceptable. However, the four wire connection (method B) provides better noise margin on logic low (when the switch is closed).

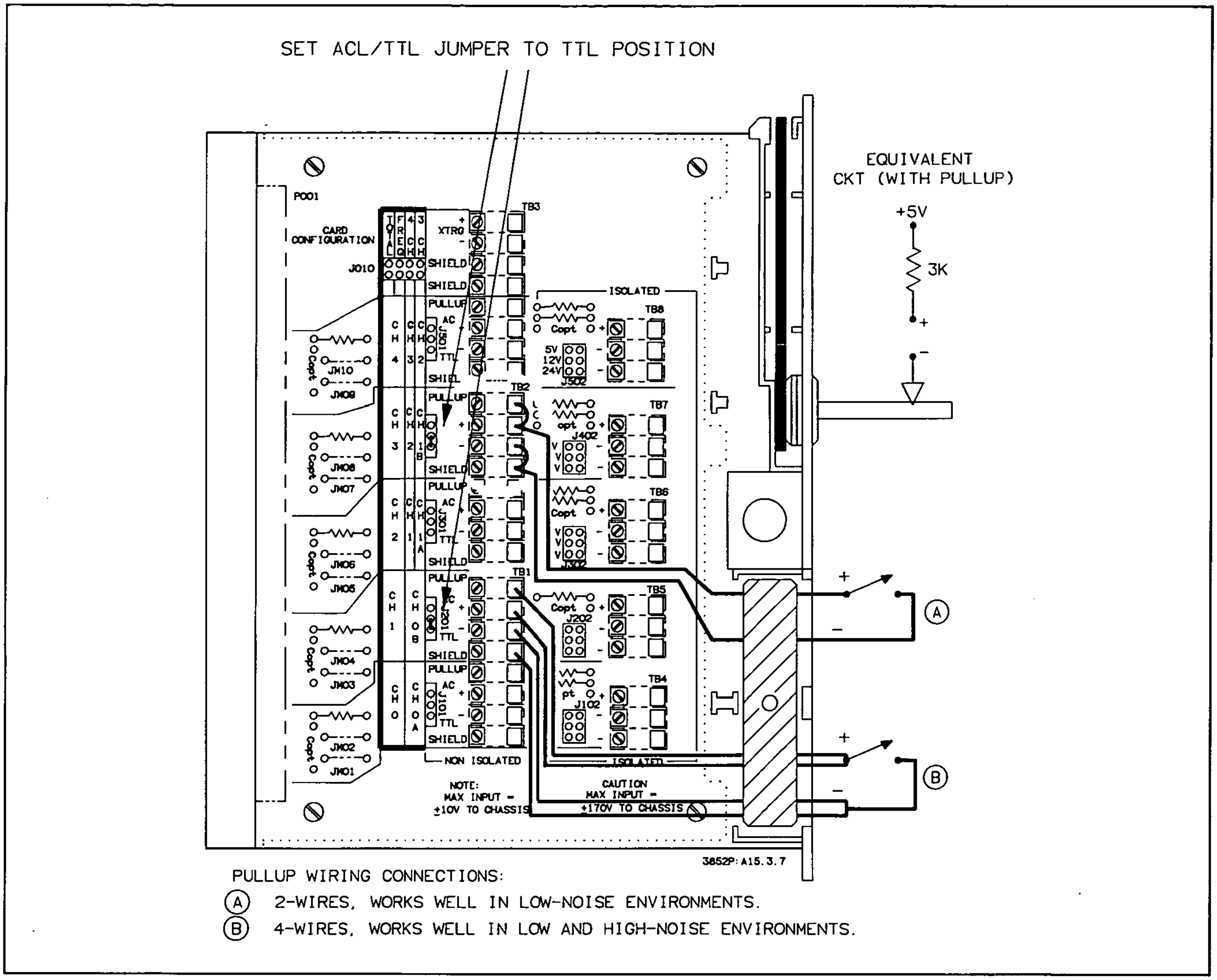

Figure 3-7. Example: Using Pullup Resistors

Typical Connections

Figure 3-8 shows example field wiring connections to channel 0 (CH0A and CH0B) and to channel 1. The Card Configuration jumper is set to the 4 CH position and the AC/TTL jumpers are set to AC for both channels. With this configuration, a double input function (any function except TOTAL, TOTALM, or FREQ) can be input to channel 0 and a TOTAL or TOTALM function can be input to channel 1.

Installation and Checkout

When required channels have been configured and field wiring connected, replace the terminal module cover, connect the terminal module to the component module, and install the counter in a desired slot. Refer to the HP 3852A Mainframe Configuration and Programming Manual to install the accessory.

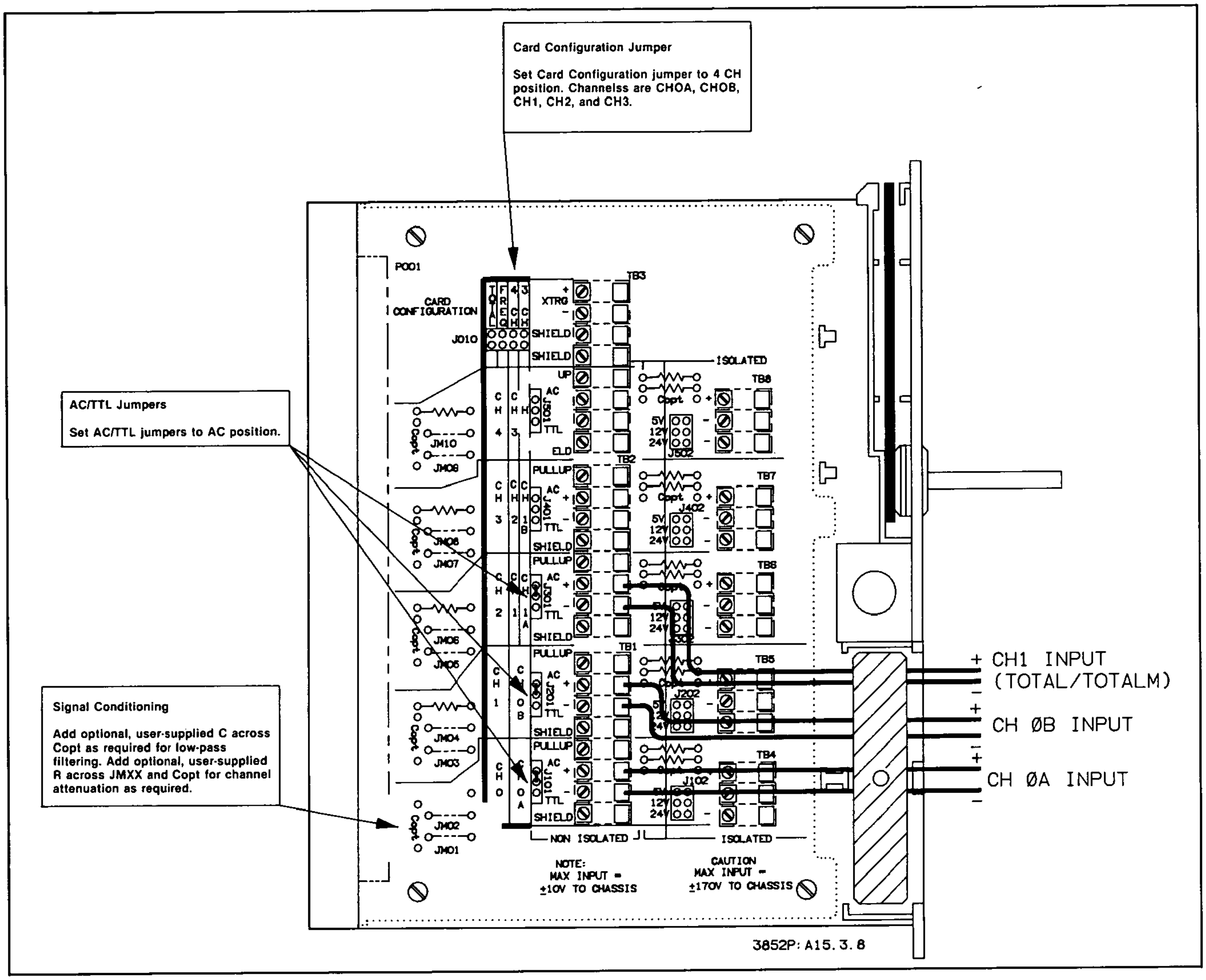

Figure 3-8. Example: Non Isolated Channels - Field Wiring

When the counter is installed, enter the ID? *slot* command from the front panel to check the counter identity. At power-on, a counter returns 44715A, while a counter component module only (no terminal module attached) returns 447XXX. Note that if the terminal module is removed after power-on, the ID? command returns 44715A.

If the counter does not return 44715A, be sure you have addressed the correct slot and the terminal module is installed. If these are correct but 44715A is not returned, refer to the HP 3852A Assembly Level Service Manual for service procedures.

This completes hardware configuration for the counter. Refer to Chapter 4 - Programming the Counter to program counter channels for your application.

Chapter 4
Programming The Counter

Contents

Chapter 4

Programming the Counter

Introduction

This chapter shows how to select channel parameters for your measurement and shows some example programs for counting and measurement functions.

Chapter Contents

Chapter sections are:

- **Introduction** summarizes chapter contents and includes an alphabetical summary of commands which apply to the counter.

- **Selecting Channel Parameters** gives guidelines to select channel parameters for your measurement. It includes guidelines to select the channel function, channel input, counts/timing, reads, and interrupts.

- **Programming Examples** contains example programs to program the counter for counting and measurement functions.

Command Summary

Table 4-1 is an alphabetical summary of commands which apply to the counter. Refer to the HP 3852A Command Reference Manual for a complete description of these commands.

Table 4-1. Counter Commands

CHREAD *ch* **[INTO** *name*] or [*fmt*]

For the channel specified by *ch*, reads the counts, the period, or the frequency of the input to the channel.

CHREADZ *ch* **[INTO** *name*] or [*fmt*]

For the channel specified by *ch*, reads and zeroes the count or the period of the input to the channel. CHREADZ does not apply to Frequency Measurements (FREQ).

CNTSET [*number*] **[USE** *ch*]

Using the channel specified by the USE *ch* command or parameter, sets the channel counter to the number specified by *number*. CNTSET is valid only when the TOTAL function is programmed.

CONF *function* **[USE** *ch*]

Configure the channel specified by the USE *ch* command or parameter to a counting (TOTAL, TOTALM, UDC, UDCM, CD, or CDM) or to a measurement (RAT, PER, PERD, or FREQ) function. In addition, CONF presets the channel to a known state and disables and clears all interrupts on the channel.

DISABLE INTR [USE *ch*]

Prevents the counter channel specified by the USE *ch* command or parameter from generating an interrupt on counter overflow or measurement complete.

EDGE *trans* [*trans*] **[USE** *ch*]

Sets edges to be detected on the channel specified by the USE *ch* command or parameter. The first *trans* parameter sets the A input edges to be detected while the second *trans* parameter sets the B input edges to be detected.

The second *trans* parameter is not valid for single input channels. If the second *trans* parameter is not specified for a double input channel, the value for the first *trans* parameter is used for both.

ENABLE INTR [USE *ch*]

Enables the channel specified by the USE *ch* command or parameter to interrupt. Depending on the function set, the channel will interrupt on counter overflow (for TOTAL or TOTALM) or on measurement complete (RAT, PER, PERD, or FREQ). The command does not generate interrrupts for the UDC, UDCM, CD, or CDM functions.

FUNC *function* [*tbase*] **[USE** *ch*]

Sets the counter to one of nine functions: TOTAL, TOTALM, UDC, UDCM, CD, CDM, RAT, PER, or PERD (FUNC does not apply to Frequency Measurements). The FUNC *tbase* parameter is valid only for PER and PERD functions. Default for *tbase* is AUTO.

NPER *number* **[USE** *ch*]

Use on the channel specified by USE *ch* command or parameter. For the TOTALM, UDCM, or CDM functions, the counter overflows at the next count after NPER-1 counts. For the RAT function, NPER periods occur on the B input during the measurement.

For the PER function, NPER periods of the A input are averaged. For the PERD function, NPER-1 gated periods will occur on the A input before the measurement begins and the B input gates the A input count. NPER is not valid for the TOTAL, UDC, CD, or FREQ functions.

SPER *number* **[USE** *ch*]

Samples all inputs to the counter at a rate specified by *number*, where *number* = sample period in seconds.

TBASE [*tbase*] **[USE** *ch*]

For the channel specified by the USE *ch* command or parameter, *tbase* sets the time base (in seconds) for use with PER, PERD, or FREQ functions. Default is AUTO selection of time base.

Table 4-1. Counter Commands (Cont'd)

TERM *terminal* [*terminal*] [**USE** *ch*] For the channel specified by the USE *ch* command or parameter, the first *terminal* parameter sets the terminal for the A input, while the second *terminal* parameter sets the terminal for the B input (for double input channels only). The second *terminal* parameter does not apply to single input channels. If the second *terminal* parameter is not used for double input channel functions, the value of first *terminal* is used for both parameters.
TRIG [*source*] [**USE** *ch*] For the channel specified by the USE *ch* command or parameter, *source* sets the trigger mode/source to one of five modes: AUTO, EXT, HOLD, SGL, or SYS. When the counter is set to the FREQ function, the trigger mode/source applies to all five channels.
USE *ch* Use the channel specified by the *ch* command or parameter in commands to follow, where *ch* is the address of the channel. When USE *ch* is executed, the address remains active until another USE statement or system reset.
XRDGS *ch* [*number*] [**INTO** *name*] or [*fmt*] For the channel specified by *ch*, transfers the number of readings specified by *number* from the counter to the mainframe. If a reading is not available, the command waits until the readings are available and then transfers the readings. Default *number* = 1.

Selecting Channel Parameters

The first step to program the counter is to select the channel parameters required for your measurement. Table 4-2 shows suggested steps to select channel parameters. The associated command to set the parameter is shown in parentheses. A discussion of each parameter area follows. When you have selected the channel parameters required, refer to "Programming Examples" for some example programs.

Table 4-2. Selecting Channel Parameters

• Select Channel Function	
- Counter Function/Presets	(CONF)
- Counter Function	(FUNC)
• Select Channel Input	
- Input Terminals	(TERM)
- Count/Gate Edges	(EDGE)
- Trigger Source	(TRIG)
• Select Counts/Timing	
- Counter Presets	(CNTSET)
- Number or Period	(NPER)
- Sample Period	(SPER)
- Time Base	(TBASE)
Select Reads	
- Single Read	(CHREAD)
- Read/Zero Results	(CHREADZ)
- Multiple Reads	(XRDGS)
• Select Interrupts	
- Enabling Interrupts	(ENABLE INTR)
- Disabling Interrupts	(DISABLE INTR)

Selecting Channel Function

The first channel parameter to select is the function to be set on each channel used. The channel function can be set with either the CONF or the FUNC command.

Channel Function/Presets (CONF)

The easiest way to set a channel function is with the CONF *function* [USE *ch*] command. CONF sets the channel function, presets the channel specified by the USE *ch* command or parameter to a known state, and clears and disables any interrupts on the channel.

CONF *function* Parameters

For convenience, Table 4-3 repeats the functions set with the CONF *function* parameter shown in Table 2-1. Refer to Chapter 2 - Selecting Counter Functions for a definition of each function.

NOTE

1. Double input functions (all except Ungated Total Counts [TOTAL], Ungated Total Counts, Modulo NPER [TOTALM], and Frequency Measurements [FREQ]) can only be programmed on channels configured for double input.

2. When the Card Configuration jumper is set to FREQ, only the FREQ parameter can be set. For other settings of the Card Configuration jumper, power-on and CONF function setting is TOTAL for all channels.

Table 4-3. CONF *function* Parameters

Function	function	Ch	Description	Inputs A	Inputs B	Interrupts Type	Interrupts When
Totalize Counts							
Ungated Total Counts	TOTAL	S	Count number of A input transitions.	Count	N/A	OVF	Rollover (−1 to 0)
Gated Total Counts	TOTAL	D	Count number of A input transitions, gate with B input.	Count	Gate	OVF	Rollover (−1 to 0)
Ungated Total Counts, Modulo NPER	TOTALM	S	Count number of A input transitions, modulo NPER.	Count	N/A	OVF	Rollover (NPER-1 to 0)
Gated Total Counts, Modulo NPER	TOTALM	D	Count number of A input transitions, modulo NPER. Gate with B input.	Count	Gate	OVF	rollover (NPER-1 to 0)

Table 4-3. CONF *function* Parameters (Cont')

Up/Down Counts							
Up/Down Counts	UDC	D	Count up on A input, count down on B input. Result is (A-B) counts.	Up Count	Down Count	——	None
Up/Down Counts, Mod NPER	UDCM	D	Count up on A input, count down on B input. Result is (A-B) counts, modulo NPER.	Up Count	Down Count	——	None
Count With Direction Control							
Count/ Direction	CD	D	Count A input up or down. B input controls direction.	Count	Dir	——	None
Count/ Direction, Mod NPER	CDM	D	Count A input up or down. B input controls direction. Count modulo NPER.	Count	Dir	——	None
Quadrature Count	CD	D	Count up on all A input transitions when B leads A. Count down on all A input transitions when A leads B.	Count	Dir	——	None
Quadrature Count, Modulo NPER	CDM	D	Same as Quadrature Count except count modulo NPER.	Count	Dir	——	None
Ratio Measurements							
Ratio	RAT	D	Measure average number of A input counts per B input period.	Count	Count	MC	After NPER B Periods
Period Measurements							
Period	PER	D	Measure average of NPER periods of A input.	Count	Not* Used	MC	After NPERth Period of A
Delayed Period	PERD	D	Measure NPERth gated period of A input, gate with B input.	Count	Gate	MC	After NPERth Gated Period of A
Frequency Measurements							
Frequency	FREQ**	S	Measure average frequency of A input.	Count	N/A	MC	After Gate Time

Notes:

* = Although B input is not used, PER function must be programmed on a double input channel.

** = FUNC command does not apply to FREQ parameter.

CONF Command Preset Values

As noted, CONF also presets the counter to a known state. That is, executing CONF is equivalent to executing the commands in Table 4-4 in the order shown. You can then use low level commands as required to modify the CONF settings.

Table 4-4. CONF Preset Values

All Functions Except FREQ

Command	Description	Preset Value	Note
TRIG	Trigger mode	HOLD	
FUNC	Counter function	Set by CONF	[a]
TERM	Input terminals	ISO,ISO	[b]
EDGE	Counted/gated edge	HL,HL	[c]
NPER	Measurement period/reset	10	
CNTSET	Start count/rollover	0	[d]
DISABLE INTR	Disable interrupt	Disabled	
SPER	Sample period	1 μsec	

[a] = TBASE AUTO is also set. TBASE is specified for PER and PERD only.
[b] = TERM ISO for single input functions.
[c] = EDGE HL for single input functions.
[d] = CNTSET applies to TOTAL functions only.

FREQ Function

TRIG	Trigger mode	HOLD
TBASE	Time base	AUTO
TERM	Input terminals	ISO
EDGE	Counted/gated edge	HL
DISABLE INTR	Disable interrupt	Disabled
SPER	Sample period	1 μsec

Channel Function (FUNC)

You can also use the FUNC *function* [*tbase*] [USE *ch*] command to select any of the functions shown for the CONF command (refer to Table 4-3) except FREQ. However, in contrast to the CONF command, FUNC does not preset the channel to a known state.

For FUNC, *tbase* is valid only for *function* = PER or PERD. The *tbase* parameter is the period of the counter internal clock which is counted during NPER periods of the input. *tbase* values are 1 μsec, 10 μsec, 100 μsec, 1 msec, and 10 msec with default value = AUTO. Refer to "Time Base (TBASE)" for details on the *tbase* parameter.

Selecting Channel Input

Three commands are used to set input channel parameters. TERM sets the input path (Isolated or Non Isolated channels), EDGE sets the input edges to be counted or sets the gate level, and TRIG sets the counter trigger source.

Input Terminals (TERM)

The input signal path (Isolated or Non Isolated) is set by the TERM *terminal* [*terminal*] [USE *ch*] command. The first *terminal* parameter sets the A input terminals and the second *terminal* parameter sets the B input terminals (for double input functions only).

TERM ISO sets Isolated Input terminals and TERM NON sets Non Isolated Input terminals. Power-on, default and CONF settings are TERM ISO for single input functions and TERM ISO,ISO for double input functions.

Example: Specifying Input Terminals (TERM)

For example, if the Card Configuration jumper is set for 4 CH configuration, TERM NON,NON,USE 200 sets the terminal inputs for channels 0A and 0B of a counter in slot 2 of the mainframe to Non Isolated input. Or, if the jumper is set for 3 CH configuration, TERM ISO,ISO,USE 201 sets channels 1A and 1B of a counter in slot 2 of the mainframe to Isolated input.

Count/Gate Edges (EDGE) Use the EDGE command to select the input edge (transition) to be counted or to set the gate level. The EDGE *trans* [*trans*] [USE *ch*] command has four values for the *trans* parameter: LH, HL, HI, and LO.

For single input functions, the second *trans* parameter is not allowed. For double input functions, the first *trans* parameter applies to the A input and the second *trans* parameter to the B input. Power-on setting is EDGE LH (EDGE LH, LH for double input functions). Note, however, that CONF sets EDGE HL (HL,HL for double input functions).

NOTE

1. Although the PER function can be used only on a double input channel, the second EDGE trans parameter need not be specified since the B "input" is internally generated by the counter.

2. The EDGE command has no effect on Quadrature Count. That is, for any EDGE setting, all A input edges are counted up when B leads A and counted down when A leads B.

Table 4-5. EDGE *trans* [*trans*] Parameters

Gated Total Counts (TOTAL/TOTALM)	
LH,HI*	Count A input LH edges when the B input is high.
LH,LO*	Count A input LH edges when the B input is low.
HL,HI	Count A input HL edges when the B input is high.
HL,LO	Count A input HL edges when the B input is low.
Up/Down Counts (UDC/UDCM)	
LH,LH	Count up on A input LH edges. Count down on B input LH edges.
LH,HL	Count up on A input LH edges. Count down on B input HL edges.
HL,LH	Count up on A input HL edges. Count down on B input LH edges.
HL,HL	Count up on A input HL edges. Count down on B input HL edges.
Count With Direction Control (CD/CDM)	
LH,HI	Count up on A input LH edges when the B input is high. Count down on A input LH edges when the B input is low.
LH,LO	Count up on A input LH edges when the B input is low. Count down on A input LH edges when the B input is high.
HL,HI	Count up on A input HL edges when the B input is high. Count down on A input HL edges when the B input is low.
HL,LO	Count up on A input HL edges when the B input is low. Count down on A input HL edges when the B input is high.
Quadrature Count (CD/CDM)	
N/A**	Count up on all A input edges when B leads A. Count down on all A input edges when A leads B.
Ratio Measurements (RAT)	
LH,LH	LH edges mark A and B input periods.
LH,HL	LH edges mark A input periods. HL edges mark B input periods.
HL,LH	HL edges mark A input periods. LH edges mark B input periods.
HL,HL	HL edges mark A input and B input periods.
Delayed Period Measurements (PERD)	
LH,HI	Count A input LH edges when B input is high.
LH,LO	Count A input LH edges when B input is low.
HL,HI	Count A input HL edges when B input is high.
HL,LO	Count A input HL edges when B input is low.

* = HI is equivalent to LH and LO is equivalent to HL.
** = Same action for any setting of EDGE.

Trigger Source (TRIG)

When the input terminals and count/gate edges have been selected, the next step is to select the counter trigger source with the TRIG [*source*] [USE *ch*] command. Table 4-6 describes the TRIG *source* parameters and shows the previous TRIG *source* state(s) cancelled.

Power-on and CONF *source* = HOLD and default *source* = SGL. Note that TRIG EXT requires a hardware connection from the external trigger source to the XTRG terminals (see Figure 3-3).

Table 4-6. TRIG *source* Parameters

source	Description	Cancels Previous source(s)
AUTO	Counter internal triggering (continuous triggering)	TRIG EXT TRIG SYS
EXT	External trigger source (requires hardware connnection from source to XTRG terminals).	TRIG AUTO TRIG SYS
HOLD	Aborts ongoing measurement, discards existing count, and disables any trigger source for the channel(s).	TRIG AUTO TRIG EXT TRIG SGL TRIG SYS
SGL	Immediate single trigger when TRIG SGL is executed.	TRIG AUTO TRIG EXT TRIG SYS
SYS	System Triggering (used with TRG command - see Figure 3-3).	TRIG AUTO TRIG EXT

The TRIG command should follow all commands which affect counter setup (CONF, TBASE, NPER, SPER, EDGE, TERM, or CNTSET), since TRIG (and these commands) aborts any ongoing measurement and destroys existing data. Also, if CONF is not used, TRIG HOLD should be set before configuring the counter since other TRIG *sources* may send a trigger to the channel before the channel is properly configured.

TRIG *source* does not change when a channel is reprogrammed to another function. When the Card Configuration jumper is set to the FREQ position, TRIG *source* applies to all five channels. Although multiple channels can be triggered with TRIG EXT or TRIG SYS sources, each channel can be assigned to only one source.

Selecting Counts/ Timing

Four commands can be used to set channel counts/timing parameters (CNTSET, NPER, SPER, and TBASE) although not each parameter applies to every function. Table 4-7 summarizes these four commands and shows the CONF (or FUNC) *function* for which the command is valid.

Table 4-7. Channel Counts/Timing Commands

Command	Description	function(s)
CNTSET	Presets counter to begin counting from a specified number of counts OR to rollover after a specified number of counts.	TOTAL
NPER	Sets the number of periods over which an input is measured OR sets the value minus 1 at which the counting sequence resets to zero.	TOTALM/UDCM/ CDM/RAT/PER/ PERD
SPER	Sets the period over which the input signal is sampled. Inputs which do not remain at the required level during the sample period are ignored.	All
TBASE	Sets the time base to be used with Period, Delayed Period, and Frequency Measurements.	PER/PERD/FREQ*

* = FUNC does not apply to FREQ parameter.

Counter Presets (CNTSET)

For Ungated and Gated Total Counts (TOTAL) functions ONLY, you can use CNTSET [*number*] [USE *ch*] to preset the A input channel to a number from −2147483648 to 2147483647, as specified by *number*.

The *number* parameter specifies the number of counts to preset the counter or sets the number of counts required to cause the counter to rollover (refer to Table 4-8). Default value and value set by the CONF command is 0.

As shown in Chapter 2 (see Figure 2-1), without a preset value the count sequence is from 0 to 2147483647 counts to −2147483648 to −1 and back to 0. When the counter rolls over (from −1 to 0), if enabled the channel generates a counter overflow (OVF) interrupt.

Therefore, without a preset, 4294967296 counts are needed to generate a counter interrupt. Note that the count range is from 0 to 4294967296, while the CNTSET [*number*] range is from −2147483648 to 2147483647.

The value to use for CNTSET [*number*] depends on the number of counts specified, as shown in Table 4-8. For example, if counts = 1000 is desired, *number* = 1000 presets the counter to start counting at 1000 counts, while *number* = -1000 causes the counter to rollover after 1000 counts.

Or, if counts = 3,000,000,000 is desired, *number* = −1294967296 (counts - 4294967296) presets the counter to start counting at 3,000,000,000 counts while *number* = 1294967296 (4294967296 - counts) causes the counter to rollover after 3,000,000,000 counts.

Table 4-8. CNTSET *number* vs. Counts

Preset Counter:	
number = counts	(counts <2147483648)
number = counts - 4294967296	(counts ≥2147483648)
Rollover After Counts:	
number = -counts	(counts <2147483648)
number = 4294967296 - counts	(counts ≥2147483648)

Number or Period (NPER)

For the TOTALM, UDCM, CDM, RAT, PER, and PERD functions, counting or measurement is done Modulo NPER, where the value is specified by NPER *number* [USE *ch*]. Modulo NPER mode is useful when you want to count up to a certain value and then generate an interrupt.

For example, with Ungated Total Counts (TOTAL) unless the counter is preset with CNTSET the channel must count 4294967296 counts before the counter rolls over. However, with Ungated (or Gated) Total Counts, Modulo NPER, the counter counts from 0 to NPER-1 and rolls over to 0 with the next count (see Figure 2-1 for counting sequences).

Depending on the function programmed, the NPER command defines either the number of counts or the number of periods to be used for the channel, as shown in Table 4-9. Power-on *number* or the value set by CONF is 10.

Table 4-9. NPER *number* vs. Counter Functions

function(s)	NPER Description	NPER Range
TOTALM, UDCM, CDM	Counting sequence resets to 0 at the next count after the NPER-1 value.	2 to 65535
RAT	Sets number of B input periods to count A input transitions. The A input count is divided by NPER to get the average number of A input counts per B input period.	1 to 65535
PER	Sets the number of A input periods to be measured. The PER function returns the average value of NPER periods of the A input.	1 to 65535
PERD	A single period measurement is taken on the NPERth gated period of the A input.	1 to 65534

Sample Period (SPER) You can use the SPER *number* [USE *ch*] command to set the sample period for ALL channels of the counter, where *number* = sample period (in seconds) at which the inputs are sampled. This command is useful to digitally filter noisy, slow inputs for applications such as debouncing switch closures. Input signals which do not remain at the required level during the sample period are ignored.

The SPER command sets the sample period for ALL channels of the counter, even though USE *ch* is specified for a single channel. For example, with a counter in slot 4 of the mainframe set for TOTAL function, SPER .000001,USE 402 sets a 1 μsec sample period for channels 0, 1, 2, 3, and 4.

The minimum input pulse width is affected by the SPER command, since minimum pulse width = [(number*2) + 0.5] μsec. For example, if *number* = 20 μsec, minimum input pulse width = 40.5 μsec.

The power on and CONF value for SPER *number* = 1 μsec. The range of *number* = 1 μsec to 0.16 seconds in incremental steps, as shown in Table 4-10. The actual sampling period used is rounded up to a valid number closest to the *number* specified.

Table 4-10. SPER *number* Range/Increments

SPER number range	Increments
1 μsec to 16 μsec	1 μsec
20 μsec to 160 μsec	10 μsec
200 μsec to 1.6 msec	100 μsec
2 msec to 16 msec	1 msec
20 msec to 160 msec	10 msec

Time Base (TBASE) For power-on, default, and CONF settings, the counter automatically selects the appropriate time base for Period Measurements (PER and PERD) or the gate time for Frequency Measurements (FREQ). However, as required, you can select the time base for Period Measurements or the gate time for Frequency Measurements with the TBASE [*tbase*] [USE *ch*] command. When *tbase* = AUTO or 0, (power-on, default, and CONF setting) the counter automatically selects the best time base or gate time.

NOTE

If tbase is not set to one of the values shown in Table 4-11 for the PER function or in Table 4-12 for the PERD function, the value is rounded down to the next lower valid time base. If tbase is not set to one of the values shown in Table 4-13 for the FREQ function, the value is rounded up to the next higher valid gate time.

Setting TBASE *tbase* for Period Measurements (PER)

As shown in Chapter 2 (see Figure 2-13), the PER function measures the average of NPER periods of the A input (5 μsec minimum period and 655.35 second maximum period). The resolution of the reading can be increased by increasing NPER (range = 1 to 65535), as shown in Table 4-11.

In Table 4-11, the sample period set by SPER *number* = 1 μsec, and NPER = the number of periods to be averaged (1 to 65535) as set with the NPER command. Note, however, that the SPER, NPER, TBASE, and CONF (or FUNC) commands interact to determine minimum and maximum pulse widths and periods of the input signal which can be measured.

To compute maximum and minimum periods which can be measured and the resolution for a given *tbase* setting, divide the values shown in the Resolution column of Table 4-11 by the value of NPER. For example, if SPER = 1 μsec, NPER = 100, and TBASE *tbase* = 10 μsec the period range is from 5 μsec (minimum period for any *tbase* setting) to 6.5535 msec with 0.1 μsec resolution.

With SPER = 1 μsec, minimum pulse width for the input = (1*2 + 0.5) μsec = 2.5 μsec. However, if SPER is changed to 10 μsec, minimum pulse width = (10*2 +0.5) μsec = 20.5 μsec, so the minimum period increases from 5 μsec to 41 μsec.

Table 4-11. TBASE *tbase* Resolution - PER Function

tbase	Period Range Minimum	Period Range Maximum	Resolution
1 μsec	5 μsec	65.535/NPER msec	1/NPER μsec
10 μsec	5 μsec	655.35/NPER msec	10/NPER μsec
100 μsec	5 μsec	6.5535/NPER sec	100/NPER μsec
1 msec	5 μsec	65.535/NPER sec	1/NPER msec
10 msec	5 μsec	655.35/NPER sec	10/NPER msec

Setting TBASE *tbase* for Delayed Period Measurements (PERD)

As shown in Chapter 2 (see Figure 2-14) the PERD function measures the period of the NPERth gated period of the A input. Thus, the considerations to set TBASE *tbase* for PERD are the same as for the PER function, except that the NPER range = 1 to 65534 for the PERD function and the resolution does not depend on the NPER value. Table 4-12 shows the TBASE *tbase* resolution for the PERD function.

Table 4-12. TBASE *tbase* Resolution - PERD Function

tbase	Period Range Minimum	Maximum	Resolution
1 μsec	5 μsec	65.535 msec	1 μsec
10 μsec	5 μsec	655.35 msec	10 μsec
100 μsec	5 μsec	6.5535 sec	100 μsec
1 msec	5 μsec	65.535 sec	1 msec
10 msec	5 μsec	655.35 sec	10 msec

Setting TBASE *tbase* for Frequency Measurements (FREQ)

As shown in Chapter 2 (see Figure 2-15), the FREQ function provides the average frequency of the input as measured over an adjustable time base (gate time). When the Card Configuration jumper is set to the FREQ position, you can set the gate time for Frequency Measurements with the TBASE [*tbase*] parameter.

For the FREQ function, the TBASE *tbase* setting applies to ALL five channels. Power-on, default, and CONF setting for *tbase* is AUTO. Table 4-13 shows the frequency range and resolution for each of the three *tbase* settings with SPER = 1 μsec.

Table 4-13. TBASE *tbase* Settings - FREQ Function

tbase	Gate Time	Frequency Range	Resolution*
1 sec	1 sec	1 Hz to 65.535 kHz	1 Hz
100 msec	100 msec	10 Hz to 200 kHz	10 Hz
10 msec	10 msec	100 Hz to 200 kHz	100 Hz

* = SPER = 1 μsec.

When the Card Configuration jumper is set to the FREQ position, SPER and TBASE interact to determine frequency range and resolution. For example, with SPER = 1 μsec and TBASE *tbase* = 100 msec, the frequency range is from 10 Hz to 200 kHz with 10 Hz resolution.

For SPER = 1 μsec, the minimum pulse width for the input = (1*2 + 0.5) μsec = 2.5 μsec. However, if SPER is changed to 10 μsec, the minumum pulse width = (10*2 + 0.5) μsec = 20.5 μsec, so minimum period = 41 μsec and maximum frequency decreases from 200 kHz to about 24.4 kHz.

Selecting Reads

There are three commands to read the results of channel measurements: CHREAD, CHREADZ, and XRDGS. Counting functions (TOTAL, TOTALM, UDC, UDCM, CD, and CDM) can be read at any time without disturbing the counting sequence. Measurement functions (RAT, PER, PERD, and FREQ) can be read only when the measurement is complete.

Single Read (CHREAD)

Use CHREAD to read the results of channel measurements. CHREAD returns the current count for the TOTAL, TOTALM, UDC, UDCM, CD, and CDM functions. CHREAD returns the most recently completed measurement (ratio, period, or frequency) for the RAT, PER, PERD, and FREQ functions. The channel addressed must have been triggered and data must be available before CHREAD will return a reading.

For measurements which can be read at any time (TOTAL, TOTALM, UDC, UDCM, CD, and CDM), CHREAD does not affect interrupts enabled for the channel. For measurements which can be read only when the measurement is complete (RAT, PER, PERD, and FREQ), CHREAD clears the measurement complete interrupt. Refer to Table 4-14 for the type of data returned by CHREAD for each counter function.

NOTE

Note that the TOTAL, UDC, and CD functions return a number between −2147483648 to +2147483647. Since the counter counts from +2147483647 to −2147483648, any number ≥2147483648 but <4294967296 is returned as a negative number.

Thus, for these functions if a negative number is returned, use 4297487296 minus the absolute value of the number returned. For example, for a channel set to the TOTAL function if −1000000000 is returned, the actual number of counts on the channel = 4294967296 - 1000000000 = 3294967296.

Table 4-14. Data Returns vs. Counter Functions

function	Data Returned	Range
TOTAL	Total counts on A input.	–2147483648 to 2147483647
TOTALM	Total counts on A input, modulo NPER.	0 to 65534
UDC	Difference between A input and B input counts (A-B).	–2147483648 to 2147483647
UDCM	Difference between A input and B input counts (A-B), modulo NPER.	0 to 65534
CD	Net counts on A input.	–2147483648 to 2147483647
CDM	Net counts on A input, modulo NPER.	0 to 65534
RAT	Average counts on A input per B input period.	0 to 65535/NPER
PER	Average of NPER periods of the A input.	5 μsec to 655.35/NPER sec
PERD	Value of NPERth gated period of the A input.	5 μsec to 655.35 sec
FREQ*	Average frequency of the A input.	1+ Hz to 200 kHz

* = CHREADZ cannot be used for the FREQ function.

Read/Zero Results (CHREADZ)

Use the CHREADZ command to read and zero the count on a channel. For measurements which can be read at any time, CHREADZ performs the same functions as CHREAD, except that the channel counter is reset to zero. For measurements which can be read only when the measurement is complete, CHREADZ performs the same functions as the CHREAD command, except that CHREADZ does not apply to the FREQ function. Refer to Table 4-14 for the data returned by CHREADZ.

Multiple Reads (XRDGS)

To read multiple results, use the XRDGS *ch* [*number*] command, where *number* specifies the number of readings to be returned on the channel specified by *ch*. To use XRDGS, the channel addressed must have been triggered and a reading must be available. The range of *number* = 1 to 2147483647 with default = 1.

For the TOTAL, TOTALM, UDC, UDCM, CD, and CDM functions, only one trigger is required. For the RAT, PER, PERD, and FREQ functions, the number of valid triggers must be the same as the number of readings transferred. Also, RAT, PER, and PERD functions require NPER input periods per measurement.

When XRDGS is executed, the number of readings specified by *number* are transferred as each becomes available. In effect, XRDGS acts like several CHREADS. XRDGS clears any measurement complete interrupt previously generated by a RAT, PER, PERD, or FREQ measurement. Refer to Table 4-14 for data returned by XRDGS.

Selecting Interrupts

Each channel can be enabled to interrupt with the ENABLE INTR [USE *ch*] command. When enabled, a channel interrupts on counter overflow or on measurement complete, depending on the function set for the channel. Also, each channel can be prevented from interrupting with the DISABLE INTR [USE *ch*] command.

Enabling Interrupts (ENABLE INTR)

Interrupts can be independently enabled for each channel with the ENABLE INTR command. Depending on the function set, counter overflow (OVF) or measurement complete (MC) interrupts can be enabled, as shown in Table 4-15. If more than one channel generates an interrupt, the mainframe services the lowest-numbered channel first, then the next-lowest, etc. The counter keeps track of the interrupts which have not been serviced.

OVF interrupts are automatically disabled and cleared when serviced. MC interrupts are automatically disabled when serviced and cleared when the reading is taken from the channel. The RST or RST *slot* (reset) command disables all channels from interrupting on counter overflow or measurement complete.

Table 4-15. Interrupts vs. Counter Functions

function	Type	When Generated	NPER range
TOTAL	OVF	Count goes from −1 to 0	N/A
TOTALM	OVF	Count goes from NPER-1 to 0	2 to 65535
RAT	MC	After NPER B input periods	1 to 65535
PER	MC	After NPER A input periods	1 to 65535
PERD	MC	After NPERth gated A input period	1 to 65534
FREQ	MC	After gate time	N/A

Disabling Interrupts (DISABLE INTR)

Each counter channel can be independently disabled from generating an OVF or MC interrupt with the DISABLE INTR [USE *ch*] command. The DISABLE INTR command disables OVF or MC interrupts (as applicable) interrupts for the channel specified by the USE *ch* command or parameter.

For a channel set to TOTAL, TOTALM, UDC, UDCM, CD, or CDM function, DISABLE INTR disables and clears the channel interrupt. Then, a subsequent ENABLE INTR will not prematurely generate an interrupt.

For the RAT, PER, PERD, and FREQ functions, DISABLE INTR clears but does not disable a pending interrupt so a subsequent ENABLE INTR could generate an interrupt. The interrupt is cleared when the measurement is read.

NOTE

1. If a parameter (edge, term, etc.) is changed on a disabled channel, the channel remains disabled but any pending interrupts are cleared. (CONF clears and disables interrupts).

2. Even if DISABLE INTR is not used, an OVF interrupt is automatically disabled and cleared when the interrupt is serviced. An MC interrupt is automatically disabled when it is serviced and is cleared when the reading has been taken on the channel.

Programming Examples

This section shows example programs for several counter functions. Refer to Table 4-16 for titles of the example programs. Also, refer to Chapter 2 - Selecting Counter Functions for a description of counter functions.

The procedure for each example will be to use the CONF command to set the counter to a known state (refer to Table 4-4) and then modify the conditions as required with low-level commands (EDGE, etc.). For all functions except FREQ, you can use FUNC rather than CONF to set the counter function. However, since FUNC does not preset the counter for other conditions, low-level commands must be used to set the conditions otherwise set by CONF.

Table 4-16. Example Program Titles

Function	Title	Description
Totalize Counts (TOTAL/TOTALM)		
Ungated Total Counts (TOTAL)	Count Switch Closures	Count number of switch closures and generate an OVF interrupt after 10 closures.
Gated Total Counts, Mod NPER (TOTALM)	Count Switch Closures, Modulo 5	Count number of switch closures only when a control switch is open. Count closures modulo 5.
Up/Down Counts (UDC/UDCM)		
Up/Down Counts (UDC)	Count Pulse Rates	Measure difference in number of pulses output from two pulse generators.
Up/Down Counts, Mod NPER (UDCM)	Count Pulse Rates, Modulo 5	Measure difference in number of pulses output from two pulse generators, count modulo 5.

Table 4-16. Example Program Titles (Cont'd)

Function	Title	Description
Count With Direction Control (CD/CDM)		
Count/ Direction (CD)	Determine Shaft Position	Determine shaft position using a shaft encoder and Count/ Direction.
Quadrature Count (CD)	Determine Shaft Position Using Quadrature	Determine shaft position using a shaft encoder and Quadrature Count.
Ratio Measurements (RAT)		
Ratio (RAT)	Measure Ratio	Determine number of pulses output from test generator for 1000 pulses output from reference generator.
Period Measurements (PER/PERD)		
Period (PER)	Measure Average Period	Measure average period of an input.
Delayed Period (PERD)	Measure Single Period	Measure the 100th gated period of an input.
Frequency Measurements (FREQ)		
Frequency (FREQ)	Measure Flow Rate	Measure paddlewheel flow meter flow rate by measuring pickup input frequency.

Totalize Counts (TOTAL/ TOTALM)

Totalize Counts functions include Ungated Total Counts (TOTAL), Gated Total Counts (TOTAL), Ungated Total Counts, Modulo NPER (TOTALM), and Gated Total Counts, Modulo NPER (TOTALM).

Two examples follow which use the TOTAL or TOTALM function. The first example "Count Switch Closures" uses Ungated Total Counts (TOTAL) to totalize switch closures and generate an OVF interrupt after 10 closures. The second example "Count Switch Closures, Modulo 5" uses Gated Total Counts, Modulo NPER (TOTALM) to count switch closures (count modulo 5) only when a control switch is open.

Example: Count Switch Closures

This program totalizes the number of times a switch (S3) closes and generates an OVF interrupt when the switch closes 10 times. See Figure 4-1 for typical connections and counter configuration for channel 503 of a counter in slot 5 of the mainframe.

When the OVF interrupt occurs (counter rolls over from −1 to 0), the program returns the time of the interrupt and the message "S503 - 10 Closures".

The STA? command reads the Status Register and clears the FPS, LCL, INTR, LMT, and ALRM bits and CLROUT clears the output buffer. SPOLL (709) clears the Status Register service request bit (SRQ bit).

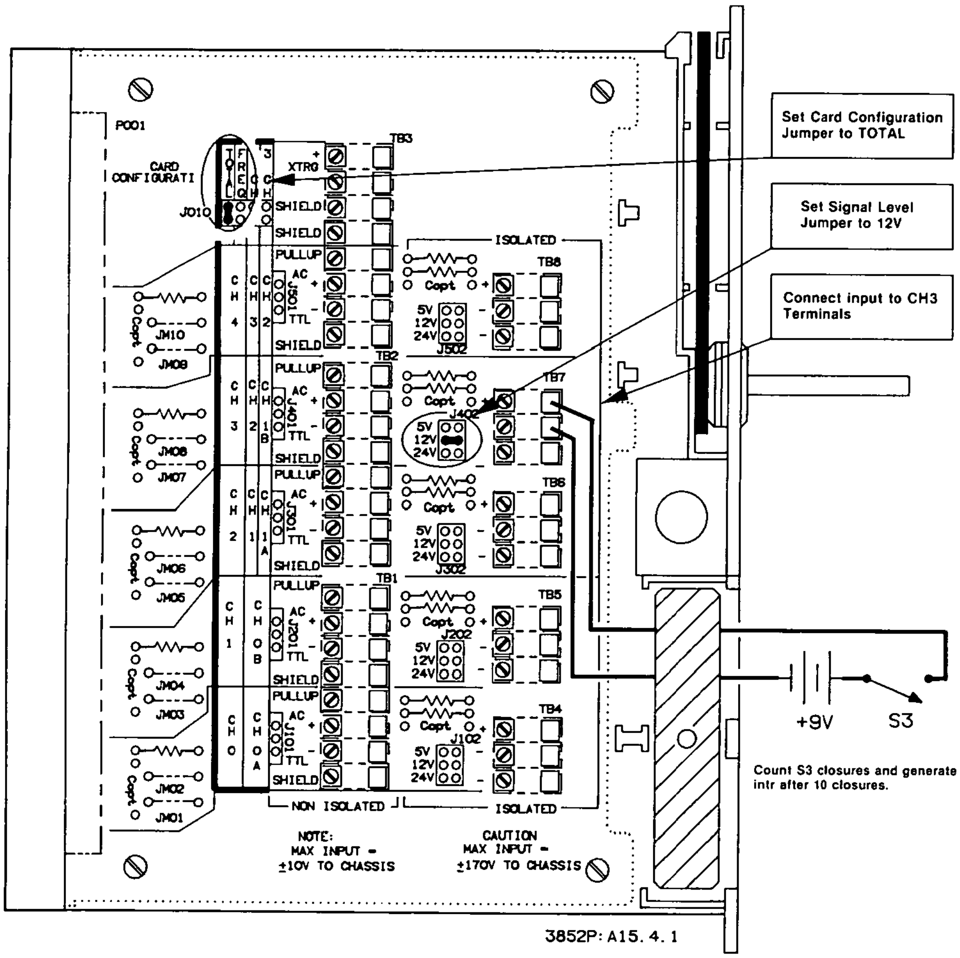

Figure 4-1. Example: Count Switch Closures

```
10 ON INTR 7 GOSUB Results            !Call sub Results on interrupt
20 ENABLE INTR 7;2                    !Enable controller intr on SRQ
30 OUTPUT 709;"RST 500"               !Reset the counter
40 OUTPUT 709;"USE 503"               !Use channel 503
50 OUTPUT 709;"RQS INTR"              !Enable RQS Mask Reg INTR bit
60 OUTPUT 709;"RQS ON"                !Set RQS mode ON
70 OUTPUT 709;"CONF TOTAL"            !Set TOTAL function
80 OUTPUT 709;"ENABLE INTR SYS"       !Enable mainframe intr capability
90 OUTPUT 709;"ENABLE INTR"           !Enable counter intr capability
100 OUTPUT 709;"STA?"                 !Clear FPS,LCL,INTR,LMT,ALRM bits
110 OUTPUT 709;"CLROUT"               !Clear output buffer
120 OUTPUT 709;"EDGE LH"              !Count LH transitions
130 OUTPUT 709;"CNTSET -10"           !Rollover after 10 counts
140 OUTPUT 709;"TRIG SGL"             !Trigger the counter
150 GOTO 150                          !Loop until interrupt occurs
160 Results: !                        !Start controller subroutine
170 OUTPUT 709;"TIME"                 !Query time of day
180 ENTER 709;T                       !Enter time of day
190 PRINT "Ch 503 Intr @ ";TIME$(T)   !Print interrupt time/message
200 PRINT "S503 - 10 Closures"        !Display message
210 A=SPOLL (709)                     !Read /clear SRQ bit
220 STOP                              !End controller subroutine
230 END
```

After 10 switch closures, an OVF interrupt is generated and a typical return is:

```
Ch 503 Intr @ 02:12:16
S503 - 10 Closures
```

Example: Count Switch Closures, Modulo 5

This example is similar to the previous example except that switch S1 closures are counted only when a control switch (S2) is open, the count is modulo 5, and an OVF interrupt is not generated. See Figure 4-2 for typical connections and counter configuration for channel 500 of a counter in slot 5 of the mainframe.

The example program counts the number of gated S1 closures which occur during a one-minute interval and returns the number modulo 5. S1 closures (A input LH transitions) are counted only when S2 is open (B input low).

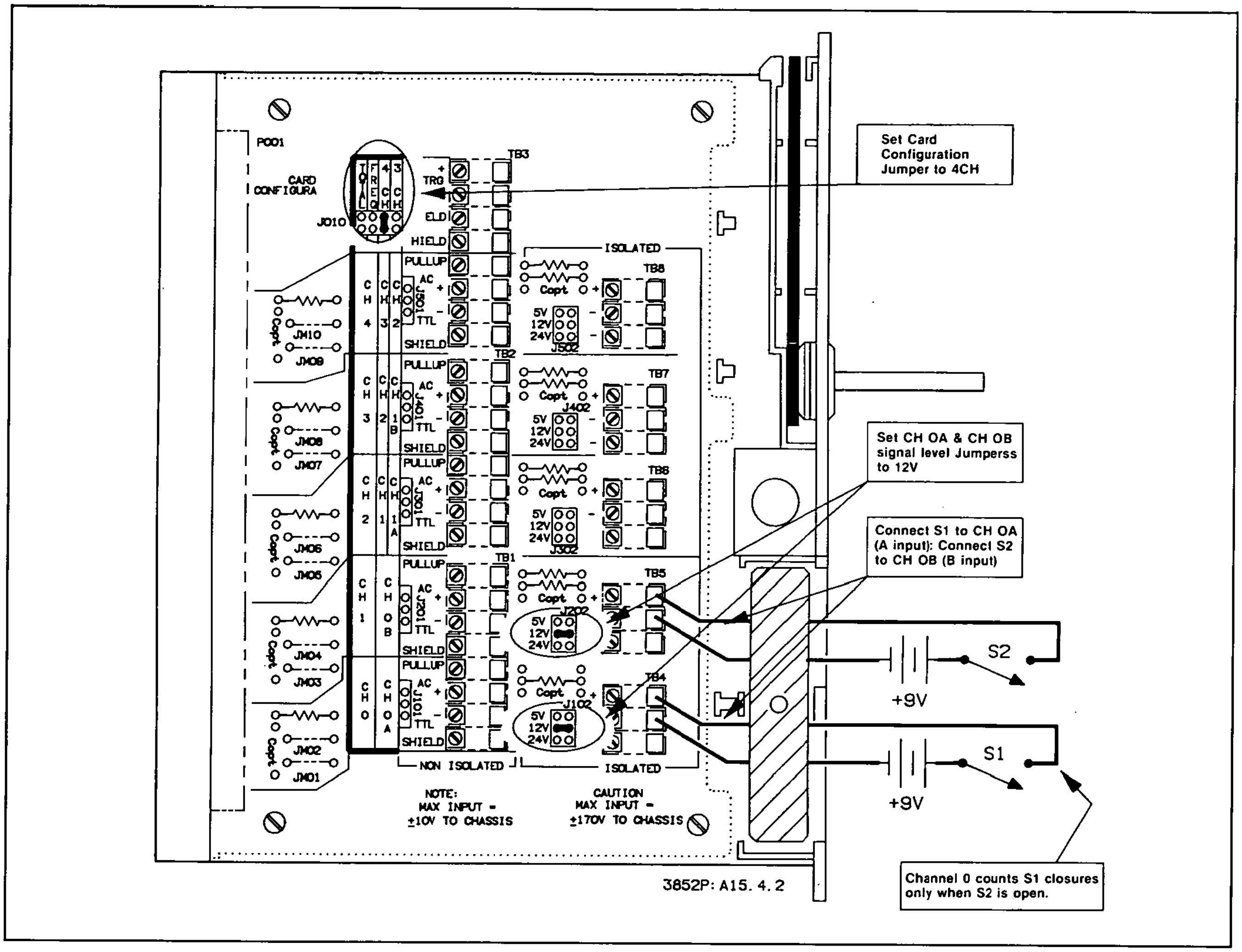

Figure 4-2. Example: Count Switch Closures, Modulo 5

```
 10 OUTPUT 709;"RST 500"            !Reset the counter
 20 OUTPUT 709;"USE 500"            !Use channel 500
 30 OUTPUT 709;"CONF TOTALM"        !Set TOTALM function
 40 OUTPUT 709;"EDGE LH,LO"         !Count S1 LH edges only when S2 open
 50 OUTPUT 709;"NPER 5"             !Set modulo 5 count
 60 OUTPUT 709;"TRIG SGL"           !Trigger the counter
 70 WAIT 60                         !Wait one minute
 80 OUTPUT 709;"CHREAD 500"         !Read S1 gated closures, modulo 5
 90 ENTER 709;A                     !Enter S1 closures
100 PRINT "S501 Closures = ";A      !Display S1 closures
110 END
```

For example, assume seven S1 closures occurred with S2 open during the one-minute interval. Then, since the count sequence for modulo 5 is 1, 2, 3, 4, 0, 1, 2, ..., the modulo 5 count is 2 and a typical return is:

```
S501 Closures = 2
```

Up/Down Counts (UDC/UDCM)

The Up/Down Counts functions include Up/Down Counts (UDC) and Up/Down Counts, Modulo NPER (UDCM). Use the Up/Down Counts functions to measure the difference in counts between two inputs.

With Up/Down Counts, the A input always increases the count, the B input always decreases the count, and the count returned is the difference (A-B) of the the two input counts. Up/Down Counts, Modulo NPER is identical, except that the count resets to zero at the next count after NPER-1 counts, where NPER = 2 to 65535 is set with the NPER command.

Two examples using the Up/Down Counts functions follow. The first example "Count Pulse Rates" counts the difference between the number of counts output from two pulse generators over a 1 minute time interval. The second example "Count Pulse Rates, Modulo 5" does the same thing except that the result is returned modulo 5.

Example: Count Pulse Rates

This program counts the difference between the number of pulses output from pulse generators A and B over a one-minute period. See Figure 4-3 for typical connections and counter configuration for channel 500 of a counter in slot 5 of the mainframe.

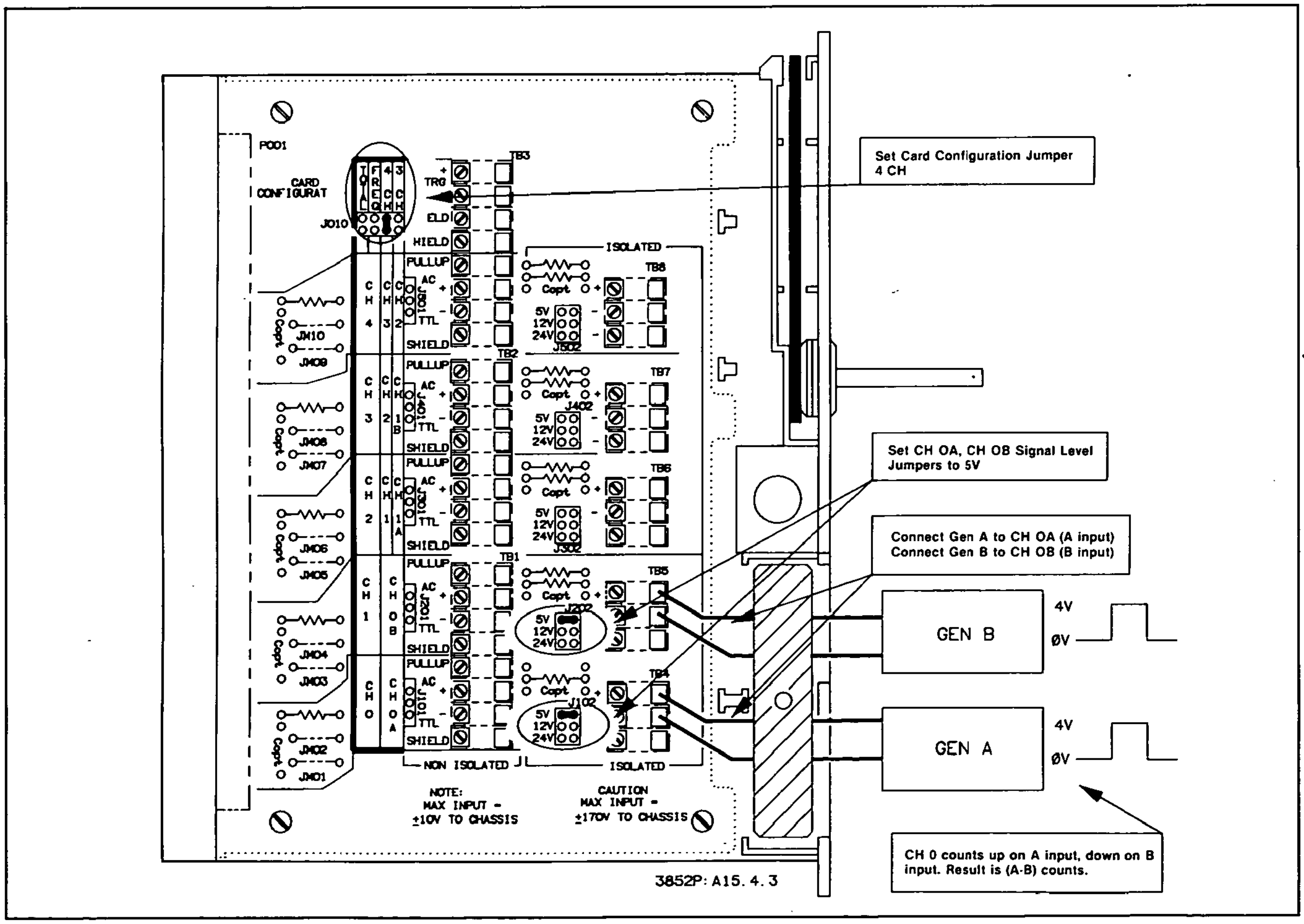

Figure 4-3. Example: Count Pulse Rates

The program sets channel 500 to count up on generator A input LH pulses and to count down on generator B LH input pulses. The program returns the difference (A-B) in the two counts.

```
 10 OUTPUT 709;"RST 500"              !Reset counter
 20 OUTPUT 709;"USE 500"              !Use channel 500
 30 OUTPUT 709;"CONF UDC"             !Set UDC function
 40 OUTPUT 709;"EDGE LH,LH"           !Set LH transitions on A and B
 50 OUTPUT 709;"TRIG SGL"             !Trigger the counter
 60 WAIT 60                           !Wait one minute
 70 OUTPUT 709;"CHREAD 500"           !Read ch 500 (A-B) count
 80 ENTER 709;A                       !Enter count
 90 PRINT "Ch 500 (A-B) Count = ";A   !Display count
100 END
```

If, during the one-minute interval, generator A outputs 500 pulses and generator B outputs 700 pulses, a typical return is:

```
Ch 500 (A-B) Count = -200
```

Example: Count Pulse Rates, Modulo 5

This program is the same as the previous program except that the count result is returned modulo 5. As with the previous example, the program counts the difference between the number of pulses output from pulse generators A and B over a one-minute period.

The program counts up on generator A input LH pulses, counts down on generator B input LH pulses, and returns the (A-B) difference, modulo 5. See Figure 4-4 for typical connections and counter configuration to channel 500 of a counter in slot 5 of the mainframe.

```
 10 OUTPUT 709;"RST 500"              !Reset counter
 20 OUTPUT 709;"USE 500"              !Use channel 500
 30 OUTPUT 709;"CONF UDCM"            !Set UDCM function
 40 OUTPUT 709;"EDGE LH,LH"           !Set LH transitions on A and B
 50 OUTPUT 709;"NPER 5"               !Set modulo 5
 60 OUTPUT 709;"TRIG SGL"             !Trigger the counter
 70 WAIT 60                           !Wait one minute
 80 OUTPUT 709;"CHREAD 500"           !Read ch 500 (A-B) count
 90 ENTER 709;A                       !Enter count
100 PRINT "Ch 500 (A-B) Count = ";A   !Display count
110 END
```

If, during the one-minute interval, generator A outputs 5 pulses and generator B outputs 12 pulses, the (A-B) difference is -7 counts. However, since the down count sequence for modulo 5 is 4, 3, 2, 1, 0, 4, 3, ..., the modulo 5 difference is 3 and a typical return is:

```
Ch 500 (A-B) Count = 3
```

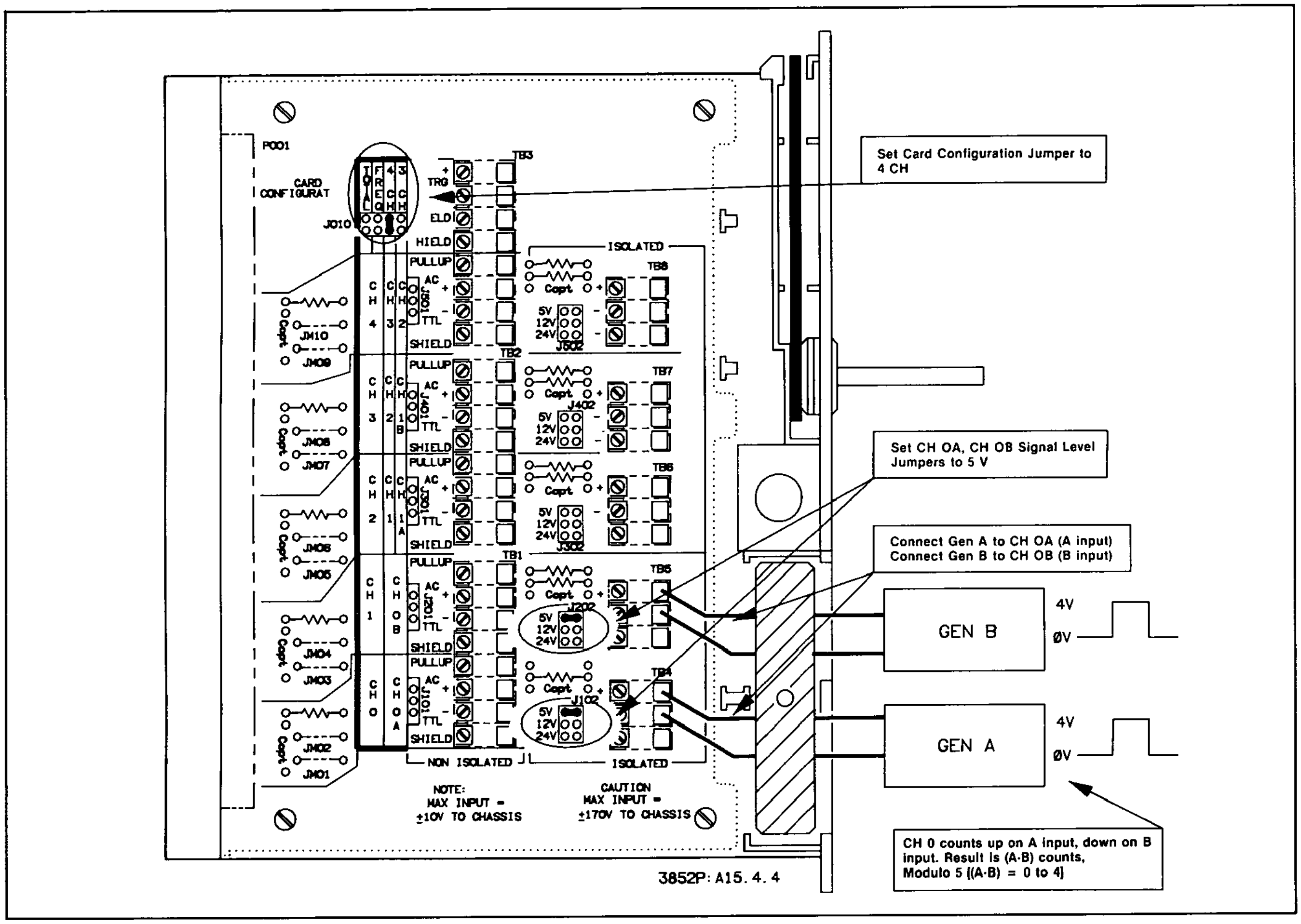

Figure 4-4. Example: Count Pulse Rates, Modulo 5

Count With Direction Control (CD/CDM)

Count With Direction Control functions include Count/Direction (CD), Count/Direction, Modulo NPER (CDM), Quadrature Count (CD), and Quadrature Count, Modulo NPER (CDM).

Use the Count/Direction (CD) function to determine the net number of counts (up counts minus down counts) for an input as controlled by a second input. Use the Count/Direction, Modulo NPER to determine the net number of counts, modulo NPER, where NPER = 2 to 65535 is set with the NPER command. For these functions, the A input is counted up or down, depending on the level of the B input (the gate level).

Quadrature Count (CD) is similar to Count/Direction (CD) except that every transition of the A input is counted and twice the number of counts are returned. Quadrature Count Modulo NPER (CDM) is similar to Count/Direction, Modulo NPER (CDM) except that every transition of the A input is counted and twice the number of counts are returned. For Quadrature Count, the A input is always counted up when the B input leads the A input and is always counted down when A leads B.

Two examples follow which use the CD function to determine a stepper motor shaft position. The first example "Determine Shaft Position" uses Count/Direction to determine the shaft position (CW or CCW) from a reference point. The second example "Determine Shaft Position Using Quadrature" uses Quadrature Count (CD) to more accurately measure the shaft position.

Example: Determine Shaft Position

This example uses Count/Direction (CD) to measure the relative number of CW and CCW rotations of a shaft during a one-minute interval. See Figure 4-5 for typical connections and counter configuration for channel 500 of a counter in slot 5 of the mainframe.

We will assume the shaft encoder generates two square wave signels (A and B) which are 90° out of phase with each other. The shaft encoder A signal is used as the A input (count) and the B signal as the B input (direction). Assume that CW rotations of the shaft cause the B input to lead the A input while CCW rotations cause the A input to lead the B input.

Since EDGE LH,HI is set, each step of CW rotation causes an up count (on the A input LH transition) while each CCW step causes a down count (on the A input LH transition). The result is the number of (CW - CCW) steps of shaft rotation.

```
 10 OUTPUT 709;"RST 500"                  !Reset counter
 20 OUTPUT 709;"USE 500"                  !Use channel 500
 30 OUTPUT 709;"CONF CD"                  !Set CD function
 40 OUTPUT 709;"EDGE LH,HI"               !Count up for B high, down for B low
 50 OUTPUT 709;"TRIG SGL"                 !Trigger the counter
 60 WAIT 60                               !Wait one minute
 70 OUTPUT 709;"CHREAD 500"               !Read ch 500 (up - down) count
 80 ENTER 709;A                           !Enter count
 90 PRINT "M500 Position = ";A;"Deg"      !Display count/message
100 END
```

For example, assume the shaft starting position is 0 degrees and each step represents one degree of rotation. Then, if the shaft makes 10 CW steps and 20 CCW steps, the number of (CW - CCW) steps = -10 and a typical return is:

```
M500 Position = -10 Deg
```

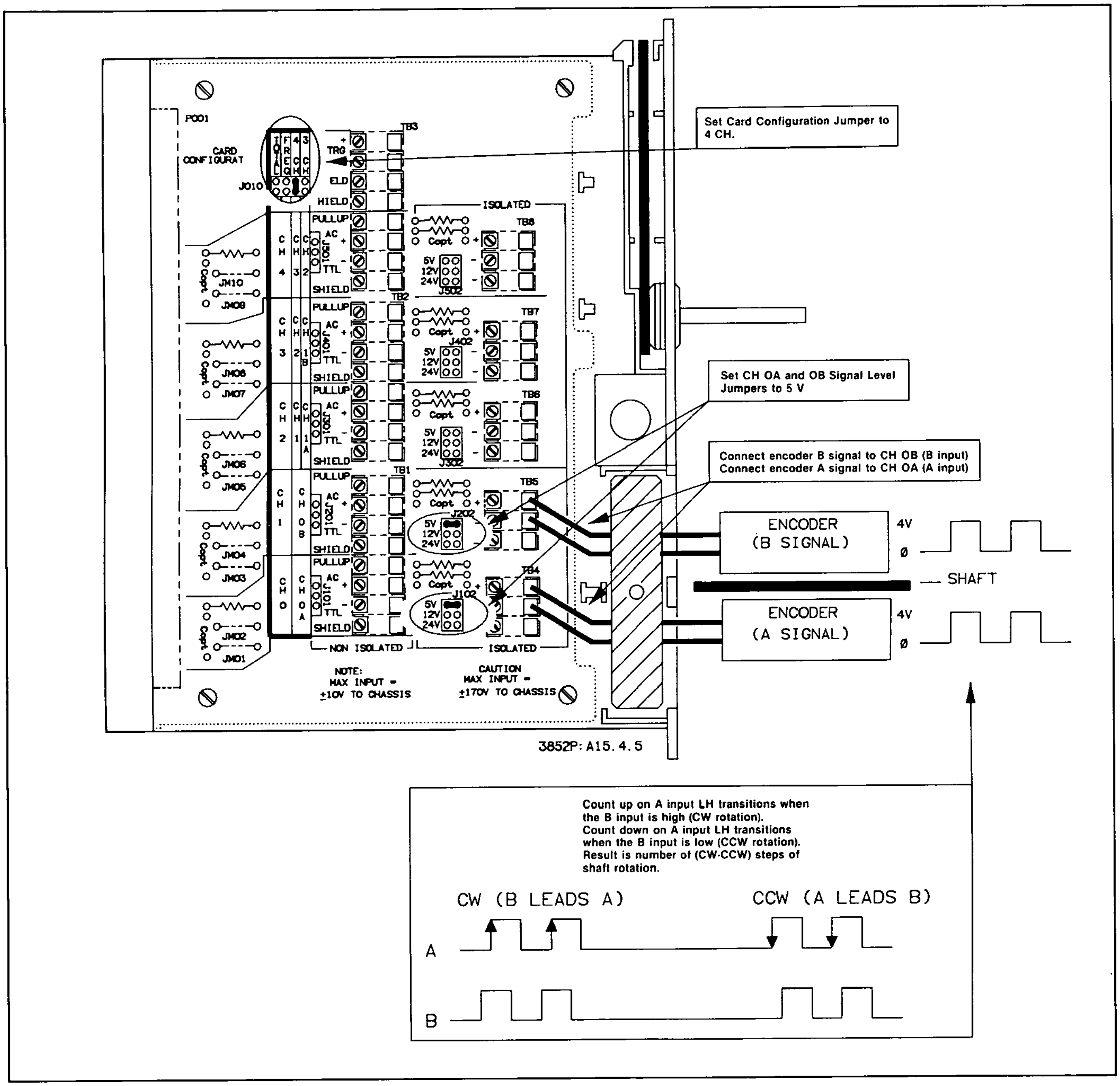

Figure 4-5. Example: Determine Shaft Position

Example: Determine Shaft Position Using Quadrature

In the previous example, we assumed that the shaft had no vibration. However, a problem can occur if the shaft vibrates just enough to change the A signal level without changing the B signal level. With Count/Direction, since only the LH (or HL as programmed) transition of the A input can generate a count, the count may increment without decrementing (or vice-versa) thus giving a false count.

To correct this problem, we will use Quadrature Count to count every transition of the A signal. Then, if the shaft vibrates enough to change the A signal without changing the B signal, the counter will not acknowledge the count and false counts will be eliminated.

This program uses Quadrature Count (CD) to measure shaft position, as in the previous example. Recall that for Quadrature Count, each edge of the A input is counted (up counts when B leads A and down counts when A leads B). Thus, the result must be divided by two to get the actual number of (CW - CCW) shaft rotations.

See Figure 4-6 for typical connections and counter configuration for channel 500 of a counter in slot 5 of the mainframe. Note that the Quadrature jumpers on the component module (J602 and J603 for 4 CH configuration) MUST be set to the Quadrature position. Since the EDGE command has no effect for Quadrature Count, the CONF preset value for EDGE (EDGE HL,HL) is used.

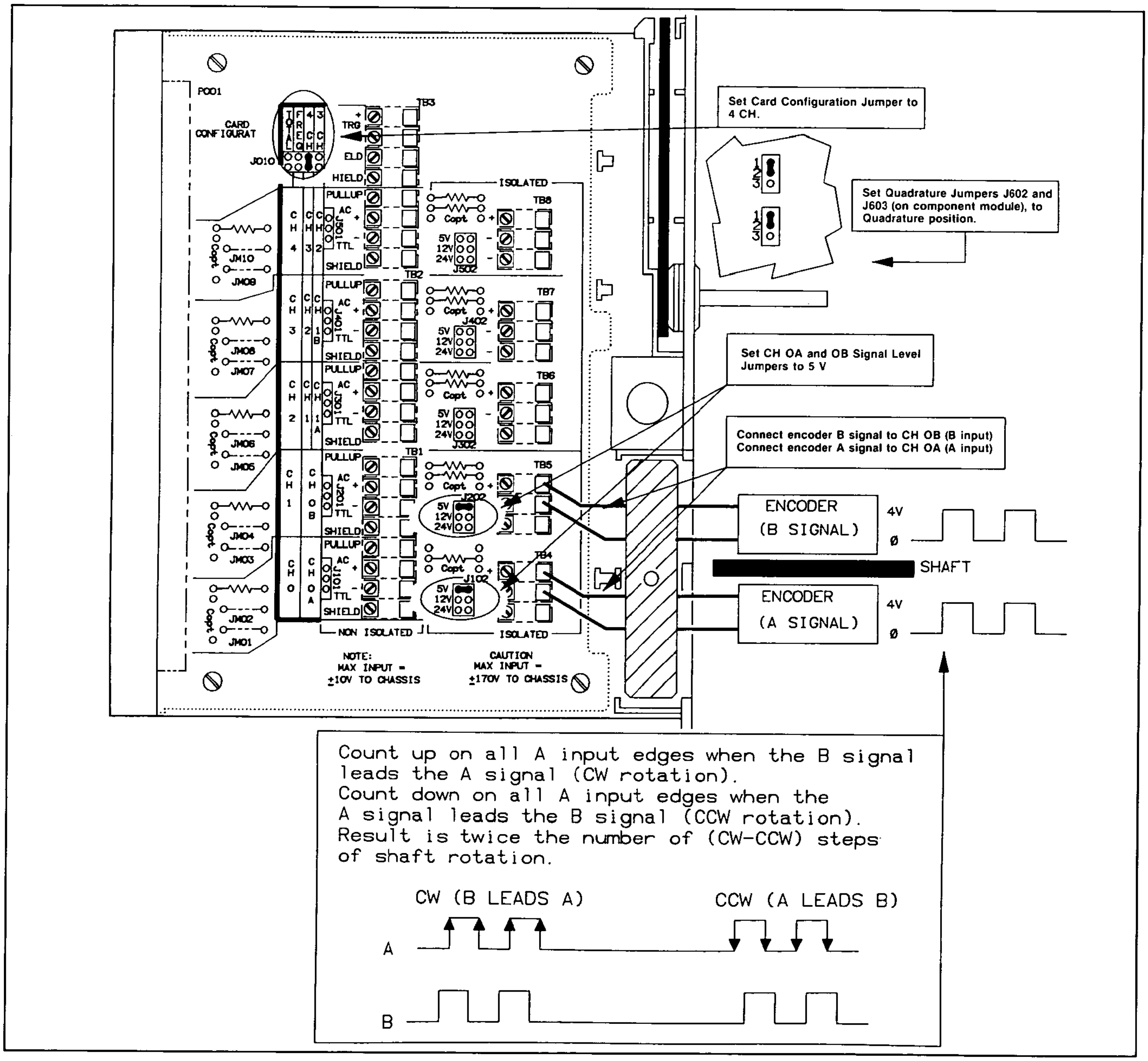

Figure 4-6. Example: Determine Shaft Position Using Quadrature

```
10 OUTPUT 709;"RST 500"                    !Reset counter
20 OUTPUT 709;"USE 500"                    !Use channel 500
30 OUTPUT 709;"CONF CD"                    !Set CD function
40 OUTPUT 709;"TRIG SGL"                   !Trigger the counter
50 WAIT 60                                 !Wait one minute
60 OUTPUT 709;"CHREAD 500"                 !Read ch 500 net count
70 ENTER 709;A                             !Enter count
80 PRINT "M500 Position = ";A/2;"Deg"      !Display count/message
90 END
```

For example, assume the shaft starting position is 0 degrees and each step represents one degree of rotation. Then, if the shaft makes 10 CW steps (20 counts on Quadrature Count) and 20 CCW steps (40 counts), a typical return is:

```
M500 Position = -10 Deg
```

Ratio Measurements (RAT)

Use Ratio Measurements (RAT) to count the number of periods of the A input for a fixed number of periods of the B input. The result is the ratio of the two inputs (A/B). (That is, the average number of A input periods per B input period.)

Example: Measure Ratio

This example program measures the ratio of the number of pulses output from a test pulse generator (A) to 1000 pulses output from a reference pulse generator (B). When the measurement is complete, a MC interrupt is generated and the interrupt time and ratio (A/B) are returned. See Figure 4-7 for typical connections and counter configuration for channel 500 of a counter in slot 5 of the mainframe.

The STA? command reads the Status Register and clears the FPS, LCL, INTR, LMT, and ALRM bits and CLROUT clears the output buffer. SPOLL (709) clears the Status Register service request bit (SRQ bit).

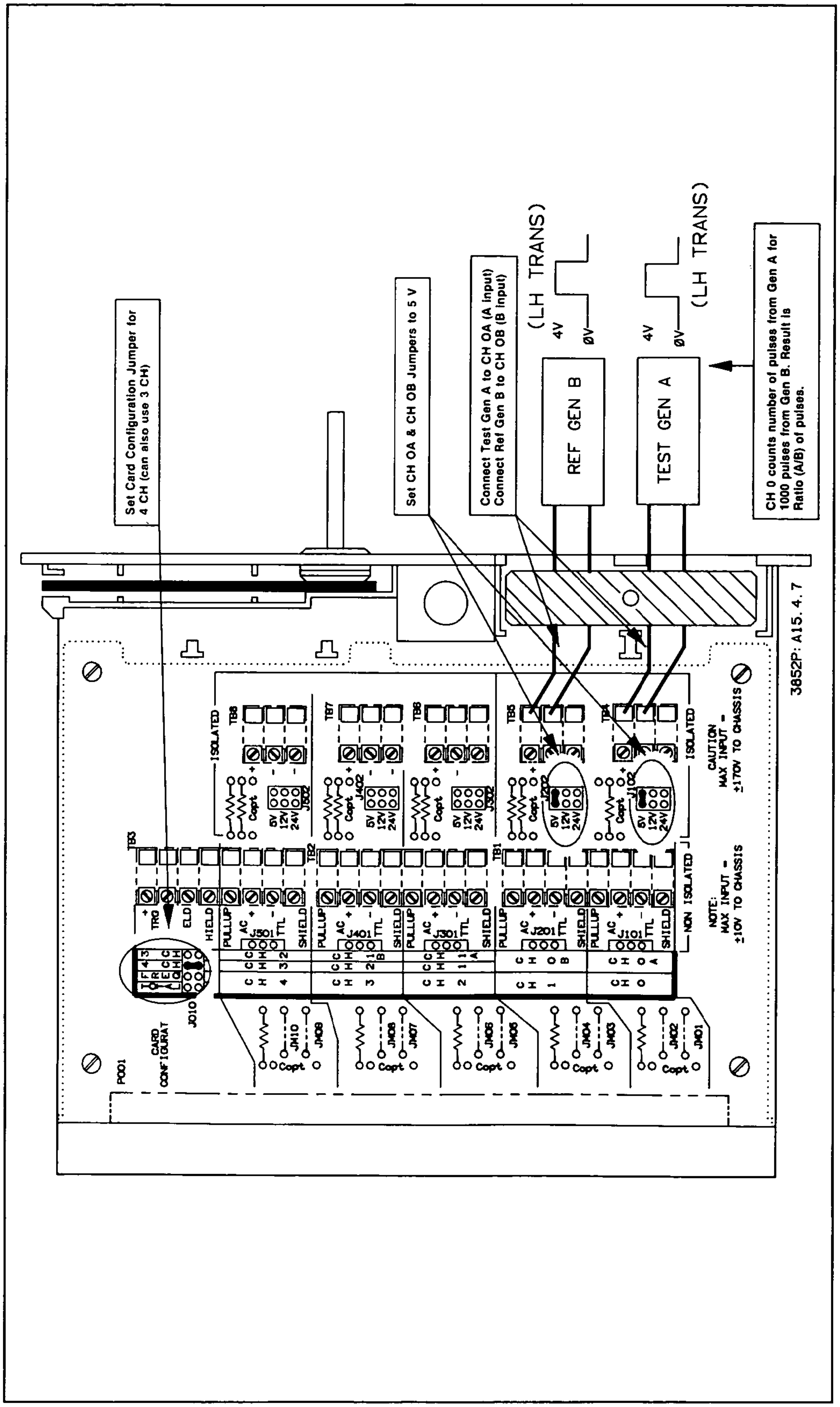

Figure 4-7. Example: Measure Ratio

```
 10 ON INTR 7 GOSUB Results          !Call sub Results on interrupt
 20 ENABLE INTR 7;2                  !Enable controller intr on SRQ
 30 OUTPUT 709;"RST 500"             !Reset the counter
 40 OUTPUT 709;"USE 500"             !Use channel 503
 50 OUTPUT 709;"RQS INTR"            !Enable RQS Mask Reg INTR bit
 60 OUTPUT 709;"RQS ON"              !Set RQS mode ON
 70 OUTPUT 709;"CONF RAT"            !Set RAT function
 80 OUTPUT 709;"ENABLE INTR SYS"     !Enable mainframe intr capability
 90 OUTPUT 709;"ENABLE INTR"         !Enable counter intr capability
100 OUTPUT 709;"STA?"                !Clear FPS,LCL,INTR,LMT,ALRM bits
110 OUTPUT 709;"CLROUT"              !Clear output buffer
120 OUTPUT 709;"EDGE LH,LH"          !Count LH trans on A and B input
130 OUTPUT 709;"NPER 1000"           !End meas after 1000 B periods
140 OUTPUT 709;"TRIG SGL"            !Trigger the counter
150 GOTO 150                         !Loop until interrupt occurs
160 Results: !                       !Start controller subroutine
170 OUTPUT 709;"TIME"                !Query time of day
180 ENTER 709;T                      !Enter time of day
190 PRINT "Ch 500 MC @ ";TIME$(T)    !Print interrupt time/message
200 OUTPUT 709;"CHREAD 500"          !Read ratio (A/B)
210 ENTER 709;A                      !Enter ratio
220 PRINT "Ratio = ";A               !Display ratio
230 A=SPOLL (709)                    !Read /clear SRQ bit
240 STOP                             !End controller subroutine
250 END
```

When the measurement is complete, a typical return for 1500 pulses output from the test generator is:

```
Ch 500 MC @ 02:12:16
Ratio = 1.5
```

Period Measurements (PER/PERD)

Period Measurements functions include Period (PER) and Delayed Period (PERD). Use the Period (PER) function to measure the average period of an input. The result is the average of NPER periods, where NPER = 1 to 65535 is set with the NPER command. Use the Delayed Period (PERD) function to measure the period of the NPERth gated period of an input, where NPER = 1 to 65534.

Two examples using Period Measurement functions follow. The first example "Measure Average Period" uses the PER function to measure the average of 100 periods of the input. The second example "Measure Single Period" uses the PERD function to measure the period of the 100th gated period of the input.

Example: Measure Average Period

This program averages 100 periods of the input. We will assume the signal has maximum period = 1 msec. See Figure 4-8 for typical connections and counter configuration for channel 500 of a counter in slot 5 of the mainframe. Note that the B input is not used, even though Period is a double input function.

In this program, NPER = 100 is used to average 100 periods of the input. Also, we will require at least 1 μsec of resolution and will set TBASE *tbase* = 10 μsec. Then (refer to Table 4-11), resolution = (10/NPER) μsec = (10/100) μsec = 0.1 μsec and maximum period which can be measured = (655.35/100) msec = 6.5535 msec.

The average frequency can also be calculated by using the reciprocal of the average period measured. This provides a way to compute average frequency which is typically more accurate than using the Frequency Measurement (FREQ) function. Therefore, this program also calculates the average frequency of the input.

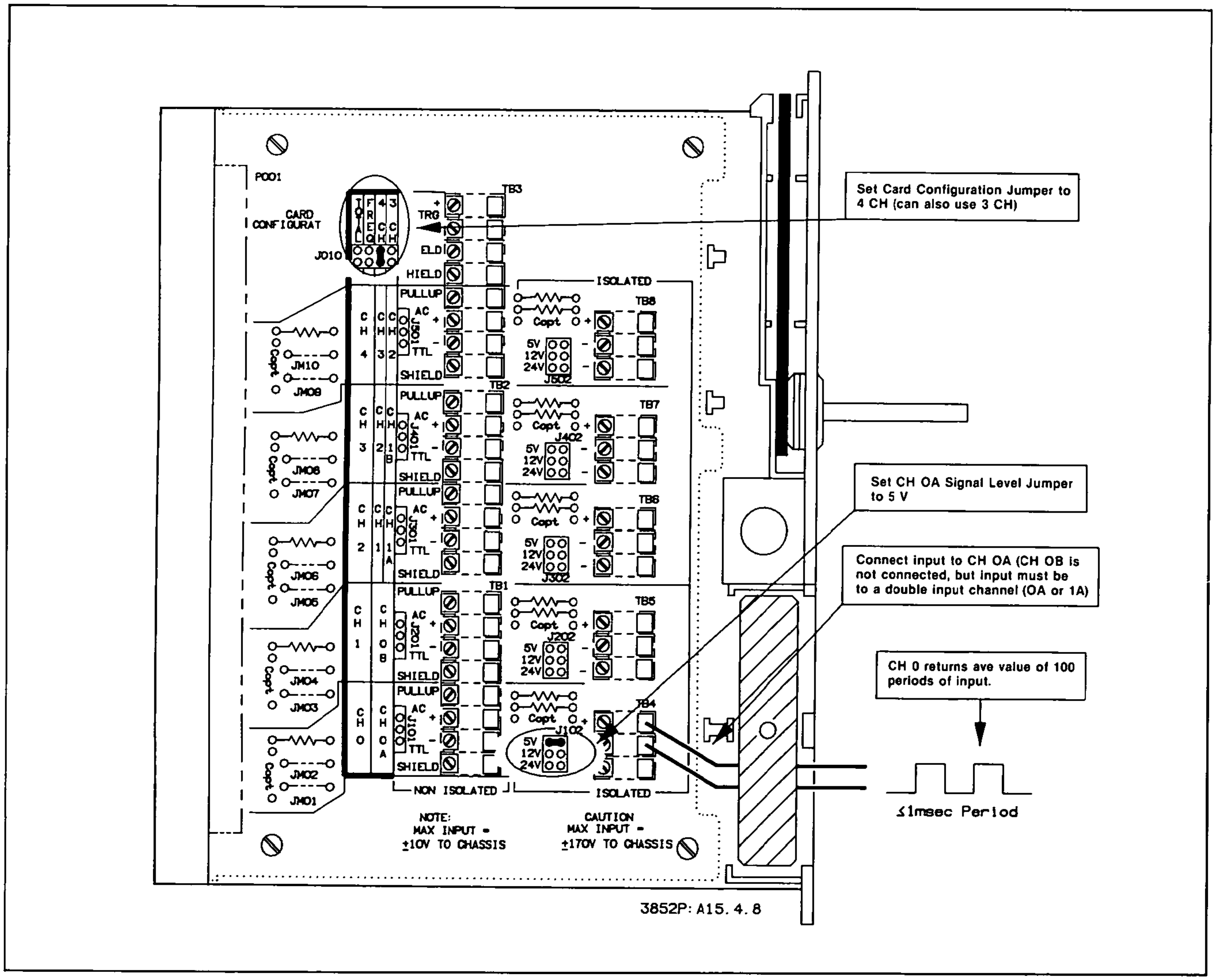

Figure 4-8. Example: Measure Average Period

```
 10 OUTPUT 709;"RST 500"            !Reset counter
 20 OUTPUT 709;"USE 500"            !Use channel 500
 30 OUTPUT 709;"CONF PER"           !Set PER function
 40 OUTPUT 709;"EDGE LH"            !Set LH transitions on A input
 50 OUTPUT 709;"NPER 100"           !Average 100 periods of input
 60 OUTPUT 709;"TBASE .00001"       !Set 10 µsec time base
 70 OUTPUT 709;"TRIG SGL"           !Trigger the counter
 80 OUTPUT 709;"CHREAD 500"         !Read ch 500 avg period
 90 ENTER 709;A                     !Enter avg period
100 PRINT "Avg Period = ";A;"sec"   !Display avg period
110 PRINT "Avg Freq = ";1/A;"Hz"    !Display avg frequency
120 END
```

If the average period of the input is 0.995 msec, the average frequency of the input is 1005.02512563 Hz and a typical return (when the measurement completes) is:

```
Avg Period = .000995 sec
Avg Freq = 1005.02512563 Hz
```

Example: Measure Single Period

This program measures the period of an input with maximum period = 10 msec, after 100 gated periods have occurred. See Figure 4-9 for typical connections and counter configuration for channel 500 of a counter in slot 5 of the mainframe.

This program counts A input LH transitions when the B input (gate) is low and measures the period of the 100th gated period of the A input. We will require at least 1 µsec of resolution and will set TBASE *tbase* = 1 µsec. Then, resolution = 0.01 µsec and maximum period which can be measured = 65.535 msec (refer to Table 4-12).

```
 10 OUTPUT 709;"RST 500"                !Reset counter
 20 OUTPUT 709;"USE 500"                !Use channel 500
 30 OUTPUT 709;"CONF PERD"              !Set PERD function
 40 OUTPUT 709;"EDGE LH,LO"             !Count LH A input when B input is low
 50 OUTPUT 709;"NPER 100"               !Meas 100th gated period of A input
 60 OUTPUT 709;"TBASE .000001"          !Set 1 µsec time base
 70 OUTPUT 709;"TRIG SGL"               !Trigger the counter
 80 OUTPUT 709;"CHREAD 500"             !Read 100th gated period value
 90 ENTER 709;A                         !Enter period
100 PRINT "Ch 500 Period = ";A;"sec"    !Display period
110 END
```

If the value of the 100th gated input period is 9.951 msec, a typical return (when the measurement completes) is:

```
Ch 500 Period = .009951 sec
```

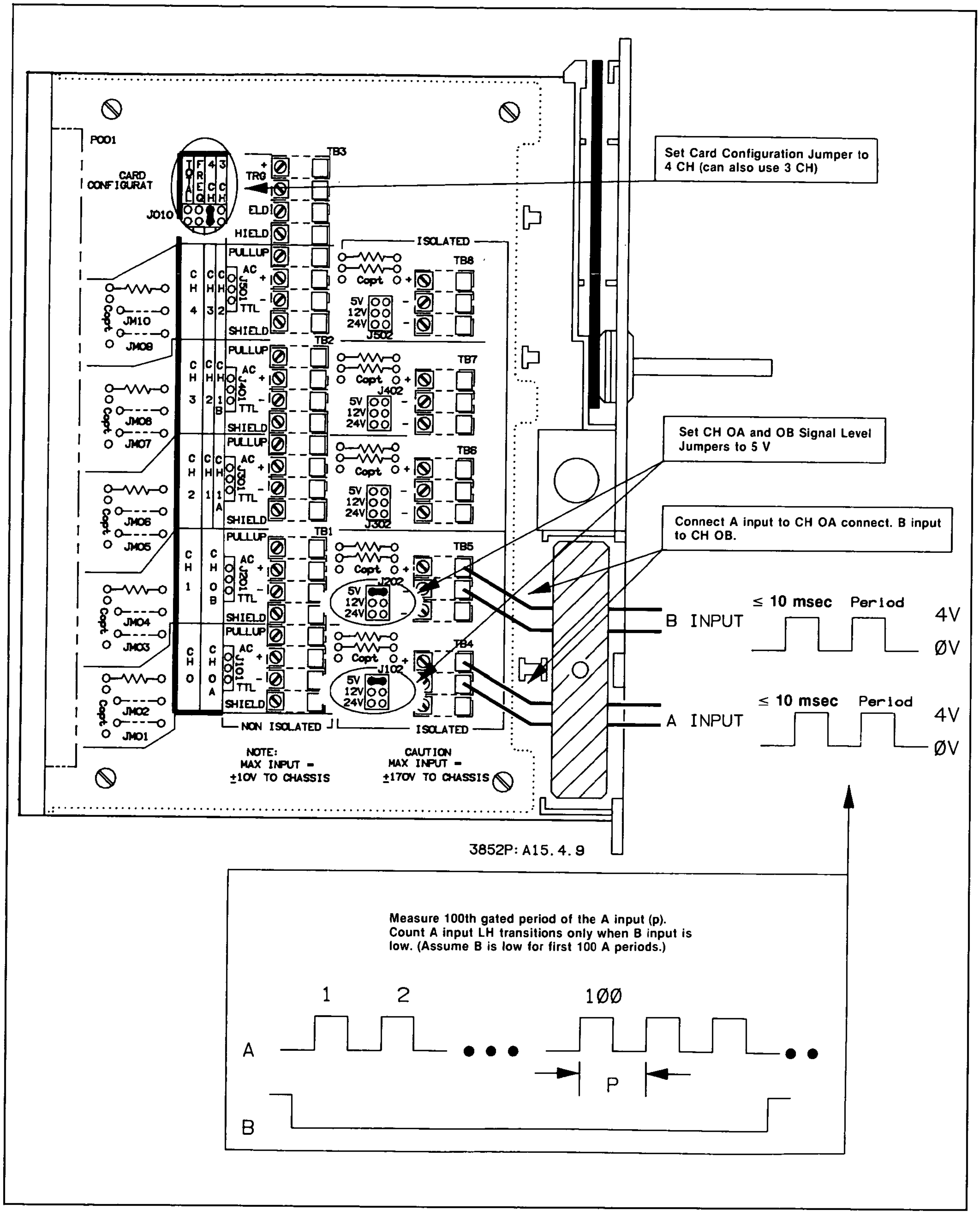

Figure 4-9. Example: Measure Single Period

Frequency Measurements (FREQ)

Use the Frequency Measurements (FREQ) function to measure the average frequency of inputs from >1 Hz up to 200 kHz. An example using the FREQ function follows.

NOTE

The PER function has more resolution and thus is more accurate than the FREQ function for measuring frequency. Refer to "Period Measurements (PER/PERD)" for an example program.

Example: Measure Flow Rate

This program measures the flow rate of a paddlewheel flow meter using magnetic pickup. See Figure 4-10 for typical connections to channel 500 of a counter in slot 5 of the mainframe. Note that the Card Configuration jumper must be set to the FREQ position. With this setting, all five channels measure frequency and no other function can be programmed on any channel. Also note that the input is to the Non Isolated terminals and that the AC/TTL jumper is set to the AC position.

The flow rate can be determined from rate = K*f, where f = the frequency of the magnetic pickup (AC) input and K (in cm) is a constant. For this program we will assume K = 3.0 cm and an approximate 100 Hz AC input.

We will require at least 50 Hz resolution, so we will set TBASE *tbase* = 100 msec which will allow the counter to measure a signal from 10 Hz to 200 kHz with 10 Hz resolution (refer to Table 4-13).

```
 10 OUTPUT 709;"RST 500"                  !Reset counter
 20 OUTPUT 709;"USE 500"                  !Use channel 500
 30 OUTPUT 709;"CONF FREQ"                !Set FREQ function
 40 OUTPUT 709;"EDGE LH"                  !Count LH A input transitions
 50 OUTPUT 709;"TERM NON"                 !Set Non Isolated input terminals
 60 OUTPUT 709;"TBASE .1"                 !Set 100 msec time base
 70 OUTPUT 709;"TRIG SGL"                 !Trigger the counter
 80 OUTPUT 709;"CHREAD 500"               !Read average frequency
 90 ENTER 709;A                           !Enter frequency
100 PRINT "Flow Rate (cm/sec) = ";3.0*A   !Display flow rate
110 END
```

If the average frequency is 100 Hz, since K = 3.0 cm is assumed, a typical return (when the measurement completes) is:

```
Flow Rate (cm/sec) = 300
```

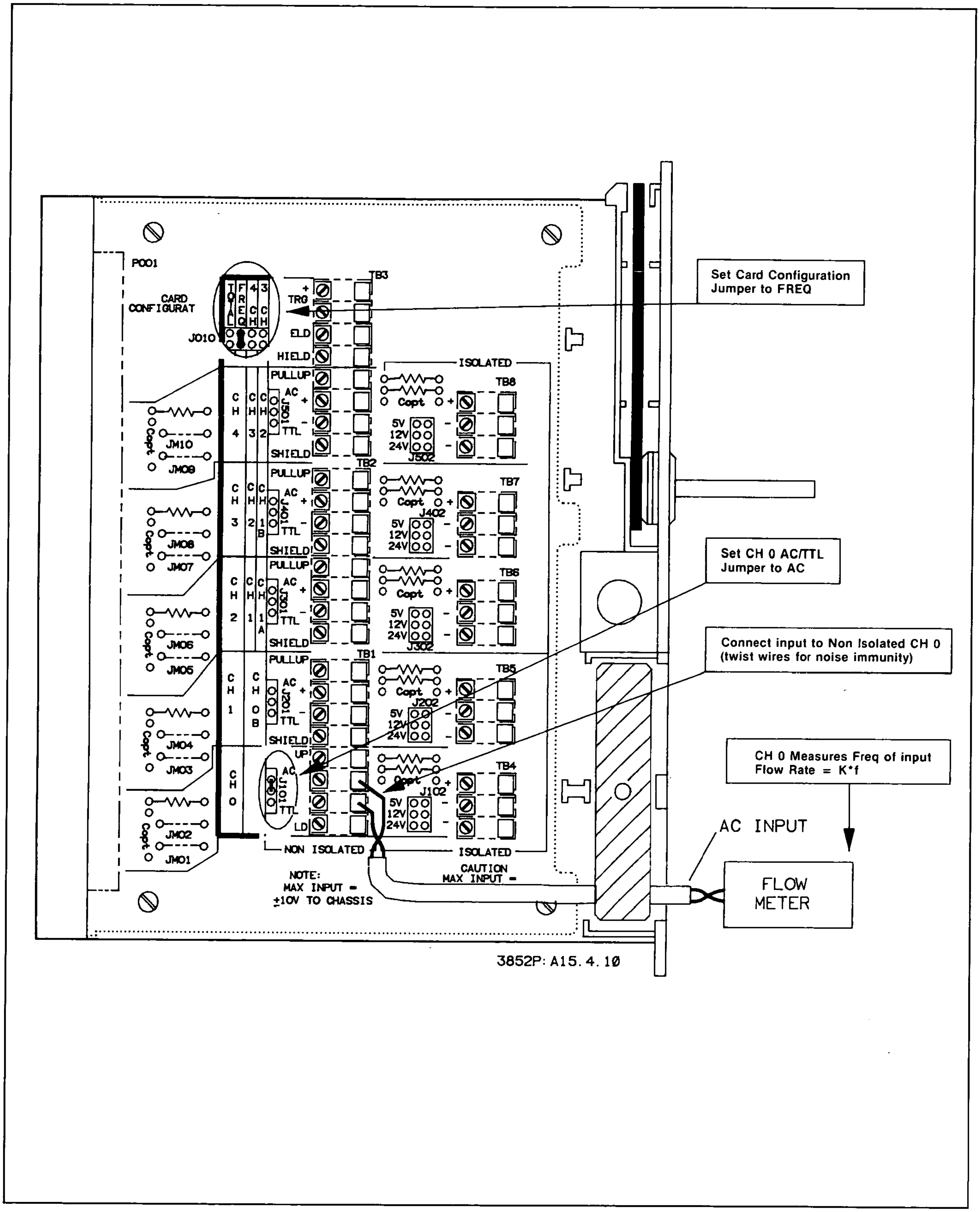

Figure 4-10. Example: Measure Flow Rate

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44715-90001

HEWLETT PACKARD

HP 3852A Data Acquisition/Control Unit

HP 44721A/44722A
16-Channel/8-Channel Digital Input Accessories

Configuration and Programming Manual

HEWLETT PACKARD

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Many product updates and fixes do not require manual changes and, conversely, manual corrections may be done without accompanying product changes. Therefore, do not expect a one-to-one correspondence between product updates and manual updates.

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HEWLETT PACKARD

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HEWLETT PACKARD

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F

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GROUND THE INSTRUMENT

To minimize shock hazard, the instrument chassis and cabinet must be connected to an electrical ground.

DO NOT OPERATE IN AN EXPLOSIVE ATMOSPHERE

Do not operate the instrument in the presence of flammable gases or fumes. Operation of any electrical instrument in such an environment constitutes a definite safety hazard.

KEEP AWAY FROM LIVE CIRCUITS

Operating personnel must not remove instrument covers. Component replacement and internal adjustments must be made by qualified maintenance personnel. Under certain conditions, dangerous voltages may exist even with the instrument switched off. To avoid injuries, always disconnect input voltages and discharge circuits before touching them.

DO NOT SERVICE OR ADJUST ALONE

Do not attempt internal service or adjustment unless another person, capable of rendering first aid and resuscitation, is present.

DO NOT SUBSTITUTE PARTS OR MODIFY INSTRUMENT

Because of the danger of introducing additional hazards, do not install substitute parts or perform any unauthorized modification to the instrument. Return the instrument to a Hewlett-Packard Sales and Service Office for service and repair to ensure that safety features are maintained.

HEWLETT PACKARD

Operating and Safety Symbols

Symbols Used On Products And In Manuals

~ LINE — AC line voltage input receptacle.

Instruction manual symbol affixed to product. Cautions the user to refer to respective instruction manual procedures to avoid possible damage to the product.

Indicates dangerous voltage – terminals connected to interior voltage exceeding 1000 volts.

 OR 

Protective conductor terminal. Indicates the field wiring terminal that must be connected to earth ground before operating equipment – protects against electrical shock in case of fault.

Clean ground (low-noise). Indicates terminal that must be connected to earth ground before operating equipment – for single common connections and protection against electrical shock in case of fault.

 OR 

Frame or chassis ground. Indicates equipment chassis ground terminal – normally connects to equipment frame and all metal parts.

Affixed to product containing static sensitive devices – use anti-static handling procedures to prevent electrostatic discharge damage to components.

NOTE

NOTE
Calls attention to a procedure, practice, or condition that requires special attention by the reader.

CAUTION

CAUTION
Calls attention to a procedure, practice, or condition that could possibly cause damage to equipment or permanent loss of data.

WARNING

WARNING
Calls attention to a procedure, practice, or condition that could possibly cause bodily injury or death.

WARNING, CAUTION, and NOTE Symbols

Some labels on the HP 3852A, HP 3853A, and plug-in accessories include an international warning symbol (triangle with subscripted number) which refers the reader to the manuals for further information. This table shows the warning symbols used for the HP 3852A/3853A and plug-in accessories. Refer to the manual set for specific information on WARNINGS, CAUTIONS, or NOTES referenced with a warning symbol.

HP 3852A WARNING, CAUTION, and NOTE Symbols

Symbol	Meaning	Location
⚠ 1	Shock hazard originating outside the instrument (field wiring)	. Analog Extender Connector on Power Supply Modules . Terminal modules on plug-in accessories . Component module covers on plug-in accessories
⚠ 2	Treat all channels as "one circuit" for safety purposes.	. Inside terminal modules on plug-in accessories . Metal cover on component modules of plug-in accessories
⚠ 3	Maximum number of certain plug-in accessories to be installed into an HP 3852A or HP 3853A.	. HP 44701A, HP 44702A/B, HP 44727A/B/C plug-in accessories
⚠ 4	If High-Speed FET multiplexers are used with the HP 44702A/B, ribbon cable may be connected.	. HP 44711A, 44712A, 44713A (referenced on HP 44702A and HP 44702B)
⚠ 5	The instrument should not be operated at a line frequency of 440 Hz with a line voltage of 200 V or greater as the AC leakage current may exceed 3.5 mA.	. HP 3852A, HP 3853A Power Supply Modules

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Chapter 1
Introduction

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Chapter 1

Introduction

Manual Contents

This manual shows how to configure and program the HP 44721A 16-Channel Digital Input with Totalize and Interrupt accessory (16-channel digital input) and the HP 44722A 8-Channel AC Digital Input with Totalize and Interrupt accessory (8-channel digital input). Refer to the HP 3852A Mainframe Configuration and Programming Manual for additional information on the acessories. Chapter sections are:

- **Introduction** contains an overview of the chapter, describes the digital inputs, and shows a suggested getting started sequence.

- **Configuring the 16-Channel Digital Input** shows how to hardware configure the 16-channel digital input.

- **Configuring the 8-Channel Digital Input** shows how to hardware configure the 8-channel digital input.

- **Programming the Digital Inputs** shows how to program the digital inputs for four main functions: detecting the input state, counting input edges, generating event interrupts, and generating counter interrupts.

Digital Input Descriptions

The 16-channel and 8-channel digital inputs can be used to detect the state of the input, count input state changes (edges), and generate interrupts on state changes and/or counter overflow conditions. A description of each digital input follows.

16-Channel Digital Input

The 16-channel digital input consists of a digital input component module and a 16-channel terminal module. The terminal module can be jumper-selected for nominal input voltages of 5, 12, 24 or 48 VDC in each of the 16 input channels. In addition, +5 VDC is supplied on the terminal module for use with dry-contact external inputs such as switches or mechanical contacts.

The accessory has digital debounce circuitry for accurate counting and edge detection. Debounce settings for input frequencies ranges of 10 Hz, 100 Hz and 1 kHz are jumper-selectable. Since the card has a single debounce jumper, the debounce jumper setting applies to all channel inputs.

8-Channel Digital Input

The 8-channel digital input consists of a digital input component module (the same as the one used for 16-channel digital input accessory) and an 8-channel terminal module. The accessory accepts inputs up to 250 VDC or 250 VAC rms @ 47-470 Hz. Each channel of the terminal module can be independently jumper-selected for nominal voltage inputs of 24, 120, or 240 volts. The accessory has a debounce jumper which is fixed at 10 Hz.

Digital Input Functions

As shown in Figure 1-1, each digital input physical channel consists of two "logical" channels: a count channel and an event (state) channel. Logical count channels are 0-15 (0-7 for the 8-channel digital input) while logical event channels are 16-31 (8-15 for the 8-channel).

For example, a 16-channel digital input in slot 1 of the mainframe has physical channels 100 through 115. For channel 100, the associated logical count channel is 100 and the logical event channel is 116, etc. Refer to Chapter 4 - Programming the Digital Inputs for details.

The digital input accessories have four main functions: detecting the input state; counting input edges; generating event interrupts; and generating counter interrupts. To perform these functions, the accessories detect input edges. The 16-channel digital input detects DC input edges while the 8-channel digital input detects both DC and AC input edges.

NOTE

For a DC input, a positive edge is an input change from LOW to HIGH while a negative edge is an input change from HIGH to LOW. For an AC input, a positive edge is an input change from OFF to ON while a negative edge is an input change from ON to OFF. Thus, for AC inputs, the channel state does NOT change with each cycle of the input.

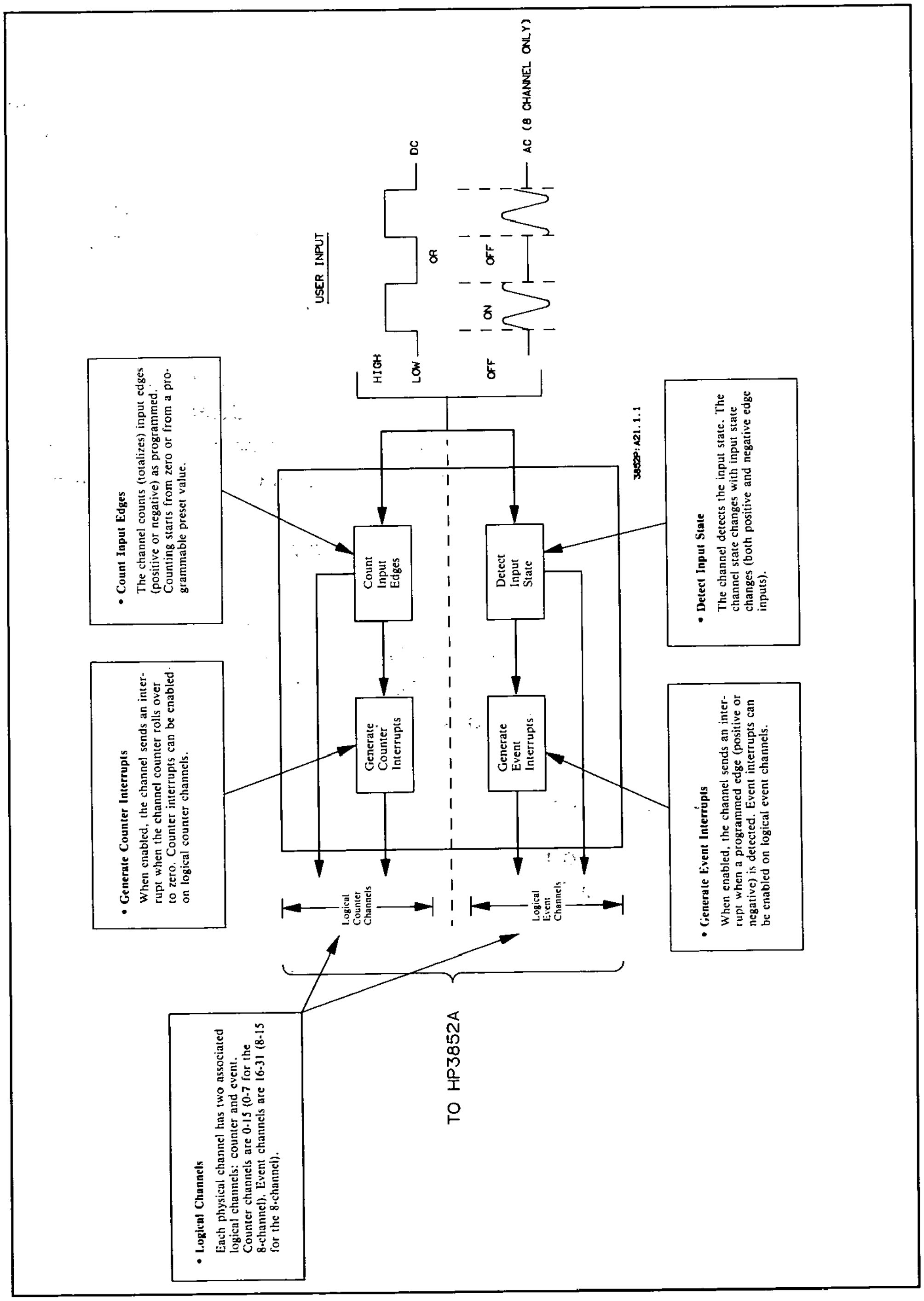


Figure 1-1. Digital Input Functions

Detect Input State

Each digital input channel continuously detects the input state and changes state with input state changes. For example, when a DC input goes from LOW to HIGH, the channel state goes from "0" to "1". Or, when an AC input goes from ON to OFF (8-channel digital input only) , the channel state goes from "1" to "0". You can read each channel state or the slot state to determine the input state.

Count Input Edges

Each channel has a separate counter which counts (totalizes) positive or negative edges, as programmed. Counting starts from zero or from a programmable preset value. You can read the totalized count to determine the number of counts (programmed input edges) on the channel. You can also read and zero the count on any channel.

Generate Event Interrupts

Each channel can be enabled to generate an interrupt when a programmed edge (positive or negative) is detected. This is defined as an event interrupt. Note that each channel can be programmed for event interrupts, counter interrupts, or for both event and counter interrupts.

Generate Counter Interrupts

Each channel can also be enabled to generate an interrupt when the channel counter rolls over to zero. This is defined as a counter interrupt. Again, each channel can be programmed for event interrupts, counter interrupts, or for both event and counter interrupts.

Getting Started

To use a 16-channel or 8-channel digital input for your application, you will need to do three things:

- Define your application.
- Configure the digital input.
- Program the digital input.

Define Your Application

The first step is to define your application and select the devices to connect to the digital input. When selecting devices, refer to the Specifications appendix in the HP 3852A Mainframe Configuration and Programming Manual to ensure that device voltage, current, and frequency are within digital input specifications.

Configure the Digital Input

The next step is to configure each digital input channel for the devices selected. Although there are four primary functions for the digital inputs (detecting input states, counting input edges, generating event interrupts, and generating counter interrupts), digital input hardware configuration is identical for any function.

Refer to Chapter 2 - Configuring the 16-Channel Digital Input to configure a 16-channel digital input. Refer to Chapter 3 - Configuring the 8-Channel Digital Input to configure an 8-channel digital input.

Program the Digital Input

The third step is to program the digital input channels used for your application. Refer to Chapter 4 - Programming the Digital Inputs to program the 16-channel or 8-channel digital input for your application.

Chapter 2
Configuring the 16-Channel Digital Input

Contents

Chapter 2

Configuring the 16-Channel Digital Input

Introduction

This chapter shows how to hardware configure the 16-channel digital input. It includes guidelines to set the attenuator jumpers and the debounce jumper on the terminal module, shows typical field wiring connections, and shows how to install and initially check the accessory.

Chapter Contents

This chapter has three sections:

- **Introduction** includes a chapter overview and lists WARNINGS, CAUTIONS, and NOTES which apply to the 16-channel digital input.

- **Terminal Module Configuration** shows how to set the attenuator and debounce jumpers and how to connect field wiring to the terminal module.

- **Installation and Checkout** shows how to install and initially check the 16-channel digital input.

Warnings, Cautions, and Notes

This section summarizes WARNINGS, CAUTIONS, and NOTES which apply to the 16-channel digital input accessory. You should review the WARNINGS and CAUTIONS shown before handling or configuring the accessory.

WARNING

⚠ 1 *SHOCK HAZARD. Only qualified, service-trained personnel who are aware of the hazards involved should install, remove, or configure any accessory. Before touching any installed accessory, turn off all power to the mainframe, extenders, and to all external devices connected to the mainframe, extenders, or accessories.*

WARNING

⚠2 *POSSIBLE OPERATOR INJURY. For safety, consider all accessory channels to be at the highest potential applied to any channel.*

CAUTION

MAXIMUM VOLTAGE/POWER LIMITATIONS. To avoid circuit damage to the 16-channel digital input, maximum input voltage is 80 VDC. Maximum total input power to avoid degrading accessory specifications is six (6) watts.

CAUTION

STATIC SENSITIVE. Use clean-handling techniques when handling the accessory. Do not install an accessory without the metal covers attached.

NOTE

HP-IB ADDRESS. The example programs in this manual use "709" as the HP-IB address for the HP 3852A. Specific slot and channel numbers are also used. Program syntax and data return formats apply to HP Series 200/300 controllers. Modify slot and channel numbers and program syntax as required.

Terminal Module Configuration

This section shows how to set the attenuator and debounce jumpers and how to connect field wiring to the 16-channel digital input terminal module.

Setting Attenuator Jumpers

To begin terminal module configuration, remove the terminal module cover. (If the accessory is installed in the mainframe or an extender, refer to the HP 3852A Mainframe Configuration and Programming Manual to remove the terminal module.)

Terminal Module Description

Figure 2-1 shows the 16-channel terminal module with the cover removed. The terminal module has 16 attenuator jumpers (J100 through J115), one for each channel. J100 sets channel 0, J101 sets channel 1,. . ., J115 sets channel 15. Each jumper can be set to 5V, 12V, 24V, or 48V. However, to properly set the attenuator jumper, we will first need to define some terms.

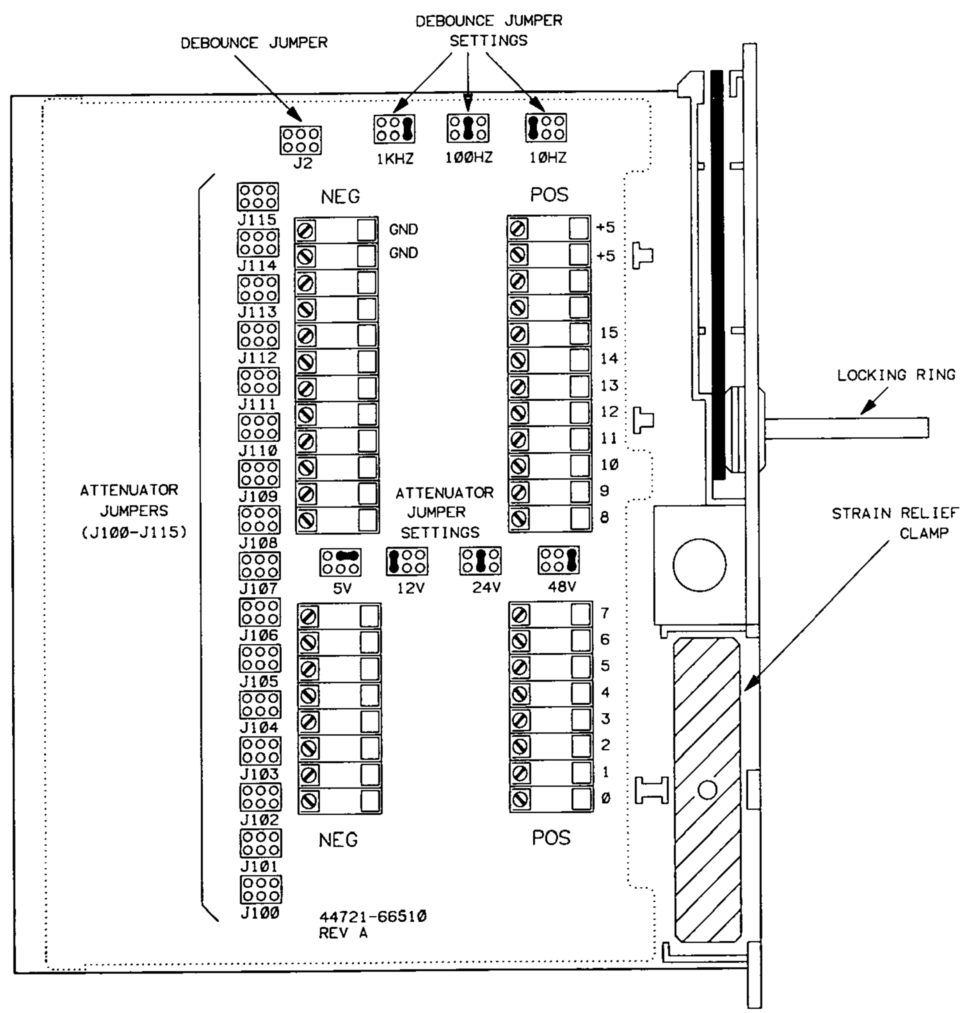


Figure 2-1. HP 44721A Terminal Module

Determining Jumper Setting

Figure 2-2 shows guidelines to select the proper attenuator jumper setting for a typical DC input, where Vhigh is the MINIMUM value of the input HIGH state and Vlow is the MAXIMUM value of the input LOW state. Vmax and Vmin are the Threshold Voltages shown in Table 2-1.

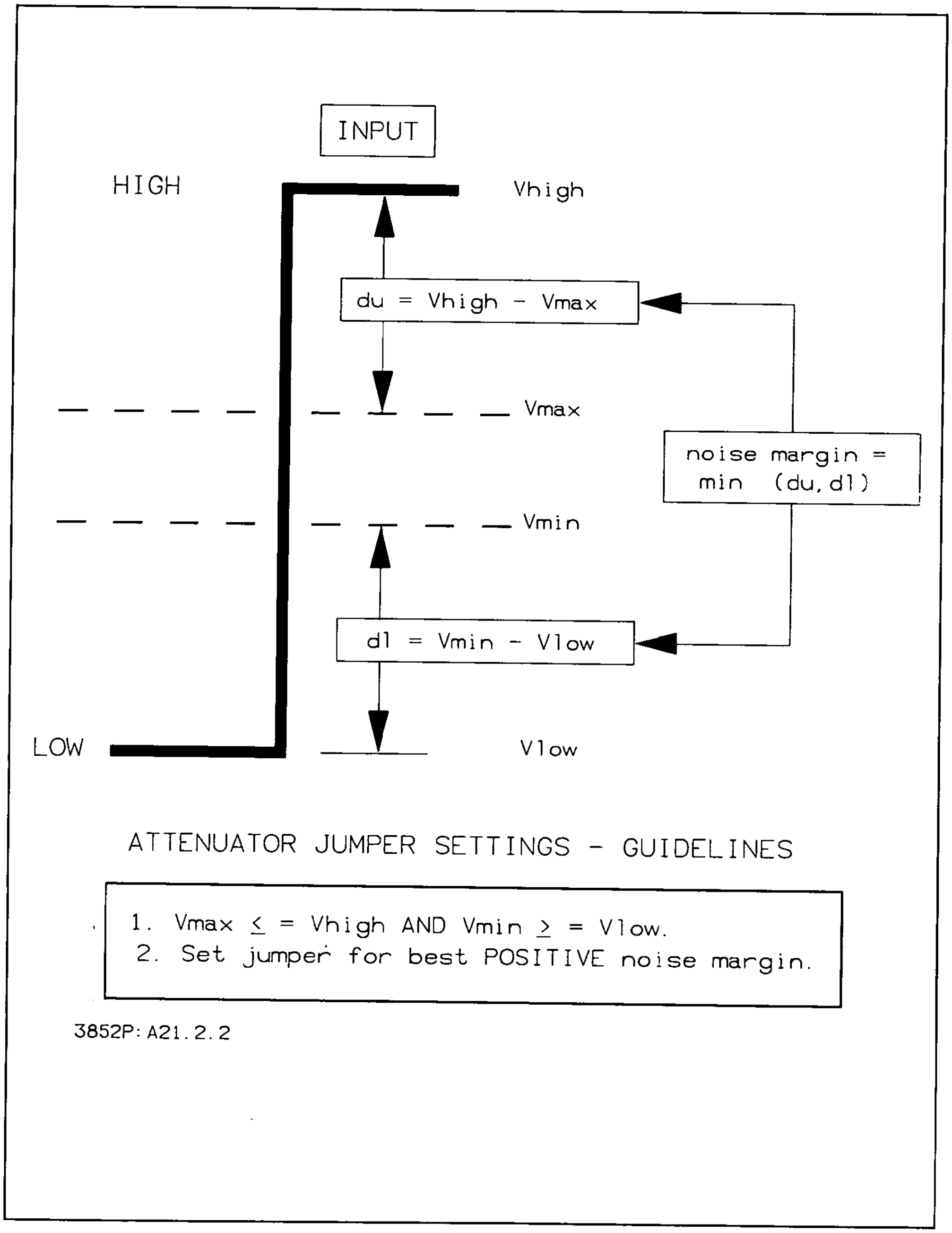


Figure 2-2. Attenuator Jumper Setting Guidelines

To determine the appropriate jumper setting, use the setting (5V, 12V, 24V, or 48V) which has the best POSITIVE noise margin, where noise margin = min (du, dl) = min (Vhigh - Vmax, Vmin - Vlow).

Table 2-1. Threshold Voltages

Attenuator Jumper Settings	Threshold Voltages		Nominal Current for Setting
	Vmin	Vmax	
5 V	1.0 VDC	4.0 VDC	0.5 mA
12 V	2.5 VDC	9.5 VDC	1.3 mA
24 V	7.0 VDC	17.0 VDC	2.8 mA
48 V	14.0 VDC	31.0 VDC	5.8 mA

Example: Selecting Attenuator Jumper Setting

You want to select the best attenuator jumper setting for a DC input with Vlow = 1.5 V and Vhigh = 30 V. The first step is to compute the noise margin for each jumper range, as shown in Figure 2-3. For example, the noise margin on the 5V range = min [(30 - 4), (1 - 1.5)] = min (26, -0.5) = -0.5.

Thus, the 5V and 48V settings cannot be used, since the noise margins (-0.5 and -1.0) are both negative. Both the 12V and 24V settings have positive noise margins. However, since the noise margin for the 24V setting (+5.5) is better than the noise margin for the 12V setting (+1), use the 24V setting.

NOTE

The 30 volt input in this example exceeds the nominal value for the 24V range. For any attenuator setting the 16-channel digital input can accept up to 80 VDC. However, to avoid degrading accessory specifications, total power to the accessory must not exceed six watts.

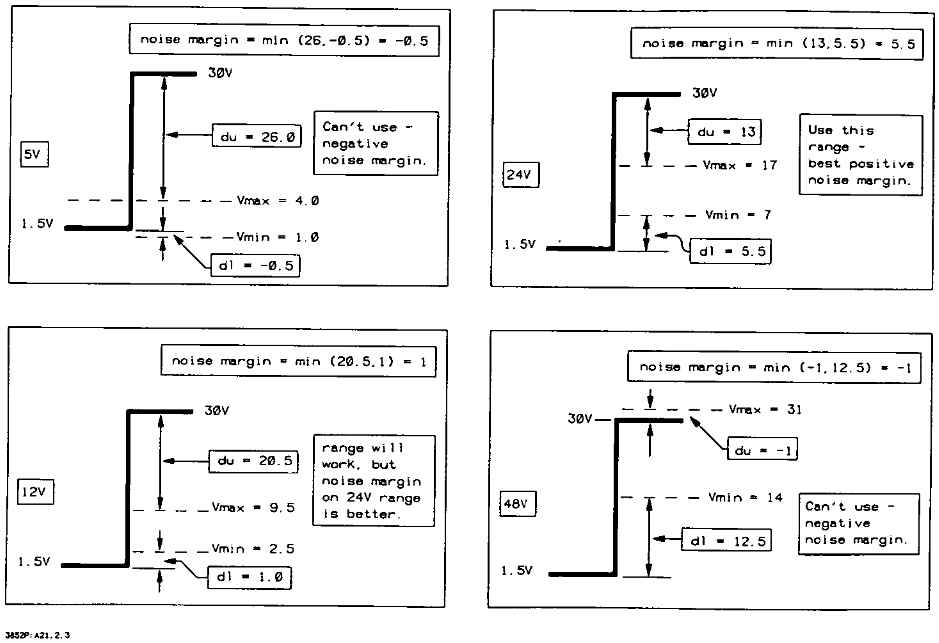


Figure 2-3. Example: Setting Attenuator Jumper

Setting Debounce Jumper

When the attenuator jumpers have been set for all channels to be used, the next step is to set the debounce jumper (J2). However, to properly set the debounce jumper, we will again need to define some terms.

Input Signal Definitions

Figure 2-4 shows input signal definitions and guidelines to set the debounce jumper. Since there is a single debounce jumper, input signal definitions refer to the maximum and minimum values for inputs to ALL channels.

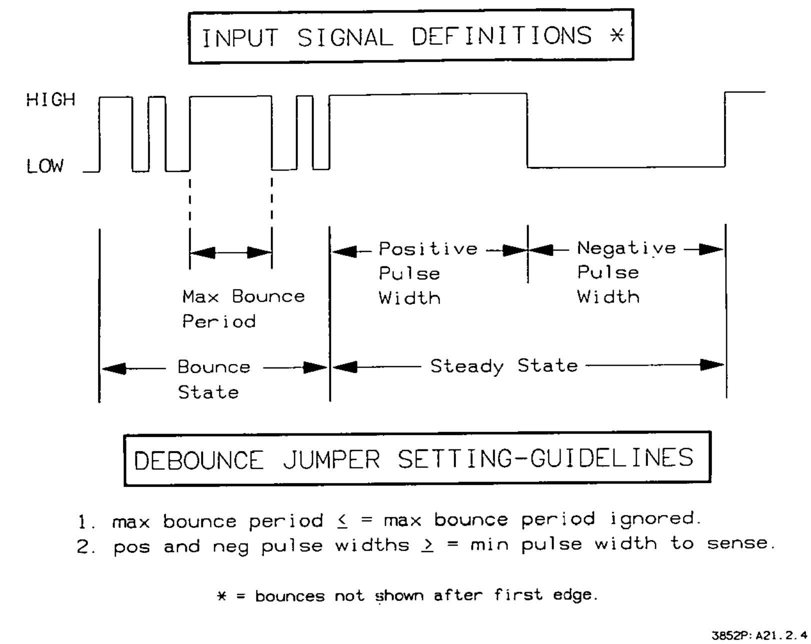


Figure 2-4. Debounce Jumper Setting Guidelines

The input signal has two distinct states: a Bounce State and a Steady State. During the Bounce State, the signal rapidly switches states due to contact bounce. In the Bounce State, the Max Bounce Period is defined as the longest time the input is in the HIGH state. During the Steady State, the Positive Pulse Width is the time the signal is in the HIGH state and the Negative Pulse Width is the time the signal is in the LOW state.

Debounce Jumper Setting Guidelines

There are two guidelines to select the best debounce jumper setting: (1) the Max Bounce Period must be ≤ Maximum Bounce Period Ignored values in Table 2-2 and (2) both the positive and negative pulse widths must be ≥ the Min Pulse Width to Sense values in Table 2-2. In addition, the input frequency (number of state changes/second) must be within the Input Freq Range in Table 2-2 for the jumper setting selected.

Table 2-2. Debounce Jumper Ratings

Debounce Jumper Setting	Maximum Bounce Period Ignored	Minimum Pulse Width to Sense	Input Freq Range
10 Hz	20 msec	50 msec	0 - 10 Hz
100 Hz	2 msec	5 msec	0 - 100 Hz
1 kHz	.2 msec	1 msec	0 - 500 Hz

Determining Maximum Bounce Period

The first step to select the debounce jumper setting is to determine the Max Bounce Period of all the inputs. To ensure that the digital input will ignore input signal bounces, select the debounce jumper setting for which the Max Bounce Period of ALL inputs is ≤ the Maximum Bounce Period Ignored value in Table 2-2.

For example, if the Max Bounce Period is 10 msec, use the 10 Hz setting since it is the only setting with Max Bounce Period (10 msec) ≤ Maximum Bounce Period Ignored (20 msec). With the 100 Hz or 1 kHz settings, the accessory may sense the bounces as state changes and give false readings.

Determining Minimum Input Pulse Widths

When the Maximum Bounce Period of the input is determined, the next step is to determine minimum input pulse widths. To ensure that the digital input will sense the input, BOTH the positive pulse widths and negative pulse widths must be ≥ the Minimum Pulse Width to Sense times shown in Table 2-2.

As shown in Figure 2-5, inputs with one or both pulse widths > Maximum Bounce Period Ignored but < Minimum Pulse Width to Sense may or may not be sensed. Inputs with one or both pulse widths < Maximum Bounce Period Ignored will not be sensed.

NOTE

For each debounce jumper setting, the 16-channel digital input has a different interrupt delay time. Since system interrupt delay depends on the controller used and customer application, maximum system delay must be determined by the user. If you have time-critical interrupt applications, refer to Chapter 4 - Programming the Digital Inputs for details on delay times.

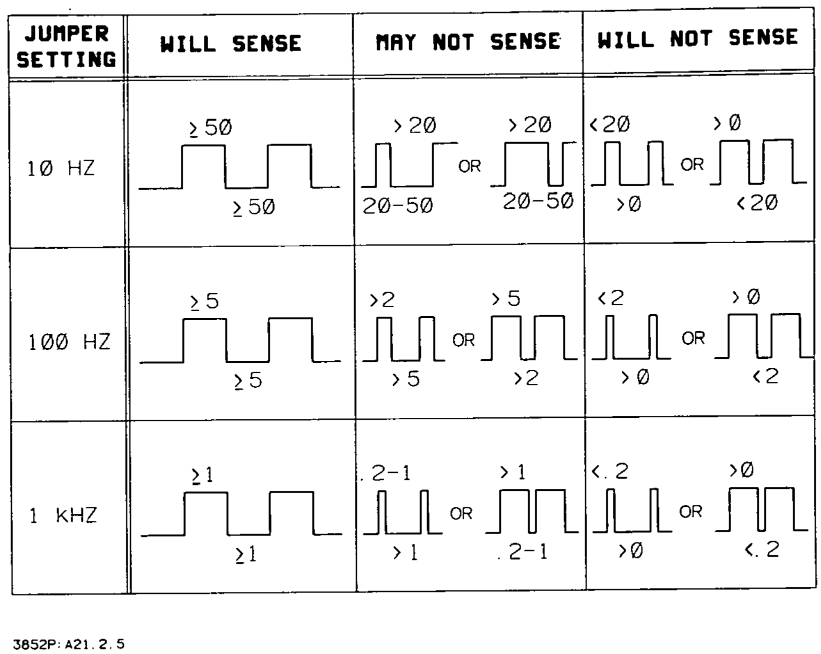


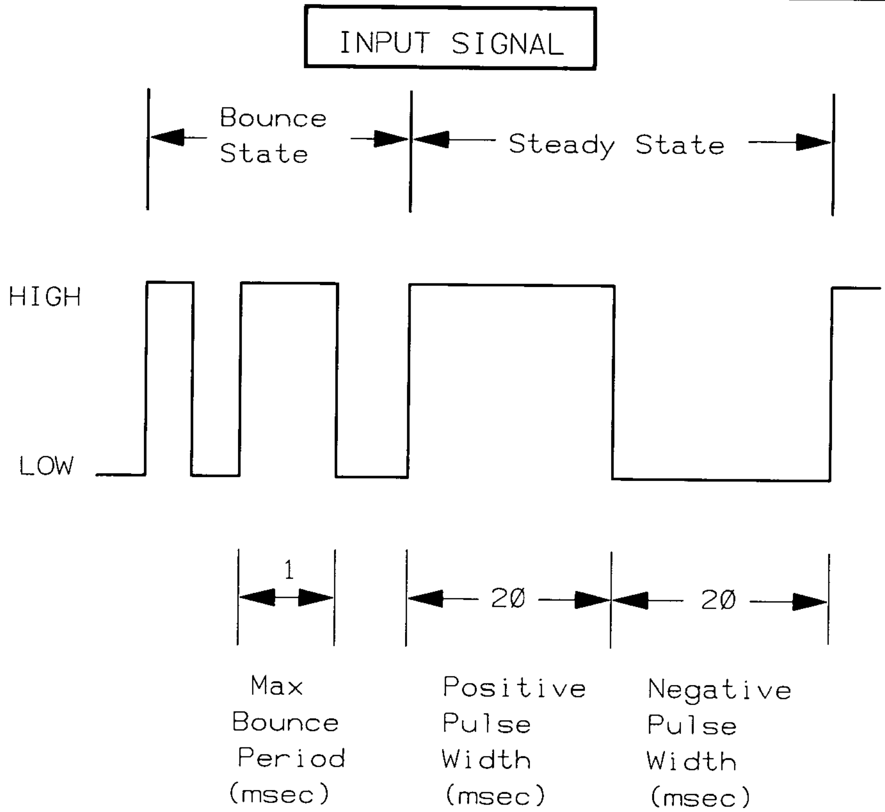
Figure 2-5. Input Pulse Width Requirements

Example: Selecting Debounce Jumper Setting

You want to set the debounce jumper for a 25 Hz square-wave input with Max Bounce Period = 1 msec and Positive Pulse Widths = Negative Pulse Widths = 20 msec (see Figure 2-6). For proper debounce jumper setting, Max Bounce Period of the input must be ≤ Maximum Bounce Period Ignored and the Positive and Negative Pulse Widths must both be ≥ Minimum Pulse Width to Sense.

From Figure 2-6, the 10 Hz setting cannot be used since the input pulse widths (20 msec) are < Min Pulse Width to Sense (50 msec). Also, the 1 kHz setting cannot be used since the Max Bounce Period (1 msec) > Maximum Bounce Period Ignored (0.2 msec).

Therefore, for this input use the 100 Hz setting since the Max Bounce Period (1 msec) < Max Bounce Period Ignored (2 msec) and both the Positive and Negative Pulse Widths (20 msec) > Minimum Pulse Width to Sense (5 msec). In addition, the input frequency of 25 Hz is well within the specified frequency range of 0 - 100 Hz.



INPUT PARAMETERS VS. DEBOUNCE JUMPER RATINGS

SETTING	BOUNCE STATE		STEADY STATE		COMMENTS
	MAX BOUNCE PERIOD	MAX * BOUNCE PERIOD IGNORED	INPUT SIGNAL PULSE WIDTHS	MIN * PULSE WIDTH TO SENSE	
10 Hz	1 msec	20 msec	20 msec	50 msec	can't use : positive and negative pulse widths < min pulse width to sense.
100 Hz	1 msec	2 msec	20 msec	5 msec	use this setting : max bounce period < max bounce period ignored and positive and negative pulse widths > min pulse width to sense.
1 KHz	1 msec	0.2 msec	20 msec	1 msec	can't use : max bounce period > max bounce period ignored.

3852P:A21.2.6

Figure 2-6. Example: Setting Debounce Jumper

Connecting Field Wiring

When you have set the attenuator jumpers and the debounce jumper, connect field wiring from your devices to the appropriate terminals on the terminal module. Each channel of the 16-channel terminal module has a POS and NEG terminal. Two +5V connectors (on the POS terminal) and two GND connectors (on the NEG terminal) are provided for dry contact inputs. See Figure 2-1 for jumper and terminal locations.

When connecting field wiring, route the field wires under the strain relief clamp and tighten the clamp screw to reduce the chance of wires being pulled out of the terminal connectors. When you have connected field wiring, replace the terminal module cover. Three example configurations follow.

Example: Connecting DC Input

A +9 VDC source and switch are connected to channel 5 as shown in Figure 2-7. The switch is opened and closed at a 5 Hz rate (100 msec pulse widths) and Max Bounce Period = 10 msec. To set the channel attenuator jumper (J105), select the setting with the best positive noise margin.

From Table 2-1, the noise margin for the 5V setting = min [(9-4), (1-0)] = min (5,1) = 1, while the 12V, 24V and 48V settings all have negative noise margins. Therefore, set J105 to the 5V setting since this is the only setting with a positive noise margin.

Any setting for the debounce jumper (J2) satisfies the condition that Pulse Widths > Min Pulse Width to Sense (refer to Table 2-2). However, set the debounce jumper to 10 Hz since this is the only setting with Maximum Bounce Period (10 msec) < Max Bounce Period Ignored (20 msec). When the jumpers have been set, route the field wires as shown in Figure 2-7.

Example: Using +5V Supply

Three ganged switches are connected to channels 2, 3, and 4 as shown in Figure 2-8 and are switched at a 5 Hz rate. For this input, set the attenuator jumpers for channel 2 (J102), channel 3 (J103), and channel 4 (J104) to 5V. For the switching rate of 5 Hz (100 msec pulse widths), set the debounce jumper to 10 Hz. (Refer to the previous example, "Connecting DC Inputs" for details to set the jumpers. When you have set the jumpers, route the field wires as shown in Figure 2-8.

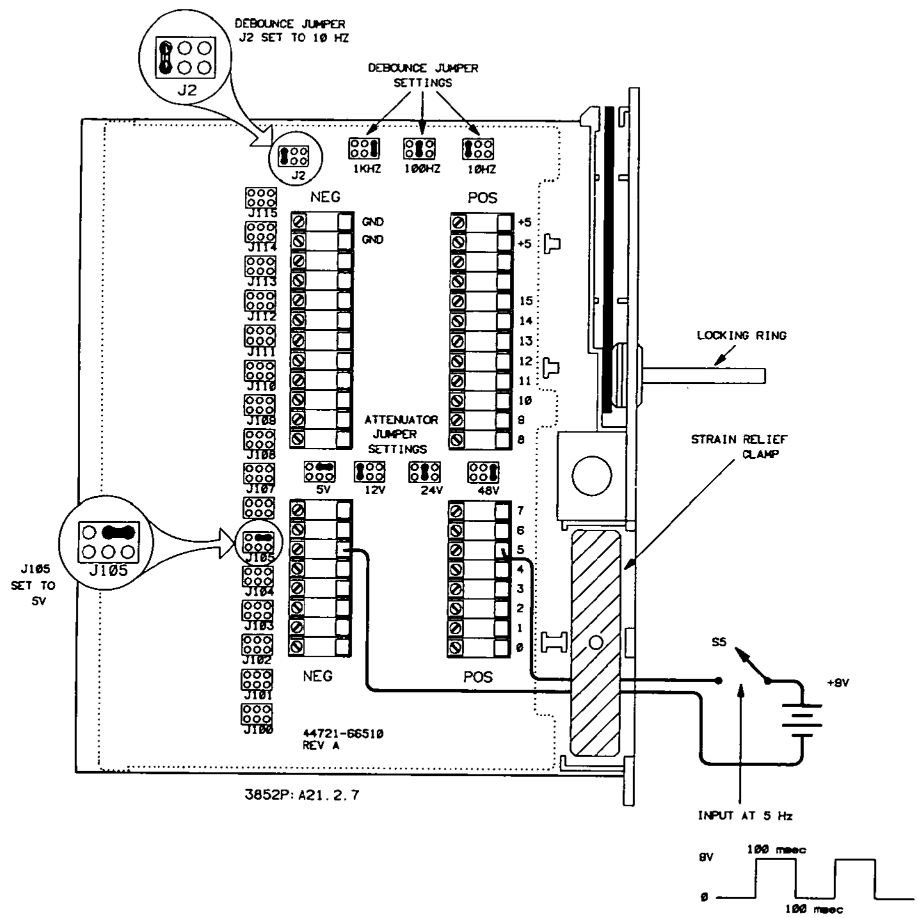


Figure 2-7. Example: Connecting DC Input

NOTE

When the +5 VDC supply on the terminal module is used, the input is NOT isolated from the mainframe. Either of the +5V and GND terminals may be used to connect field wiring.

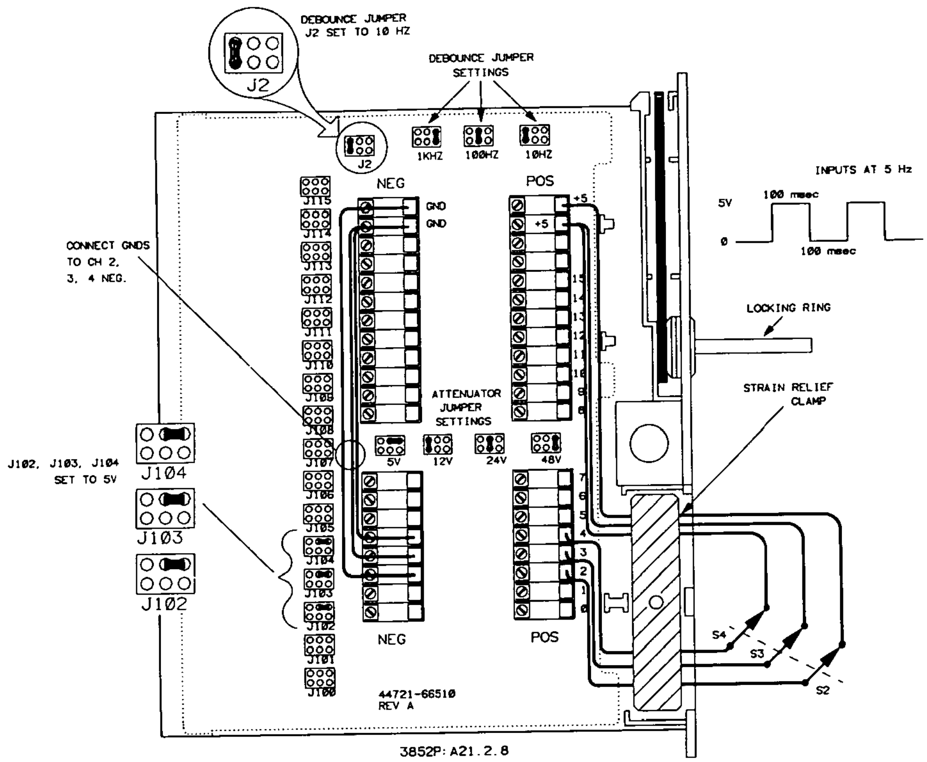


Figure 2-8. Example: Using +5V Supply

Example: Connecting TTL/CMOS Inputs

TTL and CMOS logic can also be connected to the 16-channel digital input, as shown in Figure 2-9. For TTL or CMOS inputs, set the attenuator jumper for each channel used to the 5V or 12V range, as required, and set the debounce jumper to a range appropriate for the switching rate. When you have set the jumpers, route the field wires as shown in Figure 2-9.

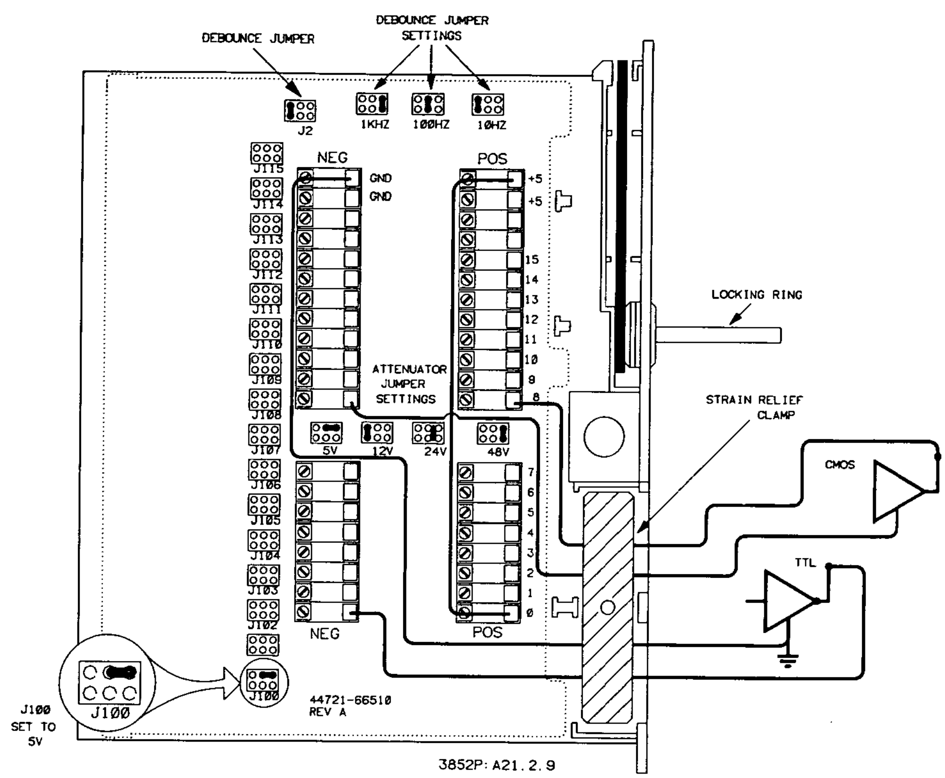


Figure 2-9. Example: Connecting TTL/CMOS Inputs

Installation and Checkout

When the attenuator jumpers and debounce jumper have been set and field wiring connected, connect the terminal module to the digital input component module and install the accessory in a desired slot. Refer to the HP 3852A Mainframe Configuration and Programming Manual to connect the modules and to install the accessory.

When the accessory input is installed, enter the ID? slot command from the front panel to check the accessory ID. At power-on, a 16-channel digital input returns 44721A, while a 16-channel digital input module only (no terminal module attached) returns 447XXX. (Note that if the terminal module is removed after power-on, the ID? command still returns 44721A for a 16-channel digital input).

If the 16-channel digital input does not return 44721A, be sure you have addressed the correct slot and the terminal module is attached. If the slot number is correct and terminal module is installed, but the correct code is not returned, refer to the HP 3852A Assembly Level Service Manual for service procedures.

This completes hardware configuration for the 16-channel digital input. Refer to Chapter 4 - Programming the Digital Inputs to program the accessory for your application.

Chapter 3
Configuring the 8-Channel Digital Input

Contents

Chapter 3

Configuring the 8-Channel Digital Input

Introduction

This chapter shows how to hardware configure the 8-channel digital input. It includes guidelines to set the attenuator jumpers on the terminal module, shows typical field wiring connections, and shows how to install and initially check the accessory.

Chapter Contents

This chapter has three sections:

- **Introduction** includes a chapter overview and lists WARNINGS, CAUTIONS, and NOTES which apply to the 8-channel digital input.
- **Terminal Module Configuration** shows how to set the attenuator jumpers and how to connect field wiring to the terminal module.
- **Installation and Checkout** shows how to install and initially check the 8-channel digital input.

Warnings, Cautions, and Notes

This section summarizes WARNINGS, CAUTIONS, and NOTES which apply to the 8-channel digital input accessory. You should review the WARNINGS and CAUTIONS shown before handling or configuring the accessory.

WARNING

⚠ 1 *SHOCK HAZARD. Only qualified, service-trained personnel who are aware of the hazards involved should install, remove, or configure any accessory. Before touching any installed accessory, turn off all power to the mainframe, extenders, and to all external devices connected to the mainframe, extenders, or accessories.*

WARNING

⚠ 2 *POSSIBLE OPERATOR INJURY. For safety, consider all accessory channels to be at the highest potential applied to any channel.*

CAUTION

MAXIMUM VOLTAGE/POWER LIMITATIONS. Absolute maximum voltage input to a channel depends on the attenuator jumper setting for the channel: 80 volts for the 24V setting; 200 volts for the 120V setting; or 250 volts for the 240V setting, where volts = VDC or VAC rms. If combined inputs to the terminal module exceed six watts, operation of other accessories installed in the box may be affected due to excessive power dissipation.

CAUTION

STATIC SENSITIVE. Use clean-handling techniques when handling the accessory. Do not install an accessory without the metal covers attached.

NOTE

HP-IB ADDRESS. The example programs in this manual use "709" as the HP-IB address for the HP 3852A. Specific slot and channel numbers are also used. Program syntax and data return formats apply to HP Series 200/300 controllers. Modify slot and channel numbers and program syntax as required.

Terminal Module Configuration

This section shows how to set the attenuator jumpers and how to connect field wiring to the 8-channel digital input terminal module.

Setting Attenuator Jumpers

To begin terminal module configuration, remove the terminal module cover. (If the accessory is installed in the mainframe or an extender, refer to the HP 3852A Mainframe Configuration and Programming Manual to remove the terminal module.)

Terminal Module Description

Figure 3-1 shows the 8-channel terminal module with the cover removed. The terminal module has 8 attenuator jumpers (J100 through J107), one for each channel. J100 sets channel 0, J101 sets channel 1,. . ., J107 sets channel 7. Each jumper can be set to 24V, 120V, or 240V. However, to properly set the attenuator jumper, we will first need to define some terms.

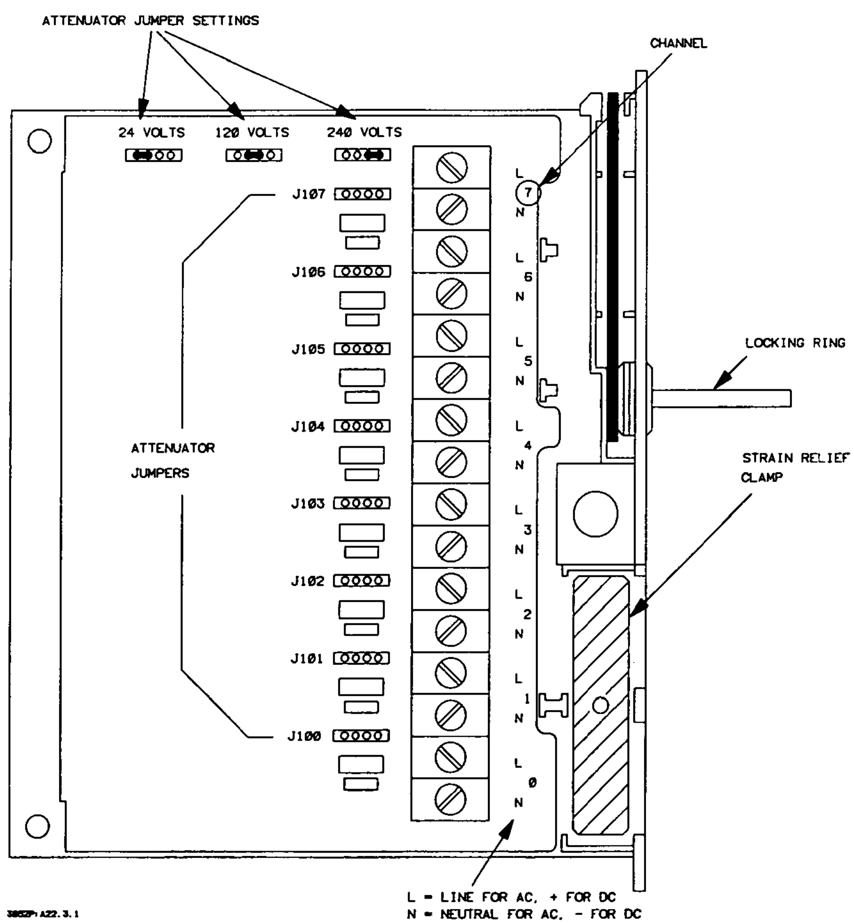


Figure 3-1. HP 44722A Terminal Module

Determining Jumper Setting

Figure 3-2 shows guidelines to select the proper attenuator jumper setting for a typical DC input, where Vhigh is the MINIMUM value of the input HIGH state and Vlow is the MAXIMUM value of input LOW state. Vmax and Vmin are the Threshold Voltages shown in Table 3-1.

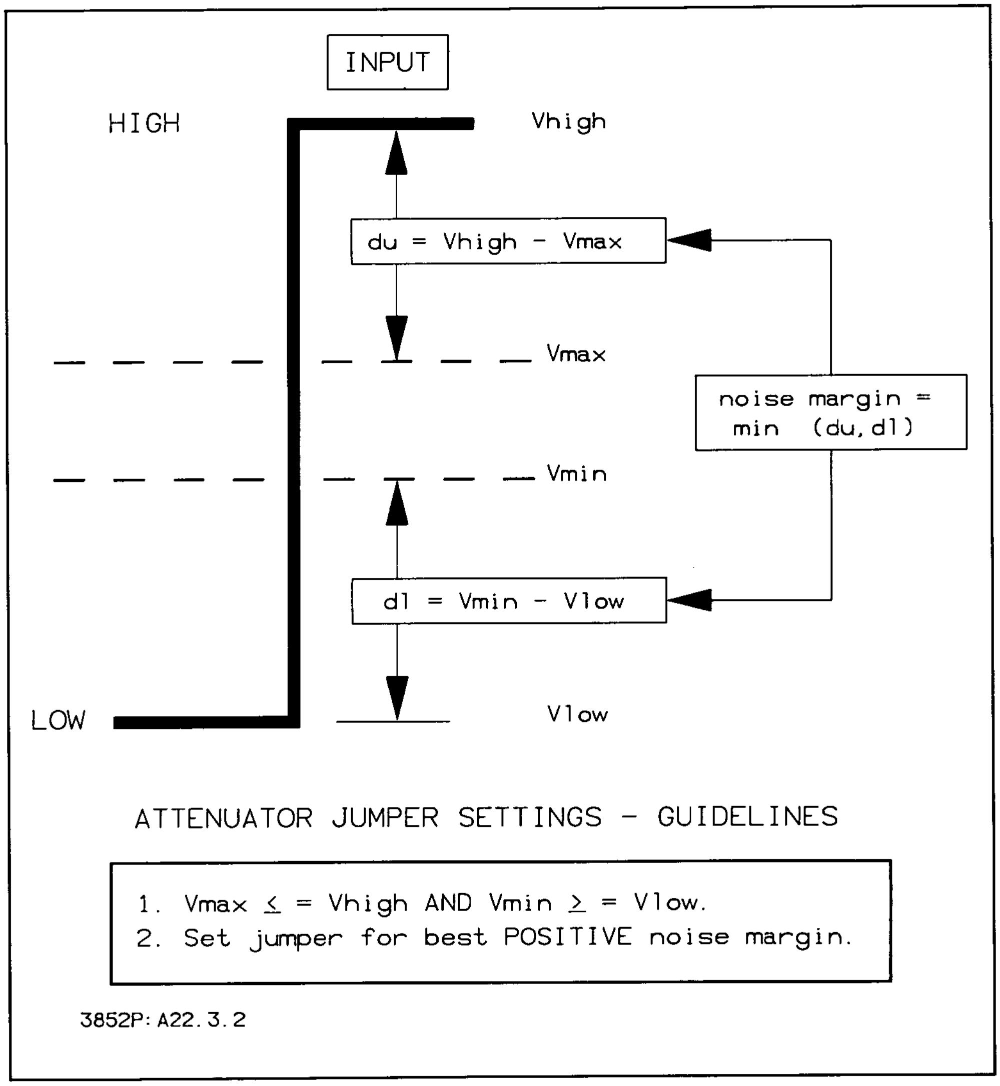


Figure 3-2. Attenuator Jumper Setting Guidelines

To determine the appropriate jumper settings, use the setting (24V, 120V, or 240V) which has the best POSITIVE noise margin, where noise margin = min (du, dl) = min (Vhigh - Vmax, Vmin - Vlow).

Table 3-1. Threshold Voltages

Attenuator Jumper Settings	Threshold Voltages Vmin	Vmax	Nominal Current for Setting
24 V	5.5	16.5	1.7 mA
120 V	30.0	90.0	1.1 mA
240 V	65.0	185.0	1.1 mA

Example: Selecting Attenuator Jumper Setting

You want to select the best attenuator jumper setting for a DC input with Vlow = 25 VDC and Vhigh = 195 VDC (or Vlow = 25 VAC rms and Vhigh = 195 VAC rms). The first step is to compute the noise margin for each jumper range, as shown in Figure 3-3. For example, the noise margin on the 24V range = min [(195 - 16.5), (5.5 - 25)] = min (178.5, -19.5) = -19.5.

Thus, the 24V setting cannot be used, since the noise margin (-19.5) is negative. Both the 120V and 240V settings have positive noise margins. However, since the noise margin for the 240V setting (+10.0) is better than the noise margin for the 120V setting (+5.0), use the 240 V setting.

Connecting Field Wiring

When you have set the channel attenuator jumpers, connect field wiring from your inputs to the 8-channel terminal module. Each channel of the 8-channel terminal module has an L and an N terminal, where L = the HIGH (+) input for DC or the LINE input for AC and N = the LOW (−) input for DC or the NEUTRAL input for AC. See Figure 3-1 for jumper and terminal locations.

NOTE

The maximum frequency which can be counted by the HP 44722A is 10 Hz for either DC or AC inputs. Recall that the AC input state is sensed as AC OFF or AC ON and the HP 44722A does NOT change state with each cycle of the input. Thus, for any acceptable range of the AC input (47 Hz - 470 Hz), the maximum rate at which input state changes (AC OFF to AC ON or AC OFF to AC ON) can be counted is 10 changes/second.

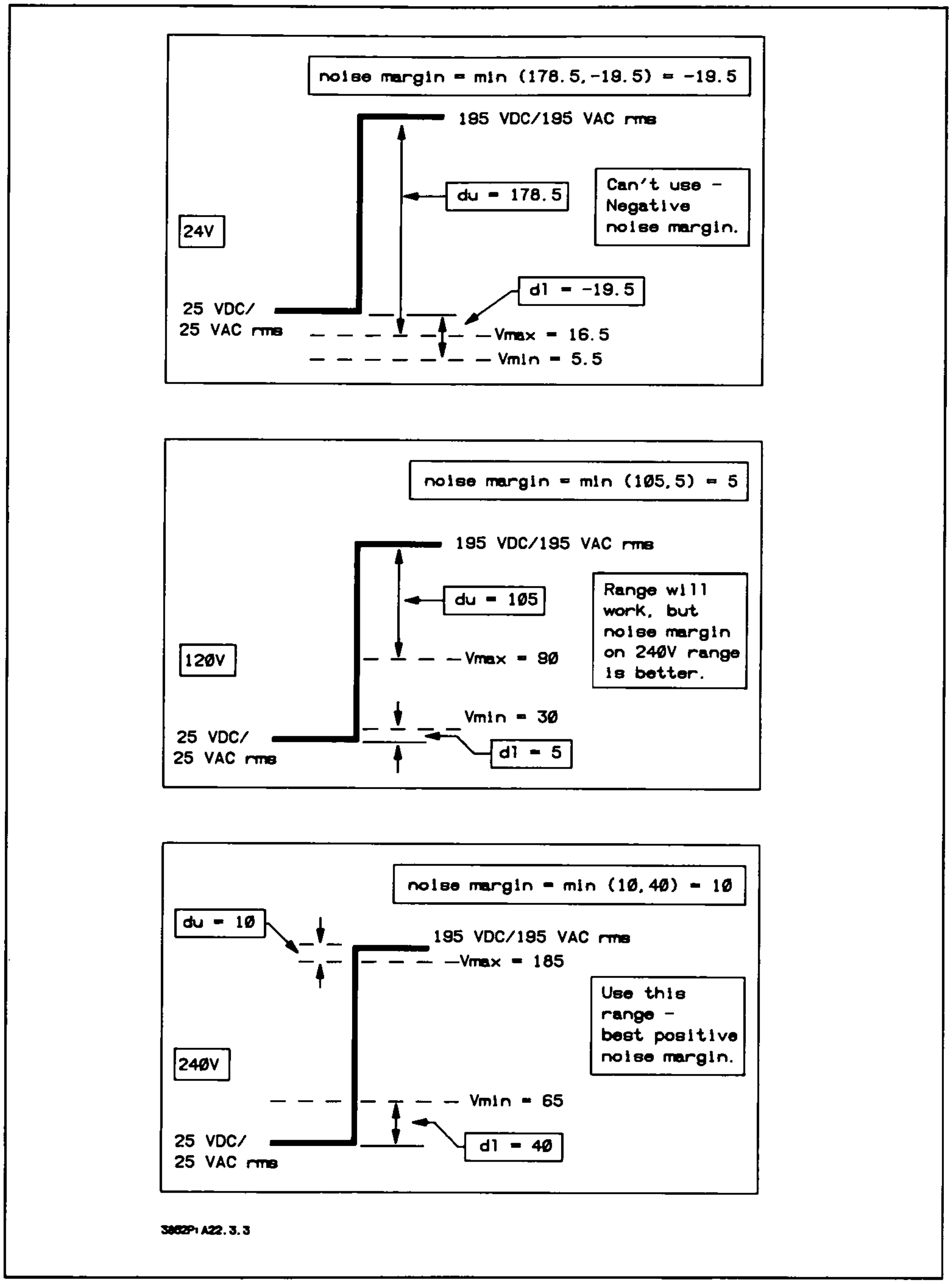


Figure 3-3. Example: Setting Attenuator Jumper

When connecting field wiring, route the field wires under the strain relief clamp and tighten the clamp screw to reduce the chance of wires being pulled out of the terminal connectors. After you have connected field wiring, replace the terminal assembly cover. Two example configurations follow.

Example: Connecting DC Input

A 100 VDC source is connected through switch S1 to channel 1 of an 8-channel digital input as shown in Figure 3-4. To set the channel attenuator jumper (J101) for this input, select the setting with the best positive noise margin.

From Table 3-1, the noise margin for the 24V setting = min [(100-16.5), (5.5-0)] = min [(83.5,5.5)] = 5.5, while the noise margin for the 120V setting = min [(10,30)] = 10. The 240V setting cannot be used since it has a negative noise margin [min (-85,65) = -85]. Therefore, set J101 to 120V since this setting has the best positive noise margin. After setting J101, connect field wires as shown in Figure 3-4.

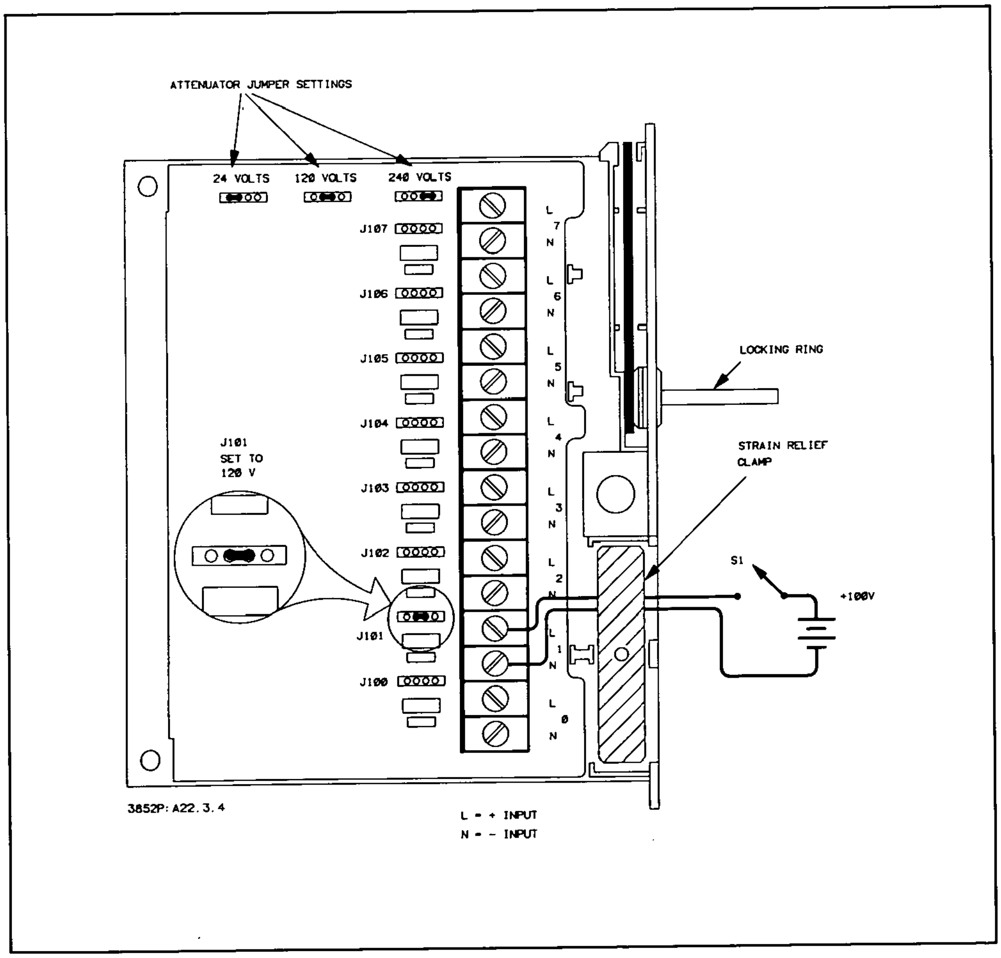


Figure 3-4. Example: Connecting DC Input

Example: Connecting AC Input

A 120 VAC rms, 60 Hz source is connected through switch S0 to channel 0 of an 8-channel digital input as shown in Figure 3-5. To set the attenuator jumper J100 for this input, select the setting with the best positive noise margin.

The noise margin for the 24V setting = min [(103.5,5.5)] = 5.5, while the noise margin for the 120V setting = min [(30,30)] = 30. The 240V setting cannot be used since it has a negative noise margin [min (-65,65) = -65]. Therefore, set J100 to 120V since this setting has the best positive noise margin. After setting J100, connect field wires as shown in Figure 3-5.

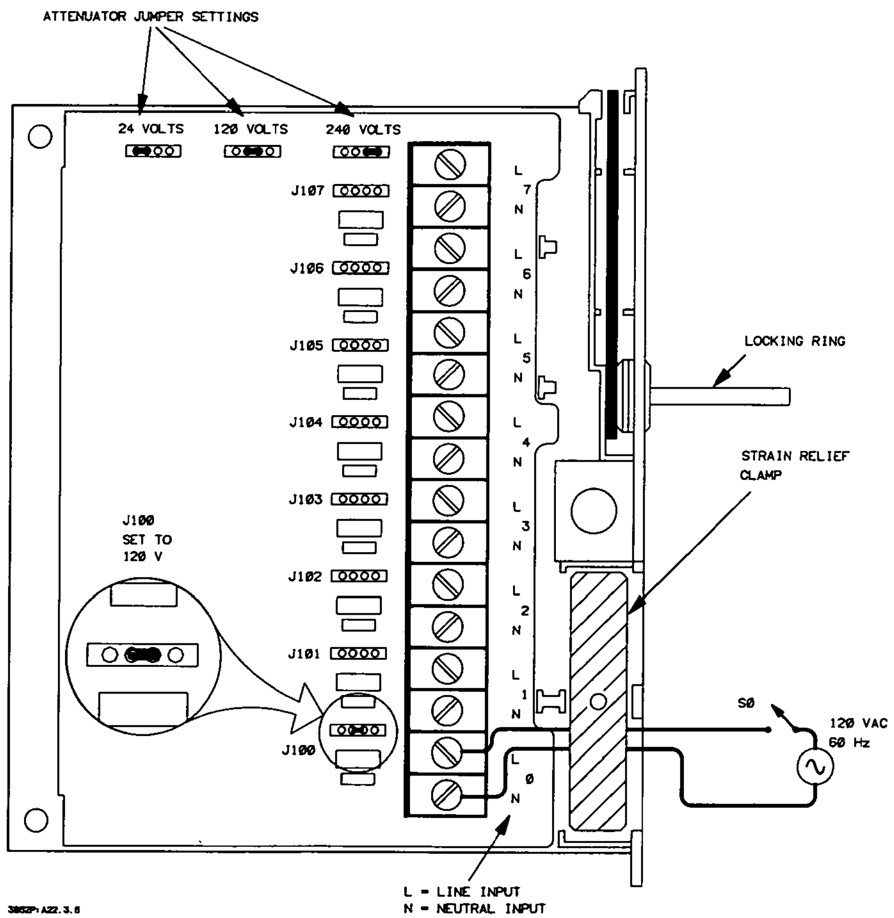


Figure 3-5. Example: Connecting AC Input

Installation and Checkout

When the attenuator jumpers have been set and field wiring connected, connect the terminal module to the digital input component module and install the accessory in a desired slot. Refer to the HP 3852A Mainframe Configuration and Programming Manual to connect the modules and to install the accessory.

When the accessory input is installed, send the ID? slot command from the front panel to check the accessory ID. At power-on, an 8-channel digital input returns 44722A, while an 8-channel digital input module only (no terminal module attached) returns 447XXX. (Note that if the terminal module is removed after power-on, the ID? command still returns 44722A for an 8-channel digital input).

If the 8-channel digital input does not return 44722A, be sure you have addressed the correct slot and the terminal module is attached. If the slot number is correct and terminal module is installed, but the correct code is not returned, refer to the HP 3852A Assembly Level Service Manual for service procedures.

This completes hardware configuration for the 8-channel digital input. Refer to Chapter 4 - Programming the Digital Inputs to program the accessory for your application.

Chapter 4
Programming the Digital Inputs

Contents

Chapter 4

Programming the Digital Inputs

Introduction

This chapter shows how to program the 16-channel and 8-channel digital inputs. The chapter has three sections:

- **Introduction** summarizes chapter contents, lists example program titles, and shows how to determine the mainframe firmware revision number.

- **Programming Overview** summarizes commands vs. logical channel numbers, gives an overview of binary-to-decimal conversions, and provides an alphabetical summary of commands.

- **Programming Digital Input Channels** shows how to program digital input channels for four functions: detecting input states; counting input edges; generating event interrupts; and generating counter interrupts.

Example Program Titles

Table 4-1 lists the titles of the example programs in this chapter.

Table 4-1. Example Program Titles

Title	Description	Commands
Detecting Input States		
Reading* DC Input State	Read the state of two channels to determine if the channel switch is open or closed.	CHREADM
Reading AC Input State	Read the state of all channels in a slot to determine the AC ON/OFF status.	READ
Counting Input Edges		
Counting DC Input Edges	Set a channel to count switch openings and closures. Read the number of openings and closures.	EDGE, CHREAD
Counting AC Input Edges	Read the number of times an AC input is ON and then zero the count.	EDGE, CHREADZ
Generating Event Interrupts		
Enable Event Interrupt - Single Channel	Enable a channel to generate an event interrupt on the first edge of a burst. Read the number of pulses in the burst.	EDGE, CHREAD, ENABLE INTR
Enable* Event Interrupt - Any Channel	Enable the accessory to generate an event interrupt on an LH edge into any channel. Read the interrupt time and channel states at the time of interrupt.	EDGE, CHREAD, ENABLE INTR
Generating Counter Interrupts		
Enable Counter Interrupt - Single Channel	Enable a channel to generate a counter interrupt after five switch closures. Read the interrupt time and number of closures after the interrupt.	EDGE, CNTSET, CHREAD, ENABLE INTR
Enable* Counter Interrupt - Any Channel	Enable any channel to generate a counter interrupt after three switch closures. Read Interrupt time and channel which generated the interrupt.	EDGE, CNTSET, CHREADM, ENABLE INTR
* = Program requires mainframe firmware revision 3.0 or greater.		

Mainframe Firmware Revision

Since some commands for the HP 44721A/44722A require mainframe firmware revision 3.0 or greater (refer to the Command Summary in Table 4-5), you may want to check the revision number for your mainframe to ensure that the accessory commands will be accepted. The following example program uses the IDN? command to check the mainframe ID, including the firmware revision number.

```
10 DIM Identity$(1:4)[17]               !Dimension controller array
20 OUTPUT 709;"IDN?"                    !Query HP 3852A identity
30 ENTER 709;Identity$(*)               !Enter identity
40 PRINT USING "K,/";Identity$(*)       !Display identity
50 END
```

A typical return for firmware revision 3.0 follows.

```
HEWLETT PACKARD   (Company name)
3852A             (Model number)
0                 (Mainframe serial number unknown)
3.0               (Firmware revision 3.0)
```

Programming Overview

This section provides an overview of programming for the 16-channel and 8-channel digital inputs. It includes a summary of commands vs. logical channel numbers, an overview of binary to decimal conversions, and an alphabetical command summary.

Commands vs. Channel Numbers

As noted, each digital input channel has a physical channel number and two associated logical channel numbers. The 16-channel digital input has physical channel numbers 0 through 15, while the 8-channel digital input has physical channel numbers 0 through 7.

However, digital input commands use logical channel numbers rather than physical channel numbers. Logical channel numbers define both the channel to be addressed and the function the channel is to perform. The channel function depends on the command sent.

Table 4-2 defines the functions set by the USE *ch* command or parameter for commands used with the 16-channel digital input. Table 4-3 defines the same functions for the 8-channel digital input.

For example, as shown in Table 4-2, CHREAD 0 reads the number of counts on a 16-channel digital input in slot 0 of the mainframe while CHREAD 16 reads the channel state. Or, as shown in Table 4-3, ENABLE INTR USE 0 enables a counter interrupt on channel 0 of an 8-channel digital input while ENABLE INTR USE 8 enables an event interrupt on this channel.

Table 4-2. Commands vs. Channel Numbers - 16-Channel

Command	Logical Channel Number				Note
	ES00-ES15	**ES16-ES31**	**ES90**	**ES91**	[1]
CHREAD	Read count on specified channel.	Read state of specified channel.	N/A	N/A	
CHREADM	Read count on specified channel(s).	Read state of specified channel(s).	N/A	N/A	
CHREADZ	Read/zero count on specified channel.	N/A	N/A	N/A	
CNTSET	Preset count on specified channel.	N/A	N/A	N/A	
DISABLE INTR	Disable counter interrupt on specified channel.	Disable event interrupt on specified channel.	Disable counter interrupt on all channels in range ES00-ES15.	Disable event interrupt on all channels in range ES16-ES31.	
EDGE	Set edge to be counted on specified channel.	Set edge to generate event interrupt on specified channel when enabled.	Set edge to be counted on all channels in range ES00-ES15.	Set edge for event interrupt on any channel in range ES16-ES31.	[2]
ENABLE INTR	Enable counter interrupt on on specified channel.	Enable event interrupt on specified channel.	Enable counter interrupt on all channels in range ES00-ES15.	Enable event interrupt on all channels in range ES16-ES31.	
READ	N/A	Read state of specified slot.	N/A	N/A	[3]
READM	N/A	Read state of specified slot(s).	N/A	N/A	[3]

Notes:

[1] = Physical channel numbers for ES16-ES31 are ES00-ES15. ES90 and ES91 require mainframe firmware revision 3.0 or greater.

[2] = EDGE sets the edge for BOTH the counting function and for interrupt transitions on a channel (e.g., EDGE LH, USE 105 sets LH edges for both counting and event interrupts on channel 105). The EDGE BOTH parameter requires mainframe firmware revision 3.0 or greater plus HP 44721A with serial number 2711A01765 or greater.

[3] = READ [number] parameter and READM require mainframe firmware revision 3.0 or greater.

Table 4-3. Commands vs. Channel Numbers - 8-Channel

Command	Logical Channel Number				Note
	ES00-ES07	ES08-ES15	ES90	ES91	[1]
CHREAD	Read count on specified channel.	Read state of specified channel.	N/A	N/A	
CHREADM	Read count on specified channel(s).	Read state of specified channel(s).	N/A	N/A	
CHREADZ	Read/zero count on specified channel.	N/A	N/A	N/A	
CNTSET	Preset count on specified channel.	N/A	N/A	N/A	
DISABLE INTR	Disable counter interrupt on specified channel.	Disable event interrupt on specified channel.	Disable counter interrupt on all channels in range ES00-ES07.	Disable event interrupt on all channels in range ES08-ES15.	
EDGE	Set edge to be counted on specified channel.	Set edge to generate event interrupt on specified channel when enabled.	Set edge to be counted on all channels in range ES00-ES07.	Set edge for event interrupt on any channel in range ES08-ES15.	[2]
ENABLE INTR	Enable counter interrupt on specified channel.	Enable event interrupt on specified channel.	Enable counter interrupt on all channels in range ES00-ES07.	Enable event interrupt on all channels in range ES08-ES15.	
READ	N/A	Read state of specified slot.	N/A	N/A	[3]
READM	N/A	Read state of specified slot(s).	N/A	N/A	[3]

Notes:

[1] = Physical channel numbers for ES08-ES15 are ES00-ES07. ES90 and ES91 require mainframe firmware revision 3.0 or greater.

[2] = EDGE sets the edge for BOTH the counting function and for interrupt transitions on a channel (e.g., EDGE LH, USE 105 sets LH edges for both counting and event interrupts on channel 105). The EDGE BOTH parameter requires mainframe firmware revision 3.0 or greater plus HP 44722A with serial number 2711A00178 or greater.

[3] = READ [number] parameter and READM require mainframe firmware revision 3.0 or greater.

Data Conversion

For HP 9000 Series 200/300 controllers (and equivalent), data inputs and returns must be in decimal format. For the digital input accessories, the READ or READM command returns the decimal equivalent of the state of each of the channels, where channel state "0" = AC OFF or DC LOW and channel state "1" = AC ON or DC HIGH. The range of the READ and READM commands is -32768 to +32767.

This section shows how to compute decimal values for desired channel bit patterns and how to determine the bit pattern for a given decimal value. Table 4-4 shows the associated weighted decimal value for each channel. For example, channel 0 has weighted decimal value 1, channel 5 has weighted decimal value 32, etc.

To compute the decimal value for any channel bit pattern, add the weighted decimal values of the "1" bits in the channel bit pattern, where "1" = AC ON or DC HIGH and "0" = AC OFF or DC LOW. Examples follow to show how to compute the decimal value for a given bit pattern or to determine the bit pattern for a given decimal value.

Table 4-4. Decimal Values vs. Channel Numbers

Channel Number	Weighted Decimal Value	Channel Number	Weighted Decimal Value
0	1	8	256
1	2	9	512
2	4	10	1024
3	8	11	2048
4	16	12	4096
5	32	13	8192
6	64	14	16384
7	128	15	-32768

Example: Finding Positive Decimal Value of Bit Pattern

To compute the positive decimal value of a bit pattern with channel 15 state = 0 (AC OFF or DC LOW), add the weighted decimal values for the "1"s in the bit pattern. For example, for a 16-channel digital input with channel 2, 4, 6, and 9 states = 1, the channel bit pattern is 0000 0010 0101 0100 and the decimal value is 596.

1. Channel Bit Pattern: 0000 0010 0101 0100 = ?
2. Decimal Value: 512 + 64 + 16 + 4 = 596

Example: Finding Negative Decimal Value of Bit Pattern

There are two ways to find the decimal value of a bit pattern when the channel 15 state = 1. The first way is to add the weighted decimal values of the "1" bits, the same as for a positive decimal value. For example, for bit pattern 1000 0000 0010 1110 (channel 1, 2, 3, 5, and 15 states = 1), the decimal value = -32722.

1. Channel Bit Pattern:	1000 0000 0010 1110
2. Decimal Value:	-32768 + 32 + 8 + 4 + 2 = -32722

The second way to compute the decimal value of a bit pattern with channel 15 state = 1 is to find the 2's complement of the bit pattern, calculate the decimal equivalent, and use the negative of this number. For example, with channels 1, 2, 3, 5, and 15 states = 1, the bit pattern is 1000 0000 0010 1110. Use the following steps to calculate the decimal value of this pattern using the 2's complement method.

1. Channel Bit Pattern:	1000 0000 0010 1110 = ?
2. 2's Complement:	0111 1111 1101 0010
3. Decimal Equivalent of 2's Complement:	16384+8192+4096+2048 +1024+512+256+128+64 +16+2 = 32722
4. Decimal Value:	1000 0000 0010 1110 = -32722

Example: Finding Bit Pattern for Positive Decimal Value

To find the channel bit pattern for a positive decimal value (0 to 32767), compute the binary equivalent of the number by doing a decimal to binary conversion. For example, the channel bit pattern for decimal 40 is:

```
Bit Pattern for +40:     40 = 32 + 8 = 0000 0000 0010 1000
                                                  /   \
                                                 32 + 8
```

Example: Finding Bit Pattern for Negative Decimal Value

To find the channel bit pattern for a negative decimal value (−32768 to −1), first determine the bit pattern for the positive decimal value. The 2's complement of this pattern is the bit pattern for the negative number. For example, the bit pattern for decimal −483 is computed as follows:

1. Decimal Value:	-483	=	?
2. Bit Pattern for +483:	483	=	0000 0001 1110 0011
3. 2's Complement of +483:		=	1111 1110 0001 1101
4. Bit Pattern for -483:	-483	=	1111 1110 0001 1101

Command Summary

Table 4-5 is an alphabetical summary of commands which apply to the digital inputs. Refer to the HP 3852A Command Reference Manual for a complete description of these commands.

Table 4-5. Command Summary

CHREAD *ch* **[INTO** *name***]** or **[***fmt***]**
For *ch* = ES00-ES15 (ES00-ES07 for 8-channel), returns the count on the channel. For *ch* = ES16-ES31 (ES08-ES15 for 8-channel), returns the state of the channel.
CHREADM *ch_list* **[INTO** *name***]** or **[***fmt***]**
For USE *ch* = ES00-ES15 (ES00-ES07 for 8-channel), returns the count on the channel(s) specified by *ch_list*. For USE *ch* = ES16-ES31 (ES08-ES15 for 8-channel), returns the state of the channel(s) specified by *ch_list*.
CHREADZ *ch* **[INTO** *name***]** or **[***fmt***]**
For USE *ch* = ES00-ES15 (ES00-ES07 for 8-channel), read and zero the channel count on the channel specified by *ch*.
CNTSET [*number***] [USE** *ch***]**
For the channel specified by USE *ch*, presets the channel counter to begin counting from the number of counts set by *number* OR to rollover after the number of counts set by *number*. Range of *number* = -2147483648 to +2147483647.
CONF *function* **[USE** *ch***]**
Configure the digital input to sense the input level or to totalize counts. CONF LVL configures the specified channel to sense the input level. CONF TOTAL configures the specified channel to totalize inputs on the channel. For CONF TOTAL, the *ch* range = ES00-ES15 (ES00-ES08 for the HP 44722A) and the channel totalizes counts. For CONF LVL, the *ch* range = ES16-ES31 (ES08-ES15 for the HP 44722A) and the channel senses the input level (LOW [0] or HIGH [1] for DC input; OFF [0] or ON [1] for AC input). CONF sets DISABLE INTR, EDGE LH, and CNTSET 0 on the specified channel. CONF clears and disables all interrupts enabled on the channel.
DISABLE INTR [USE *ch***]**
Prevents enabled channel(s) from generating event or counter interrupts. Type of interrupt disabled is specified by USE *ch*.
EDGE *trans* **[USE** *ch***]**
For channel specified by USE *ch* command, *trans* sets edge (positive, negative, or either) which will be counted AND sets the edge transition which will cause an event interupt when enabled.

Table 4-5. Command Summary (Cont'd)

ENABLE INTR [USE *ch*]

Enables channel(s) specified by USE *ch* to generate event or counter interrupts. For USE *ch* = ES00-ES15 (ES00-ES07 for 8-channel), enables channel specified by *ch* to interrupt on counter overflow (counter interrupt). For USE *ch* = ES16-ES31 (ES08-ES15 for 8-channel), enables channel specified by *ch* to interrupt when the edge specified by EDGE occurs (event interrupt).

For USE *ch* = ES90, enables counter interrupt when counter overflow occurs on any channel in range ES00-ES15 (ES00-ES07 for 8-channel). For USE *ch* = ES91, enables event interrupt when the edge(s) specified by EDGE occurs on any channel in range ES16-ES31 (ES08-ES15 for 8-channel). ENABLE INTR USE ES90 or ES91 requires mainframe firmware revision 3.0 or greater.

ID? *slot*

Reads identity of digital input in slot specified by *slot*. An HP 44721A returns 44721A, while an HP 44722A returns 44722A.

READ *slot* [*number*] [INTO *name*] or [*fmt*]

Reads the state of all channels in the slot specified by *slot* and returns the equivalent decimal value of the bit pattern (0 = AC OFF or DC LOW, 1 = AC ON or DC HIGH). Range is -32768 to 32767, where the LSB = channel ES00 state and the MSB = channel ES15 state (channel ES07 state for the HP 44722A). *number* reads the slot the specified number of times. The *number* parameter requires mainframe firmware revision 3.0 or greater.

READM *slot_list* [INTO *name*] or [*fmt*]

Reads the state of all channels in the slot(s) specified by *slot_list* and returns the equivalent decimal value of the bit pattern(s) (0 = AC OFF or DC LOW, 1 = AC ON or DC HIGH). Range is -32768 to 32767, where the LSB = channel ES00 state and the MSB = channel ES15 state (channel ES07 state for the HP 44722A). One value is returned for each slot read.

RST *slot*

Resets digital input in slot specified by *slot* to power-on state.

USE *ch*

Use channel specified by *ch* in commands to follow (unless USE parameter is given) where *ch* specifies logical channel number and function.

XRDGS *ch* [*number*] [INTO *name*] or [*fmt*]

For the channel specified by the *ch* parameter or by the USE *ch* command, XRDGS transfers the number of readings specified by *number* from a digital input channel to the mainframe. XRDGS transfers each reading as it becomes available without disturbing the counting or state sensing function. Range of *number* is 1 to 2147483647. Default *number* = 1.

Programming Digital Input Channels

This section shows how to program the 16-channel and 8-channel digital input channels for four functions:

- Detecting Input States
- Counting Input Edges
- Generating Event Interrupts
- Generating Counter Interrupts

Detecting Input States

One of the programming functions for the digital inputs is to detect (read) the state of an input. When the channel input is DC HIGH or AC ON, the channel is set to the "1" state. When the input is DC LOW or AC OFF, the channel is set to the "0" state. Figure 4-1 summarizes commands and operation for this function.

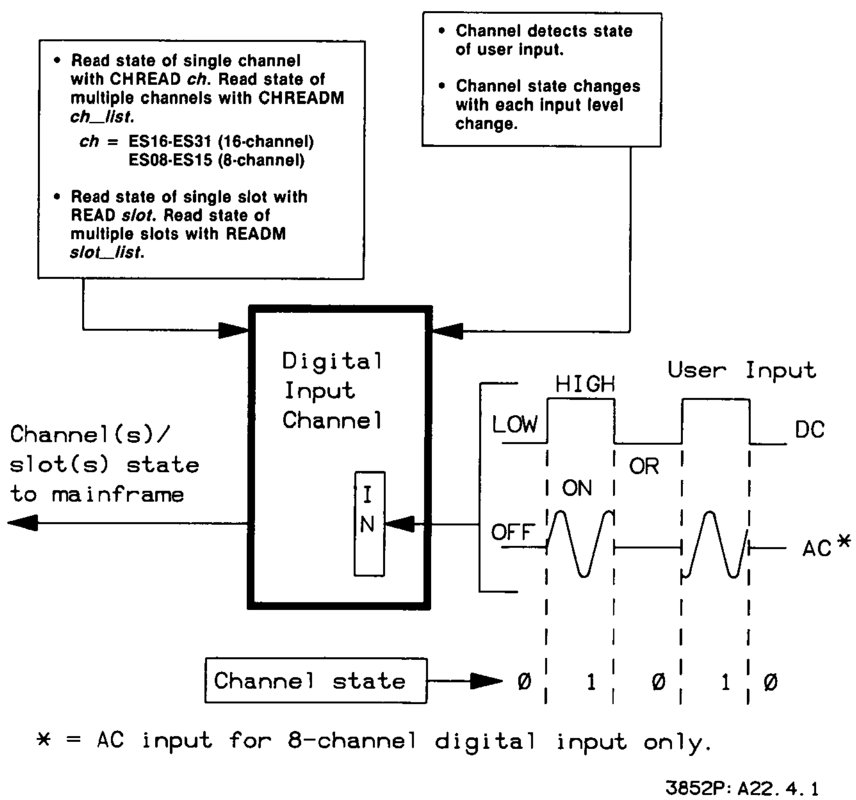


Figure 4-1. Detecting Input States

Reading Channel States

CHREAD and CHREADM read the state of individual digital input channels. For USE *ch* = ES16-ES31 (ES08-ES15 for the HP 44722A), use CHREAD *ch* to read the state of the channel specified by *ch*. (You can also use the XRDGS *ch* command which acts as a multiple CHREAD command).

Use CHREADM *ch_list* to read the state of the channel(s) specified by *ch_list*. (CHREADM requires mainframe firmware revision 3.0 or greater.) For example, use CHREAD 220 to read the state of channel 204 of an HP 44721A in slot 2 of the mainframe. Or, use CHREADM 220-230 to read the state of channels 204 through 214.

Reading Slot States

READ and READM read the state of all channels in a slot or slots. Use READ *slot* to read the state of all channels in the slot specified by *slot*. For mainframe firmware revision 3.0 or greater, use READ *slot* [*number*] to read the specified slot the number of times specified by [*number*] or use READM *slot_list* to read the state of all channels in the slot(s) specified by *slot_list*.

For example, use READ 100,3 to read the state of all channels of an HP 44721A or HP 4472A in slot 1 of the mainframe three times. Or, use READM 100,200,300-500 to read the state of slots 100, 200, and 300 through 500.

NOTE

READ and READM read the state of the specified slot(s) but do not read the number of counts on the channels in these slot(s).

Example: Reading DC Input State

This program determines if switches S1 and S8 are open or closed by reading the state of channels 401 and 408 of a 16-channel digital input in slot 4 of the mainframe. See Figure 4-2 for typical connections to the terminal module.

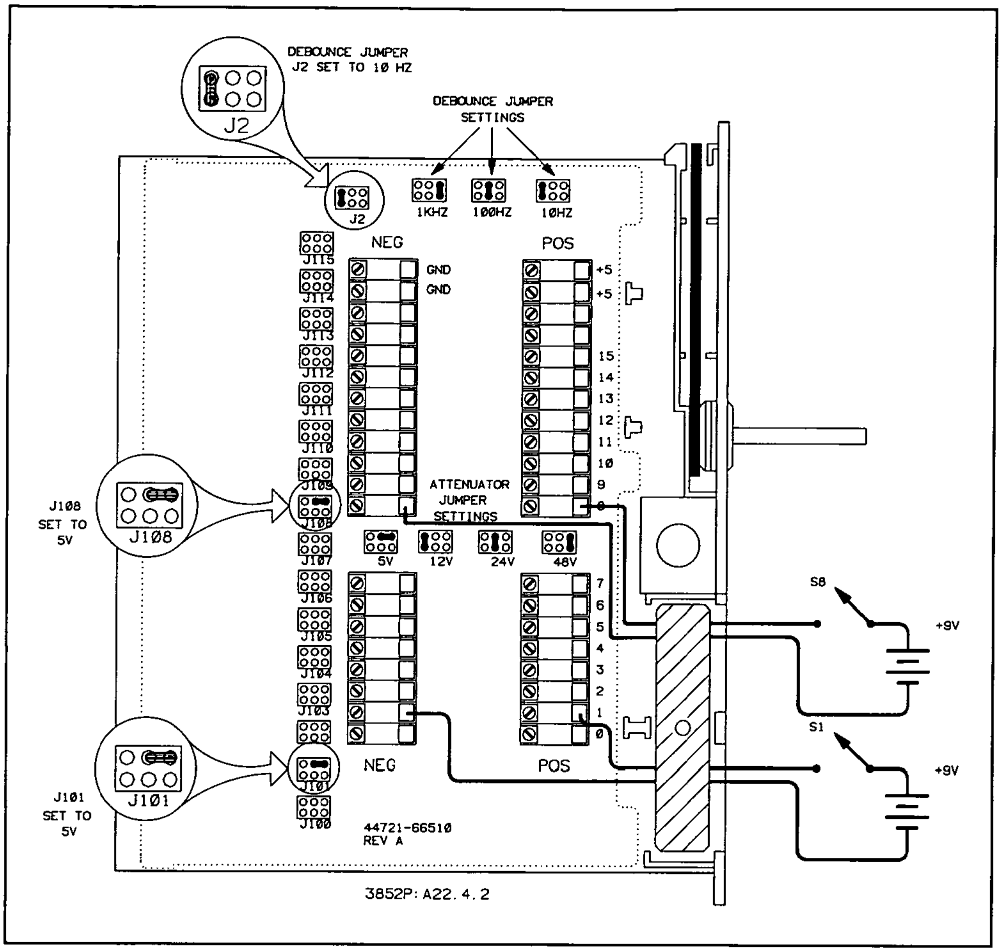


Figure 4-2. Example: Reading DC Input State

An example program using CHREADM follows. Note that mainframe firmware revision 3.0 or greater is required.

```
10 INTEGER A(0:1)
20 OUTPUT 709;"CHREADM 417,424"     !Read channel 401, 408 states
30 ENTER 709;A(*)                   !Enter channel 401, 408 states
40 PRINT "S1 state = ";A(0)         !Display channel 401 state
50 PRINT "S8 state = ";A(1)         !Display channel 408 state
60 END
```

If S1 is open and S8 is closed when CHREADM is executed, a typical return is:

```
S1 state = 0
S8 state = 1
```

Example: Reading AC Input State

This program determines the ON/OFF status of eight AC inputs to an 8-channel digital input in slot 3 of the mainframe. Inputs are connected to the channels through switches S0 through S7. When a channel switch is closed, AC is present on the channel (AC ON). When a channel switch is open, AC is absent (AC OFF). See Figure 4-3 for typical connections to the terminal module.

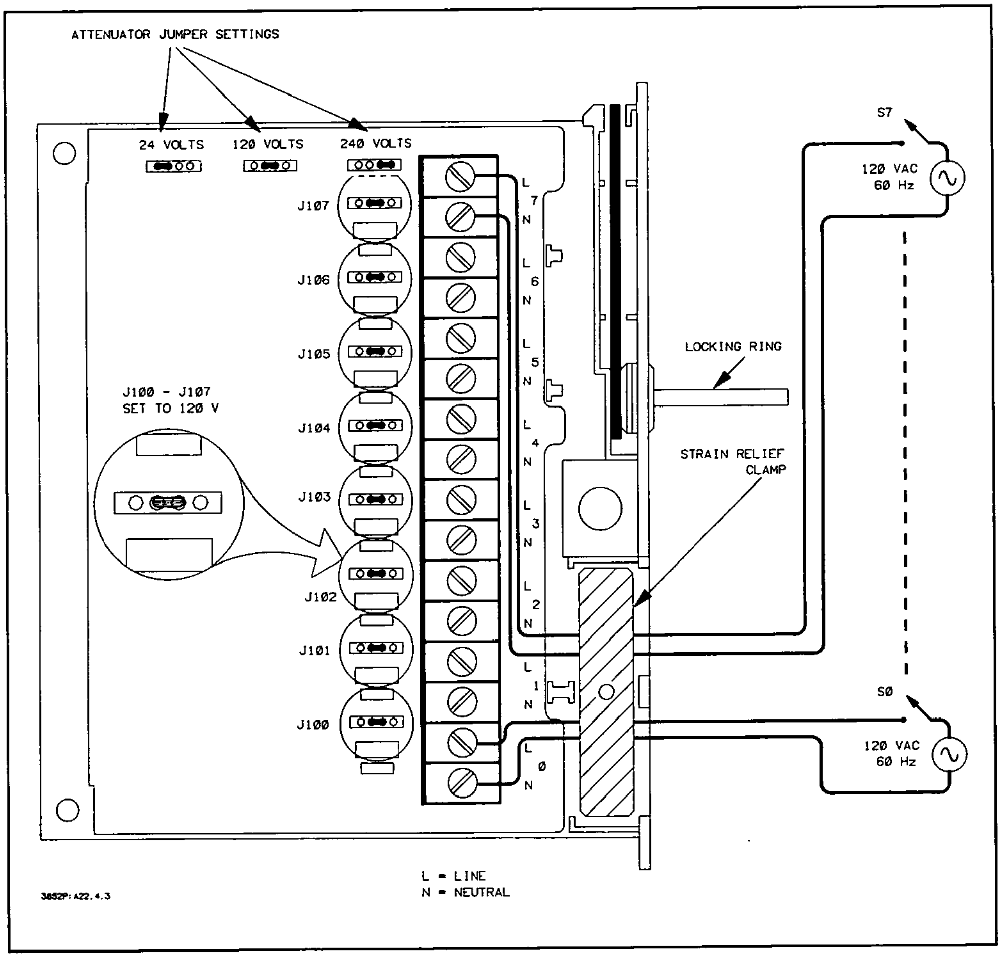


Figure 4-3. Example: Reading AC Input State

This program determines the status of all AC inputs in slot 300 by using the READ *slot* command. The data returned is the decimal value of the current channel states where 1 = switch closed (AC ON) for the channel and 0 = switch open (AC OFF) for the channel.

```
10 OUTPUT 709;"READ 300"              !Read state of slot 300
20 ENTER 709;A                        !Enter decimal equiv of state
30 PRINT "Switch States = ";A         !Display decimal equiv
40 END
```

For example, with switches S0, S1, S4, and S6 closed (AC ON for channels 300, 301, 304 and 306; AC OFF for channels 302, 303, 305, and 307), READ returns 83, where 83 = the decimal value of channel bit pattern 0101 0011. A typical return is:

```
Switch States = 83
```

Counting Input Edges

A second programming function for the digital inputs is to count specified input edges. The edges to be counted are set with the EDGE command. The count can be set to start at zero or at a programmable point with the CNTSET command. Figure 4-4 summarizes commands and operation for the counting function.

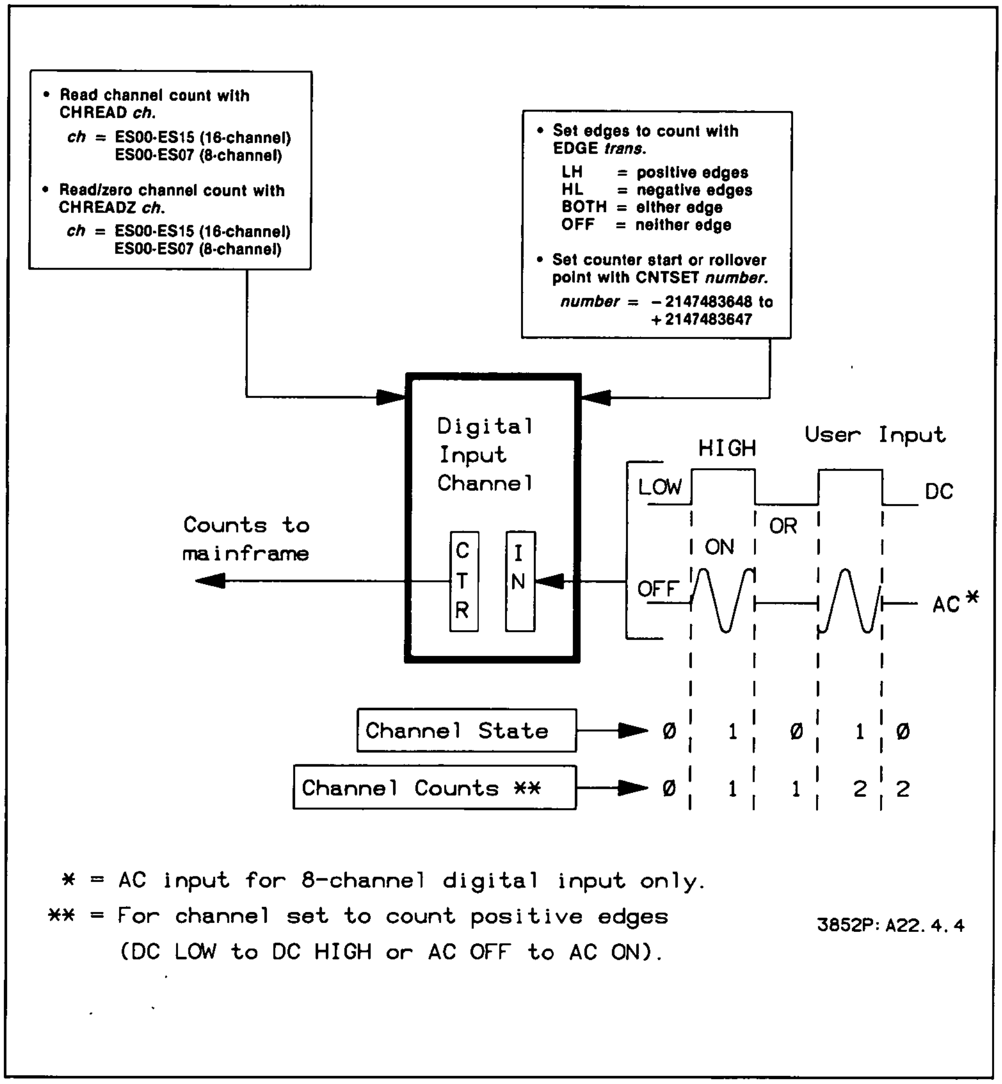


Figure 4-4. Counting Input Edges

Enabling Channel to Count Edges (EDGE)

Although a digital input channel automatically detects all input edges, the channel must be enabled to count programmed input edges. To enable a channel to count edges, use EDGE *trans* [USE *ch*] where *trans* = LH, HL, BOTH, or OFF defines the edges to be counted and USE *ch* = ES00-ES15 (ES00-ES07 for the 8-channel) sets the channel to count the programmed edges. (The EDGE BOTH parameter requires mainframe firmware revision 3.0 or greater plus an HP 44721A with serial number 2711A01765 or greater or an HP 44722A with serial number 2711A00178 or greater.)

For USE *ch* = ES00-ES15 (ES00-ES07 for the 8-channel), EDGE LH sets the channel to count positive edges, EDGE HL sets the channel to count negative edges, EDGE BOTH sets the channel to count both edges, and EDGE OFF sets the channel to idle (does not count either edge).

For USE *ch* = ES00-ES15 (ES00-ES07 for the 8-channel), you can use CHREAD *ch* to read accumulated counts on the channel specified by *ch*. Or, you can use CHREADZ *ch* to read and zero the counts on the channel specified by *ch*. (CHREADM cannot be used to read channel counts.)

For example, Figure 4-4 shows a digital input channel enabled to count positive edges (with EDGE LH). Although the channel state changes from "0" to "1" and back to "0" with each input change, the channel count totalizes with each positive edge.

NOTE

1. At power-on or after a RST or RST slot command, EDGE OFF is set and all channels are disabled from counting edges.

2. EDGE is NOT independently selectable for counts and interrupts. For example, setting EDGE LH USE 300 also sets EDGE LH USE 316 (16-channel) or sets EDGE LH USE 308 (8-channel).

3. For USE ch = ES91, when enabled with ENABLE INTR, an event interrupt is generated when the edge specified by EDGE occurs on any channel in the range ES16-ES31 (ES08-ES15 for the 8-channel). Refer to "Generating Event Interrupts" for details.

Setting Counter Presets/Rollovers (CNTSET)

Each channel has a separate counter with range from -2147483648 to +2147483647 counts. For DC inputs, the counter registers one count for each programmed edge detected (positive, negative, or both). For AC inputs (8-channel digital input only), the counter registers one count for each transition from AC OFF to AC ON and/or from AC ON to AC OFF, as programmed.

Each channel counter can be preset to begin counting from a specified number of counts or to rollover after a specified number of counts with the CNTSET [*number*] command. The *number* parameter specifies the number of counts at which the channel starts counting OR specifies the number of counts required to cause the counter to rollover.

As shown in Figure 4-5, the counter sequence is from 0 or from the preset value up to 2147483647 then to -2147483648 to -1 to 0. When the counter goes from -1 to 0, counter rollover occurs. Note that the count range is from 0 to 4294967296, while the CNTSET [*number*] range is from -2147483648 to 2147483647. Default [*number*] = 0.

The value to use for CNTSET [*number*] depends on the number of counts specified, as shown in Figure 4-5 where the decision point is counts = 2147483648. For example, with 1000 counts, since 1000 is <2147483648, CNTSET 1000 presets the counter to start counting at 1000 counts, while CNTSET -1000 causes the counter to rollover after 1000 counts.

However, for 3,000,000,000 counts, since 3000000000 is ≥ 2147483648, CNTSET -1294967296 (counts - 4294967296) presets the counter to start counting at 3,000,000,000 counts while CNTSET 1294967296 (4294967296 - counts) causes the counter to rollover after 3,000,000,000 counts.

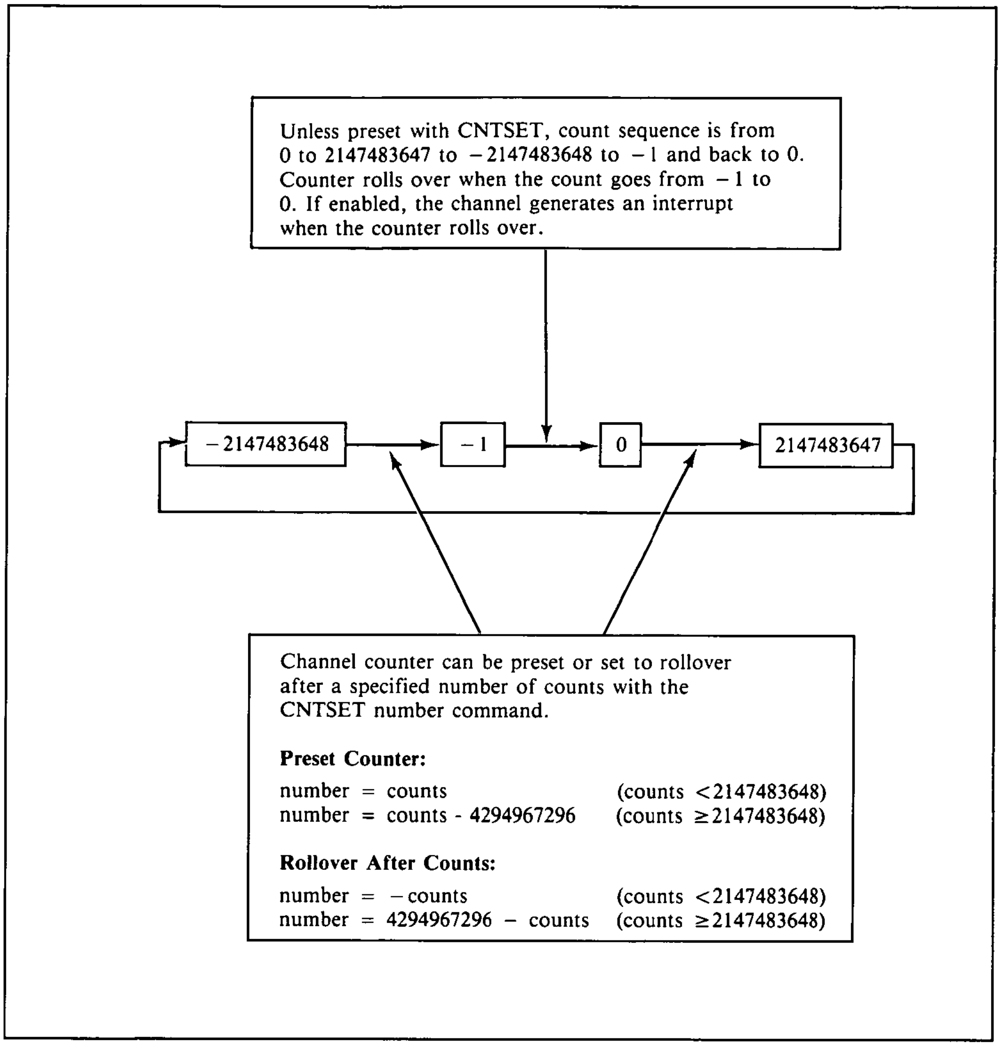


Figure 4-5. Channel Counter - Count Sequence

Example: Counting DC Input Edges

This program counts the total number of switch (S0) openings and closures during a ten-second interval by counting both edges on channel 100. See Figure 4-6 for typical connections to channel 100 of a 16-channel digital input in slot 1 of the mainframe. This program requires mainframe firmware revision 3.0 or greater.

The program sets channel 100 of a 16-channel digital input to count both edges, waits 10 seconds, and then reads the count.

```
10 OUTPUT 709;"RST"                 !Reset HP 3852A
20 OUTPUT 709;"USE 100"             !Use ch is 100
30 OUTPUT 709;"EDGE BOTH"           !Count both edges on ch 100
40 WAIT 10                          !Wait 10 seconds
50 OUTPUT 709;"CHREAD 100"          !Read counts on ch 100
60 ENTER 709;A                      !Enter ch 100 counts
70 PRINT "S0 Opens/Closes = ";A     !Display ch 100 counts
80 END
```

For a total of five switch openings and closures during the 10 seconds, a typical return is:

```
S0 Opens/Closes = 5
```

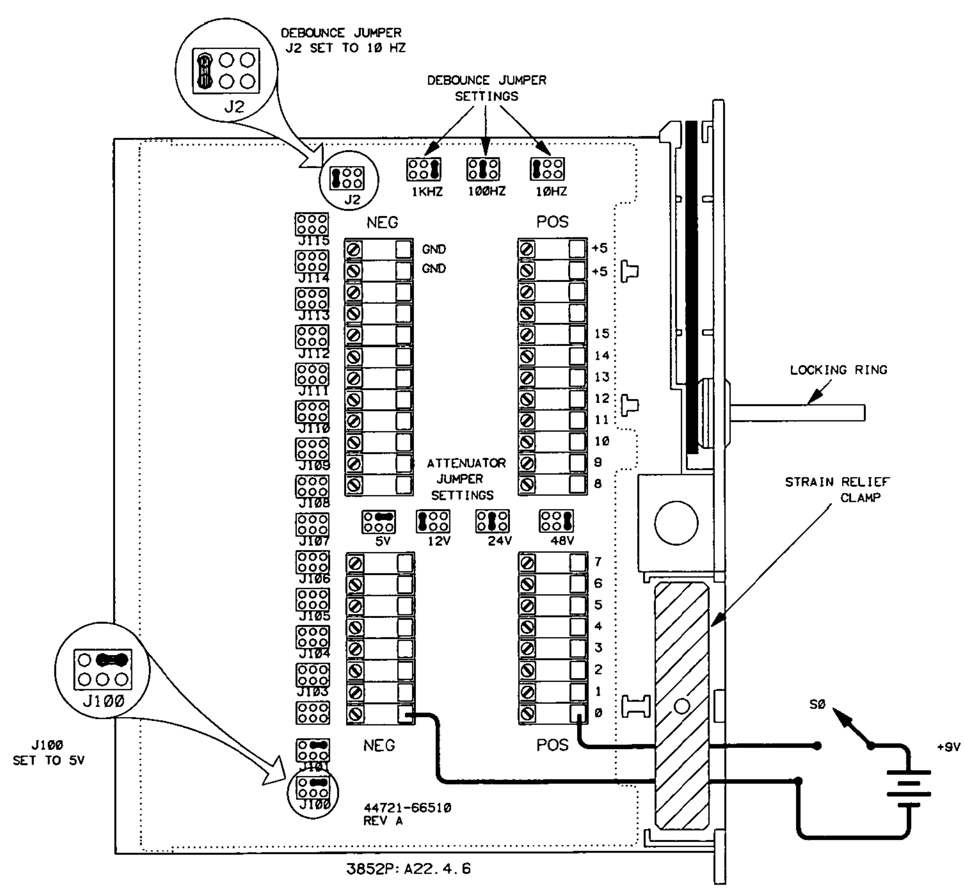


Figure 4-6. Example: Counting DC Input Edges

Example: Counting AC Input Edges

This program counts the number of times an AC input was switched ON during a one-minute interval and then zeroes the count. See Figure 4-7 for typical connections to channel 304 of a 16-channel digital input in slot 3 of the mainframe.

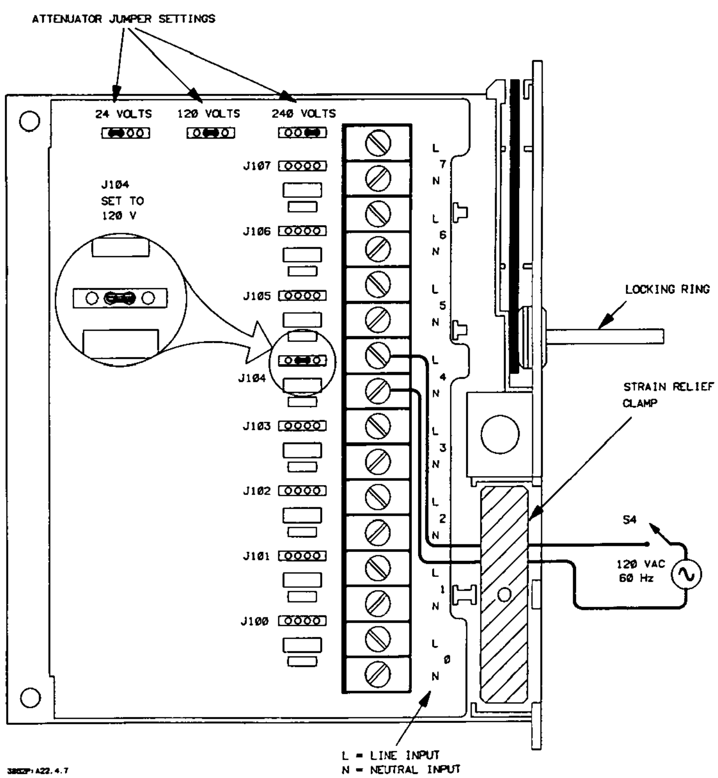


Figure 4-7. Example: Counting AC Input Edges

This program sets channel 304 to count positive edges, waits 60 seconds, and then reads and zeroes the count on channel 304. The number of positive edges counted = the number of times S4 was closed during the one-minute interval = the number of AC ON states during this time.

```
10 OUTPUT 709;"EDGE LH,USE 304"        !Count pos edges on ch 304
20 WAIT 60                             !Wait 60 seconds
30 OUTPUT 709;"CHREADZ 304"            !Read/zero count on ch 304
40 ENTER 709;A                         !Enter count
50 PRINT "Channel 304 AC ON = ";A      !Display count
60 END
```

For five switch closures, a typical return is:

```
Channel 304 AC ON = 5
```

Generating Event Interrupts

A third programming function for the digital inputs is to generate event interrupts. Each channel can be independently enabled to generate an interrupt when a programmed edge is detected. This is called an event interrupt. Enabled channels can be disabled from generating an event interrupt. Figure 4-8 summarizes commands and operation for event interrupts.

Enabling Event Interrupts

Two commands are required to enable a channel for an event interrupt: EDGE and ENABLE INTR. EDGE sets the edge (positive, negative, or either) on which to interrupt. EDGE LH sets positive edges, EDGE HL sets negative edges, and EDGE BOTH sets either edge. (EDGE BOTH requires mainframe firmware revision 3.0 or greater plus an HP 44721A with serial number 2711A01765 or greater or an HP 44722A with serial number 2711A00178 or greater.)

For USE *ch* = ES16-ES31 (ES08-ES15 for the 8-channel), ENABLE INTR [USE *ch*] enables the channel specified by *ch* to generate an event interrupt when the edge specified by EDGE occurs on the channel.

For USE *ch* = ES91, ENABLE INTR USE ES91 enables the accessory to generate an event interrupt when the edge specified by EDGE occurs on any channel in range ES16-ES31 (ES08-ES15 for the 8-channel). (USE ES91 is valid only for mainframe firmware revision 3.0 and greater.)

For example, to enable channel 100 of a 16-channel digital input to interrupt on a positive edge, EDGE LH USE 116 sets the channel to detect positive edges and ENABLE INTR USE 116 enables channel 100 to generate an event interrupt on the first positive edge. (To enable channel 100 of an 8-channel digital input in this slot, use EDGE LH USE 208 and ENABLE INTR USE 208).

For mainframe firmware revision 3.0 and greater, EDGE BOTH USE 191 plus ENABLE INTR USE 191 enables a 16-channel digital input in mainframe slot 1 to generate an event interrupt on the first edge (positive or negative) received on any channel in range ES16-ES31.

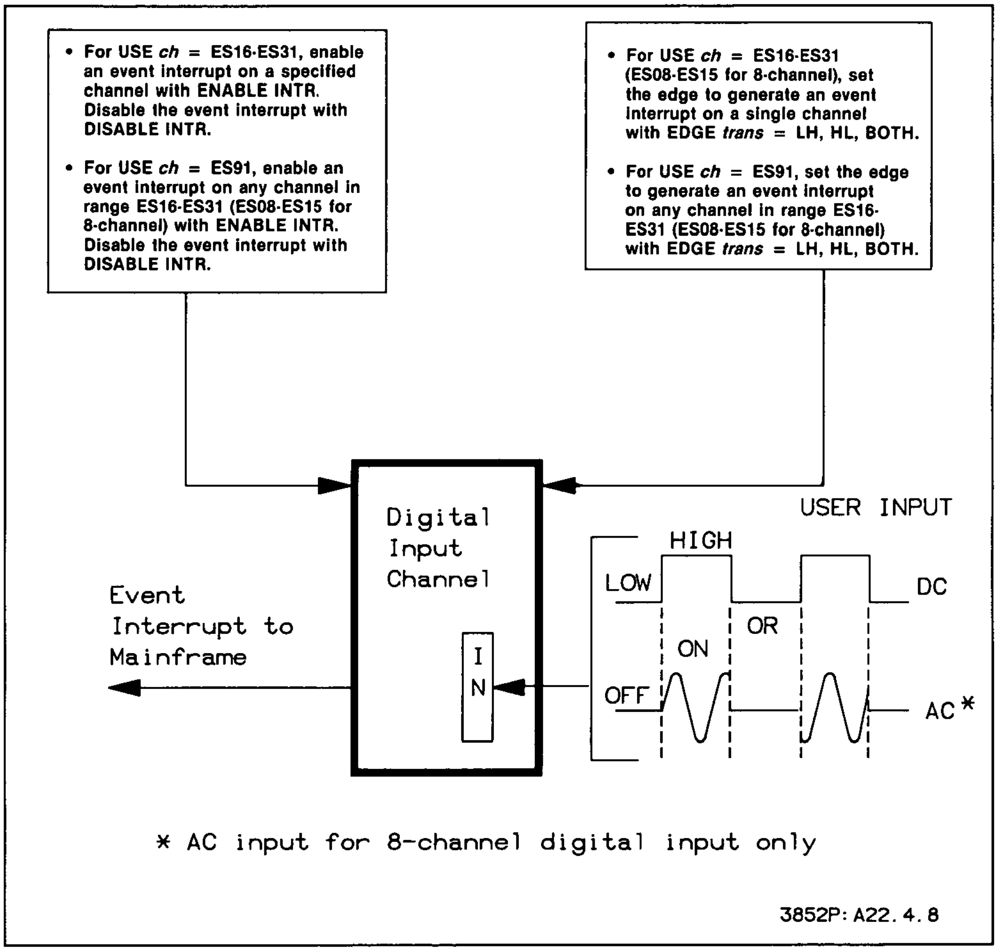


Figure 4-8. Generating Event Interrupts

Disabling Event Interrupts

A channel which has been enabled for event interrupts can be disabled from sending an event interrupt with DISABLE INTR [USE *ch*], where *ch* = ES16-ES31 (ES08-ES15 for the 8-channel). Also, for mainframe firmware revision 3.0 and greater, DISABLE INTR USE ES91 disables event interrupts on all channels in range ES16-ES31 (ES08-ES15 for the 8-channel).

NOTE

Since a channel can be enabled for event and counter interrupts, disabling event interrupts does NOT disable counter interrupts set on the channel(s) and vice-versa.

Servicing Event Interrupts

Whether or not DISABLE INTR is used, an event interrupt which is serviced by the mainframe is automatically cleared and disabled. This means that any programmed edges after the first programmed edge will not generate an interrupt unless the channel is first reenabled with another ENABLE INTR command.

For example, if the channel in Figure 4-9 is set to detect positive edges (EDGE LH) and enabled for event interrupts (ENABLE INTR), edge 1 will generate an event interrupt. However, edge 2 (and any following programmed edges) will not generate an interrupt unless another ENABLE INTR command is sent before edge 2 occurs AND the mainframe has serviced the interrupt from edge 1.

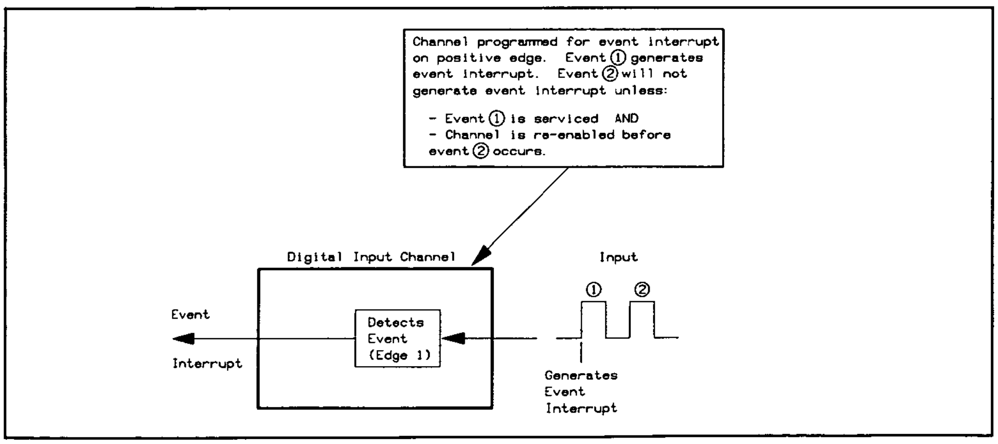


Figure 4-9. Servicing Event Interrupts

Event Interrupt Priorities

A channel can be enabled for event interrupts, counter interrupts, or both. Refer to "Generating Counter Interrupts" to program a channel for counter interrupts. At power-on or after a RST or RST *slot* (reset) command, all channels are disabled from generating event interrupts and/or counter interrupts.

If a channel generates an event interrupt and a counter interrupt, the counter interrupt is serviced first, then the event interrupt. Each interrupting channel is automatically cleared and disabled when serviced.

If more than one channel generates an interrupt, the mainframe services the lowest-numbered channel first, then the next lowest-numbered channel, and so on. The digital input keeps track of the interrupts which have not been serviced.

Event Interrupt Delay Times

Interrupt delay time for the 16-channel digital input varies, depending on the debounce jumper setting, as shown in Table 4-6. Total SYSTEM delay time, in turn, depends on the application program response time which is a function of the user program.

The delay times shown in Table 4-6 are accessory response times only. You must add the application program response time to get the total delay. That is, system interrupt delay time = (application program response time) + (interrupt delay time from Table 4-6).

For example, with the debounce jumper set for 100 Hz, minimum accessory interrupt delay time is 2 msec and maximum delay is 6.5 msec which must be added to the application program response time to get total system interrupt delay time.

NOTE

Maximum interrupt delay time for the 8-channel digital input is 50 msec. Add this delay to the application program response time to get total system interrupt delay time.

Table 4-6. Accessory Interrupt Delay Times

Debounce Jumper Setting	Accessory Response Time (msec)		Debounce Response Time (msec)		Interrupt* Delay Time (msec)	
	Min	Max	Min	Max	Min	Max
10 Hz	0	1.5	20	50	20	51.5
100 Hz	0	1.5	2	5	2	6.5
1 kHz	0	1.5	0.2	1	0.2	2.5

* = Interrupt Delay Time = Accessory Response Time + Debounce Response Time.

Example: Enable Event Interrupt - Single Channel

For this example, we will monitor a digital channel which has LOW state = 0 volts and HIGH state = 1 volt, but is prone to bursts of noise. The noise bursts are typically 5 volt positive pulses at about 5 Hz and bursts generally last about 1 to 2 seconds.

To detect the noise bursts, we will generate an event interrupt when the burst begins (first positive pulse) and then count the pulses for 5 seconds following the interrupt. (We will assume any burst lasts less than 5 seconds). See Figure 4-10 for typical connections to channel 105 of a 16-channel digital input in slot 1 of the mainframe.

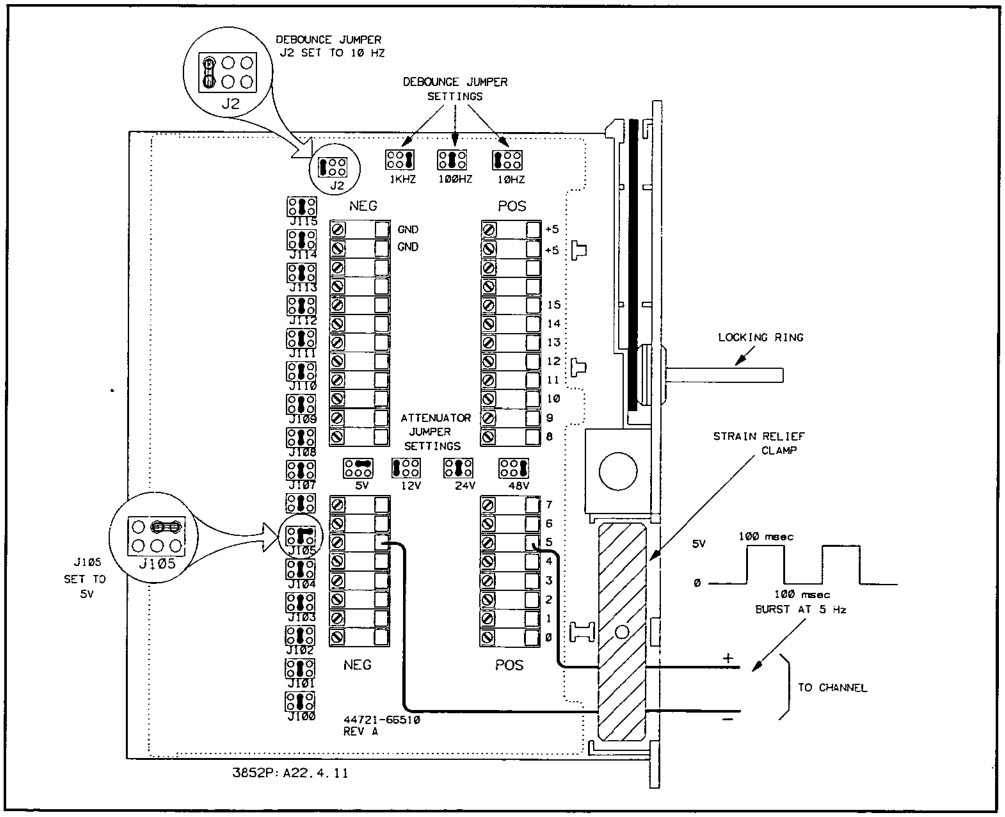


Figure 4-10. Example: Enable Event Interrupt - Single Channel

```
10    ON INTR 7 GOTO Results                !Call sub Results on interrupt
20    ENABLE INTR 7;2                       !Enable controller intr on SRQ
30    OUTPUT 709;"RST"                      !Reset HP 3852A
40    OUTPUT 709;"RQS ON;RQS INTR"          !Enable interrupt on SRQ
50    OUTPUT 709;"USE 121"                  !Physical channel is 105
60    OUTPUT 709;"EDGE LH"                  !Detect positive edges
70    OUTPUT 709;"ENABLE INTR SYS"          !Enable mainframe intr capability
80    OUTPUT 709;"ENABLE INTR"              !Enable ch to intr on neg edge
90   Idle:GOTO Idle                         !Loop until interrupt occurs
100   !
110  Results: !                             !Start controller subroutine
120   OUTPUT 709;"TIME"                     !Query time of day
130   ENTER 709;T                           !Enter time of day
140   PRINT "Ch 105 intr @ ";TIME$(T)       !Print intr time/message
150   WAIT 5                                !Wait 5 seconds
160   OUTPUT 709;"CHREAD 105"               !Read channel 105 counts
170   ENTER 709;B                           !Enter counts
180   PRINT "Ch 105 counts = ";B            !Display counts/message
190   A=SPOLL(709)                          !Read/clear SRQ bit
200   STOP                                  !End controller subroutine
210   END
```

When the first positive edge is detected on channel 105, an event interrupt is generated. If the burst following the interrupt has 3 pulses (3 positive edges), a typical return is as follows. Note that the number of counts (4) includes the 3 edges in the burst plus the edge which caused the event interrupt.

```
Ch 105 intr @ 02:02:04
Ch 105 counts = 4
```

Example: Enable Event Interrupt - Any Channel

This program generates an event interrupt when the switch connected to any channel of a 16-channel digital input is closed. (See Figure 4-11 for typical connections.) The program requires mainframe firmware revision 3.0 or greater.

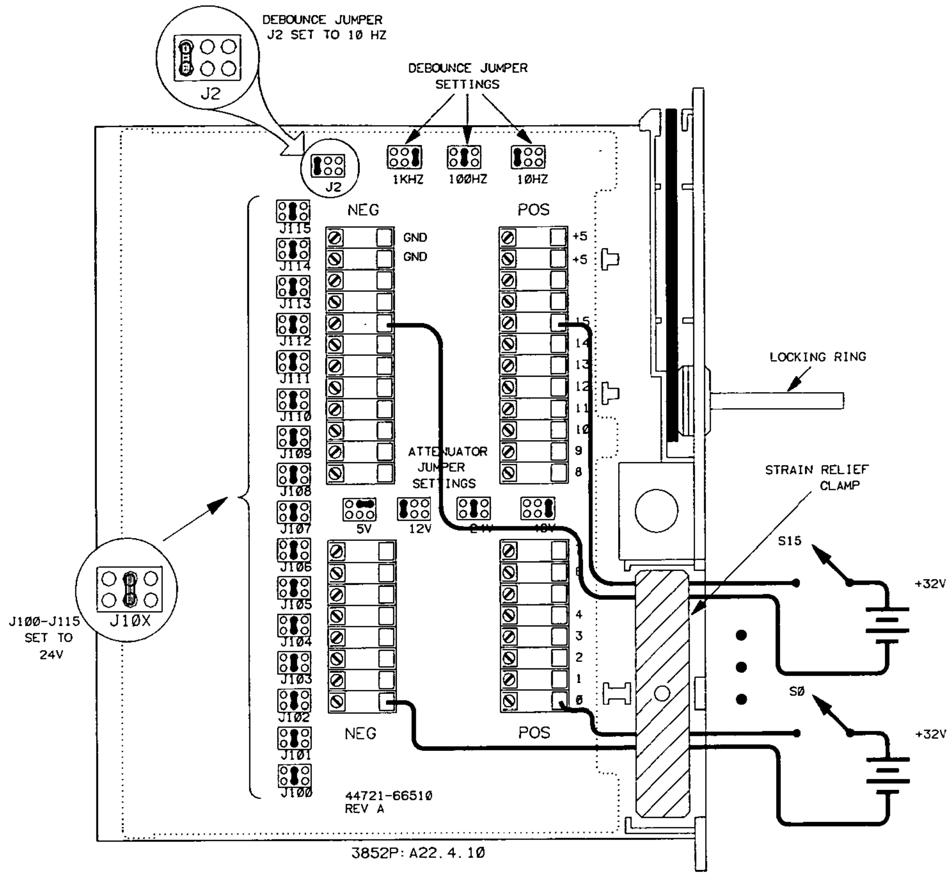


Figure 4-11. Example: Enable Event Interrupt - Any Channel

```
10    !
20    !Initial setup
30    !
40    INTEGER B(0:15)                       !Define controller array
50    ON INTR 7 GOTO Results                !Call sub Results on interrupt
60    ENABLE INTR 7;2                       !Enable controller intr on SRQ
70    OUTPUT 709;"RST"                      !Reset HP 3852A
80    OUTPUT 709;"RQS ON;RQS INTR"          !Enable interrupt on SRQ
90    !
100   !Enable event interrupt
110   !
120   OUTPUT 709;"EDGE LH USE 191"          !Detect LH edges on all channels
130   OUTPUT 709;"ENABLE INTR SYS"          !Enable mainframe intr capability
140   OUTPUT 709;"ENABLE INTR USE 191"      !Enable event intr on all chs
```

```
150 Idle:GOTO Idle                        !Loop until interrupt occurs
160   !
170 Results: !                            !Start controller subroutine
180   OUTPUT 709;"TIME"                   !Query time of day
190   ENTER 709;T                         !Enter time of day
200   !
210   !Read/display channel states
220   !
230   OUTPUT 709;"CHREADM 116-131"        !Read state of all channels
240   ENTER 709;B(*)                      !Enter channel states
250   PRINT "Slot 100 intr @ ";TIME$(T)   !Print intr time/message
260   PRINT "Channel states:"             !Print header
270   PRINT B(*)                          !Print channel states
280   A=SPOLL(709)                        !Read/clear SRQ bit
290   STOP                                !End controller subroutine
300   END
```

For example, when the switch connected to channel 108 (S8) is closed, an event interrupt occurs. A typical return follows, if the switches for all other channels are open when the interrupt occurs.

```
Slot 100 intr @ 02:02:04
Channel states:
0     0     0     0     0     0     0     0
1     0     0     0     0     0     0     0
```

Generating Counter Interrupts

A fourth programming function for the digital inputs is to generate counter interrupts. Each channel can be independently enabled to generate an interrupt when the channel counter rolls over from -1 to 0. This is called a counter interrupt. In addition, a channel enabled for counter interrupts can be disabled from generating the interrupt. Figure 4-12 summarizes commands and operation for counter interrupts.

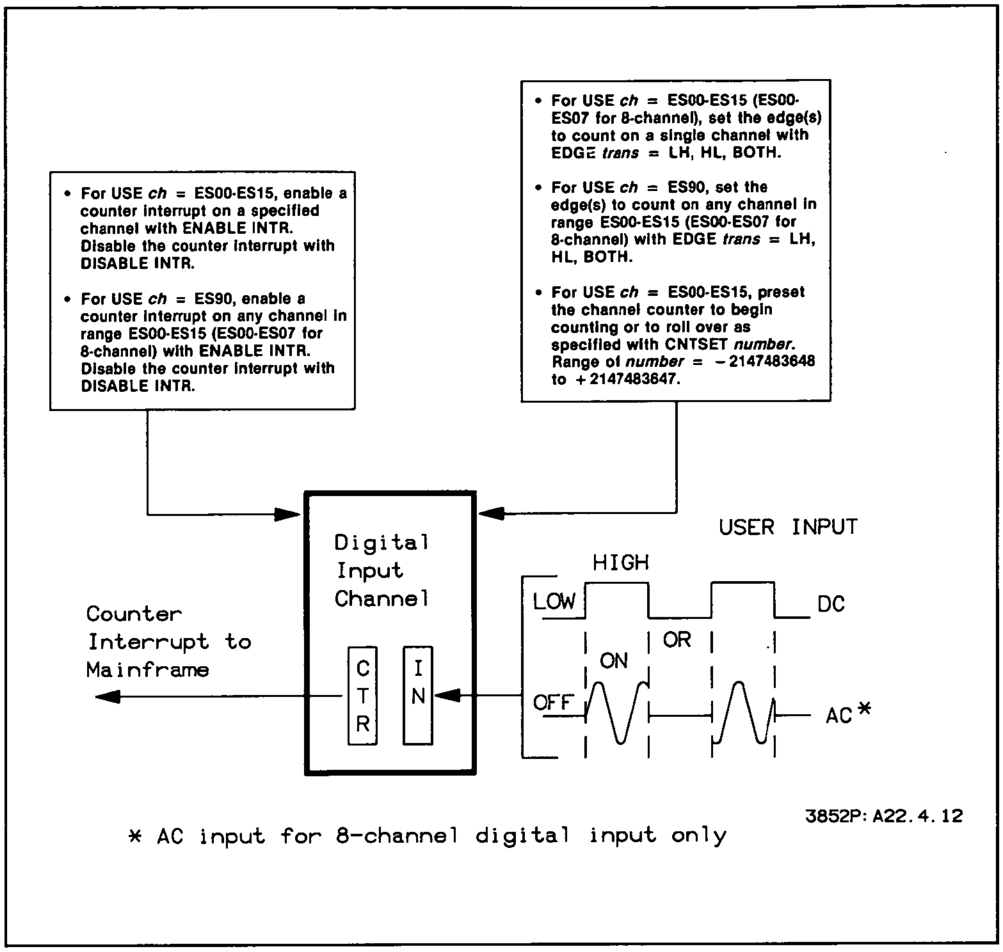


Figure 4-12. Generating Counter Interrupts

Enabling Counter Interrupts

Each channel of a digital input can be enabled to send a counter interrupt when the channel counter rolls over from -1 to 0. Two commands are required to enable a channel for counter interrupt: EDGE and ENABLE INTR. In addition, CNTSET can be used to preset the counter or to set the number of counts to cause rollover.

For USE *ch* with *ch* = ES00-ES15 (ES00-ES07 for the 8-channel), EDGE *trans* sets the channel to count positive, negative, or either edge. EDGE LH sets positive edges, EDGE HL sets negative edges, and EDGE BOTH sets either edge. (EDGE BOTH is valid only for mainframe firmware revision 3.0 and greater.)

For USE *ch* = ES00-ES15 (ES00-ES07 for the 8-channel), ENABLE INTR [USE *ch*] enables the channel specified by *ch* to generate a counter interrupt when the channel counter rolls over (from -1 to 0). For USE *ch* = ES90, ENABLE INTR USE ES90 enables a counter interrupt when counter overflow occurs on any channel in range ES00-ES15 (ES00-ES07 for the 8-channel). (ENABLE INTR USE ES90 is valid only for mainframe firmware revision 3.0 and greater.)

For example, to enable channel 100 of a 16-channel digital input in slot 1 of the mainframe to interrupt on counter rollover, use EDGE LH USE 100 to count positive edges and use ENABLE INTR USE 100 to enable the channel for counter interrupt. Or, to count either edge of inputs and enable counter interrupt for counter overflow on any channel, use EDGE BOTH USE 100 and ENABLE INTR USE 190.

Presetting the Channel Counter

Use CNTSET [*number*] to preset the counter so that a counter interrupt can be generated after a specified number of counts. The range of CNTSET [*number*] is from -2147483648 to +2147483647, with default [*number*] value = 0.

Without a preset value, the count sequence starts from 0 and goes to 2147483647 counts to -2147483648 counts to -1 and back to 0 (see Figure 4-5). When the counter rolls over to 0, the channel (if enabled) generates a counter interrupt. Without a preset, 4294967296 counts are needed to generate a counter interrupt.

However, you can preset a channel to interrupt after a desired number of counts with the CNTSET [*number*] command. To do this, first decide how many counts are required to generate counter rollover. Then, compute CNTSET *number* from Figure 4-5, where count = desired number of counts to cause counter rollover.

For example, to cause counter rollover after 1000 counts, since count = 1000 is ≤ 2147483648, *number* = -counts = -1000. Or, to cause counter rollover after 3,000,000,000 counts, *number* = 4294967296 - 3000000000 = 1294967296.

Disabling Counter Interrupts

You can prevent a channel enabled for counter interrupts from generating a counter interrupt by using DISABLE INTR [USE *ch*] with *ch* = ES00-ES15 (ES00-ES07 for the 8-channel). Or, for mainframe firmware revision 3.0 and greater, use DISABLE INTR USE ES90 to disable counter interrupts on all channels in range ES00-ES15 (ES00-ES07 for the 8-channel).

NOTE

Since a channel can be enabled for both event and counter interrupts, disabling a counter interrupt does NOT disable an event interrupt set on the channel(s) and vice-versa.

Servicing Counter Interrupts

Whether or not DISABLE INTR has been sent to the channel, when a counter interrupt has been serviced by the mainframe, the interrupt is automatically cleared and disabled. This means that any programmed edges after the edge which causes counter rollover will not generate another interrupt unless the channel is reenabled with another ENABLE INTR command.

For example, assume the channel in Figure 4-13 is programmed to count positive edges and is enabled for counter interrupts. Also, assume that edge 1 causes the channel counter to rollover to zero and to generate a counter interrupt.

When the interrupt has been serviced, the interrupt is cleared and disabled. Therefore, edge 2 will not generate an interrupt unless another ENABLE INTR command is sent before edge 2 occurs AND the counter is set to -1. However, all positive edges will continue to be counted by the channel counter, with edge 2 = count 1, etc. Also, note that edges 2 through n will not generate an interrupt if the mainframe has not serviced the interrupt from edge 1.

Interrupt Priorities

As noted, a channel can be enabled for event interrupts, counter interrupts, or both. Refer to "Generating Event Interrupts" to program a channel for event interrupts. At power-on or after a RST or RST *slot* (reset) command, all channels are disabled from generating event interrupts and/or counter interrupts.

If a channel generates an event interrupt and a counter interrupt, the counter interrupt is serviced first, then the event interrupt. Each interrupting channel is automatically cleared and disabled when serviced.

If more than one channel generates an interrupt, the mainframe services the lowest-numbered channel first, then the next lowest-numbered channel, and so on. The digital input keeps track of the interrupts which have not been serviced.

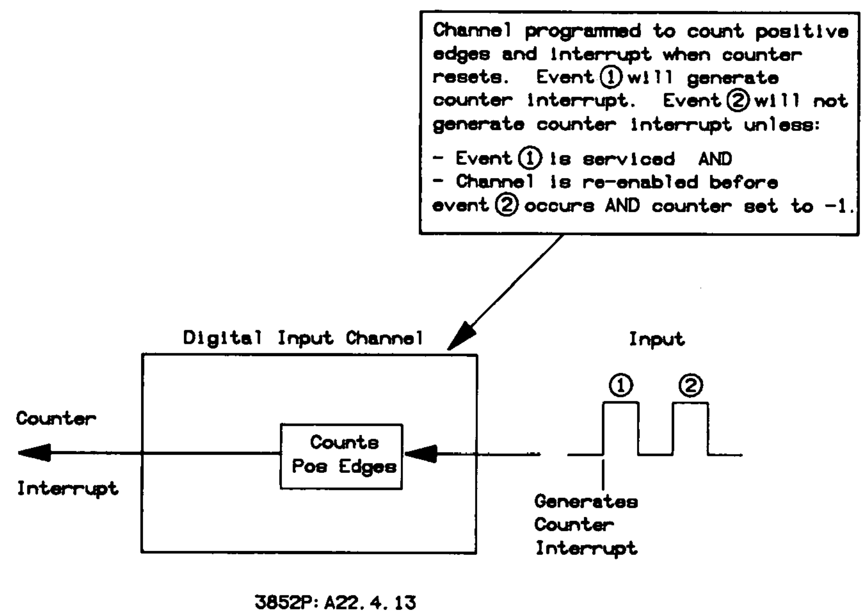


Figure 4-13. Servicing Counter Interrupts

Interrupt Delay Times

Interrupt delay times for the 16-channel digital input vary, depending on the debounce jumper setting. For the 8-channel digital input, maximum accessory interrupt delay time is 50 msec. Refer to "Generating Event Interrupts" for a discussion of interrupt delay times.

Example: Enable Counter Interrupt - Single Channel

This program sends a counter interrupt after a switch (S2) connected to channel 102 of a 16-channel digital input has closed five times. See Figure 4-14 for typical connections.

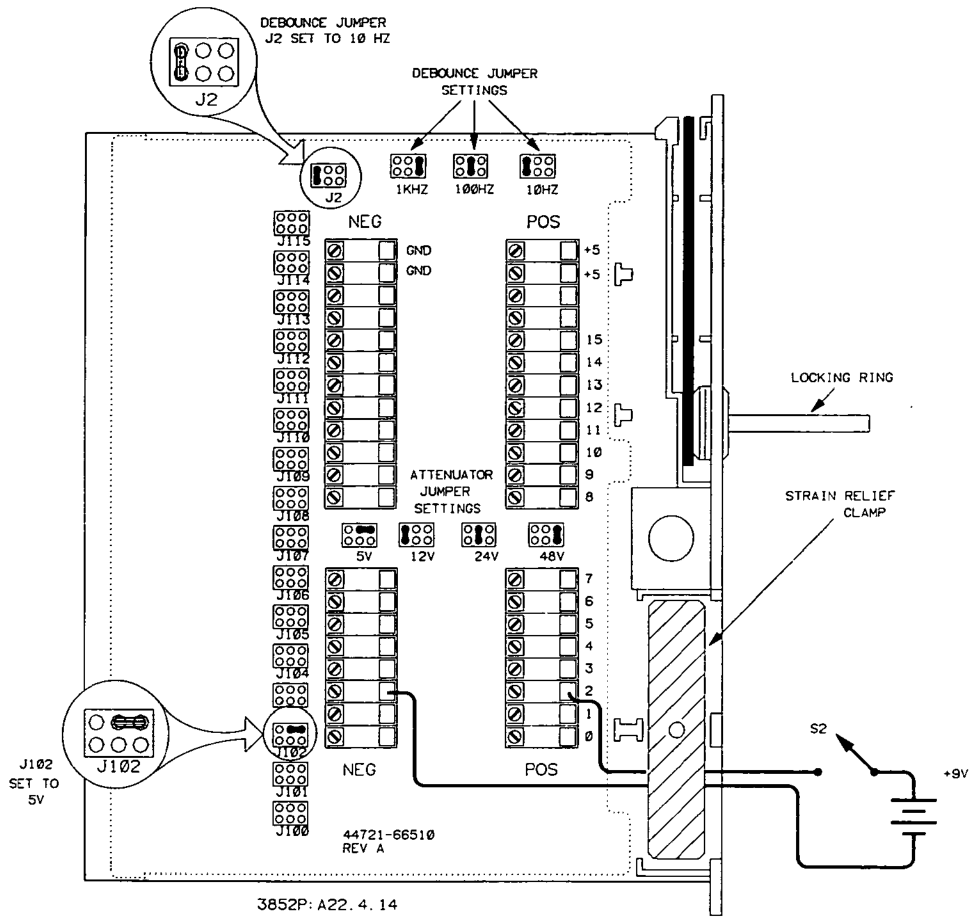


Figure 4-14. Example: Enable Counter Interrupt - Single Channel

The program enables channel 102 of a 16-channel digital input in slot 1 of the mainframe to count positive edges (switch closures) and enables the channel for counter interrupt. CNTSET -5 presets the channel counter so that it will roll over after five counts (five switch closures). After a 10 second wait, CHREAD reads the number of times S2 was closed after the counter roll over (does NOT include the edge which caused the roll over).

```
10   ON INTR 7 GOTO Results              !Call sub Results on interrupt
20   ENABLE INTR 7;2                     !Enable controller intr on SRQ
30   OUTPUT 709;"RST"                    !Reset HP 3852A
40   OUTPUT 709;"RQS ON;RQS INTR"        !Enable interrupt on SRQ
50   OUTPUT 709;"USE 102"                !Use ch is 102
60   OUTPUT 709;"CNTSET -5"              !Set roll over after 5 counts
70   OUTPUT 709;"EDGE LH"                !Detect positive edges
80   OUTPUT 709;"ENABLE INTR SYS"        !Enable mainframe intr capability
90   OUTPUT 709;"ENABLE INTR"            !Enable ch to intr on neg edge
```

```
100  Idle:GOTO Idle                        !Loop until interrupt occurs
110    !
120  Results: !                            !Start controller subroutine
130    OUTPUT 709;"TIME"                   !Query time of day
140    ENTER 709;T                         !Enter time of day
150    PRINT "Ch 102 intr @ ";TIME$(T)     !Print intr time/message
160    WAIT 10                             !Wait 10 seconds
170    OUTPUT 709;"CHREAD 102"             !Read channel 102 counts
180    ENTER 709;B                         !Enter counts
190    PRINT "Ch 102 counts = ";B          !Display counts/message
200    A=SPOLL(709)                        !Read/clear SRQ bit
210    STOP                                !End controller subroutine
220    END
```

When switch S2 has been closed five times, a counter interrupt is generated. If S2 is closed four times within the 10 seconds after the interrupt, a typical return is as shown. Note that the number of counts (4) does NOT include the edge which caused the interrupt.

```
Ch 102 Intr @ 02:02:04
Ch 102 Counts = 4
```

Example: Enable Counter Interrupt - Any Channel

This program generates a counter interrupt after three closures of a switch connected to any channel of a 16-channel digital input. (See Figure 4-15 for typical connections.) Note that the program requires mainframe firmware revision 3.0 or greater.

```
10    !
20    !Initial setup
30    !
40    INTEGER B(0:15)                       !Define controller array
50    ON INTR 7 GOTO Results                !Call sub Results on interrupt
60    ENABLE INTR 7;2                       !Enable controller intr on SRQ
70    OUTPUT 709;"RST"                      !Reset HP 3852A
80    OUTPUT 709;"INTEGER A(15),I,J"        !Define HP 3852A array, variables
90    OUTPUT 709;"RQS ON;RQS INTR"          !Enable interrupt on SRQ
100   OUTPUT 709;"EDGE LH USE 190"          !Set LH edges on all channels
110   !
120   !Preset channel counters
130   !
140   OUTPUT 709;"SUB Cntst"                !Start Cntset subroutine
150   OUTPUT 709;" FOR J=0 TO 15"           !Start counter set loop
160   OUTPUT 709;"   CNTSET -3 USE (J+100)"    !Set ctr to -3 on each ch
170   OUTPUT 709;" NEXT J"                  !Increment counter set loop
180   OUTPUT 709;"SUBEND"                   !End Cntst subroutine
190   OUTPUT 709;"CALL Cntst"               !Call Cntst subroutine
200   !
```

```
210    !Read channel counters
220    !
230    OUTPUT 709;"SUB Dta"                      !Start Dta subroutine
240    OUTPUT 709;" FOR I=0 TO 15"               !Start read loop
250    OUTPUT 709;"   CHREAD (100+I) INTO A(I)"    !Read count on each ch
260    OUTPUT 709;" NEXT I"                      !Increment read loop
270    OUTPUT 709;"SUBEND"                       !End Dta subroutine
280    !
290    !Enable counter interrrupt
300    !
310    OUTPUT 709;"ENABLE INTR SYS"              !Enable mainframe intr capability
320    OUTPUT 709;"ENABLE INTR USE 190"          !Enable any ch for ctr interrupt
330  Idle:GOTO Idle                              !Loop until interrupt occurs
340    !
350  Results: !                                  !Start controller subroutine
360    OUTPUT 709;"TIME"                         !Query time of day
370    ENTER 709;T                               !Enter time of day
380    OUTPUT 709;"CALL Dta"                     !Call Dta subroutine
390    !
400    !Enter channel count
410    !
420    OUTPUT 709;"VREAD A"                      !Trans ch counts to out buffer
430    ENTER 709;B(*)                            !Enter ch counts
440    !
450    !Display interrupt message
460    !
470    FOR I=0 TO 15                             !Start print loop
480      IF B(I)=0 THEN                          !Decision point
490        PRINT "Ch";I+100;"intr @ ";TIME$(T)     !Print intr time/message
500      END IF                                  !End decision point
510    NEXT I                                    !Increment print loop
520    A=SPOLL(709)                              !Read/clear SRQ bit
530    STOP                                      !End controller subroutine
540    END
```

For example, if the switch connected to channel 108 (S8) is the first switch to be closed three times after the program executes, the counter in channel 108 rolls over to 0 and a counter interrupt occurs. A typical return follows.

```
Ch 108 intr @ 02:02:04
```

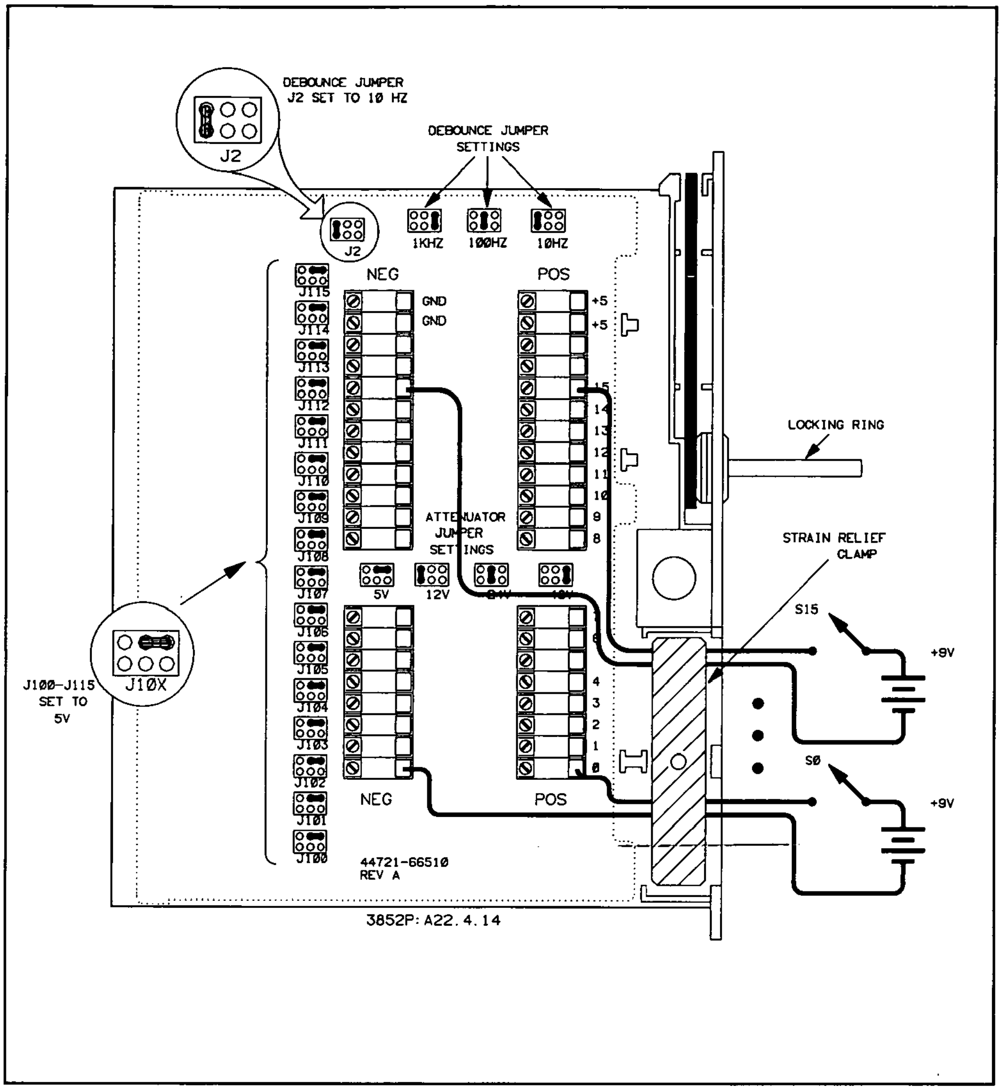


Figure 4-15. Example: Enable Counter Interrupt - Any Channel

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HP 44723A
16-Channel High-Speed Digital Sense/Control Accessory

Configuration and Programming Manual

The HP 44723A Assembly Level Service Manual (Chapter 19 of the HP 3852A Assembly Level Service Manual) is available. Order HP Part Number 03852-90091.

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Printing History

The Printing History shown below lists the printing dates of all Editions and Updates created for this manual. The Edition number changes as the manual undergoes subsequent revisions. Editions are numbered sequentially starting with Edition 1. Updates, which are issued between Editions, contain individual replacement pages which the customer uses to update the current Edition of the manual. Updates are numbered sequentially starting with Update 1. When a new Edition is created, all Updates associated with the previous Edition are merged into the manual. Each new Edition or Update also includes a revised copy of this printing history page.

Many product updates and revisions do not require manual changes and, conversely, manual corrections may be done without accompanying product changes. Therefore, do not expect a one-to-one correspondence between product updates and manual updates.

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GROUND THE INSTRUMENT

To minimize shock hazard, the instrument chassis and cabinet must be connected to an electrical ground.

DO NOT OPERATE IN AN EXPLOSIVE ATMOSPHERE

Do not operate the instrument in the presence of flammable gases or fumes. Operation of any electrical instrument in such an environment constitutes a definite safety hazard.

KEEP AWAY FROM LIVE CIRCUITS

Operating personnel must not remove instrument covers. Component replacement and internal adjustments must be made by qualified maintenance personnel. Under certain conditions, dangerous voltages may exist even with the instrument switched off. To avoid injuries, always disconnect input voltages and discharge circuits before touching them.

DO NOT SERVICE OR ADJUST ALONE

Do not attempt internal service or adjustment unless another person, capable of rendering first aid and resuscitation, is present.

DO NOT SUBSTITUTE PARTS OR MODIFY INSTRUMENT

Because of the danger of introducing additional hazards, do not install substitute parts or perform any unauthorized modification to the instrument. Return the instrument to a Hewlett-Packard Sales and Service Office for service and repair to ensure that safety features are maintained.

DO NOT OPERATE A DAMAGED INSTRUMENT

Whenever it is possible that the safety protection features built into this instrument have been impaired, either through physical damage, excessive moisture, or any other reason, REMOVE POWER and do not use the instrument until safe operation can be verified by service-trained personnel. If necessary, return the instrument to a Hewlett-Packard Sales and Service Office for service and repair to ensure that safety features are maintained.

C

Operating and Safety Symbols

Symbols Used On Products And In Manuals

~ LINE — AC line voltage input receptacle.

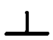
Instruction manual symbol affixed to product. Cautions the user to refer to respective instruction manual procedures to avoid possible damage to the product.

Indicates dangerous voltage – terminals connected to interior voltage exceeding 1000 volts.

 OR 

Protective conductor terminal. Indicates the field wiring terminal that must be connected to earth ground before operating equipment – protects against electrical shock in case of fault.

Clean ground (low-noise). Indicates terminal that must be connected to earth ground before operating equipment – for single common connections and protection against electrical shock in case of fault.

 OR 

Frame or chassis ground. Indicates equipment chassis ground terminal – normally connects to equipment frame and all metal parts.

Affixed to product containing static sensitive devices – use anti-static handling procedures to prevent electrostatic discharge damage to components.

NOTE

NOTE

Calls attention to a procedure, practice, or condition that requires special attention by the reader.

CAUTION

CAUTION

Calls attention to a procedure, practice, or condition that could possibly cause damage to equipment or permanent loss of data.

WARNING

WARNING

Calls attention to a procedure, practice, or condition that could possibly cause bodily injury or death.

WARNING, CAUTION, and NOTE Symbols

Some labels on the HP 3852A, HP 3853A, and plug-in accessories include an international warning symbol (triangle with subscripted number) which refers the reader to the manuals for further information. This table shows the warning symbols used for the HP 3852A/3853A and plug-in accessories. Refer to the manual set for specific information on WARNINGS, CAUTIONS, or NOTES referenced with a warning symbol.

HP 3852A WARNING, CAUTION, and NOTE Symbols

Symbol	Meaning	Location
⚠ $_1$	Shock hazard originating outside the instrument (field wiring)	. Analog Extender Connector on Power Supply Modules . Terminal modules on plug-in accessories . Component module covers on plug-in accessories
⚠ $_2$	Treat all channels as "one circuit" for safety purposes.	. Inside terminal modules on plug-in accessories . Metal cover on component modules of plug-in accessories
⚠ $_3$	Maximum number of certain plug-in accessories to be installed into an HP 3852A or HP 3853A.	. HP 44701A, HP 44702A/B, HP 44727A/B/C plug-in accessories
⚠ $_4$	If High-Speed FET multiplexers are used with the HP 44702A/B, ribbon cable may be connected.	. HP 44711A, 44712A, 44713A (referenced on HP 44702A and HP 44702B)

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Introduction

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Chapter 1

Introduction

Using This Manual

This manual shows how to configure and program the HP 44723A 16-Channel High-Speed Digital Sense/Control accessory (HP 44723A). Refer to the HP 3852A Mainframe Configuration and Programming Manual for additional details on the accessory.

Manual Contents

This manual has four chapters and an appendix.

- **Chapter 1 - Introduction** shows how to use the manual, summarizes accessory operation, and includes a programming overview.

- **Chapter 2 - Configuring the HP 44723A** shows how to configure digital input and digital output channels and how to initially check the accessory.

- **Chapter 3 - Programming Digital Input Channels** describes programming for digital input channel triggering, reads, and interrupts.

- **Chapter 4 - Programming Digital Output Channels** describes programming for digital output channel triggering, writes, and interrupts.

- **Appendix - Specifications** summarizes specifications and typical speed characteristics for the accessory.

Getting Started

There are three main steps to configure and program the HP 44723A for your application:

- Define your application
- Configure the HP 44723A
- Program the HP 44723A

Define Your Application

To begin, read "HP 44723A Description" and "Programming Overview" in this chapter for an overview of HP 44723A capabilities for digital input and digital output applications and a programming overview.

Then, define your application requirements. When defining your requirements, refer to the Specifications Table in the Appendix to ensure that the voltage and current requirements are within the HP 44723A range.

Configure the HP 44723A

Next, hardware configure the HP 44723A for your application. Refer to Chapter 2 - Configuring the HP 44723A to connect user inputs/outputs and trigger sources (as required) and to initially check the HP 44723A for proper operation.

Program the HP 44723A

When you have configured the HP 44723A, refer to Chapter 3 - Programming Digital Input Channels to program the HP 44723A for digital input channel triggering, reads, and/or interrupts as required. Or, refer to Chapter 4 - Programming the Digital Output Channels to program the HP 44723A for digital output channel triggering, writes, and/or interrupts as required.

HP 44723A Description

The HP 44723A 16-Channel High-Speed Digital Sense/Control contains 16 digital input channels and 16 separate digital output channels which provide a variety of high-speed digital input or output capabilities. The HP 44723A directly provides input level readings, TTL and open collector outputs, and input/output interrupts. Table 1-1 summarizes the main features of the HP 44723A.

Table 1-1. HP 44723A Features

Digital Input Features
• Detect the presence of DC inputs (non-isolated).
• Read input states at rates up to 176,000 times/second.
• Interrupt on edge, bit pattern, or user input.
• Sample an input state and capture a second state before reading the first state.
• Use internal, external, or backplane triggering to sample input states at desired times.
• Use the built-in pull-up for each input channel to detect switch closures.
Digital Output Features
• Update output channels at rates up to 189,000 times/second.
• Output a bit pattern to the user circuitry and store a second pattern to be output on an external trigger.
• Synchronize multiple HP 44723A accessories with the trigger inputs and outputs on each accessory.
• Use TTL-compatible or open-collector outputs to configure output channels for your application.

Digital Input Channels

The HP 44723A consists of 16 digital input channels and 16 separate output channels. The 16 digital input channels have channel numbers 0 through 15 (USE *ch* = ES00-ES15), while the 16 digital output channels have channel numbers 16 through 31 (USE *ch* = ES16-ES31). Figure 1-1 summarizes digital input channel operation for the HP 44723A.

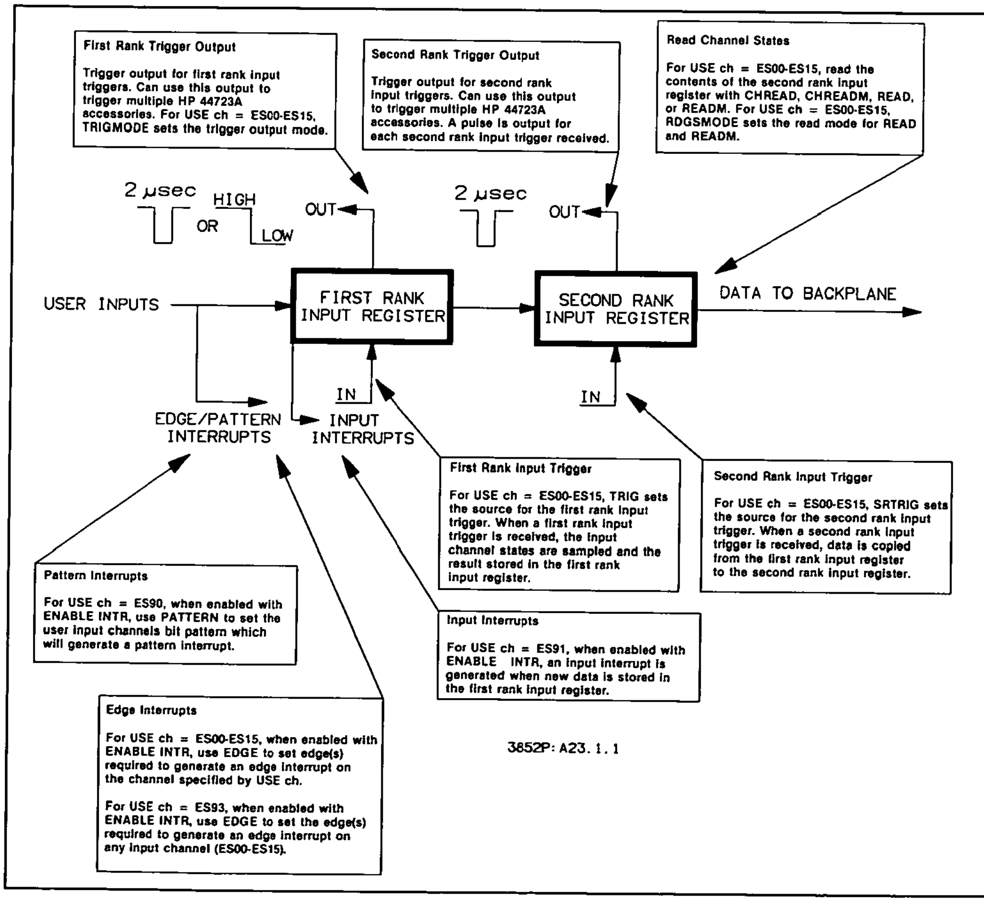

Figure 1-1. HP 44723A Digital Input Channels

Reading Input Channel States

As shown in Figure 1-1, the digital input channels include a first rank input register and a second rank input register. These registers store input channel state data. When a first rank input trigger is received, the state of each of the 16 input channels is sampled and the result stored in the first rank input register. For USE *ch* = ES00-ES15, the TRIG command specifies the source for the first rank input trigger.

The first rank input register stores a 0 for channel LOW and a 1 for channel HIGH. For example, if channels 1 and 5 are HIGH and all other channels are LOW at the time the first rank input trigger is received, 0000 0000 0010 0010 is stored in the first rank input register.

When a second rank input trigger is received, the contents of the first rank input register are copied into the second rank input register (the first rank register contents remain the same after the copy). For USE *ch* = ES00-ES15, the SRTRIG command sets the source for the second rank input trigger.

Input channel data is ALWAYS read from the second rank input register using a CHREAD, CHREADM, READ, or READM command. Since these commands read the contents of the second rank input register, the data returned by a read command may not reflect the current input channel states.

CHREAD returns the second rank input register contents for a specified channel, CHREADM returns the contents for a specified channel list, and READM returns the contents of the second rank input register(s) in the slot(s) specified. READ returns the register contents for a specified slot a specified number of times at rates up to 176,000 readings/second.

Trigger Outputs for Input Channels

Trigger outputs for the digital input channels can be used to synchronize multiple HP 44723A accessories or used with external digital devices. As shown in Figure 1-1, both a first rank trigger output and a second rank trigger output can be generated. For USE *ch* = ES00-ES15, the TRIGMODE command sets the mode for trigger outputs associated with the digital input channels.

With TRIGMODE ALL, the first rank input register is updated by all first rank input triggers. In addition, the first rank trigger output terminal on the terminal module sources a 2 μsec negative pulse which can be used to synchronize multiple accessories.

NOTE

2 μsec is a nominal value for the trigger output pulse width. Typical trigger output pulse width range is 1.7 μsec to 2.8 μsec.

With TRIGMODE FIRST, only the **first** first rank input trigger received after a second rank input trigger updates the first rank input register. All subsequent first rank input triggers are ignored until the next second rank input trigger.

Also, with TRIGMODE FIRST, the trigger output for a first rank input trigger is set HIGH by a second rank input trigger and is set LOW by a first rank input trigger. Thus, the trigger output level can be used to synchronize input data with an external device.

In addition, regardless of the TRIGMODE setting, a 2 μsec negative pulse is sourced from the second rank trigger output terminal on the terminal module for **each** second rank input trigger received. This pulse can be used to synchronize multiple HP 44723A accessories.

Input Channel Interrupts

Three types of interrupts can be generated for digital input channels: edge, pattern, and input. Edge and pattern interrupts are generated from channel input data while an input interrupt is generated when new data is stored in the first rank input register.

- Edge Interrupts:

For USE *ch* = ES00-ES15, when enabled by ENABLE INTR, an edge interrupt is generated when the edge (positive, negative, or either) set by EDGE occurs on the channel specified by USE *ch*. Or, for USE *ch* = ES93, when enabled by ENABLE INTR, an edge interrupt is generated when the edge set by EDGE occurs at any input channel (ES00-ES15).

- Pattern Interrupts:

For USE *ch* = ES90, when enabled by ENABLE INTR, a pattern interrupt is generated when the bit pattern on the input channels (ES00-ES15) matches the conditions set by the PATTERN command.

• Input Interrupts:

For USE *ch* = ES91, when enabled by ENABLE INTR, an input interrupt occurs when new data is stored in the first rank input register (when a first rank input trigger is received).

Digital Output Channels

Figure 1-2 summarizes operation for HP 44723A digital output channels. As noted, the 16 digital output channel numbers are 16 through 31 (USE *ch* = ES16-ES31).

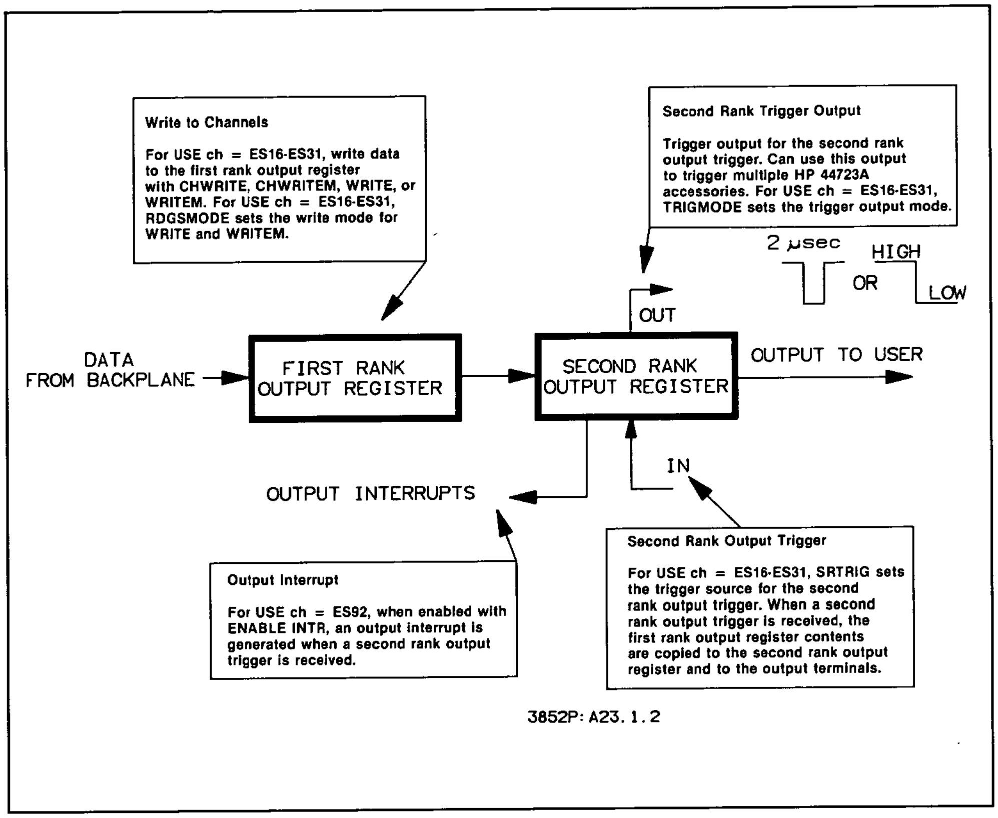

Figure 1-2. HP 44723A Digital Output Channels

Writing to Digital Output Channels

The HP 44723A includes a first rank output register and a second rank output register to store digital output data. For digital output channels, data is ALWAYS written to the first rank output register with a CHWRITE, CHWRITEM, WRITE, or WRITEM command.

CHWRITE writes a state (0 = LOW or nonzero integer = HIGH) for the specified output channel, CHWRITEM writes the states for each channel in the specified channel list, and WRITEM writes the states for each channel to the first rank output register(s) in the specified slot(s). WRITE writes to the first rank output register in the specified slot at rates up to 176,000 times per second.

For USE *ch* = ES16-ES31, SRTRIG sets the source for the second rank output trigger. When a second rank output trigger is received, the data in the first rank output register is copied to the second rank output register AND to the user output terminals.

Trigger Output for Output Channels

For USE *ch* = ES16-ES31, TRIGMODE sets the mode for the second rank output trigger. With TRIGMODE FIRST, the trigger output for a second rank output trigger is set HIGH by a write to the first rank output register and is set LOW by a second rank output trigger. Therefore, the trigger output level can be used to synchronize output data with an external digital device. With TRIGMODE ALL, a 2 μsec negative pulse is sourced when a second rank output trigger is received.

Output Interrupts

For USE *ch* = ES92, when enabled with ENABLE INTR, an output interrupt is generated when a second rank output trigger is received.

Programming Overview

This overview includes a summary of logical channels (USE *ch*) for the HP 44723A, a review of data conversion, and a summary of the commands for the HP 44723A.

Logical Channel Numbers

As noted, the HP 44723A has 16 input channels and 16 output channels. The USE *ch* command or parameter defines the logical channel numbers for the accessory, as shown in Table 1-2. Note that the USE *ch* command or parameter defines both the input and output channel numbers and types of interrupts.

Also, recall that the input channels use logical channel numbers ES00-ES15 while the output channels use logical channel numbers ES16-ES31. For example, for an HP 44723A in slot 2 of the mainframe, USE 201 specifies digital input channel 201, while USE 217 specifies digital output channel 217.

Table 1-2. HP 44723A Logical Channel Numbers

USE ch	Definition
ES00-ES15	Input channels. ES00 refers to input channel 0,..., ES15 refers to input channel 15. Also, set the specified channel for edge interrupts.
ES16-ES31	Output channels. ES16 refers to output channel 16,..., ES31 refers to output channel 31.
ES90	Set the HP 44723A in the specified slot for pattern interrupts.
ES91	Set the HP 44723A in the specified slot for input interrupts.
ES92	Set the HP 44723A in the specified slot for output interrupts.
ES93	Set all input channels for edge interrupts.

Data Conversion

Data is stored in the HP 44723A input and output registers in 16-bit 2's complement integer form. HP 9000 Series 200/300 (and equivalent) controllers convert this format to an equivalent decimal value with range from −32768 to +32767.

Therefore, to determine the equivalent bit pattern from a read of the HP 44723A input channels, you will need to do a decimal-to-binary conversion. Or, to write desired bit patterns to HP 44723A output channels, you will need to send the equivalent decimal value.

Channel Numbers vs. Decimal Value

Table 1-3 shows input and output channel numbers vs. weighted decimal values. To convert a bit pattern to the equivalent decimal value, add the values for the "1" bits (channel HIGH) in the bit pattern. For example, with bit pattern 0000 0000 0110 1001, input channels 0, 3, 5, and 6 have a 1 bit, so the equivalent decimal value = 1 + 8 + 32 + 64 = 105. Or, for bit pattern 1000 1000 1000 1000, channels 3, 7, 11, and 15 have a 1 bit so the equivalent decimal value = 8 + 128 + 2048 − 32768 = −30584.

Table 1-3. Channel Numbers vs. Weighted Decimal Value

Ch Number Input	Ch Number Output	Value	Ch Number Input	Ch Number Output	Value
0	16	1	8	24	256
1	17	2	9	25	512
2	18	4	10	26	1024
3	19	8	11	27	2048
4	20	16	12	28	4096
5	21	32	13	29	8192
6	22	64	14	30	16384
7	23	128	15	31	−32768

Converting Input Channel Data

For USE *ch* = ES00-ES15, the READ and READM commands return the decimal equivalent of the input channel bit pattern. To find the equivalent bit pattern when a positive decimal value (0 to 32767) is returned, do a decimal-to-binary conversion using the weighted values in Table 1-3. For example, the channel bit pattern for decimal value 40 = 8 + 32 = 0000 0000 0010 1000 ("1" bits on channels 3 and 5).

To find the channel bit pattern when a negative decimal value (−32768 to −1) is returned, determine the bit pattern for the positive decimal value and take the 2's complement of the pattern. The result is the bit pattern for the (negative) decimal value. For example, compute the equivalent bit pattern for −483 as follows:

1. Decimal value:	−483	= ?
2. Bit pattern for +483:	483	= 0000 0001 1110 0011
3. 2's complement of +483:		= 1111 1110 0001 1101
4. Bit pattern for −483:	−483	= 1111 1110 0001 1101

Converting Output Channel Data

For USE *ch* = ES16-ES31, the WRITE and WRITEM commands write data to set the output channel states. For these commands, you must send the decimal equivalent of the desired output channel bit pattern. Again, you can use the weighted decimal values in Table 1-3 to determine the required decimal value. For example, use decimal value 24 (8 + 16) to write bit pattern 0000 0000 0001 1000 to the output channels ("1" bits on channels 19 and 20, "0" bits on the other output channels).

Command Summary

A summary of commands for the HP 44723A follows. Table 1-4 summarizes commands by function and Table 1-5 summarizes commands alphabetically. Refer to the HP 3852A Command Reference Manual for further details on each command.

NOTE

For operation with the HP 44723A, all commands in Tables 1-4 and 1-5 require mainframe firmware revision 3.0 or greater.

Table 1-4. HP 44723A Commands - by Function

General	
ID? [*slot*]	- Returns accessory ID
RST [*slot*]	- Reset to power-on
TEST [*slot*]	- Self-test accessory
USE *ch*	- Default USE ch
Interrupts	
EDGE [USE ES00-ES15]	- Set channel(s) for edge interrupt
PATTERN [USE ES90]	- Set accessory for pattern interrupt
ENABLE INTR [USE ES00-ES15]	- Enable edge interrupt (specified ch)
ENABLE INTR [USE ES90]	- Enable pattern interrupt
ENABLE INTR [USE ES91]	- Enable input interrupt
ENABLE INTR [USE ES92]	- Enable output interrupt
ENABLE INTR [USE ES93]	- Enable edge interrupt (all input ch)
DISABLE INTR [USE ES00-ES15]	- Disable/clear edge intrs (specified ch)
DISABLE INTR [USE ES90]	- Disable/clear pattern interrupts
DISABLE INTR [USE ES91]	- Disable input interrupts (does not clear)
DISABLE INTR [USE ES92]	- Disable output interrupts (does not clear)
DISABLE INTR [USE ES93]	- Disable/clear edge intrs (all input chs)
Triggering	
TRIGMODE [USE ES00-ES15]	- Trigger output mode (first rank input reg)
TRIGMODE [USE ES16-ES31]	- Trigger output mode (second rank output reg)
TRIG [USE ES00-ES15]	- Trigger source (first rank input reg)
SRTRIG [USE ES00-ES15]	- Trigger source (second rank input reg)
SRTRIG [USE ES16-ES31]	- Trigger source (second rank output reg)
Reads (Read state of second rank input register)	
CHREAD *ch*	- Read state of input channel in *ch*
CHREADM *ch_list*	- Read state of input channels in *ch_list*
READ *slot* [*number*]	- Read state of input channels in *slot*
READM *slot_list*	- Read state of input channels in *slot_list*
RDGSMODE *mode* [USE ES00-ES15]	- Sets mode for READ/READM
Writes (Write data to first rank output register)*	
CHWRITE *ch*	- Write data to output channel in *ch*
CHWRITEM *ch_list*	- Write data to output channel(s) in *ch_list*
WRITE *slot*	- Write data to output channels in *slot*
WRITEM *slot_list*	- Write data to output channels in *slot_list*
RDGSMODE *mode* [USE ES16-ES31]	- Sets mode for WRITE/WRITEM

* = Zero sets ch LOW (0), nonzero integer between −32768 and 32767 sets ch HIGH (1). LSB to channel ES16, MSB to channel ES31.

Table 1-5. HP 44723A Command Summary

CHREAD *ch* **[INTO** *name*] or [*fmt*]

Returns the state of the specified input channel as read from the second rank input register.

CHREADM *ch_list* **[INTO** *name*] or [*fmt*]

Returns the state of the specified input channel(s) as read from the second rank input register.

CHWRITE *ch state*

Write the state (0/1) to the specified output channel. State is written to the first rank output register. A second rank output trigger is required to transfer the new state to the user outputs.

CHWRITEM *ch_list* **DATA** *state_list*

Write the state (0/1) to each specified output channel in the channel list. States are written to the first rank output register. A second rank output trigger is required to transfer the new state to the user outputs.

Table 1-5. HP 44723A Command Summary (Cont'd)

DISABLE INTR [USE *ch*]

Disables interrupts for the specified channel. Types of interrupts which can be disabled are edge (channel range ES00-ES15 and ES93), pattern (ES90), input (ES91), and output (ES92).

EDGE *trans* **[USE** *ch*]

Sets the edge(s) (positive, negative, or both) of the specified input channel which will generate an edge interrupt when enabled.

ENABLE INTR [USE *ch*]

Enables interrupts for the specified channel. Types of interrupts which can be enabled are edge (channel range ES00-ES15 and ES93), pattern (ES90), input (ES91), and output (ES92).

ID? *slot*

Reads identity of digital input in slot specified by *slot*. An HP 44723A returns 44723A.

PATTERN [*mode*] *pattern* [*mask*] **[USE** *ch*]

Specifies the input pattern and mask which will generate a pattern interrupt when enabled.

RDGSMODE *mode* **[USE** *ch*]

Selects the mode for the READ, READM, WRITE, and WRITEM commands. Specifying any input channel (ES00-ES15) sets the mode for READ and READM. Specifying any output channel (ES16-ES31) sets the mode for WRITE and WRITEM.

READ *slot* [*number*] **[INTO** *name*] or [*fmt*]

Reads the contents of the second rank input register in the slot specified by *slot* the number of times specified by *number*.

READM *slot_list* **[INTO** *name*] or [*fmt*]

Reads the contents of the second rank input register(s) in the slot(s) specified by *slot_list*.

RST *slot*

Resets the accessory in slot specified by *slot* to its power-on state.

SRTRIG [*source*] **[USE** *ch*]

For channel numbers ES00-ES15, *source* specifies the trigger source for second rank input triggers. For channels numbers ES16-ES31, *source* specifies the second rank output trigger source. When a second rank trigger is received, data in the first rank register is copied to the second rank register.

TRIG [*source*] **[USE** *ch*]

For channel numbers ES00-ES15, *source* specifies the trigger source for first rank input triggers. When a first rank input trigger is received, the input channel states are sampled and the result is stored in the first rank input register.

TRIGMODE *mode* **[USE** *ch*]

For channel numbers ES00-ES15, *mode* selects the trigger mode for first rank input triggers. For channel numbers ES16-ES31, *mode* selects the trigger mode for second rank output triggers.

USE *ch*

Use the channel specified by *ch* in commands to follow (unless USE parameter is given) where *ch* specifies logical channel number and function. *ch* range is ES00-ES15 for input channels; ES00-ES15 and ES93 for edge interrupts; ES16-ES31 for output channels; ES90 for pattern interrupts; ES91 for input interrupts; and ES92 for output interrupts.

WRITE *slot data_list* or *array*

Write data to the first rank output register in the slot specified by *slot*. Write the decimal equivalent of the desired channel bit pattern with *data_list*, where the LSB goes to channel ES16 and the MSB goes to channel ES31.

Use *array* to define an array of decimal equivalents to be written to the slot (used for high-speed writes). A second rank output trigger is required to copy data from the first rank output register to the second rank output register and to the user terminals.

WRITEM *slot_list* **DATA** *data_list*

Write data to the first rank output register(s) in the slot(s) specified by *slot_list*. DATA *data_list* specifies the decimal equivalent of the desired state of the channel(s). The LSB goes to channel ES16, the MSB to channel ES31. A second rank output trigger is required to copy data from the first rank output register to the second rank output register and to the user terminals.

Chapter 2
Configuring the HP 44723A

Contents

Chapter 2

Configuring the HP 44723A

Introduction

This chapter shows how to hardware configure the HP 44723A digital input and digital output channels and shows how to initially check the accessory for proper operation.

Chapter Contents

This chapter has four sections:

- **Introduction** includes a chapter overview, lists warnings, cautions, and notes which apply to the accessory, and describes terminal module configuration.

- **Configuring Digital Input Channels** shows how to set the input channel jumpers and how to connect field wiring to the input channels and to the external input trigger ports.

- **Configuring Digital Output Channels** shows how to set the output channel jumpers and how to connect field wiring to the output channels and to the external output trigger port.

- **Initial Checks** shows how to initially check the HP 44723A using the ID? and TEST commands. It also shows how to check the mainframe firmware revision number and lists the power-on and reset values for the accessory.

Warnings, Cautions, and Notes

This section summarizes WARNINGS, CAUTIONS, and NOTES which apply to the HP 44723A 16-Channel High-Speed Digital Sense/Control accessory. You should review the WARNINGS and CAUTIONS shown before handling or configuring the accessory.

WARNING

⚠ 1 *SHOCK HAZARD. Only qualified, service-trained personnel who are aware of the hazards involved should install, remove, or configure any accessory. Before touching any installed accessory, turn off all power to the mainframe, extenders, and to all external devices connected to the mainframe, extenders, or accessories.*

WARNING

⚠2 *POSSIBLE OPERATOR INJURY. For safety, consider all accessory channels to be at the highest potential applied to any channel.*

CAUTION

VOLTAGE/CURRENT LIMITS. To avoid circuit damage to the HP 44723A, maximum input voltage to be applied to the digital input channels is 24 Vdc. Voltage/current limits for digital output open-collector channels are 24 Vdc (HIGH) or 0.4 Vdc @ 40 mA (LOW). Limits for TTL digital output channels are 5.5 Vdc @ −5.2 mA (HIGH) and 0.4 Vdc @ 48 mA (LOW)

CAUTION

STATIC SENSITIVE. Use clean-handling techniques when handling the accessory. Do not install an accessory without the metal covers attached.

NOTE

HP-IB ADDRESS. The example programs in this manual use "709" as the HP-IB address for the HP 3852A. Specific slot and channel numbers are also used. Program syntax and data return formats apply to HP 9000 Series 200/300 controllers. Modify slot and channel numbers and program syntax as required.

NOTE

REVISION 3.0 OR GREATER REQUIRED. All commands for the HP 44723A require mainframe firmware revision 3.0 or greater for operation. Refer to "Initial Checks" for a procedure to check the firmware revision number for your mainframe.

Terminal Module Description

Figure 2-1 shows the HP 44723A terminal module with the cover removed. The terminal module includes 16 non-isolated digital input channels numbered 0 through 15 and 16 separate non-isolated digital output channels numbered 16 through 31. Input jumpers CH0 through CH15 set the input levels for input channels 0 through 15. Output jumpers CH16 through CH31 set the output mode (OC or TTL) for output channnels 16 through 31.

The 1ST IN jumper sets the input level for the First Rank Input Trigger terminal (1ST IN TRIG), the 2ND IN jumper sets the input level for the Second Rank Input Trigger terminal (2ND IN TRIG), and the 2ND OUT jumper sets the input level for the Second Rank Output Trigger terminal (2ND OUT TRIG).

Input channels jumpers settings are PULL-UP (internal 5 V source and pull-up resistor), 5V, 12V, and 24V as shown on the terminal module. Output channels jumper settings are OC (open-collector) or TTL (totem-pole TTL). A user-supplied source is required for OC but not for TTL outputs.

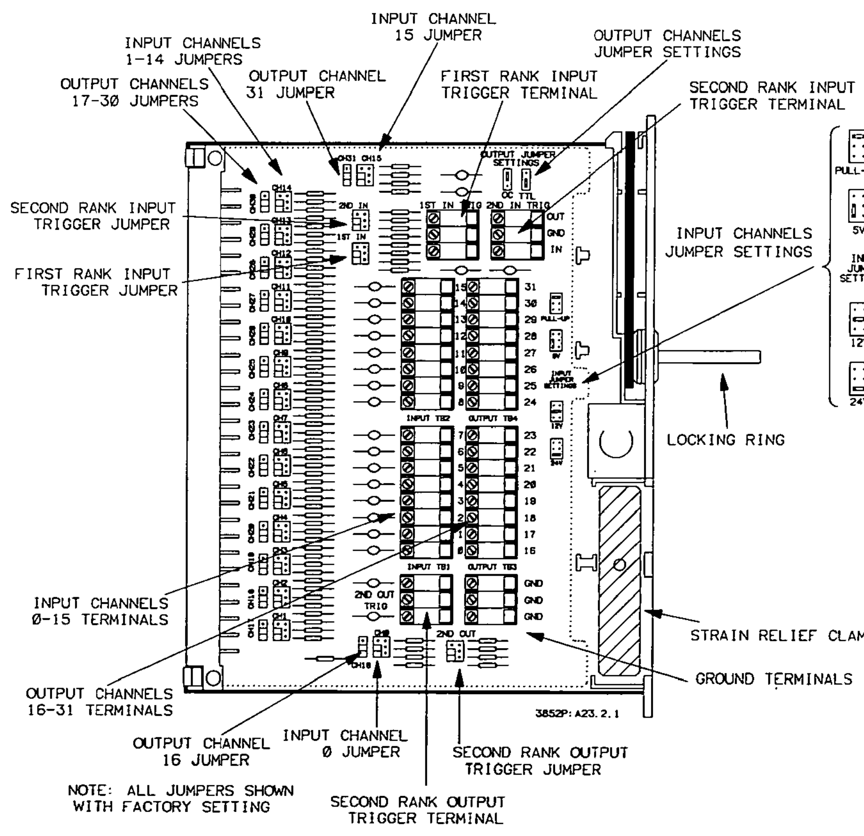

Figure 2-1. HP 44723A Terminal Module

Configuring Digital Input Channels

This section shows how to configure HP 44723A digital input channels. It shows how to set input channel jumpers and how to connect user inputs to input channel and input trigger terminals. Refer to "Configuring Digital Output Channels" to configure HP 44723A digital output channels.

Setting Input Jumpers

From Figure 2-1, each digital input channel has an associated input jumper (CH0 for channel 0, . . ., CH15 for channel 15). Each input jumper can be independently set to the PULL-UP, 5V, 12V, or 24V position.

For the PULL-UP position, an on-board +5 V supply and 2.2 kΩ pull-up resistor are used. For the 5V, 12V, and 24V positions, a user source is required. Figure 2-2 shows the equivalent circuit for each input channel. Refer to the Specifications Table in the Appendix for the input threshold voltage required to set the channel HIGH or LOW.

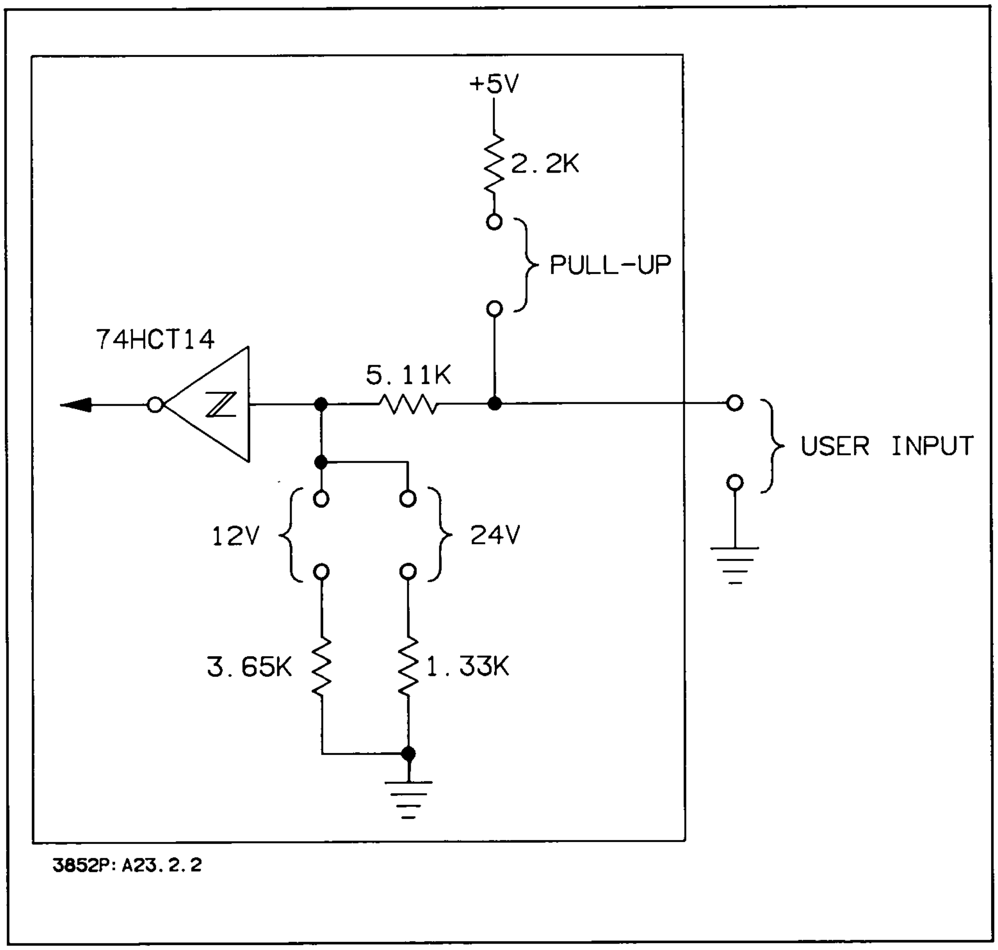

Figure 2-2. Input Channels - Equivalent Circuit

Using Input Trigger Terminals

The terminal module also includes two trigger terminals for the digital input channels: the First Rank Input Trigger terminal (1ST IN TRIG) and the Second Rank Input Trigger terminal (2ND IN TRIG). Figure 2-3 summarizes the inputs and outputs for the 1ST IN TRIG and 2ND IN TRIG terminals.

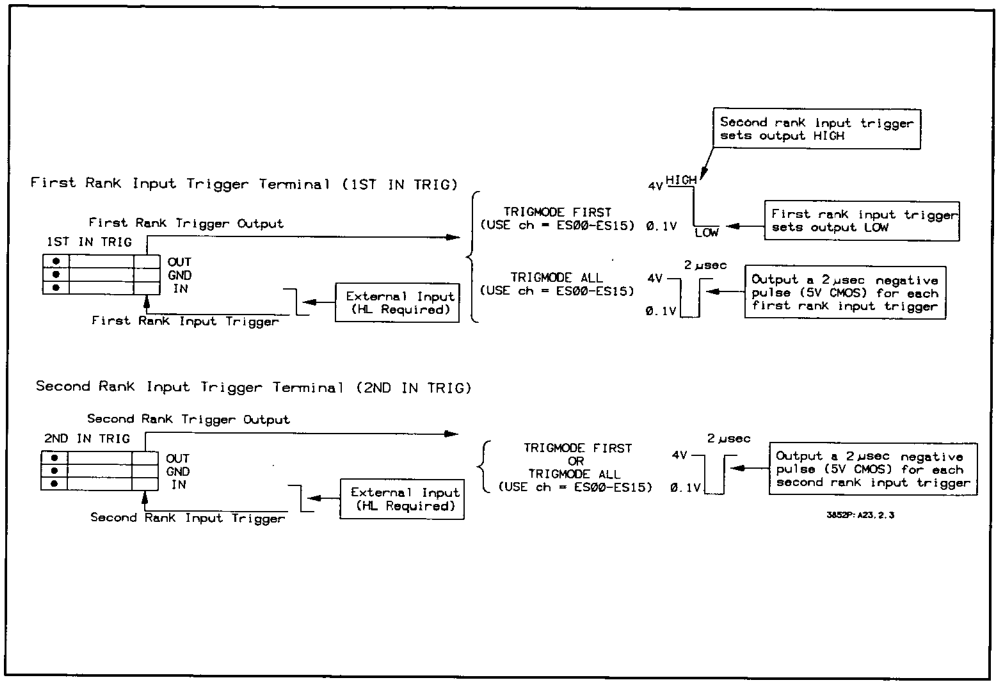

Figure 2-3. Input Channels Trigger Terminals

First Rank Input Trigger Terminal

For USE *ch* = ES00-ES15, when TRIG EXT is set the 1ST IN TRIG terminal is the source for first rank input triggers. The input level for the 1ST IN TRIG terminal is set by the 1ST IN jumper (see Figure 2-1). The 1ST IN TRIG terminal accepts external trigger inputs into the IN terminal and sources first rank trigger outputs from the OUT terminal.

As shown in Figure 2-3, the OUT terminal sources a 2 µsec negative pulse OR a high-to-low edge, depending on the TRIGMODE command setting. This output can be used to synchronize multiple HP 44723A accessories or can be used with external devices. Refer to Chapter 3 - Programming Digital Input Channels for details.

NOTE

2 µsec is a nominal value for the pulse width of the output from the First Rank Input Trigger terminal, the Second Rank Input Trigger terminal, and the Second Rank Output Trigger terminal. Typical range of values is 1.7 µsec to 2.8 µsec.

Second Rank Input Trigger Terminal

For any USE *ch* = ES00-ES15, when SRTRIG EXT is set, the Second Rank Input Trigger terminal (2ND IN TRIG) is the source for second rank input triggers. The input level for the 2ND IN TRIG terminal is set by the jumper labeled 2ND IN (see Figure 2-1). Refer to the Specifications Table in the Appendix for input trigger thresholds.

The 2ND IN TRIG terminal accepts external trigger inputs into the IN terminal and sources second rank trigger output pulses from the OUT terminal. As shown in Figure 2-3, the OUT terminal sources a 2 μsec negative pulse for each second rank input trigger received, regardless of the TRIGMODE command setting. This output can be used to synchronize multiple HP 44723A accessories. Refer to Chapter 3 - Programming Digital Input Channels for details.

Connecting Field Wiring

To begin connecting field wiring to the input channels, remove the terminal module cover, set the appropriate input channel jumpers, and connect field wiring from user circuits to the desired channel INPUT and GND terminals. (Use any of the three GND terminal connectors.) Also, as required, connect field wiring to the 1ST IN TRIG terminal and/or to the 2ND IN TRIG terminal for trigger inputs/outputs.

When connecting field wiring, route the field wires under the strain relief clamp and tighten the clamp screw to reduce the chance of wires being pulled out of the terminal connectors. Then, if you do not need to configure digital output channels, replace the terminal module cover and install the accessory in a desired slot.

NOTE

If required, connect field wiring to digital output channels before making connections to digital input channels, since input wires may cover the output channel terminals. Refer to "Connecting Digital Output Channels" for details.

Example: Connecting User Inputs

Figure 2-4 shows typical connections to digital input channels, with channel 0 using the PULL-UP setting and channel 8 using the 5V position. Setting the CH0 jumper to the PULL-UP position connects the internal 5 V supply and pull-up resistor, so a user source is not required for channel 0. Thus, the PULL-UP position offers a convenient way to detect switch closures without requiring an external source.

For channel 8, the CH8 jumper is set to the 5V position. From the Specifications Table (see Appendix), a user input level ≤0.79 V will set channel 8 LOW while an input level ≥2.06 V will set the channel HIGH.

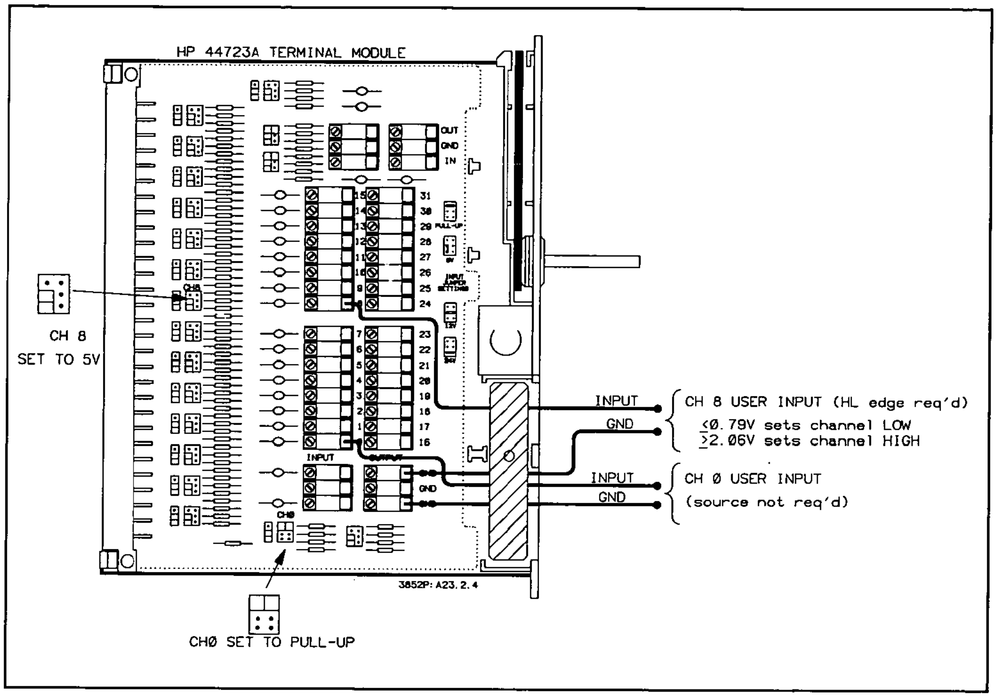

Figure 2-4. Example: Connecting User Inputs

Example: Connecting Input Trigger Terminals

In Figure 2-5, field wiring connections have been made to the 1ST IN TRIG IN and OUT terminals. For any USE *ch* between ES00 and ES15, if TRIG EXT (external first rank input trigger) is set, the 1ST IN TRIG IN terminal is the source for the first rank input trigger.

The OUT terminal on the 1ST IN TRIG terminal block sources either a 2 μsec negative pulse OR a high-to-low edge which can be used to synchronize multiple HP 44723A accessories or used with external devices. Refer to Chapter 3 - Programming Digital Input Channels for details.

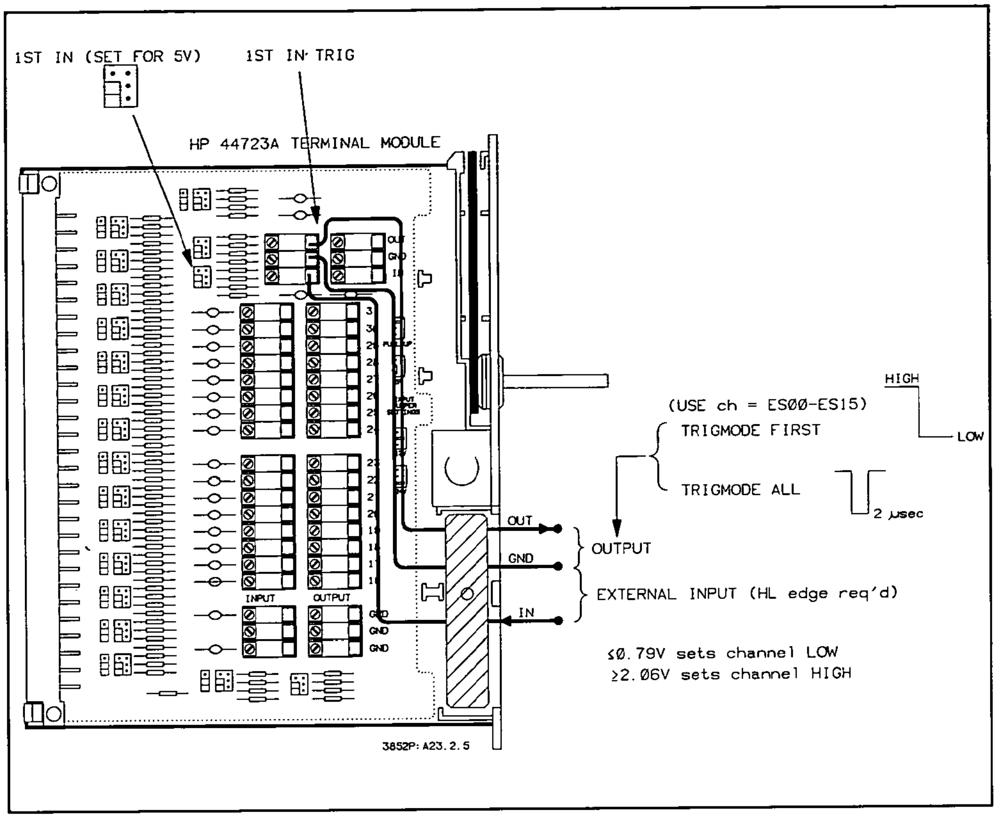

Figure 2-5. Example: Connecting Input Trigger Terminals

Configuring Digital Output Channels

This section shows how to configure HP 44723A digital output channels. It shows how to set output channel jumpers and how to connect user circuits to output channel and output trigger terminals. Refer to "Configuring Digital Input Channels" to configure HP 44723A digital input channels.

Setting Output Jumpers

From Figure 2-1, each digital output channel has an associated output jumper (CH16 for channel 16, ..., CH31 for channel 31). Each jumper can be independently set to the TTL (totem-pole TTL) or OC (open-collector) position. A user source is required for a channel set to the OC position, but is not required for a channel set to the TTL position. Figure 2-6 shows the equivalent TTL and OC circuits for each output channel.

Using Output Trigger Terminals

The terminal module also includes the Second Rank Output Trigger terminal (2ND OUT TRIG) and associated jumper labeled 2ND OUT which sets the level for the 2ND OUT TRIG terminal. Figure 2-7 summarizes the output triggers associated with the 2ND OUT TRIG terminal.

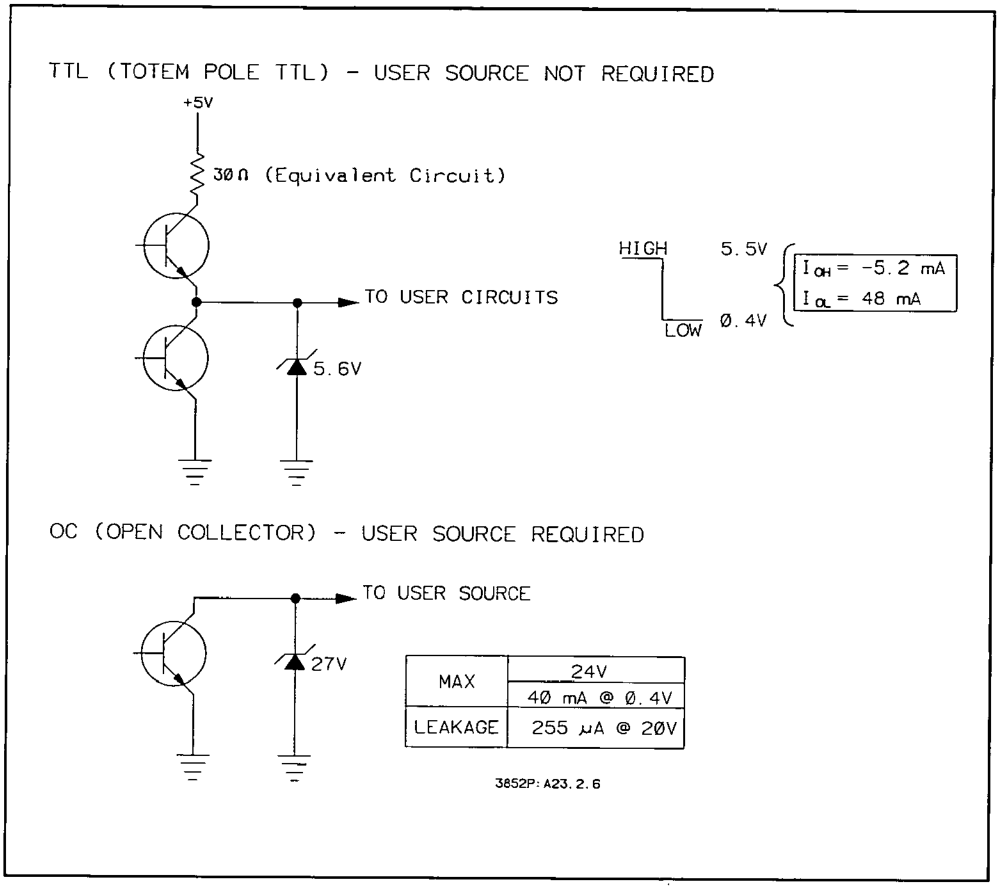

Figure 2-6. Output Channels - Equivalent Circuit

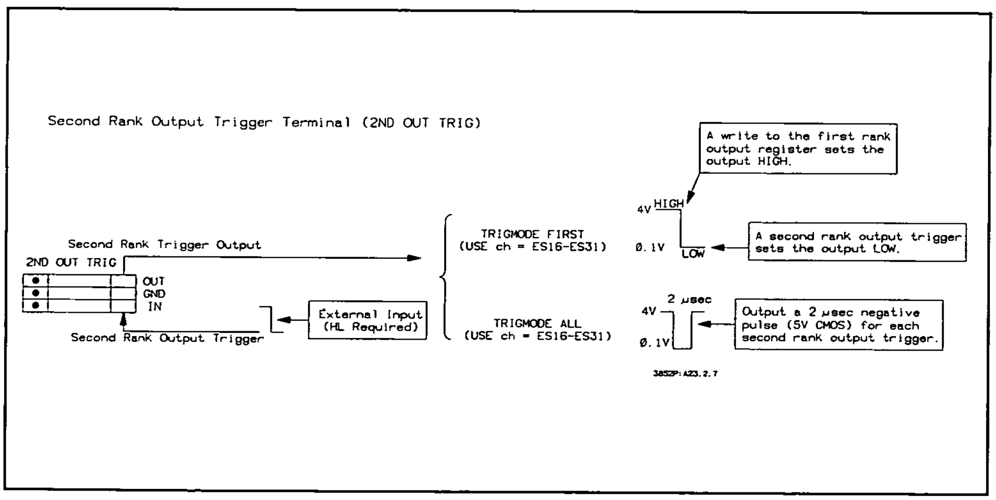

Figure 2-7. Output Channels Trigger Terminals

For any USE *ch* = ES16-ES31, when SRTRIG EXT is set, the 2ND OUT TRIG terminal is the source for second rank output triggers. The input level for the 2ND OUT TRIG terminal is set by the 2ND IN jumper. Refer to the Specifications Table in the Appendix for input trigger thresholds. The 2ND TRIG OUT terminal accepts external trigger inputs into the IN terminal and sources second rank trigger output pulses from the OUT terminal.

As shown in Figure 2-7, the OUT terminal sources a 2 μsec negative pulse OR a high-to-low edge, depending on the TRIGMODE command setting. This output can be used to synchronize multiple HP 44723A accessories or with external devices. Refer to Chapter 4 - Programming Digital Output Channels for details.

Connecting Field Wiring

To begin connecting field wiring to the output channels, remove the terminal module cover, set the appropriate output channel jumpers, and connect field wiring from the user circuits to the desired channel OUTPUT and GND terminals on the terminal module. (Use any of the three GND terminal connectors.) Also, as required, connect field wiring to the 2ND OUT TRIG terminal for trigger inputs/outputs.

When connecting field wiring, route the field wires under the strain relief clamp and tighten the clamp screw to reduce the chance of wires being pulled out of the terminal connectors. When field wiring connections have been made, replace the terminal module cover and install the accessory in a desired slot.

Example: Connecting User Circuits

Figure 2-8 shows typical connections to digital output channels, with channel 16 using the TTL position and channel 24 using the OC position. Setting the CH16 jumper to the TTL position connects the internal 5 V supply and pull-up resistor, so a user source is not required for channel 16. For the TTL position, channel 16 outputs the standard TTL signal shown. For channel 24, jumper CH24 is set to the OC position. With OC settings, maximum user source should be 24 Vdc with 600 Ω series impedance (low-level = 0.4 Vdc @ 40 mA).

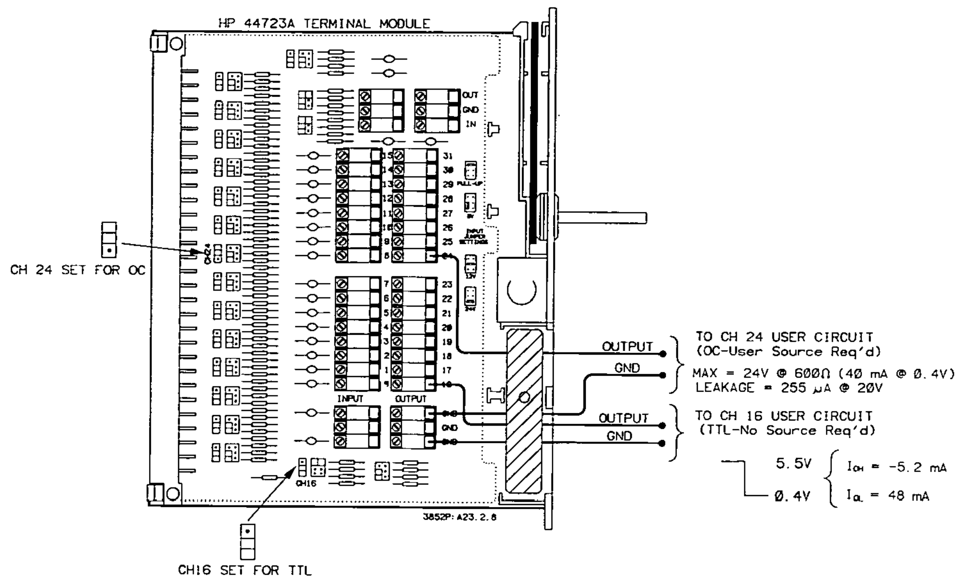

Figure 2-8. Example: Connecting User Circuits

Example: Connecting Output Trigger Terminals

In Figure 2-9, field wiring connections have been made to the 2ND OUT TRIG IN and OUT terminals. For any USE *ch* = ES16-ES31, if SRTRIG EXT (external second rank output trigger) is set, the 2ND OUT TRIG IN terminal is the input for the second rank output trigger.

The OUT terminal on the 2ND OUT TRIG terminal block sources either a 2 μsec negative pulse OR a high-to-low edge which can be used to synchronize multiple HP 44723A accessories or can be used with external devices. Refer to Chapter 4 - Programming Digital Output Channels for details.

Initial Checks

This section shows how to check the mainframe firmware revision with the IDN? command, how to initially the the HP 44723A for proper operation with the ID? and TEST commands, and how to reset the accessory to its power-on condition with the RST command. It also includes a summary of the power-on/reset conditions for the accessory.

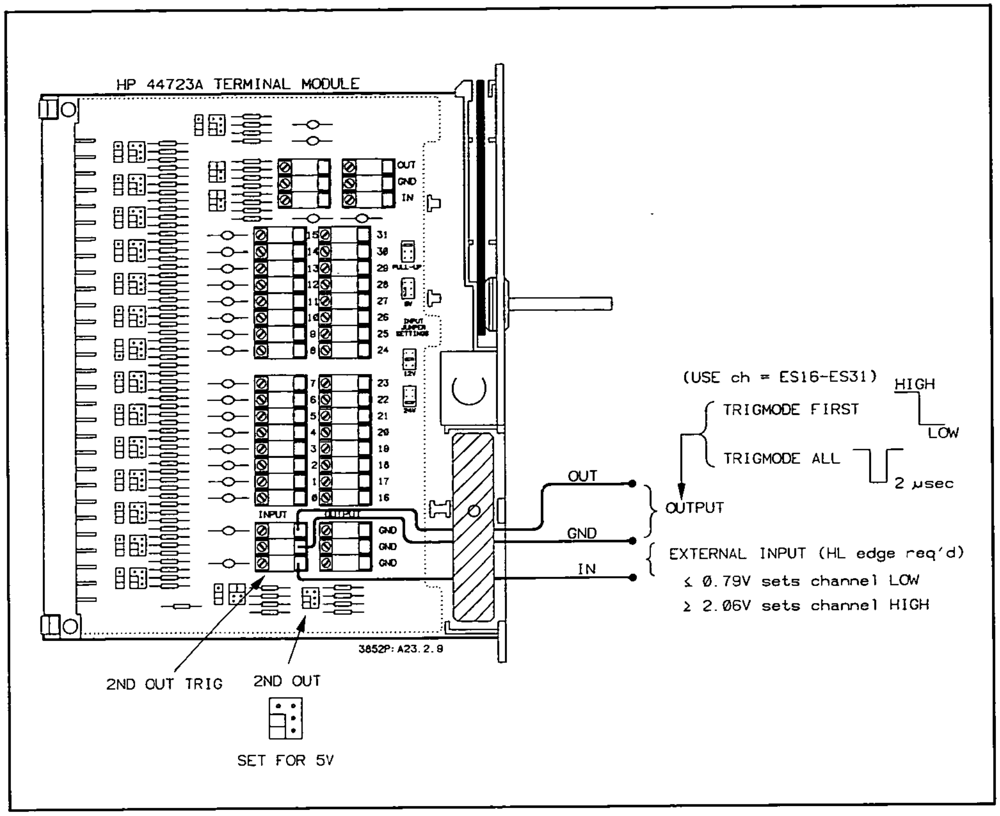

Figure 2-9. Example: Connecting Output Trigger Terminals

Checking Mainframe ID

Since the commands for the HP 44723A require mainframe firmware revision 3.0 or greater, you may want to check the revision number for your mainframe to ensure that the accessory commands will be accepted. The following example program uses the IDN? command to check the mainframe ID, including the firmware revision number.

```
10 DIM Identity$(1:4)[17]            !Dimension controller array
20 OUTPUT 709;"IDN?"                 !Query HP 3852A identity
30 ENTER 709;Identity$(*)            !Enter identity
40 PRINT USING "K,/";Identity$(*) !Display identity
50 END
```

A typical return for firmware revision 3.0 follows.

```
HEWLETT PACKARD   (Company name)
3852A             (Model number)
0                 (Mainframe serial number unknown)
3.0               (Firmware revision 3.0)
```

Checking Accessory ID

You can use the ID? [*slot*] command to check proper installation of the HP 44723A. For example, to check the identity of an accessory in slot 2 of the mainframe, enter ID? 200 from the front panel. An HP 44723A in this slot displays 44723A on the front panel display.

Accessory Self-Test

The TEST [*slot*] command initiates a pass/fail self-test. This test exercises about 80% of the accessory circuitry, including the first and second rank input registers, the first rank output register, and the edge and pattern interrupt circuits.

The currently programmed state of the accessory is maintained and user outputs are not affected and register contents will be restored after the test. Trigger outputs are pulsed several times and, except for the input interrupt which is set, old interrupts are cleared (but not disabled). In addition, the accessory responds as though a first rank input trigger and a second rank input trigger had been received.

NOTE

Enabling input interrupts after TEST generates an immediate input interrupt. Also, executing TEST with input interrupts enabled generates an interrupt at the end of TEST.

To run the accessory self-test, enter TEST *slot* from the front panel. For example, to self-test an HP 44723A in slot 2 of the mainframe, enter TEST 200 from the front panel. If the self-test passes, SELF-TEST OK is displayed on the front panel display. If the self-test fails, do not attempt to use the accessory. Refer to the HP 3852A Assembly Level Service Manual for details.

Power-On/Reset Settings

At power-on or following a RST or RST *slot* command, the HP 44723A is reset to the conditions shown in Table 2-1.

Table 2-1. HP 44723A Power-On/Reset Conditions

Command Settings:

Command	Setting	Description
DISABLE	INTR	All HP 44723A interrupts disabled.
EDGE	OFF	Neither edge set on all input channels.
PATTERN	EQU,0,0	All input channels masked (no input channels set for pattern interrupt).
RDGSMODE	IMMED	Immediately read second rank input register. Immediately write to first rank output register.
SRTRIG	INT	Internal second rank input trigger and second rank output trigger.
TRIG	INT	Internal first rank input trigger.
TRIGMODE	ALL	Update first rank input register with each first rank input trigger received.

Accessory Settings:

- Output interrupts set and disabled. All other interrupts cleared and disabled.
- All channel outputs set LOW.
- First and second input/output ranks set to 0.

Chapter 3
Programming Digital Input Channels

Contents

Chapter 3

Programming Digital Input Channels

Introduction

This chapter shows how to program HP 44723A digital input channels. Refer to Chapter 4 - Programming Digital Output Channels to program HP 44723A digital output channels. The chapter has three sections:

• **Digital Input Reads** shows how to read the state of digital input channels, including single and multiple channel reads and single and multiple slot reads. Use this section to read digital input channel states.

• **Digital Input Triggering** describes triggering methods for the digital input channels. It lists sources for first rank and second rank input triggers; shows input channel trigger and readings modes; and shows how to use trigger outputs. Use this section to set alternate trigger sources/modes for the input channels or to generate trigger outputs for applications such as synchronization.

• **Digital Input Interrupts** shows how to set edge, pattern, and input interrupts for digital input channels. Use this section to set desired interrupts for digital input channels.

Digital Input Reads

The HP 44723A digital input channels sense (detect) the state of user inputs connected to the channels and, if enabled, generate interrupts for specified conditions. This section shows how to read input channel states with CHREAD, CHREADM, READ, or READM.

Refer to "Digital Input Triggering" to select input trigger sources; to set input channel trigger/readings modes; or to use output triggers. Refer to "Digital Input Interrupts" to enable edge, pattern, or input interrupts.

NOTE

The results returned by a read command (CHREAD, CHREADM, READ, or READM) may be affected by the TRIGMODE and/or RDGSMODE command settings. Refer to "Triggering/Readings Modes" in "Digital Input Triggering" for details. In this section, power-on/reset conditions (RDGSMODE IMMED, SRTRIG INT, TRIG INT, and TRIGMODE ALL) are assumed unless otherwise specified.

Making Channel Reads

The HP 44723A has a first rank input register and a second rank input register which are used with the 16 digital input channels (see Figure 1-1). For USE *ch* = ES00-ES15, the CHREAD command can be used to read the contents of the second rank input register for a specified channel or the CHREADM command can be used to read the contents for a specified list of channels.

Single Channel Reads (CHREAD)

CHREAD *ch* [INTO *name*] or [*fmt*] returns the state of the input channel specified by *ch* as read from the second rank input register. The state is returned as a 1 for channel HIGH or as a 0 for channel LOW.

When a first rank input trigger is received (from the source set by the TRIG command), the state of each of the 16 input channels is sampled and the result stored in the first rank input register. This sampling action, in effect, takes a "picture" of the state of the input channels at the time the first rank input trigger is generated. (If TRIG INT is set, the first rank input trigger is generated as part of the CHREAD command execution.)

NOTE

The TRIGMODE command setting may affect the results returned by CHREAD (and by CHREADM). Refer to "Input Trigger Mode (TRIGMODE)" for details.

When a second rank input trigger is received (from the source set by the SRTRIG command), the contents of the first rank input register are copied to the second rank input register (the first rank input register contents remain the same).

If the second rank input trigger source is set for internal (SRTRIG INT), a second rank input trigger is generated immediately before the second rank input register is read by CHREAD. Also, as noted, if the first rank input trigger source is set for internal (TRIG INT), a first rank input trigger is generated as part of the CHREAD execution. Therefore, with TRIG INT and SRTRIG INT, CHREAD reads the current state of the specified input channel.

Example: Read Channel State

This program reads the current state of channel 203 of an HP 44723A in slot 2 of the mainframe. Since TRIG INT and TRIGMODE ALL are set, when CHREAD is executed a first rank input trigger is generated, the channel 203 input state is sampled, and the result stored in the first rank input register.

Next, since SRTRIG INT is set, a second rank input trigger is generated and the first rank input register contents are copied into the second rank input register. Then, CHREAD reads the second rank input register contents and returns the current state of channel 203.

```
10 OUTPUT 709;"USE 203"              !Use ch is 203
20 OUTPUT 709;"TRIG INT"             !Sample input when CHREAD executed
30 OUTPUT 709;"SRTRIG INT"           !Copy data when CHREAD executed
40 OUTPUT 709;"CHREAD 203"           !Read ch 203 state
50 ENTER 709;A                       !Enter ch 203 state
60 PRINT "Channel 203 state =";A     !Display ch 203 state
70 END
```

A typical return for channel 203 state HIGH follows.

```
Channel 203 state = 1
```

Multiple Channel Reads (CHREADM)

CHREADM is similar to CHREAD, except that CHREADM reads the states of the input channel(s) for a specified channel list. For USE *ch* = ES00-ES15, CHREADM *ch_list* [INTO *name*] or [*fmt*] returns the state (1 for channel HIGH or 0 for channel LOW) of each of the channel(s) specified in *ch_list*. As with CHREAD, CHREADM reads the state of the second rank input register.

When a first rank input trigger is received (from the source set by the TRIG command), the state of each of the 16 input channels is sampled and the result stored in the first rank input register. This sampling action, in effect, takes a "picture" of the state of the input channels at the time the first rank input trigger is received. (If TRIG INT is set, the first rank input trigger is generated as part of the CHREADM command execution.)

NOTE

The TRIGMODE command setting may affect the results returned by CHREADM (and by CHREAD). Refer to "Input Trigger Mode (TRIGMODE)" for details.

If the second rank input trigger source is set for internal (SRTRIG INT), a second rank input trigger is generated immediately before the second rank input register is read by CHREADM. Also, if the first rank input trigger source is set for internal (TRIG INT), a first rank input trigger is generated as part of the CHREADM execution. Therefore, with TRIG INT and SRTRIG INT, CHREADM returns the current state of the input channels in the specified channel list.

Example: Read Multiple Channel States

This program reads the states of channels 203, 204, and 205 of an HP 44723A in slot 2 of the mainframe. Since TRIG INT and TRIGMODE ALL are set, when CHREADM is executed a first rank input trigger is generated, the channel input states are sampled, and the result is stored in the first rank input register.

Next, since SRTRIG INT is set, a second rank input trigger is generated and the first rank input register contents are copied into the second rank input register. Then, CHREADM reads the contents of the second rank input register and returns the states of channels 203 through 205.

```
10 DIM A(0:2)                     !Dimension controller array
20 OUTPUT 709;"USE 200"           !Use ch is 200
30 OUTPUT 709;"TRIG INT"          !Sample inputs when CHREADM executed
40 OUTPUT 709;"SRTRIG INT"        !Copy data when CHREADM executed
50 OUTPUT 709;"CHREADM 203-205"   !Read ch 203-205 states
60 ENTER 709;A(*)                 !Enter states
70 PRINT A(*)                     !Display states
80 END
```

A typical return for channels 203 and 204 HIGH and channel 205 LOW follows, where the leftmost bit is the channel 203 state and the rightmost bit is the channel 205 state.

```
 1  1  0
```

Making Slot Reads

The READ command returns the state of all input channels for a specified slot, while the READM command returns the state of all input channels for one or more specified slots. As with CHREAD and CHREADM, READ and READM read the contents of the second rank input register. In addition, the READ command can be used for high-speed reads on a slot at rates up to 176,000 readings per second.

Single Slot Reads (READ)

The READ command can be used to read the current state of all input channels on a slot at rates up to 176,000 readings per second. For USE *ch* = ES00-ES15, the READ *slot* [*number*] [INTO *name*] or [*fmt*] command reads the contents of the second rank input register in the slot specified by *slot* the number of times specified by the *number* parameter. Default *number* = 1.

If SRTRIG INT is set, a second rank input trigger is generated immediately before the second rank input register is read. If both TRIG INT and SRTRIG INT are set, READ returns the current state of all input channels in the slot specified by *slot*.

The "current state" of the input channels refers to the state which exists at the time the first rank input trigger is generated. For TRIG INT, a first rank input trigger is generated as a part of a read command (CHREAD, CHREADM, READ, or READM). For TRIG < >INT, a first rank input trigger is generated when a valid trigger signal from the source set by TRIG is received.

NOTE

The symbol "< >" means "other than". For example, TRIG < >INT means that TRIG is set for a parameter other than INT.

If an ASCII data format is specified, READ returns the decimal equivalent of the bit pattern stored in the second rank input register. The range of returned values is −32768 to +32767, with the LSB = channel ES00 state and the MSB = channel ES15 state. A "1" returned for a channel indicates a HIGH input while a "0" indicates a LOW input.

Example: Read Single Slot · High-Speed Read

This program uses the READ command to take 1000 readings of the current state of all input channels of an HP 44723A in slot 2 of the mainframe at rates up to 176,000 readings per second. Readings are taken from the second rank input register and stored in mainframe array A. Since RDGSMODE IMMED, TRIGMODE ALL, SRTRIG INT, and TRIG INT are set, the READ command reads the current state of all input channels in slot 200.

NOTE

Data storage in a mainframe INTEGER array is necessary to achieve the maximum read rate. Also, the read rate will be significantly less than 176,000 readings/second for an HP 44723A in an HP 3853A extender.

```
10  INTEGER B(1:1000)                     !Dimension controller array
20  OUTPUT 709;"INTEGER A(999)"           !Define mainframe array
30  OUTPUT 709;"USE 200"                  !Use slot 2 in mainframe
40  OUTPUT 709;"TRIG INT"                 !First rank input trigger on READ
50  OUTPUT 709;"SRTRIG INT"               !Second rank input trigger on READ
60  OUTPUT 709;"READ 200,1000 INTO A"     !Read slot 1000 times, store in A
70  OUTPUT 709; "VREAD A"                 !Transfer rdgs to output buffer
80  ENTER 709;B(*)                        !Enter decimal equiv of states
90  FOR I=1 TO 1000                       !Start print loop
100 PRINT "Reading";I;":";B(I)            !Display decimal equiv of states
110 NEXT I                                !Increment loop
120 END
```

If channel 201, 209, and 215 states remain HIGH during the read time and the other channel states remain LOW, the value returned for each read is −32254 which is the decimal equivalent of 1000 0010 0000 0010 (−32768 + 512 + 2). A typical return for this program with channel 201, 209, and 215 states HIGH follows.

```
Reading 1 : -32254
Reading 2 : -32254
     .
     .
Reading 1000 : -32254
```

For HP 9000 Series 200/300 controllers (and equivalent), the BASIC command IVAL$ can be used to convert the decimal value returned by READ to the equivalent bit pattern. For this program, replace line 100 with the following line.

```
100 PRINT "Reading";I;":";IVAL$(B(I),2)
```

Then, a typical return for channels 201, 209, and 215 HIGH follows, where the MSB is the channel 215 state and the LSB is the channel 200 state.

```
Reading 1 :1000001000000010
Reading 2 :1000001000000010
      .
      .
Reading 1000 :1000001000000010
```

Multiple Slot Reads (READM)

The READM command reads the contents of the second rank input register(s) in specified slot(s). READM *slot_list* [INTO *name*] or [*fmt*] reads the second rank input register contents for the slot(s) specified by *slot_list*.

If SRTRIG INT is set, a second rank input trigger is generated immediately before the second rank input register is read. If both TRIG INT and SRTRIG INT are set, READM returns the current state of the input channels in the slot(s) addressed.

If an ASCII data format is specified, READM returns the decimal equivalent of the bit pattern(s) stored in the second rank input register(s) read. The range of returned values is −32768 to +32767, with the LSB = channel ES00 state and the MSB = channel ES15 state. A "1" returned for a channel indicates a HIGH input while a "0" indicates a LOW input.

Example: Read Multiple Slots

This program reads the current state of all input channels for HP 44723A accessories in slots 1 and 2 of the mainframe, as read from the second rank input registers. Since RDGSMODE IMMED, TRIGMODE ALL, TRIG INT, and SRTRIG INT are set, the READM command returns the current state of all input channels in slots 100 and 200.

```
10  INTEGER A(0:1)                  !Dimension controller array
20  OUTPUT 709;"USE 100"            !Use slot 1 in mainframe
30  OUTPUT 709;"TRIG INT"           !First rank input trigger on READM
40  OUTPUT 709;"SRTRIG INT"         !Second rank input trigger on READM
50  OUTPUT 709;"USE 200"            !Use slot 2 in mainframe
60  OUTPUT 709;"TRIG INT"           !First rank input trigger on READM
70  OUTPUT 709;"SRTRIG INT"         !Second rank input trigger on READM
80  OUTPUT 709;"READM 100-200"      !Read slot 100 and 200 input states
90  ENTER 709;A(*)                  !Enter decimal equiv of states
100 PRINT A(*)                      !Display decimal equiv of states
110 END
```

If channel 101, 105, and 110 states are HIGH and the other slot 100 channel states are LOW, the value returned for slot 100 is 1058 which is the decimal equivalent of 0000 0100 0010 0010 (1024 + 32 + 2). If channel 201, 209, and 215 states are HIGH and the other slot 200 channel states are LOW, the value returned for slot 200 is −32254 which is the decimal equivalent of 1000 0010 0000 0010 (−32768 + 512 + 2). For these conditions, a typical return is:

```
1058 -32254
```

Digital Input Triggering

This section describes triggering for the digital input channels. It includes the following:

- "Input Trigger Sources" defines first rank input trigger sources (set with TRIG) and second rank input trigger sources (set with SRTRIG).

- "Triggering/Readings Modes" describes the TRIGMODE command which sets input channel triggering mode and the RDGSMODE command which sets input channel readings mode.

- "Trigger Outputs" describes the first rank input trigger terminal (1ST IN TRIG) and the second rank input trigger terminal (2ND IN TRIG) and shows how to use the TRIG and SRTRIG commands to generate trigger sources.

Input Trigger Sources

Although the examples in "Digital Input Reads" used only internal first and second rank input triggering (TRIG INT and SRTRIG INT) there are actually four sources for these triggers. TRIG sets the source for the first rank input trigger and SRTRIG sets the source for the second rank input trigger.

First Rank Input Trigger (TRIG)

When a first rank input trigger is received from the source set by TRIG, the current state of the input channels is sampled and the result stored in the first rank input register. For USE *ch* = ES00-ES15, TRIG [*source*] [USE *ch*] sets the source for first rank input triggers, as shown in Table 3-1. Power-on/reset value = TRIG INT and default value = TRIG SGL. Descriptions of TRIG *source* parameters follow.

Table 3-1. TRIG *source* Parameters

source/mode	Description
HOLD	No triggering.
EXT	Terminal module external trigger input. [1]
INT	Trigger when a read command is executed. [2]
SGL	Immediate single trigger when command executes.
SYS	System trigger (used with TRG command).

[1] = Input to First Rank Trigger terminal (1ST IN TRIG IN).
[2] = Power-on value. Read commands are CHREAD, CHREADM, READ, and READM.

TRIG HOLD

For USE *ch* = ES00-ES15, no first rank input triggers are generated when TRIG HOLD is set. Thus, with TRIG HOLD, if a second rank input trigger occurs, the contents of the first rank input register are copied to the second rank input register, but the contents may not be the same as the current state of the input channels.

TRIG EXT

For USE *ch* = ES00-ES15, with TRIG EXT, the first rank input trigger IN terminal (1ST IN TRIG IN) is the source for first rank input triggers. With TRIG EXT, a first rank input trigger is generated when a high-to-low (HL) transition is received at the 1ST IN TRIG IN terminal.

TRIG INT

For USE *ch* = ES00-ES15, with TRIG INT, a read command (CHREAD, CHREADM, READ, or READM) generates a first rank input trigger as part of the command execution. For example, with TRIG INT and SRTRIG INT (internal first and second rank input triggering), when CHREAD is executed a first rank input trigger is generated, then a second rank input trigger is generated, and then the second rank input register is read by CHREAD.

NOTE

1. Setting TRIG INT does NOT generate a first rank input trigger. The trigger is generated only when a read command is executed.

2. Changing the TRIG source may generate a first rank input trigger.

TRIG SGL

For USE *ch* = ES00-ES15, with TRIG SGL, a single first rank input trigger is generated immediately when the command is executed.

TRIG SYS

For USE *ch* = ES00-ES15, with TRIG SYS, a single first rank input trigger is generated when a trigger is received from the source specified by the TRG command. Refer to the HP 3852A Mainframe Configuration and Programming Manual for details on the TRG command.

Example: External First Rank Input Triggering

This program uses an external (HL) input as the source for the first rank input triggers (TRIG EXT). When an external first rank input trigger is received at the 1ST IN TRIG IN terminal, the state of each input channel is sampled and the result stored in the first rank input register. Since SRTRIG INT is set, when CHREAD is executed the first rank input register contents are copied to the second rank input register and the second rank input register is then read.

```
10 OUTPUT 709;"USE 207"                  !Use ch is 207
20 OUTPUT 709;"TRIG EXT"                 !Ext first rank input trig source
30 OUTPUT 709;"SRTRIG INT"               !Second rank input trigger on CHREAD
40 WAIT 1                                !Allow time for ext trig to be input
50 OUTPUT 709;"CHREAD 207"               !Read ch 207 state
60 ENTER 709;A                           !Enter ch 207 state
70 PRINT "Channel 207 state = ";A        !Display ch 207 state
80 END
```

If channel 207 state is HIGH when the external trigger is received, a typical return is:

```
Channel 207 state = 1
```

Second Rank Input Trigger (SRTRIG)

When a second rank input trigger is generated (from the source set by SRTRIG), the contents of the first rank input register are copied into the second rank input register. For USE *ch* = ES00-ES15, SRTRIG [*source*] [USE *ch*] sets the source for second rank input triggers, as shown in Table 3-2. Power-on/reset value = SRTRIG INT and default value = SRTRIG SGL. Descriptions of SRTRIG *source* parameters for digital input channels follow.

NOTE

1. For USE ch = ES16-ES31, SRTRIG sets the source for second rank output triggers used with digital output channels. Refer to Chapter 4 - Programming Digital Output Channels for details.

2. Changing the SRTRIG source may generate a second rank trigger.

Table 3-2. SRTRIG *source* Parameters

source/mode	Description
HOLD	No second rank input triggering.
EXT	Terminal module external trigger input. [1]
INT	Trigger when a read command is executed. [2]
SGL	Immediate single trigger when command executes.
SYS	System trigger (used with TRG command).

[1] = input to second rank input trigger terminal (2ND IN TRIG).
[2] = Power-on setting. Read commands are CHREAD, CHREADM, READ, and READM.

SRTRIG HOLD

For USE *ch* = ES00-ES15, with SRTRIG HOLD no second rank input triggers are generated. Thus, for SRTRIG HOLD, multiple read commands (CHREAD, CHREADM, READ, or READM) on a slot will return identical data since the second rank input register will not be updated.

SRTRIG EXT

For USE *ch* = ES00-ES15, with SRTRIG EXT, the second rank input trigger terminal (2ND IN TRIG IN terminal) is the source for second rank input triggers. With SRTRIG EXT, when a high-to-low (HL) transition is input to the 2ND IN TRIG IN terminal, a second rank input trigger is generated.

NOTE

If input interrupts are enabled, SRTRIG EXT or SRTRIG SYS cannot be set for the second rank input trigger and vice-versa.

SRTRIG INT

For USE *ch* = ES00-ES15, with SRTRIG INT, a read command (CHREAD, CHREADM, READ, or READM) generates a second rank input trigger as part of the command execution. For example, with TRIG INT and SRTRIG INT, when CHREAD is executed a first rank input trigger is generated, then a second rank input trigger is generated, and then the second rank input register is read by CHREAD.

NOTE

1. Setting SRTRIG INT does NOT generate a second rank input trigger. The trigger is generated only when a read command is executed.

2. When RDGSMODE DAV is set, SRTRIG INT is the ONLY setting allowed for SRTRIG.

SRTRIG SGL

For USE *ch* = ES00-ES15, with SRTRIG SGL, a single second rank input trigger is generated immediately when the command is executed.

SRTRIG SYS

For USE *ch* = ES00-ES15, with SRTRIG SYS, a single second rank input trigger is generated when a trigger is received from the source specified by the TRG command. Refer to the HP 3852A Mainframe Configuration and Programming Manual for details on the TRG command.

NOTE

If input interrupts are enabled, SRTRIG SYS or SRTRIG EXT cannot be set for the second rank input trigger and vice-versa.

Example: Internal Second Rank Input Triggering

This program uses SRTRIG INT (internal second rank input triggering) as the source for second rank input triggers. Since TRIG INT is set, when CHREAD is executed the state of each input channel is sampled and the result stored in the first rank input register.

Since SRTRIG INT is set, the first rank input register contents are copied to the second rank input register and the second rank input register is read when CHREAD is executed. For these settings, CHREAD reads the current state of input channel 207.

```
10 OUTPUT 709;"USE 207"                 !Use ch is 207
20 OUTPUT 709;"TRIG INT"                !First rank input trigger on CHREAD
30 OUTPUT 709;"SRTRIG INT"              !Second rank input trigger on CHREAD
40 OUTPUT 709;"CHREAD 207"              !Read ch 207 state
50 ENTER 709;A                          !Enter ch 207 state
60 PRINT "Channel 207 state = ";A       !Display ch 207 state
70 END
```

If channel 207 state is HIGH when CHREAD is executed, a typical return is:

```
Channel 207 state = 1
```

Triggering/Readings Modes

The "Digital Input Reads" section showed how to make slot reads with the READ and READM commands when power-on/reset conditions were set (RDSMODE IMMED, TRIGMODE ALL, SRTRIG INT, and TRIG INT). However, the results returned by the READ and READM commands may be affected by the TRIGMODE, RDGSMODE, SRTRIG, and TRIG settings. In addition, CHREAD and CHREADM results may be affected by the TRIGMODE, STRTIG, and TRIG settings.

Figure 3-1 summarizes the actions of RDGSMODE, TRIGMODE, SRTRIG, and TRIG and shows the effect of RDGSMODE on READ/READM returns. Descriptions of the TRIGMODE and RDGSMODE commands and the effect of the RDGSMODE, TRIGMODE, SRTRIG, and TRIG commands on READ/READM results follow.

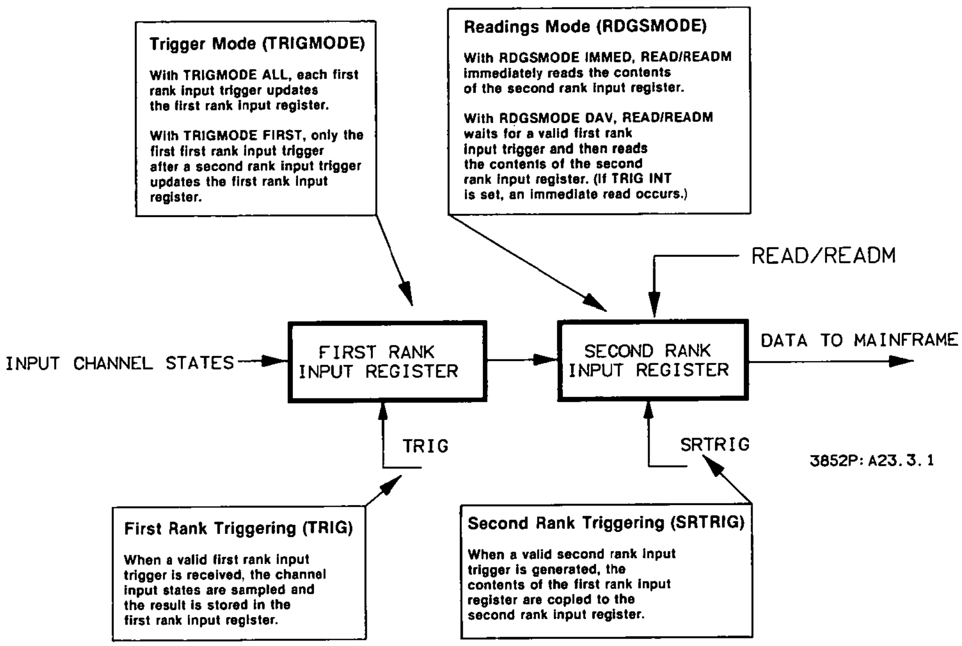

Figure 3-1. Input Channel Trigger/Readings Modes

Input Trigger Mode (TRIGMODE)

The TRIGMODE *mode* [USE *ch*] command selects the trigger mode for first rank input triggers and for second rank output triggers. For any USE *ch* = ES00-ES15, TRIGMODE selects the trigger mode for first rank input triggers. (Note that TRIGMODE affects **all** input channels for any USE *ch* between ES00 and ES15.)

NOTE

For any USE ch = ES16-ES31, TRIGMODE selects the trigger mode for second rank output triggers. Refer to Chapter 4 - Programming Digital Output Channels for details.

For digital input channels, TRIGMODE affects the mode of operation in two areas: (1) updating the first rank input register; and (2) setting the trigger output mode for first rank input triggers. Refer to "Trigger Outputs" to set trigger outputs for first rank input triggers.

TRIGMODE *modes* are ALL (power-on/reset) or FIRST. With TRIGMODE ALL, the first rank input register is updated by each first rank input trigger. With TRIGMODE FIRST, only the first first rank trigger following a second rank input trigger updates the first rank input register. All subsequent first rank input triggers are ignored until the next second rank input trigger. Figure 3-2 shows how the first rank input register is updated for TRIGMODE ALL and TRIGMODE FIRST.

TRIGMODE ALL

With TRIGMODE ALL, each first rank input trigger (points 1, 2, and 3 in Figure 3-2) causes the HP 44723A to sample all input channel states and store the result in the first rank input register (updates the register). Then, when a second rank input trigger is received, the most recently sampled state (state at point 3) is copied into the second rank input register.

TRIGMODE FIRST

With TRIGMODE FIRST, only the first first rank input trigger received after a second rank input trigger updates the first rank input register. (At power-on or following a reset, a second rank input trigger is automatically generated, so the first first rank trigger received will be acknowledged.)

In Figure 3-2, only the first first rank input trigger (at point 1) updates the first rank input register, while the triggers at points 2 and 3 are ignored. Thus, when a second rank input trigger is received, the earliest sampled state (state at point 1) is copied into the second rank input register.

Readings Mode (RDGSMODE)

The RDGSMODE command sets the readings mode for the READ, READM, WRITE, and WRITEM commands. For any USE *ch* = ES00-ES15, RDGSMODE *mode* [USE *ch*] sets the mode for READ and READM. Valid modes are IMMED (power-on/reset) or DAV.

NOTE

For any USE ch = ES16-ES31, RDGSMODE sets the mode for WRITE and WRITEM. Refer to Chapter 4 - Programming Digital Output Channels to use RDGSMODE with WRITE and WRITEM.

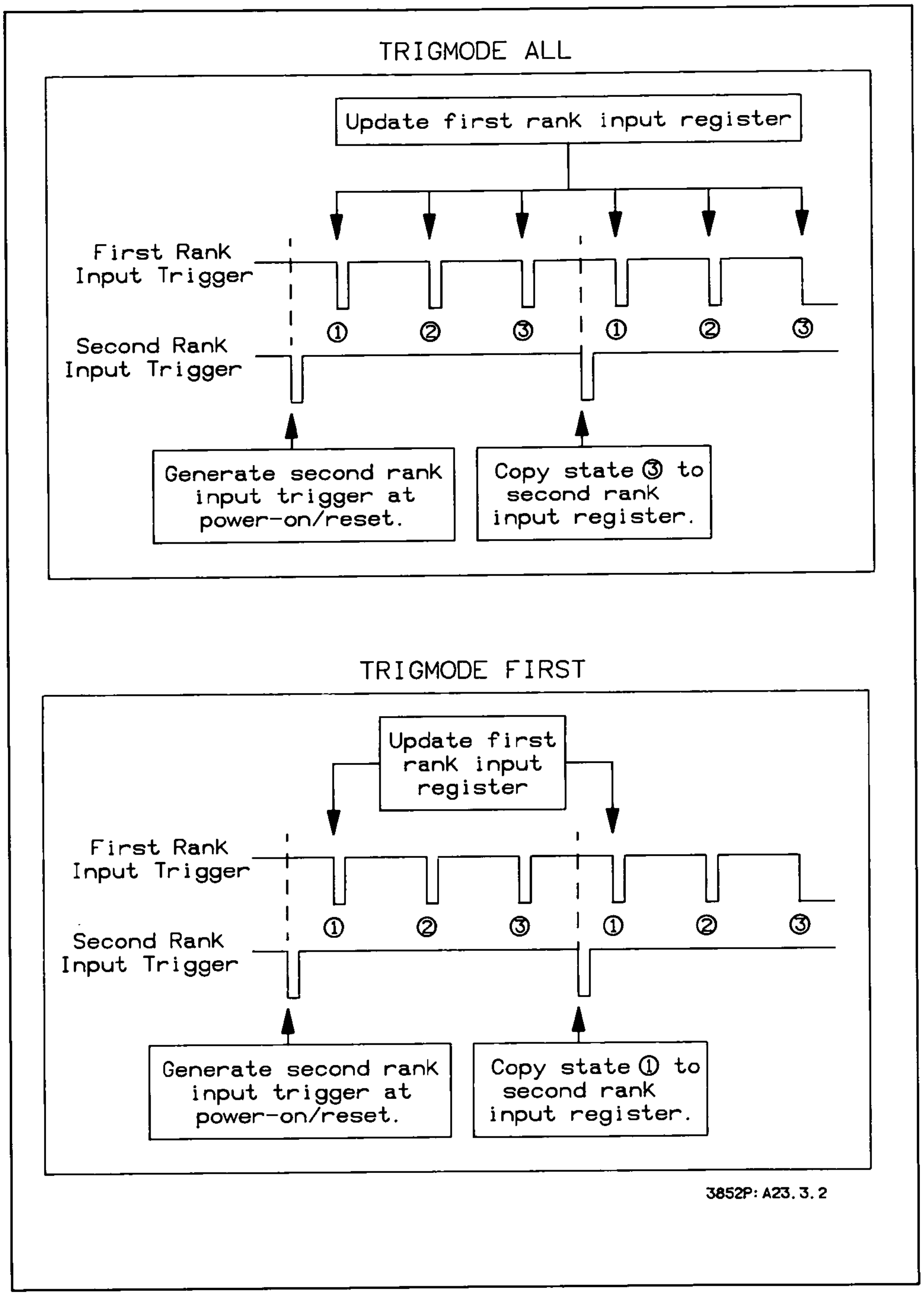

Figure 3-2. Input Channel Trigger Modes

RDGSMODE IMMED

With RDGSMODE IMMED, READ/READM always immediately reads the contents of the second rank input register. With RDGSMODE IMMED, READ or READM may not return the current state of the input channels.

For example, suppose RDGSMODE IMMED, SRTRIG EXT, TRIG INT, and TRIGMODE ALL are set. When a READ command is executed, the current state of the input channels is immediately sampled (since TRIG INT is set). However, if an external second rank input trigger is not received before READ executes, the new data is not copied to the second rank input register. Therefore, the READ command reads the existing contents of the second rank input register - which are not necessarily the same as the current state of the channels.

RDGSMODE DAV

With RDGSMODE DAV, READ/READM waits until "new data" is available in the first rank input register before reading the contents of the second rank input register. "New data" is defined as having received a valid first rank input trigger after a second rank input trigger.

NOTE

At power-on/reset, a second rank input trigger is automatically generated without an accompanying first rank input trigger so the first first rank input trigger received after power-on/reset is acknowledged.

For input channels, SRTRIG INT must be set when RDGSMODE DAV is set. Therefore, with RDGSMODE DAV, when TRIG INT is set READ/READM returns the current state of the input channels. If TRIG INT is not set, READ/READM waits for a valid first rank input trigger and then returns the contents of the first rank input register.

For example, suppose RDGSMODE DAV, SRTRIG INT, TRIG EXT, and TRIGMODE ALL are set. In this case, READ/READM will wait until a valid first rank input trigger is received before executing. Since TRIGMODE ALL is set, the first first rank input trigger received will cause READ/READM execution.

If the input channel states have not changed between the external first rank input trigger and READ/READM execution, READ/READM returns the current state of the input channels. Otherwise, READ/READM returns the first rank input register contents.

READ/READM Returns vs. RDGSMODE Settings

Table 3-3 summarizes READ/READM returns for RDGSMODE IMMED and RDGSMODE DAV with various SRTRIG and TRIG settings, where the "< >" symbol means "other than" (e.g., TRIG < >INT means TRIG parameter other than INT).

NOTE

SRTRIG INT must be set when RDGSMODE DAV is set.

Table 3-3. READ/READM Returns vs. RDGSMODE Settings

		RDGSMODE IMMED	
SRTRIG	**TRIG**	**READ/READM Returns:**	
INT	INT	Current state of input channels.	
INT	< >INT	Current first rank input register contents.	[1]
< >INT	INT	Current second rank input register contents.	[2]
< >INT	< >INT	Current second rank input register contents.	
		RDGSMODE DAV	
SRTRIG	**TRIG**	**READ/READM Returns:**	
INT	INT	Current state of input channels.	
INT	< >INT	Current first rank input register contents.	[3]

[1] = Contents may depend on TRIGMODE setting.
[2] = READ/READM also updates first rank input register.
[3] = Waits, as required, for first rank input trigger.

Trigger/Readings Modes Summary

Table 3-4 summarizes register update and read actions for READ and READM with each setting of the RDGSMODE and TRIGMODE commands. Refer to Table 3-3 for data returned by READ/READM for various settings of SRTRIG and TRIG.

Table 3-4. Trigger/Readings Modes Summary

Trigger/Readings Mode	Update First Rank Input Register	Read Second Rank Input Register	Note
TRIGMODE ALL/ RDGSMODE IMMED	With each first rank input trigger.	Immediately.	
TRIGMODE FIRST/ RDGSMODE IMMED	Only with first first rank input trigger after second rank input trigger.	Immediately.	
TRIGMODE ALL/ RDGSMODE DAV	With each first rank input trigger.	Wait for valid first rank input trigger.	[1]
TRIGMODE FIRST/ RDGSMODE DAV	Only with first first rank input trigger after second rank input trigger.	Wait for valid first rank input trigger.	[1]

[1] = A separate first rank input trigger is required for each read on a slot. Also, SRTRIG INT must be set for RDGSMODE DAV.

Example: Read Slot - Wait For External Trigger

This program uses READ to return the state of all input channels for an HP 44723A in slot 2 of the mainframe. Since RDGSMODE DAV and TRIG EXT are set, the program waits until an external first rank input trigger is received at the 1ST IN TRIG IN terminal. (An HL input to the terminal is required - refer to Chapter 2 for connections). When an external trigger is received, the program returns the state of the input channels.

```
10 OUTPUT 709;"USE 200"             !Use slot is mainframe slot 2
20 OUTPUT 709;"TRIG EXT"            !First rank input trig on ext input
30 OUTPUT 709;"SRTRIG INT"          !Second rank input trig on READ command
40 OUTPUT 709;"RDGSMODE DAV"        !Wait for first rank input trigger
50 OUTPUT 709;"READ 200"            !Read slot 200 input channel state
60 ENTER 709;A                      !Enter state
70 PRINT Slot 200 state = ;A        !Display state
80 END
```

When an external (HL) pulse is input to the 1ST IN TRIG IN terminal, READ returns the decimal equivalent of the input channel states at the time of the input (first rank input trigger). If channel 201, 205, and 208 states are HIGH and the other channel states are LOW, a typical return is:

```
Slot 200 state = 290
```

Trigger Outputs

The HP 44723A terminal module includes a first rank input trigger terminal (1ST IN TRIG) and a second rank input trigger terminal (2ND IN TRIG) which can be used to output trigger pulses or edges. In addition, the module includes a second rank output trigger terminal (2ND OUT TRIG) which can be used to output triggers. See Chapter 4 - Programming Digital Output Channels to use the 2ND OUT TRIG terminal. Refer to Chapter 2 - Configuring the HP 44723A for a description of the terminals.

First Rank Trigger Output As shown in Figure 3-3, the first rank input trigger terminal (labeled 1ST IN TRIG on the terminal module) generates either an HL edge or 2 μsec negative pulses from the OUT terminal, depending on the TRIGMODE setting.

NOTE

2 μsec is a nominal value for the output trigger pulse width. Typical range of values is from 1.7 μsec to 2.8 μsec.

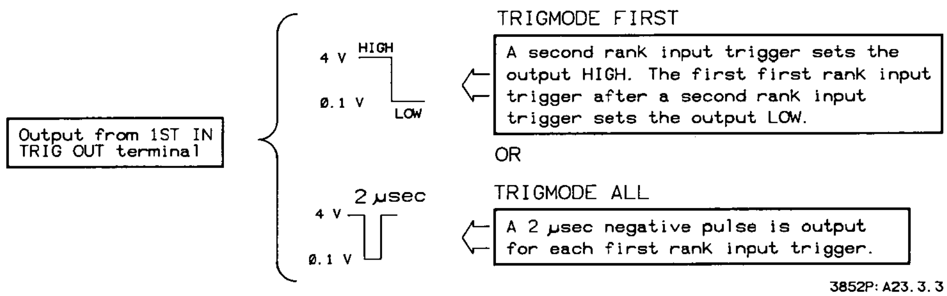

Figure 3-3. First Rank Trigger Outputs

Output With TRIGMODE FIRST

For USE *ch* = ES00-ES15, with TRIGMODE FIRST set, a second rank input trigger sets the output from the 1ST IN TRIG OUT terminal HIGH, while the first first rank input trigger received after a second rank input trigger sets the output LOW.

With TRIGMODE FIRST, the negative edge output from the 1ST IN TRIG OUT terminal can be used for applications such as synchronizing input data reads, as long as the external device can accept a negative edge.

Output With TRIGMODE ALL

When TRIGMODE ALL is set, a 2 μsec negative pulse is output from the 1ST IN TRIG OUT terminal for each first rank input trigger received. This output can be used for applications such as triggering (synchronizing) other digital devices.

Example: Synchronize Input Data Reads

For this example, the first rank trigger output (the HL edge output from the 1ST IN TRIG OUT terminal) is used to synchronize data reads of user device input states. Figure 3-4 shows typical trigger connections and timing diagrams, assuming a user source of 5 V. Refer to Chapter 2 - Configuring the HP 44723A for typical input channel data connections and for timing when the user source is other than 5 V.

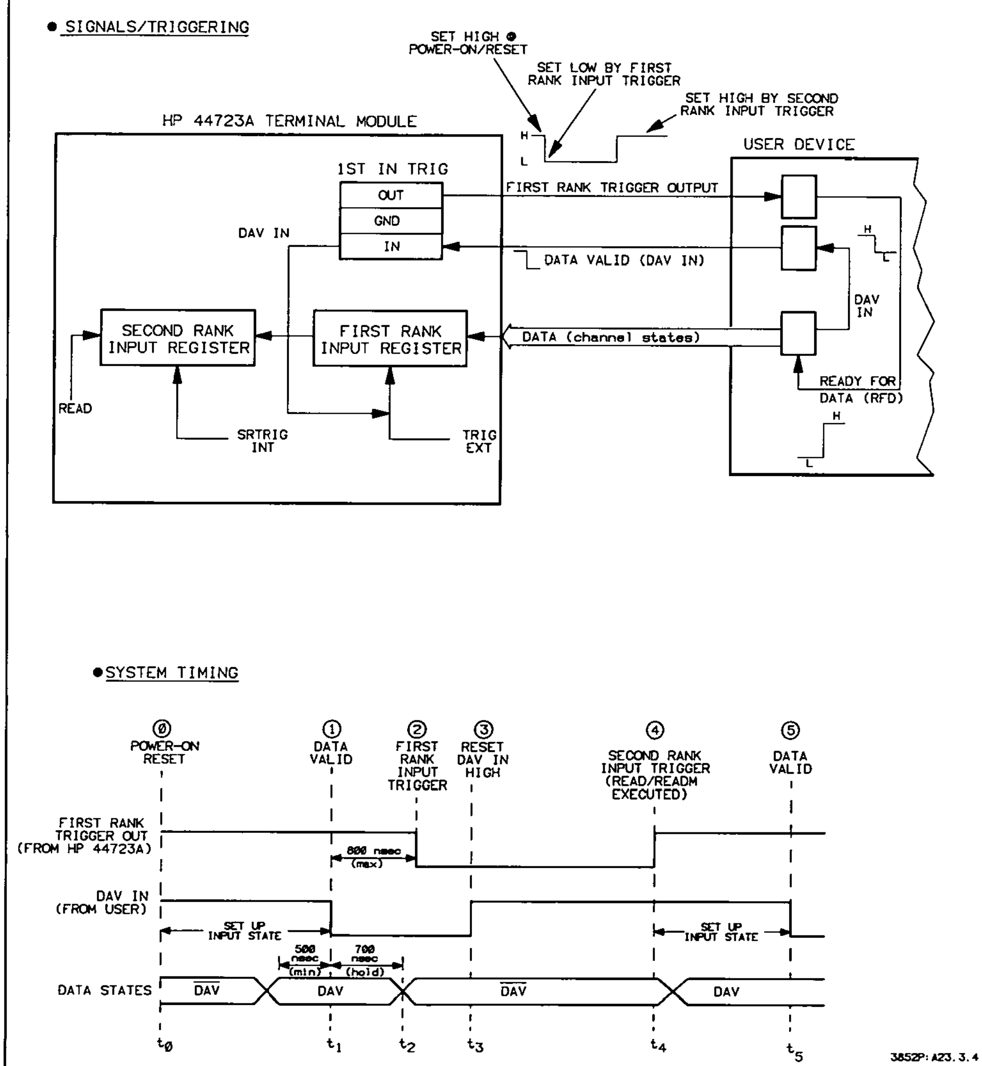

Figure 3-4. Example: Synchronize Input Data Reads

- Sequence of Operation:

For the (hypothetical) user device in Figure 3-4, we want to immediately read the input channel states (data) whenever any valid input channel state exists. In addition, as soon as the input state has been read, we want to signal the device that the HP 44723A is ready to accept new data. RDGSMODE DAV, SRTRIG INT, TRIG EXT, and TRIGMODE FIRST are set and READ is used to read the input channel states.

Read Data Valid State

To read the input channel states, a DAV IN pulse is generated by the user device and is input to the 1ST IN TRIG IN terminal when a data valid state exists. Since TRIG EXT is set, when the DAV IN pulse is received, a first rank input trigger is generated.

When the first rank input trigger occurs, the input channel state is sampled and the result stored in the first rank input register. After the first rank input trigger is generated, READ is executed, a second rank input trigger is generated, and the data read. Therefore, user input channel states are read only when a data valid state exists. A separate first rank input trigger (separate DAV IN pulse) is required for each read.

Signal Ready For Data

To signal the user device that the HP 44723A is ready to accept new data, we will use the trigger output from the 1ST IN TRIG OUT terminal. At power-on/reset, the 1ST IN TRIG OUT line is set HIGH. Since TRIGMODE FIRST is set, when the first first rank input trigger occurs, the 1ST IN TRIG OUT line is set LOW. Then, when a second rank input trigger occurs, the OUT line is reset HIGH.

The HP 44723A is ready to accept new data after a second rank input trigger occurs. Since the second rank input trigger sets the 1ST IN TRIG OUT output HIGH, the LH pulse from the 1ST IN TRIG OUT terminal signals the user device that the HP 44723A is ready to accept new data (RFD). If a data valid state exists, a new DAV IN pulse is generated and the cycle repeats. If not, the user device waits for a data valid state and then repeats the sequence.

• System Timing:

Power-on/Reset (point 0)

In Figure 3-4, t_0 is the power-on/reset state. At t_0, the output from the 1ST IN TRIG OUT terminal is set HIGH by an internally generated second rank input trigger. This LH pulse is output to the user device to signal that the HP 44723A is ready to accept new data (RFD).

Data Valid (point 1)

From point t_0 to 500 nsec before t_1, we will assume a "data not valid" state, so a DAV IN pulse is not generated until t_1. Then, at t_1, when a data valid state exists, a DAV IN pulse from the user device is input to the 1ST IN TRIG IN terminal.

First Rank Input Trigger (point 2)

Since TRIG EXT is set and the user source is 5 V, a first rank input trigger is generated a maximum of 700 nsec after the DAV IN pulse is received. Thus, at point t_2, the input state is sampled and the result stored in the first rank input register.

Reset DAV IN Line HIGH (point 3)

At some time t_3, the DAV IN line is reset HIGH in preparation for the next read cycle. (For maximum read rate, the DAV IN line should be reset HIGH before the second rank input trigger occurs.)

Second Rank Input Trigger (point 4)

Since SRTRIG INT is set, a second rank input trigger is generated (at t_4) as part of the READ command execution and the 1ST IN TRIG OUT line is reset HIGH. This LH edge again signals the user device that the HP 44723A is ready to accept new data (RFD).

At t_4, if a data valid state exists a new DAV IN pulse is generated and the read cycle is repeated. The maximum read rate is about 125,000 readings per second.

Data Valid (point 5)

If the data is not valid when the second rank input trigger is generated (at point t_4), the user device waits until a data valid state occurs (point t_5) and then generates a DAV IN pulse to start the read cycle again.

NOTE

This program runs continuously until aborted by the user. The DISP OFF command (line 20) is optional and is intended primarily for high-speed operation.

```
10  INTEGER A(0:9)                          !Dimension controller array
20  OUTPUT 709;"DISP OFF"                   !Turn front panel display off
30  OUTPUT 709;"INTEGER B(9)"               !Dimension mainframe array
40  OUTPUT 709;"USE 200"                    !Use mainframe slot 2
50  OUTPUT 709;"TRIG EXT"                   !First rank input trig on ext input
60  OUTPUT 709;"SRTRIG INT"                 !Sec rank input trig on READ comm
70  OUTPUT 709;"TRIGMODE FIRST"             !Update reg on first first rank trig
80  OUTPUT 709;"RDGSMODE DAV"               !Read only when new data avail
90  WHILE 1                                 !Continue program while true
100     OUTPUT 709;"READ 200,10 INTO B"     !Read slot 200 10 times, store in B
110     OUTPUT 709;"VREAD B"                !Transfer 10 readings to out buff
120     ENTER 709;A(*)                      !Enter 10 readings
130     PRINT TABXY(1,2);A(*)               !Display 10 readings
140 END WHILE                               !End when line 80 not true
150 END
```

As noted, this program continues to take readings indefinitely, 10 readings at a time (as long as an external trigger is received for each read) until aborted by the user. Since RDGSMODE DAV is set, the READ command waits for an external first rank input trigger between each read of the second rank input register.

Since the latest set of readings overwrites the readings currently on the CRT display, the display shows the input channel states for the last 10 readings. If, for example, the user "data valid" states are 0010 0110 0010 1000 (9768), 1000 1000 0100 1000 (−30648), or 0000 1010 0100 0001 (2625), a typical return for the last 10 reads of the input states is:

```
2625  -30648  -30648  9768  2625  9768  2625  2625
-30648  9768
```

Second Rank Trigger Output

As shown in Figure 3-5, for any USE *ch* = ES00-ES15, with either TRIGMODE FIRST or TRIGMODE ALL a 2 μsec negative pulse is output from the OUT terminal of the 2ND IN TRIG terminal for each second rank input trigger received. This pulse can be use for applications such as simultaneously second rank input triggering multiple HP 44723A accessories. An example follows.

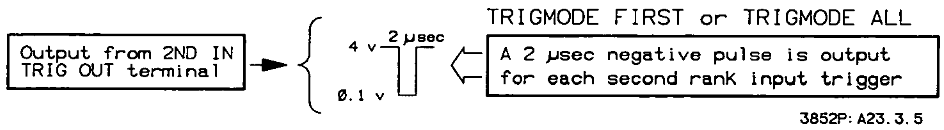

Figure 3-5. Second Rank Trigger Output

Example: Synchronize Multiple Accessory Reads

This program simultaneously reads the most recently sampled states of all HP 44723A channels in slots 100, 200, and 300 when an external trigger is input to the accessories. Figure 3-6 shows required field wiring connections.

Note that the 2ND IN TRIG OUT terminal on the HP 44723A in slot 100 must be connected to the 2ND IN TRIG IN terminals on the HP 44723As in slots 200 and 300. (The slot 200 and 300 2ND IN TRIG IN jumpers must be set for 5V.) In addition, external first rank trigger inputs are required for the 1ST IN TRIG IN terminals in slots 100, 200, and 300.

For this program, the READM command waits until an external first rank input trigger is received and then simultaneously reads the states of slots 100, 200, and 300. Note that internal second rank input triggering (SRTRIG INT) is set for slot 100, while external second rank input triggering (SRTRIG EXT) is set for slots 200 and 300.

The sequence of operation is:

(a) When an external first rank trigger is received, slot 100, 200, and 300 states are sampled and the result stored in the first rank input registers. In addition, READM command execution begins.

(b) Since SRTRIG INT is set for slot 100, an internal second rank input trigger is generated for slot 100. When this trigger is generated, the first rank input register contents are copied to the second rank input register. Also, a 2 μsec pulse is output from the 2ND IN TRIG OUT terminal to the 2ND IN TRIG IN terminals for the HP 44723As in slots 200 and 300.

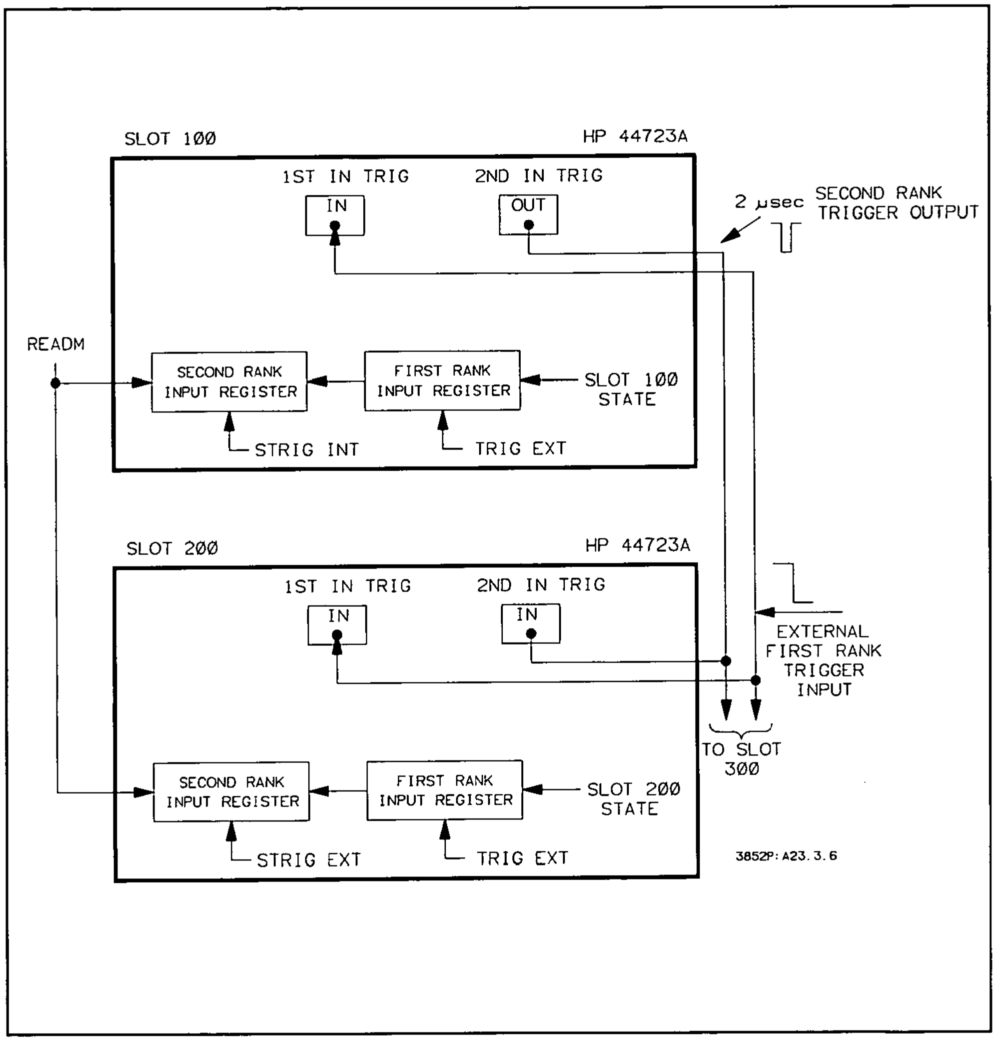

Figure 3-6. Example: Synchronize Multiple Accessory Reads

(c) Since SRTRIG EXT is set for slots 200 and 300, the 2 μsec pulse generates second rank input triggers for slots 200 and 300 and the first rank register contents are copied to the second rank input registers in these slots.

(d) The READM command completes execution and reads the most recently sampled states of slots 100, 200, and 300. Again, since RDGSMODE DAV is set for slot 100, READM does not begin execution until an external first rank input trigger is received (at the 1ST IN TRIG IN terminal in slot 100).

```
10 INTEGER A(0:2)                       !Dimension controller array
20 OUTPUT 709;"USE 100"                 !Use ch is 100
30 OUTPUT 709;"RDGSMODE DAV"            !Wait for ext trigger to execute READM
40 OUTPUT 709;"TRIGMODE ALL"            !Gen 2 µsec output on sec rank input trig
50 OUTPUT 709;"TRIG EXT"                !External first rank input trig source
60 OUTPUT 709;"SRTRIG INT"              !Trigger on READM command
70 OUTPUT 709;"USE 200"                 !Use ch is 200
80 OUTPUT 709;"RDGSMODE IMMED"          !Immediately read slot 200 state
90 OUTPUT 709;"TRIGMODE ALL"            !Read most recently sampled state
100 OUTPUT 709;"TRIG EXT"               !External first rank input trig source
110 OUTPUT 709;"SRTRIG EXT"             !External second rank input trig source
120 OUTPUT 709;"USE 300"                !Use ch is 300
130 OUTPUT 709;"RDGSMODE IMMED"         !Immediately read slot 300 state
140 OUTPUT 709;"TRIGMODE ALL"           !Read most recently sampled state
150 OUTPUT 709;"TRIG EXT"               !External first rank input trig source
160 OUTPUT 709;"SRTRIG EXT"             !External second rank input trig source
170 OUTPUT 709;"READM 100-300"          !Read slots 100, 200, and 300
180 ENTER 709;A(*)                      !Enter decimal equiv of bit patterns
190 PRINT A(*)                          !Display decimal equiv
200 END
```

If channels 101, 107, 111, 200, 202, 301, 314, and 315 states are HIGH and the other channel states are LOW when READM executes, a typical return is as follows. Note that READM returns a single value for each slot.

```
2178    5    -16382
```

Digital Input Interrupts

There are three types of interrupts which can be enabled for digital input channels: edge, pattern, and input. This section shows how to use EDGE, PATTERN, ENABLE INTR, and DISABLE INTR to enable or disable interrupts on digital input channels.

Edge Interrupts (EDGE)

Edge interrupts can be enabled for digital input channels using the EDGE and ENABLE INTR commands. Edge interrupts can be disabled with the DISABLE INTR command. When enabled, an edge interrupt is generated when the edge(s) set by the EDGE *trans* [USE *ch*] command occurs at the specified digital input channel(s). Table 3-5 lists the EDGE *trans* parameters. Power-on and reset *trans* = OFF.

Table 3-5. EDGE *trans* Parameters

trans	Description
OFF	Neither edge.
LH	Interrupt on low-to-high edge.
HL	Interrupt on high-to-low edge.
BOTH	Interrupt on either edge.

Types of Edge Interrupts

There are two ways to set edge interrupts. The first way is to enable a single input channel for edge interrupts. For USE *ch* = ES00-ES15, when enabled by ENABLE INTR, an edge interrupt occurs when the edge specified by EDGE (LH, HL, or BOTH) occurs on the channel specified by USE *ch*. For example, when enabled with ENABLE INTR, the EDGE BOTH USE 205 command sets channel 205 to interrupt when an LH or HL edge appears at the channel 205 input.

The second way to set edge interrupts is to enable all input channels. For USE *ch* = ES93, when enabled by ENABLE INTR, an edge interrupt occurs when the edge specified by EDGE occurs on any input channel. For example, when enabled with ENABLE INTR, the EDGE LH USE 293 command sets all input channels (200 through 215) to interrupt when an LH edge appears at any of the channels.

Edge Interrupt Actions

Table 3-6 summarizes the EDGE and ENABLE INTR actions for edge interrupts. ENABLE INTR must be set for an edge interrupt to occur.

NOTE

Edge interrupts are cleared and disabled when serviced by the mainframe or by the DISABLE INTR command.

Table 3-6. Edge Interrupt Actions

USE *ch*	EDGE	ENABLE INTR
ES00-ES15	For the channel specified by USE ch, EDGE specifies the edge(s) which will cause an edge interrupt when enabled with ENABLE INTR.	Enables an edge interrupt when the edge(s) set by EDGE occurs on the channel specified by USE ch. ENABLE INTR clears any pending edge interrupts on the specified channel.
ES93	For all input channels, EDGE specifies the edge(s) which will cause an edge interrupt when enabled with ENABLE INTR.	Enables an edge interrupt when the edge(s) set by EDGE occurs on any input channel. ENABLE INTR clears any pending edge interrupts on all input channels.

Example: Enable Edge Interrupt - Specified Channel

This program enables channel 206 of an HP 44723A in slot 2 of the mainframe to generate an edge interrupt on either a low-to-high (LH) or a high-to-low (HL) input edge. The program loops until an LH or HL edge on channel 206 generates an SRQ (the edge causes an edge interrupt which generates the SRQ). The interrupt is serviced by controller subroutine Results. When the program completes, the time of the interrupt is displayed.

When the interrupt occurs, the HP-IB SRQ line is set TRUE and an SRQ is sent to the controller. Also, the INTR bit (bit 9) and the service request bit (bit 6) in the status register are set. Because the interrupt is handled by the controller, both bits must be cleared (STA? clears bit 9, SPOLL clears bit 6) before the controller can respond to the next interrupt that occurs.

```
10  ON INTR 7 GOTO Results              !Call sub on interrupt
20  ENABLE INTR 7;2                     !Enable controller intr on SRQ
30  OUTPUT 709;"USE 206"                !Use ch 206
40  OUTPUT 709;"RQS ON;RQS INTR"        !Enable interrupt on SRQ
50  OUTPUT 709;"STA?"                   !Clear FPS,LCL,INTR,LMT,ALRM bits
60  OUTPUT 709;"CLROUT"                 !Clear STA? data from output buffer
70  OUTPUT 709;"EDGE BOTH"              !Interrupt on either edge transition
80  OUTPUT 709;"ENABLE INTR"            !Enable accessory to interrupt
90  OUTPUT 709;"ENABLE INTR SYS"        !Enable mainframe to sense interrupt
100 GOTO 100                            !Loop until SRQ occurs
110 Results: !                          !Start controller subroutine
120 OUTPUT 709;"TIME"                   !Query time of day
130 ENTER 709;T                         !Enter time of day
140 PRINT "Ch 206 intr @ ";TIME$(T)     !Display interrupt time/message
150 A=SPOLL(709)                        !Read/clear SRQ bit
160 STOP                                !End controller subroutine
170 END
```

When the interrupt occurs (an HL or LH edge on channel 206), the controller queries the time of day and enters the time. A typical return is:

```
Ch 206 intr @ 02:46:50
```

Example: Enable Edge Interrupt - Any Input Channel

This program enables any input channel of an HP 44723A in slot 2 of the mainframe to generate an edge interrupt on either a low-to-high (LH) or a high-to-low (HL) input edge. The program loops until an LH or HL edge on any input channel (200-215) generates an SRQ (the edge causes an edge interrupt which generates the SRQ). The interrupt is serviced by controller subroutine Results. When the program completes, the time of the interrupt is displayed.

When the interrupt occurs, the HP-IB SRQ line is set TRUE and an SRQ is sent to the controller. Also, the INTR bit (bit 9) and the service request bit (bit 6) in the status register are set. Because the interrupt is handled by the controller, both bits must be cleared (STA? clears bit 9, SPOLL clears bit 6) before the controller can respond to the next interrupt that occurs.

```
10  ON INTR 7 GOTO Results                 !Call sub on interrupt
20  ENABLE INTR 7;2                        !Enable controller intr on SRQ
30  OUTPUT 709;"RQS ON;RQS INTR"           !Enable interrupt on SRQ
40  OUTPUT 709;"STA?"                      !Clear FPS,LCL,INTR,LMT,ALRM bits
50  OUTPUT 709;"CLROUT"                    !Clear STA? data from output buffer
60  OUTPUT 709;"USE 293"                   !Edge intr for edge on any input ch
70  OUTPUT 709;"EDGE BOTH"                 !Interrupt on either edge transition
80  OUTPUT 709;"ENABLE INTR"               !Enable accessory to interrupt
90  OUTPUT 709;"ENABLE INTR SYS"           !Enable mainframe to sense interrupt
100 GOTO 100                               !Loop until SRQ occurs
110 Results: !                             !Start controller subroutine
120 OUTPUT 709;"TIME"                      !Query time of day
130 ENTER 709;T                            !Enter time of day
140 PRINT "Slot 200 intr @ ";TIME$(T)      !Display interrupt time/message
150 A=SPOLL(709)                           !Read/clear SRQ bit
160 STOP                                   !End controller subroutine
170 END
```

When an HL or LH edge occurs on any input channel, an edge interrupt occurs and the controller queries the time of day and enters the time of the interrupt. A typical return is:

```
Slot 200 intr @ 02:46:50
```

Pattern Interrupts (PATTERN)

When enabled by ENABLE INTR, the PATTERN command can be used to generate a pattern interrupt when a specified state occurs on the digital input channels.

Setting Pattern Interrupts (PATTERN)

For USE *ch* = ES90 when enabled by the ENABLE INTR command, PATTERN [*mode*] *pattern* [*mask*] [USE *ch*] specifies the input channel bit pattern and mask which will generate a pattern interrupt. Table 3-7 summarizes the PATTERN command parameters.

Table 3-7. PATTERN Parameters

mode	Sets the pattern interrupt mode. Modes are EQU (power-on, reset, and default) and NEQ. When enabled, *mode* = EQU generates a pattern interrupt when the input channel bit pattern for the channels specified by *mask* is the same as the bit pattern specified by *pattern*. When enabled, *mode* = NEQ generates a pattern interrupt when the input channel bit pattern for the channels specified by *mask* is not the same as the bit pattern specified by *pattern*.
pattern	Sets the bit pattern required to generate a pattern interrupt when enabled. Power-on and reset *pattern* = 0.
mask	Sets the mask for pattern interrupts. A 1 bit in the mask includes the corresponding channel in the pattern, while a 0 bit omits the channel. Power-on and reset *mask* = 0. Default *mask* = -1 (all channels included).
USE *ch*	For *ch* = ES90, sets the HP 44723A in the slot specified by ES for pattern interrupt.

Example: Setting PATTERN Parameters

For example, we want to generate a pattern interrupt for an HP 44723A in slot 0 of the mainframe when channels 2 and 11 states are HIGH and channel 6 state is LOW. The bit pattern required is xxxx 1xxx x0xx x1xx (channels 2 and 11 HIGH, channel 6 LOW, and a "don't care" state for the other channels). Figure 3-7 shows the settings for the *mask*, *pattern*, and *mode* parameters.

Since only the states of channels 2, 6, and 11 are of concern for this example, the *mask* parameter will be set for 2116 which is the decimal equivalent of 0000 1000 0100 0100. Since a "1" bit in *mask* includes the channel in the pattern, while a "0" bit omits the channel, only the channel 2, 6, and 11 states will be compared with the *pattern* parameter. That is, only the channel 2, 6, and 11 states will "pass through" the mask set by *mask*.

For this example, *mode* will be set for EQU. Then, when the states of the input channels specified by *mask* match the pattern set by *pattern*, since ENABLE INTR USE 90 is set, a pattern interrupt will be generated. To set the pattern required, we will use 2052 for *pattern* which is the decimal equivalent of 0000 1000 0000 0100. (We could have used any decimal value which is the equivalent of xxxx 1xxx x0xx x1xx.)

Then, when the input channel states are xxxx 1xxx x0xx x1xx (channels 2 and 11 HIGH and channel 6 LOW), a pattern interrupt will be generated. Refer to "Example: Enable Pattern Interrupt" for a typical program to generate a pattern interrupt.

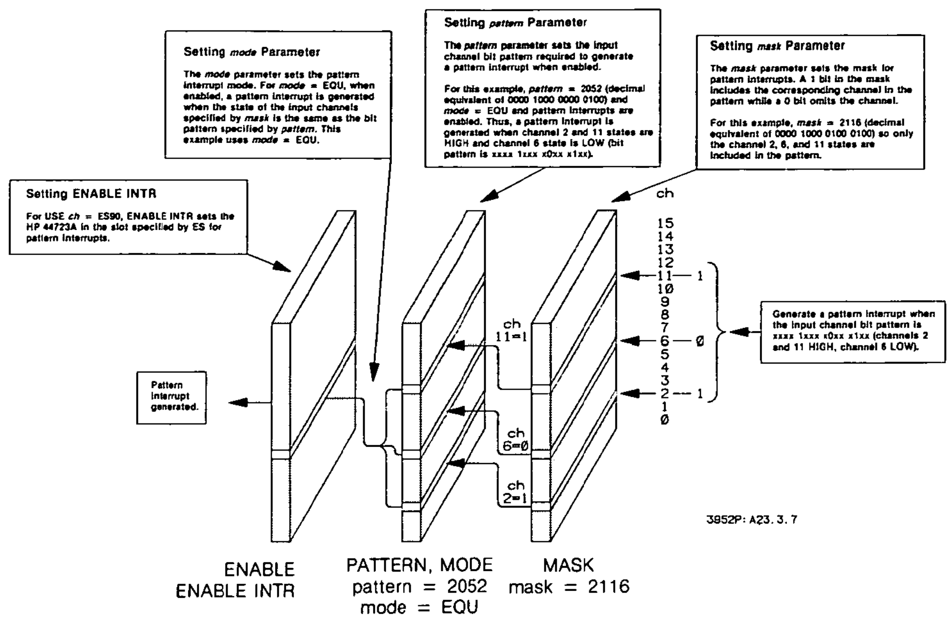

Figure 3-7. Example: Setting PATTERN Parameters

Pattern Interrupt Actions

Table 3-8 summarizes the PATTERN and ENABLE INTR actions for pattern interrupts. ENABLE INTR and USE ES90 must be set for a pattern edge interrupt to occur. Pattern interrupts are cleared and disabled when serviced by the mainframe or by the DISABLE INTR command.

Table 3-8. Pattern Interrupt Actions

USE *ch*	PATTERN	ENABLE INTR
ES90	When enabled, for *mode* = EQU, PATTERN generates a pattern interrupt when the bit pattern for the channels specified by *mask* is the same as the bit pattern set by *pattern*. When enabled, for *mode* = NEQ, PATTERN generates a pattern interrupt when the bit pattern for the channels specified by *mask* is not the same as the bit pattern set by *pattern*.	Enables a pattern interrupt when user inputs match the mode/pattern mask conditions set by PATTERN. ENABLE INTR clears any pending pattern interrupts on all input channels.

Example: Enable Pattern Interrupt

This program enables an HP 44723A in slot 2 of the mainframe to generate a pattern interrupt on input channel pattern xxxx 1111 xxxx 0000. The *pattern* parameter is set for 0000 1111 0000 0000 (3840), the *mask* parameter is set for 0000 1111 0000 1111 (3855), and the *mode* parameter is set for EQU (equal). Since the mask enables only channels 200 through 203 and 208 through 211, when the input channel bit pattern is xxxx 1111 xxxx 0000, a pattern interrupt is generated.

The program loops until an SRQ is generated. When the input channel states matches the pattern set, a pattern interrupt occurs which generates the SRQ. The interrupt is serviced by controller subroutine Results. When the program completes, the time of the interrupt is displayed.

When the interrupt occurs, the HP-IB SRQ line is set TRUE and an SRQ is sent to the controller. Also, the INTR bit (bit 9) and the service request bit (bit 6) in the status register are set. Because the interrupt is handled by the controller, both bits must be cleared (STA? clears bit 9, SPOLL clears bit 6) before the controller can respond to the next interrupt that occurs.

```
10  ON INTR 7 GOTO Results                 !Call sub on interrupt
20  ENABLE INTR 7;2                        !Enable controller intr on SRQ
30  OUTPUT 709;"USE 290"                   !Set for pattern interrupt
40  OUTPUT 709;"RQS ON;RQS INTR"           !Enable interrupt on SRQ
50  OUTPUT 709;"STA?"                      !Clear FPS,LCL,INTR,LMT,ALRM bits
60  OUTPUT 709;"CLROUT"                    !Clear STA? data from output buffer
70  OUTPUT 709;"PATTERN EQU,3840,3855"     !Set pattern for interrupt
80  OUTPUT 709;"ENABLE INTR"               !Enable accessory to interrupt
90  OUTPUT 709;"ENABLE INTR SYS"           !Enable mainframe to sense intr
100 GOTO 100                               !Loop until interrupt occurs
110 Results: !                             !Start controller subroutine
120 OUTPUT 709;"TIME"                      !Query time of day
130 ENTER 709;T                            !Enter time of day
140 PRINT "Slot 200 intr @ ";TIME$(T)      !Display interrupt time/message
150 A=SPOLL(709)                           !Read/clear SRQ bit
160 STOP                                   !End controller subroutine
170 END
```

When the interrupt occurs (input channel states match the pattern/mask), an interrupt is generated and the controller queries the time of day and enters the time. A typical return is:

```
Slot 200 intr @ 02:46:50
```

Input Interrupts (ENABLE INTR)

As noted, three types of interrupts can be generated for input channels: edge, pattern, and input. When enabled, an input interrupt is generated when a valid first rank input trigger is received (and "new data" are therefore stored in the first rank input register) and is cleared by a second rank input trigger.

Enabling Input Interrupts

For USE *ch* = ES91, when enabled, an input interrupt occurs when a valid first rank input trigger occurs. For TRIGMODE ALL, any first rank trigger is a "valid" trigger. However, for TRIGMODE FIRST, only the first first rank input trigger received after a second rank input trigger is a "valid" trigger.

To enable an input interrupt, use ENABLE INTR and USE *ch* = ES91. In contrast to edge and pattern interrupts, DISABLE INTR disables but does NOT clear input interrupts. Input interrupts are cleared ONLY by a second rank input trigger.

Input interrupts cannot be enabled if SRTRIG EXT or SRTRIG SYS is set for the second rank input register, and vice-versa. Enabling input interrupts results in an immediate interrupt: (a) after a TEST *slot* command; or (b) if a first rank input trigger without a corresponding second rank input trigger was previously received.

Example: Enable Input Interrupt

This program enables an HP 44723A in slot 2 of the mainframe to generate input interrupts when external (HL) triggers are input to the first rank input trigger terminal (1ST IN TRIG IN terminal). The program loops until an SRQ is generated. When 10 input triggers have been received (and 10 input interrupts generated), an SRQ is sent to the controller and the interrupt times and channel states are displayed. The sequence of operation follows.

(a) First External Input Trigger:

When the first external input trigger is received, the channel states are entered into the first rank input register, an input interrupt is generated, and mainframe subroutine DTA is called. Then, the time of the first input interrupt is stored in mainframe array T and the channel state at the time of the interrupt is stored in mainframe array A.

(b) Second Through Tenth Input Triggers:

When the second, third, ..., tenth external input trigger is received, the cycle in (a) is repeated for each trigger. When 10 input triggers have been received, an SRQ is generated and controller subroutine Read_in is called. The 10 values in T and the 10 values in A are sent to the output buffer and then to the controller and displayed. (Note that 10 separate external triggers are required before an SRQ is generated.)

NOTE

To avoid generating an immediate input interrupt when the program executes, the external trigger source must be set HIGH before the program is run. Input interrupts are then generated when the source goes from HIGH to LOW.

```
10    REAL T(9)                             !Dim T as REAL array
20    INTEGER A(9)                          !Dim A as INTEGER array
30    CLEAR 709                             !Clear interface
40    OUTPUT 709;"RST"                      !Reset HP 3852A
50    ON INTR 7 GOTO Read_in                !Go to Read_in on intr
60    ENABLE INTR 7;2                       !Enable interface
70    OUTPUT 709;"RQS ON;RQS DAV"           !Send SRQ on data avail
80    OUTPUT 709;"OUTBUF ON"                !Set output buffer ON
90    OUTPUT 709;"REAL T(9)"                !Define T as REAL array
100   OUTPUT 709;"INTEGER A(9),I"           !Define A, I as INTEGER
110   OUTPUT 709;"SUB DTA"                  !Start subroutine
120   OUTPUT 709;"TIME INTO T"              !Read time, store in T
130   OUTPUT 709;"READ 200 INTO A"          !Read state, store in A
140   OUTPUT 709;"IF I=9 THEN"              !Start read routine
150   OUTPUT 709;" VREAD T"                 !Trans time to out buffer
160   OUTPUT 709;" VREAD A"                 !Trans state to out buffer
170   OUTPUT 709;"ELSE"                     !Decision point
180   OUTPUT 709;" I=I+1"                   !Increment count
190   OUTPUT 709;" ENABLE INTR USE 291"     !Enable input interrupt
200   OUTPUT 709;"END IF"                   !End read routine
210   OUTPUT 709;"SUBEND"                   !End subroutine
220   OUTPUT 709;"TRIG EXT USE 200"         !Ext first rank input trig
230   OUTPUT 709;"ON INTR USE 291 CALL DTA" !Call sub on interrupt
240   OUTPUT 709;"ENABLE INTR USE 291"      !Enable input interrupt
250   OUTPUT 709;"ENABLE INTR SYS"          !Enable mf intr capability
```

```
260 Idle:GOTO Idle                      !Loop until interrupt
270     !
280 Read_in: !                          !Start controller sub
290     ENTER 709;T(*)                  !Enter interrupt times
300     ENTER 709;A(*)                  !Enter slot states
310     FOR I=0 TO 9                    !Start print loop
320         PRINT TIME$(T(I)),A(I)      !Disp intr times, ch states
330     NEXT I                          !Increment count
340     STOP                            !End controller sub
350     END
```

After the tenth input interrupt occurs (tenth HL edge into the 1ST IN TRIG IN terminal), the controller displays the time of day and the input channel states for each of the ten interrupts. A typical return is:

```
03:45:17   65 ]
03:48:29    8 ]     10 readings
    .         ]
    .         ]
03:55:01   20 ]
```

Chapter 4
Programming Digital Output Channels

Contents

Chapter 4

Programming Digital Output Channels

Introduction

This chapter shows how to program HP 44723A digital output channels. Refer to Chapter 3 - Programming Digital Input Channels to program HP 44723A digital input channels. The chapter has three sections:

- **Digital Output Writes** shows how to write desired states to a single digital output channel, to a specified list of channels, to a single slot, or to multiple slots. Use this section to write data to set output channel states.

- **Digital Output Triggering** describes triggering methods for the digital output channels. It lists sources for second rank output triggers; shows output channel write modes; and shows how to use trigger outputs. Use this section to set alternate trigger sources/modes for the output channels or to generate trigger outputs.

- **Digital Output Interrupts** shows how to set output interrupts for the output channels. Use this section to set desired interrupts for digital output channels.

Digital Output Writes

The HP 44723A digital output channels output a HIGH or LOW level to user circuits connected to the channels and, if enabled, generate interrupts for specified conditions. This section shows how to write data to set output channel states with CHWRITE, CHWRITEM, WRITE, or WRITEM.

NOTE

Refer to "Digital Output Triggering" to select second rank output trigger sources, to set output channel trigger/readings modes, or to use second rank trigger outputs. Refer to "Digital Output Interrupts" to enable output interrupts.

Making Channel Writes

The HP 44723A has a first rank output register and a second rank output register which are used with the 16 digital output channels (see Figure 1-2). For USE *ch* = ES16-ES31, the CHWRITE command can be used to write data to the first rank output register for a specified channel or the CHWRITEM command can be used to write data for a specified list of channels.

Single Channel Writes (CHWRITE)

For USE *ch* = ES16-ES31, CHWRITE *ch state* writes the state specified by *state* to the output channel specified by *ch*. The state is always written to the first rank output register. Any nonzero integer for *state* between −32768 and +32767 is interpreted as a 1 (HIGH), while zero is interpreted as a 0 (LOW).

Since CHWRITE writes data to the first rank output register, a second rank output trigger is required to copy the data from the first rank output register to the second rank register and to the user output terminals.

When a second rank output trigger is received (from the source set by the SRTRIG command), the contents of the first rank output register are copied to the second rank output register and to the user output terminals.

For an internal second rank output trigger source (SRTRIG INT), a second rank output trigger is generated immediately after a write to the first rank output register.

Example: Write to Single Channel

This program sets channel 219 of an HP 44723A in slot 2 of the mainframe HIGH. When CHWRITE is executed, a "1" (set channel 219 HIGH) is written to the first rank output register. Then, since internal second rank output triggering is set (SRTRIG INT), a second rank output trigger is generated and the first rank output register contents are immediately copied to the second rank input register and to the user output terminals.

```
10 OUTPUT 709;"USE 219"                  !Use ch is 219
20 OUTPUT 709;"SRTRIG INT"               !Immed copy data to sec rank output reg
30 OUTPUT 709;"CHWRITE 219,1"            !Write "1" to first rank output reg
40 END
```

Multiple Channel Writes (CHWRITEM)

CHWRITEM is similar to CHWRITE, except that CHWRITEM writes to the output channel(s) for a specified channel list. For USE *ch* = ES16-ES31, CHWRITEM *ch_list* DATA *state_list* writes the state (1 for channel HIGH or 0 for channel LOW) to each of the channel(s) specified in *ch_list*. As with CHWRITE, CHWRITEM writes the state to the first rank output register.

There is one DATA *state_list* for each channel OR range of channels specified in *ch_list*. For example, in CHWRITEM 216,219,222-225 DATA 1,1,0 the first "1" in the DATA *state_list* parameter applies to channel 216, the second "1" to channel 219, and the "0" to channels 222 through 225.

Since CHWRITEM writes data to the first rank output register, a second rank output trigger is required to copy data from the first rank output register to the second rank output register and to the user output terminals.

If the second rank output trigger source is set for internal (SRTRIG INT), a second rank output trigger is generated immediately after a write to the first rank output register.

Example: Write to Multiple Channels

This program sets channels 216 and 219 HIGH and sets channels 222 through 225 LOW for an HP 44723A in slot 2 of the mainframe. Note that the first "1" in the DATA *state_list* parameter applies to channel 216, the second "1" to channel 219, and the "0" to channels 222 through 225. Since SRTRIG INT is set, the new channel states are immediately copied to the second rank output register and to the user output terminals.

```
10 OUTPUT 709;"USE 216"                                 !Use channel is 216
20 OUTPUT 709;"SRTRIG INT"                              !Trans data on CHWRITEM
30 OUTPUT 709;"CHWRITEM 216,219,222-225 DATA 1,1,0"     !Write data
40 END
```

Making Slot Writes

The WRITE command writes the states for output channels in a specified slot, while the WRITEM command writes the states for output channels in one or more specified slots. As with CHWRITE and CHWRITEM, WRITE and WRITEM write to the first rank output register. In addition, the WRITE command can be used for high-speed writes (at rates up to 189,000 transitions/second) to a slot.

NOTE

The write mode for WRITE and WRITEM may be affected by the SRTRIG and RDGSMODE command settings. Refer to "Digital Output Triggering" for details. In this section, power-on/reset conditions (RDGSMODE IMMED and SRTRIG INT) are assumed unless otherwise specified.

Single Slot Writes (WRITE)

The WRITE command can be used to write data to the output channels at rates up to 189,000 transitions/second. For USE *ch* = ES16-ES31, the WRITE *slot data_list* or *array* command writes data to the first rank output register in the slot specified by *slot*.

Using the WRITE *data_list* Parameter

If the *data_list* parameter is specified, WRITE writes the decimal equivalent of the desired state of the output channels in the slot specified by *slot*. The LSB goes to channel ES16, the MSB to channel ES31. A "0" sets the channel LOW, a "1" sets the channel HIGH.

For example, WRITE 200,5 writes 0000 0000 0000 0101 to the first rank output register of an HP 44723A in slot 2 of the mainframe. When a second rank output trigger is received, this state is copied to the second rank output register and to the output terminals to set channels 216 and 218 HIGH and set the rest of the channels in slot 200 LOW.

Using the WRITE *array* Parameter

The WRITE *array* parameter can be used for high-speed writes to a slot (up to 189,000 transitions/second), where *array* is a mainframe memory INTEGER array. The *array* parameter defines an array of decimal equivalent values to be written to the slot specified by *slot*. Refer to "Example: High-Speed Write to Slot" for an example program to write data to arrays.

NOTE

REAL arrays can also be used, but write speed will be lower than for INTEGER arrays.

Interaction With SRTRIG

Since WRITE writes data to the first rank output register, a second rank output trigger (from the source set by SRTRIG) is required to copy the data from the first rank output register to the second rank output register and to the output terminals. If SRTRIG INT is set, a second rank output trigger is generated immediately after data is written to the first rank output register.

Interaction with RDGSMODE

With RDGSMODE IMMED, WRITE always immediately writes data to the first rank output register. Thus, multiple writes without intervening second rank triggers will overwrite the first rank register contents.

With RDGSMODE DAV, WRITE waits to write data to the first rank output register until a second rank output trigger is received after the last write. That is, with RDGSMODE DAV, WRITE waits for second rank output triggers between writes. (If SRTRIG INT is set with RDGSMODE DAV, the WRITE operation for RDGSMODE DAV is the same as that for RDGSMODE IMMED.)

Example: Write Data to Slot

This program writes data to the first rank output register to set the states of all output channels of an HP 44723A in slot 2 of the mainframe. WRITE 200,545 (line 40) sets channels 216, 221, and 225 HIGH and sets the rest of the channels in slot 200 LOW. Since RDGSMODE IMMED is set, WRITE immediately writes data to the first rank output register. Since SRTRIG INT is set, the new states are then automatically copied to the second rank output register and to the user output terminals.

```
10 OUTPUT 709;"USE 216"             !Use ch is 216
20 OUTPUT 709;"RDGSMODE IMMED"      !Write data immediately
30 OUTPUT 709;"SRTRIG INT"          !Copy data to output terminals
40 OUTPUT 709;"WRITE 200,545"       !Write data to first rank out reg
50 END
```

Example: High-Speed Write to Slot

This program writes the four bit patterns shown to the output channels of an HP 44723A in slot 2 of the mainframe 1000 times at rates up to 189,000 writes/sec. The decimal equivalents of the bit patterns (65, 136, −32768, and 2) are first written to mainframe array A (using subroutine WRTE) and are then output to the user terminals at an approximate 189 kHz rate with WRITE. The following bit patterns are output 1000 times. (Note that data storage in a mainframe INTEGER array is necessary to achieve the maximum write rate.)

```
Output State 1 (65)      = 0000 0000 0100 0001 ┐
Output State 2 (136)     = 0000 0000 1000 1000 │  1000 times
Output State 3 (-32768)  = 1000 0000 0000 0000 │
Output State 4 (2)       = 0000 0000 0000 0010 ┘
```

```
10  OUTPUT 709;"RST"                          !Reset HP 3852A
20  OUTPUT 709;"INTEGER A(3999),I"            !Define INTEGER array, variable
30  OUTPUT 709;"SUB WRTE"                     !Begin subroutine
40  OUTPUT 709;"FOR I=0 TO 3999 STEP 4"       !Begin data storage loop
50  OUTPUT 709;"A(I)=65"                      !Store output state 1
60  OUTPUT 709;"A(I+1)=136"                   !Store output state 2
70  OUTPUT 709;"A(I+2)=-32768"                !Store output state 3
80  OUTPUT 709;"A(I+3)=2"                     !Store output state 4
90  OUTPUT 709;"NEXT I"                       !Increment count
100 OUTPUT 709;"SUBEND"                       !End subroutine
110 OUTPUT 709;"DISP OFF"                     !Turn display OFF
120 OUTPUT 709;"CALL WRTE"                    !Call subroutine
130 OUTPUT 709;"SRTRIG INT USE 216"           !Internal sec rank out trigger
140 OUTPUT 709;"WRITE 200 A"                  !Write states to output chs
150 OUTPUT 709;"BEEP"                         !Signal end of write
160 END
```

Multiple Slot Writes (WRITEM)

The WRITEM *slot_list* DATA *data_list* command can be used to write data to the first rank output register(s) in the slot(s) specified by *slot_list*. A second rank output trigger (from the source specified by SRTRIG) is required to copy the first rank output register contents to the second rank output register and to the user output channels.

Using the DATA *data_list* Parameter

The DATA *data_list* parameter sets the decimal equivalent of the state to be written to the channels in the slot(s) specified by *slot_list*. The LSB goes to channel ES16, the MSB to channel ES31. A "0" sets the channel LOW, a "1" sets the channel HIGH.

For example, for HP 44723A accessories in mainframe slots 2 and 3, with the command WRITEM 200,300 DATA 322,2, the "322" parameter sets channels 217, 222, and 224 HIGH and sets the rest of the channels in slot 200 LOW. The "2" parameter sets channel 317 HIGH and the rest of the channels in slot 300 LOW.

There must be a single DATA *data_list* parameter for each slot OR sequence of slots in the *slot_list* parameter. For example, WRITEM 200,300 DATA 5,32 or WRITEM 200-400 DATA 5,32,65 are valid commands since there is a single DATA *data_list* parameter for each slot or or sequence of slots in *slot_list*. However, WRITEM 200,300 DATA 5,32,65 generates an error (ERROR 21 - WRITEM: TOO MANY ARGUMENTS) since there are two *slot_list* entries, but three DATA *data_list* entries.

Interaction with SRTRIG

The WRITEM command always writes data to the first rank output register(s). If SRTRIG INT is set, a second rank output trigger is generated immediately after WRITEM writes data to the first rank output register(s) in the slot(s) specified.

Interaction with RDGSMODE

With RDGSMODE IMMED, WRITEM always immediately writes data to the first rank output register(s). Thus, multiple writes to a slot without intervening second rank output triggers will overwrite the first rank output register contents.

With RDGSMODE DAV, WRITEM waits to write data to the first rank output register(s) until a second rank output trigger is received after the last write. That is, with RDGSMODE DAV, WRITEM waits for second rank output triggers between writes to an individual slot. If SRTRIG INT is set with RDGSMODE DAV, WRITEM operation for RDGSMODE DAV is the same as for RDGSMODE IMMED.

Example: Write to Multiple Slots

This program writes data to the first rank output registers to set the state of all output channels of HP 44723A accessories in slots 2 and 3 of the mainframe. Writing "322" sets channels 217, 222, and 224 HIGH and sets the rest of the channels in slot 2 LOW. Writing "−32735" sets channels 316, 321, and 331 HIGH and sets the rest of the channels in slot 3 LOW.

Since RDGSMODE IMMED and SRTRIG INT are set for both slots, when the WRITEM command is executed, data is immediately written to the first rank output register in each slot and then copied to the second rank output registers and to the output channels.

```
10 OUTPUT 709;"USE 200"                          !Use slot is 200
20 OUTPUT 709;"RDGSMODE IMMED"                   !Write data immediately
30 OUTPUT 709;"SRTRIG INT"                       !Int sec rank out trig
40 OUTPUT 709;"USE 300"                          !Use slot is 300
50 OUTPUT 709;"RDGSMODE IMMED"                   !Write data immediately
60 OUTPUT 709;"SRTRIG INT"                       !Int sec rank out trig
70 OUTPUT 709;"WRITEM 200,300 DATA 322,-32735"   !Write data to slots
80 END
```

Digital Output Triggering

This section shows how to select second rank output trigger sources with STRIG, how to select the mode for output channel writes with RDGSMODE, and how to use TRIGMODE to set output trigger modes.

Second Rank Output Trigger (SRTRIG)

For USE *ch* = ES16-ES31, SRTRIG [*source*] [USE *ch*] sets the source for second rank output triggers. When a second rank output trigger is received from the source set by SRTRIG, the contents of the first rank output register are copied to the second rank output register and to the user output terminals.

Table 4-1 shows the SRTRIG parameters for output channels. The power-on/reset value = SRTRIG INT and default value = SRTRIG SGL. Descriptions of SRTRIG *source* parameters for digital output channels follow.

NOTE

1. For USE ch = ES00-ES15, SRTRIG sets the source for second rank input triggers used with digital input channels. Refer to Chapter 3 - Programming Digital Input Channels for details.

2. For USE ch = ES16-ES31, changing the SRTRIG source may generate a second rank output trigger.

Table 4-1. SRTRIG *source* Parameters

source/mode	Description
HOLD	No second rank output triggering.
EXT	Terminal module external trigger input. [1]
INT	Trigger when a write command is executed. [2]
SGL	Immediate single trigger when command executes.
SYS	System trigger (used with TRG command).

[1] = Input to second rank output trigger terminal (2ND OUT TRIG).

[2] = Power-on/reset state. The write commands are CHWRITE, CHWRITEM, WRITE, and WRITEM.

SRTRIG HOLD

For USE *ch* = ES16-ES31, with SRTRIG HOLD, no second rank output triggers are generated. Therefore, multiple write commands (CHWRITE, CHWRITEM, WRITE, or WRITEM) on a slot will overwrite the first rank output register contents.

SRTRIG EXT

For USE *ch* = ES16-ES31, with SRTRIG EXT, the second rank output trigger IN terminal (2ND OUT TRIG IN terminal) is the source for second rank output triggers. With SRTRIG EXT, when a high-to-low (HL) pulse is input to the 2ND OUT TRIG IN terminal, a second rank output trigger is generated.

SRTRIG INT

For USE *ch* = ES16-ES31, with SRTRIG INT, a write command (CHWRITE, CHWRITEM, WRITE, or WRITEM) generates a second rank output trigger as part of the command execution. For example, with SRTRIG INT, when CHWRITE is executed, an immediate write is made to the first rank output register. The first rank output register contents are then copied to the second rank output register and to the user output terminals.

NOTE

Setting SRTRIG INT does NOT generate a second rank output trigger. The trigger is generated only when a write command is executed.

SRTRIG SGL

For USE *ch* = ES16-ES31, with SRTRIG SGL, a single second rank output trigger is generated immediately when the command is executed.

SRTRIG SYS

For USE *ch* = ES16-ES31, with SRTRIG SYS, a single second rank output trigger is generated when a trigger from the source specified by the TRG command occurs. Refer to the HP 3852A Mainframe Configuration and Programming Manual for details on the TRG command.

Example: Second Rank Output Triggering

This program uses both internal and external second rank output triggering to write a known state to the output channels of an HP 44723A in slot 2 of the mainframe. The program demonstrates one way to output a known state to the user terminals and then store a second state to be output when an external signal is received.

- Output New State Immediately:

In line 20, WRITE 200,34 sets channels 217 and 221 states HIGH and the other channel states LOW. If power-on/reset conditions are assumed, RDGSMODE IMMED and SRTRIG INT are set, so the new state is immediately written to the first rank output register and copied to the second rank output register and to the output terminals.

- Store New State - Output on External Signal:

In line 40, since RDGSMODE IMMED is set, WRITE 200,20 immediately writes new state "20" (channels 218 and 220 states HIGH) to the first rank output register. However, the new state is not copied to the second rank output register and to the output terminals until an external (HL) signal is received at the second rank output trigger IN terminal (2ND OUT TRIG IN) to generate the second rank output trigger.

Therefore, the HP 44723A is set to a known output state (channels 217 and 221 states HIGH) until an external second rank output trigger is received. At that time, the new state (channels 218 and 220 states HIGH) stored in the HP 44723A is output to the user terminals.

```
10 OUTPUT 709;"USE 216"          !Use ch is 200
20 OUTPUT 709;"WRITE 200,34"     !Set ch 217 and 221 HIGH
30 OUTPUT 709;"SRTRIG EXT"       !Set external sec rank output trigger
40 OUTPUT 709;"WRITE 200,20"     !Set ch 218, 220 HIGH on sec rank out trig
50 END
```

Output Write Mode (RDGSMODE)

For USE *ch* = ES16-ES31, the RDGSMODE *mode* [USE *ch*] command sets the mode of operation for the WRITE and WRITEM commands. Valid *mode* = DAV or IMMED (power-on/reset). Specifying any output channel (ES16 - ES31) sets the mode for WRITE and WRITEM. (RDGSMODE does not affect CHWRITE or CHWRITEM).

RDGSMODE IMMED Operation

With RDGSMODE IMMED, a WRITE or WRITEM command **always** immediately writes data to the first rank output register. Therefore, with RDGSMODE IMMED, WRITE or WRITEM may overwrite the contents of the first rank output register. Although WRITE or WRITEM immediately writes data to the first rank output register, the contents are not copied to the second rank register and to the user output terminals until a second rank output trigger is received from the SRTRIG source.

RDGSMODE DAV Operation

With RDGSMODE DAV, if the last data written to the first rank output register have not been copied to the second rank output register, WRITE or WRITEM waits until a second rank output trigger is received before writing new data.

If SRTRIG INT is set when RDGSMODE DAV is set, WRITE or WRITEM immediately writes data to the first rank output register, since WRITE or WRITEM generates the required second rank output trigger. Therefore, WRITE or WRITEM operation for RDGSMODE DAV and SRTRIG INT is the same as operation for RDGSMODE IMMED.

Second Rank Trigger Output (TRIGMODE)

For USE *ch* = ES16-ES31, the TRIGMODE *mode* [USE *ch*] command selects the mode for the trigger output from the second rank output trigger OUT terminal (2ND OUT TRIG OUT terminal). TRIGMODE has two *mode* parameters: FIRST or ALL (power-on/reset).

Figure 4-1 shows the output from the 2ND OUT TRIG OUT terminal for TRIGMODE FIRST and TRIGMODE ALL. Although Figure 4-1 shows only an external input into the IN terminal, the second rank trigger outputs shown occur when a second rank output trigger is generated from ANY valid source (INT, EXT, SGL, or SYS).

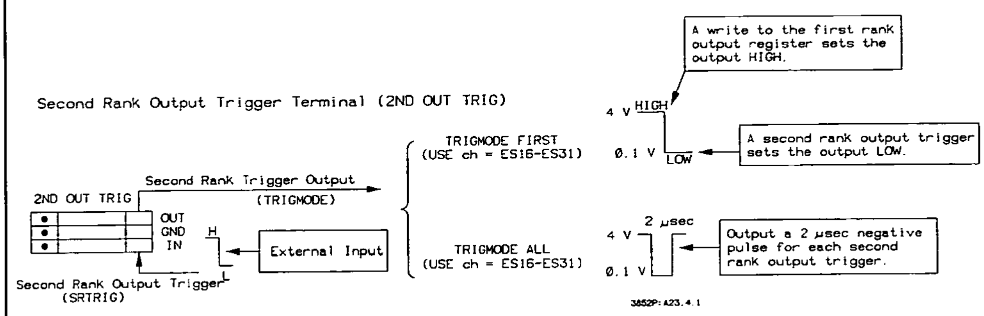

Figure 4-1. Output Channels Trigger Modes

TRIGMODE FIRST Output

With TRIGMODE FIRST, the output level from the 2ND OUT TRIG OUT terminal is set HIGH by a write to the first rank output register (with CHWRITE, CHWRITEM, WRITE, or WRITEM) and is set LOW by a second rank output trigger. Thus, a negative edge is produced only by the first second rank output trigger received after a write. This trigger output level may be used for applications such as synchronizing data writes to an external device.

TRIGMODE ALL Output

With TRIGMODE ALL, each second rank output trigger causes the 2ND OUT TRIG OUT terminal to source a 2 μsec negative pulse which may be used for synchronizing multiple accessories or for timing.

NOTE

2 μsec is a nominal value for the trigger output pulse width. Typical range of values is from 1.7 μsec to 2.8 μsec.

Example: Synchronize Multiple Accessory Writes

This program writes new data to HP 44723As in mainframe slots 100, 200, and 300 and then simultaneously outputs the new states to user circuits. The 2ND OUT TRIG OUT terminal in slot 300 must be connected to the 2ND OUT TRIG IN terminals in slots 100 and 200, as shown in Figure 4-2. Also, the 2ND OUT TRIG IN jumpers for slots 100 and 200 must be set to 5V.

In the program, the WRITEM command first writes the desired output channel states (5, 65, 8) to the first rank output registers in slots 100, 200, and 300. These states are then simultaneously output to user circuits. The sequence of operation follows.

(a) Write States to Output Registers:

Since RDGSMODE IMMED is set, the WRITEM command immediately writes the new output states (5, 65, 8) to the first rank output registers in slots 100, 200, and 300.

(b) Copy State to Slot 300 Output Channels:

Since SRTRIG INT is set for slot 300, when the write to slot 300 occurs, a second rank output trigger is generated and the new state is copied to the second rank output register and the output channels.

(c) Generate Second Rank Trigger Output:

When the second rank output trigger occurs on slot 300, since TRIGMODE ALL is set a 2 μsec pulse is output from the 2ND OUT TRIG OUT terminal in slot 300 and is sent to the 2ND OUT TRIG IN terminals in slots 100 and 200.

(d) Copy States to Slots 100 and 200 Output Channels:

Since SRTRIG EXT is set for slots 100 and 200, the 2 μsec trigger output from slot 300 generates second rank output triggers for slots 100 and 200 which immediately copies the new states for these slots to the second rank output registers and to the output channels.

The result is that the new output states (5, 65, 8) are first written to the first rank output registers with the WRITEM command and are then simultaneously copied to the second rank output registers and to the output channels in slots 100, 200, and 300.

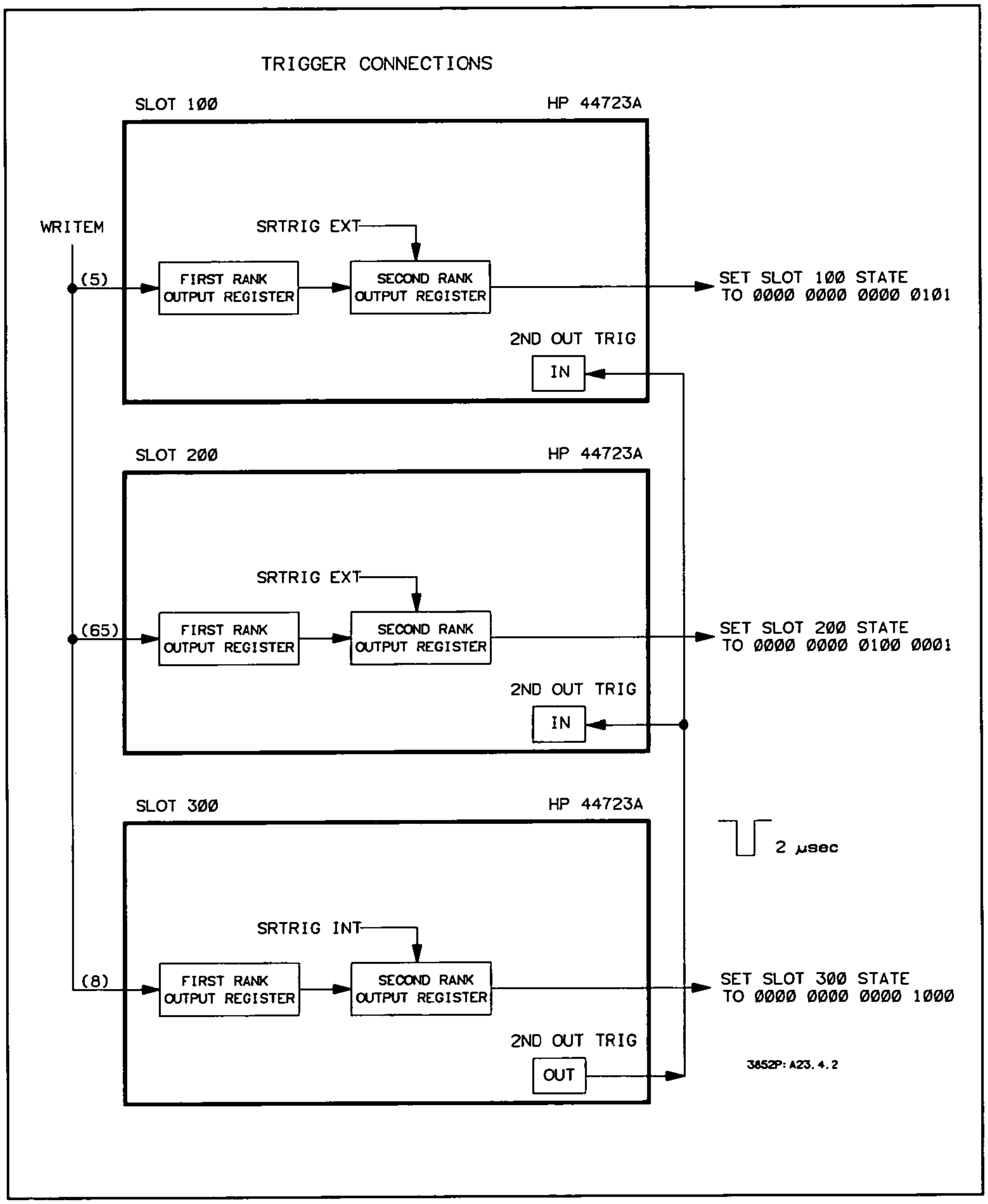

Figure 4-2. Example: Synchronize Multiple Accessory Writes

```
10  OUTPUT 709;"USE 116"                          !Use ch is 116
20  OUTPUT 709;"RDGSMODE IMMED"                   !Immed write to slot 100
30  OUTPUT 709;"SRTRIG EXT"                       !Ext sec rank out trig source
40  OUTPUT 709;"USE 216"                          !Use ch is 216
50  OUTPUT 709;"RDGSMODE IMMED"                   !Immed write to slot 200
60  OUTPUT 709;"SRTRIG EXT"                       !Ext sec rank out trig source
70  OUTPUT 709;"USE 316"                          !Use ch is 316
80  OUTPUT 709;"RDGSMODE IMMED"                   !Immed write to slot 300
90  OUTPUT 709;"TRIGMODE ALL"                     !2 μsec pulse out on SRTRIG
100 OUTPUT 709;"SRTRIG INT"                       !Int sec rank out trig source
110 OUTPUT 709;"WRITEM 100-300 DATA 5,65,8"       !Write states to registers
120 END
```

Digital Output Interrupts

The only type of interrupt which can be enabled for digital output channels is the output interrupt. When enabled, an output interrupt is generated when a second rank output trigger is received.

Enable Output Interrupts (ENABLE INTR)

For USE *ch* = ES92, when enabled by ENABLE INTR, output interrupts occur when a second rank output trigger is received from the source set by SRTRIG. Output interrupts are cleared by a write to the first rank output register (with CHWRITE, CHWRITEM, WRITE, or WRITEM).

Enabling Output Interrupts

Enabling output interrupts results in an immediate interrupt: (a) at power-on; (b) after RST or RST *slot* is executed; or (c) if the last data written to the first rank output register (with CHWRITE, CHWRITEM, WRITE, or WRITEM) have been transferred to the second rank output register by a second rank output trigger.

Example: Enable Output Interrupt

This program generates an output interrupt and writes a new state to the output channels of an HP 44723A in mainframe slot 2 when an external (HL) trigger is input to the 2ND OUT TRIG IN terminal. (Refer to Chapter 2 for typical connections to the 2ND OUT TRIG IN terminal.) The sequence of operation is:

(a) Write Data to Mainframe Array:

When the program executes, ten output states (-4, -3,...,5) are written to mainframe array A with the VWRITE command. Also, since output interrupts are enabled, an immediate output interrupt is generated (by RST) which calls subroutine OUTINTR. The WRITE command then writes the first output state (-4) to the first rank output register.

(b) Copy Data to Output Channels:

Since SRTRIG EXT is set, when the first external trigger is received at the 2ND OUT TRIG IN terminal, a second rank output trigger is generated which copies the first state (-4) stored in the first rank output register to the second rank output register and to the output channels.

Also, since the WRITE command clears the output interrupt, the interrupt is reenabled with ENABLE INTR (line 170). Each successive external trigger causes the next state to be written to the output channels using this procedure, until nine triggers have been received.

(c) Transfer Interrupt Times to Controller:

The progam loops (at Idle) until nine external triggers are received at the 2ND OUT TRIG IN terminal. After nine triggers have been received, VREAD transfers the ten interrupt times to the output buffer. In addition, an SRQ is generated and controller subroutine Read_in is called. The ten interrupt times are then returned to the controller and displayed.

Note that ten output interrupts have occurred after nine triggers, since the first interrupt was generated when the program executed. However, a tenth external trigger is required to copy the last state (5) from the first rank output register to the output channels.

```
10    REAL T(9)                                  !Dim T as REAL array
20    CLEAR 709                                  !Clear interface
30    OUTPUT 709;"RST"                           !Reset HP 3852A
40    ON INTR 7 GOTO Read_in                     !Go to Read_in on intr
50    ENABLE INTR 7;2                            !Enable interface
60    OUTPUT 709;"RQS ON;RQS DAV"                !Send SRQ on data avail
70    OUTPUT 709;"REAL T(9)"                     !Define T as REAL array
80    OUTPUT 709;"INTEGER A(9),I"                !Define A, I as INTEGER
90    OUTPUT 709;"VWRITE A -4,-3,-2,-1,0,1,2,3,4,5"   !Write data to A
```

```
100    OUTPUT 709;"SUB OUTINTR"                 !Start subroutine
110    OUTPUT 709;"TIME INTO T"                 !Read time, store in T
120    OUTPUT 709;"WRITE 200,A(I)"              !Write data to A
130    OUTPUT 709;"IF I=9 THEN"                 !Start write routine
140    OUTPUT 709;" VREAD T"                    !Trans time to out buffer
150    OUTPUT 709;"ELSE"                        !Decision point
160    OUTPUT 709;" I=I+1"                      !Increment count
170    OUTPUT 709;" ENABLE INTR USE 292"        !Enable output interrupt
180    OUTPUT 709;"END IF"                      !End write routine
190    OUTPUT 709;"SUBEND"                      !End subroutine
200    OUTPUT 709;"SRTRIG EXT USE 216"          !Ext sec rank output trig
210    OUTPUT 709;"ON INTR USE 292 CALL OUTINTR"    !Call sub on interrupt
220    OUTPUT 709;"ENABLE INTR USE 292"         !Enable input interrupt
230    OUTPUT 709;"ENABLE INTR SYS"             !Enable mf intr capability
240  Idle:GOTO Idle                             !Loop until interrupt
250    !
260  Read_in: !                                 !Start controller sub
270    ENTER 709;T(*)                           !Enter interrupt times
280    FOR I=0 TO 9                             !Start print loop
290        PRINT TIME$(T(I))                    !Disp intr times
300    NEXT I                                   !Increment count
310    STOP                                     !End controller sub
320    END
```

Again, since an immediate output interrupt is generated by the RST command, after nine external second rank output triggers have been received, the time of the ten output interrupts is displayed. (A tenth trigger is required to copy the last state to the output channels.) A typical return is:

```
03:45:17        Immediate interrupt @ RST
03:48:29        External trigger #1
   .                 .
   .                 .
03:55:01        External trigger #9
```

Disable Output Interrupts (DISABLE INTR)

For USE *ch* = ES92, DISABLE INTR [USE *ch*] disables output interrupts for an HP 44723A in the slot associated with *ch*. Note that DISABLE INTR disables, but does not clear, output interrupts. Output interrupts are cleared only by a write to the first rank output register. For example, line 110 disables output interrupts for an HP 44723A in slot 2 of the mainframe.

```
      .
      .
110    OUTPUT 709;"DISABLE INTR USE 292"        !Disable output intr for slot 200
      .
      .
```

Appendix
Specifications

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Appendix

Specifications

Introduction

This appendix lists specifications for the HP 44723A and shows some speed characteristics for the accessory. The speed characteristics in Part 2 show TYPICAL or NOMINAL but non-warranted performance parameters.

Specifications Table

HP 44723A specifications and speed characteristics follow.

HP 44723A Specifications Table

Part 1 - Accessory Specifications

Operating Range (Inputs, Outputs, and Triggers)

	Input Voltage (Vdc)		
	5*	12	24
Threshold Voltage:			
Vlow (max)	0.79	1.89	3.80
Vhigh (min)	2.06	4.92	9.90
Input Current (mA) at Nominal Voltage:	0.001	1.39	3.77
Minimum Pulse Widths (ns)	600	420	355

* = Also includes PULLUP position.

Maximum Voltages/Currents

Maximum Input Voltage:	±24 Vdc between channels or between any terminal and chassis.
Maximum Voltage/Current: (Open Collector Output)	24 Vdc (max) @ 600 Ω. Low-level voltage/current = 0.4 Vdc @ 40 mA.
Maximum Voltage/Current: (TTL Output)	5.5 Vdc (max) @ −5.2 mA. Low-level voltage/current = 0.4 Vdc @ 48 mA.

Trigger Terminals Outputs

With TRIGMODE FIRST:*	5 Vdc (CMOS) negative (HL) edge.
With TRIGMODE ALL:	5 Vdc negative TTL pulse. Nominal value = 2 μsec. Range = 1.7 μsec to 2.8 μsec.

* = Does not apply to Second Rank Input Trigger Output.

Miscellaneous

Maximum Wire Size:	16 AWG
Relative Power Consumption:	0.7**

** = For multiple accessories, ensure that the sum of the relative power consumptions does not exceed 8 for the HP 3852A or 10 for an HP 3853A.

Part 2 - Speed Characteristics

This part provides supplemental characteristics which show TYPICAL or NOMINAL, but non-warranted performance parameters.

Input Speeds

Rates (readings/sec) to program and execute reads of digital inputs and to transfer the readings.

Readings to Mainframe Memory (rdgs/sec):

- Packed Format: 176,000
- IN16 Format: 176,000

Readings to Controller via HP-IB (rdgs/sec):

- Packed Format: 2550
- IN16 Format: 2550
- IASC Format: 625

Output Speeds

Times to program and execute digital writes (16 channels at one time).

	Commands from Downloaded Subroutine	Commands from HP Series 200/ 300 Controller via HP-IB
Response Time (msec)	0.5	4.0
Continuous Operation (transitions/second)	189,000	110

Interrupts

Time (msec) between event occurrence and resulting action for a single interrupt and the maximum continuous interrupt rate (interrupt occurs, is serviced and reenabled, and the sequence repeats).

Interrupt Condition	Resulting Action		
	Max time for single call to interrupt subroutine (msec)	Max time to enable SRQ line once (msec)	Max continuous interrupt rate (interrupts/sec)
Digital Input:			
Edge Occurrence	2.6	0.4	400
Bit Pattern	2.6	0.4	400
Input Trigger	2.6	0.4	320

Set-Up and Hold Times

Time (nsec) from valid input to reception of first rank input trigger.

Source	Conditions LOW (0)	HIGH (1)	Setup Time (nsec)	Hold Time (nsec)
5 V	0 V	3 V	500	700
12 V	0 V	7 V	300	500
24 V	0 V	14 V	225	425

Input Trigger Timing

Minimum time (nsec) between first and second rank input triggers.

5 V:	590 nsec
12 V:	390 nsec
24V:	320 nsec

Trigger Output Delays

Delay time from reception of an external trigger into the IN trigger terminal to generation of a trigger output from the OUT trigger terminal or to generation of valid output data.

- 1ST IN TRIG IN to 1ST IN TRIG OUT.
- 2ND IN TRIG IN to 2ND IN TRIG OUT. [1]
- 2ND OUT TRIG IN to 2ND OUT TRIG OUT.
- 2ND OUT TRIG IN to valid data output. [2]

[1] = add 600 nsec if a "collision" occurs between the first and second rank input triggers (i.e., the second rank input trigger occurs too soon after the first rank input trigger). See "Input Trigger Timing" for minimum times.

[2] = add 600 nsec if a "collision" occurs between the write to the first rank output register and generation of a second rank output trigger.

5 V:	800 nsec
12 V:	600 nsec
24 V:	530 nsec

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HP 3852A Data Acquisition/Control Unit

HP 44724A
16-Channel Digital Output (Open Drain) Accessory

Configuration and Programming Manual

HEWLETT PACKARD

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Many product updates and fixes do not require manual changes and, conversely, manual corrections may be done without accompanying product changes. Therefore, do not expect a one-to-one correspondence between product updates and manual updates.

Edition 1 . . . . FEBRUARY 1987

HEWLETT PACKARD

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F

SAFETY SUMMARY

The following general safety precautions must be observed during all phases of operation, service, and repair of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended use of the instrument. Hewlett-Packard Company assumes no liability for the customer's failure to comply with these requirements.

GROUND THE INSTRUMENT

To minimize shock hazard, the instrument chassis and cabinet must be connected to an electrical ground.

DO NOT OPERATE IN AN EXPLOSIVE ATMOSPHERE

Do not operate the instrument in the presence of flammable gases or fumes. Operation of any electrical instrument in such an environment constitutes a definite safety hazard.

KEEP AWAY FROM LIVE CIRCUITS

Operating personnel must not remove instrument covers. Component replacement and internal adjustments must be made by qualified maintenance personnel. Under certain conditions, dangerous voltages may exist even with the instrument switched off. To avoid injuries, always disconnect input voltages and discharge circuits before touching them.

DO NOT SERVICE OR ADJUST ALONE

Do not attempt internal service or adjustment unless another person, capable of rendering first aid and resuscitation, is present.

DO NOT SUBSTITUTE PARTS OR MODIFY INSTRUMENT

Because of the danger of introducing additional hazards, do not install substitute parts or perform any unauthorized modification to the instrument. Return the instrument to a Hewlett-Packard Sales and Service Office for service and repair to ensure that safety features are maintained.

C

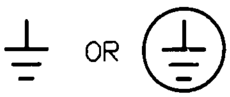
Operating and Safety Symbols

Symbols Used On Products And In Manuals

~ LINE — AC line voltage input receptacle.

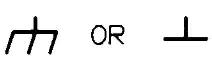
Instruction manual symbol affixed to product. Cautions the user to refer to respective instruction manual procedures to avoid possible damage to the product.

Indicates dangerous voltage – terminals connected to interior voltage exceeding 1000 volts.



Protective conductor terminal. Indicates the field wiring terminal that must be connected to earth ground before operating equipment – protects against electrical shock in case of fault.

Clean ground (low-noise). Indicates terminal that must be connected to earth ground before operating equipment – for single common connections and protection against electrical shock in case of fault.



Frame or chassis ground. Indicates equipment chassis ground terminal – normally connects to equipment frame and all metal parts.

Affixed to product containing static sensitive devices – use anti-static handling procedures to prevent electrostatic discharge damage to components.

NOTE

NOTE
Calls attention to a procedure, practice, or condition that requires special attention by the reader.

CAUTION

CAUTION
Calls attention to a procedure, practice, or condition that could possibly cause damage to equipment or permanent loss of data.

WARNING

WARNING
Calls attention to a procedure, practice, or condition that could possibly cause bodily injury or death.

WARNING, CAUTION, and NOTE Symbols

Some labels on the HP 3852A, HP 3853A, and plug-in accessories include an international warning symbol (triangle with subscripted number) which refers the reader to the manuals for further information. This table shows the warning symbols used for the HP 3852A/3853A and plug-in accessories. Refer to the manual set for specific information on WARNINGS, CAUTIONS, or NOTES referenced with a warning symbol.

HP 3852A WARNING, CAUTION, and NOTE Symbols

Symbol	Meaning	Location
⚠$_1$	Shock hazard originating outside the instrument (field wiring)	. Analog Extender Connector on Power Supply Modules . Terminal modules on plug-in accessories . Component module covers on plug-in accessories
⚠$_2$	Treat all channels as "one circuit" for safety purposes.	. Inside terminal modules on plug-in accessories . Metal cover on component modules of plug-in accessories
⚠$_3$	Maximum number of certain plug-in accessories to be installed into an HP 3852A or HP 3853A.	. HP 44701A, HP 44702A/B, HP 44727A/B/C plug-in accessories
⚠$_4$	If High-Speed FET multi-plexers are used with the HP 44702A/B, ribbon cable may be connected.	. HP 44711A, 44712A, 44713A (referenced on HP 44702A and HP 44702B)

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Chapter 1
Introduction

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Chapter 1

Introduction

Manual Contents

This manual shows how to configure and program the HP 44724A 16-Channel Digital Output (Open Drain) Plug-In Accessory (digital output). Refer to the HP 3852A Configuration and Programming Manual for additional information on the accessory. The manual has three chapters: Introduction, Configuring the Digital Output, and Programming the Digital Output.

- **Introduction** contains a manual overview, describes the digital output, and shows a suggested getting started sequence.

- **Configuring the Digital Output** shows how to connect field wiring to digital output channels and how to install and checkout the accessory.

- **Programming the Digital Output** shows how to program the digital output for two primary programming functions: reading channel states and writing to channels.

Digital Output Description

The digital output consists of a digital output component module and a terminal module. Each channel acts as an ON-OFF switch to control low-voltage DC devices (up to 55 VDC) or to drive logic levels (such as TTL or CMOS). An external power supply is required for DC devices and for logic devices. In addition, a pull-up resistor is required for logic devices. Since channel states can be programmatically switched, the digital output can be used to switch devices on or off at rates up to 1 kHz.

Getting Started

To use the digital output accessory for your application, you will need to:

- Define your application.
- Configure the digital output.
- Program the digital output.

Define Your Application

The first step is to define your application and decide which devices are to be connected to the digital output channels. The digital output can control up to 16 low-level DC devices or logic levels. Devices to be connected must use voltages $\leq$ 55 VDC and must have an external power supply. Logic devices must have an external power supply and a pull-up resistor.

Typical applications for the digital output are switching DC devices (such as lighting an LED or closing a relay) or controlling logic levels (such as TTL or CMOS). When selecting devices, refer to the Specifications appendix in the HP 3852A Mainframe Configuration and Programming Manual for voltage and current limitations.

Configure the Digital Output

The next step is to configure the digital output for your application. Since there are no jumpers or switches to set on the accessory, the only requirement is to connect the devices selected to desired channels of the digital output. Refer to Chapter 2 - Configuring the Digital Output for example field wiring diagrams and procedures to check the digital output ID.

Program the Digital Output

The third step is to program the digital output channels to control the devices connected. Refer to Chapter 3 - Programming the Digital Output to program the accessory for two primary programming functions: reading channel states and writing to channels.

Chapter 2
Configuring The Digital Output

Contents

Chapter 2

Configuring the Digital Output

Chapter Contents

This chapter shows how to hardware configure the digital output accessory. It shows how to connect field wiring to the terminal module and how to check the digital output identity. There are two steps to configure a digital output:

- Connect field wiring.
- Install/checkout the digital output.

When all required channels have been configured, refer to Chapter 3 - Programming the Digital Output to program the digital output for your application.

Connecting Field Wiring

To begin configuring the digital output, remove the terminal module cover. If the accessory is installed in the mainframe or an extender, refer to the HP 3852A Configuration and Programming Manual to remove the terminal module. Figure 2-1 shows the terminal module with the cover removed.

WARNING

⚠ 1 *SHOCK HAZARD. Only qualified, service-trained personnel who are aware of the hazards involved should install, remove, or configure any accessory. Before touching any installed accessory, turn off all power to the mainframe and extenders, to all installed accessories, and to all external devices connected to the mainframe, extenders or accessories.*

WARNING

⚠2 *For safety, consider all accessory channels to be at the highest voltage applied to any channel.*

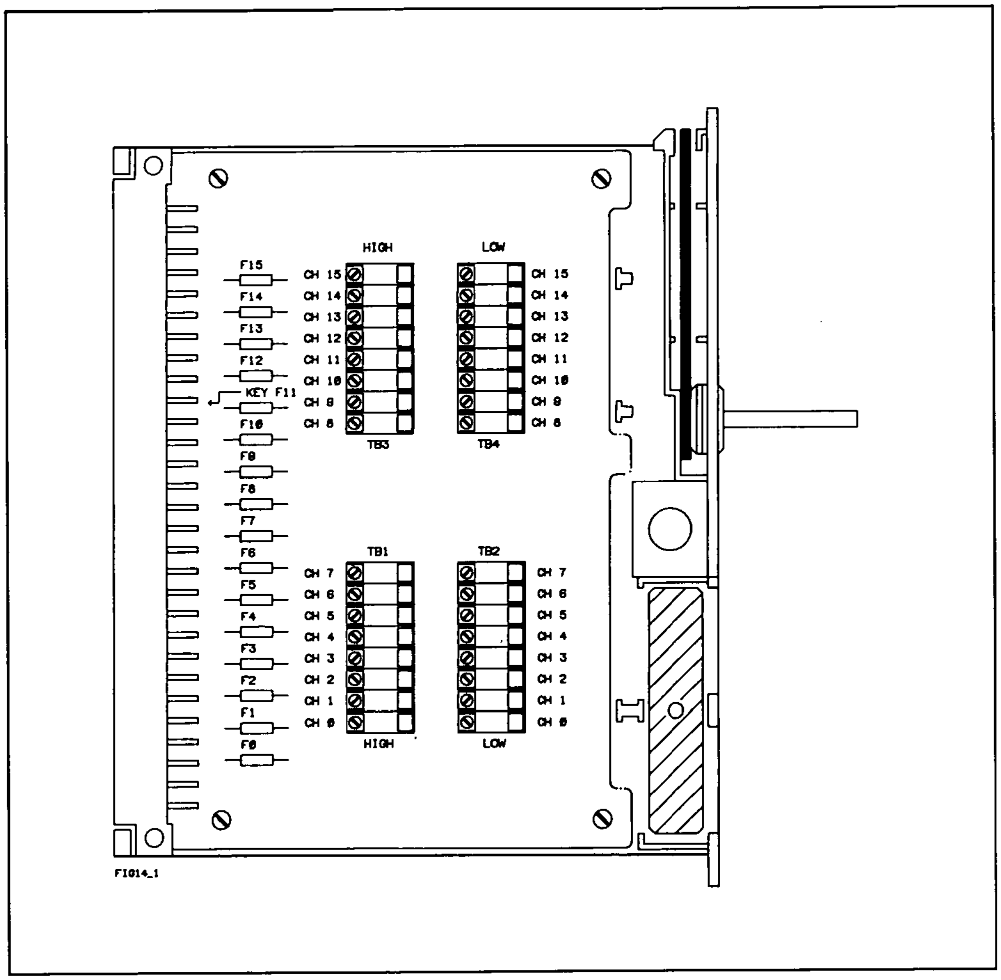

Figure 2-1. Digital Output Terminal Module

As shown in Figure 2-1, each channel of the digital output terminal module has a HIGH and a LOW terminal to connect user input field wiring. When you connect field wiring, route the wires under the strain relief clamp and tighten the clamp screw to reduce the chance of wires being pulled out of the terminal connectors. After you connect field wiring from your devices to all channels to be used, replace the terminal module cover.

NOTE

A channel wired with reverse polarity (+ to LOW and - to HIGH) will always appear to be closed (ON), with current ratings identical to a properly wired channel.

Figure 2-2 shows three applications for the digital output and typical field wiring connections. Channel 8 is used to turn an LED on or off and an external source (+5V) and current-limiting resistor (R) are required.

Channel 7 is used to open or close a relay and an external power supply is required. Channel 0 is used to control TTL logic level. TTL logic connections require an external power supply (+5V) and pull-up resistor (R).

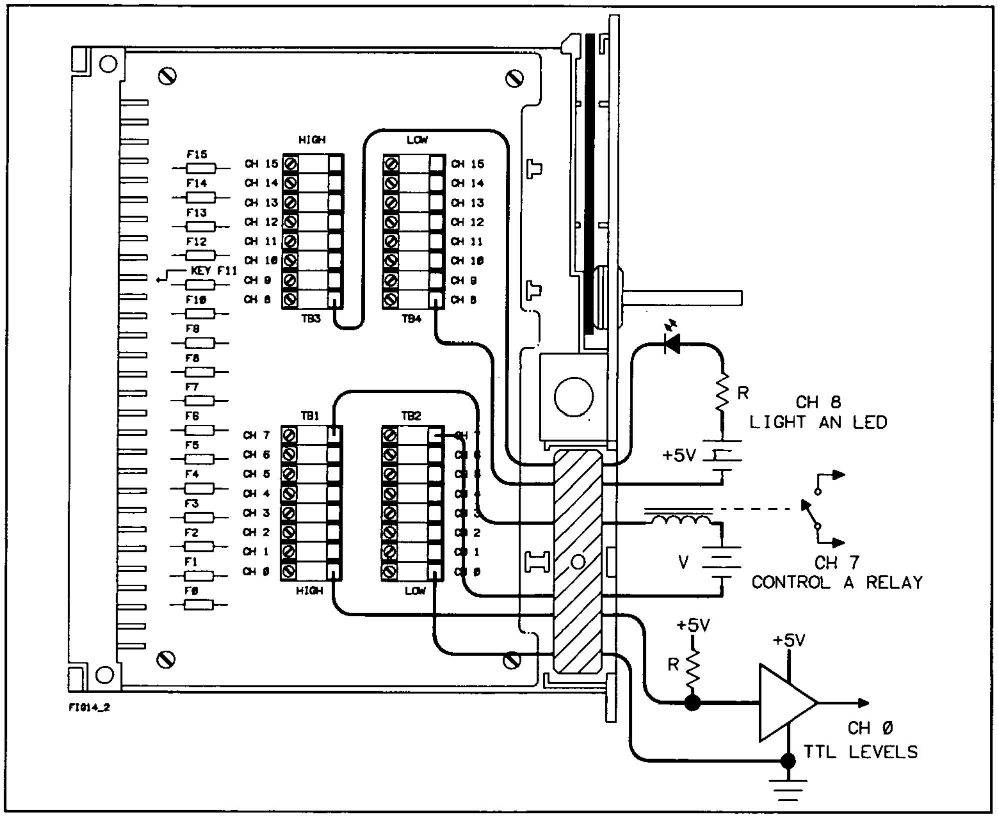

Figure 2-2. Typical Field Wiring Connections

Installation/Checkout

After connecting field wiring, connect the terminal module to the component module and install the digital output in a desired slot. Refer to the HP 3852A Mainframe Configuration and Programming Manual for installation.

When the accessory is installed, send the ID? command to check the accessory ID. At power-on, a digital output returns HP 44724A, while a digital output component module only (no terminal module attached) returns 447XXX. (Note that if the terminal module is removed after power-on, the digital output still returns 44724A).

For example, the following program determines the identity of an accessory in slot 4 of the mainframe. A digital output in this slot returns 44724A.

```
10 OUTPUT 709;"ID? 400"      !Query ID in mainframe slot 4
20 ENTER 709;A$              !Enter ID
30 PRINT A$                  !Display ID
40 END
```

If the digital output does not return 44724A, be sure you have addressed the correct slot and the terminal module is installed. If these are correct but 44724A is not returned, refer to the HP 3852A Assembly Level Service Manual for service procedures.

This completes hardware configuration. Refer to Chapter 3 - Programming the Digital Output to program the digital output for your application.

Chapter 3
Programming The Digital Output

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Chapter 3

Programming the Digital Output

Chapter Contents

The digital output has two primary programming functions: reading channel states and writing to channels. This chapter shows how to program the accessory for these functions. It includes a description of each function, applicable commands for the function, and programming examples.

NOTE

The example programs use HP-IB address 709 and specific slot and channel numbers. Program syntax and data returns apply to HP Series 200/300 controllers. If you use a different controller, modify the syntax and data returns as required. Modify addresses as necessary for the slots and channels you use.

Programming Overview

This section summarizes decimal values vs. bit patterns and the command set for the digital output. It also lists the titles of the example programs in this chapter.

Example Program Titles

Discussion for each programming function includes example programs to show how to program the digital output. Table 3-1 lists the titles of the example programs.

Table 3-1. Example Program Titles

Example	Description	Commands
Reading Channel States		
Read LED Status Using READ	Read state of all channels to determine LED on/off state.	READ
Read LED Status Using CLOSE?	Read state of individual channels to determine LED states.	CLOSE?
Writing to Channels		
Opening/Closing Relays	Write data to channels to open or close relays connected to the channels.	OPEN, CLOSE
Controlling TTL Logic	Write data to channels to control TTL logic states.	WRITE, CHWRITE

Decimal Values vs. Bit Patterns

For HP Series 200/300 controllers, data inputs and returns must be in decimal format. For the digital output accessory, the number parameter in the WRITE *ch number* command must be the decimal equivalent of the desired channel bit pattern. The range of the WRITE command is -32768 to +32767 or 0 to 65535.

NOTE

Data returned to the controller by READ slot is the decimal equivalent of the channel bit pattern. The range of data returned by the READ command is -32768 to +32767 only.

This section shows how to compute decimal values for desired channel bit patterns and how to determine the bit pattern for a given decimal value. Table 3-2 shows the decimal value for some channel bit patterns. Each digital output channel has an associated weighted decimal value. For example, channel 0 has weighted decimal value 1, channel 5 has weighted decimal value 32, etc.

To compute the decimal value for any channel bit pattern, add the weighted decimal values of the "1" bits in the pattern, where "1" = channel closed (ON) and "0" = channel open (OFF). Examples follow to show how to compute the decimal value for a given bit pattern or to determine the bit pattern for a given decimal value.

NOTE

For the number values in the WRITE command ONLY, you can add +32768 to the weighted decimal values in Table 3-2 to provide output range 0 to 65535. The range of values shown in Table 3-2 is −32768 to +32767.

Table 3-2. Decimal Values vs. Channel Bit Patterns

Channel Number	Weighted Decimal Value	Channel Number	Weighted Decimal Value
0	1	8	256
1	2	9	512
2	4	10	1024
3	8	11	2048
4	16	12	4096
5	32	13	8192
6	64	14	16384
7	128	15	-32768

Example: Finding Positive Decimal Value of Bit Pattern

To compute the positive decimal value of a bit pattern with channel 15 open (OFF), add the weighted decimal values for the "1"s in the bit pattern. For example, with channels 2, 4, 6, and 9 closed (ON), the channel bit pattern is 0000 0010 0101 0100 and the decimal value is 596.

1. Channel Bit Pattern: 0000 0010 0101 0100 = ?

2. Decimal Value: 512 + 64 + 16 + 4 = 596

Example: Finding Negative Decimal Value of Bit Patterns

There are two ways to find the decimal value of a bit pattern with channel 15 closed (ON). The first way is to add the weighted decimal values of the "1" bits, the same as for a positive decimal value. For example, for bit pattern 1000 0000 0010 1110 (channels 1, 2, 3, 5, and 15 closed (ON)), the decimal value = -32722.

1. Channel Bit Pattern: 1000 0000 0010 1110

2. Decimal Value: -32768 + 32 + 8 + 4 + 2 = -32722

The second way to compute the decimal value of a bit pattern with channel 15 closed (ON), is to find the 2's complement of the bit pattern, calculate the decimal equivalent, and use the negative of this number. For example, with channels 1, 2, 3, 5, and 15 closed (ON), the bit pattern is 1000 0000 0010 1110. Use the following steps to calculate the decimal value of this pattern using the 2's complement method.

1. Channel Bit Pattern:	1000 0000 0010 1110 = ?
2. 2's Complement:	0111 1111 1101 0010
3. Decimal Equivalent of 2's Complement:	16384+8192+4096+2048 +1024+512+256+128+64 +16+2 = 32722
4. Decimal Value:	1000 0000 0010 1110 = −32722

Example: Finding Bit Pattern for Positive Decimal Value

To find the channel bit pattern for a positive decimal value (0 to 32767), compute the binary equivalent of the number by doing a decimal to binary conversion. For example, the channel bit pattern for decimal 40 is:

```
Bit Pattern for +40: 40 = 32 + 8 = 0000 0000 0010 1000
                                            \   \
                                            32 + 8
```

Example: Finding Bit Pattern for Negative Decimal Value

To find the channel bit pattern for a negative decimal value (-32768 to -1), first determine the bit pattern for the positive decimal value. The 2's complement of this pattern is the bit pattern for the negative number. For example, the bit pattern for decimal -483 is computed as follows:

1. Decimal Value:	-483 = ?
2. Bit Pattern for +483:	483 = 0000 0001 1110 0011
3. 2's Complement of +483:	= 1111 1110 0001 1101
4. Bit Pattern for -483:	-483 = 1111 1110 0001 1101

Digital Output Command Summary

Table 3-3 is an alphabetical summary of commands which apply to the digital output. Refer to the HP 3852A Command Reference Manual for a complete description of these commands.

Table 3-3. Digital Output Command Summary

CHWRITE *ch number*
Write number to channel specified by *ch*. *number* = 0 sets channel open (OFF), *number* other than 0 sets channel closed (ON).
CLOSE *ch_list*
Sets channels specified by *ch_list* closed (ON).
CLOSE? *ch_list* **[INTO** *name***]** or **[***fmt***]**
Query state of channels of digital output as specified by *ch_list*. Data returned for each channel in *ch_list*.
ID? *slot*
Reads identity of accessory in slot specified by *slot*. Digital output returns 44724A.
OPEN *ch_list*
Sets channels specified by *ch_list* open (OFF).
READ *slot* **[INTO** *name***]** or **[***fmt***]**
Read state of all channels on digital output in slot specified by *slot*. Returned data is decimal value of channel states. Range = −32768 to +32767.
RST *slot*
Resets accessory in slot specified by *slot* to power-on state.
WRITE *slot number*
Write data to digital output in slot specified by *slot*. *number* = decimal value of desired bit pattern, where 0 sets all channels open (OFF),..., −1 or 65535 sets all channels closed (ON). LSB sets channel 0 state, ..., MSB sets channel 15 state. Range = −32768 to +32767 or 0 to 65535.

Reading Channel States

A primary programming function for the digital output is to read the state (open [OFF] or closed [ON]) of channels to determine if devices connected to the channels are ON or OFF. This section shows how to use the READ and CLOSE? commands to read channel states.

NOTE

The READ and CLOSE? commands return the programmed state of the channels. If a hardware failure occurs, the programmed state returned may not reflect the actual state of the device connected to the channel.

Using READ

The READ *slot* command reads the programmed state of all channels in the specified slot. The following example shows how to use the READ command to determine the on/off status of 16 LEDs connected to the channels of a digital output in slot 1 of the mainframe.

Example: Read LED Status Using READ

The following program uses the READ command to determine the on/off status of 16 LEDs connected to the channels of a digital output in slot 1 of the mainframe. When a channel is closed (ON), the channel LED turns on. When a channel is open (OFF), the channel LED turns off. (See Figure 2-2 for a typical configuration diagram.)

```
10 OUTPUT 709;"READ 100"          !Read state of slot 1
20 ENTER 709;State1               !Enter slot 1 state
30 PRINT "LED Status = ";State1   !Display slot 1 state
40 END
```

If, for example, channels 100, 105, and 109 are closed (ON), READ returns 545, where 545 is the decimal value of channel bit pattern 0000 0010 0010 0001. A typical return for this bit pattern is:

```
LED Status = 545
```

Using CLOSE?

The CLOSE? *ch_list* command reads the programmed state of all channels specified by *ch_list*. Therefore, you can use the CLOSE? command to read the state of individual channels. The following program uses the CLOSE? command to read the status of LEDs.

Example: Read LED Status Using CLOSE?

This program uses the CLOSE? command to read the programmed states of all channels of a digital output in slot 2 of mainframe. (See Figure 2-2 for a typical connection diagram.)

```
10 INTEGER State2 (0:15)              !Define array
20 OUTPUT 709;"CLOSE? 200-215"        !Query channel states
30 ENTER 709;State2(*)                !Enter channel states
40 PRINT "LED States = ";State2(*)    !Display channel states
50 END
```

For example, with channels 202, 205, and 213 closed (ON), CLOSE? returns the following data, where 0 = LED off and 1 = LED on. Since data is returned in the order requested by the command, the first number is the channel 0 state and the 16th number is the channel 15 state.

```
LED States = 0 0 1 0 0 1 0 0 0 0 0 0 0 1 0 0
```

Writing to Channels

A second primary programming function for the digital output is to write data to open or close channels. You can use the OPEN, CLOSE, WRITE, or CHWRITE commands to write data. This section shows how to use these commands.

NOTE

The RST slot (reset) command sets all channels in slot addressed to open (OFF).

Using OPEN and CLOSE

The OPEN *ch_list* command sets all channels specified by *ch_list* open (OFF), while the CLOSE *ch_list* command sets all channels specified by *ch_list* closed (ON). The *ch_list* parameter can be a single channel, a list of channels, or a combination of channels and channel lists. The following example shows a way to use the OPEN and CLOSE commands to control relays.

Example: Opening/Closing Relays

The following program segments use the OPEN and CLOSE commands to control relays connected to channels of a digital output. Writing a 1 (or any non-zero number) to a channel closes the channel relay, while writing a 0 to the channel opens the relay. (See Figure 2-2 for a typical connection diagram.)

This program uses the CLOSE command to close relays in channels 400 and 403 through 406 and uses the OPEN command to open relays in the remaining channels of a digital output in slot 4 of mainframe.

```
          .
          .
170 OUTPUT 709;"CLOSE 400,403-406"          !Close ch 400 and 403 through 406
180 OUTPUT 709;"OPEN 401,402,407-415"       !Open ch 401, 402, 407 through 415
          .
          .
```

Using WRITE and CHWRITE

In contrast to the OPEN and CLOSE commands which can write data to a single channel or to multiple channels, the WRITE command addresses all channels in a slot, while the CHWRITE command addresses only a single channel.

The WRITE *slot number* command writes a decimal number specified by *number* to the slot specified by *slot*. The *number* range is -32768 to 32767 or 0 to 65535 and is the decimal value of the desired bit pattern for the channels, where channel bit 0 = channel open (OFF) and channel bit 1 = channel closed (ON). Refer to Table 3-2 for decimal values vs bit patterns.

NOTE

The WRITE command affects all channels and may change the previous state of channels in the slot addressed.

The CHWRITE *ch number* command sets a single channel specified by *ch* open (OFF) or closed (ON), depending on the value of *number*. For *number* = 0, the channel is open (OFF). For *number* other than 0, the channel is closed (ON). An example with two program segments follows to show how to use the WRITE and CHWRITE commands to control TTL logic levels.

Example: Controlling TTL Logic

The following example uses the WRITE and CHWRITE commands to set logic levels for TTL devices connected to each channel of a digital output in slot 4 of the mainframe. (See Figure 2-2 for a typical connection diagram.)

Two example program segments follow. The first program segment uses the WRITE command to set all channels of a digital output in mainframe slot 4. The second program segment uses the CHWRITE command to set the state of channels 405 and 413 only.

- Using WRITE to Set all Channels

This program line uses WRITE to set TTL high for channels 400, 403, and 405 of digital output in slot 4 of mainframe and set TTL low for all other channels ("41" = decimal equivalent of bit pattern 0000 0000 0010 1001).

```
        .
        .
80 OUTPUT 709;"WRITE 400,41"     !Set TTL high for ch 400, 403, and 405
        .
        .
```

- Using CHWRITE to Set Channels 405 and 413 Only

This program segment uses the CHWRITE command to set TTL low in channel 405 and set TTL high in channel 413 of digital output in slot 4 of mainframe. Channels not addressed remain in previous state.

```
        .
        .
90 OUTPUT 709;"CHWRITE 405,0"     !Set TTL low in channel 405
100 OUTPUT 709;"CHWRITE 413,1"    !Set TTL high in channel 413
        .
        .
```

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44724-90001

HEWLETT PACKARD

HP 3852A Data Acquisition/Control Unit

HP 44725A
16-Channel General Purpose Switch Accessory

Configuration and Programming Manual

This is the HP 44725A 16-Channel General Purpose Switch Accessory Configuration and Programming Manual. Insert this manual and tab page into the Plug-In Accessories Configuration and Programming Manuals Binder supplied with your HP 3852 Data Acquisition/Control Unit.

44725-90001

HEWLETT PACKARD

HP 3852A Data Acquisition/Control Unit

HP 44725A
16-Channel General Purpose Switch Accessory

Configuration and Programming Manual

HEWLETT PACKARD

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Many product updates and fixes do not require manual changes and, conversely, manual corrections may be done without accompanying product changes. Therefore, do not expect a one-to-one correspondence between product updates and manual updates.

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HEWLETT PACKARD

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HEWLETT PACKARD

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For warranty service or repair, this product must be returned to a service facility designated by -hp-. Buyer shall prepay shipping charges to -hp- and -hp- shall pay shipping charges to return the product to Buyer. However, Buyer shall pay all shipping charges, duties, and taxes for products returned to -hp- from another country.

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Hewlett-Packard warrants that its software and firmware designated by -hp- for use with an instrument will execute its programming instructions when properly installed on that instrument. Hewlett-Packard does not warrant that the operation of the instrument, or software, or firmware will be uninterrupted or error free.

LIMITATION OF WARRANTY

The foregoing warranty shall not apply to defects resulting from improper or inadequate maintenance by Buyer, Buyer-supplied software or interfacing, unauthorized modification or misuse, operation outside of the environmental specifications for the product, or improper site preparation or maintenance.

NO OTHER WARRANTY IS EXPRESSED OR IMPLIED. HEWLETT-PACKARD SPECIFICALLY DISCLAIMS THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

EXCLUSIVE REMEDIES

THE REMEDIES PROVIDED HEREIN ARE BUYER'S SOLE AND EXCLUSIVE REMEDIES. HEWLETT-PACKARD SHALL NOT BE LIABLE FOR ANY DIRECT, INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES, WHETHER BASED ON CONTRACT, TORT, OR ANY OTHER LEGAL THEORY.

ASSISTANCE

Product maintenance agreements and other customer assistance agreements are available for Hewlett-Packard products.

For any assistance, contact your nearest Hewlett-Packard Sales and Service Office. Addresses are provided at the back of this manual.

F

HEWLETT PACKARD

SAFETY SUMMARY

The following general safety precautions must be observed during all phases of operation, service, and repair of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended use of the instrument. Hewlett-Packard Company assumes no liability for the customer's failure to comply with these requirements.

GROUND THE INSTRUMENT

To minimize shock hazard, the instrument chassis and cabinet must be connected to an electrical ground.

DO NOT OPERATE IN AN EXPLOSIVE ATMOSPHERE

Do not operate the instrument in the presence of flammable gases or fumes. Operation of any electrical instrument in such an environment constitutes a definite safety hazard.

KEEP AWAY FROM LIVE CIRCUITS

Operating personnel must not remove instrument covers. Component replacement and internal adjustments must be made by qualified maintenance personnel. Under certain conditions, dangerous voltages may exist even with the instrument switched off. To avoid injuries, always disconnect input voltages and discharge circuits before touching them.

DO NOT SERVICE OR ADJUST ALONE

Do not attempt internal service or adjustment unless another person, capable of rendering first aid and resuscitation, is present.

DO NOT SUBSTITUTE PARTS OR MODIFY INSTRUMENT

Because of the danger of introducing additional hazards, do not install substitute parts or perform any unauthorized modification to the instrument. Return the instrument to a Hewlett-Packard Sales and Service Office for service and repair to ensure that safety features are maintained.

C

HEWLETT PACKARD

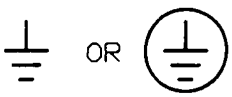
Operating and Safety Symbols

Symbols Used On Products And In Manuals

~ LINE — AC line voltage input receptacle.

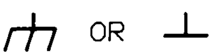
Instruction manual symbol affixed to product. Cautions the user to refer to respective instruction manual procedures to avoid possible damage to the product.

Indicates dangerous voltage – terminals connected to interior voltage exceeding 1000 volts.



Protective conductor terminal. Indicates the field wiring terminal that must be connected to earth ground before operating equipment – protects against electrical shock in case of fault.

Clean ground (low-noise). Indicates terminal that must be connected to earth ground before operating equipment – for single common connections and protection against electrical shock in case of fault.



Frame or chassis ground. Indicates equipment chassis ground terminal – normally connects to equipment frame and all metal parts.

Affixed to product containing static sensitive devices – use anti-static handling procedures to prevent electrostatic discharge damage to components.

NOTE

> **NOTE**
> *Calls attention to a procedure, practice, or condition that requires special attention by the reader.*

CAUTION

> **CAUTION**
> *Calls attention to a procedure, practice, or condition that could possibly cause damage to equipment or permanent loss of data.*

WARNING

> **WARNING**
> *Calls attention to a procedure, practice, or condition that could possibly cause bodily injury or death.*

HEWLETT PACKARD

WARNING, CAUTION, and NOTE Symbols

Some labels on the HP 3852A, HP 3853A, and plug-in accessories include an international warning symbol (triangle with subscripted number) which refers the reader to the manuals for further information. This table shows the warning symbols used for the HP 3852A/3853A and plug-in accessories. Refer to the manual set for specific information on WARNINGS, CAUTIONS, or NOTES referenced with a warning symbol.

HP 3852A WARNING, CAUTION, and NOTE Symbols

Symbol	Meaning	Location
⚠ 1	Shock hazard originating outside the instrument (field wiring)	. Analog Extender Connector on Power Supply Modules . Terminal modules on plug-in accessories . Component module covers on plug-in accessories
⚠ 2	Treat all channels as "one circuit" for safety purposes.	. Inside terminal modules on plug-in accessories . Metal cover on component modules of plug-in accessories
⚠ 3	Maximum number of certain plug-in accessories to be installed into an HP 3852A or HP 3853A.	. HP 44701A, HP 44702A/B, HP 44727A/B/C plug-in accessories
⚠ 4	If High-Speed FET multiplexers are used with the HP 44702A/B, ribbon cable may be connected.	. HP 44711A, 44712A, 44713A (referenced on HP 44702A and HP 44702B)
⚠ 5	The instrument should not be operated at a line frequency of 440 Hz with a line voltage of 200 V or greater as the AC leakage current may exceed 3.5 mA.	. HP 3852A, HP 3853A Power Supply Modules

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Chapter 1
Introduction

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Chapter 1

Introduction

Manual Contents

This manual provides configuration and programming information for the HP 44725A 16-Channel General Purpose Switch (GP switch). For additional information on the accessory, refer to the HP 3852A Mainframe Configuration and Programming Manual. This manual contains three chapters:

- **Introduction** contains a manual overview, describes the GP switch, and shows a suggested getting started sequence.

- **Configuring the GP Switch** shows how to connect field wiring to the GP switch and how to install and check the accessory.

- **Programming the GP Switch** shows how to program the GP switch for two primary programming functions: reading channel states and writing to channels.

GP Switch Description

The HP 44725A 16-Channel General Purpose Switch (GP switch) provides 16 channels of moderate voltage level switching (up to 30 VDC or 42 VAC peak). Signals of up to 100 kHz can also be effectively switched because of excellent between-channel isolation.

All switches are low noise, break-before-make, SPDT Form C relays. Each switch (one for each channel) can be individually programmed, with accessory memory holding the switch in its programmed state until reprogrammed. At power-down, all switches return to the NORMALLY CLOSED (NC) position.

Getting Started

To use the GP switch for your application, you will need to:

- Define your application.
- Configure the GP switch.
- Program the GP switch.

Define Your Application

The first step is to determine the required configuration, current required for each output channel, and total current requirements. Refer to the Specifications appendix in the HP 3852A Mainframe Configuration and Programming Manual for current limitations per channel and for the accessory.

Configure the GP Switch

The next step is to configure the GP switch for your application. Since there are no jumpers or switches to set on the accessory, the only requirement is to connect the devices selected to desired channels on the GP switch terminal module. Refer to Chapter 2 - Configuring the GP Switch for example field wiring diagrams and procedures to check the GP switch ID.

Program the GP Switch

The third step is to program the GP switch channels to control the devices connected. Refer to Chapter 3 - Programming the GP Switch to program the accessory for two primary programming functions: reading channel states and writing to channels.

Chapter 2
Configuring The GP Switch

Contents

Chapter 2

Configuring the GP Switch

Chapter Contents

This chapter shows how to hardware configure the GP switch. It shows how to connect field wiring to the terminal module and how to check the GP switch identity. There are two steps to configure a GP switch:

- Connect field wiring.
- Install/checkout the GP switch.

When all required channels have been configured, refer to Chapter 3 - Programming the GP Switch to program the GP switch for your application.

Connecting Field Wiring

To begin configuring the GP switch, remove the terminal module cover. If the accessory is installed in the mainframe or an extender, refer to the HP 3852A Configuration and Programming Manual to remove the terminal module. Figure 2-1 shows the terminal module with the cover removed.

WARNING

⚠ 1

SHOCK HAZARD. Only qualified, service-trained personnel who are aware of the hazards should install, remove, or configure any accessory. Before touching any installed accessory, turn off all power to the mainframe and extenders, to all installed accessories, and to all external devices connected to the mainframe, extenders, or accessories.

WARNING

⚠ 2

For safety, consider all accessory channels to be at the highest voltage applied to any channel.

CAUTION

Damage to accessory components can result from static discharge or excessive voltage. Use static-free handling methods and hold each module by its edges when installing, removing, or configuring the accessory.

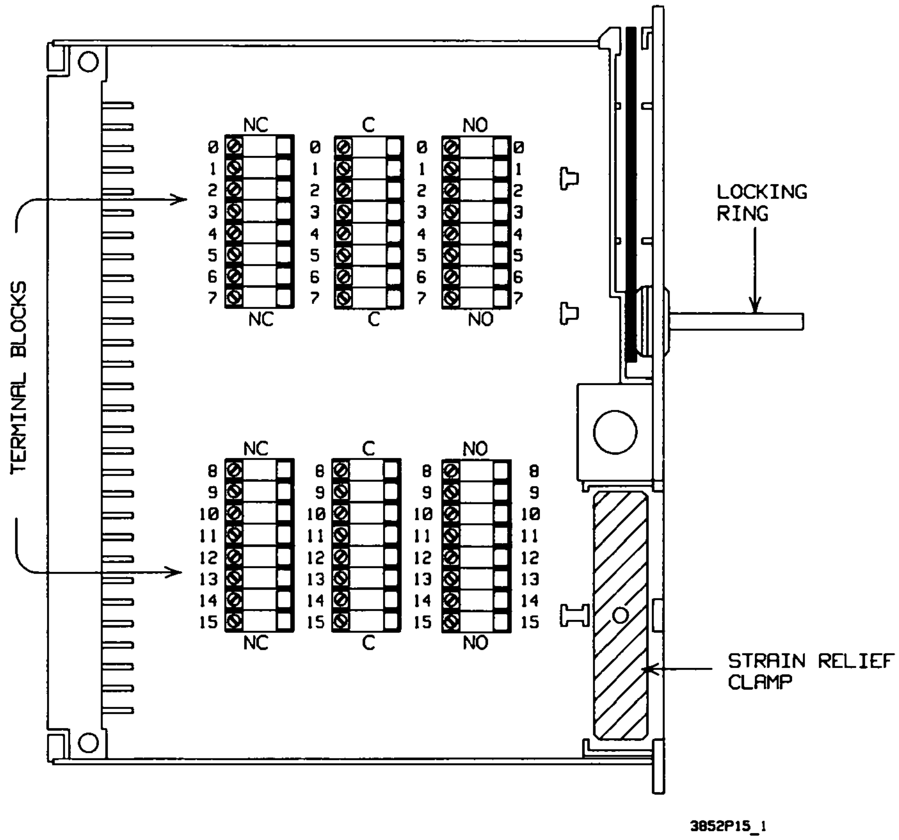


Figure 2-1. GP Switch Terminal Module

Redundant Switching Control

Before connecting field wiring to the GP switch, it is important to consider redundant switching control.

WARNING

⚠ 1 *GP switch failure during control of a critical process or function may cause danger to people or damage equipment. Always use redundant switching when configuring the GP switch to prevent danger to people or damage to equipment.*

Figure 2-2 shows an example way to provide redundant switching control for the GP switch. The Redundancy Failure Indicator will light if the redundant control (Overtemp Control) relay NO contacts fuse together and the Overtemp Control relay deenergizes.

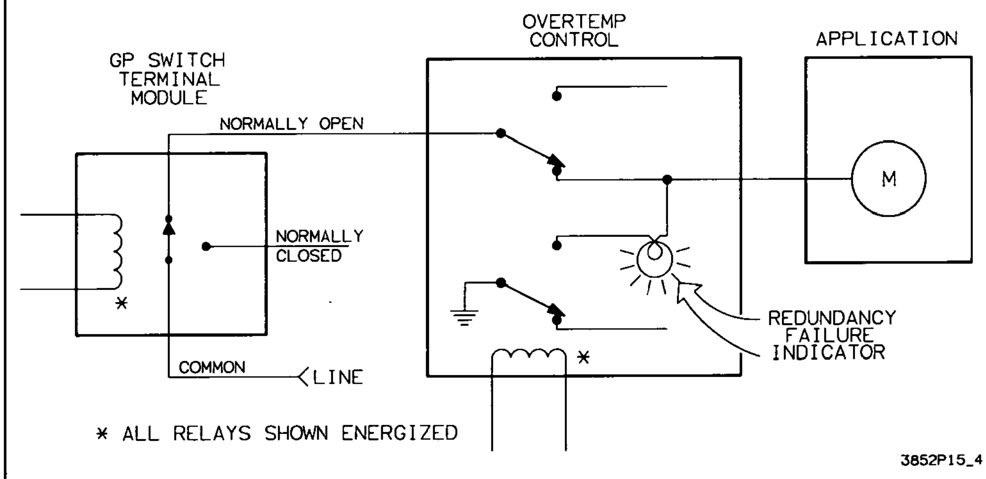


Figure 2-2. Redundant Switching Control Example

Field Wiring Connections

Configure the GP switch by connecting user field wiring to the NORMALLY OPEN (NO), COMMON (C), and NORMALLY CLOSED (NC) terminal blocks on the terminal module for required channels. Note that there are no jumpers or configuration switches on either the GP switch component module or on the terminal module which require setting.

Figure 2-3 shows simplified examples of field wiring connections for load switching, while Figure 2-4 shows some example connections for voltage and matrix switching. When connecting field wiring, place all field wiring leads under the module strain relief clamp. Tighten the clamp to ensure that all field wires are held firmly in place.

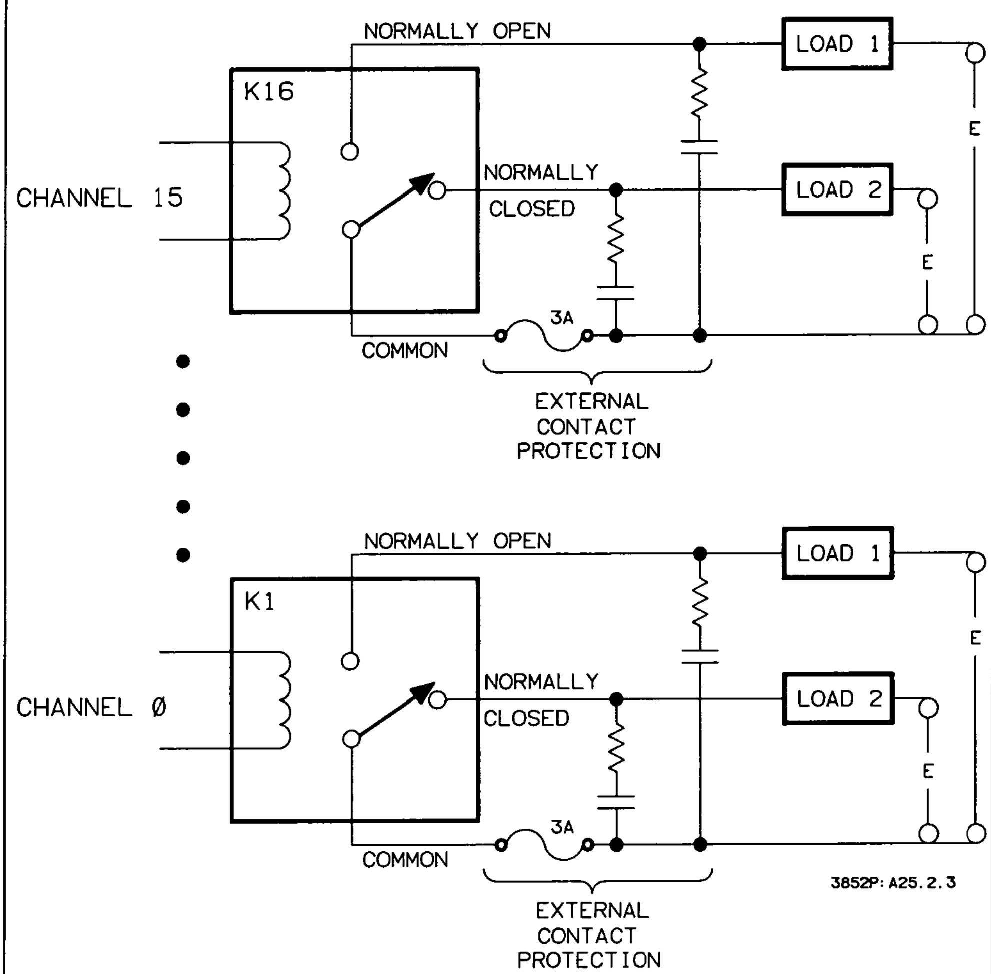
CAUTION

When switching inductive loads, provide external contact protection circuitry as required to limit the peak induction kick at switching to the maximum peak voltage specifications shown in the Specifications appendix of the HP 3852A Mainframe Configuration and Programming Manual.

NOTE

1. An RFI filter may be required for switching speeds greater than three-per-minute in order to comply with local conducted RFI limits (e.g., VDE 0875 in the Federal Republic of Germany).

2. Once gold (Au) plated silver-cadmium oxide (AgCdO) relay contacts have been used to switch moderate power (< 10 A) that supports arcing, the gold plating is vaporized and contact surfaces become AgCdO. The relay cannot then be used for signal switching, as AgCdO contact surfaces do not stay clean and may have increased resistance. The relay remains suitable for power switching, however.



CAUTION

External (user-supplied) contact protection and fusing may be required for loads >12 V and current >400 mA. The 3A fuse shown is the maximum size recommended. Maximum voltage (E) to be applied is 30 Vdc @ 1.5A or 42 Vac peak @ 1.5A RMS.

Figure 2-3. Load Switching Examples

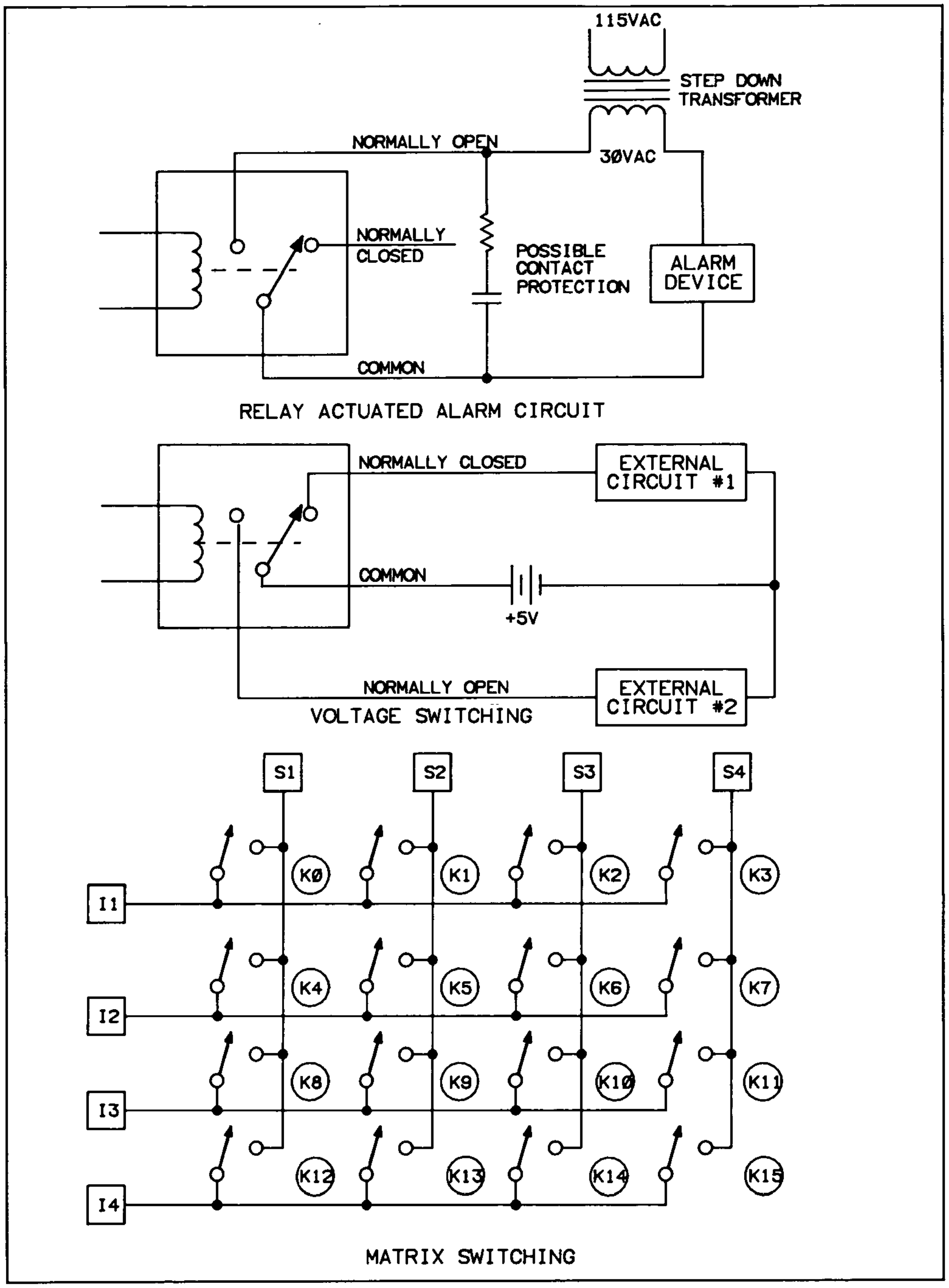


Figure 2-4. Voltage/Matrix Switching Examples

Installation/Checkout

When field wiring has been connected, connect the terminal module to the GP switch module and install the accessory in the desired slot. Refer to the HP 3852A Mainframe Configuration and Programming Manual to install the accessory.

When the accessory is installed, send the ID? command to check the accessory ID. At power-on, the GP switch returns 44725A, while a GP switch module only (no terminal module attached) returns 447XXX. (Note that if the terminal module is removed after power-on, the GP switch still returns 44725A.)

For example, the following program determines the identity of an accessory in slot 4 of the mainframe. A GP switch in this slot returns 44725A.

```
10 OUTPUT 709;"ID? 400"     !Query ID in mainframe slot 4
20 ENTER 709;A$             !Enter ID
30 PRINT A$                 !Display ID
40 END
```

If the GP switch does not return 44725A, be sure you have addressed the correct slot and the terminal module is installed. If these are correct but 44725A is not returned, refer to the HP 3852A Assembly Level Service Manual for service procedures.

This completes GP switch configuration. Refer to Chapter 3 - Programming the GP Switch to program the GP switch for your application.

Chapter 3
Programming The GP Switch

Contents

Chapter 3

Programming the GP Switch

Introduction

This chapter shows how to program the GP switch accessory. The chapter has four sections:

Introduction summarizes chapter contents, lists example program titles, and shows how to determine the mainframe firmware revision number.

Programming Overview gives an overview of binary-to-decimal conversion and provides an alphabetical summary of commands.

Reading Channel States shows how to read GP switch channel states using the READ and CLOSE? commands.

Writing Channel States shows how to write GP switch channel states using the OPEN, CLOSE, CHWRITE, CHWRITEM, WRITE, and WRITEM commands.

NOTE

The example programs in this chapter use HP-IB address 709 and specific slot and channel numbers. Program syntax and data returns apply to HP 9000 Series 200/300 controllers. If you use a different controller, modify the syntax and data returns as required. Modify addresses as necessary for the slots and channels you use.

Example Program Titles

Discussion for each programming function includes example programs to show how to program the GP switch. Table 3-1 lists the titles of the example programs.

Table 3-1. Example Program Titles

Example	Description	Commands
Reading Channel States		
Read Channel States Using CLOSE?	Read state of individual channels in a slot using CLOSE?.	CLOSE?
Read Slot State Using READ	Read state of all channels in a slot using READ.	READ
Writing Channel States		
Write to Channels Using OPEN and CLOSE	Write data to open or close channels using the OPEN and CLOSE commands.	OPEN, CLOSE
Write to Channels Using CHWRITE	Write data to open or close a single channel using the CHWRITE command.	CHWRITE
Write to Channels Using CHWRITEM*	Write data to open or close several channels using the CHWRITEM command.	CHWRITEM
Write to Slot Using WRITE	Write data to open or close all channels on a slot using the WRITE command.	WRITE
Write to Slots Using WRITEM*	Write data to open or close all channels on two slots using the WRITEM command.	WRITEM

* = Program requires mainframe firmware revision 3.0 or greater.

Mainframe Firmware Revision

Since some commands for the GP switch require mainframe firmware revision 3.0 or greater (refer to the GP Switch Command Summary in Table 3-3), you may want to check the revision number for your mainframe to ensure that the accessory commands will be accepted. The following example program uses the IDN? command to check the mainframe ID, including the firmware revision number.

```
10  DIM Identity$(1:4)[17]              !Dimension controller array
20  OUTPUT 709;"IDN?"                   !Query HP 3852A identity
30  ENTER 709;Identity$(*)              !Enter identity
40  PRINT USING "K,/";Identity$(*)      !Display identity
50  END
```

A typical return for firmware revision 3.0 follows.

```
HEWLETT PACKARD     (Company name)
3852A               (Model number)
0                   (Mainframe serial number unknown)
3.0                 (Firmware revision 3.0)
```

Programming Overview

This section provides an overview of programming for the GP switch accessory. It includes a discussion of binary-to-decimal conversion and an alphabetical summary of commands for the GP switch.

Decimal Values vs. Bit Patterns

For HP 9000 Series 200/300 controllers, data inputs and returns must be in decimal format. For the GP switch, the *number* parameter in the WRITE *ch number* or the *data_list* parameter in the WRITEM *slot_list* DATA *data_list* command must be the decimal equivalent of the desired channel bit pattern. The range for the WRITE and WRITEM commands is −32768 to +32767 or 0 to 65535.

NOTE

Data returned to the controller by READ slot is the decimal equivalent of the channel bit pattern. The range of data returned by the READ command is −32768 to +32767 only.

This section shows how to compute decimal values for desired channel bit patterns and how to determine the bit pattern for a given decimal value. Table 3-2 shows the weighted decimal value for each channel number. For example, channel 0 has weighted decimal value 1, channel 5 has weighted decimal value 32, etc.

To compute the decimal value for a channel bit pattern, add the weighted decimal values of the "1" bits in the pattern, where "1" = channel closed (ON/NO) and "0" = channel open (OFF/NC). Examples follow to show how to compute the decimal value for a given bit pattern or to determine the bit pattern for a given decimal value.

Table 3-2. Decimal Values vs. Channel Numbers

Channel Number	Weighted Decimal Value	Channel Number	Weighted Decimal Value
0	1	8	256
1	2	9	512
2	4	10	1024
3	8	11	2048
4	16	12	4096
5	32	13	8192
6	64	14	16384
7	128	15	±32768

Example: Finding Positive Decimal Value of Bit Pattern

To compute the positive decimal value of a bit pattern with channel 15 open (OFF/NC), add the weighted decimal values for the "1"s in the bit pattern. For example, with channels 2, 4, 6, and 9 closed (ON/NO), the channel bit pattern is 0000 0010 0101 0100 and the decimal value is 596.

1. Channel Bit Pattern: 0000 0010 0101 0100 = ?
2. Decimal Value: 512 + 64 + 16 + 4 = 596

Example: Finding Negative Decimal Value of Bit Patterns

There are two ways to find the decimal value of a bit pattern with channel 15 closed (ON/NO). The first way is to add the weighted decimal values of the "1" bits, the same as for a positive decimal value. For example, for bit pattern 1000 0000 0010 1110 (channels 1, 2, 3, 5, and 15 closed (ON/NO)), the decimal value = −32722.

1. Channel Bit Pattern: 1000 0000 0010 1110
2. Decimal Value: −32768 + 32 + 8 + 4 + 2 = −32722

The second way to compute the decimal value of a bit pattern with channel 15 closed (ON/NO), is to find the 2's complement of the bit pattern, calculate the decimal equivalent, and use the negative of this number. For example, with channels 1, 2, 3, 5, and 15 closed (ON/NO), the bit pattern is 1000 0000 0010 1110. Use the following steps to calculate the decimal value of this pattern using the 2's complement method.

1. Channel Bit Pattern: 1000 0000 0010 1110 = ?
2. 2's Complement: 0111 1111 1101 0010
3. Decimal Equivalent of 2's Complement: 16384+8192+4096+2048 +1024+512+256+128+64 +16+2 = 32722
4. Decimal Value: 1000 0000 0010 1110 = −32722

Example: Finding Bit Pattern for Positive Decimal Value

To find the channel bit pattern for a positive decimal value (0 to 32767), compute the binary equivalent of the number by doing a decimal to binary conversion. For example, the channel bit pattern for decimal 40 is:

```
Bit Pattern for +40:    40 = 32 + 8 = 0000 0000 0010 1000
                                              /  |
                                             32 + 8
```

Example: Finding Bit Pattern for Negative Decimal Value

To find the channel bit pattern for a negative decimal value (−32768 to −1), first determine the bit pattern for the positive decimal value. The 2's complement of this pattern is the bit pattern for the negative number. For example, the bit pattern for decimal −483 is computed as follows:

1. Decimal Value:	−483	=	?
2 Bit Pattern for +483:	483	=	0000 0001 1110 0011
3. 2's Complement of +483:		=	1111 1110 0001 1101
4. Bit Pattern for −483:	−483	=	1111 1110 0001 1101

GP Switch Command Summary

Table 3-3 is an alphabetical summary of commands which apply to the GP switch. Refer to the HP 3852A Command Reference Manual for a complete description of these commands.

Table 3-3. GP Switch Command Summary

CHWRITE *ch number*

Write state to the channel specified by *ch*. *number* = 0 sets the channel open (OFF/NC), while any non-zero integer between −32768 and +32767 sets the channel closed (ON/NO).

CHWRITEM *ch_list* **DATA** *state_list*

Write channel state(s) to open or close channels specified by *ch_list*. *state_list* = 0 opens the channels while any non-zero integer between −32768 and +32767 closes the channels. CHWRITEM uses one item from DATA *state_list* for each channel OR channel range in *ch_list*.

Up to ten channels or channel ranges can be specified along with up to ten channel states. If *ch_list* and *state_list* are stored in arrays, a larger number of channels and states can be specified. CHWRITEM requires firmware revision 3.0 or greater.

CLOSE *ch_list*

Sets channels specified by *ch_list* closed (ON/NO).

CLOSE? *ch_list* **[INTO** *name*] or [*fmt*]

Query state of channels of GP switch as specified by *ch_list*. Data returned for each channel in *ch_list*.

ID? *slot*

Reads identity of accessory in slot specified by *slot*. GP switch returns 44725A.

OPEN *ch_list*

Sets channels specified by *ch_list* open (OFF/NC).

Table 3-3. GP Switch Command Summary (Cont'd)

READ *slot* [*number*] [**INTO** *name*] or [*fmt*]
Read state of all GP switch channels in slot specified by *slot*. Returned data is decimal value of channel states with range = −32768 to +32767. *number* reads the slot the specified number of times. The *number* parameter requires firmware revision 3.0 or greater.
RST *slot*
Resets accessory in slot specified by *slot* to power-on state.
WRITE *slot number* or **WRITE** *slot data_list* or *array*
Write data to GP switch in slot specified by *slot*. *number* = decimal value of desired bit pattern, where 0 sets all channels open (OFF/NC),..., −1 or 65535 sets all channels closed (ON/NO). LSB sets channel ES00 state, ..., MSB sets channel ES15 state. Range = −32768 to +32767 or 0 to 65535.
Specifying *data_list* or *array* writes successive numbers (bit patterns) to the GP switch. Up to ten bit patterns can be specified in a data list or the number of bit patterns can equal the size of a previously defined array. The range for numbers specified in the data list or stored in the array is −32768 to +32767. The *data_list* and *array* parameters require firmware revision 3.0 or greater.
WRITEM *slot_list* **DATA** *data_list*
Writes the state(s) to open and close specified channels in specified slots. *slot_list* is the address of the slots to which the desired bit patterns are written. *data_list* is the decimal equivalent(s) of the desired bit pattern(s).
Up to ten slot ranges or individual slots can be specified along with up to ten bit patterns. If the slot list and data list are stored in arrays, a larger number of slots and bit patterns can be specified. The range for the numbers is −32768 to +32767 or 0 to 65535. WRITEM requires firmware revision 3.0 or greater.

Reading Channel States

A main programming function for the GP switch is to read the state (open [OFF/NC] or closed [ON/NO]) of the channels. This section shows how to use the CLOSE? and READ commands to read channel states.

NOTE

The CLOSE? and READ commands return the programmed state of of the channels. If a hardware failure occurs, the programmed state returned may not reflect the actual state of the channel.

Using CLOSE?

The CLOSE? *ch_list* [INTO *name*] or [*fmt*] command reads the programmed state of all channels specified by *ch_list*. Use CLOSE? to read the state of individual channels.

Example: Read Channel States Using CLOSE?

This program uses CLOSE? to read the programmed states of all channels of a GP switch in slot 2 of mainframe.

```
10  INTEGER A(0:15)                  !Define array
20  OUTPUT 709;"CLOSE? 200-215"      !Query channel states
30  ENTER 709;A(*)                   !Enter channel states
40  PRINT A(*)                       !Display channel states
50  END
```

For example, with channels 202, 205, and 213 closed (ON/NO), CLOSE? returns the following data, where 0 = channel OFF/NC and 1 = channel ON/NO. Since data is returned in the order requested, the first number is the channel 200 state and the last number is the channel 215 state.

```
0  0  1  0  0  1  0  0
0  0  0  0  0  1  0  0
```

Using READ

The READ *slot* [*number*] [INTO *name*] or [*fmt*] command reads the programmed state of all channels in the slot specified by *slot* the number of times specified by *number*. The [*number*] parameter requires mainframe firmware revision 3.0 or greater.

Example: Read Slot State Using READ

This program uses READ to determine the open/closed states of the 16 channels of a GP switch in slot 1 of the mainframe. Data is returned as the decimal equivalent of the channel bit pattern, where channel open (OFF/NC) = 0 and channel closed (ON/NO) = 1.

```
10  INTEGER B                        !Define controller variable
20  OUTPUT 709;"INTEGER A"           !Define mainframe variable
30  OUTPUT 709;"READ 100 INTO A"     !Read slot 100 state, store in A
40  OUTPUT 709;"VREAD A"             !Transfer cont of A to out buffer
50  ENTER 709;B                      !Enter slot 100 state
60  PRINT "Slot 100 State"           !Display header
70  PRINT B                          !Display slot 100 state
80  END
```

For example, if channels 100, 105, and 109 are closed (ON/NO), READ returns 545 which is the decimal value for channel bit pattern 0000 0010 0010 0001. A typical return is:

```
Slot 100 State
545
```

Writing Channel States

The second programming function for the GP switch is to write data to open or close channels. Use the OPEN, CLOSE, CHWRITE, and CHWRITEM commands to write data to channels or use the WRITE or WRITEM commands to write data to slots. Table 3-4 summarizes the functions of these commands. A discussion of each command follows.

Table 3-4. GP Switch Write Commands

Command	Function
OPEN *ch_list*	Open ch(s) specified by *ch_list*.
CLOSE *ch_list*	Close ch(s) specified by *ch_list*.
CHWRITE *ch number*	Open/close ch specified by *ch*.
CHWRITEM *ch_list* DATA *state_list**	Open/close ch(s) specified by *ch_list*.
WRITE *slot number*	Open/close all chs in specified slot.
WRITEM *slot_list* DATA *data_list**	Open/close all chs in specified slot(s).

* = Requires mainframe firmware revision 3.0 or greater.

NOTE

The RST slot (reset) command sets all channels in slot addressed to open (OFF/NC).

Using OPEN and CLOSE

The OPEN *ch_list* command sets all channels specified by *ch_list* open (OFF/NC), while the CLOSE *ch_list* command sets all channels specified by *ch_list* closed (ON/NO). The *ch_list* parameter can be a single channel, a list of channels, or a combination of channels and channel lists.

Example: Write to Channels Using OPEN and CLOSE

In this program, the CLOSE command closes channels 400 and 403 through 406 and the OPEN command opens the remaining channels of a GP switch in slot 4 of mainframe.

```
10  OUTPUT 709;"CLOSE 400,403-406"        !Close ch 400 and 403-406
20  OUTPUT 709;"OPEN 401,402,407-415"  !Open ch 401, 402, and 407-415
30  END
```

Using CHWRITE and CHWRITEM

The CHWRITE and CHWRITEM commands can also be used to write data to one or more channels in a slot. Use CHWRITE to write data to a single channel on a slot. For mainframe firmware revision 3.0 or greater, use CHWRITEM to write data to one or more channels on a slot.

The CHWRITE Command

CHWRITE *ch number* sets the channel specified by *ch* open (OFF/NC) or closed (ON/NO), depending on the value of *number*. For *number* = 0, the channel is open (OFF/NC). For non-zero integer values of *number* between −32768 and +32767, the channel is closed (ON/NO).

Example: Write to Channels Using CHWRITE

This program uses CHWRITE to open channel 405 and to close channel 413 of a GP switch in slot 4 of mainframe. Channels not addressed remain in their previous state.

```
10  OUTPUT 709;"CHWRITE 405,0"    !Open channel 405
20  OUTPUT 709;"CHWRITE 413,1"    !Close channel 413
30  END
```

The CHWRITEM Command

For mainframe firmware revision 3.0 or greater, CHWRITEM *ch_list* DATA *state_list* writes channel states (open or closed) to specific channels or channel ranges. A "0" for *state_list* opens the corresponding channel or range of channels. Any non-zero integer for *state_list* between −32768 and +32767 closes the associated channel or range of channels. Up to ten channels or channel ranges can be specified along with up to ten channel states. If the channel list and state list are stored in arrays, a larger number of channels and states can be specified.

Example: Write to Channels Using CHWRITEM

In this program, CHWRITEM closes channels 300 and 308 of a GP switch in slot 3 of the mainframe. When the command executes, the first "1" in the DATA *state_list* parameter closes channel 300 and the second "1" closes channel 308.

```
10  OUTPUT 709;"CHWRITEM 300,308 DATA 1,1"   !Close channels 300, 308
20  OUTPUT 709;"READ 300"                    !Read channel states
30  ENTER 709;A                              !Enter channel states
40  PRINT IVAL$(A,2)                         !Display channel pattern
50  END
```

By using the READ command and the HP 9000 Series 200/300 controller IVAL$ function, channel closures can be verified. A typical return for this program follows, where the LSB = the channel 300 state and the MSB = the channel 315 state.

```
0000000100000001
```

Using WRITE and WRITEM

The WRITE and WRITEM commands can be used to write data to all channels in one or more slots. Use the WRITE command to write data to all channels in a single slot. For mainframe firmware revision 3.0 or greater, use the WRITEM command to write data to all channels in one or more slots.

The WRITE Command

WRITE *slot number* writes a decimal number specified by *number* to the slot specified by *slot*. The *number* range is −32768 to 32767 or 0 to 65535 and is the decimal value of the desired bit pattern for the channels, where channel bit 0 = channel open (OFF/NC) and channel bit 1 = channel closed (ON/NO). Refer to Table 3-2 for weighted decimal values for each channel.

For mainframe revision 3.0 or greater, the WRITE *slot data_list* or *array* command writes successive decimal numbers (bit patterns) specified by a data list or stored in an array. Up to ten bit patterns can be specified using a data list or the number of bit patterns can equal the size of the array. The range for the numbers specified or stored in the array is −32768 to +32767.

For example, WRITE 200,3,2,8,-1 writes state "3", followed by states "2", "8", and "−1" to slot 200. Or, if A has been defined as a 20-element mainframe array, WRITE 200,A(5) writes the state stored in element A(5) to slot 200.

Example: Write to Slot Using WRITE

This program uses the WRITE command to write state 97 (channels 200, 205, and 206 closed) to a GP switch in slot 200 of the mainframe. As a check, the READ command reads the state of the channels after WRITE is executed.

```
10  OUTPUT 709;"RST"                 !Reset HP 3852A
20  OUTPUT 709;"WRITE 200,97"        !Write to channels
30  OUTPUT 709;"READ 200"            !Read slot 200 state
40  ENTER 709;A                      !Enter slot 200 state
50  PRINT IVAL$(A,2)                 !Display slot 200 state
60  END
```

Since the IVAL$ function is used, a typical return for HP 9000 Series 200/300 (and equivalent) controllers follows, where the LSB = the channel 200 state and the MSB = the channel 215 state.

```
0000000001100001
```

The WRITEM Command

For mainframe firmware revision 3.0 or greater, WRITEM *slot_list* DATA *data_list* writes specified decimal numbers (bit patterns) to GP switch channel(s) in specified slot(s). Up to ten slot ranges or individual slots can be specified along with up to ten bit patterns. If the slot list and data list are stored in arrays, a larger number of slots and bit patterns can be specified. The range for *data_list* is −32768 to +32767 or 0 to 65535.

Example: Write to Slots Using WRITEM

In this program, WRITEM writes bit patterns to close channels 210, 211, and 215 of a GP switch in slot 2 of the mainframe and to close channels 301, 303, 304, 306, and 308 of a GP switch in slot 3 of the mainframe.

```
10   OUTPUT 709;"OUTBUF ON"                          !Enable output buffering
20   OUTPUT 709;"WRITEM 200,300 DATA -29696,346"     !Write bit patterns
30   OUTPUT 709;"READ 200"                           !Read slot 200 states
40   OUTPUT 709;"READ 300"                           !Read slot 300 states
50   FOR I=1 TO 2                                    !Start print loop
60       ENTER 709;A                                 !Enter ch states
70       PRINT IVAL$(A,2)                            !Display ch states
80       PRINT                                       !Space
90   NEXT I                                          !Increment print loop
100  END
```

When WRITEM executes, the bit pattern represented by −29696 (1000 1100 0000 0000) is written to slot 200 and the bit pattern represented by 346 (0000 0001 0101 1010) is written to slot 300.

By using the READ command to verify the channel states and the HP 9000 Series 200/300 controller IVAL$ function, the bit patterns can be displayed. A typical return follows, where the LSB = the channel ES00 state and the MSB = the channel ES15 state.

```
1000110000000000
0000000101011010
```

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