Errata

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HP References in this Manual

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HEWLETT PACKARD

HP 3852A DATA ACQUISITION/CONTROL UNIT

Plug-in Accessories Configuration & Programming Manual

Part 2
Chapters 12 - 19

Manual Part No. 03852-90002

Microfiche Part No. 03852-90052

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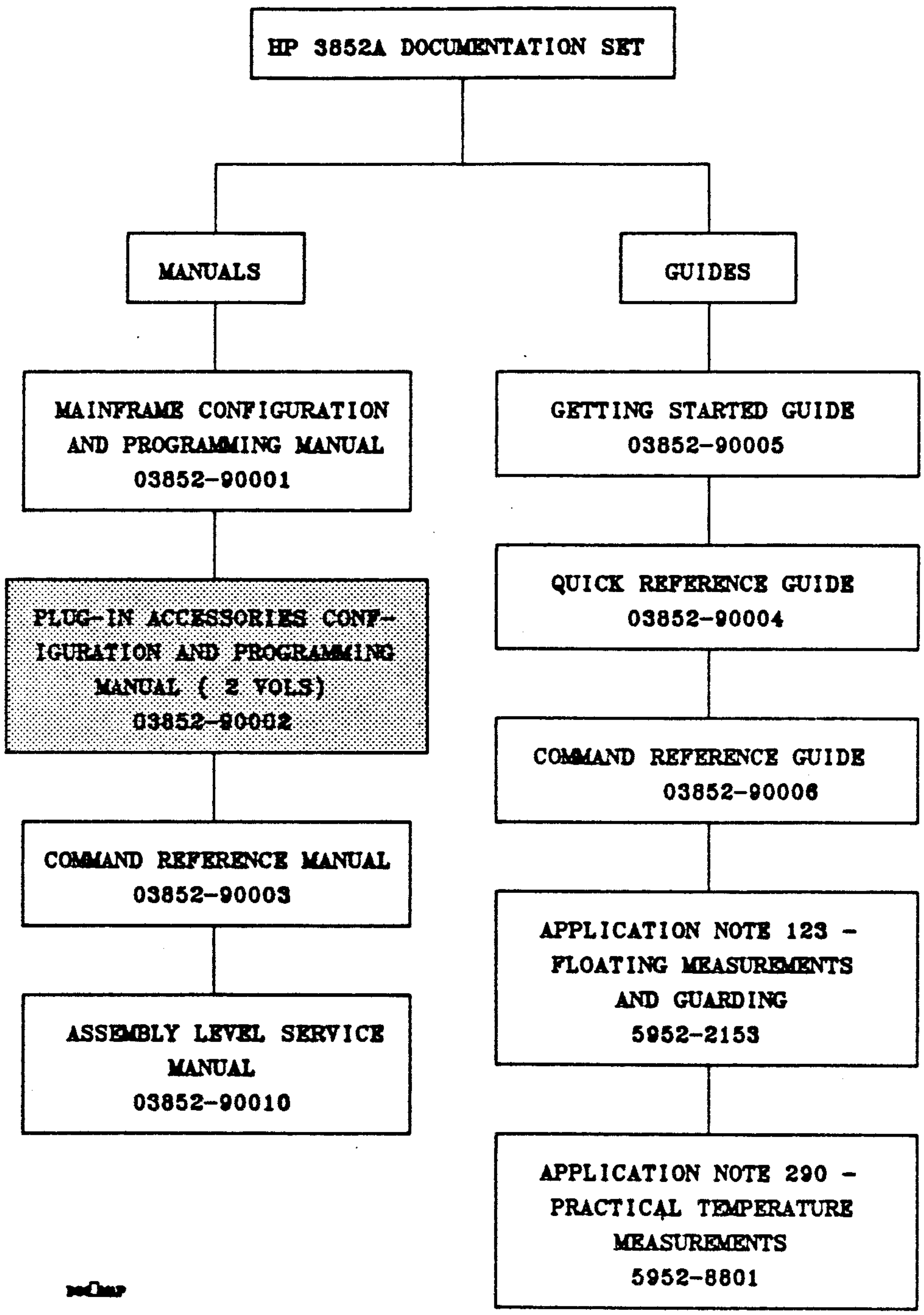
HP 3852A DOCUMENTATION MAP

This figure shows the documentation set for the HP 3852A Data Acquisition/Control Unit. The shaded box identifies this manual or guide.



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1. Analog and digital sections are interconnected.
2. HP 3852A/HP 3853A power supply limitations are exceeded.
3. Component height/protrusion restrictions are violated.
4. Maximum input on the digital lines is exceeded.

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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.

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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. Warns and cautions the user to refer to respective instruction manual procedures to avoid personal injury or possible damage to the product.
ϟ	Indicates dangerous voltage – terminals connected to interior voltage exceeding 1000 volts.
⏚ OR ⏚ (circled)	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.
⏚ (circled)	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.
ATTENTION Static Sensitive	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.*

HP 3852A Caution and Warning Labels

WARNING ⚠1
HAZARDOUS VOLTAGES MAY BE EXPOSED WHEN CONNECTOR IS REMOVED. DISCONNECT ALL FIELD WIRING POWER BEFORE REMOVING CONNECTOR.

This symbol and warning statement is found beside the Analog Extender port on the HP 3852A and HP 3853A. The analog extender port enables the HP 3852A backplane analog bus to be expanded to an extender. The analog bus routes signals from channels on multiplexer accessories to the voltmeter accessories. Depending on the multiplexer combinations installed and the application wired to the accessories, up to 350V peak (equivalent to 250V AC rms or 250V DC) can be present on the bus and, therefore, on the terminals of the port.

WARNING ⚠1
SHOCK HAZARD
DISCONNECT ALL
FIELD WIRING
POWER BEFORE
REMOVING
TERMINAL CARD

TURN OFF POWER SOURCES TO INSTRUMENT AND FIELD WIRING BEFORE INSTALLING/REMOVING ANY ACCESSORY.

The symbol and these statements are found below the locking ring on the terminal module and on the metal cover fastened to the component module of the plug-in accessories. Since all field wiring and most of the configuration involves the terminal module, the warnings serve as a reminder that even when the terminal module is separated from the component module, hazardous voltages can still be present on the terminal module due to the field wiring connected.

WARNING ⚠2 FOR SAFTY CONSIDER ALL CHANNELS TO BE AT THE HIGHEST VOLTAGE APPLIED TO ANY CHANNEL

⚠2 REGARD ALL ACCESSORY CHANNELS AS BEING AT THE SAME POTENTIAL AS THE HIGHEST VOLTAGE APPLIED TO ANY CHANNEL.

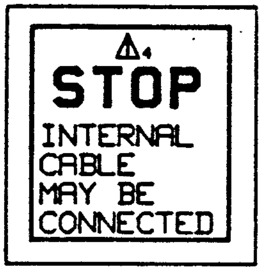
The symbol and these statements are found inside the terminal module and on the metal cover fastened to the component module of the plug-in accessories. The statements serve as a reminder to be careful when wiring in close proximity to other channels in which field wiring is already connected. Recall that hazardous voltages can still be present on the wiring terminals even though the accessory has been removed from the instrument. Note that all field wiring and configuration should be performed with the accessory removed from the instrument and with the terminal module separated from the component module.

⚠3 SEE MANUAL FOR MAXIMUM NUMBER OF THESE ASSEMBLIES PER 3852/3853

This symbol and statement is found above the locking ring on the terminal module of the HP 44727A, HP 44727B, and HP 44727C DAC (Digital-to-Analog Converter) accessories and on the side of the HP 44701A and HP 44702A/B voltmeter accessories. The symbol and statement refer to the fact that when a specific number of these accessories are installed in the same instrument, they place an excessive drain on the HP 3852A and HP 3853A power supply which in turn, causes degraded and often unpredictable system performance.

CAUTION ⚠4
IF PLUG-IN ACCESSORIES ARE PRESENT, DISCONNECT INTERNAL CABLE BEFORE REMOVING COMPLETELY

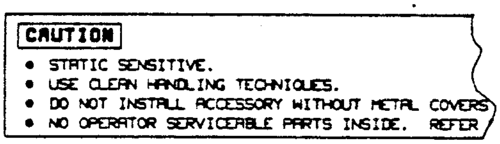
This symbol and statement is found on the name plate of the HP 44702A/B 13 bit High Speed Voltmeter accessory. The statement serves as a reminder that before removing the accessory, check to see that an HP 44711A, HP 44712A, or HP44713A High Speed FET multiplexer accessory is not connected to the voltmeter by the ribbon cable.



This symbol and statement is found on the bottom "rail" of the HP 44711A, HP 44712A, and HP 44713A High Speed FET multiplexer accessories and is exposed when the accessory's terminal module is removed. The "internal cable" is the ribbon cable that connects the FET multiplexer to the HP 44702A 13 bit High Speed Voltmeter accessory.

This statement appears at the bottom of the HP 3852A and HP 3853A power modules and under the CAUTION label on the metal cover of an accessory's component module. All equipment configuration and repair should be performed by service-trained personnel only.

This statement appears by the fuse socket on the HP 3852A and HP 3853A power modules. The HP 3852A and HP 3853A are shipped without the fuse installed. A 1.5 AT and 750 mAT fuse and a fuse cap are packaged together in a small static shielding bag which accompanies the instruments. A service-trained individual should install the correct fuse and set the LINE SELECTOR switches to the proper position before power is applied to the instrument.



These statements are found under the CAUTION label on the metal cover of an accessory's component module. The statements serve as a reminder to avoid touching the connector contacts and to use care when handling the accessory. Note that the protective cover should be attached following any necessary configuration in order to prevent damage to the components resulting from static discharge or when other accessories are installed.

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Contents

Chapter 12
5-Channel Counter/Totalizer

Chapter 12
5-Channel Counter/Totalizer
HP 44715A

Introduction

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

The chapter has six sections: Introduction, Specifications, Selecting Counter Functions, Configuring Counter Channels, Selecting Channel Parameters, and Programming Counter Channels.

- **Introduction** contains a chapter overview, describes the counter and its functions and shows suggested steps to configure and program the counter.
- **Specifications** lists specifications for the counter.
- **Selecting Counter Functions** describes each of the twelve counter functions and suggests applications for each function.
- **Configuring Counter Channels** shows how to hardware configure counter channels.
- **Selecting Channel Parameters** describes the counter commands to set input signal conditioning, channel function, timing and presets, interrupts, triggering, and reads.
- **Programming Counter Channels** describes each of the twelve counter functions, summarizes the commands to set a channel to the function and shows an example program for the function.

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 twelve functions. Each channel can be hardware configured to one of four operating modes.

Getting Started

As shown in Figure 12-1, there are four main steps to program a counter channel for any of the twelve counter functions. This section summarizes these four steps. In Figure 12-1, the section of the chapter which describes each step is listed at the right side of the figure.

Figure 12-1. Steps to Program Counter Channels

Step 1. Select Counter Functions

The first step is to select the counter function required for each counter channel to be used. Counter functions and typical applications are summarized in Table 12-2 in "Selecting Counter Functions". Refer to Table 12-2 to select the functions for your application. Then, refer to the applicable section of "Selecting Counter Functions" for a description of the functions you want to use.

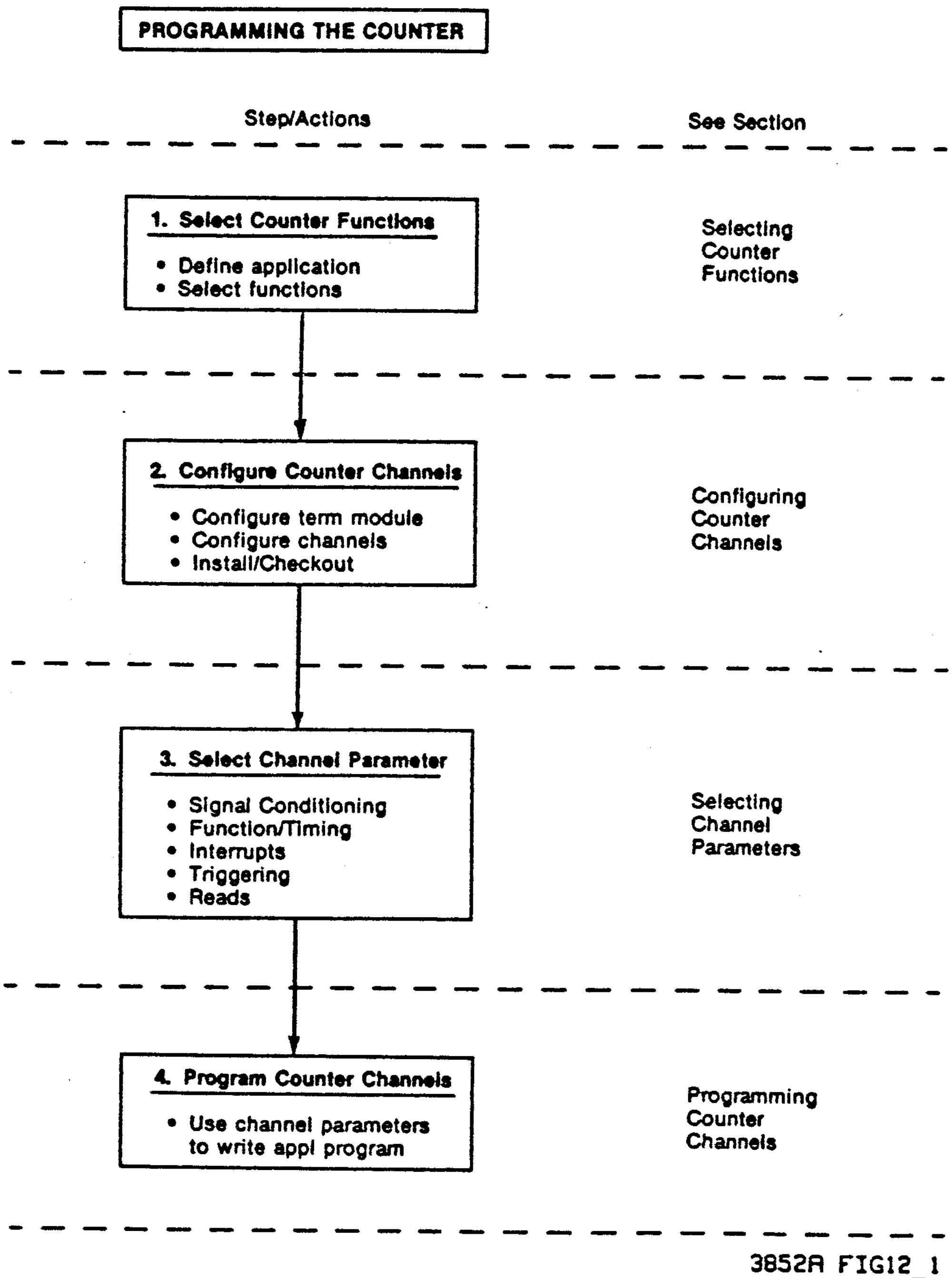


Figure 12-1. Steps to Program Counter Channels

Step 2. Configure Counter Channels

When you've selected the function for each channel to be used, the next step is to hardware configure the channels as required for your application. Refer to "Configuring Counter Channels" to hardware configure counter channels. When selecting devices to be connected to the counter, refer to Table 12-1, "Counter Specifications" for details on voltage, current, and frequency imitations.

Step 3. Select Channel Parameters

When channels have been hardware configured, the next step is to select parameters for each channel, including type of input signal conditioning, channel function, timing, presets, interrupts, triggering, and reads as required. Refer to "Selecting Channel Parameters" for commands and guidelines to select required channel parameters.

Step 4. Program Counter Channels

When you have configured the channels and selected the channel parameters, the last step is to program each channel for your application. Refer to "Programming Counter Channels" for a summary of each counter function and some example programs.

Specifications

Table 12-1 lists specifications for the counter.

Table 12-1. Counter Specifications

A. Max Voltage to Chassis		
1. Isolated Inputs	<=170 volts	[1]
2. Non-Isolated Inputs	<= 10 volts	
B. Min Pulse Width/Period (Any range or function)		[2]
1. Min pulse width	>2.5 usec	
2. Min period	>5.0 usec	
C. Logic input low (max.) (Over common mode voltage range)		
1. Isolated 5V range	1.0 volts	
2. Isolated 12V range	1.2 volts	
3. Isolated 24V range	1.5 volts	
4. Non Iso 5V range (TTL)	0.8 volts	
D. Logic input high (min) (Over common mode voltage range)		
1. Isolated 5V range	4.0 volts	
2. Isolated 12V range	10.0 volts	
3. Isolated 24V range	16.0 volts	
4. Non Iso 5V range (TTL)	2.25 volts	

E. Low Level Non-Isolated Input
  1. Frequency response
     DC to 10 kHz — 25 mV rms [3]
     DC to 200 kHz — 50 mV rms
  2. Common mode rejection — 60 dB [4]

F. Max Input Voltage
  (Continuous - no damage)
  1. Isolated 5V range — <24 volts
  2. Isolated 12V range — <24 volts
  3. Isolated 24V range — <42 volts
  4. Non Iso 5V range (TTL) — <20 volts
  5. Non Iso AC (low level) — <20 volts

G. Input Impedance
  1. Non Iso, Hi to Low — >1 Mohm [5]
     Non Iso, Hi/Low to Chassis — 10 Mohms +/-5%
  2. Isolated Input Currents
     Logic High — >=1.8 mA
     Logic Low — <= 50 uA
  3. Non Iso pullup resistor
     to +5V chassis ref. — 3.0 Kohms +/-5%

H. Period Range and Resolution
  (reciprocal counter, N period averages,
  N = 1 to 65535 and sample period
  =0.000001 seconds)

TBASE	Min Period Range Max	Resolution
0.000001	5 us <=P<= 65.535/N ms	1/N us
0.00001	5 us <= 20/N us <=P<= 655.35/N ms	10/N us
0.0001	5 us <= 200/N us <=P<= 6.5535/N sec	100/N us
0.001	5 us <= 2/N ms <=P<= 65.535/N sec	1/N ms
0.01	5us <= 20/N ms <=P<= 655.35/N sec	10/N ms

I. Period Accuracy
  (Count resolution shown in H. above).
  All ranges — +/- 0.01% +/- 1 count resolution

J. Frequency Range & Resolution (gated counter)

TBASE	Gate Time	Range	Resolution
1.0	1 sec	1 Hz to 65.535 kHz	1 Hz
0.1	100 msec	10 Hz to 200 kHz	10 Hz
0.01	10 msec	100 kHz to 200 kHz	100 Hz

K. Frequency Accuracy (gated counter)
  All ranges — +/-0.01% +/- 1 count

L. Ratio N
  1. Max counts A or B — 65535 counts

Table 12-1. Counter Specifications (cont'd)

2. Accuracy (N presets B)	+/- 1/N
M. Modulo N	
1. Accuracy	+/- 1 count
2. Range of N	2 to 65535
N. Totalize	
1. Accuracy	+/- 1 count
2. Max counts	2147483647 counts
3. Min counts	-2147483648 counts
4. Rollover point	From -1 to 0
5. Setup Time from B to A	>2 usec [6]
6. Hold Time from A to B	>1 usec [6]
O. Up/Down Counter	
1. Accuracy	
up/down	+/- 2 counts
counts/direction	+/- 1 count
2. Max count	2147483647 counts
3. Min count	-2147483648 counts
4. Rollover points	From 2147483647 to -2147483648 (up-counts); from -2147483648 to 2147483647 (down-counts).

Notes:

[1] = +/- volts to chassis
[2] = Affected by sample period value.
[3] = RMS volts for counts.
[4] = No counts for +/-10 volts of common mode voltage @ f <= 60 Hz and source impedance < 10 Kohm.
[5] = Common mode input impedance.
[6] = Applies to Counts/Direction and all gated functions; A = counts input; B = direction input.

Selecting Counter Functions

As noted in the Introduction, the first step to program counter channels is to select the function required for each channel to be used. This section describes the twelve counter functions. It also summarizes the functions (refer to Table 12-2), and shows the count sequence for each of the counting functions (see Figure 12-2).

Use this section to select the counter functions you need for your application. When you have selected the functions required, refer to "Selecting Channel Parameters" to select parameters for each channel to be used.

Counter Function Summary

Table 12-2 summarizes the twelve counter functions. For convenience, Table 12-2 groups the twelve functions into six categories: Total Counts, Up/Down Counts, Counts/Direction, Ratio, Period, and Frequency. However, each function is discussed separately in the text.

Except for the Frequency function, all counter functions are set with the FUNC command. The Frequency function is automatically set when the card configuration jumper is set to the FREQ position, so the FUNC command does not apply to the Frequency function. In Table 12-2, the "Para" column lists the FUNC command parameter which sets the channel to the function. For example, FUNC UDC sets a channel to Up/Down Counts.

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.

Therefore, in Table 12-2, 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 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 command. Refer to "Selecting Number or Period" for details on the NPER command.

Table 12-2. Summary of Counter Functions

Function	Para	Ch	Description	Application
Total Counts				
Ungated Total Counts	TOTAL	S	Totalizes A input.	Total counts on single input.
Gated Total Counts	TOTAL	D	Totalizes A input, gated by B input.	Total counts on single input, gated by second input.
Ungated Total Counts, Mod NPER	TOTALM	S	Totalizes A input, count modulo NPER.	Total counts on single input, modulo NPER.
Gated Total Counts, Mod NPER	TOTALM	D	Totalizes A input, gated by B input, count modulo NPER.	Total counts on single input, gated by second input, count modulo NPER.
Up/Down Counts				
Up/Down Counts	UDC	D	Count up on A input, count down on	Count difference between

Table 12-2. Summary of Counter Functions (cont'd)

			B input. Result is (A-B) counts.	counts of two inputs.
Up/Down Counts, Mod NPER	UDCM	D	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.
<u>Counts/Direction</u>				
Counts/ Direction	CD	D	Count A input up or down. B input controls direction.	Count relative number of up counts and down counts.
Counts/ Direction, Mod NPER	CDM	D	Count A input up or down. B input controls direction. Count modulo NPER.	Count relative number of up counts and down counts, modulo NPER.
<u>Ratio</u>				
Ratio	RAT	D	Count A input until NPER periods to B input occur.	Measure ratio of A input to B input counts.
<u>Period</u>				
Period	PER	D	Measure average of NPER periods of A input.	Measure average value of NPER periods of input
Delayed Period	PERD	D	Measure NPERth period of A input, as gated by B input.	Measure value of single period of input, delayed by NPER periods.
<u>Frequency</u>				
Frequency	N/A	S	Measure frequency of A input.	Measure frequency of single input.

Count Sequences

As shown in Table 12-2, the counter has two primary modes of operation: counting or measuring. Total Counts (TOTAL/TOTALM), Up/Down Counts (UDC/UDCM), and Counts/Direction (CD/CDM) are counting functions, while Ratio (RAT), Period (PER/PERD), and Frequency are measurement functions. The counting functions continuously repeat the count sequence, while the measurement functions perform a one-time measurement.

To effectively use the counting functions, it is important to understand the count sequence for each function. Figure 12-2 summarizes the count sequence for each of the eight counting functions. Note the difference between normal count sequences and Modulo NPER sequences.

With normal count sequence functions (TOTAL, UDC, and CD), the sequence is from 0 to maximum (positive) value to minimum (negative) value and back to 0 for up counts. The sequence is from 0 to minimum (negative) value to maximum (positive) value and back to 0 for down-counts.

However, for Modulo NPER count functions (TOTALM, UDCM, and CDM), the count sequence is from 0 to NPER-1 and back to 0 for up-counts, or from 0 to NPER-1, NPER-2, ..., 0 for down-counts. There are no negative numbers in the count sequence for Modulo NPER count functions.

For example, with Ungated Total Counts (TOTAL), the counter counts from 0 up to 2147483647. With the next count, the counter goes to -2147483648 and counts down to -1. With the next count, the counter rolls over to 0 and (if the channel is enabled) generates an overflow interrupt.

With the Ungated Total Counts, Modulo NPER (TOTALM) function, the count sequence starts from 0 up to NPER-1, where NPER = 2 to 65535 is selected with the NPER command. With the next count, the counter rolls over to 0 and (if the channel is enabled) generates an overflow interrupt.

Figure 12-2. Count Sequences

Ungated Total Counts

You can use Ungated Total Counts (TOTAL) to count and totalize single inputs. For example, you can use this function to totalize switch closures. You can also set the channel to generate an overflow interrupt after a desired number of counts.

With Ungated Total Counts, the channel totalizes programmed edges (positive or negative) of the A input, starting at 0 (or at a preset value set by CNTSET) and counts up to 2147483647. With the next count, the counter rolls over to -2147483648 and begins to count up from -2147483648 to 0. This count process continuously repeats as long as the channel is programmed for the TOTAL function.

The channel can be preset to any number between -2147483648 and +2147483647 by using the CNTSET command. The preset number is used only once, and the count then resumes the sequence described in the previous paragraph. For example, if the preset = 1000000000, the count sequence is 1000000000 to 2147483647 to -2147483647 and back to 0 (not to the preset).

If enabled, the channel generates an overflow interrupt when the count goes from -1 to 0. Since the channel can be preset, an overflow interrupt can be generated after a desired number of counts rather than having to wait for the full count cycle (4294967296 counts). A trigger to an idle channel starts the channel counting from 0 or from the preset value.

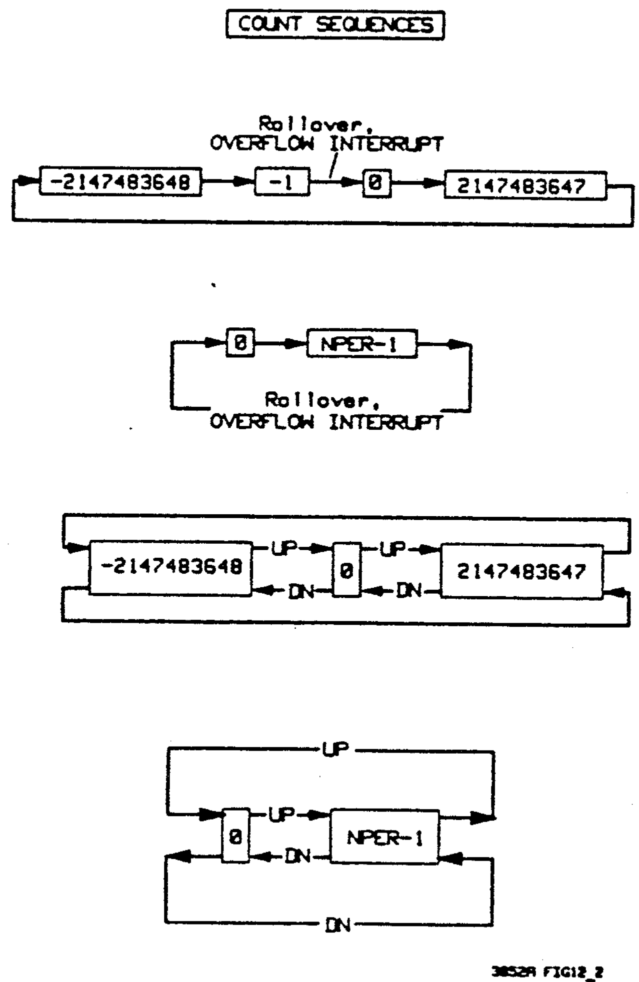


Figure 12-2. Count Sequences

Gated Total Counts

You can use Gated Total Counts (TOTAL) to count and 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. You can also enable the channel to interrupt after a desired number of counts.

Gated Total Counts is similar to Ungated Total Counts except that the B input gates the A input count. The B input can be selected so that the programmed edges (positive or negative) of the A input are counted only when the B input is high or low, as required. For example, you can set the channel to count positive A edges only when the B input is high, count negative A edges when the B input is low, etc.

The channel totalizes programmed edges (positive or negative) of the A input, starting at 0 (or at a preset value set by CNTSET) and counts up to 2147483647. With the next count, the counter rolls over to -2147483648 and begins to count up from -2147483648 to 0. This count process continuously repeats as long as the channel is programmed for the TOTAL function.

The channel can be preset to any number between -2147483648 and +2147483647 by using the CNTSET command. The preset number is used only once, and the count then resumes the sequence described in the previous paragraph. For example, if the preset = 1000000000, the count sequence is 1000000000 to 2147483647 to -2147483648 and back to 0 (not to the preset).

If enabled, the channel generates an overflow interrupt when the count goes from -1 to 0. Since the channel can be preset, an overflow interrupt can be generated after a desired number of counts rather than having to wait for the full count cycle (4294967296 counts). A trigger to an idle channel starts the channel counting from 0 or from the preset value.

Ungated Total Counts, Modulo NPER

You can use Ungated Total Counts, Modulo NPER (TOTALM) when you want to totalize counts and restart the count after a fixed number of counts. With the TOTALM function, you can set a channel to count up from 0 to a number from 2 to 65534 (as set by the NPER command), roll over to 0 with the next count edge, and begin counting up again.

With Ungated Total Counts, Modulo NPER, the channel counts programmed edges (positive or negative) of the A input, starting at 0 up to NPER-1 counts, where NPER = 2 to 65534. (There is no preset value other than 0). A trigger begins the count at 0 and the channel counts up to NPER-1 counts. When the next programmed edge occurs, the counter rolls over to 0. The count then begins counting up from 0 to NPER-1 and again rolls over to 0. This process continuously repeats.

Each channel can be enabled for an overflow interrupt when the count reaches NPER-1 counts and the next count edge is received. However, disabled interrupts are recommended for interrupt rates >10 Hz.

With Ungated Total Counts, Modulo NPER, the channel can be set to generate an interrupt after a set number of counts between 2 and 65534. In contrast, with Ungated Total Counts (if a preset is not used), an overflow interrupt can be generated only after 4294967296 counts (after -CNTSET counts with a preset).

Gated Total Counts, Modulo NPER

You can use the Gated Total Counts, Modulo NPER (TOTALM) to totalize counts on one input, modulo NPER, as gated by a second input. For example, you could 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 Gated Total Counts, Modulo NPER, the channel counts programmed edges (positive or negative) of the A input starting at 0 up to NPER-1 counts, where NPER = 2 to 65534, as gated by the B input. (There is no preset value other than 0). A trigger begins the count at 0 and the channel counts up to NPER-1 counts. When the next gated count edge occurs, the counter rolls over to 0. The count then begins counting up from 0 to NPER-1 and again rolls over to 0. This process continuously repeats.

The B input gates the A input count. The B input gate can be set for high or low level. For example, you can set the channel to count positive A edges only when the B input is high, to count negative A edges only when the B input is low, etc.

The channel can be enabled to generate an overflow interrupt when the count reaches NPER-1 counts and the next gated count edge is received. However, disabled interrupts are recommended for interrupt rates where rate/NPER > 10 Hz.

With Gated Total Counts, Modulo NPER, the channel can be set to generate an interrupt after a set number of gated counts between 2 and 65534. In contrast, with Ungated/Gated Total Counts (if a preset is not used), an overflow interrupt can be generated only after 4294967296 counts.

Up/Down Counts

You can use the Up/Down Counts (UDC) function to measure the difference in counts between two inputs. With the Up/Down Counts function, the A input always increases the count and the B input always decreases the count. Thus, at any time, the count in the counter is the difference (A-B) between the the two input counts.

For Up/Down Counts, the channel counts up programmed edges (positive or negative) of the A input starting from 0 up to 2147483647. The channel counts down programmed edges of the B input (positive or negative) starting at 0 down to -2147483648. A trigger starts the count for both inputs.

When the counter reaches 2147483647 counts and the next A input count edge is received, the counter rolls over to -2147483648 and continues counting up. When the counter reaches -2147483648 and the next B input count edge is received, the counter rolls over to 2147483647 and continues to count down. No interrupts are generated for Up/Down Counts.

Up/Down Counts, Modulo NPER

You can use Up/Down Counts, Modulo NPER (UDCM) to measure the difference (A-B) between two inputs to a channel, modulo NPER. For Up/Down Counts, Modulo NPER, the channel counts up on programmed edges (positive or negative) of the A input to NPER-1, where NPER = 2 to 65534. The channel counts down from NPER-1 to 0 on programmed edges (positive or negative) of the B input.

A trigger starts the count for both inputs. When the count reaches NPER-1 and the next A input count edge is received, the counter rolls over to 0 and continues counting up. When the count reaches 0 and the next B input count edge is received, the counter rolls over to NPER-1 and continues to count down. No interrupts are generated for Up/Down Counts, Modulo NPER.

Counts/ Direction

You can use the Counts/Direction (CD) function to measure the net number of counts (up-counts minus down-counts) for an input as controlled by a second input. For example, you can use the Counts/Direction function to measure shaft position.

With Counts/Direction, the channel counts programmed edges (positive or negative) of the A input up or down, depending on the the B input level. The B input level can be set. When the B input level is set for high, A input counts are up-counts when B is high, down-counts when B is low. When the B input level is set for low, A input counts are up-counts when B is low, down-counts when B is high.

A trigger starts the count on the A input. When the count reaches 2147483647 and the next up-count edge is received, the counter rolls over to -2147483648 and continues counting up without missing a count. When the counter reaches -2147483648 and the next down-count edge is received, the counter rolls over to 2147483647 and continues to count down without missing a count. No interrupts are generated for Counts/Direction.

Quadrature Measurements

A variation of the Counts/Direction function is Quadrature Measurements. A typical application for Quadrature Measurements is to measure the output of a shaft encoder. Shaft encoders typically generate two square wave signals (A and B) 90 degrees out of phase with each other. If the shaft rotates one way, A leads B (arbitrarily called CW). If the shaft rotates the opposite way, A lags B (CCW).

Quadrature Measurements can be used to measure the position of a shaft by connecting the A input for the Counts function and the B input for the Direction function and programming the channel for the Counts/Direction function. With this configuration, the count increments once per period of the A input when the shaft rotates in the CW direction and decrements once per period of the A input when the shaft rotates in the CCW direction.

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 problem, the counter component module (not the terminal module) has jumpers which can be set so that all transitions of the A input (positive and negative) are counted (refer to "Configuring Counter Channels" for details).

When the counter is configured for Quadrature Measurements, the channel counts double the number of counts for Counts/Direction. Table 12-3 lists the differences between Counts/Direction and Quadrature Measurements.

Table 12-3. Counts/Direction vs. Quadrature Measurements

Counts/Direction	Quadrature

Table 12-3. Counts/Direction vs. Quadrature Measurements (cont'd)

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 Counts/Dir:	+/-(1+#reversals/2)	+/-1
Output:	1/period of A	2/period of A
Polarity:	Up when B leads A (default pos edge)	Up when B leads A (always)
Other functions	No effect	Will not work

* = Setting the A jumpers to "Quad" and the B jumpers to "Normal" causes the TOTAL and TOTALM functions to count double the normal counts and is not recommended.

Counts/ Direction, Modulo NPER

You can use Counts/Direction, Modulo NPER (CDM) to measure the difference between up-counts and down-counts, module NPER. For example, shaft encoder output can be measured by counting the A input up or down, depending on the direction of rotation (CW or CCW) of the B input. Refer to "Quadrature Measurements" for a discussion of shaft encoder outputs.

For Counts/Direction, Modulo NPER, the channel counts programmed edges (positive or negative) of the A input up or down, depending on the level of the B input. The channel counts up from 0 to NPER-1 and counts down to 0 from NPER-1, where NPER = 2 to 65534.

The B input level can be set. When the B input level is set for high, A inputs are up-counts when the B input is high, down-counts when the B input is low. When the B input level is set for low, A inputs are up-counts when the B input is low, down-counts when the B input is high.

A trigger starts the count for both inputs. When the count reaches NPER-1 and the next up-count edge is received, the counter rolls over to 0 and continues counting up. When the count reaches 0 and the next down-count edge is received, the counter rolls over to NPER-1 and counts down to 0 No interrupts are generated for Counts/Direction, Modulo NPER.

Ratio

You can use the Ratio (RAT) function to count the number of pulses input to the A channel for a fixed number of pulses input to the B channel. For example, use the Ratio function to determine the number of pulses output from a pulse generator when 100 pulses have been output from a reference pulse generator. The counter returns the ratio of the two inputs (A/B).

For the Ratio function, the channel counts programmed edges (positive or negative) of the A input until NPER periods have occurred on the B input, where NPER = 1 to 65535. The data returned by the Ratio function is the ratio of the number of counts on the A input to NPER counts on the B input (A/B).

A trigger to the A input starts the measurement on the first programmed edge to the B input and ends after NPER periods to the B input. The channel can be enabled to generate a reading available interrupt when NPER B periods have been counted.

Period

You can use the Period (PER) function to measure the average period of an input. (Use Delayed Period (PERD) to measure a single period of an input).

With the Period function, the channel averages NPER periods of the A input, where NPER = 1 to 65535. The B input is not used for the Period function. A trigger begins Period measurement with the first count edge (positive or negative) after the function is programmed and ends after NPER periods of the A input.

The data returned is the average value of NPER periods of the A input. The channel can be enabled to generate a reading available interrupt when NPER periods of the A input have been received.

Delayed Period

You can use Delayed Period (PERD) to measure a single period of the A input as gated by the B input. With Delayed Period, the channel measures the NPERth gated period of the A input.

You can set the B input gate level. When the B input level is set for high, the A input periods are counted when the B input is high. When the B input level is set for low, the A input periods are counted when the B input is low. The channel can be enabled to generate a reading available interrupt when the NPERth period of the A input has been received.

Frequency

You can use the Frequency function to measure the frequency of inputs from >1 Hz up to 200 kHz. With the Frequency function, all five channels simultaneously perform frequency measurement. When the card configuration jumper is set for FREQ (refer to "Configuring Counter Channels"), all channels are set for Frequency function and no other function can be performed. If enabled, each channel generates a reading available interrupt when the frequency measurement is complete.

NOTE

You can also make frequency measurements by setting a channel to Period (PER) or Delayed Period (PERD) and taking the reciprocal of the period measured. Refer to "Period (PER)" or "Delayed Period (PERD)" to set the counter for these functions.

Configuring Counter Channels

This section shows how to hardware configure counter channels. It shows how to set the jumpers on the terminal and component modules, provides guidelines to install user-supplied signal conditioning elements, and shows typical field wiring connections.

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 and extenders, to all installed accessories, and to all external devices connected to the mainframe, extenders or accessories.

WARNING

For safety, consider all accessory channels to be at the highest voltage applied to any channel.

There are four major actions required to configure counter channels:

```
1. Set terminal module/component module jumpers
      . Set card configuration jumper
      . Set quadrature jumpers

2. Set hardware triggering method
      . Set external triggering
      . Set backplane triggering

3. Configure isolated input channels
      . Set signal level jumpers
      . Install signal conditioning
      . Connect field wiring

4. Configure non-isolated input channels
      . Set AC/TTL jumpers
      . Install signal conditioning
      . Connect field wiring
```

Although there are (potentially) four major actions required to hardware configure counter channels, the specific actions to take depend on the application requirements, as shown below. For example, if your application requires hardware triggering and isolated channels, use steps 1, 2, and 3. If your application requires software triggering and non-isolated channels, use steps 1 and 4.

When all required channels have been configured, refer to "Installation/Checkout" to install the counter in the mainframe or in an extender.

<u>Actions Required to Configure Channels</u>

Triggering	Channel Input	Actions Required
Hardware	Isolated	1,2,3
Hardware	Non-Isolated	1,2,4
Hardware	Both	1,2,3,4
Software	Isolated	1,3
Software	Non-Isolated	1,4
Software	Both	1,3,4

Setting Jumpers

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 Configuration and Programming Manual to remove the terminal module. Figure 12-3 shows the terminal module with the cover removed.

Figure 12-3. Terminal Module - Hardware Configuration

Regardless of the counter function selected, channels used must be hardware configured by setting the card configuration jumper on the terminal module. Also, for quadrature measurements (a version of the Counts/Direction function), the quadrature jumpers on the counter component module must be set to the quadrature position (refer to "Setting Quadrature Jumpers").

Setting Card Configuration Jumper

By setting the card configuration jumper, each channel of the counter can be set to one of four hardware configurations: TOTAL, FREQ, 4-CH, or 3-CH. Table 12-4 describes the four hardware settings, shows the hardware channel numbering for each setting, and lists the counter functions for the setting. Refer to "Selecting Counter Functions" for a description of the counter functions.

Hardware channel numbering depends on the card configuration jumper setting. As shown in Figure 12-3, 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 as printed in the column under the 4-CH setting.

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 type of input path (isolated or non-isolated) is software-selectable by using the TERM command. Refer to "Selecting Input Signal Conditioning" for a description of the TERM command.

Table 12-4. Card Configuration Jumper Settings

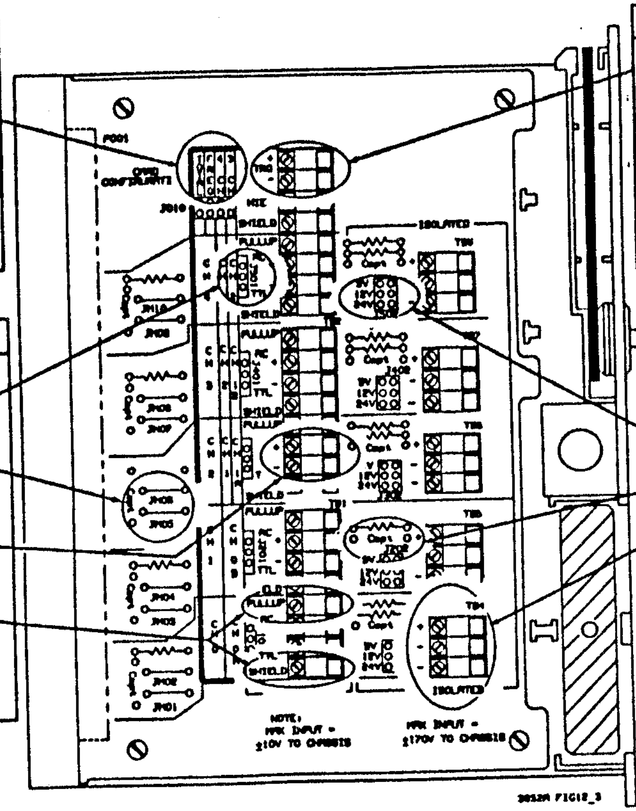
Card	Description	Channel*	Counter

1 Set CARD CONFIGURATION Jumper

- TOTAL - Single-channel measurements only on channels 0 through 4.
- FREQ - All five channels measure frequency only.
- 4-CH - Double-channel measurements on channel 0; single-channel measurements on channels 1, 2, and 3.
- 3-CH - Double-channel measurements on channels 0 and 1; single-channel measurements on channel 2.

4 Configure Non-Isolated Input Channels

- Set AC/TTL jumpers for type of input to each channel. Use AC to detect zero crossings. Use TTL for TTL level signals.
- If required, install user-supplied signal conditioning elements (C in Copt, matched resistors in JMXX and JMXX). See Figure 12-6.
- Connect field wiring from non-isolated inputs to + and – connectors on appropriate terminal blocks of TB1, TB2, or TB3. NOTE: maximum input = +/– 10 volts to chassis for either input.
- For otherwise floating inputs (relays or open collector outputs), connect field wiring to PULLUP, +, –, and SHIELD terminals. Connect PULLUP to + and connect SHIELD to - and use TTL position. With these connections, relay close = low signal, relay open = high signal.



2 Select Hardware Triggering Method

There are two methods for hardware triggering: External Triggering or Backplane Triggering.

- For External Triggering, connect connector from external (user) source or from Pacer Out BNC on mainframe to XTRG + and - terminals and to SHIELD.
- For Backplane Triggering, connect connector from external (user) trigger source to SYSTEM TRIGGER IN BNC on mainframe. Use TRIG SYS and TRG EXT commands to enable triggering on USEd channel.

3 Configure ISOLATED Input Channels

- For each isolated input, select 5 V, 12 V, or 24 V signal conditioning level.
- As required, install user-supplied passive (R or C) signal conditioning elements.
- Connect field wiring from isolated input devices to TB4, TB5, TB6, TB7, or TB8. CAUTION: Maximum voltage = +/– 170 volts to chassis.

Notes

1. Type of input path (Isolated or Non-Isolated) is software-selectable with the TERM command.
2. For Quadrature Measurements, must also set quadrature jumpers on counter component module. See Figure 12-4.

Figure 12-3. Terminal Module - Hardware Configuration

Table 12-16. Example Program Titles (cont'd)

Period		
Period (PER)	Measure Average Period	Measure average period of square wave input.
Delayed Period (PERD)	Measure Single Period	Measure period of square wave input. Measure after 100 periods of input.
Frequency		
Frequency (N/A)	Measure Flow Meter Flow Rate	Measure paddlewheel flow meter flow rate by measuring pickup input frequency.

Ungated Total Counts

You can use Ungated Total Counts (TOTAL) when you have a single input for which you want to totalize counts. In addition, by presetting the counter (with the CNTSET command), you can enable channels to interrupt after a desired number of counts. Figure 12-9 summarizes the Ungated Total Counts function and the commands to set a channel to the function.

Figure 12-9. Ungated Total Counts

Example: Totalize Switch Closures

You want to totalize the number of times switch S3 closes and generate an interrupt when the switch closes 100 times. One way to do this is to connect the switch to channel 3 of a counter in slot 5 of the mainframe. See Figure 12-10 for a connection diagram and counter configuration. An example program follows.

NOTE

In the following program, interrupts are handled by the mainframe. However, interrupts can also be handled by the controller. Refer to the example "Totalize Stepper Motor Steps" for a way to handle interrupts with an HP 200 Series or HP 300 Series controller.

Figure 12-10. Example: Totalize Switch Closures

```
10  !
20  !This program sets channel 3 of a counter in
30  !slot 5 of the mainframe to totalize number
40  !of switch closures.  Channel enabled to
50  !interrupt  after 100 switch closures.
60  !
70  !Set Signal Conditioning:
```

Table 12-4. Card Configuration Jumper Settings (cont'd)

Setting		Numbers Hdwe	Numbers Prog	Functions
TOTAL	Single-channel totalizing measurements ONLY.	0,1, 2,3, 4	0,1, 2,3, 4	Ungated Total Counts (TOTAL/ TOTALM)
FREQ	Frequency measurements ONLY on all five channels.	0,1, 2,3, 4	0,1, 2,3, 4	Frequency
4-CH	Double-channel measurements on channel 0; single-channel measurements on channels 1, 2, and 3.	0A,0B, 1,2,3	0,1, 2,3	All except Frequency
3-CH	Double-channel measurements on channels 0 and 1; single-channel measurements on channel 2.	0A,0B, 1A,1B, 2	0,1, 2	All except Frequency

* Hdwe = hardware channel numbers
Prog = programming channel numbers

To set counter channels for your application, first determine the function to be used for each channel (refer to Table 12-2). Then, set the card configuration jumper to configure the channels for these functions.

To set all five channels for the Frequency function, 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 functions, set the jumper to the 4-CH or 3-CH position, as required.

Example: Setting Card Configuration Jumper

You want to make a Ratio (RAT) measurement, 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, for example, connect the Ratio 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

To do quadrature measurements (a version of the Counts/Direction function), you'll need to change the settings of the quadrature jumpers on the counter component module (not the terminal module) in addition to setting 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 measurements. For 4-CH configuration, set jumpers J602 and J603 to pins 1 and 2 to configure channel 0 for quadrature measurements.

When the card configuration jumper is set for 3-CH, both channels 0 and 1 can be used for quadrature measurements. 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 12-4 for quadrature jumper locations and settings.

Figure 12-4. Setting Quadrature Jumpers

Setting Hardware Triggering

For certain applications, you may require hardware triggering of the channels used. This section describes the two methods of hardware triggering: external and backplane. Refer to this section if your application requires hardware triggering. Refer to "Selecting Triggering Mode" in "Selecting Channel Parameters" if your application requires software triggering.

Setting External Triggering

To set External Triggering, 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 +, -, and SHIELD terminals. Triggering is on the high-to-low transition, and inputs must have high >= 4.0 volts and low <= 0.9 volts.

Setting Backplane Triggering

There are several ways to set Backplane Triggering. One way is to connect a BNC connector from an external (user) trigger source to the SYSTEM TRIGGER IN BNC terminal on the mainframe and use the TRIG SYS and TRG EXT commands. Another way is to use the TRG SGL command with a previously set TRIG SYS command. A third way is to use TRG GET and Group Execute Trigger over HP-IB. Refer to the HP 3852A Configuration and Programming Manual (the TRG command) for details on Backplane Triggering.

Configuring Isolated Input Channels

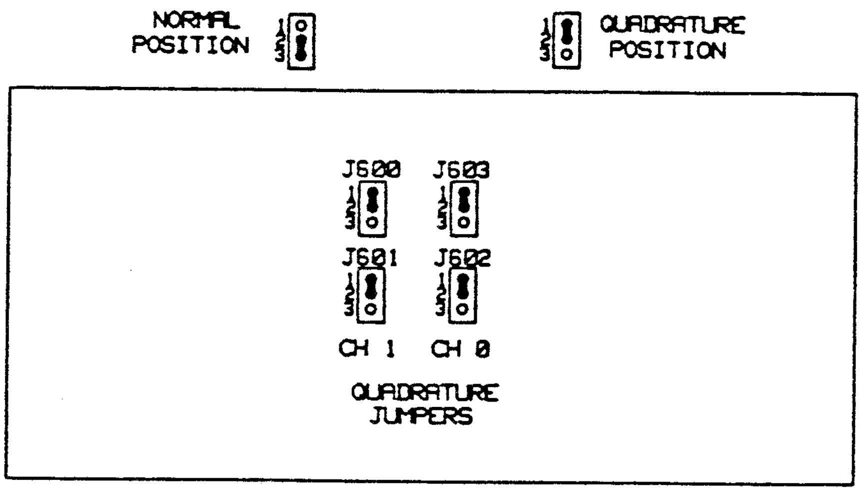
This section shows how to hardware configure isolated input channels. There are three steps to configure an isolated input channel:

- Set signal level jumpers.
- Install signal conditioning.
- Connect field wiring.

Setting Signal Level Jumpers

As shown in Figure 12-3, 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.

- For 4-CH configuration, move J602 and J603 to Quadrature position to set channel 0, (Ch 1 N/A for 4-CH configuration).
- For 3-CH configuration, move J602 and J603 to set channel 0. Move J600 and J601 to set channel 1.



3852A FIG112_4

Figure 12-4. Setting Quadrature Jumpers

CAUTION

Maximum input voltage = +/-170 volts to chassis. This means that maximum voltage between Vhigh and Vlow or between Vhigh and chassis or between Vlow and chassis must be <= +/-170 volts.

Installing Signal Conditioning

If required, you can install an optional, user-supplied capacitor as a signal conditioning element in each isolated input channel to act as a low-pass filter. Each isolated input channel includes a connector labeled Copt (see Figure 12-3 for location).

When a capacitor is placed across the Copt position, the input signal attenuation for the channel is shown in equation (1), where C = capacitance (in Farads) to be placed across Copt, R (in ohms) depends on the range set by the Signal Level Jumper, and f = frequency of the desired 3 dB point.

$$(1)\ \text{Attenuation} = \frac{1100 + R}{1100 + R + 1100\,(2*pi*f*R*Copt)}$$

```
R = Rsource                ( 5V range, R in ohms)
R = Rsource + 2700 ohm     (12V range, R in ohms)
R = Rsource + 6600 ohm     (24V range, R in ohms)
C = Copt value (Farads)
f = Frequency of 3 dB point.
```

To determine the value of Copt for a specific frequency, in equation (1) let 1100 + R = 1100*(2*pi*f*R*Copt). Then, to find Copt for a specified 3dB point, use equation (2).

$$(2)\quad Copt = \frac{1100 + R}{6911.5\,(R*f)} \qquad \text{(Copt in Farads)}$$

As required, determine the capacitance values needed for Copt and install the capacitors in the channels required.

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 channel 3, channel 2, or channel 1B inputs, depending on the setting of the card configuration jumper.

There are two types of measurements for the counter: single-input and double-input. Single-input measurements require only one input (the A input), while double-input measurements require two inputs (A and B input). Ungated Total Counts (TOTAL); Ungated Total Counts, Modulo NPER (TOTALM); and Frequency are single-input functions. All other functions are double-input.

NOTE

The Period (PER) function is a double-input measurement. 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.

Figure 12-5 shows example field wiring connections for single-input and double-input channels. Note that the card configuration jumper must be set to the 3-CH or 4-CH position to measure double-input channels.

Figure 12-5. Field Wiring - Isolated Inputs

Configuring Non-Isolated Input Channels

This section shows how to hardware configure non-isolated input channels. There are three steps to hardware configure a non-isolated input channel:

- Set AC/TTL jumpers.
- Install signal conditioning.
- Connect field wiring.

Setting AC/TTL Jumpers

As shown in Figure 12-3, 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.

Installing Signal Conditioning

Each non-isolated input channel has connections (JMXX) for optional, user-supplied resistors and a connector (Copt) for an optional, user-supplied capacitor. See Figure 12-6 for location of JM and Copt connectors. 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 a 2:1 DC attenuation on a channel, place 1 Kohm resistors across each of the JM jumpers and a 2 Kohm resistor across Copt. For a low-pass filter, compute capacitance value from Copt = 1/(2*pi*R*f), where R = resistor value in K ohms to be placed across each of the JM jumpers, f = desired rolloff frequency in kHz, and Copt = capacitor value in uF. 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 Kohm across JM01 and across JM01, and use Copt = 0.08 uF. For filter rolloff frequency = 10 kHz on this channel, use R = 1 Kohm across JM01 and across

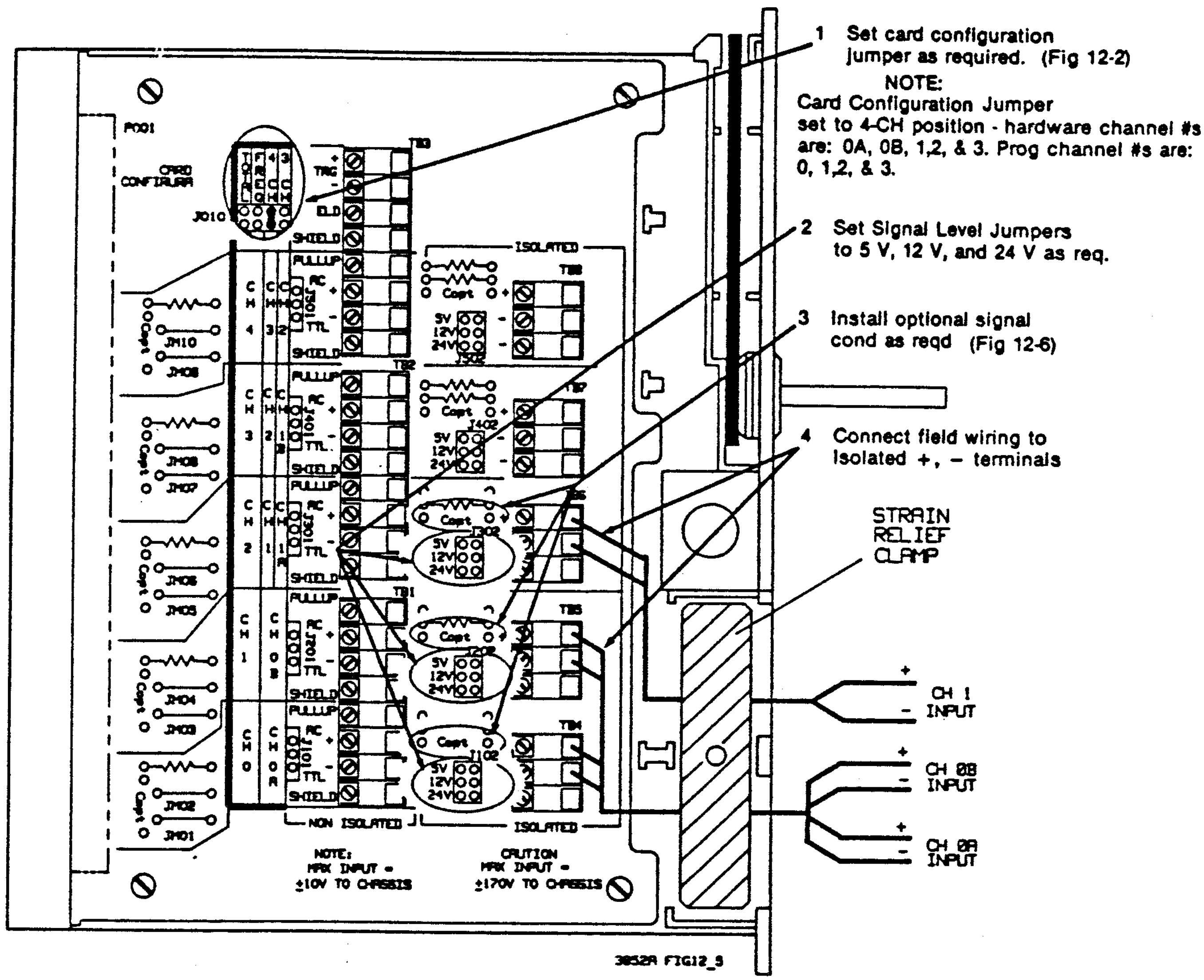


Figure 12-5. Field Wiring - Isolated Inputs

JM02, and use Copt = 0.008 uF.

Figure 12-6. Signal Conditioning - Non-Isolated Channels

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 the terminals on 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 3K 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 12-7 shows typical connection diagrams using the pullup resistor. The two-wire connection (method A) is acceptable. However, the 4-wire connection (method B) provides better noise margin on logic low (when the switch is closed).

Figure 12-7. Using Pullup Resistors

Typical Field Wiring Connections

There are two types of measurements for the counter: single-input and double-input. Single-input measurements require only one input (the A input), while double-input measurements require two inputs (A and B input). Ungated Total Counts (TOTAL); Ungated Total Counts, Modulo NPER (TOTALM); and Frequency are single-input functions. All other functions are double-input functions.

NOTE

The Period (PER) function is a double-input measurement. However, the B "input" comes from the counter and is NOT used as 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.

Figure 12-8 shows example field wiring connections to both single-input and double-input channels. Note that the card configuration jumper must be set to 3-CH or 4-CH to measure double-input channels.

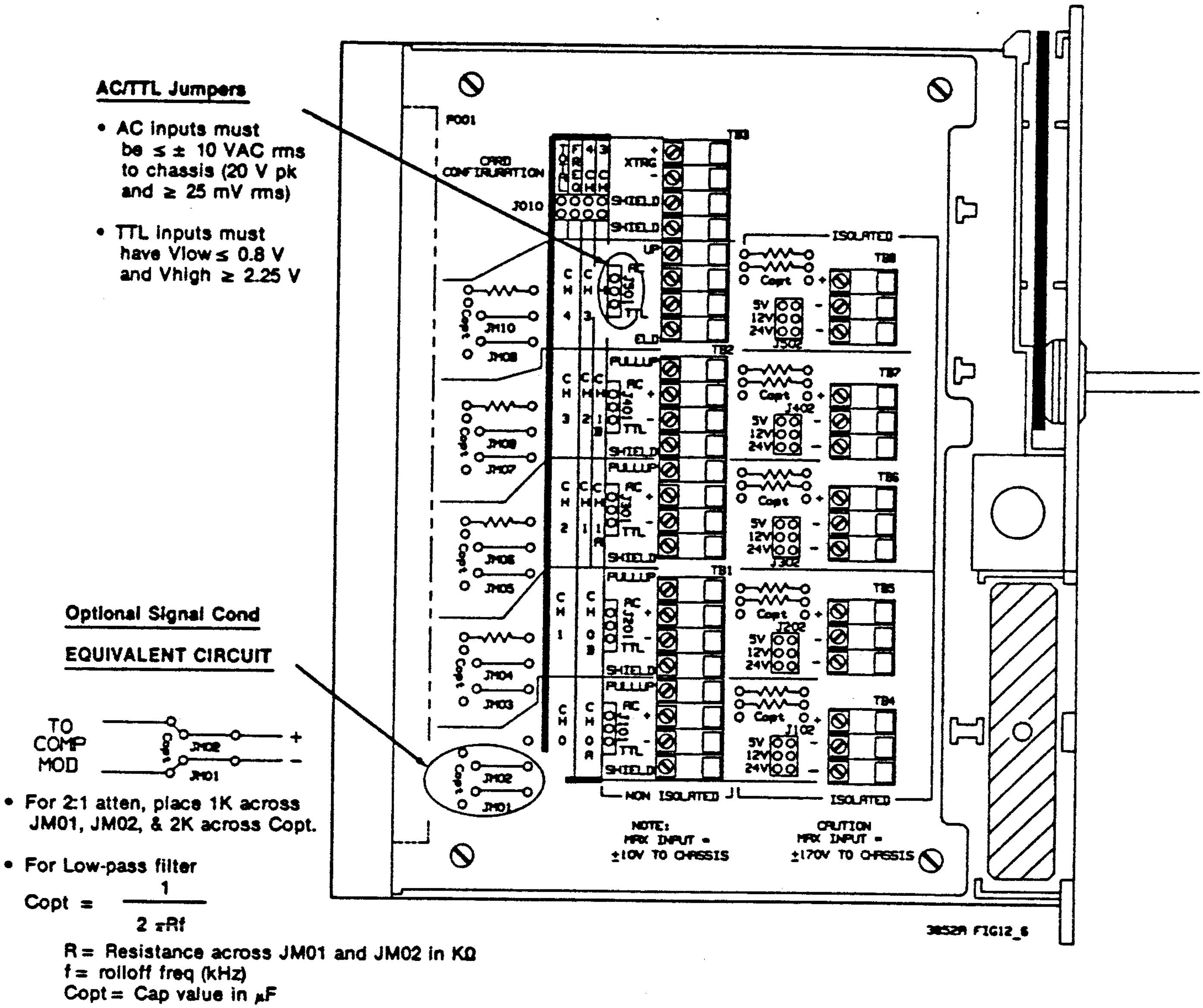
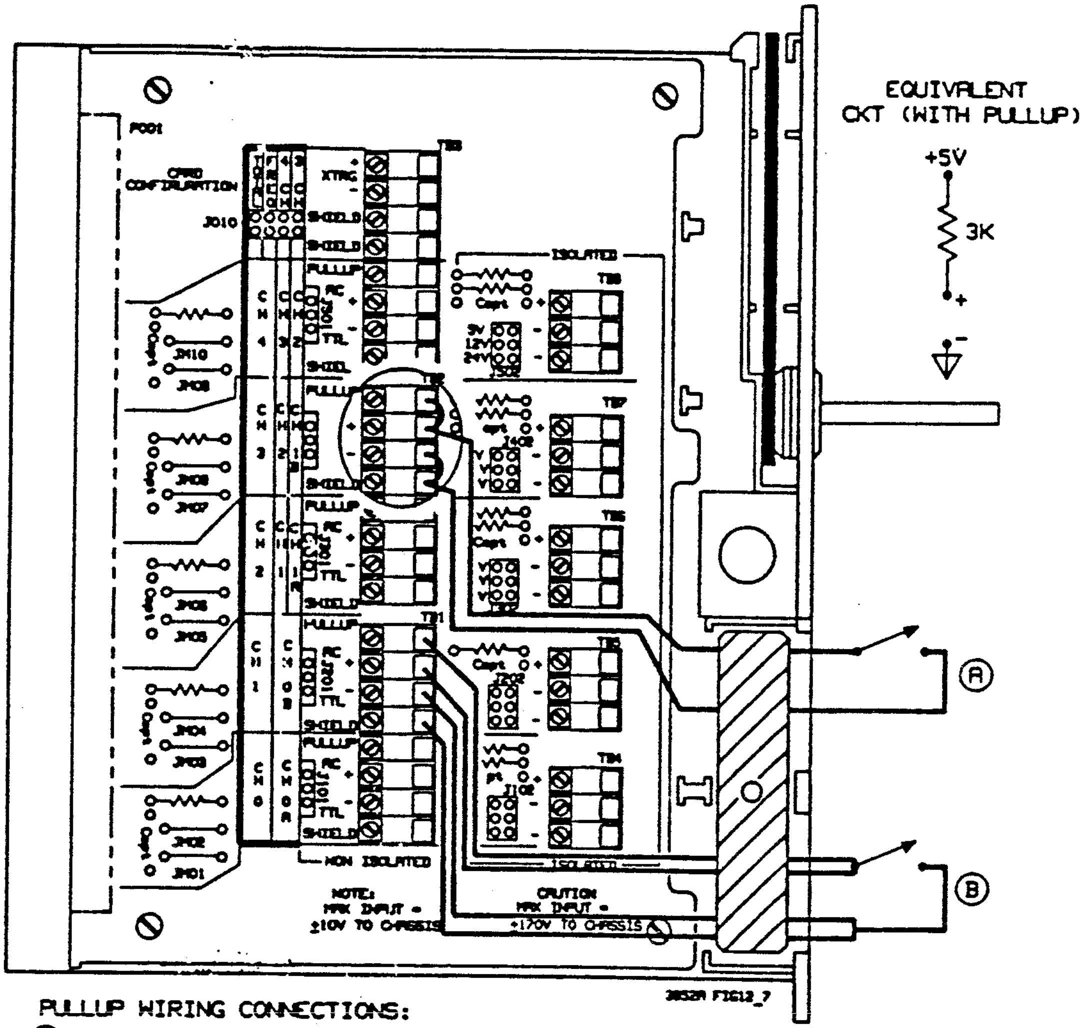


Figure 12-6. Signal Conditioning - Non-Isolated Channels



PULLUP WIRING CONNECTIONS:

Ⓐ 2-WIRES, WORKS WELL IN LOW-NOISE ENVIRONMENTS.

Ⓑ 4-WIRES, WORKS WELL IN LOW AND HIGH-NOISE ENVIRONMENTS.

Figure 12-7. Using Pullup Resistors

NOTE

Hardware channel numbers depend on the setting of the card configuration jumper. When connecting field wiring, be sure the inputs match the desired channel numbers. For example, depending on the setting of the card configuration jumper, inputs connected to the top four terminals of TB2 can be to channel 3, channel 2, or channel 1B, while the inputs connected to the bottom four terminals of TB2 can be channel 2, channel 1, or channel 1A.

Figure 12-8. Field Wiring - Non-Isolated Inputs

Installation/ Checkout

When all required channels have been configured and field wiring connected, replace the terminal module cover, re-connect the terminal module to the component module, and install the counter in a desired slot. Refer to the HP 3852A Configuration and Programming Manual for procedures to install the accessory.

When the counter is installed, send OUTPUT 709; "ID? *slot*" to check the counter identity. When the HP 3852A is powered up, a counter returns 44715A, while a counter component module only (no terminal module attached) returns 447XXX. Note, however, if the terminal module is removed after power-up, the ID? command returns 44715A. For example, the following program returns the identity of an accessory in slot 4 of the mainframe. A counter in this slot returns 44715A.

```
10 OUTPUT 709; "ID? 400"
20 ENTER 709; A
30 DISP A
40 END
```

If the counter does not return 44715A, be sure you have addressed the correct slot and the terminal module is installed. If the address is correct and the terminal module is installed, but 44715A is not returned, refer to the HP 3852A Assembly Level Service Manual for service procedures.

To self-test the counter, send OUTPUT 709; "TEST *slot*". If the self-test passes, "SELF-TEST OK" appears on the front panel display. If the test fails, an error message is returned. (If the quadrature jumpers are set for quadrature mode, the self-test will always fail).

If the self-test fails (and the counter is not set for quadrature mode), use OUTPUT 709; "RST *slot*" to reset the counter and then re-send the self-test command. If the test fails again, refer to the HP 3852A Assembly Level Service Manual for service procedures.

This completes hardware configuration for the counter. Refer to "Selecting Channel Parameters" to set the counter channel parameters for your application.

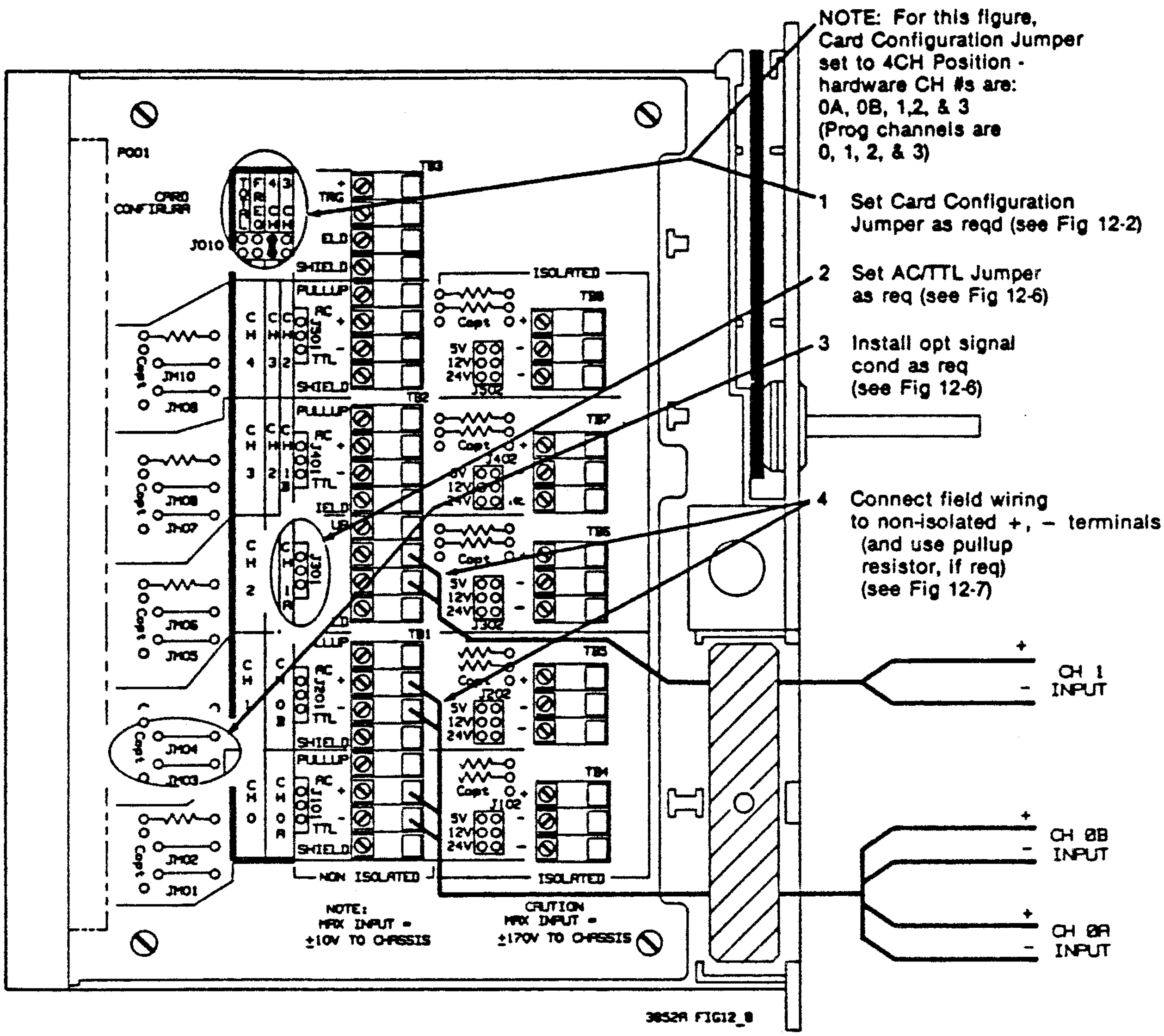


Figure 12-8. Field Wiring - Non-Isolated Inputs

Selecting Channel Parameters

When you have selected the channel function and hardware configured the channel for the function, the next step is to select the channel parameters required for your application. This section describes the commands used to select input signal conditioning, channel timing and presets, interrupts, trigger modes, and channel reads.

The section also includes a summary of the commands which apply to the counter and a suggested sequence of steps to select channel parameters. When you have selected required channel parameters, refer to "Programming Counter Channels" for some examples to program channels for the twelve counter functions.

Command Summary

Table 12-5 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 12-5. Counter Commands

CHREAD *ch* **[INTO** *name***]** or **[***fmt***]**

Read Channel Count.
For channel specified by *ch*, reads counts, period, or frequency of input to channel.

CHREADZ *ch* **[INTO** *name***]** or **[***fmt***]**

Read and Zero Count.
For channel specified by *ch*, reads and zeroes count or period of input to channel. Does not apply to frequency measurements.

CNTSET [*number***] [,USE** *ch***]**

Set Counter.
Using channel specified by USE *ch* parameter, set counter to number specified by *number*.
Valid only when TOTAL function programmed.

DISABLE INTR [,USE *ch***]**

Channel Interrupt Disable.
Prevents counter on channel specified by USE *ch* from generating interrupt on counter overflow or reading available.

EDGE *trans* **[,***trans***] [,USE** *ch***]**

Set Relevant Edge for Counter.
Sets edges to be detected on channel specified by USE *ch*. The first *trans* parameter sets A input edges to be detected, second *trans* parameter sets B input edges to be detected.

Table 12-5. Counter Commands (cont'd)

Second *trans* parameter not valid for single-input channels. If second *trans* parameter not specified for a double-input channel, value for first *trans* parameter used for both.

ENABLE INTR [,USE *ch*]

Channel Interrupt Enable.
Enables counter in channel specified by USE *ch* to interrupt. Depending on function set, channel will interrupt on counter overflow or reading available. Command does not generate interrrupts for UDC, UDCM, CD, or CDM functions.

FUNC *function* [,*tbase or* AUTO] [,USE *ch*]

Set Counter Function.
Sets counter to one of nine functions: TOTAL, TOTALM, UDC, UDCM, CD, CDM, RAT, PER, or PERD. Does not apply to Frequency configuration. *tbase* parameter valid only for PER and PERD functions. Default for *tbase* is AUTO.

NPER *number* [,USE *ch*]

Number or Periods to Use.
Use channel specified by USE *ch* parameter.
For TOTALM, UDCM, or CDM, counter overflows at next count after NPER-1 counts. For RAT, NPER periods occur on the B input during the measurement.

For PER, NPER periods occur on the A input during the measurement. For PERD, NPER-1 periods will occur on the A input before measurement begins, and B input must gate A input count. NPER not valid for TOTAL, UDC, CD, or Frequency functions.

SPER *number* [,USE *ch*]

Sample Period for Counter.
Samples all inputs to the counter at a rate specified by *number*, where *number* = sample period in seconds.

TBASE [*tbase or* AUTO] [,USE *ch*]

Set Time Base of Counter.
For the channel specified by USE *ch*, *tbase* sets time base (in seconds) for use with PER, PERD, or Frequency functions.
Default is AUTO selection of time base.

Table 12-5. Counter Commands (cont'd)

TERM *terminal* [,*terminal*][,**USE** *ch*]

Select Input Terminals for Counter.
For the channel specified by USE *ch*, first *terminal* parameter sets terminal for the A input, second *terminal* sets terminal for the B input (double-input channels only).

Second *terminal* parameter does not apply to single-input channels. If second *terminal* parameter is not used for double-input channel functions, value of first *terminal* is used for both parameters.

TRIG [*source*] [,**USE** *ch*]

Set Trigger and Trigger Source for Counter.
For channel specified by USE *ch*, *source* sets trigger and source to one of five modes: SGL, HOLD, EXT, SYS, or INT. When counter set to Frequency function, trigger mode applies to all five channels.

USE *ch*

Use This Channel in Commands to Follow.
Use channel specified by *ch* parameter in commands to follow, where *ch* is address of channel. When USE *ch* is executed, the address remains active until another USE statement or system reset.

XRDGS *ch* [*count*] [**INTO** *name*] or [*fmt*]

Transfer Reading Storage from Channel.
For channel specified by *ch*, transfers reading from counter to mainframe. If reading is not available, command waits until reading is available and then transfers reading. For the counter, default *count* = 1.

Steps to Select Parameters

Regardless of the function selected for the counter, the procedure to select parameters for a channel consists of five steps, as shown in Table 12-6. In Table 12-6, the command which sets the channel parameter is shown at the right of the parameter. For example, use the TERM command to select the type of input terminals, etc.

Table 12-6. Steps to Select Channel Parameters

1. Select Input Signal Conditioning

Table 12-6. Steps to Select Channel Parameters (cont'd)

```
      - Input Terminals            [TERM]
      - Count Edges                [EDGE]

2. Select Function/Timing

      - Channel Function           [FUNC]
      - Counter Preset             [CNTSET]
      - Number or Period           [NPER]
      - Sample Period              [SPER]
      - Time Base                  [TBASE]

3. Select Interrupts

      - Enable Interrupts          [ENABLE INTR]
      - Disable Interrupts         [DISABLE INTR]

4. Select Triggering

      - Hardware Modes             [TRIG EXT, SYS]
      - Software Modes             [TRIG SGL, HOLD, INT]

5. Select Reads

      - Read Results               [CHREAD]
      - Read/Zero Results          [CHREADZ]
      - Transfer Readings          [XRDGS]
```

Selecting Input Signal Conditioning

The first step in selecting channel parameters is to select the type of input signal conditioning. To set input signal conditioning for a channel, use the TERM command to select the type of input terminals (isolated or non-isolated) and use the EDGE command to select the edges (positive or negative) to be detected.

Selecting Input Terminals

The type of path for the input signal (isolated or non-isolated) is set by the TERM *terminal [,terminal]* [,USE *ch*] command. In the TERM command, the first *terminal* parameter sets the A input terminals and the second *terminal* parameter sets the B input terminals (for double-channel inputs only).

If the second *terminal* parameter is not used for double-input channels, the value specified for the first *terminal* parameter will be used for both inputs. Settings for the *terminal* parameter are:

```
TERM ISO  Isolated Terminal Input
TERM NON  Non-Isolated Terminal Input
```

For example, if the counter is set for 4-CH configuration, TERM NON, NON, USE 200 sets the terminal inputs for hardware channels 0A and 0B of a counter in slot 2 to non-isolated input. Or, if the counter is set for 3-CH configuration, TERM ISO, ISO, USE 201 sets channels 1A and 1B of a counter in slot 2 to isolated input.

Selecting Count Edges

When the input terminals have been selected, use the EDGE command to set the edges of the input signal (positive or negative) to be detected.

The EDGE *trans* [*trans*], USE *ch* command has four values for the *trans* parameter: LH, HL, HI, and LO. For double-channel inputs, the first *trans* parameter applies to the A input, the second parameter to the B input. For single-channel inputs, the second parameter is not valid.

For single-input channels, EDGE LH sets the channel to detect low-to-high transitions (positive edges) of the A input and EDGE HL sets the channel to detect high-to-low transitions (negative edges) of the A input. For double-input channels, the EDGE *trans* parameters are:

```
EDGE LH,LH  Detect pos A edges, pos B edges
EDGE LH,HL  Detect pos A edges, neg B edges
EDGE HL,LH  Detect neg A edges, pos B edges
EDGE HL,HL  Detect neg A edges, neg B edges
```

For functions which use gating, such as Gated Total Counts, for convenience you may want to use LO or HI as the second EDGE *trans* parameter, where LO = count A input when B input is low and HI = count A input when B input is high. Note that LO = HL and HI = LH are equivalent parameters. Therefore, the channel action for LO is the same as for HL and the action for HI is the same as for LH. When using LO or HI, the EDGE *trans* parameters are:

```
EDGE LH, LO  Count pos A edges when B input is low.
EDGE LH, HI  Count pos A edges when B input is high.
EDGE HL, LO  Count neg A edges when B input is low..
EDGE HL, HI  Count neg A edges when B input is high.
```

Selecting Function/ Timing

When input signal conditioning parameters have been selected, the next step is to select channel function/timing parameters. There are five commands to select channel function/timing parameters, although not all commands apply to each function.

Function/Timing Parameter	Command
- Channel Function	FUNC
- Counter Preset	CNTSET
- Number or Period	NPER
- Sample Period	SPER
- Time Base	TBASE

Selecting Channel Function

Each counter channel can be independently set to one of twelve functions. The FUNC command is used to set eleven of the functions. The exception is the Frequency function, which is automatically set when the card configuration jumper (refer to "Configuring Counter Channels") is set to the FREQ position. The FUNC command is not valid for the Frequency function.

Use the FUNC *function* [*,tbase or* AUTO] [,USE *ch*] command to select eleven of the functions, where *function* is shown below. Refer to "Selecting Counter Functions" for a description of each function.

function	Counter Function
TOTAL	Ungated/Gated Total Counts
TOTALM	Ungated/Gated Total Counts, Modulo NPER
UDC	Up/Down Counts
UDCM	Up/Down Counts, Modulo NPER
CD	Counts/Direction
CDM	Counts/Direction, Modulo NPER
RAT	Ratio
PER	Period
PERD	Delayed Period

The FUNC command is not valid when the card configuration jumper is set to the FREQ position. In the FREQ position, all five channels simultaneously measure frequency only. Sending the FUNC command to a channel when the counter is set for FREQ function will generate an error message.

For the FUNC command, *tbase* or AUTO is valid only for *function* = PER or PERD. The *tbase* parameter is the time base (in seconds) for the input signal. If *tbase* is not specified, the default is AUTO range selection of time base. Refer to "Selecting Time Base" for details on *tbase*.

Selecting Counter Preset

For the Ungated and Gated Total Counts (TOTAL) functions ONLY, you can use the CNTSET *number*, USE *ch* command to preset the A input channel to a number from -2147483648 to +2147483647, as specified by *number*. The default value for CNTSET is 0.

You can use the CNTSET command to preset a channel to any value within this range so that the counter will overflow after a specified number of counts. This is useful when you want to generate an overflow interrupt after a specified number of input counts.

To compute the CNTSET *number* parameter value, first decide how many counts are required to generate counter rollover. Then, compute *number* from the following equations, where count = desired number of counts to cause counter rollover.

```
number = - counts                  (counts <= 2147483648)
number = 4294967296 - counts       (counts >  2147483648)
```

For example, to cause counter rollover after 1000 counts, since c = 1000 is <= 2147483648, *number* = - counts = -1000. To cause counter rollover after 3,000,000,000 counts, *number* = 4294967296 - 3000000000 = 1294967296.

Selecting Number or Period

For several counter functions, counting or measurement is done Modulo NPER, where the value is specified by the NPER command. Modulo NPER mode is useful when you want to count up to a certain value and then generate an interrupt.

For example, with Ungated or Gated Total Counts (TOTAL) the counter must count a total of 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. Therefore, for NPER = 100, the counter rolls over after 100 counts rather than waiting until 4294967296 counts have been totalized.

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. The NPER command applies only to the Ungated/Gated Total Counts, Modulo NPER (TOTALM); Up/Down Counts, Modulo NPER (UDCM); Counts/Direction, Modulo NPER (CDM); Ratio (RAT); Period (PER); and Delayed Period (PERD) functions. Table 12-7 summarizes the NPER definition for these functions.

Table 12-7. NPER Command vs. Counter Functions

<u>Ungated/Gated Total Counts, Modulo NPER</u>

Channel counts A input edges, starting at 0 up to NPER-1, where NPER = 2 to 65535. With the next count, the counter rolls over to 0 and starts counting up to NPER-1 again. If enabled, channel generates an overflow interrupt at rollover.

<u>Up/Down Counts, Modulo NPER</u>

Channel counts up on A input edges and counts down on B input edges. Count-up sequence is 0, 1, ..., NPER-1, 0. Count-down sequence is 0, NPER-1, NPER-2, ..., 1, 0, where NPER = 2 to 65535. No interrupts available.

<u>Counts/Direction, Modulo NPER</u>

Channel counts A input edges up or down depending on the B input gate level. Count sequence and NPER values are the same as for Up/Down Counts, Modulo NPER. No interrupts available.

<u>Ratio</u>

Channel counts A input edges until NPER periods have occurred on the B input, where NPER = 1 to 65535. If enabled, channel generates interrupt when measurement completes and reading is available.

Table 12-7. NPER Command vs. Counter Functions (cont'd)

Period Channel counts NPER periods of the A input, where NPER = 1 to 65535. Measurement begins when function is programmed and ends after NPER periods. If enabled, channel generates interrupt when measurement completes and reading is available. **Delayed Period** Channel measures the NPERth period of the A input, where NPER = 1 to 65535. If enabled, channel generates interrupt when measurement completes and reading is available.

Selecting Sample Period

You can use the SPER *number* [,USE *ch*] command to set the sample period for ALL channels of the counter, where *number* = period (in seconds) at which the inputs are sampled. This command is useful for debouncing switch closures. The power on value for SPER = 1 usec, and the range of *number* = 1 usec to 0.16 seconds, in incremental steps. Table 12-8 shows the settings for the SPER *number* parameter.

NOTE

1. 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, for a counter in slot 4 of the mainframe set for TOTAL function, SPER number, USE 400 sets the sample period for channels 0, 1, 2, 3, and 4.

2. The minimum input pulse width is affected by the SPER command, since min pulse width = (number/2) + 0.5 usec. For example, if number = 0.10 seconds, minimum input pulse width = 0.0000055 sec.

Table 12-8. SPER number Range/Increments

SPER number range	Increments
1 usec to 16 usec	1 usec
20 usec to 160 usec	10 usec
200 usec to 1.6 msec	100 usec
2 msec to 16 msec	1 msec
20 msec to 160 msec	10 msec

Selecting Time Base

For power-on and default conditions, the counter is set to automatically select the time base for period measurements or the range for frequency measurements. However, if required for your application, you can select the time base for period measurements or the range for frequency measurements.

For Period (PER) and Delayed Period (PERD) functions ONLY, the time base may be set with the *tbase* parameter in the FUNC *function* [,*tbase* or AUTO] [USE *ch*] command. Since the FUNC command does not apply to the Frequency function, use the TBASE [*tbase* or AUTO] command to specify the range for the Frequency function.

For either command, if *tbase* is not specified, the default is AUTO selection of the time base or range. However, for the FUNC command, *tbase* applies ONLY to the channel set with the USE *ch* parameter. For the TBASE command, if the counter is set for the Frequency function, *tbase* sets the time base for all five channels.

Setting Time Base for Period Function

Table 12-9 shows period values for each value of *tbase* for the PER function. In Table 12-9, the sample period as set by SPER *number* = 1 usec, and NPER = the number of periods to be averaged = 1 to 65535, where NPER is set with the NPER *number* command. The *tbase* column shows the available settings for the *tbase* parameter in the FUNC command.

To compute maximum and minimum periods which can be measured and the resolution for a given *tbase* setting, divide values shown by the value of NPER. For example, if NPER = 100 and *tbase* = 0.00001 sec, period range = 5 us (since this is the minimum period range for any *tbase* setting) to 6.5535 msec, with resolution = 0.1 usec.

Table 12-9. Period Range/Resolution - Period Function

tbase (sec)	Period Range	Resolution
.000001	5 us <=P<= 65.535/NPER ms	1/NPER us
.00001	5 us <= 20/NPER us <=P<= 655.35/NPER ms	10/NPER us
.0001	5 us <=200/NPER us <=P<= 6.5535/NPER sec	100/NPER us
.001	5 us <= 2/NPER ms <=P<= 65.535/NPER sec	1/NPER ms
.01	5 us <= 20/NPER ms <=P<= 655.35/NPER sec	10/NPER ms

Notes:

1. Period accuracy (all ranges) = +/- 0.01 % +/- 1 count.
2. TBASE as set by FUNC *tbase* parameter.
   Power-on/default value for FUNC *tbase* = AUTO.
3. Range/Resolution when SPER = .000001 seconds.

Setting Time Base for Delayed Period Function

Table 12-10 shows period values for each value of *tbase* for the PERD function. In Table 12-10, the sample period as set by SPER *number* = 1 usec. Since the number of periods to be averaged = 1, Table 12-10 is the same as Table 12-9 with NPER = 1. The *tbase* column shows the available settings for the *tbase* parameter in the FUNC command.

Table 12-10. Period Range/Resolution - Delayed Period

tbase (sec)	Period Range	Resolution
.000001	5 us <=P<= 65.535 ms	1 us
.00001	5 us <=P<= 655.35 ms	10 us
.0001	5 us <=P<= 6.5535 sec	100 us
.001	5 us <=P<= 65.535 sec	1 ms
.01	5 us <=P<= 655.35 sec	10 ms

Notes:

1. Period accuracy (all ranges) = +/- 0.01 % +/- 1 count.
2. TBASE as set by FUNC *tbase* parameter. Power-on/default value for FUNC *tbase* = AUTO.
3. Range/Resolution when SPER = .000001 seconds.

Setting Time Base for Frequency Function

Since the FUNC command does not apply to the Frequency function, use the TBASE [*tbase* or AUTO] command to set the time base for the Frequency function. Note that the *tbase* setting applies to ALL five channels, and that the power-on/default setting for *tbase* is AUTO. Table 12-11 shows the frequency range and resolution for each of the three *tbase* settings. In Table 12-11, SPER = 1 usec is assumed.

Table 12-11. TBASE Settings vs. Frequency Ranges

tbase (sec)	Gate Time	Frequency Range	Resolution
1	1 sec	2 Hz - 65.5 kHz	1 Hz
0.1	100 msec	20 Hz - 200 kHz	10 Hz
0.01	10 msec	200 Hz - 200 kHz	100 Hz

Notes:

1. tbase value set by TBASE *tbase* command. Power-on/default value for *tbase* = AUTO.
2. Range/Resolution when SPER = .000001 seconds.

Selecting Interrupts

Each channel of the counter can be enabled to interrupt with the ENABLE INTR [,USE *ch*] command. When enabled, a channel interrupts on counter overflow or reading available, 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

Interrupts can be independently enabled for each channel with the ENABLE INTR command. Depending on the function set, overflow or reading available interrupts can be enabled.

Each channel set for Total Counts (TOTAL/TOTALM) can be independently enabled for overflow interrupt. Each channel set for Ratio (RAT), Period (PER/PERD), or Frequency functions can be independently enabled for reading available interrupts. Interrupts are not available for Up/Down Counts (UDC/UDCM) or Counts/Direction (CD/CDM).

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.

Overflow interrupts are automatically disabled and cleared when serviced. Reading available interrupts are automatically disabled when serviced and cleared when the reading is taken from the channel. The RST *slot* (reset) command disables all channels from interrupting on overflow or reading available. Table 12-12 summarizes the interrupts which can be enabled for each function.

Table 12-12. Interrupts vs. Counter Functions

Function:	Rollover Value:	Interrupt:
TOTAL	From -1 to 0	Overflow
TOTALM	From NPER-1 to 0*	Overflow
RAT	Does Not Rollover	Reading Available
PER,PERD	Does Not Rollover	Reading Available
Frequency	Does Not Rollover	Reading Available

* NPER = 2 to 65535, as set by NPER *number*.

Enabling Channel Interrupts - Total Counts Functions

Overflow interrupts can be enabled for each channel set to the Ungated/Gated Total Counts (TOTAL) or Ungated/Gated Total Counts, Modulo NPER (TOTALM) functions. When the channel is enabled, an overflow interrupt is generated when the channel counter rolls over (from -1 to 0 for TOTAL or from NPER-1 to 0 for TOTALM).

Enabling Channel Interrupts - Ratio Function

Reading available interrupts can be enabled on each channel set for the Ratio (RAT) function. For an enabled channel, a reading available interrupt is generated when the B input reaches NPER periods (NPER = 1 to 65535).

Enabling Channel Interrupts - Period Functions

Reading available interrupts can be enabled on each channel set for the Period (PER) or Delayed Period (PERD) functions. For an enabled channel, a reading available interrupt is generated when NPER (NPER = 1 to 65535) periods have been received by the A input.

Enabling Channel Interrupts - Frequency Function

Reading available interrupts can be enabled on each channel set for the Frequency function. For an enabled channel, a reading available interrupt is generated when the channel completes its measurement and the reading is available.

Disabling Interrupts

Each counter channel can be independently disabled from generating an overflow or reading available interrupt with the DISABLE INTR, USE *ch* command. The DISABLE INTR command disables overflow or reading available (as applicable) interrupts for the channel specified by the USE*ch* parameter.

NOTE

Even if DISABLE INTR is not used, an overflow interrupt is automatically disabled and cleared when the interrupt is serviced. A reading available interrupt is automatically disabled when it is serviced and cleared when the reading has been taken from the channel.

Selecting Triggering Mode

When input signal conditioning, channel function/timing, and interrupt parameters have been selected, the next step is to select the triggering mode for the channels. There are two methods to trigger a measurement on a counter channel: hardware and software. The channel triggering mode is set with the TRIG [*source*] [,USE *ch*] command, where TRIG *source* is shown in Table 12-13.

Table 12-13. TRIG Command vs. Triggering Modes

Hardware Triggering:		
TRIG EXT	Terminal Mod Conn	(external source)
TRIG SYS*	System Trig Pulse	(use TRG command)
Software Triggering:		
TRIG SGL	HP-IB/Keyboard	(default)
TRIG HOLD	Triggering Off	(power-on)
TRIG INT	Internal Trigger	(continuous)

* = TRIG SYS may also be used for synchronous software triggering of several accessories with TRG SGL command.

NOTE

1. Any TRIG command (or FUNC, TBASE, CNTSET, TERM, EDGE, NPER, or SPER command) cancels any ongoing measurement and causes existing data to be discarded.

2. The trigger source or mode does not change when a channel is re-programmed to another function.

Selecting Hardware Triggering

There are two TRIG command parameters to set hardware triggering: TRIG EXT and TRIG SYS. To use these parameters, hardware connections to external sources are also required. Refer to "Configuring Counter Channels" for details.

Setting TRIG EXT Mode

TRIG EXT mode requires a hardware connection from an external (user) triggering source to the XTRG terminals on the terminal module. The TRIG EXT command stops any ongoing measurement and removes the channel from the TRIG SYS or TRIG INT mode. The next trigger occurs with next input (user) trigger and triggers all channels set to TRIG EXT mode.

Setting TRIG SYS Mode

The TRIG SYS command is used to synchronously trigger several accessories. There are several ways to use TRIG SYS mode. One way is to connect an external (user) trigger source to the SYSTEM TRIGGER IN BNC connector on the mainframe and send the TRG EXT command. Another way is to use TRG SGL, while a third way is to use the TRG GET and Group Execute Trigger over HP-IB. Refer to the discussion for the TRG command in the HP 3852A Configuration and Programming Manual for details.

The TRIG SYS command stops any ongoing measurment and removes the channel from the TRIG EXT or TRIG INT mode. The next trigger occurs with next input (user) trigger and triggers all channels set to TRIG SYS mode.

Selecting Software Triggering

There are three TRIG command parameters to set software triggering: TRIG SGL, TRIG HOLD, and TRIG INT.

Setting TRIG SGL Mode

Except for the Frequency function, the TRIG SGL command sends a single trigger to the channel specified by USE *ch*. For the Frequency function, TRIG SGL sends a single trigger to all five channels. TRIG SGL stops any ongoing measurement and removes the channel from SYS, EXT, or INT trigger mode.

Setting TRIG HOLD Mode

TRIG HOLD terminates any triggering and is the power-on condition for the counter. TRIG HOLD stops any ongoing measurement and removes the channel from the SYS, INT, or EXT mode. At power-on, all channels are automatically set to TRIG HOLD.

NOTE

It is good programming practice to set TRIG HOLD before any programming involving the counter, since other trigger modes may send a trigger to the channel before the channel is properly configured.

Setting TRIG INT Mode

With TRIG INT mode, the channel immediately begins taking measurements when the TRIG INT command is sent and continues to trigger on measurement complete. Sending the TRIG INT command stops any ongoing measurement and removes the channel from the TRIG SYS or TRIG EXT modes.

Selecting Reads

There are three commands to read the results of channel measurements: CHREAD, CHREADZ, and XRDGS. There are two types of measurements for the counter: (1) measurements which can be read at any time; or (2) measurements which can be read only when the measurement is complete. Table 12-14 shows the functions which apply to each category.

Table 12-14. Counter Functions vs. Reads

Function	Command
Read Any Time	
Total Counts	(TOTAL/TOTALM)
Up/Down Counts	(UDC/UDCM)
Counts/Direction	(CD/CDM)
Read Only on Measurement Complete	
Ratio	(RAT)
Period	(PER/PERD)
Frequency	(N/A)

Reading Results

Use the CHREAD *ch* command to read the results of channel measurements (counts, period, or frequency, depending on the function set). CHREAD returns the current count for the TOTAL, TOTALM, UDC, UDCM, CD, and CDM functions. CHREAD returns the most recently completed measurement (period or frequency) for the RAT, PER, PERD, and Frequency functions.

For measurements which can be read at any time (Total Counts, Up/Down Counts, and Counts/Direction), CHREAD does not affect interrupts enabled for the channel. For measurements which can be read only when the measurement is complete (Ratio, Period, and Frequency), the CHREAD command clears the reading available interrupt. Refer to Table 12-15 for the type of data returned by the CHREAD command for each counter function.

For the Ungated/Gated Total Counts, Up/Down Counts, Counts/Direction, and

Ratio functions, the range of the number returned is -2147483648 to +2147483647. Since the counter rolls over from +2147483647 to -2147483648, any number > 2147483648 but < 4294967296 will be returned as a negative number.

If a negative number is returned, use 4297487296 - 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.

Reading/ Zeroing Results

Use the CHREADZ *ch* 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 exactly the same functions as the CHREAD command. Table 12-15 shows the types of data returned by the CHREADZ command for each counter function. Refer to the CHREAD command to see how to handle negative number returns.

Transferring Reading Storage

The XRDGS command can also be used to read counter channels. If you want to read multiple results, use the XRDGS command. The CHREAD or CHREADZ commands return a single value and must be resent for each reading. However, XRDGS continuously returns readings as they become available. Therefore, XRDGS acts the same as multiple CHREAD commands. Table 12-15 shows the type of data returned by the XRDGS command for each counter function.

Table 12-15. Data Returns vs. Counter Functions

Function:	Read Returns:	Range:
Ungated/ Gated Total Counts	Total counts on A input.	-2147483648 to +2147483647
Ungated/ Gated Total Counts, Mod NPER	Total counts on A input, modulo NPER.	0 to 65534
Up/Down Counts	Difference between A input and B input counts (A-B).	-2147483648 to +2147483647
Up/Down Counts, Mod NPER	Difference between A input and B input counts (A-B), modulo NPER counts.	-65534 to +65534
Counts/ Direction	Total counts on A input.	-2147483648 to +2147483647
Counts/	Total counts on A input,	-65534 to

Table 12-15. Data Returns vs. Counter Functions (cont'd)

Direction, Mod NPER	Modulo NPER counts.	+65534
Ratio	Ratio of A input counts to B input counts (A/B).	0 to 65535/NPER
Period	Period of A input, as averaged over NPER periods.	0.000005 to 655.35/NPER sec
Delayed Period	Period of single A input, not averaged.	0.000005 to 655.35 sec
Frequency	Frequency of A input.	>1 Hz to 200 kHz

Programming Counter Channels

When you have selected the channel function required for each channel, hardware configured the channels, and selected the channel parameters, the last step is to program each channel for the parameters selected.

This section shows how to program counter channels for each of the twelve counter functions. Discussion for each function includes a summary description of the function, commands to set a channel to the function, and an example program.

Refer to Table 12-16 for titles of the example programs. For convenience, Table 12-6 divides the functions into six categories: Total Counts, Up/Down Counts, Counts/Direction, Ratio, Period, and Frequency. However, each example is listed with its associated function.

NOTE

1. All example programs use HP-IB address 709 and specific slot and channel numbers. Program syntax and data returns apply to HP 200 or HP 300 Series controllers. If you use a different controller, modify the syntax and data formats as required. Modify addresses as necessary for the slots and channels you use.

2. Examples are not meant to be all-inclusive. For instance, single trigger is used for all example programs and default/power-on settings are used in most cases. However, by following the guidelines to select channel parameters shown in "Selecting Channel Parameters" you can modify the programs as required for your application.

Table 12-16. Example Program Titles

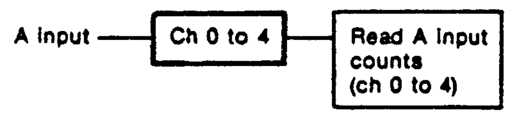
Function	Title	Description
Total Counts		

Table 12-16. Example Program Titles (cont'd)

Ungated Total Counts (TOTAL)	Totalize Switch Closures	Totalize number of switch closures and generate interrupt after 100 closures.
Gated Total Counts (TOTAL)	Totalize Gated Switch Closures	Count switch closures only when control switch is open.
Ungated Total Counts, Mod NPER (TOTALM)	Totalize Stepper Motor Steps	Count stepper motor steps modulo 360 and generate interrupt after each motor revolution.
Gated Total Counts, Mod NPER (TOTALM)	Gated Stepper Motor Counts	Count stepper motor steps only when control switch is open.
<u>Up/Down Counts</u>		
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 100	Measure difference in number of pulses output from two pulse generators. Measure modulo 100.
<u>Counts/Direction</u>		
Counts/ Direction (CD) [Quadra- ture]	Quadrature Measurement	Measure position of shaft encoder, using quadrature measurement.
Counts/ Direction, Mod NPER (CDM)	Measure Shaft Position	Measure shaft position using shaft encoder, modulo 100.
<u>Ratio</u>		
Ratio (RAT)	Measure Pulse Output Ratios	Determine number of pulses output from test generator for 1000 pulses output from reference generator.

UNGATED TOTAL COUNTS (TOTAL)

Count A Input



Channel counts A input edges (HL or LH), starting at 0 or at a preset value (-2147483648 to +2147483647). Count sequence (with no preset) is from 0 to +2147483647 to -2147483648 to -1 to 0. Count sequence continuously repeats.

Channel preset is used only once, after which count sequence with no preset is used. If enabled, channel generates an overflow interrupt when counter overflows from -1 to 0.

Ungated Total Counts Commands

Input Signal Conditioning		
Input Terminals		
-Isolated	TERM ISO	
-Non-Isolated	TERM NON	
Count Edges		
-Count pos A edges	EDGE LH	
-Count neg A edges	EDGE HL	
Function/Timing		
Channel Function	FUNC TOTAL	
Counter Preset	CNTSET number	(-2147483648 to +2147483647) (power-on = 0)
Sample Period	SPER number	(1 μsec to .16 sec) (power-on = 1 μsec)
Interrupts		
Enable overflow Intr	ENABLE INTR	
Disable overflow Intr	DISABLE INTR	
Triggering		
Hardware		
-External	TRIG EXT	
-System	TRIG SYS (see TRG command)	
Software		
-Trigger Off	TRIG HOLD (power on)	
-Single Trig	TRIG SGL (default)	
-Int Trigger	TRIG INT	
Read Counts		
Read A input counts	CHREAD ch (ch = 0 to 4)	
Read/Zero Results	CHREADZ ch (ch = 0 to 4)	
Transfer Readings	XRDGS ch (ch = 0 to 4)	

Figure 12-9. Ungated Total Counts

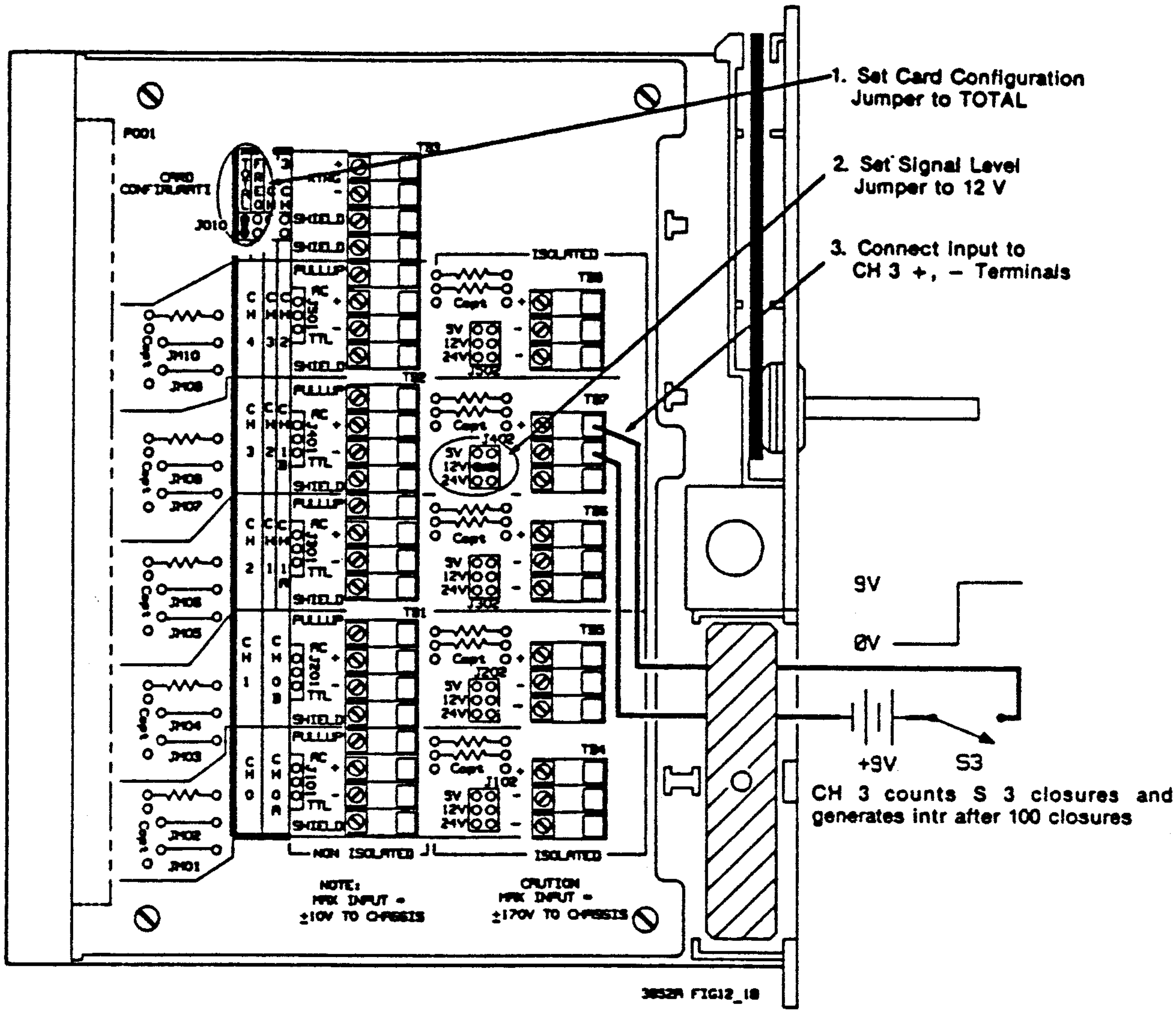


Figure 12-10. Example: Totalize Switch Closures

```
80  !Set input terminals to isolated, set
90  !triggering off, count pos edges.
100 !
110 OUTPUT 709; "USE 503"
120 OUTPUT 709; "TRIG HOLD"
130 OUTPUT 709; "TERM ISO; EDGE LH"
140 !
150 !Set Channel Parameters:
160 !Preset counter to overflow after 100
170 !counts, set Ungated Total Counts.
180 !
190 OUTPUT 709; "FUNC TOTAL; CNTSET -100"
200 !
210 !Define subroutine INTR_1 for interrupt:
220 !
230 OUTPUT 709; "SUB INTR_1"
240 OUTPUT 709; "DISP 'Interrupt on Ch 503'"
250 OUTPUT 709; "SUBEND"
260 !
270 !Enable mainframe for overflow interrupt:
280 !
290 OUTPUT 709; "ON INTR CALL INTR_1"
300 OUTPUT 709; "ENABLE INTR; ENABLE INTR SYS"
310 !
320 !Trigger Counter:
330 !
340 OUTPUT 709; "TRIG SGL"
350 END
```

After 100 switch closures have occurred, a typical readout is:

```
Interrupt on Ch 503
```

Gated Total Counts

You can use the Gated Total Counts (TOTAL) function to count and totalize an input (A input) when the second input (B input gate) is high or low, as required. For example, use this function to totalize switch closures when a second switch is open or closed, as required. You can preset the channel to enable counter overflow and interrupt after a desired number of counts. Figure 12-11 summarizes the Gated Total Counts function and commands to set a channel to the function.

Figure 12-11. Gated Total Counts

Example: Totalize Gated Switch Closures

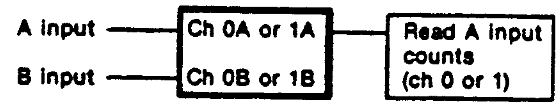
You want to totalize the number of times switch S1 closes when switch S2 is open and then read the number of S1 closures 10 minutes later. One way to do this is to connect switch S1 to channel 0A and switch S2 to channel 0B of a counter in slot 3 of the mainframe. See Figure 12-12 for a connection diagram and counter configuration.

Figure 12-12. Example: Totalize Gated Switch Closures

An example program follows to set the channel for Gated Total Counts which will totalize switch S1 closures when switch S2 is open.

GATED TOTAL COUNTS (TOTAL)

Count A input, gate with B input



Channel counts A input edges (HL or LH), starting from 0 or from preset value (-2147483648 to +2147483647). Count sequence (without preset) is from 0 to 2147483647 to -2147483647 to -1 to 0 and sequence continuously repeats.

Preset value is used only once, after which the count sequence without preset is used. The A input is gated by the B input level and is counted only when the B input is high or low, as selected. If enabled, channel generates overflow interrupt when counter overflows from -1 to 0.

Gated Total Counts Commands

Input Signal Conditioning		
Input Terminals		
-Isolated	TERM ISO	
-Non-Isolated	TERM NON	
Count Edges		
-pos A, pos B edges	EDGE LH,LH or EDGE LH,HI	
-pos A, neg B edges	EDGE LH,HL or EDGE LH,LO	
-neg A, pos B edges	EDGE HL,LH or EDGE HL,HI	
-neg A, neg B edges	EDGE HL,HL or EDGE HL,LO	
Function/Timing		
Channel Function	FUNC TOTAL	
Counter Preset	CNTSET number	(-2147483648 to +2147483647) (power-on = 0)
Sample Period	SPER number	(1 μs to .16 s) (power-on = 1 μs)
Interrupts		
Enable overflow Intr	ENABLE INTR	
Disable overflow Intr	DISABLE INTR	
Triggering		
Hardware		
-External	TRIG EXT	
-System	TRIG SYS (see TRG command)	
Software		
-Trigger Off	TRIG HOLD (power on)	
-Single Trig	TRIG SGL (default)	
-Int Trigger	TRIG INT	
Read Counts		
Read A input counts	CHREAD ch (ch = 0 or 1)	
Read/Zero Results	CHREADZ ch (ch = 0 or 1)	
Transfer Readings	XRDGS ch (ch = 0 or 1)	

Figure 12-11. Gated Total Counts

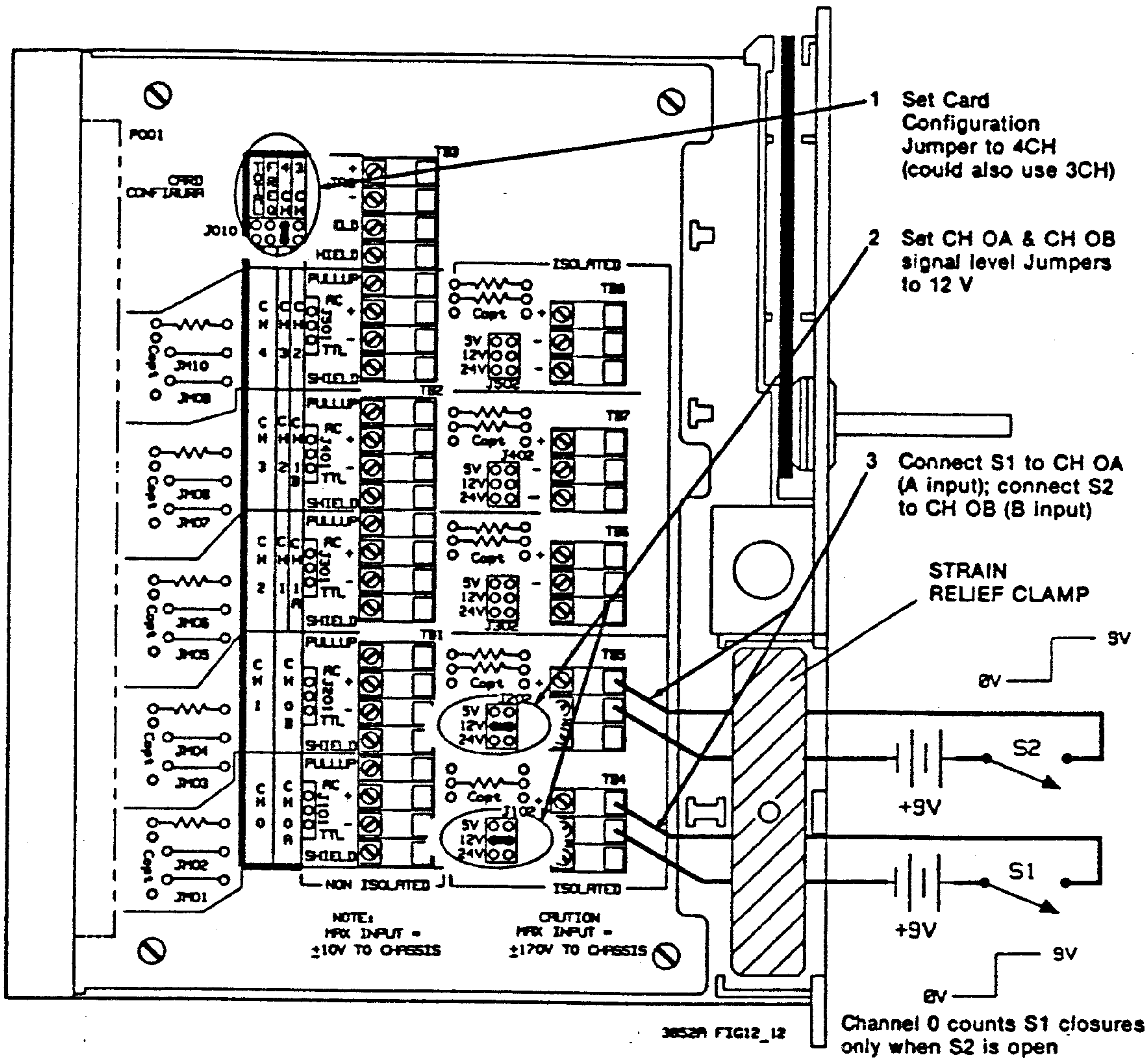


Figure 12-12. Example: Totalize Gated Switch Closures

```
          •
          •
310  !
320  !This program sets channel 0 of a counter in
330  !slot 3 of the mainframe to totalize number
340  !of switch S1 closures when switch S2 is open.
350  !
360  !Set Signal Conditioning:
370  !Set input terminals to isolated, set
380  !triggering off, set channel to count
390  !only when S1 is closed and S2 is open.
400  !
410  OUTPUT 709; "USE 300"
420  OUTPUT 709; "TRIG HOLD"
430  OUTPUT 709; "TERM ISO, ISO; EDGE LH, LO"
440  !
450  !Set Channel Parameters:
460  !Set function to Ungated Total Counts.
470  !
480  OUTPUT 709; "FUNC TOTAL"
490  !
500  !Trigger Counter:
510  !
520  OUTPUT 709; "TRIG SGL"
530  !
540  !Read Counts:
550  !Wait 10 minutes, then read counts on
560  !channel 0.
570  !
580  WAIT 600
590  OUTPUT 709; "CHREAD 300"
600  ENTER 709; Ch_Counts
610  !
620  !Print Results:
630  !
640  PRINT "Ch 300 Switch Closures = ";Ch_Counts
650  END
```

During the 10 minutes, if switch S1 closed 100 times while switch S2 was open, a typical readout is:

```
Ch 300 Switch Closures = 100
```

Ungated Total Counts, Modulo NPER

You can use Ungated Total Counts, Modulo NPER (TOTALM) when you have a single-input (such as switch closures) which you want to totalize and generate an interrupt after a fixed number of counts (closures).

With the TOTALM function, you can also set the channel to interrupt after a set number of input counts from 2 through 65534, by setting the NPER *number* value. Figure 12-13 summarizes the Ungated Total Counts, Modulo NPER function and summarizes commands to set a channel to the function.

Figure 12-13. Ungated Total Counts, Modulo NPER

<u>Example: Totalize Stepper Motor Steps</u>

You have a (fictitious) stepper motor which has 360 incremental (CW only) steps and want to generate an interrupt each time the motor completes one revolution. One way to do this is to connect the translator terminals to channel 0 of a counter in slot 3 of the mainframe. See Figure 12-14 for a typical connection diagram and counter configuration.

Figure 12-14. Example: Totalize Stepper Motor Steps

An example program follows to set the channel for Ungated Total Counts, Modulo 360. For this function, the counter will count up until 359 inputs (359 stepper motor movements) have occurred. On the 360th input (one motor revolution), the counter rolls over to 0 and an overflow interrupt is generated.

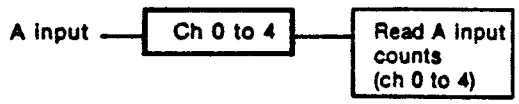
NOTE

The following program uses the controller to handle interrupts. However, interrupts can also be handled by the mainframe. Refer to the example "Totalize Switch Closures" for one way to handle interrupts with the mainframe.

```
.
.
110 !
120 !This program sets channel 0 of a counter in
130 !slot 5 of the mainframe to totalize number
140 !of stepper motor movement, modulo 360.
150 !
160 !Set Signal Conditioning:
170 !Set input terminals to isolated, set
180 !triggering off, count pos edges.
190 !
200 OUTPUT 709; "USE 500"
210 OUTPUT 709; "TRIG HOLD"
220 OUTPUT 709; "EDGE LH"
230 !
240 !Set Channel Parameters:
250 !Set counter function to Ungated Total
260 !Counts, Modulo NPER. Set number of
270 !counts = 360.
280 !
290 OUTPUT 709; "FUNC TOTALM; NPER 360"
300 !
310 !Enable controller to process interrupt:
320 !
330 ON INTR 7 CALL INTR_2
340 ENABLE INTR 7;2
```

UNGATED TOTAL COUNTS, MODULO NPER (TOTALM)

Count A input, modulo NPER



Channel counts A input edges (HL or LH), from 0 to NPER-1, where NPER = 2 to 65535. Count starts at 0 and goes up to NPER-1. With the next count edge, counter rolls over to 0 and starts counting up to NPER-1 again. Count process continuously repeats. If enabled, channel generates overflow interrupt when counter rolls over.

Ungated Total Counts, Modulo NPER Commands

Input Signal Conditioning		
Input Terminals		
-Isolated	TERM ISO	
-Non-Isolated	TERM NON	
Count Edges		
-Count pos A edges	EDGE LH	
-Count neg A edges	EDGE HL	
Function/Timing		
Channel Function	FUNC TOTALM	
Number Counts	NPER number	(2 to 65535) (power-on = 10)
Sample Period	SPER number	(1 μsec to .16 sec) (power-on = 1 μsec)
Interrupts		
Enable overflow Intr	ENABLE INTR	
Disable overflow Intr	DISABLE INTR	
Triggering		
Hardware		
-External	TRIG EXT	
-System	TRIG SYS	(see TRG command)
Software		
-Trigger Off	TRIG HOLD	(power on)
-Single Trig	TRIG SGL	(default)
-Int Trigger	TRIG INT	
Read Counts		
Read A input counts	CHREAD ch	(ch = 0 to 4)
Read/Zero Results	CHREADZ ch	(ch = 0 to 4)
Transfer Readings	XRDGS ch	(ch = 0 to 4)

Figure 12-13. Ungated Total Counts, Modulo NPER

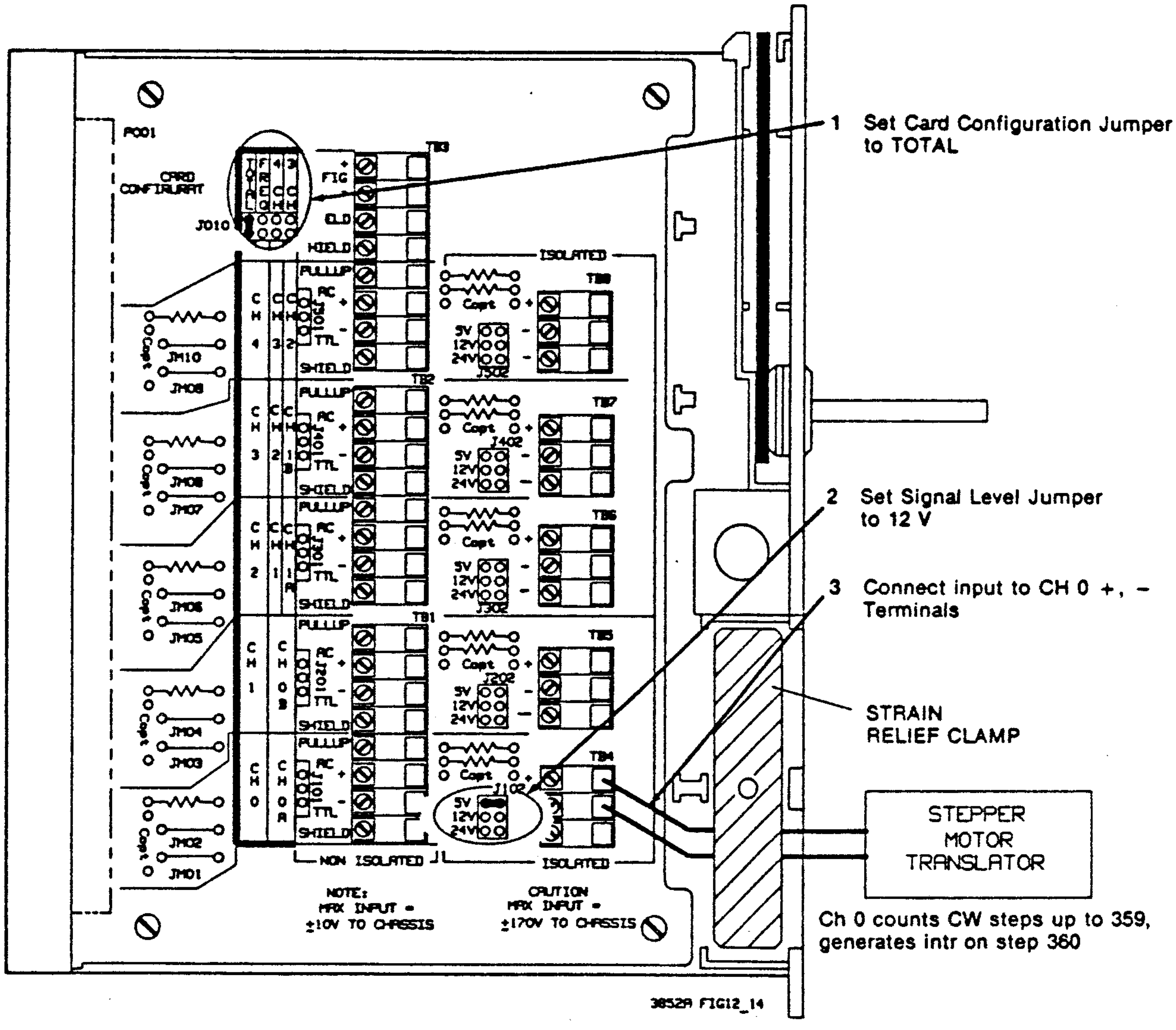


Figure 12-14. Example: Totalize Stepper Motor Steps

```
350  !
360  !Enable mainframe to send intr to controller:
370  !
380  OUTPUT 709; "ENABLE INTR; ENABLE INTR SYS"
390  OUTPUT 709; "RQS INTR; RQS ON"
400  !
410  !Trigger Counter:
420  !
430  OUTPUT 709; "TRIG SGL"
              .
              .
800  SUB INTR_2
810  DISP "Interrupt on Ch 500"
820  SUBEND
```

When the motor completes one revolution and an interrupt is generated, a typical readout is:

```
Interrupt on Ch 500
```

Gated Total Counts, Modulo NPER

You can use the Gated Total Counts, Modulo NPER (TOTALM) to totalize counts on the A input as gated by the B input. In addition, you can enable channel interrupt after a desired number of counts.

For example, you can count the number of stepper motor movements when an associated switch is open and reset the counter to zero with each complete revolution of the motor. Figure 12-15 summarizes the Gated Total Counts, Modulo NPER function and the commands to set a channel to the function.

Figure 12-15. Gated Total Counts, Modulo NPER

Example: Gated Stepper Motor Counts

You have a (fictitious) stepper motor which has 360 incremental steps (CW only) and want to generate an interrupt each time the motor completes one revolution. In addition, you want to count motor steps only when associated switch S1 is open.

One way to do this is to connect the translator terminals to channel 0A of a counter in slot 3 of the mainframe and connect the S1 inputs to channel 0B. See Figure 12-16 for a typical connection diagram and counter configuration.

Figure 12-16. Example: Gated Stepper Motor Counts

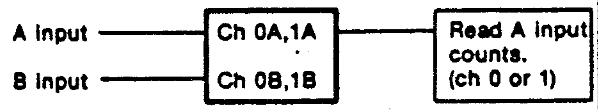
An example program follows to set the channel for Gated Total Counts, Modulo 360. For this function, the counter will count up until 359 inputs (359 stepper motor steps) have occurred. On the 360th input (one motor revolution), the counter is reset to 0 and an overflow interrupt is generated. Note that counter will count motor steps only when switch S1 is open.

.

.

GATED TOTAL COUNTS, MODULO NPER (TOTALM)

Count A input modulo NPER, gate with B input



Channel counts A input edges (HL or LH), starting from 0 up to NPER-1, where NPER = 2 to 65535. The count starts at 0 and goes to NPER-1. With the next count edge, the counter rolls over to 0. This count sequence continuously repeats.

The B input gates the A input count. The A input is counted when the B input is high or low, as selected. If enabled, when the count reaches NPER-1 the next A input count edge generates an overflow interrupt.

Gated Total Counts, Modulo NPER Commands

Input Signal Conditioning		
Input Terminals		
-Isolated	TERM ISO	
-Non-Isolated	TERM NON	
Count Edges		
-pos A, pos B edges	EDGE LH,LH or EDGE LH,HI	
-pos A, neg B edges	EDGE LH,HL or EDGE LH,LO	
-neg A, pos B edges	EDGE HL,LH or EDGE HL,HI	
-neg A, neg B edges	EDGE HL,HL or EDGE HL,LO	
Function/Timing		
Channel Function	FUNC TOTALM	
Number of Counts	NPER number	(2 to 65535) (power-on = 10)
Sample Period	SPER number	(1 µsec to .16 sec) (power-on = 1 µsec)
Interrupts		
Enable overflow intr	ENABLE INTR	
Disable overflow intr	DISABLE INTR	
Triggering		
Hardware		
-External	TRIG EXT	
-System	TRIG SYS	(see TRG command)
Software		
-Trigger Off	TRIG HOLD	(power on)
-Single Trig	TRIG SGL	(default)
-Int Trigger	TRIG INT	
Read Counts		
Read A input counts	CHREAD ch	(ch = 0 or 1)
Read/Zero A input	CHREADZ ch	(ch = 0 or 1)
Transfer A input	XRDGS ch	(ch = 0 or 1)

Figure 12-15. Gated Total Counts, Modulo NPER

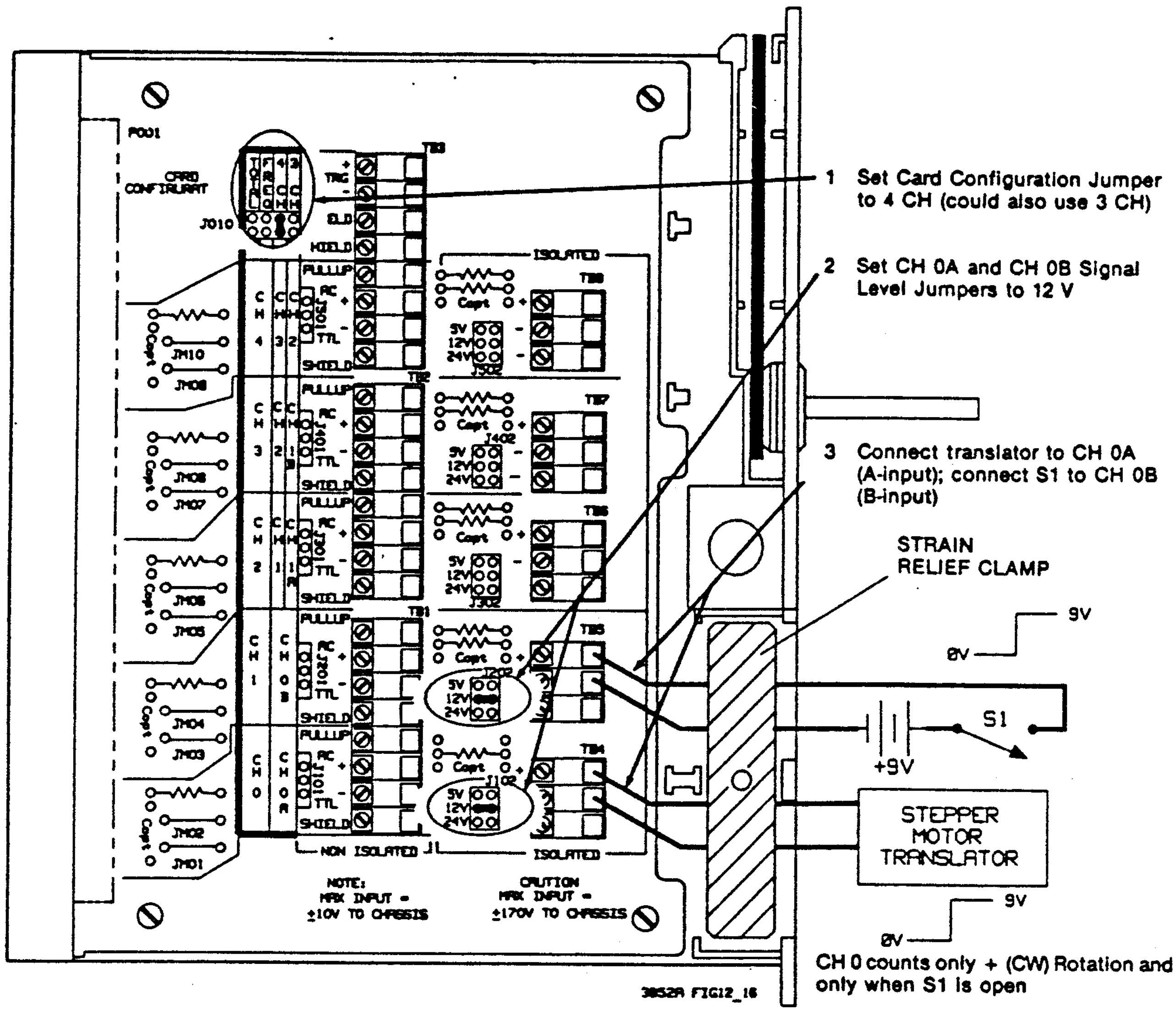


Figure 12-16. Example: Gated Stepper Motor Counts

```
110 !
120 !This program sets channel 0 of a counter in
130 !slot 5 of the mainframe to totalize number
140 !of stepper motor movement, modulo 360.
150 !Counter counts steps only when switch S1
160 !is open.
170 !
180 !Set Signal Conditioning:
190 !Set input terminals to isolated, set
200 !triggering off, count motor steps
210 !only when S1 is open.
220 !
230 OUTPUT 709; "USE 500"
240 OUTPUT 709; "TRIG HOLD"
250 OUTPUT 709; "TERM ISO, ISO; EDGE LH, LO"
260 !
270 !Set Channel Parameters:
280 !Set counter function to Gated Total
290 !Counts, Modulo NPER. Set number of
300 !counts = 360.
310 !
320 OUTPUT 709; "FUNC TOTALM; NPER 360"
330 !
340 !Enable Interrupt:
350 !Enable chan for overflow intr, enable
360 !controller to take intr action.
370 !
380 OUTPUT 709; "ENABLE INTR"
390 OUTPUT 709; "RQS INTR;RQS ON;ENABLE SYS INTR"
400 !
410 !Trigger counter:
420 !
430 OUTPUT 709; "TRIG SGL"
          .
          .
```

Up/Down Counts

You can use the Up/Down Counts (UDC) function to measure the difference in counts between two inputs. With Up/Down Counts, the A input always increases the count and the B input always decreases the count, so the count in the counter is always the difference (A-B) of the the two input counts. Figure 12-17 summarizes the Up/Down Counts function and the commands to set a channel to the function.

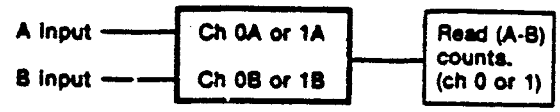
Figure 12-17. Up/Down Counts

<u>Example: Count Pulse Rates</u>

You want to count the difference between the number of pulses output from pulse generators A and B over a ten-minute period. One way to do this is to connect generator A to channel 0A and generator B to channel 0B and set channel 0 to the Up/Down Counts function. Figure 12-18 shows typical

UP/DOWN COUNTS (UDC)

Count up on A input, count down on B input



Channel counts up on A input edges (HL or LH) starting at 0 up to 2147483647. With the next A input count edge, counter rolls over to -2147483648 and continues to count up. Channel counts down on B input edges (HL or LH) starting at 0 down to -2147483648. With the next B input count edge, counter rolls over to +2147483647 and continues to count down. Output of channel is the difference (A-B) between the counts on A and the counts on B. No interrupts generated.

Up/Down Counts Commands

Input Signal Conditioning		
Input Terminals		
-Isolated	TERM ISO	
-Non-Isolated	TERM NON	
Count Edges		
-pos A, pos B edges	EDGE LH,LH or EDGE LH, HI	
-pos A, neg B edges	EDGE LH,HL or EDGE LH, LO	
-neg A, pos B edges	EDGE HL,LH or EDGE HL, HI	
-neg A, neg B edges	EDGE HL,HL or EDGE HL, LO	
Function/Timing		
Channel Function	FUNC UDC	
Sample Period	SPER number	(1 μsec to .16 sec) (power-on = 1 μsec)
Interrupts		
Can't enable interrupts		
Triggering		
Hardware		
-External	TRIG EXT	
-System	TRIG SYS	(see TRG command)
Software		
-Trigger Off	TRIG HOLD (power on)	
-Single Trig	TRIG SGL (default)	
-Int Trigger	TRIG INT	
Read Counts		
Read (A-B) counts	CHREAD ch (ch = 0 or 1)	
Read/Zero (A-B)	CHREADZ ch (ch = 0 or 1)	
Transfer (A-B)	XRDGS ch (ch = 0 or 1)	

Figure 12-17. Up/Down Counts

connections and counter configuration for a counter in slot 4 of the mainframe.

Figure 12-18. Example: Count Pulse Rates

An example program follows to set the channel for Up/Down Counts which will count up on generator A input pulses and count down on generator B input pulses.

```
                    .
                    .
310  !
320  !This program sets channel 0 of a counter in
330  !slot 4 of the mainframe to totalize the
340  !difference (A-B) of input pulses.
350  !
360  !Set Signal Conditioning:
370  !Set input terminals to isolated, set
380  !triggering off, set channel to count
390  !positive edges of A and B inputs.
400  !
410  OUTPUT 709; "USE 400"
420  OUTPUT 709; "TRIG HOLD"
430  OUTPUT 709; "TERM ISO,ISO; EDGE LH,LH"
440  !
450  !Set Channel Parameters:
460  !Set function to Up/Down Counts.
470  !
480  OUTPUT 709; "FUNC UDC"
490  !
500  !Trigger Counter:
510  !
520  OUTPUT 709; "TRIG SGL"
530  !
540  !Read Counts:
550  !Wait 10 minutes, then read counts on
560  !channel 0.
570  !
580  WAIT 600
590  OUTPUT 709; "CHREAD 400"
600  ENTER 709; Ch_Counts
610  !
620  !Print Results:
630  !
640  PRINT "Ch 400 (A-B) Counts = ";Ch_Counts
650  END
```

If, during the 10 minutes, generator A outputs 500 pulses and generator B outputs 700 pulses, a typical readout is:

```
Ch 400 (A-B) Counts = -200
```

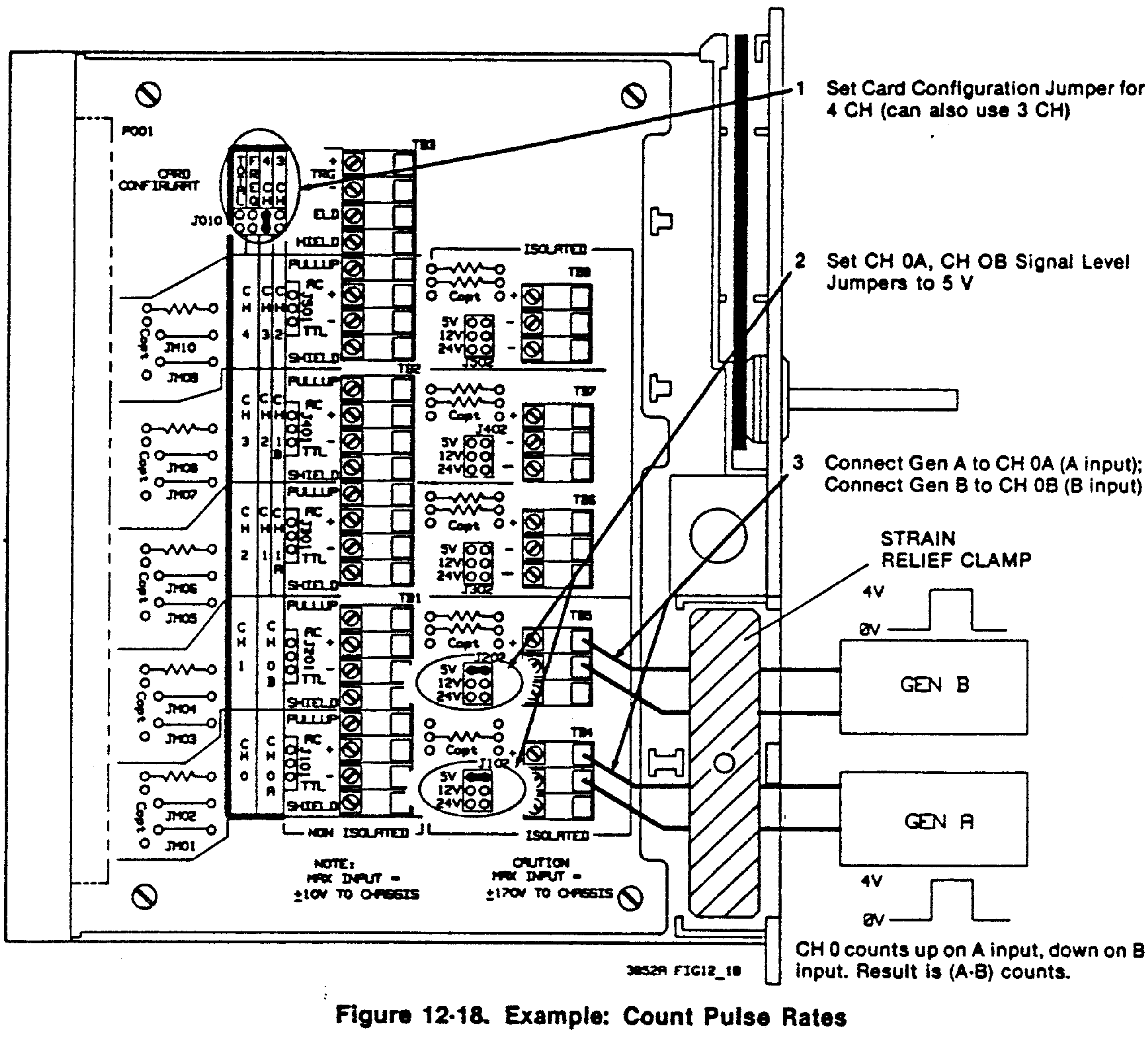


Figure 12-18. Example: Count Pulse Rates

Up/Down Counts Modulo NPER

You can use Up/Down Counts, Modulo NPER (UDCM) to measure the difference (A-B) between two inputs to a channel. In addition, you can reset the counter with the next count after NPER-1 counts. Figure 12-19 summarizes the Up/Down Counts, Modulo NPER function and the commands to set a channel to the function.

Figure 12-19. Up/Down Counts, Modulo NPER

Example: Count Pulse Rates, Modulo 100

You want to count the difference between the number of pulses output from pulse generators A and B over a ten-minute period. You also want the count in the counter to be 99 or less at any time, regardless of the count difference between A and B.

One way to do this is to connect generator A to channel 0A and generator B to channel 0B and set channel 0 to the Up/Down Counts, Modulo NPER function. Figure 12-20 shows typical connections and counter configuration for a counter in slot 4 of the mainframe.

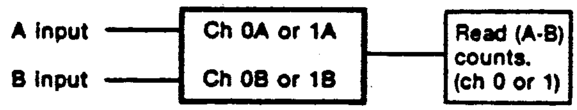
Figure 12-20. Example: Count Pulse Rates, Modulo 100

An example program follows to set the channel for Up/Down Counts, Modulo NPER which will count up on generator A input pulses, count down on generator B input pulses, and cause counter rollover whenever the count difference between A and B = 100 counts.

```
            .
            .
310  !
320  !This program sets channel 0 of a counter in
330  !slot 4 of the mainframe to totalize the
340  !difference (A-B) of input pulses.  Counter
350  !rolls over after 99 counts.
360  !
370  !Set Signal Conditioning:
380  !Set input terminals to isolated, set
390  !triggering off, set channel to count
400  !positive edges of A and B inputs.
410  !
420  OUTPUT 709; "USE 400"
430  OUTPUT 709; "TRIG HOLD"
440  OUTPUT 709; "TERM ISO, ISO; EDGE LH, LH"
450  !
460  !Set Channel Parameters:
470  !Set function to Up/Down Counts, Modulo NPER,
480  !set NPER = 100.
490  !
500  OUTPUT 709; "FUNC UDCM; NPER 100"
510  !
520  !Trigger Counter:
530  !
540  OUTPUT 709; "TRIG SGL"
```

UP/DOWN COUNTS, MODULO NPER (UDCM)

Count up on A input, count down on B input



Channel counts up on A input edges (HL or LH) starting at 0 up to NPER-1, where NPER = 2 to 65535. With the next A input count edge, counter rolls over to 0 and continues to count up. Channel counts down on B input edges (HL or LH) starting at 0. With the next B input count edge, counter rolls over to NPER-1 and continues to count down. Output of channel is the difference (A-B) between the counts on A and the counts on B, modulo NPER. No interrupts generated.

Up/Down Counts, Modulo NPER Commands

Input Signal Conditioning

Input Terminals

-Isolated	TERM ISO	
-Non-Isolated	TERM NON	

Count Edges

-pos A, pos B edges	EDGE LH,LH or EDGE LH, HI	
-pos A, neg B edges	EDGE LH,HL or EDGE LH, LO	
-neg A, pos B edges	EDGE HL,LH or EDGE HL, HI	
-neg A, neg B edges	EDGE HL,HL or EDGE HL, LO	

Function/Timing

Channel Function	FUNC UDCM	
Number of Counts	NPER number	(2 to 65535) (power-on = 10)
Sample Period	SPER number	(1 µs to .16 s) (power-on = 1 µs)

Interrupts

Can't enable interrupts

Triggering

Hardware

-External	TRIG EXT	
-System	TRIG SYS (see TRG command)	

Software

-Trigger Off	TRIG HOLD (power on)	
-Single Trig	TRIG SGL (default)	
-Int Trigger	TRIG INT	

Read Counts

Read (A-B) counts	CHREAD ch (ch = 0 or 1)	
Read/Zero (A-B)	CHREADZ ch (ch = 0 or 1)	
Transfer (A-B)	XRDGS ch (ch = 0 or 1)	

Figure 12-19. Up/Down Counts, Modulo NPER

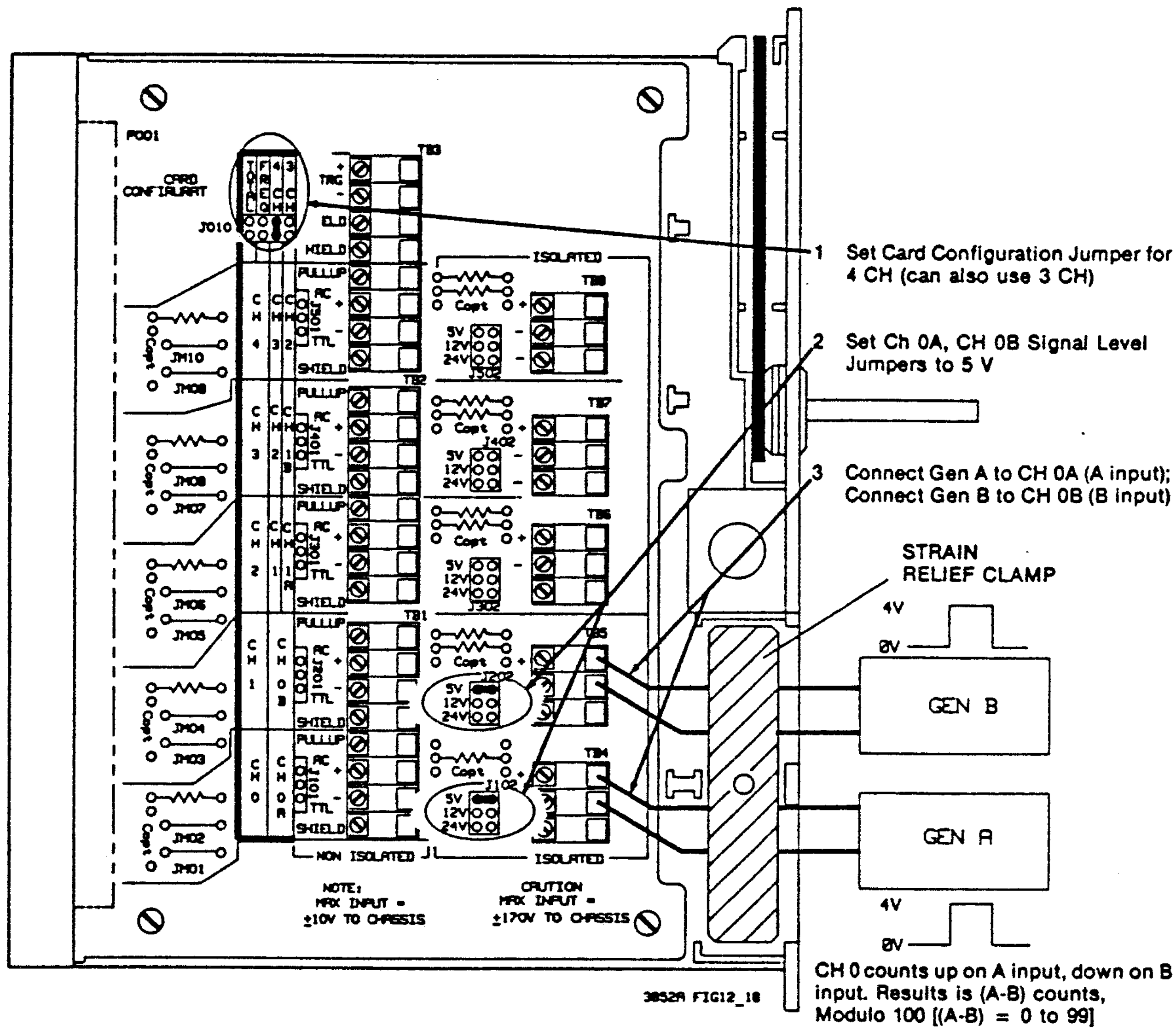


Figure 12-20. Example: Count Pulse Rates, Modulo 100

```
550  !
560  !Read Counts:
570  !Wait 10 minutes, then read counts on
580  !channel 0.
590  !
600  WAIT 600
610  OUTPUT 709; "CHREAD 400"
620  ENTER 709; Ch_Counts
630  !
640  !Print Results:
650  !
660  PRINT "Ch 400 (A-B) Counts = ";Ch_Counts
670  END
```

If, during the 10 minutes, generator A outputs 50 pulses and generator B outputs 70 pulses, a typical readout is:

```
Ch 400 (A-B) Counts = 20
```

Counts/ Direction

You can use the Counts/Direction (CD) function to measure the net number of counts (up-counts minus down-counts) for an input as controlled by a second input. For example, you can use the Counts/Direction function to measure shaft encoder position (refer to "Example: Measure Shaft Position"). Figure 12-21 summarizes the Counts/Direction function and the commands to set a channel to the function.

Figure 12-21. Counts/Direction

<u>Example: Quadrature Measurements</u>

You want to accurately measure the position of a shaft encoder by using quadrature measurement. For this example, assume CW rotation causes A to lead B and CCW rotation causes A to lag B and the encoder is connected to channel 0 (A input to channel 0A, B input to channel 0B) of a counter in slot 3 of the mainframe. Figure 12-22 shows typical connections and counter configuration.

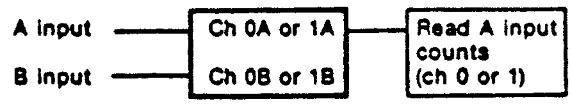
Figure 12-22. Example: Quadrature Measurements

An example program follows to set the channel for the Quadrature Measurement mode of Counts/Direction to count the relative numbers of CW and CCW rotations of the shaft. Since the channel is hardware configured for quadrature measurements, the count will be double the number of counts for normal Counts/Direction function.

```
          .
          .
310  !
320  !This program sets channel 0 of a counter in
330  !slot 3 of the mainframe to count A input.
340  !Shaft rotation direction sets count direction.
350  !CW = up counts, CCW = down counts.
360  !
```

COUNTS/DIRECTION (CD)

Count A input, B sets count direction



Channel counts A input edges (HL or LH) up or down, starting at 0 up to 2147483647 or down to -2147483648. B input polarity determines if count is up or down. If B input is set for EDGE HI or EDGE LH, counts on A are up counts when B is high, down counts when B is low. Vice-versa when the B input is set for EDGE LO or EDGE HL.

For count up, when count reaches 2147483647, counter rolls over to -2147483648 with the next count edge and continues counting up. For count down, when count reaches -2147483468, counter rolls over to 2147483647 with the next count edge and continues counting down. No interrupts generated.

Counts/Direction Commands

Input Signal Conditioning

Input Terminals		
-Isolated	TERM ISO	
-Non-Isolated	TERM NON	
Count Edges		
-Count pos A edges: up for B high, down for B low.	EDGE LH,LH or EDGE LH,HI	
-Count pos A edges: up for B low, down for B high.	EDGE LH,HL or EDGE LH,LO	
-Count neg A edges: up for B high, down for B low.	EDGE HL,LH or EDGE HL,HI	
-Count neg A edges: up for B low, down for B high	EDGE HL,HL or EDGE HL,LO	
Function/Timing		
Channel Function	FUNC CD	
Sample Period	SPER number	(1 µs to .16 s) power-on = 1 µs)
Interrupts		
Can't enable interrupts.		
Triggering		
Hardware		
-External	TRIG EXT	
-System	TRIG SYS (see TRG command)	
Software		
-Trigger Off	TRIG HOLD (power on)	
-Single Trig	TRIG SGL (default)	
-Int Trigger	TRIG INT	
Read Counts		
Read A input count	CHREAD ch (ch = 0 or 1)	
Read/Zero A count	CHREADZ ch (ch = 0 or 1)	
Transfer A count	XRDGS ch (ch = 0 or 1)	

Figure 12-21. Counts/Direction

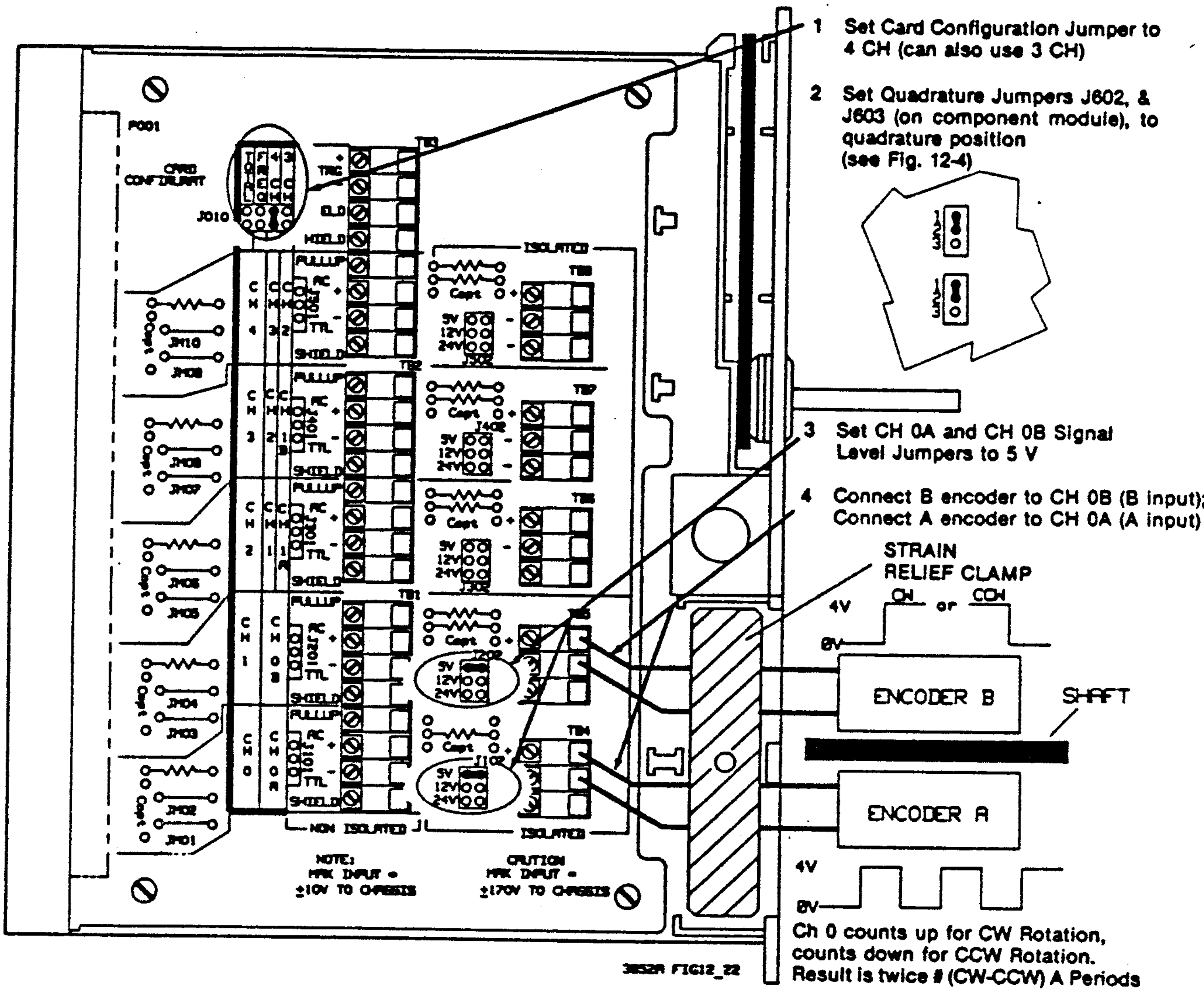


Figure 12-22. Example: Quadrature Measurements

```
370  !Set Signal Conditioning:
380  !Set input terminals to isolated, set
390  !triggering off, channel hardware-jumpered
400  !to count all edges of A and B inputs.
410  !
420  OUTPUT 709; "USE 300"
430  OUTPUT 709; "TRIG HOLD"
440  OUTPUT 709; "TERM ISO, ISO"
450  !
460  !Set Channel Parameters:
470  !Set function to Counts/Direction.
480  !
480  OUTPUT 709; "FUNC CD"
490  !
500  !Trigger Counter:
510  !
520  OUTPUT 709; "TRIG SGL"
530  !
540  !Read Counts:
550  !Wait 10 minutes, then read counts on
560  !channel 0.
570  !
580  WAIT 600
590  OUTPUT 709; "CHREAD 300"
600  ENTER 709; Ch_Counts
610  !
620  !Print Results:
630  !
640  PRINT "Ch 300 Encoder Counts = ";Ch_Counts/2
650  END
```

If, after 10 minutes, the shaft has made 100 CW rotations and 120 CCW rotations, a typical readout is:

```
Ch 300 Encoder Counts = -20
```

Counts/ Direction, Modulo NPER

You can use Counts/Direction, Modulo NPER (CDM) to measure the difference in up-counts and down-counts, module NPER. For example, shaft encoder output can be measured by counting the A input up or down, depending on the direction of rotation (CW or CCW) of the B input (refer to "Quadrature Measurements" for a discussion of shaft encoder outputs). Figure 12-23 summarizes the Counts/Direction, Modulo NPER function and commands to set a channel to the function.

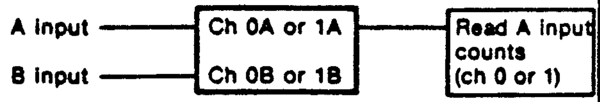
Figure 12-23. Counts/Direction, Modulo NPER

__Example: Measure Shaft Position__

You want to measure the relative number of CW and CCW rotations of a shaft encoder, but don't want the count to exceed 100. One way to do this is to connect the A input to channel 0A and the B input to channel 0B and set channel 0 to the Counts/Direction, Modulo NPER function. Figure 12-24 shows typical connections and counter configuration for a counter in slot 4 of the mainframe.

COUNTS/DIRECTION, MODULO NPER (CDM)

Count A input, B sets count direction



Channel counts A input edges (HL or LH) up or down, starting at 0 up to NPER-1 or down from NPER-1 to 0. B input polarity determines if count is up or down. If B input is set for EDGE HI or EDGE LH, counts on A are up counts when B is high, down counts when B is low. Vice-versa when the B input is set for EDGE LO or EDGE HL.

For count up, when count reaches NPER-1, counter rolls over to 0 with the next count edge and continues counting up. For count down, when count reaches 0, counter rolls over to NPER-1 with the next count edge and continues counting down. No interrupts generated.

Counts/Direction, Modulo NPER Commands

Input Signal Conditioning

Input Terminals

-Isolated	TERM ISO	
-Non-Isolated	TERM NON	

Count Edges

-Count pos A edges: up for B high, down for B low.	EDGE LH,LH or EDGE LH,HI	
-Count pos A edges: up for B low, down for B high.	EDGE LH,HL or EDGE LH,LO	
-Count neg A edges: up for B high, down for B low.	EDGE HL,LH or EDGE HL,HI	
-Count neg A edges: up for B low, down for B high.	EDGE HL,HL or EDGE HL,LO	

Function/Timing

Channel Function	FUNC CDM	
Number of Counts	NPER number	(2 to 65535) (power-on = 10)
Sample Period	SPER number	(1 μs to .16 s) (power-on = 1 μs)

Interrupts

Can't enable interrupts.

Triggering

Hardware

-External	TRIG EXT	
-System	TRIG SYS (see TRG command)	

Software

-Trigger Off	TRIG HOLD (power on)	
-Single Trig	TRIG SGL (default)	
-Int Trigger	TRIG INT	

Read Counts

Read A input count	CHREAD ch (ch = 0 or 1)	
Read/Zero A count	CHREADZ ch (ch = 0 or 1)	
Transfer A count	XRDGS ch (ch = 0 or 1)	

Figure 12-23. Counts/Direction, Modulo NPER

Figure 12-24. Example: Measure Shaft Position

An example program follows to set the channel for Counts/Direction, Modulo NPER which will count up the A input when the shaft rotates CW (B input high), count down the A input when the shaft rotates CCW (B input low), and cause counter rollover whenever the count difference = 100 (difference between CW and CCW counts).

```
                    .
                    .
310  !
320  !This program sets channel 0 of a counter in
330  !slot 4 of the mainframe to totalize the
340  !difference between the number of CW and CCW
350  !rotations. Counter rolls over after 100 counts.
360  !
370  !Set Signal Conditioning:
380  !Set input terminals to isolated, set
380  !triggering off, set channel to count
390  !positive edges of A and B inputs.
400  !
410  OUTPUT 709; "USE 400"
420  OUTPUT 709; "TRIG HOLD"
430  OUTPUT 709; "EDGE LH, LH"
440  !
450  !Set Channel Parameters:
460  !Set function to Up/Down Counts, Modulo NPER.
470  !
480  OUTPUT 709; "FUNC UDCM"
490  !
500  !Trigger Counter:
510  !
520  OUTPUT 709; "TRIG SGL"
530  !
540  !Read Counts:
550  !Wait 10 minutes, then read counts on
560  !channel 0.
570  !
580  WAIT 600
590  OUTPUT 709; "CHREAD 400"
600  ENTER 709; Ch_Counts
610  !
620  !Print Results:
630  !
640  PRINT "Ch 400 (CW-CCW) Counts = ";Ch_Counts
650  END
```

If, during the 10 minutes, the shaft encoder made 30 CW rotations and 20 CCW rotations, a typical readout is:

```
Ch 400 (CW-CCW) Counts = 10
```

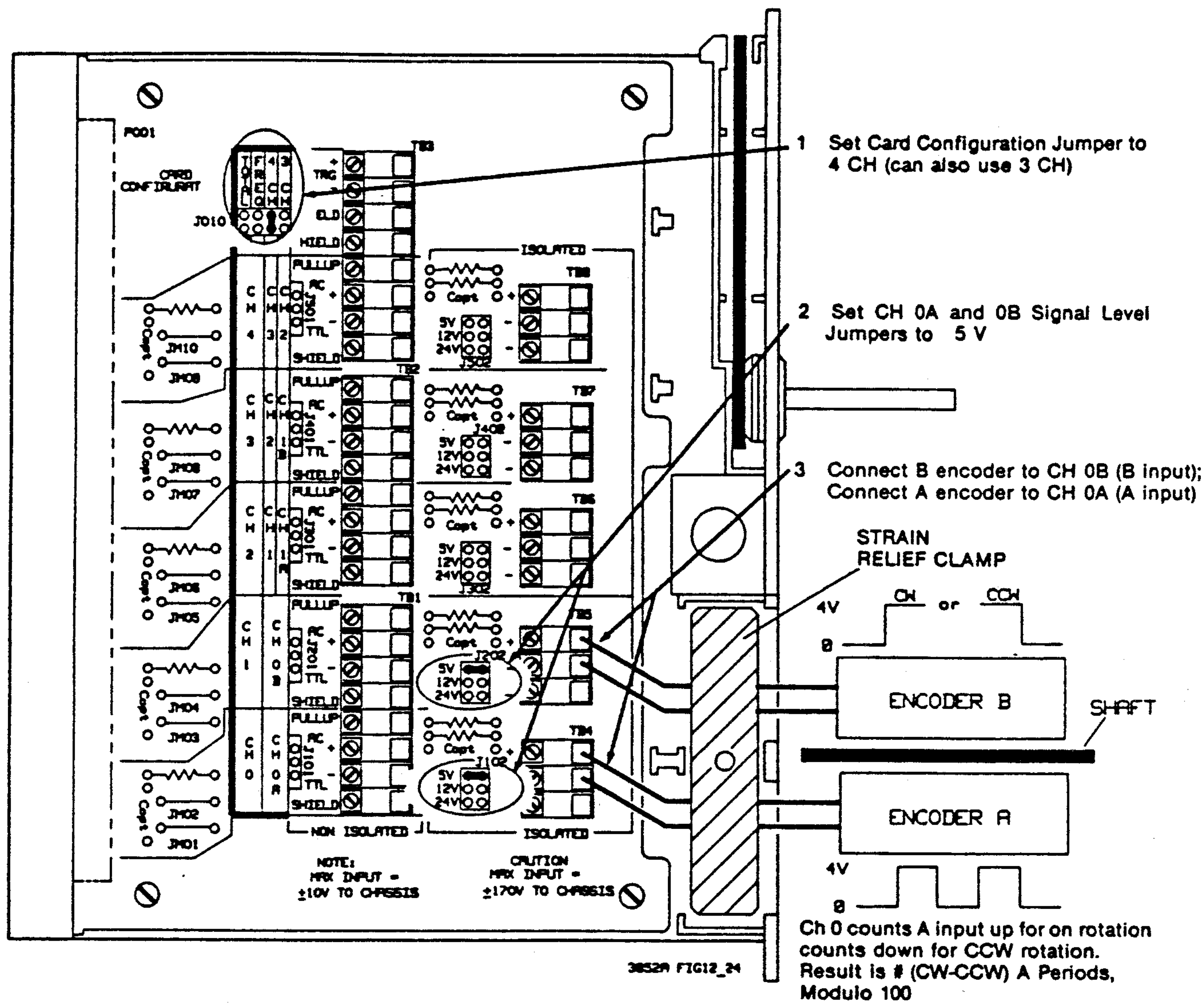


Figure 12-24. Example: Measure Shaft Position

Ratio

You can use the Ratio (RAT) function to count the number of pulses on an input to the A channel for a fixed number of pulses input to the B channel. For example, use the Ratio function to determine the number of pulses output from a test generator when 100 pulses have been output from a reference generator. The counter returns the ratio of the two inputs (A/B). Figure 12-25 summarizes the Ratio function and commands to to set a channel to the function.

Figure 12-25. Ratio

<u>Example: Measure Pulse Output Ratios</u>

You want to want to determine the ratio of the number of pulses output from a test pulse generator to 1000 pulses output from a reference pulse generator. One way to do this is to connect the test generator leads to channel 0A and the reference generator leads to channel 0B and set the counter for the Ratio function. Figure 12-26 shows a typical connection diagram and counter configuration for a counter in slot 4 of the mainframe.

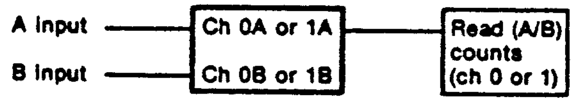
Figure 12-26. Example: Measure Pulse Output Ratios

An example program follows to set the channel for Ratio function which will count the number of pulses output from the test generator (A input) while 1000 pulses are output from the reference generator (B input). Note that the program returns the ratio (A/B) of the counts. For the Ratio function, the counter counts down NPER periods (1000 in this case) at which time a reading available interrupt is generated.

```
10  !
20  !This program sets channel 0 of a counter in
30  !slot 4 of the mainframe to compute ratio of
40  !A input pulses to 1000 B input pulses.
50  !
60  !Set Signal Conditioning:
70  !Set input terminals to isolated, set
80  !triggering off, set channel to count
90  !pos A edges, pos B input edges.
100 !
110 OUTPUT 709; "USE 400"
120 OUTPUT 709; "TRIG HOLD"
130 OUTPUT 709; "TERM ISO,ISO; EDGE LH,LH"
140 !
150 !Set Channel Parameters:
160 !Set function to Ratio, set number of
170 !periods on B input = 1000.
180 !
190 OUTPUT 709; "FUNC RAT; NPER 1000"
200 !
210 !Enable controller to handle interrupt
220 !(after 1000 periods of the B input):
230 !
240 ON INTR 7 CALL INTR_3
250 ENABLE INTR 7;2
```

RATIO (RAT)

Count A input for NPER inputs on B



Channel counts A input edges (HL or LH), starting at 0 until NPER periods have occurred on B input, where NPER = 1 to 65535. Data returned is ratio of A input counts to B input counts (A/B). If enabled, measurement complete interrupt generated after NPER periods have occurred on B channel.

Ratio Commands

Input Signal Conditioning

Input Terminals		
-Isolated	TERM ISO	
-Non-Isolated	TERM NON	
Count Edges		
-pos A, pos B edges	EDGE LH,LH	
-pos A, neg B edges	EDGE LH,HL	
-neg A, pos B edges	EDGE HL,LH	
-neg A, neg B edges	EDGE HL,HL	

Function/Timing

Channel Function	FUNC RAT	
Number B periods	NPER number	(1 to 65535) (power-on = 10)
Sample Period	SPER number	(1 μs to .16 s) (power-on = 1 μs)

Interrupts

Enable Meas Cmpl Intr	ENABLE INTR
Disable Meas Cmpl Intr	DISABLE INTR

Triggering

Hardware	
-External	TRIG EXT
-System	TRIG SYS (see TRG command)
Software	
-Trigger Off	TRIG HOLD (power on)
-Single Trig	TRIG SGL (default)
-Int Trigger	TRIG INT

Read Counts

Read (A/B) count	CHREAD ch (ch = 0 or 1)
Read/Zero (A/B)	CHREADZ ch (ch = 0 or 1)
Transfer (A/B)	XRDGS ch (ch = 0 or 1)

Figure 12-25. Ratio

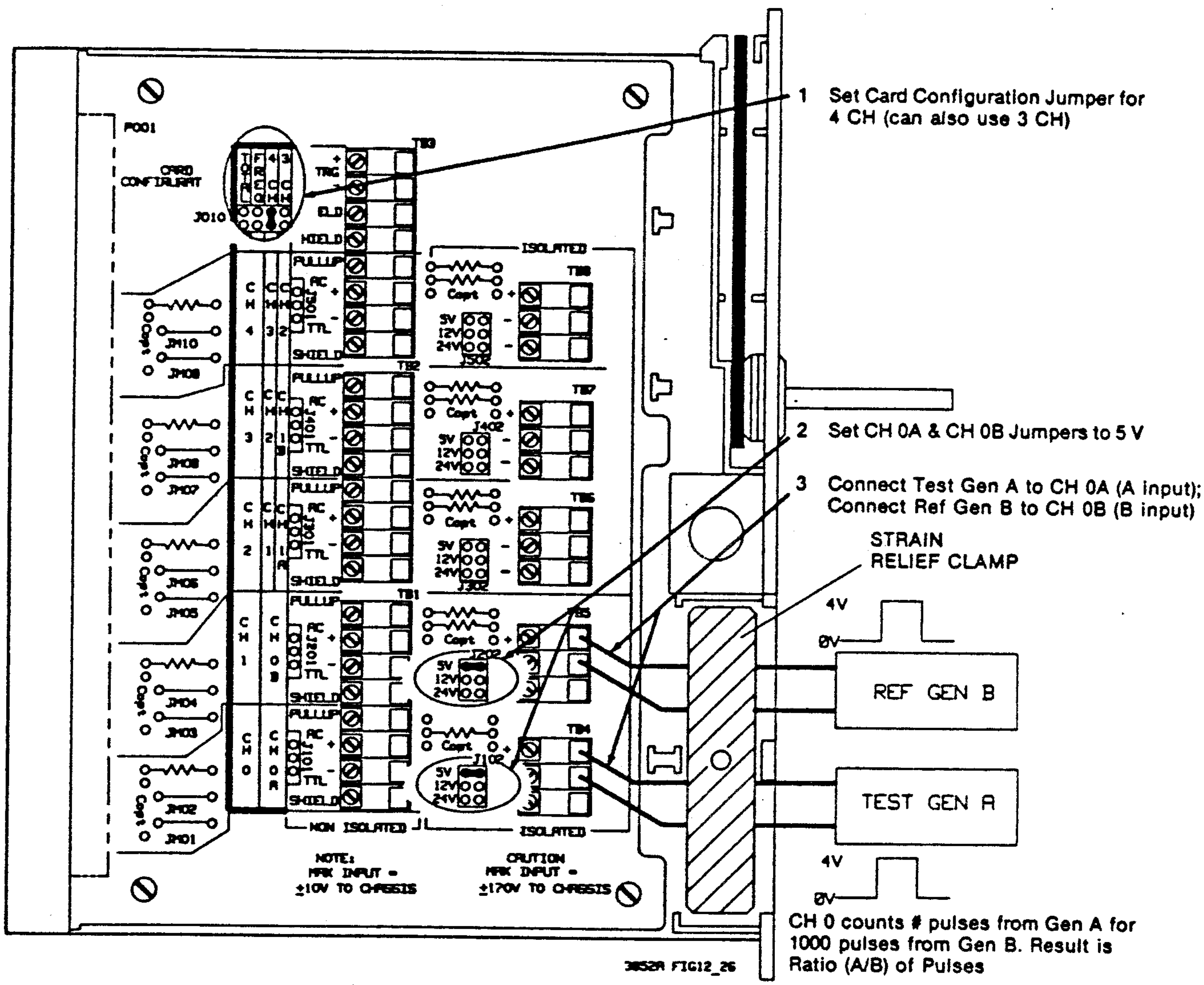


Figure 12-26. Example: Measure Pulse Output Ratios

```
260  !
270  !Enable mainframe to send interrupt to controller:
280  !
290  OUTPUT 709; "RQS INTR;RQS ON"
300  OUTPUT 709; "ENABLE INTR; ENABLE INTR SYS"
310  !
320  !Trigger Counter:
330  !
340  OUTPUT 709; "TRIG SGL"
           .
           .
500  SUB INTR_3
510  OUTPUT 709; "CHREAD 400"
520  ENTER 709; Ratio
530  PRINT "Ch 400 Pulse (A/B) Ratio = "; Ratio
540  SUBEND
```

If the test pulse generator outputs 1300 pulses in the time it takes to count 1000 reference generator pulse outputs, a typical readout is:

```
Ch 400 Pulse (A/B) Ratio = 1.300
```

Period

You can 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. Figure 12-27 summarizes the Period function and commands to set a channel to the function.

Figure 12-27. Period

Example: Measure Average Period

You want to measure the average period of an input square wave with maximum period = 1 msec. One way to do this is to connect the input to channel 0 of a counter in slot 4 of the mainframe and set the channel to the Period function. See Figure 12-28 for a connection diagram and counter configuration. Note that the B input is not used, even though Period is a double-input function.

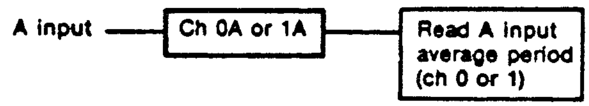
Figure 12-28. Example: Measure Average Period

An example program follows to set channel 0 for Period function. For this program, select NPER = 100 so that the counter will average 100 periods of the input. Also, assume you need at least 1 usec of resolution. Therefore, set *tbase* = 0.00001 (sec), so that resolution = (10/100) usec = 0.1 usec and maximum average period which can be measured = (655.35/100) msec = 6.5535 msec (refer to Table 12-2, "Counter Specifications").

```
           .
           .
110  !
120  !This program computes the average period of
130  !100 input periods to channel 0 of counter
140  !in slot 4 of mainframe.
150  !
```

PERIOD (PER)

Average NPER A input periods



Channel averages NPER periods of the A input, where NPER = 1 to 65535. Period measurement begins at first count edge (LH or HL) to the A input after the function is programmed and ends NPER periods later. If channel is enabled, measurement complete interrupt generated after NPER periods have been measured.

Period Commands

Input Signal Conditioning

Input Terminals		
-Isolated	TERM ISO	
-Non-Isolated	TERM NON	
Count Edges		
-Count pos A edges	EDGE LH	
-Count neg A edges	EDGE HL	

Function/Timing

Channel Function	FUNC PER	[,tbase or AUTO] (default = AUTO) (tbase = .01 to .000001 to sec)
Number Periods to Average	NPER number	(1 to 65535) (power-on = 10)
Sample Period	SPER number	(1 µs to .16 s) (power-on = 1 µs)

Interrupts

Enable Meas Cmpl Intr	ENABLE INTR
Disable Meas Cmpl Intr	DISABLE INTR

Triggering

Hardware	
-External	TRIG EXT
-System	TRIG SYS (see TRG command)
Software	
-Trigger Off	TRIG HOLD (power on)
-Single Trig	TRIG SGL (default)
-Int Trigger	TRIG INT

Read Ave Period

Read Ave A period	CHREAD ch (ch = 0 or 1)
Read/Zero A period	CHREADZ ch (ch = 0 or 1)
Transfer A period	XRDGS ch (ch = 0 or 1)

Figure 12-27. Period

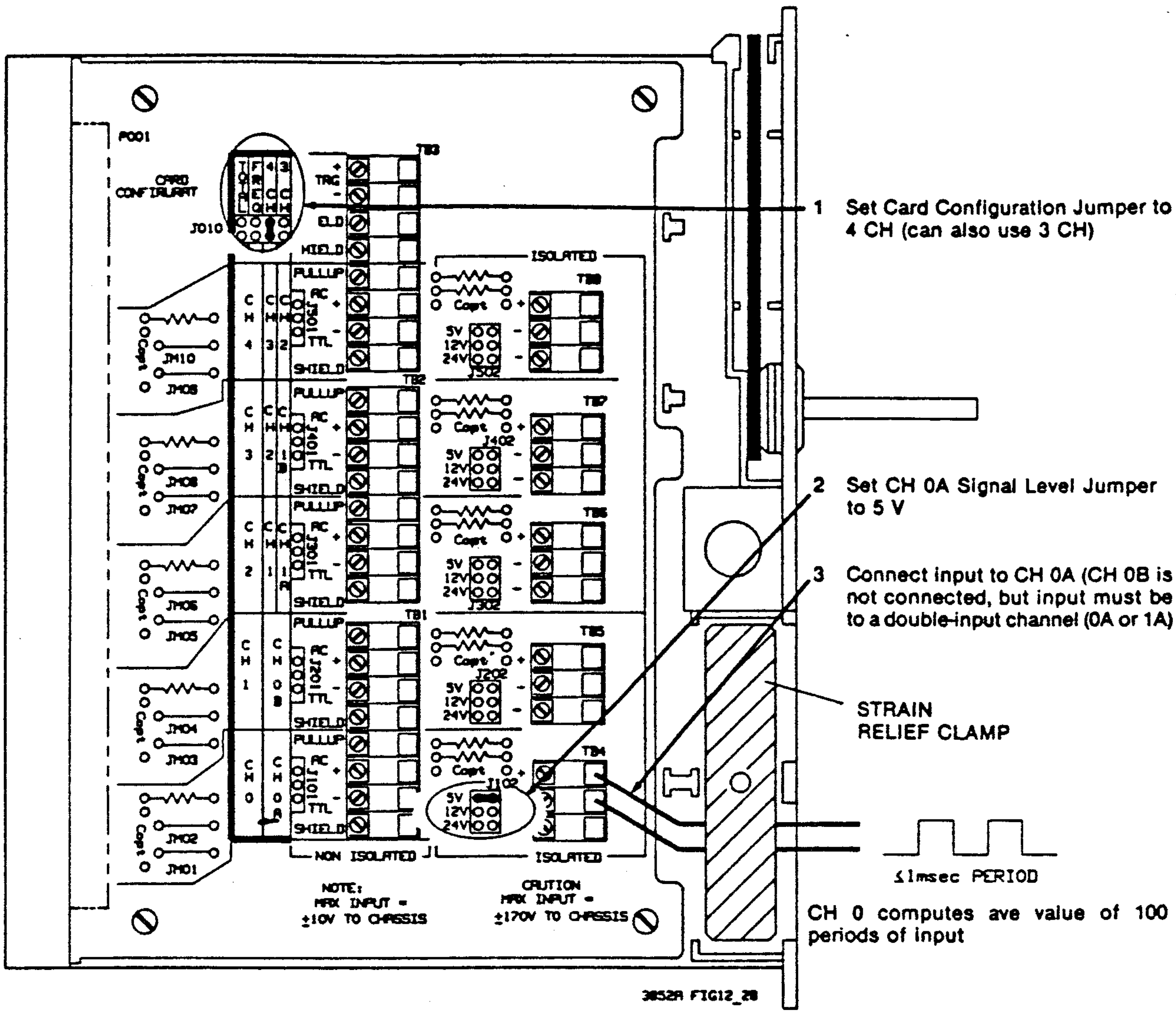


Figure 12-28. Example: Measure Average Period

```
160  !Set Signal Conditioning:
170  !Set input terminals to isolated, set
180  !triggering off, set channel to
190  !count positive edges of A input.
200  !
210  OUTPUT 709; "USE 400"
220  OUTPUT 709; "TRIG HOLD"
230  OUTPUT 709; "TERM ISO; EDGE LH"
240  !
250  !Set Channel Parameters:
260  !Set function to Period, set tbase.
270  !
280  OUTPUT 709; "FUNC PER, 0.00001"
290  !
300  !Trigger Counter:
310  !
320  OUTPUT 709; "TRIG SGL"
330  !
340  !Read average of 100 periods of input:
350  !
360  OUTPUT 709; "CHREAD 400"
370  ENTER 709; Period
380  !
390  !Print Results:
400  !
410  PRINT "Ch 400 Period = ";Period; "seconds"
420  END
```

If the average period of the input is 0.9935 msec, a typical readout (when the reading is available) is:

```
Ch 400 Period  = .0009935 seconds
```

Delayed Period

You can use Delayed Period (PERD) to do a single period measurement of the A input as gated by the B input. With Delayed Period, the single measurement is made after NPER periods of the A input. Figure 12-29 summarizes the Delayed Period function and commands to set a channel to the function.

Figure 12-29. Delayed Period

<u>Example: Measure Single Period</u>

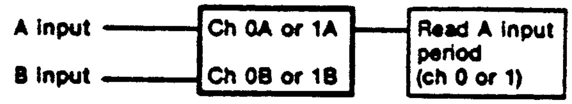
You want to measure the period of an input square wave with maximum period = 100 msec, after 100 periods have occurred. One way to do this is to connect the input to channel 0 of a counter in slot 4 of the mainframe and set the channel to the Delayed Period function. See Figure 12-30 for a connection diagram and counter configuration.

Figure 12-30. Example: Measure Single Period

An example program follows to set channel 0 for Delayed Period function. For this program, select NPER = 100 so the counter will measure the 100th period of the input. Also, assume you need at least 50 usec of resolution. Therefore, set

DELAYED PERIOD (PERD)

Measure single A input period



Channel measures a single period of the A input, delayed by NPER periods of the A input, where NPER = 1 to 65535. The B input gates the A input. The A input edges are counted when the B input is high or low, as selected. If enabled, the channel generates a measurement complete interrupt when NPER periods of the A input have been input.

Delayed Period Commands

Input Signal Conditioning

Input Terminals

-Isolated	TERM ISO
-Non-Isolated	TERM NON

Count Edges

-Count pos A edges when B input high	EDGE LH,LH or EDGE LH,HI
-Count pos A edges when B input low	EDGE LH,HL or EDGE LH,LO
-Count neg A edges when B input high	EDGE HL,LH or EDGE HL,HI
-Count neg A edges when B input low	EDGE HL,HL or EDGE HL,LO

Function/Timing

Channel Function	FUNC PERD	[,tbase or AUTO] (default = AUTO) (tbase = .01 to .000001 sec)
Set Number Periods to Delay	NPER number	(1 to 65535) (power-on = 10)
Sample Period	SPER number	(1 µs to .16 s) (power-on = 1 µs)

Interrupts

Enable Meas Cmpl Intr	ENABLE INTR
Disable Meas Cmpl Intr	DISABLE INTR

Triggering

Hardware

-External	TRIG EXT
-System	TRIG SYS (see TRG command)

Software

-Trigger Off	TRIG HOLD (power on)
-Single Trig	TRIG SGL (default)
-Int Trigger	TRIG INT

Read Single Period

Read Single A period	CHREAD ch (ch = 0 or 1)
Read/Zero A period	CHREADZ ch (ch = 0 or 1)
Transfer A period	XRDGS ch (ch = 0 or 1)

Figure 12-29. Delayed Period

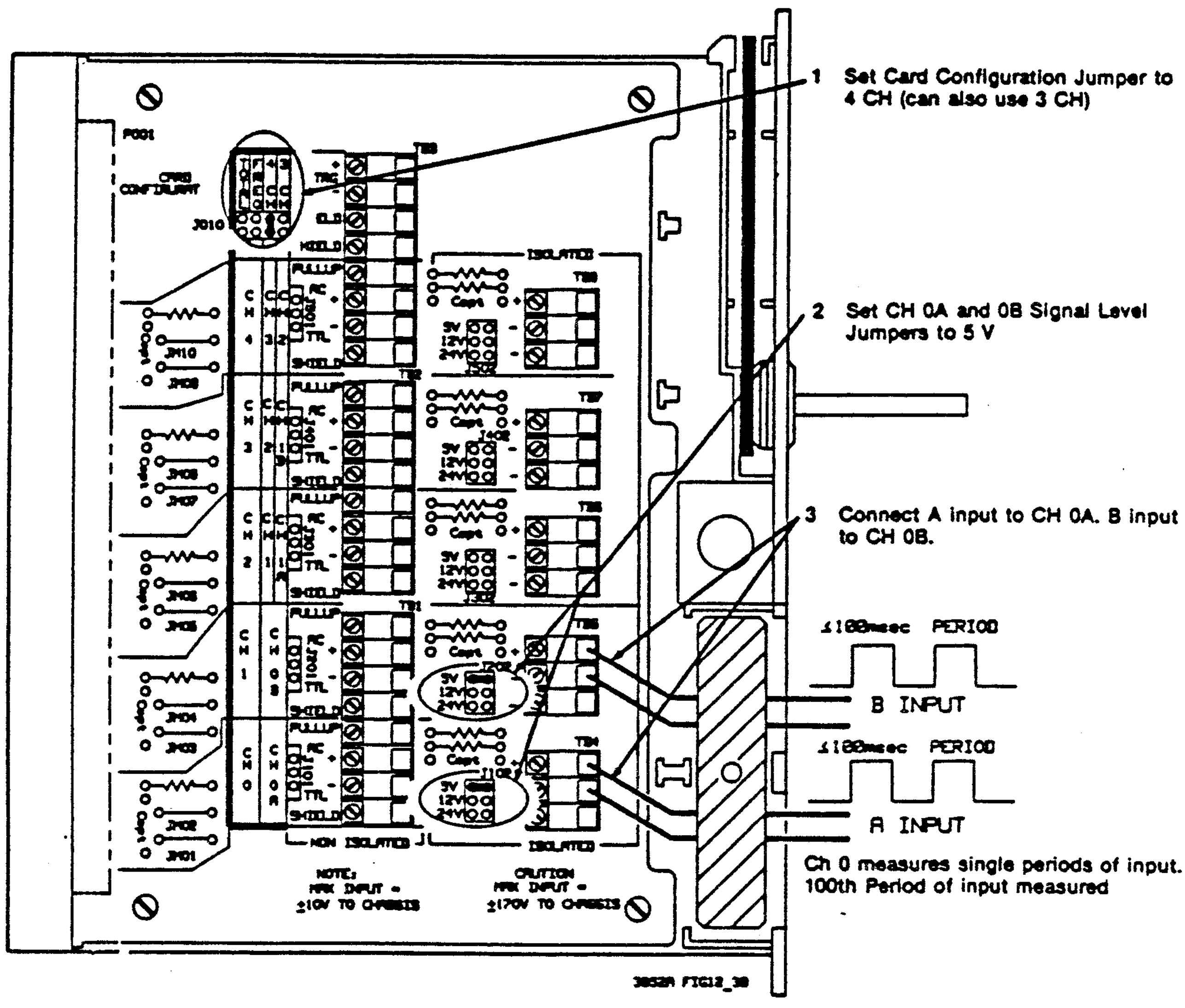


Figure 12-30. Example: Measure Single Period

tbase = 0.00001 (sec) so that resolution = 10 usec and maximum average period which can be measured = 655.35 msec (refer to Table 12-2, "Counter Specifications").

```
        .
        .
110  !
120  !This program computes the value of the
130  !100th input period to channel 0 of
140  !a counter in slot 4 of mainframe.
150  !
160  !Set Signal Conditioning:
170  !Set input terminals to isolated, set
180  !triggering off, set channel to
190  !count positive edges of A input when
200  !B input is low.
210  !
220  OUTPUT 709; "USE 400"
230  OUTPUT 709; "TRIG HOLD"
240  OUTPUT 709; "TERM ISO; EDGE LH,LO"
250  !
260  !Set Channel Parameters:
270  !Set function to Delayed Period, set tbase =
280  !.0001, set number periods = 100.
290  !
300  OUTPUT 709; "FUNC PERD, 0.00001; NPER 100"
310  !
320  !Trigger Counter:
330  !
340  OUTPUT 709; "TRIG SGL"
350  !
360  !Read value of 100th period of input:
370  !
380  OUTPUT 709; "CHREAD 400"
390  ENTER 709; Period
400  !
410  !Print Results:
420  !
430  PRINT "Ch 400 Period = ";Period; "seconds"
440  END
```

If the period of the 100th input is 99.35 msec, a typical readout is:

```
Ch 400 Period  = .09935 seconds
```

Frequency

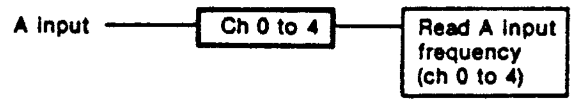
You can use the Frequency function to measure the frequency of inputs from >1 Hz up to 200 kHz. Figure 12-31 summarizes the Frequency function and the commands to set a channel to the function.

Figure 12-31. Frequency

<u>Example: Measure Flow Meter Flow Rate</u>

FREQUENCY (N/A)

Measure A input frequency



Frequency measurement is performed simultaneously on all five channels. If enabled, channel generates a measurement complete interrupt when the channel measurement is complete.

Frequency Commands

Input Signal Conditioning		
Input Terminals		
-Isolated	TERM ISO	
-Non-Isolated	TERM NON	
Count Edges		
-Count pos A edges	EDGE LH	
-Count neg A edges	EDGE HL	
Function/Timing		
Channel Function	FUNC command does not apply.	
Set Time Base	TBASE	[tbase or AUTO] (default = AUTO) (tbase = 1, 0.1, or 0.01 sec)
Sample Period	SPER number	(1 μsec to .16 sec) (power-on = 1 μsec)
Interrupts		
Enable Meas Cmpl Intr	ENABLE INTR	
Disable Meas Cmpl Intr	DISABLE INTR	
Triggering		
Hardware		
-External	TRIG EXT	
-System	TRIG SYS (see TRG command)	
Software		
-Trigger Off	TRIG HOLD (power on)	
-Single Trig	TRIG SGL (default)	
-Int Trigger	TRIG INT	
Read Frequency		
Read A input freq	CHREAD ch (ch = 0 to 4)	
Transfer A freq	XRDGS ch (ch = 0 to 4)	

Figure 12-31. Frequency

You want to measure the flow rate of a paddlewheel flow meter using magnetic pickup. One way to do this is to connect the input to channel 0 of a counter in slot 4 of the mainframe and set the channel to the Frequency function. The flow rate can then be determined from rate = Kf, where f = the frequency of the magnetic pickup (AC) input and K is a constant. See Figure 12-32 for a connection diagram and counter configuration.

Figure 12-32. Example: Measure Flow Meter Flow Rate

An example program follows to set channel 0 for Frequency function. For this program, assume the input frequency is about 100 kHz and you require a measurement with at least 20 Hz resolution. For these conditions, set TBASE *tbase* = TBASE .1 which will measure a signal with frequency range from 10 Hz to 200 kHz with 10 Hz resolution (refer to Table 12-2, "Counter Specifications"). Also assume K = 3.0.

```
        .
        .
110  !
120  !This program measures the frequency of a 100 kHz
130  !input to channel 0 of counter in slot
140  !4 of mainframe.
150  !
160  !Set Signal Conditioning:
170  !Set input terminals to non-isolated, set
180  !triggering off, set channel to
190  !count positive edges of A input.
200  !
210  OUTPUT 709; "USE 400"
220  OUTPUT 709; "TRIG HOLD"
230  OUTPUT 709; "TERM NON; EDGE LH"
240  !
250  !Set Channel Parameters:
260  !Set TBASE tbase = 0.1.
270  !
280  OUTPUT 709; "TBASE .1"
290  !
300  !Trigger Counter:
310  !
320  OUTPUT 709; TRIG SGL"
330  !
340  !Read AC input frequency:
350  !
360  OUTPUT 709; "CHREAD 400"
370  ENTER 709; Freq
380  !
390  !Print Flow Rate:
400  !
410  PRINT "Flow Rate (cm/sec) = ";3.0*Freq
420  END
```

If the AC input frequency is 100.000 kHz, since K = 3.0 cm a typical readout f(the assumed conditions is:

```
Flow Rate (cm/sec) = 300.000
```

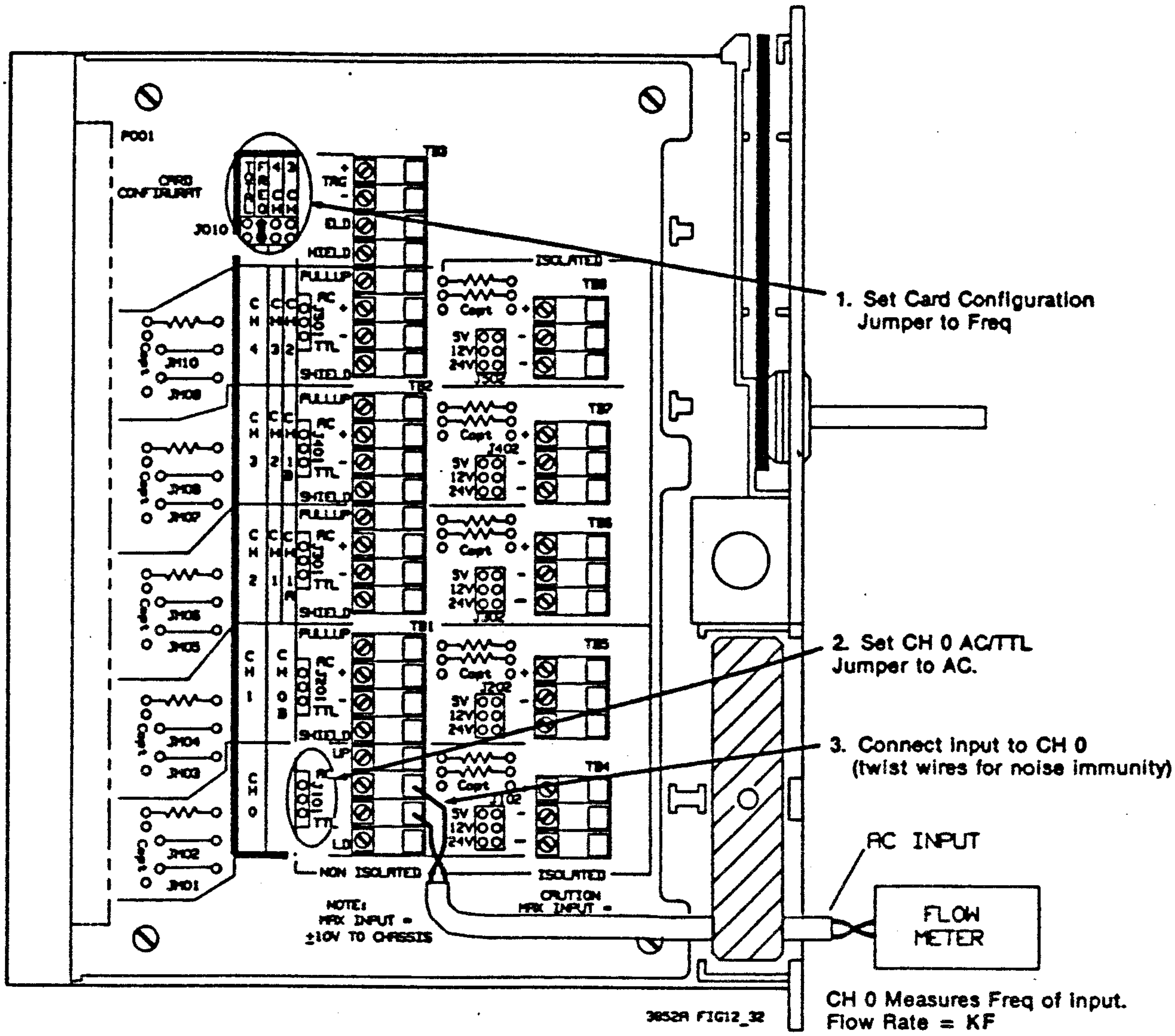


Figure 12-32. Example: Measure Flow Meter Flow Rate

Chapter 13

HP 44721A/44722A
16-Channel/8-Channel Digital Inputs

Contents

Chapter 13
HP 44721A/44722A Digital Inputs

Chapter 13

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HP 44721A/44722A

Introduction

This chapter 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 Configuration and Programming Manual for additional information on the acessories.

The chapter has five sections: Introduction, Specifications, Configuring the 16-Channel Digital Input, Configuring the 8-Channel Digital Input, and Programming the Digital Inputs.

- **Introduction** contains an overview of the chapter, describes the digital inputs, and shows a suggested getting started sequence.
- **Specifications** lists specifications for the 16-channel and 8-channel digital inputs.
- **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 programming functions: reading input states, counting input events, enabling event interrupts, and enabling counter interrupts.

Digital Input Descriptions

This section briefly describes the 16-channel digital input and 8-channel digital input accessories. Since both accessories detect input edges, it is important to define an input "edge". The 16-channel digital input detects DC input edges, while the 8-channel digital input detects both AC and DC input edges. Therefore, the definition of an "edge" depends on whether AC or DC is input.

For a DC input, a positive edge is an input change from LOW to HIGH, while a negative edge is a change from HIGH to LOW. For an AC input, a positive edge is an input change from AC OFF to AC ON, while a negative edge is a change from AC ON to AC OFF. Thus, for AC inputs, the channel state does NOT change with each cycle of the input.

16-Channel Digital Input Description

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, this jumper setting applies to all channel inputs.

8-Channel Digital Input Description

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 13-1, there are four main functions for the digital inputs: reading input states; counting input events; enabling event interrupts; and enabling counter interrupts.

Figure 13-1. Digital Input Functions

Reading Input States

To read the state of the input, the channel continuously detects each edge of the input and changes state with input state changes. For example, when a DC input to a channel goes from LOW to HIGH, the channel state goes from "0" to "1". When the DC input goes from HIGH to LOW, the channel state goes back to "0". You can read each channel state or the slot state to determine the input states.

Counting Input Events

For the digital inputs, an "event" is defined as any action which generates an input state change (positive or negative edge). To count events, each channel has a separate counter which totalizes positive or negative edges, as programmed. You can read the totalized count to determine the number of events on the channel. You can also read and zero the count on any channel.

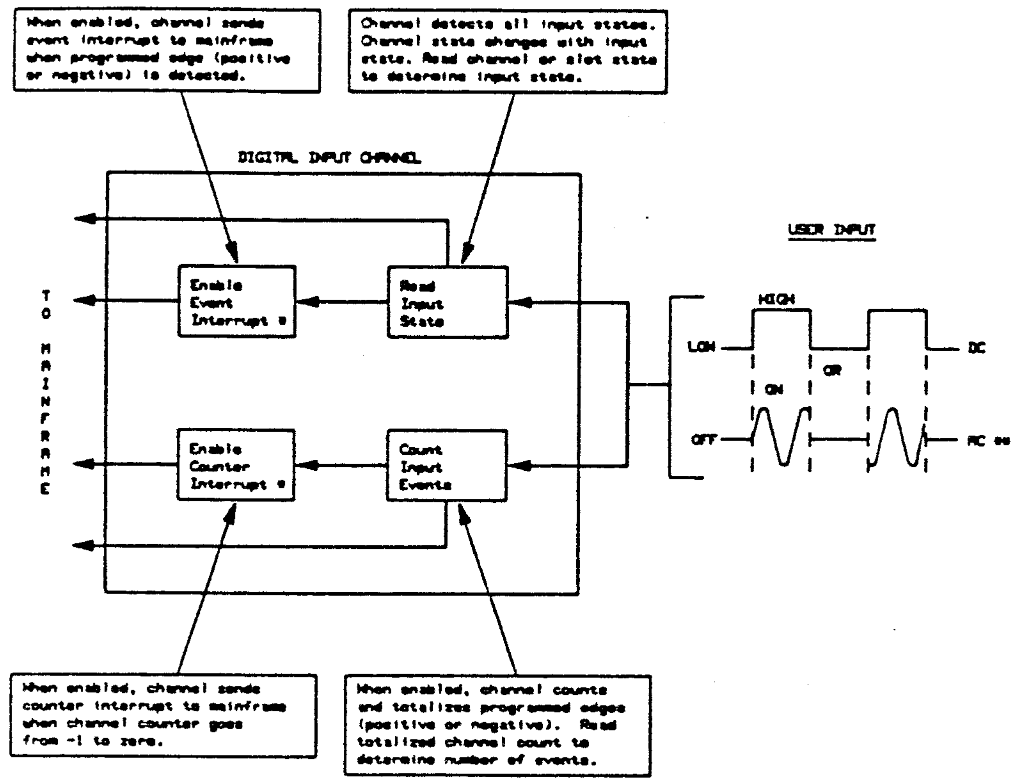
Enabling Event Interrupts

Each channel can be enabled to send an interrupt to the mainframe when a programmed edge (positive or negative) is detected. Each channel can be programmed for event interrupts, counter interrupts, or for both event and counter interrupts.

Enabling Counter Interrupts

Each channel can be enabled to send an interrupt to the mainframe when the channel counter rolls over from -1 to zero. The count sequence is from 0 (or from the preset value) up to 2147483647 counts. With the next count, the counter goes to -2147483648 and begins counting from -2147483648 to 0.

If the channel is enabled for counter interrupt, the channel generates an interrupt when the count goes from -1 to 0. Again, each channel can be programmed for event interrupts, counter interrupts, or for both event and counter interrupts.



NOTES

* = Channel can be enabled for event interrupts, counter interrupts, or both.

** = AC input for 8-channel digital input only.

Figure 13-1. Digital Input Functions

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 Digital Input Channels.
- Program Digital Input Channels.

Defining Your Application

The first step is to define your application and select the devices you want to connect to the digital input. The 16-channel digital input can accept DC voltage inputs up to 80 VDC. Since each channel can be independently configured and programmed, up to 16 devices can be connected to the accessory.

The 16-channel digital input has a +5 VDC supply so you can connect logic devices (such as TTL or CMOS) or dry contact devices (such as switches or mechanical contacts). When selecting devices, refer to Table 13-2, "16-Channel Digital Input Specifications", for voltage, current, and power limitations.

The 8-channel digital input can accept DC inputs up to 250 VDC or AC inputs up to 250 VAC rms @ 47-470 Hz. Since each channel can be independently configured and programmed, up to eight devices can be connected. Refer to Table 13-3, "8-Channel Digital Input Specifications" to for voltage, current, and power limitations.

Configuring Digital Input Channels

The next step is to configure each digital input channel for the devices selected. Although there are four primary functions for the digital inputs (reading input states, counting input events, enabling event interrupts, and enabling counter interrupts), hardware configuration for a digital input is the same for all functions.

Refer to "Configuring the 16-Channel Digital Input" to configure a 16-channel digital input. Refer to "Configuring the 8-Channel Digital Input" to configure an 8-channel digital input.

Programming Digital Input Channels

The third step is to program the digital input channels used for your application. Programming is the same for both digital inputs. There are four main programming functions for the digital inputs:

- Reading Input States
- Counting Input Events
- Enabling Event Interrupts
- Enabling Counter Interrupts

To program a digital input for your application, select the programming function for your application. Then, refer to "Programming the Digital Inputs" to program the digital input channels for this function. For example, to program a digital input channel to count input state changes, refer to "Counting Input Events".

Table 13-1 summarizes the four programming functions. Note that each channel of a digital input can be programmed for event interrupts, counter interrupts, or both.

Table 13-1. Digital Input Programming Functions

Reading Input States

Each channel of a digital input continuously reads the state of the input to the channel (OFF or ON for AC inputs, HIGH or LOW for DC inputs). You can read the state of the channel to determine the current state of devices such as switches, mechanical contacts, or voltage sources. You can also read the state of all channels in a slot.

Counting Input Events

Each channel of a digital input can be programmed to count positive or negative edges. You can read the number of counts on the channel to count the number of times an event, such as switch openings or closures, has occurred. You can also read the number of counts on the channel and then zero the count.

Enabling Event Interrupts

Each channel can be programmed to send an interrupt signal to the mainframe when a positive or negative edge (as programmed) is detected on the channel. This is defined as an event interrupt. You can use an event interrupt to send an interrupt signal to the mainframe when an event (such as an alarm, for example) occurs.

Enabling Counter Interrupts

Each channel can be programmed to send an interrupt signal to the mainframe when the channel counter resets from -1 to 0. This is defined as a counter interrupt. By presetting the counter, you can use a counter interrupt to send an interrupt to the mainframe after a number of events (such as ten switch closings, for example) have occurred.

Specifications

This section lists specifications for the 16-channel and 8-channel digital inputs. Refer to Table 13-2 for 16-channel digital input specifications. Refer to Table 13-3 for 8-channel digital input specifications.

16-Channel Digital Input Specifications

Table 13-2 lists specifications for the 16-channel digital input accessory.

Table 13-2. 16-Channel Digital Input Specifications

General:

The HP 44721A 16-Channel Digital Input with Totalize and Interrupt Accessory can read and count inputs for 16 digital input channels. Each channel can independently sense input edge transitions, totalize the number of edges for inputs up to 500 Hz, and generate interrupts for edge transitions or for counter overflow.

Each channel has an attenuator jumper which can be set for nominal input voltages of 5, 12, 24 or 48 VDC, with maximum input voltage of 80 VDC. The accessory has a debounce jumper with 10 Hz, 100 Hz, or 1 kHz settings. Debounce jumper setting is common to all channels. A +5 VDC supply is available for dry contacts. When the +5 VDC supply is used the channel is no longer isolated.

Isolation/Voltage Maximums:

Maximum Input Voltage: +- 80 V peak

Isolation: Max volts between channels or between channels and chassis ground: 250 V rms

+5 VDC Supply (Used for source to measure dry contact switches):

Accuracy: 5 VDC +- 20%
Max Current: 8 mA

Input Voltage Levels:

Attenuator Jumper Setting [1]	Threshold Voltage [2] Vmin	Threshold Voltage [2] Vmax	Nominal I @ Jumper Setting
5V	1.0 VDC	4.0 VDC	0.5 mA
12V	2.5 VDC	9.5 VDC	1.3 mA
24V	7.0 VDC	17.0 VDC	2.8 mA
48V	14.0 VDC	31.0 VDC	5.8 mA

Table 13-2. 16-Channel Digital Input Specifications (cont'd)

[1] Absolute maximum input voltage = 80 VDC @ 8.0 mA, for any jumper setting. Accessory will respond only to inputs of proper polarity. Operation will be impaired if total power input exceeds six (6) watts. Therefore, maximum input = 60 volts/channel when all channels used, 80 volts/channel when nine (9) channels are used, etc.

[2] Vmax must be <= minimum value of HIGH state of input (Vhigh) and Vmin must be >= maximum value of LOW state of input (Vlow). Select jumper setting which has best positive noise margin, where noise margin = min (Vhigh - Vmax, Vmin - Vlow). See Figures 13-3 and 13-4 for an example.

Debounce Jumper Ratings:

Debounce Jumper Setting [1]	Max Bounce Period Ignored [2]	Min Pulse Width to Sense [3]	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

[1] Select debounce jumper setting so that: (a) maximum bounce period of input signal <= Max Bounce Period Ignored and (b) both positive and negative pulse widths of input signal >= Min Pulse Width to Sense. See Figure 13-5 for input signal definitions.

[2] Inputs with pulse widths less than Max Bounce Period Ignored will not be sensed.

[3] Inputs with pulse widths > Max Bounce Period Ignored but < Min Pulse Width to Sense may not be sensed.

Interrupt Delay Times:

When enabled, the accessory generates interrupts for positive or negative edges or for counter overflow to zero. Interrupt delay time for the accessory varies, depending on debounce jumper setting.

ACCESSORY Interrupt Delay Time = Accessory Response Time + Debounce Response Time.

SYSTEM Interrupt Delay Time = Accessory Interrupt Delay Time + Application Program Response Time.

Table 13-2.16-Channel Digital Input Specifications (cont'd)

Since System Interrupt Delay Time depends on customer programming, the delay times listed below are the ACCESSORY Response Times ONLY. Add Application Program Response Time to get SYSTEM Interrupt Delay Time.

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	.2	1	.2	2.5

Counters:

Number of Counters: 16 (one per channel)
Range: -2147483648 to 2147483647
Maximum Input Freq: 10 Hz, 100 Hz, or 500 Hz

To be counted, both the HIGH state and LOW state input pulse widths must be >= Min Pulse Width to Sense. For example, with a 10 Hz debounce jumper setting, both the HIGH state and LOW state pulse widths of an input must be >= 50 msec for programmed edges to be counted.

Maximum Input Freq depends on setting for Debounce Jumper setting. Refer to "Debounce Jumper Ratings" chart for Min Pulse Width to Sense values.

8-Channel Digital Input Specifications

Table 13-3 lists specifications for the 8-channel digital input accessory.

Table 13-3. 8-Channel Digital Input Specifications

General:

The HP 44722A 8-Channel AC Digital Input with Totalize and Interrupt Accessory can read and count inputs for eight digital input channels. Each channel can be independently set to sense events (edge transitions), totalize events for inputs up to 10 Hz, and generate interrupts for events or counter overflow.

Each channel has an attenuator jumper which can be set for nominal input voltage levels of 24, 120, or 240 volts. Maximum input voltage depends on jumper setting.

Isolation:

Isolation: Max volts between channels or between channels and chassis ground: 250 V rms

Table 13-3. 8-Channel Digital Input Specifications (cont'd)

Input Voltage Levels:

Attenuator Jumper Setting	Maximum Input Voltage [1]	Threshold Voltage Vmin [2]	Threshold Voltage Vmax [2]	Input Current @ Nominal Setting
24 volts	80	5.5	16.5	1.7 mA
120 volts	200	30.0	90.0	1.1 mA
240 volts	250	65.0	185.0	1.1 mA

[1] Maximum input voltage (VDC or VAC rms) which can be applied to a channel for this attenuator jumper setting. If combined channel inputs are > six (6) watts, operation of other accessories in the box cannot be guaranteed due to excessive power dissipation.

[2] Vmax must be <= minimum value of HIGH state of input (Vhigh) and Vmin must be >= maximum value of LOW state of input (Vlow). Select jumper setting which has maximum positive noise margin, where noise margin = min (Vhigh - Vmax, Vmin - Vlow). See Figures 13-12 and 13-13 for an example.

Interrupts:

The accessory detects positive or negative edges and, when enabled, generates an interrupt signal to the mainframe for programmed edges or for counter overflow. For DC inputs, a positive edge is an input transition from LOW to HIGH, while a negative edge is a transition from HIGH to LOW. For AC inputs, a positive edge is an input transition from AC OFF to AC ON, while a negative edge is a transition from AC ON to AC OFF.

Maximum interrupt delay time for the accessory = 50 msec. Total system interrupt delay time depends on application program. Add 50 msec to application program delay time to get system interrupt delay time.

Counters:

Number of counters:	8 (one per channel)
Range:	-2147483648 to 2147483647
Maximum Frequency:	10 Hz [1]

[1] To be counted, both positive and negative pulse widths must be >= 50 msec. For DC inputs, both HIGH and LOW states must be >= 50 msec. For AC inputs, both AC OFF state and AC ON state must be >= 50 msec.

Configuring the 16-Channel Digital Input

This section 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 and shows typical field wiring connections. Refer to Table 13-2, "16-Channel Digital Input Specifications" for accessory specifications.

There are four steps to configure 16-channel digital input channels. When all required channels have been configured, refer to "Programming the Digital Inputs" to program the 16-channel digital input for your application.

- Set attenuator jumpers.
- Set debounce jumper.
- Connect field wiring.
- Install/checkout digital input.

Setting Attenuator Jumpers

To begin configuring the 16-channel digital input, 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 13-2 shows the 16-channel terminal module with the cover removed.

WARNING

SHOCK HAZARD. Only qualified, service-trained personnel who are aware of the hazards involved should install, remove, or configure any accessory. Before touching an 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

For safety, consider all accessory channels to be at the highest voltage applied to any channel.

Figure 13-2. 16-Channel Terminal Module

The 16-channel 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 jumpers we must first define some terms. Figure 13-3 shows a typical DC input with HIGH and LOW states. For this input, Vhigh = the MINIMUM value of the HIGH state input and Vlow = the MAXIMUM value of the LOW state of the input. Vmax and Vmin are the

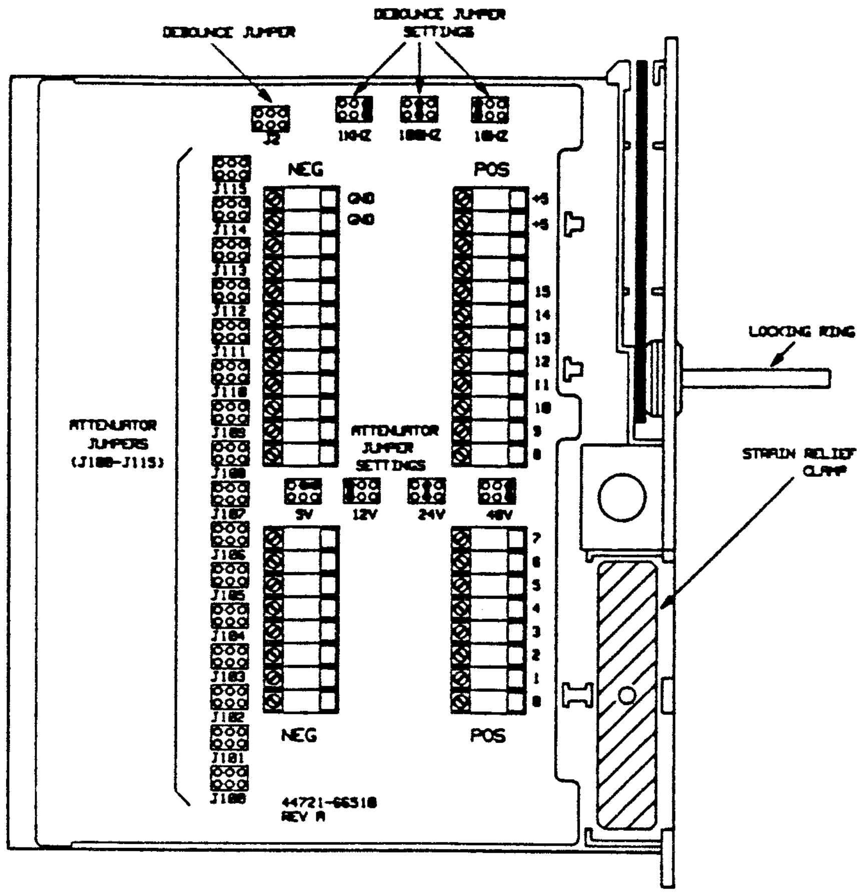


Figure 13-2. 16-Channel Terminal Module

Threshold Voltages defined in Table 13-2, "16-Channel Digital Input Specifications". For convenience, Table 13-4 repeats the Threshold Voltage values.

To set a channel attenuator jumper, use the setting which has the best positive noise margin, where noise margin = min (du, dl) = min (Vhigh - Vmax, Vmin - Vlow). This means that (1) Vmax must be <= Vhigh AND Vmin must be >= Vlow and (2) the noise margin for the setting must be >= the noise margin for any other setting.

Figure 13-3. 16-Channel Attenuator Jumper - Guidelines

To compute the best attenuator jumper setting, first determine the minimum value of the HIGH state of the input (Vhigh) and the maximum value of the LOW state of the input (Vlow). Next, using the Vmax and Vmin values in Table 13-4, compute the noise margin for each attenuator jumper setting by using noise margin = min (Vhigh - Vmax, Vmin - Vlow). Then, select the setting with the best positive noise margin. See Figure 13-2 for attenuator jumper locations. An example follows.

Table 13-4. 16-Channel Digital Input Threshold Voltages

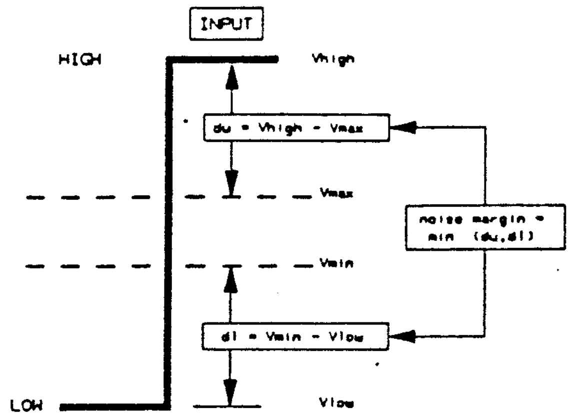
16-Channel Attenuator Jumper Settings	Input Threshold Voltages		Nominal Current for Jumper Setting
	Vmin	Vmax	
5V	1.0 VDC	4.0 VDC	0.5 mA
12V	2.5 VDC	9.5 VDC	1.3 mA
24V	7.0 VDC	17.0 VDC	2.8 mA
48V	14.0 VDC	31.0 VDC	5.8 mA

Example: Setting 16-Channel Attenuator Jumpers

You want to select the best attenuator jumper setting for a DC input with Vlow = 1.5V and Vhigh = 30V. Figure 13-4 shows this input compared to Vmax and Vmin for the four settings of the attenuator jumpers: 5V, 12V, 24V, or 48V. Since noise margin = min [(Vhigh-Vmax), (Vmin-Vlow)], noise margins for the four ranges are:

```
 5V: noise margin = min [(30.0- 4.0),  (1.0-1.5)]  = -0.5
12V: noise margin = min [(30.0- 9.5),  (2.5-1.5)]  =  1.0
24V: noise margin = min [(30.0-17.0),  (7.0-1.5)]  =  5.5
48V: noise margin = min [(30.0-31.0), (14.0-1.5)]  = -1.0
```

The 5V setting can't be used, since the noise margin = min (26,- 0.5) = -0.5 is negative. Similarly, the 48V setting can't be used since the noise margin = min (-1,12.5) = -1 is also negative. Both the 12V and 24V settings have positive noise margins. However, since the noise margin for the 24V setting = min (13,5.5) = 5.5 is better than the noise margin for the 12V setting = min (20.5,1) = 1, use the 24V setting.



ATTENUATOR JUMPER SETTINGS - GUIDELINES

1. Vmax < = Vhigh AND Vmin> = Vlow.
2. Set jumper for best POSITIVE noise margin.

Figure 13-3. 16-Channel Attenuator Jumper - Guidelines

NOTE

The 30V input in this example exceeds the nominal value for the 24V setting. For any attenuator jumper 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 (6) watts.

Figure 13-4. Setting 16-Channel Attenuator Jumper

Setting Debounce Jumper

The next step in hardware configuration is to set the debounce jumper (J2). However, to properly set the debounce jumper, we'll need to define some terms. Figure 13-5 shows input signal definitions and guidelines to set the debounce jumper. Since the accessory has a single debounce jumper, input signal definitions refer to the maximum and minimum values for inputs to all channels.

Figure 13-5. 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.

There are three steps to set the debounce jumper:

- Determine Maximum Bounce Period.
- Determine Minimum Pulse Widths.
- Set Debounce Jumper.

Determining Maximum Bounce Period

The first step to select the debounce jumper setting is to determine the maximum bounce period of all 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 <= Maximum Bounce Period Ignored value shown in Table 13-5.

For example, if the Max Bounce Period is 10 msec, use the 10 Hz setting since it is the only setting with Maximum Bounce Period Ignored >10 msec. With the 100 Hz or 1 kHz settings, the accessory may sense the bounces as state changes and give false readings.

Table 13-5. 16-Channel Digital Input Debounce Jumper Ratings

Debounce Jumper	Maximum Bounce	Minimum Pulse	Input Freq

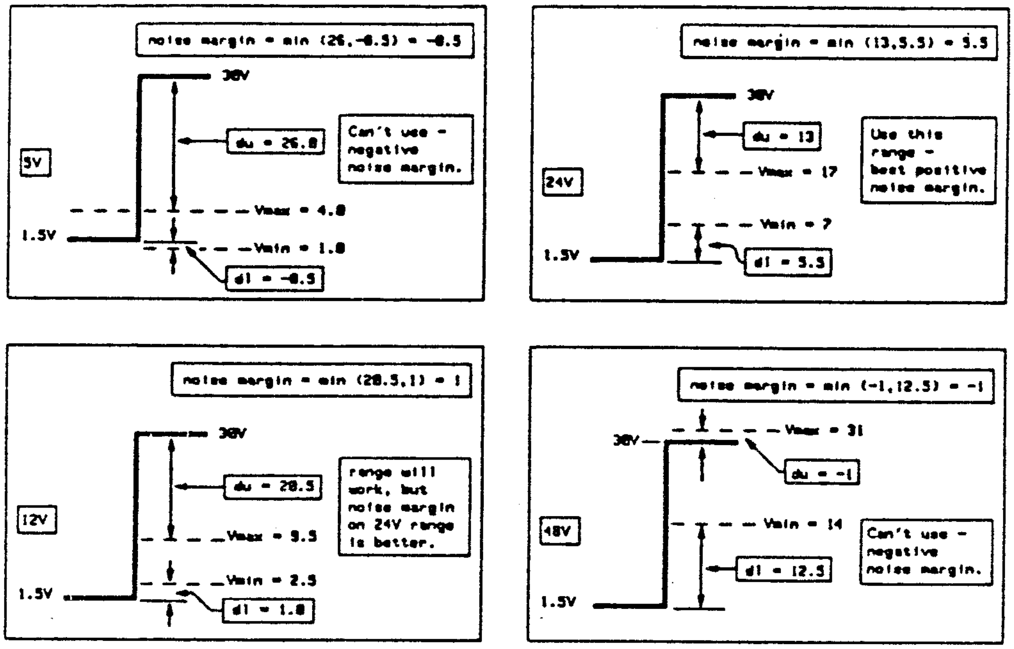
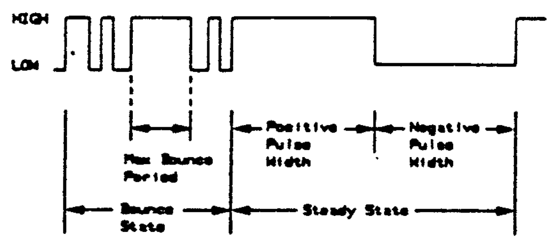


Figure 13-4. Setting 16-Channel Attenuator Jumper

INPUT SIGNAL DEFINITIONS *



DEBOUNCE JUMPER SETTING-GUIDELINES

1. Max Bounce Period < = Max Bounce Period Ignored.**
2. Pos and neg pulse widths > = Min Pulse Width to Sense.**

* = Bounces not shown after first edge.
** = Refer to Table 13-5 for values.

Figure 13-5. Debounce Jumper Setting - Guidelines

Table 13-5. 16-Channel Digital Input Debounce Jumper Ratings (cont'd)

Setting	Period Ignored	Width to Sense	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 Minimum Input Pulse Widths

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 >= Minimum Pulse Width to Sense times shown in Table 13-5.

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. Figure 13-6 summarizes input pulse width requirements for each debounce jumper setting.

Figure 13-6. Input Pulse Widths - Requirements

Setting the Debounce Jumper

When you have determined the minimum input pulse widths and the maximum bounce period, set the debounce jumper to meet these conditions. An example follows to show how to set the debounce jumper.

NOTE

For each debounce jumper setting, the 16-channel digital input has a different interrupt delay time (refer to "Interrupt Delay Times" in Table 13-2). 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, check the interrupt delay times in Table 13-2 to ensure that the delay is acceptable.

Example: Setting 16-Channel Debounce Jumper

You want to set the debounce jumper for a DC input with Max Bounce Period = 1 msec and Positive Pulse Widths = Negative Pulse Widths = 20 msec. See Figure 13-7. For proper debounce jumper setting, the Maximum Bounce Period of the input must be <= Maximum Bounce Period Ignored and the Positive and Negative Pulse Widths must be >= Minimum Pulse Width to Sense.

From Figure 13-7, the 10 Hz setting can't be used since the input pulse widths (20 msec) are < Min Pulse Width to Sense (50 msec). Also, the 1 kHz setting can't be used since the Max Bounce Period (1 msec) > Maximum Bounce Period Ignored (0.2 msec).

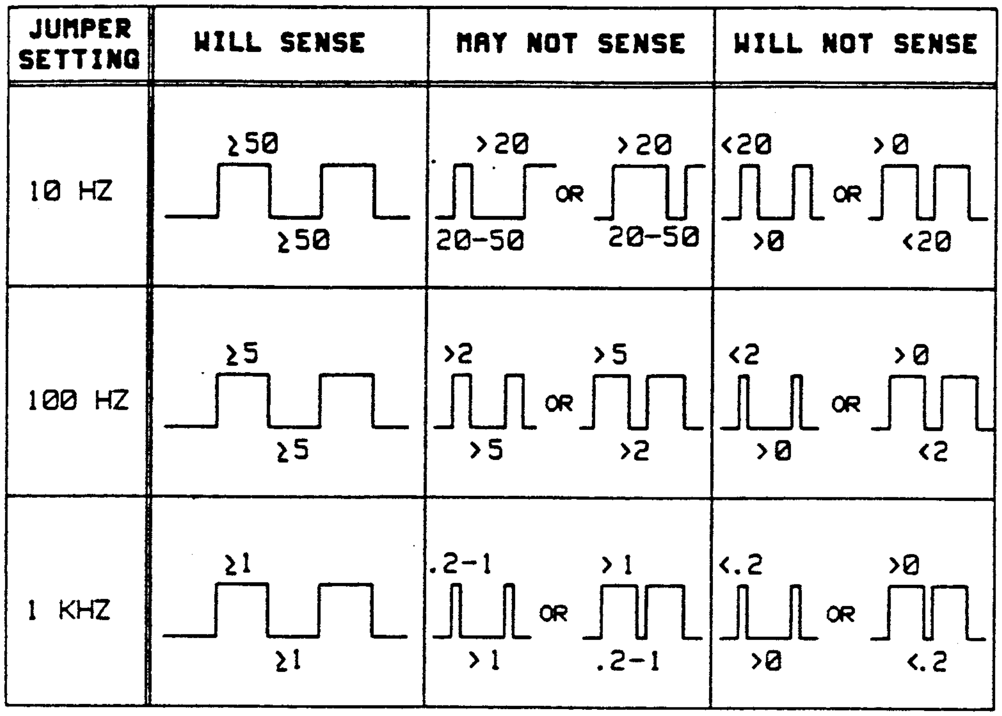


Figure 13-6. Input Pulse Widths - Requirements

Therefore, for this input, use the 100 Hz setting since the Max Bounce Period (1 msec) < Max Bounce Period Ignored (2 msec) and 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.

Figure 13-7. Setting 16-Channel 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 +5 connectors (on the POS terminal) and two GND connectors (on the NEG terminal) are provided for dry contact inputs. See Figure 13-2 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.

CAUTION

Maximum input voltage to avoid circuit damage to the 16-channel digital input is 80 VDC. Maximum total input power to avoid degrading accessory specifications is six (6) watts.

Example: Connecting DC to 16-Channel Digital Input

A +9 VDC source and switch are connected to channel 5 as shown in Figure 13-8. The switch opens and closes 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 13-4, the noise margin for the 5V setting = min [(9-4), (1-0)] = min (1,5) = 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.

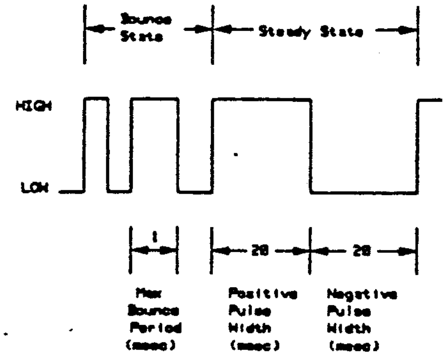
Any setting for the debounce jumper satisfies the condition that Pulse Widths > Min Pulse Width to Sense (refer to Table 13-5). However, you must set the debounce jumper (J2) to 10 Hz since this is the only setting with Maximum Bounce Period (10 msec) < Max Bounce Period Ignored (20 msec). When the jumpers have been set, route the field wires as shown in Figure 13-8.

Figure 13-8. Connecting DC to 16-Channel Digital Input

Example: Using +5V Supply on 16-Channel Digital Input

Three ganged switches are connected to channels 2, 3, and 4 as shown in Figure 13-9 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

INPUT SIGNAL



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			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			20 msec	1 msec	CAN'T USE: Max Bounce Period > Max Bounce Period Ignored.

* = Refer to table 13-5 for values

Figure 13-7. Setting 16-Channel Debounce Jumper

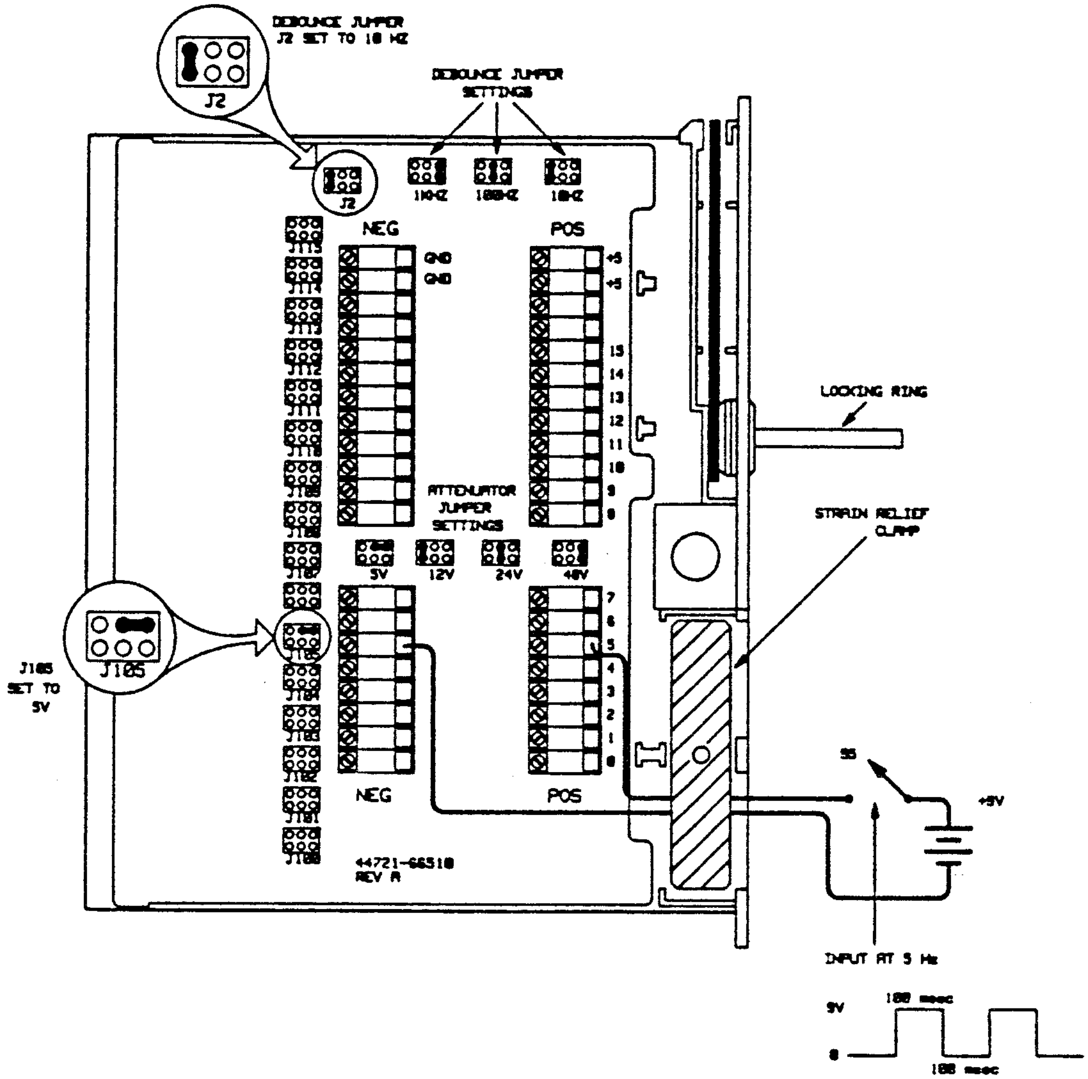


Figure 13-8. Connecting DC to 16-Channel Digital Input

switching rate of 5 Hz (100 msec pulse widths), set the debounce jumper to 10 Hz. Refer to the previous example, "Connecting DC to 16-Channel Digital Input" for details to set the jumpers. When you have set the jumpers, route the field wires as shown in Figure 13-9.

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 13-9. Using +5V Supply on 16-Channel Digital Input

Example: Connecting TTL/CMOS to 16-Channel Digital Input

TTL and CMOS logic can also be connected to the 16-channel digital input, as shown in Figure 13-10. For TTL or CMOS inputs, set the attenuator jumper for each channel used to 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 13-10.

Figure 13-10. Connecting TTL/CMOS to 16-Channel Digital Input

Installation/ 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 16-channel digital input in a desired slot. Refer to the HP 3852A Configuration and Programming Manual to connect the modules and to install the accessory.

When the 16-channel digital input is installed, send the ID? command to check the accessory ID. After 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).

For example, the following program will determine the identity of an accessory in slot 4 of the mainframe. A 16-channel digital input in this slot returns 44721A.

```
10 OUTPUT 709; "ID? 400"
20 ENTER 709; A
30 DISP A
40 END
```

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 44721A is not returned refer to the HP 3852A Assembly Level Service Manual for service procedures.

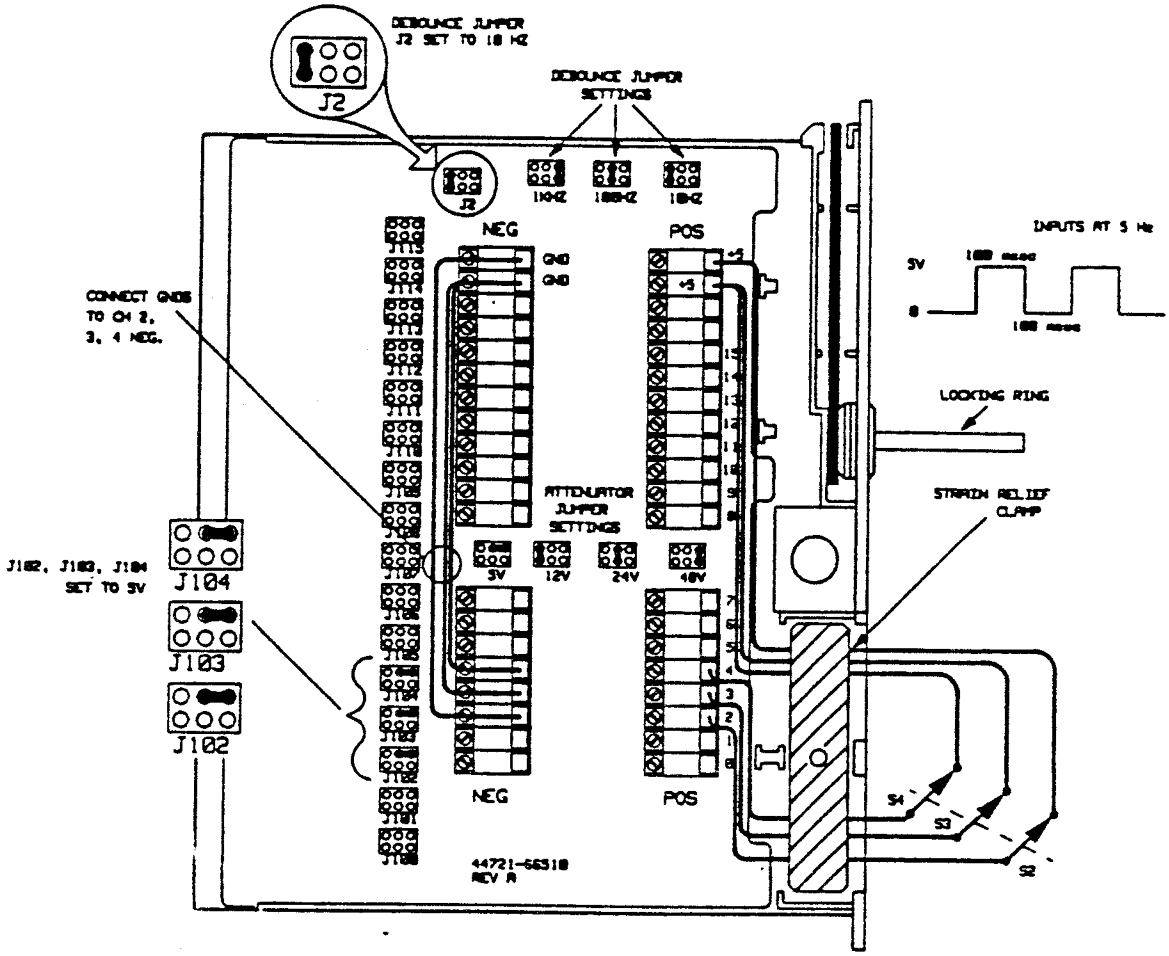


Figure 13-9. Using +5V Supply on 16-Channel Digital Input

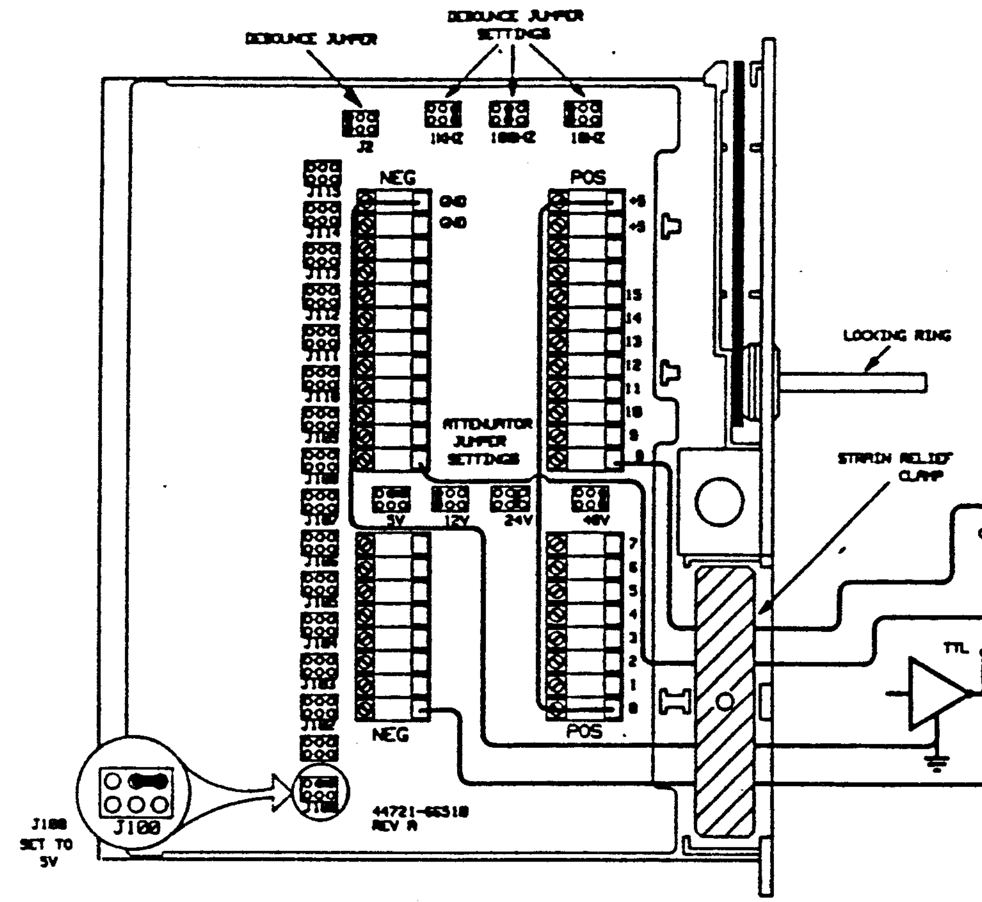


Figure 13-10. Connecting TTL/CMOS to 16-Channel Digital Input

This completes hardware configuration. Refer to "Programming the Digital Inputs" to program the 16-channel digital input for your application.

Configuring the 8-Channel Digital Input

This section shows how to hardware configure the 8-channel digital input. It includes guidelines to set the attenuator jumpers on the terminal module and shows typical field wiring connections. Refer to Table 13-3, "8-Channel Digital Input Specifications" for 8-channel digital input specifications.

As shown below, there are three steps to hardware configure 8-channel digital input channels. When all required channels have been configured, refer to "Programming the Digital Inputs" to program the 8-channel digital input for your application.

- Set attenuator jumpers.
- Connect field wiring.
- Install/checkout digital input.

Setting Attenuator Jumpers

To begin configuring the 8-channel digital input, remove the terminal module cover. If the 8-channel digital input is installed in the mainframe or in an extender, refer to the HP 3852A Configuration and Programming Manual to remove the terminal module. Figure 13-11 shows the 8-channel terminal module with the cover removed.

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 and extenders, to all installed accessories, and to all external devices connected to the mainframe, extenders or accessories.

WARNING

For safety, consider all accessory channels to be at the highest voltage applied to any channel.

Figure 13-11. 8-Channel Terminal Module

The 8-channel terminal module has eight attenuator jumpers (J100 through J107), one for each channel. Since an attenuator jumper is provided for each channel, each channel can be configured independently. J100 sets channel 0, J101 sets channel 1, . . J107 sets channel 7.

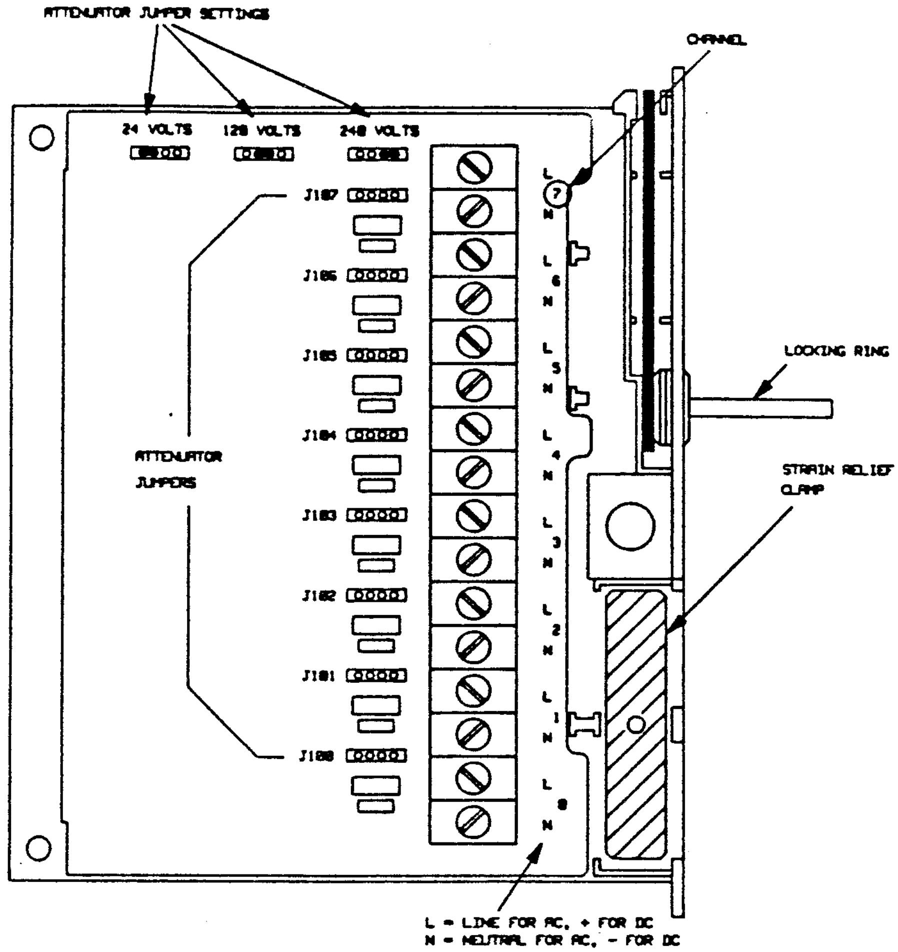


Figure 13-11. 8-Channel Terminal Module

However, to properly set the attenuator jumpers, we must define some terms. Figure 13-12 shows a typical DC input with HIGH and LOW states. For this input, Vhigh = the MINIMUM value of the HIGH state of the input and Vlow = the MAXIMUM value of the LOW state of the input. Vmax and Vmin are the Threshold Voltages defined in Table 13-3, "8-Channel Digital Input Specifications". For convenience, Table 13-6 repeats the Threshold Voltage values.

To set a channel attenuator jumper, select the setting which has the best positive noise margin. This means that (1) Vmax must be <= Vhigh AND Vmin must be >= Vlow and (2) the noise margin for the setting must be >= the noise margin for any other setting, where noise margin = min (Vhigh - Vmax, Vmin - Vlow).

Figure 13-12. 8-Channel Attenuator Jumper - Guidelines

To compute the best attenuator jumper setting for a channel, first determine the minimum value of the HIGH state of the input (Vhigh) and the maximum value of the LOW state of the input (Vlow) to the channel. Next, using the Vmax and Vmin values in Table 13-6, compute the noise margin for each setting from noise margin = min (Vhigh - Vmax, Vmin - Vlow). Then, select the setting with the best positive noise margin. An example follows.

Table 13-6. 8-Channel Digital Input Threshold Voltages

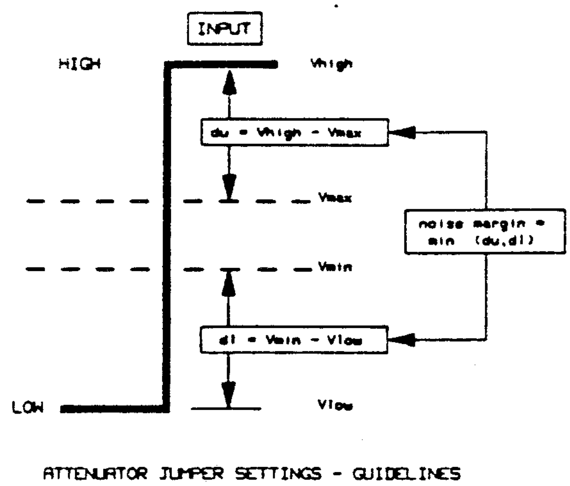
8-Channel Attenuator Jumper Settings	Maximum Input Voltage	Input Threshold Voltages		Nominal Current for Jumper Setting
		Vmin	Vmax	
24V	80	5.5	16.5	1.7 mA
120V	200	30.0	90.0	1.1 mA
240V	250	65.0	185.0	1.1 mA

Example: Setting 8-Channel Attenuator Jumpers

You want to select the best attenuator jumper setting for an input with Vlow = 25 VDC and Vhigh = 195 VDC (or Vlow = 25 VAC rms, Vhigh = 195 VAC rms). Figure 13-13 shows the input compared to Vmax and Vmin for the three settings of the attenuator jumpers: 24V, 120V, and 240V. Since noise margin = min [(Vhigh-Vmax),(Vmin-Vlow)], the noise margins for each range are:

```
 24V:  noise margin = min [(195-16.5),(5.5-25)] = -19.5
120V:  noise margin = min [(195-90),   (30-25)] =   5.0
240V:  noise margin = min [(195-185),  (65-25)] =  10.0
```

The 24V setting can't be used, since the noise margin = min (178.5,-19.5) = -19.5 is negative. Both the 120V and 240V settings have positive noise margins. However, since the noise margin = min (10,40) = 10 for the 240V setting is better than the noise margin = min (105,5) = 5 for the 120V setting, use the 240V setting for this input.



1. Vmax < = Vhigh AND Vmin > = Vlow.
2. Set jumper for best POSITIVE noise margin.

Figure 13-12. 16-Channel Attenuator Jumper - Guidelines

Figure 13-13. Setting 8-Channel Attenuator Jumper

CAUTION

Absolute maximum voltage input to a channel depends on the attenuator jumper setting for the channel: 80 volts for 24V setting, 200 volts for 120V settng, or 250 volts for 240V setting, where volts = VDC or VAC rms. If combined inputs to the terminal module exceed six (6) watts, operation of other accessories installed in the box may be affected due to excessive power dissipation.

Connecting Field Wiring

When you have set the channel attenuator jumpers, connect field wiring from your system devices to the terminals on the 8-channel terminal module. Each channel of the 8-channel terminal module has an L and an N terminal, where L = + input for DC or LINE input for AC and N = - input for DC or NEUTRAL for AC inputs. See Figure 13-11 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. After you have connected field wiring, replace the terminal assembly cover. Two example configurations follow.

Example: Connecting DC to 8-Channel Digital Input

A 100 VDC source is connected through switch S1 to channel 1 of an 8-channel digital input as shown in Figure 13-14. To set the channel attenuator jumper (J101) for this input, select the setting with the best positive noise margin.

From Table 13-6, 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 can't 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 13-14.

Figure 13-14. Connecting DC to 8-Channel Digital Input

Example: Connecting AC to 8-Channel Digital 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 13-15. 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 can't 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 13-15.

Figure 13-15. Connecting AC to 8-Channel Digital Input

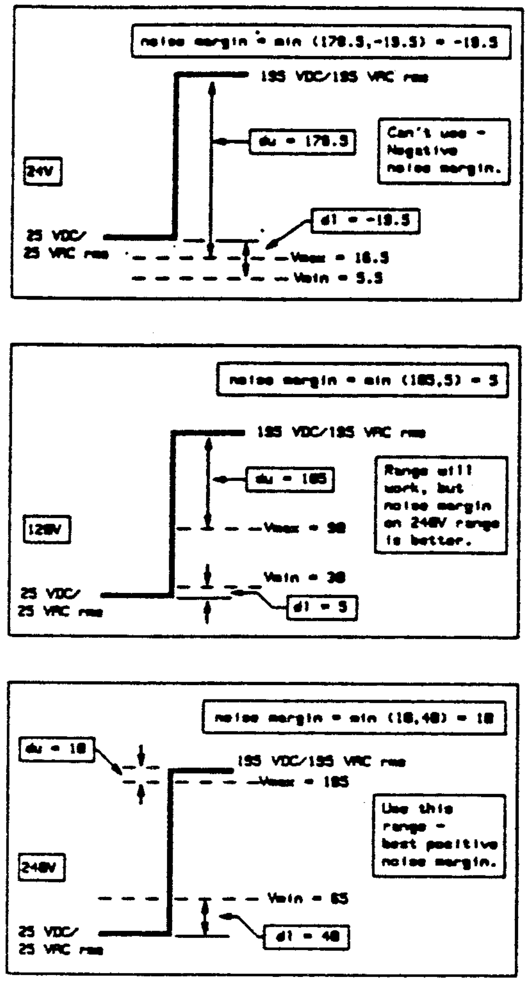


Figure 13-13. Setting 8-Channel Attenuator Jumper

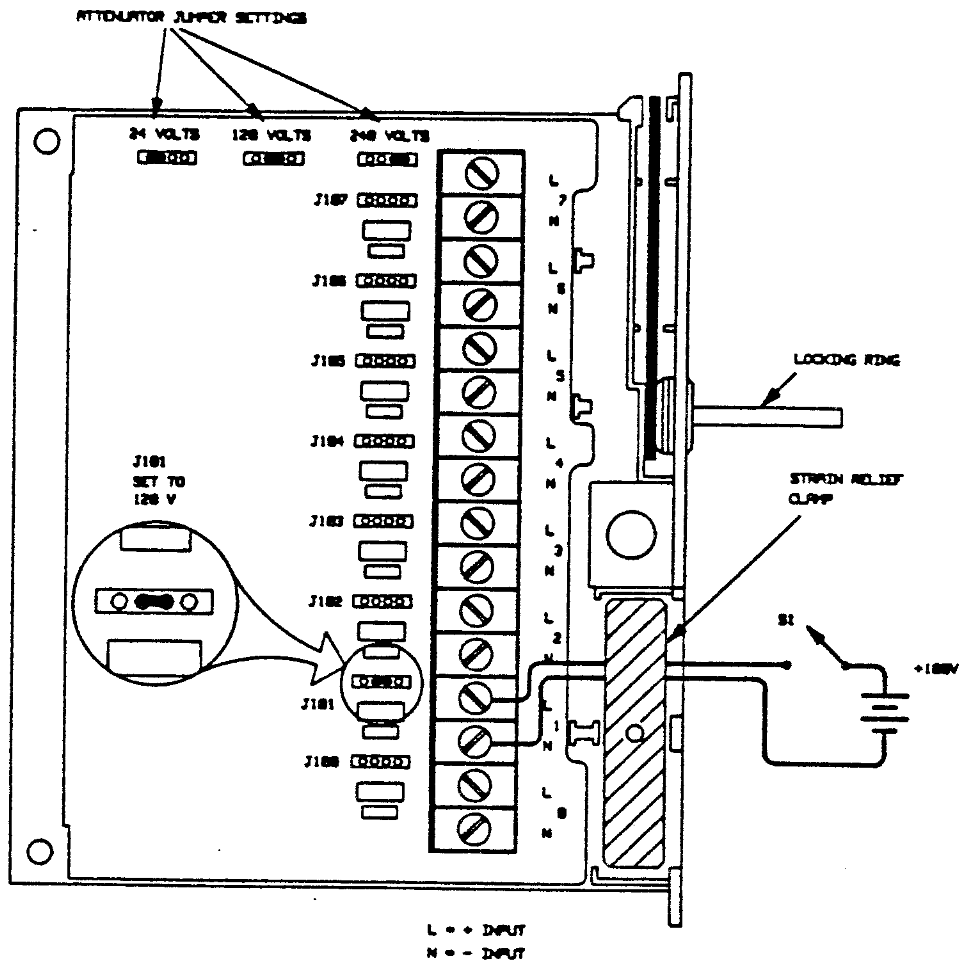


Figure 13-14. Connecting DC to 8-Channel Digital Input

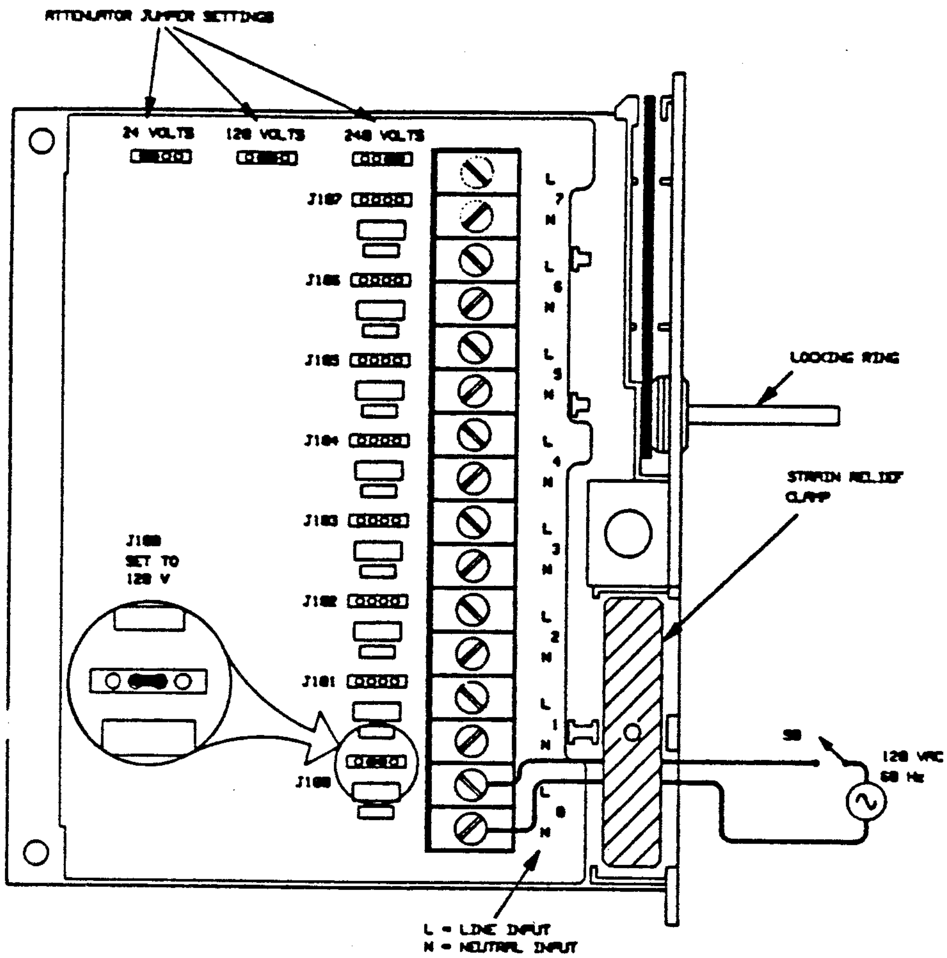


Figure 13-15. Connecting AC to 8-Channel Digital Input

Installation/ Checkout

When the channel attenuator jumpers have been set and field wiring connected, connect the terminal module to the digital input component module and install the 8-channel digital input in a desired slot. Refer to the HP 3852A Configuration and Programming Manual to connect the two modules and to install the accessory.

After the digital input is installed, send the ID? command to check the 8-channel digital input identity. After 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 returns 44722A for the 8-channel digital input).

For example, the following program will determine the identity of an accessory in slot 4 of the mainframe. An 8-channel digital input in this slot returns 44722A.

```
10 OUTPUT 709; "ID? 400"
20 ENTER 709; A
30 DISP A
40 END
```

If the 8-channel digital input does not return 44722A, be sure you have addressed the correct slot and the terminal module is installed. If the slot is correct and the terminal module is installed but 44722A is not returned, refer to the HP 3852A Assembly Level Service Manual for service procedures.

This completes hardware configuration. Refer to "Programming the Digital Inputs" to program the 8-channel digital input for your application.

Programming the Digital Inputs

As noted, the digital inputs have four primary programming functions: reading states, counting input events, enabling event interrupts, and enabling counter interrupts.

This section shows how to program the digital inputs for these functions. It includes a description of each function, applicable commands for the function, and programming examples. Each programming example includes a connection diagram, sample program, and (where applicable) typical readouts for assumed conditions.

The section also lists the titles of the example programs (refer to "Example Program Titles"), includes a discussion of digital input channel numbers vs. commands (refer to "Channel Numbers vs. Commands"), and summarizes the commands for the digital inputs (refer to "Digital Input Command Summary").

NOTE

The example programs use HP-IB address 709 and specific slot and channel numbers. Program syntax and data returns apply to HP 200 Series and HP 300 Series controllers. If you use a different controller, modify the syntax and data formats as required. Modify addresses as necessary for the slots and channels you use.

Example Program Titles

Discussion for each programming function includes one or two example programs to show how to program the digital inputs for the function. Table 13-7 lists the titles of the example programs.

Table 13-7. Example Program Titles

Title	Description	Commands
Reading Input States		
Reading Switch State	Read state of channel to determine if switch is open or closed.	CHREAD
Reading AC ON/OFF Status	Read state of all channels in slot to determine AC ON/OFF status.	READ
Counting Input Events		
Counting Switch Openings/ Closures	Set channel to count switch openings and closures and read number of openings/ closures.	USE, EDGE, CHREAD
Reading/ Zeroing AC ON Counts	Read number of times AC input is ON and zero the count.	USE, EDGE, CHREADZ
Enabling Event Interrupts		
Interrupt On Switch Opening	Enable channel to generate interrupt when a switch opens by detecting negative edge and using event interrupt enable.	USE, EDGE, ENABLE INTR
Interrupt on Burst	Enable channel to generate interrupt for first event in burst of	USE, EDGE, ENABLE INTR

Table 13-7. Example Program Titles (cont'd)

	events. Count and read number of events in burst.	
Enabling Counter Interrupts		
Interrupt After Ten Switch Closures	Enable channel to generate interrupt after ten switch closures by using counter interrupt.	USE, EDGE, CNTSET, ENABLE INTR

Channel Numbers vs. Commands

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, the 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.

Six digital input commands use logical channel numbers: CHREAD, CHREADZ, CNTSET, DISABLE INTR, EDGE, and ENABLE INTR. Table 13-8 defines the logical channel number functions by command for the 16-channel digital input. Table 13-9 shows the same information for the 8-channel digital input. In Tables 13-8 and 13-9, logical channel numbers give the value of the *ch* parameter in the command or in the associated USE *ch* parameter.

For example, in Table 13-8, the CHREAD *ch* command sets a channel to one of two functions, depending on the value of the *ch* parameter. Thus, for physical channel 0, CHREAD with *ch* = 0 reads the number of counts on channel 0, while CHREAD with *ch* = 16 reads the state of channel 0.

The logical channel numbers in Tables 13-8 and 13-9 are the "CC" numbers in the standard ESCC format, with leading zeroes suppressed. To form the command parameter, the logical channel numbers must be preceded by the appropriate extender and slot number so that the *ch* parameter will have the standard ESCC form. For example, to read the state of channel 5 of a 16-channel digital input in slot 3 of extender 1, the logical channel number for the CHREAD *ch* command = 21, so the command is CHREAD 1321.

Table 13-8. Channel Numbers vs. Commands - 16-Channel

Table 13-9. Channel Numbers vs. Commands - 8-Channel

Digital Input Command Summary

Table 13-10 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 13-10. Commands for the Digital Inputs

Table 13-8. Channel Numbers vs. Commands - 16-Channel

Channel Number	CHREAD ch	
	Read Channel Counts	Read Channel State
0	0	16
1	1	17
2	2	18
3	3	19
4	4	20
5	5	21
6	6	22
7	7	23
8	8	24
9	9	25
10	10	26
11	11	27
12	12	28
13	13	29
14	14	30
15	15	31

Channel Number	CNTSET [number] [,USE ch]	
	Set channel ctr to [number]	N/A
0	0	16
1	1	17
2	2	18
3	3	19
4	4	20
5	5	21
6	6	22
7	7	23
8	8	24
9	9	25
10	10	26
11	11	27
12	12	28
13	13	29
14	14	30
15	15	31

Channel Number	ENABLE INTR [,USE ch]	
	Enable counter Interrupt	Enable Event Interrupt
0	0	16
1	1	17
2	2	18
3	3	19
4	4	20
5	5	21
6	6	22
7	7	23
8	8	24
9	9	25
10	10	26
11	11	27
12	12	28
13	13	29
14	14	30
15	15	31

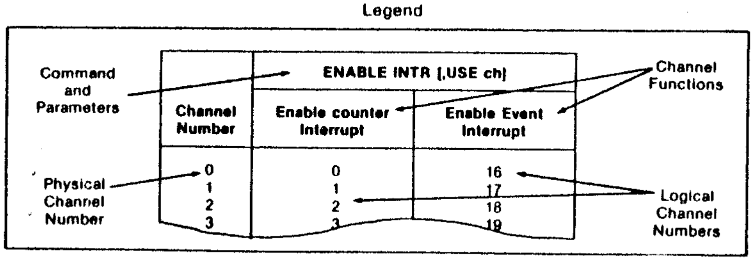
Channel Number	CHREADZ ch	
	Read/zero count on channel	N/A
0	0	16
1	1	17
2	2	18
3	3	19
4	4	20
5	5	21
6	6	22
7	7	23
8	8	24
9	9	25
10	10	26
11	11	27
12	12	28
13	13	29
14	14	30
15	15	31

Channel Number	DISABLE INTR, [,USE ch]	
	Disable counter Interrupt	Disable Event Interrupt
0	0	16
1	1	17
2	2	18
3	3	19
4	4	20
5	5	21
6	6	22
7	7	23
8	8	24
9	9	25
10	10	26
11	11	27
12	12	28
13	13	29
14	14	30
15	15	31

Channel Number	EDGE [trans] [,USE ch]*	
	Count pos or neg edges	Detect pos or neg edges
0	0	16
1	1	17
2	2	18
3	3	19
4	4	20
5	5	21
6	6	22
7	7	23
8	8	24
9	9	25
10	10	26
11	11	27
12	12	28
13	13	29
14	14	30
15	15	31

* = EDGE LN sets positive edges, EDGE ML sets negative edges.

Legend



Example

Assume 16-channel digital input in slot 4 of mainframe. To program channel 14 to detect positive edges, use the EDGE [,USE ch] command. From the table, the logical channel number = 30 so the command is EDGE LN, USE 430.

Table 13-9. Channel Numbers vs. Commands - 8-Channel

Channel Number	CHREAD ch: Read Channel Counts	CHREAD ch: Read Channel State
0	0	8
1	1	9
2	2	10
3	3	11
4	4	12
5	5	13
6	6	14
7	7	15

Channel Number	CNTSET [number] [,USE ch]: Set channel ctr to [number]	CNTSET [number] [,USE ch]: N/A
0	0	8
1	1	9
2	2	10
3	3	11
4	4	12
5	5	13
6	6	14
7	7	15

Channel Number	ENABLE INTR [,USE ch]: Enable counter Interrupt	ENABLE INTR [,USE ch]: Enable Event Interrupt
0	0	8
1	1	9
2	2	10
3	3	11
4	4	12
5	5	13
6	6	14
7	7	15

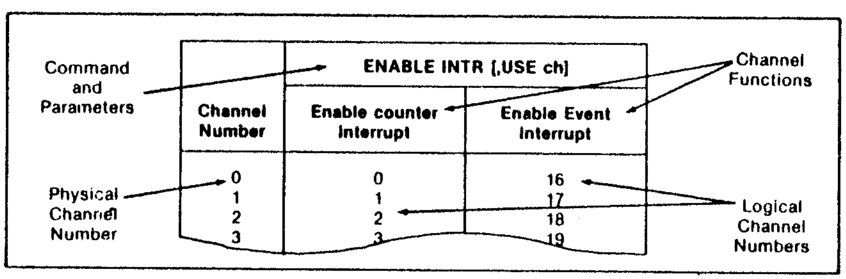
Channel Number	CHREADZ ch: Read/zero count on channel	CHREADZ ch: N/A
0	0	8
1	1	9
2	2	10
3	3	11
4	4	12
5	5	13
6	6	14
7	7	15

Channel Number	DISABLE INTR, [,USE ch]: Disable counter Interrupt	DISABLE INTR, [,USE ch]: Disable Event Interrupt
0	0	8
1	1	9
2	2	10
3	3	11
4	4	12
5	5	13
6	6	14
7	7	15

Channel Number	EDGE [trans] [,USE ch]*: Count pos or neg edges	EDGE [trans] [,USE ch]*: Detect pos or neg edges
0	0	8
1	1	9
2	2	10
3	3	11
4	4	12
5	5	13
6	6	14
7	7	15

* = EDGE LN sets positive edges, EDGE ML sets negative edges.

Legend



Example

Assume 16-channel digital input in slot 4 of mainframe. To program channel 14 to detect positive edges, use the EDGE [,USE ch] command. From the table, the logical channel number = 30 so the command is EDGE LN, USE 430.

Table 13-10. Commands for the Digital Inputs (cont'd)

CHREAD *ch* [INTO *name*] or [*fmt*]

Read a Single Bit or Count.
Depending on *ch* value, reads counts on channel or reads channel state.

CHREADZ *ch* [INTO *name*] or [*fmt*]

Read and Zero Count.
Reads and zeroes count on channel specified by *ch*.

CNTSET [*number*] [,USE *ch*]

Set Counter.
Presets counter in channel specified by USE *ch* parameter or command to number specified by *number*.

DISABLE INTR [,USE *ch*]

Channel Interrupt Disable.
Prevents enabled channel from sending event or counter interrupts. The type of interrupt which is disabled is specified by *ch*.

EDGE *trans* [,USE *ch*]

Set Relevant Edge on Channel.
For channel specified by USE *ch* parameter or command, *trans* sets positive or negative edges to detect and (when enabled) to count.

ENABLE INTR [,USE *ch*]

Channel Enable Interrupt.
Enables channel to send interrupt signal to mainframe for event or counter interrupts. Cause of interrupt set by USE *ch* parameter or command.

ID? *slot*

Identity of Accessory.
Reads identity of digital input in slot specified by *slot*.

READ *slot* [INTO *name*] or [*fmt*]

Read Digital Input Slot.
Reads state of all channels in slot specified by *slot*.

RST *slot*

Table 13-10. Commands for the Digital Inputs (cont'd)

Reset Accessory. Resets digital input in slot specified by *slot* to power-on state. **USE** *ch* Use This Channel in Following Commands. Use channel specified by *ch* in commands to follow (unless USE parameter is given) where *ch* specifies channel number and function. **XRDGS** *ch*[*count*] [INTO *name*] or [*fmt*] Transfer Reading Storage from Channel. For channel specified by *ch*, transfers reading from digital input to mainframe. If reading is not available, command waits until reading is available and then transfers reading. For the digital inputs, default *count* = 1.

Reading Input States

One of the four main programming functions for the digital inputs is to read the state of an input. When the channel input is HIGH (AC ON for AC inputs), the channel is set to the 1 state. When the input is LOW (AC OFF for AC inputs), the channel is set to the 0 state. See Figure 13-16 for a summary of the commands for this function.

Figure 13-16. Reading Input States

The READ or CHREAD commands read the state of digital input channels. Use CHREAD *ch* with *ch* = 16-31 (8-15 for the 8-channel) to read the state of a channel. Use READ *slot* to read the state of all channels in a slot. (You can also use the XRDGS *ch* command which acts as a multiple CHREAD command).

For example, use CHREAD 121 to read the state of channel 5 of a 16-channel digital input in slot 1 of the mainframe. Use CHREAD 113 to read the state of channel 5 of an 8-channel digital input in slot 1 of the mainframe. Use READ 100 to read the state of all channels of an 8-channel or 16-channel digital input in slot 1 of the mainframe.

Example: Reading Switch State

You want to determine if switch S1 is open or closed by reading the state of channel 1 of a 16-channel digital input in slot 4 of the mainframe. See Figure 13-17 for a configuration diagram.

Figure 13-17. Reading Switch State

You can determine the state of S1 by sending the CHREAD command to channel 1. A "1" returned means S1 is closed; a "0" returned means S1 is open. An example program for the 16-channel digital input follows. For an 8-channel digital input, modify line 150 to OUTPUT 709; "CHREAD 409".

```
110  !
120  !Read state of channel 1 of 16-channel
```

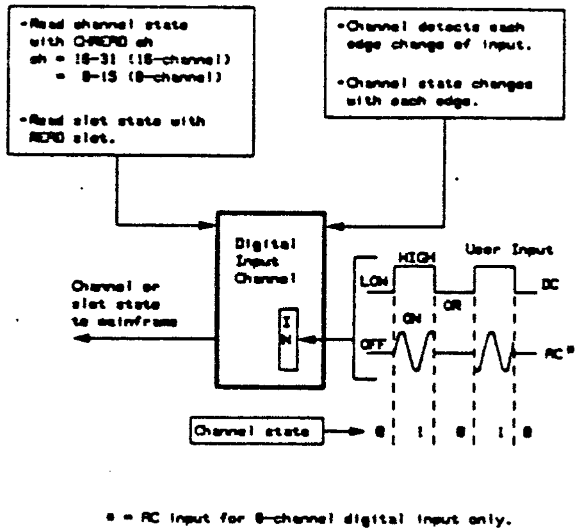


Figure 13-16. Reading Input States

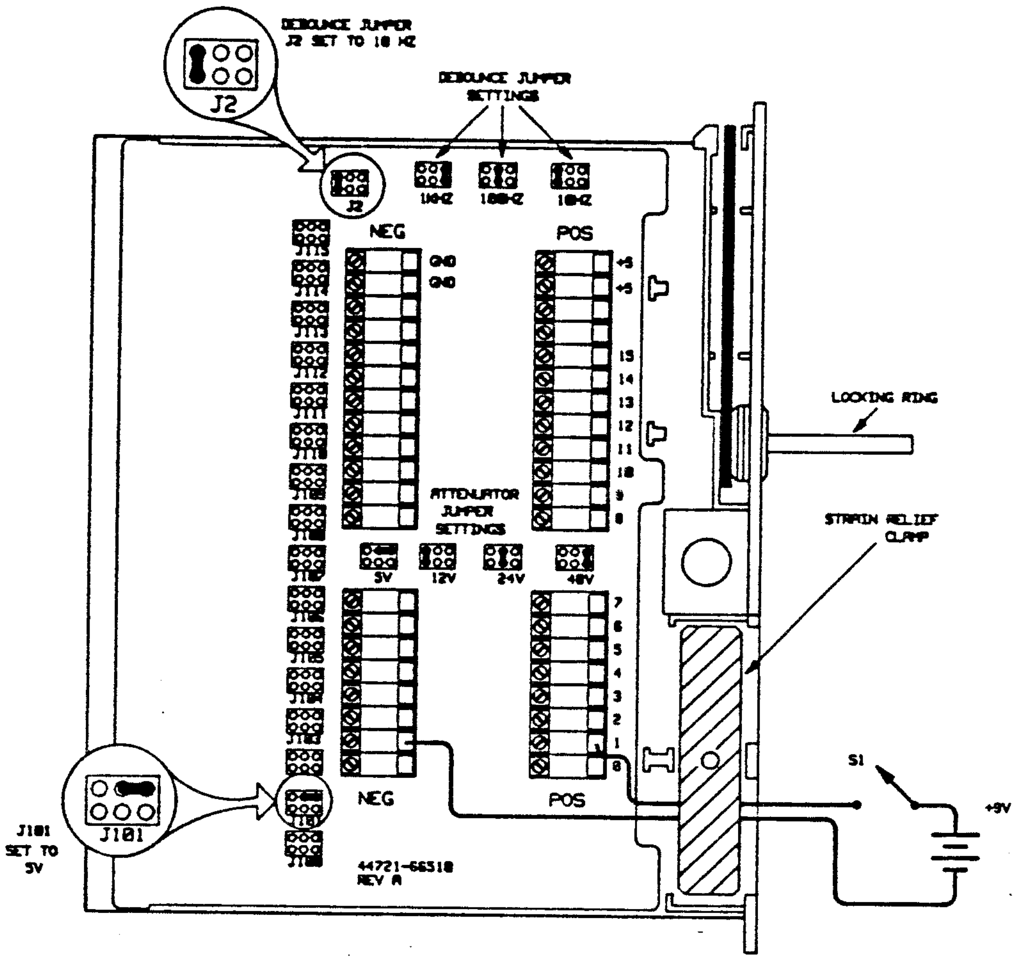


Figure 13-17. Reading Switch State

```
130  !digital input in slot 4 of mainframe.
140  !
150  OUTPUT 709; "CHREAD 417"
160  ENTER 709; State
170  PRINT "S1 = ";State
180  END
```

Depending on the position of switch S1, the program returns one of the following (S1 = 0 for switch open, S1 = 1 for switch closed):

```
S1 = 0
S1 = 1
```

Example: Reading AC ON/OFF Status

You want to determine 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 13-18 for a configuration diagram.

Figure 13-18. Reading AC ON/OFF Status

One way to determine the status of all AC inputs in slot 3 is to send the READ command to the slot. 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. An example program follows.

```
10  !
20  !Read state of all channels of 8-channel digital
30  !input in slot 3 of mainframe.
40  !
50  OUTPUT 709; "READ 300"
60  ENTER  709; State
70  PRINT "Slot 300 Switch Conditions = ";State
80  END
```

For (assumed) channel conditions of switches S0, S1, S4, and S6 closed (AC ON for channels 0, 1, 4 and 6; AC OFF for channels 2, 3, 5, and 7), the READ command returns 83, where 83 = the decimal value of channel bit pattern 0101 0011. A typical readout for these conditions is:

```
Slot 300 Switch Conditions = 83
```

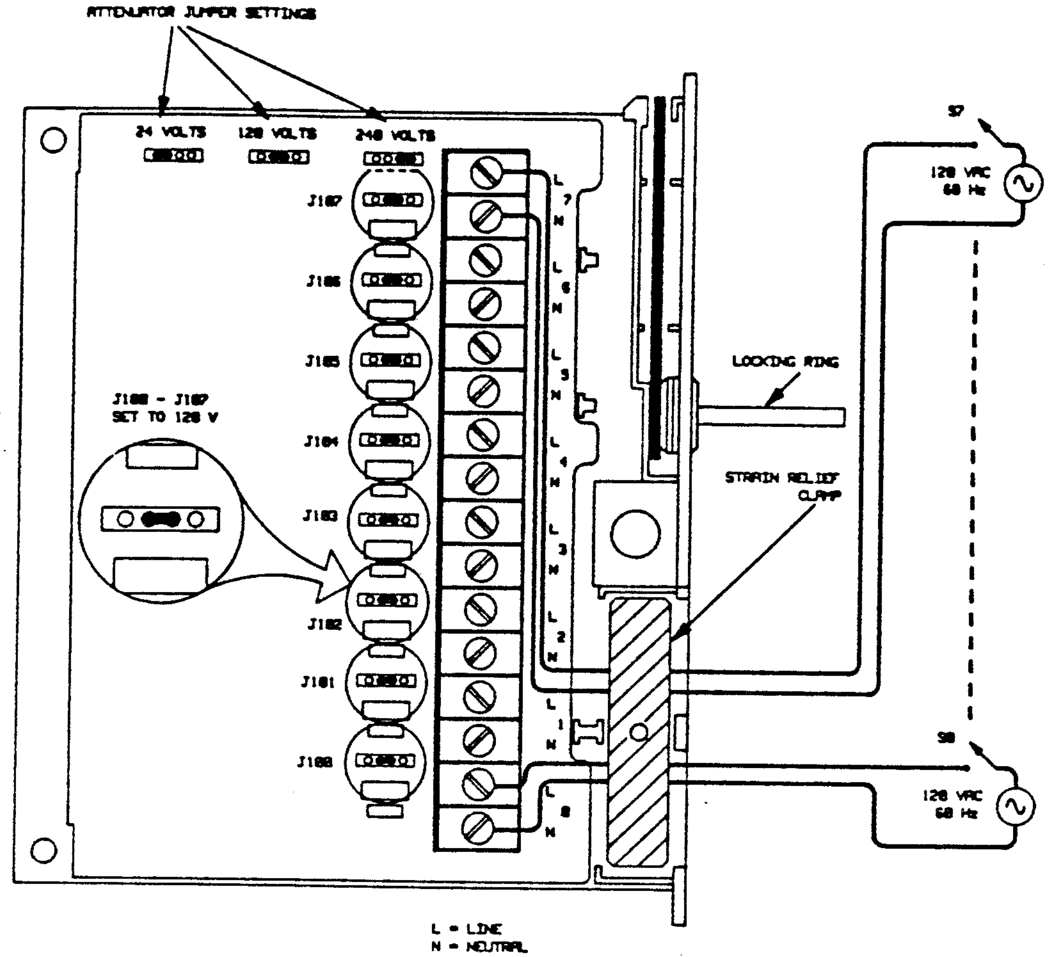


Figure 13-18. Reading AC ON/OFF Status

Counting Input Events

A second programming function for the digital inputs is to count the number of times an "event" occurs. The event can be switch closures or openings, AC ON to AC OFF, or any other action which causes an input state change (positive or negative edge). See Figure 13-19 for a summary of the commands for this function.

Figure 13-19. Counting Input Events

Each channel has a separate up-counter with count range from -2147483648 to +2147483647 counts. For DC inputs, the counter registers one count for each edge detected in the programmed (positive or negative) direction. For AC inputs (8-channel digital input only), the counter registers one count for each transition from AC OFF to AC ON or from AC ON to AC OFF, as programmed.

Although a digital input channel continuously detects all input edges, the channel must be enabled to count the programmed input edges. To enable a channel to count edges, use the EDGE *trans* ,USE *ch* command where *trans* = LH, HL, or OFF defines the edges to be counted and USE *ch* = 0-15 (0-7 for the 8-channel) sets the channel to count the programmed edges.

When USE *ch* = 0-15 (0-7 for 8-channel), EDGE LH sets the channel to count positive edges, EDGE HL sets the channel to count negative edges, and EDGE OFF sets the channel to idle (does not count either edge). You can read the accumulated counts on the channel with CHREAD *ch*, where *ch* = 0-15 (0-7 for 8-channel). You can read and zero the channel count with CHREADZ *slot*, where *slot* = 0-15 (0-7 for 8-channel).

For example, Figure 13-19 shows a digital input channel enabled to count positive edges of a DC input (or AC transitions from AC OFF to AC ON). 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 (or AC OFF to AC ON). For a channel programmed to count negative edges (or AC ON to AC OFF), the counter totalizes negative edges.

NOTE

1. The RST slot (reset) command disables all channels from counting edges.

2. EDGE OFF is the power-on condition for the digital inputs.

3. EDGE is NOT independently selectable for events and counts. For example, setting EDGE LH, USE 300 also sets EDGE LH, USE 316 (16-channel) or sets EDGE LH, USE 308 (8-channel).

4. A channel can't be programmed to simultaneously count positive and negative edges. However, you can connect an input to two channels, set one channel to count positive edges and the other to count negative edges, and sum the channel counts to count both edges. Refer to the example "Counting Switch Openings/Closures".

Example: Counting Switch Openings/Closures

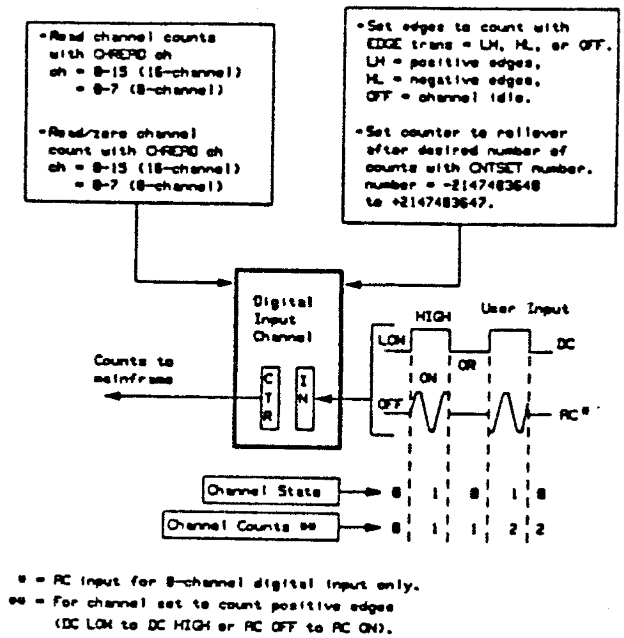


Figure 13-19. Counting Input Events

You want to count the number of times switch S0 opens and closes during a 100 second interval by counting positive edges (S0 closures) and negative edges (S0 openings). One way to do this is to connect the input to two channels, use one channel to count positive edges, use the other channel to count negative edges, and sum the counts.

Figure 13-20 shows a typical configuration diagram with switch S0 connected to channels 0 and 1 of a 16-channel digital input in slot 2 of the mainframe. Switch S0 is assumed to switch at a 5 Hz rate, so the debounce jumper (J2) is set to 10 Hz.

NOTE

For any application involving counting events, be sure to set the debounce jumper to the proper setting to avoid false counts.

Figure 13-20. Counting Switch Openings/Closures

The following program sets channel 0 of a 16-channel digital input in slot 2 to count positive edges, sets channel 1 to count negative edges, waits 100 seconds, and then reads the summed counts. For channel numbers 0-7, this program also applies to an 8-channel digital input.

```
10 !
20 !Set channels 0 and 1 of a 16-channel digital input
30 !in slot 2 of mainframe to count and sum switch
40 !closures and openings.
50 !
60 !Set channel 0 to count positive edges.
70 !
80 OUTPUT 709; "EDGE LH, USE 200"
90 !
100 !Set channel 1 to count negative edges.
110 !
120 OUTPUT 709; "EDGE HL, USE 201"
130 !
140 !Wait 100 seconds for switch openings/
150 !closures.  Then read counts on channels
160 !0 and 1.
170 !
180 WAIT 100
190 OUTPUT 709; "CHREAD 200"
200 ENTER 709; Count0
210 OUTPUT 709; "CHREAD 201"
220 ENTER 709; Count1
230 PRINT "S0 Opens/Closes = ";Count0 + Count1
240 END
```

For an (assumed) total of ten switch openings and closures, the program returns the following readout:

```
S0 Opens/Closes = 10
```

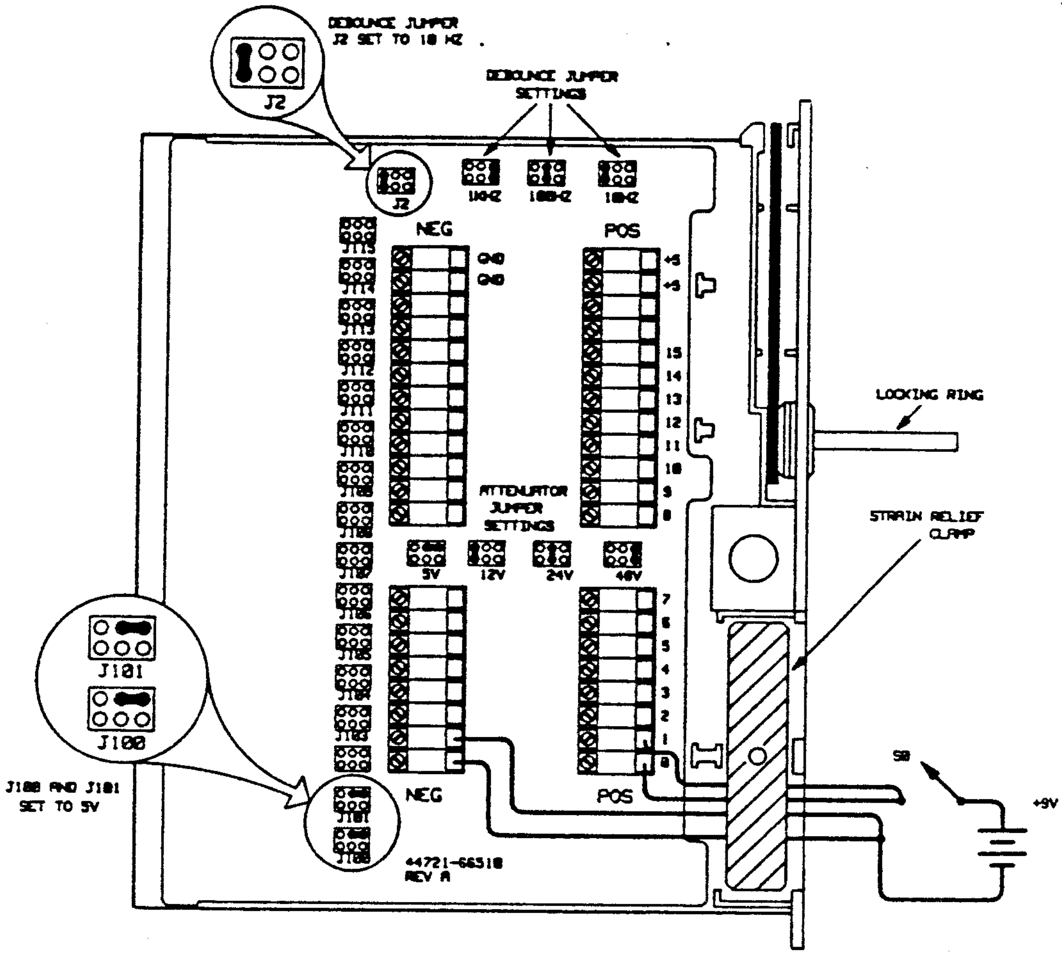


Figure 13-20. Counting Switch Openings/Closures

Example: Reading/Zeroing AC ON Counts

You want to count the number of times an AC input was switched ON during a one-minute interval and then zero the count. One way to do this is to connect the input to channel 4 of an 8-channel digital input in slot 3 of the mainframe. See Figure 13-21 for a configuration diagram.

Figure 13-21. Reading/Zeroing AC ON Counts

This example program sets channel 4 to count positive edges, waits 60 seconds, and then reads and zeroes the count on channel 4. 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.

```
        .
        .

220  !
230  !Set channel 4 of 8-channel digital input in slot
240  !3 of mainframe to count pos edges (AC ON states).
250  !
260  OUTPUT 709; "EDGE LH, USE 304"
270  !
280  !Wait 60 seconds, then read and
290  !zero counts on channel 4.
300  !
310  WAIT 60
320  OUTPUT 709; "CHREADZ 304"
330  ENTER 709; Counts
340  PRINT "Channel 304 AC ON = ";Counts
350  END
```

For (assumed) five switch closures, the program returns the following readout:

```
Channel 304 AC ON = 5
```

Enabling Event Interrupts

A third programming function for the digital inputs is to enable event interrupts. Each channel can be independently enabled to generate an interrupt to the mainframe when a programmed edge is detected. This is called an event interrupt. Enabled channels can be disabled from generating an event interrupt. See Figure 13-22 for a summary of commands for this function.

Figure 13-22. Enabling Event Interrupts

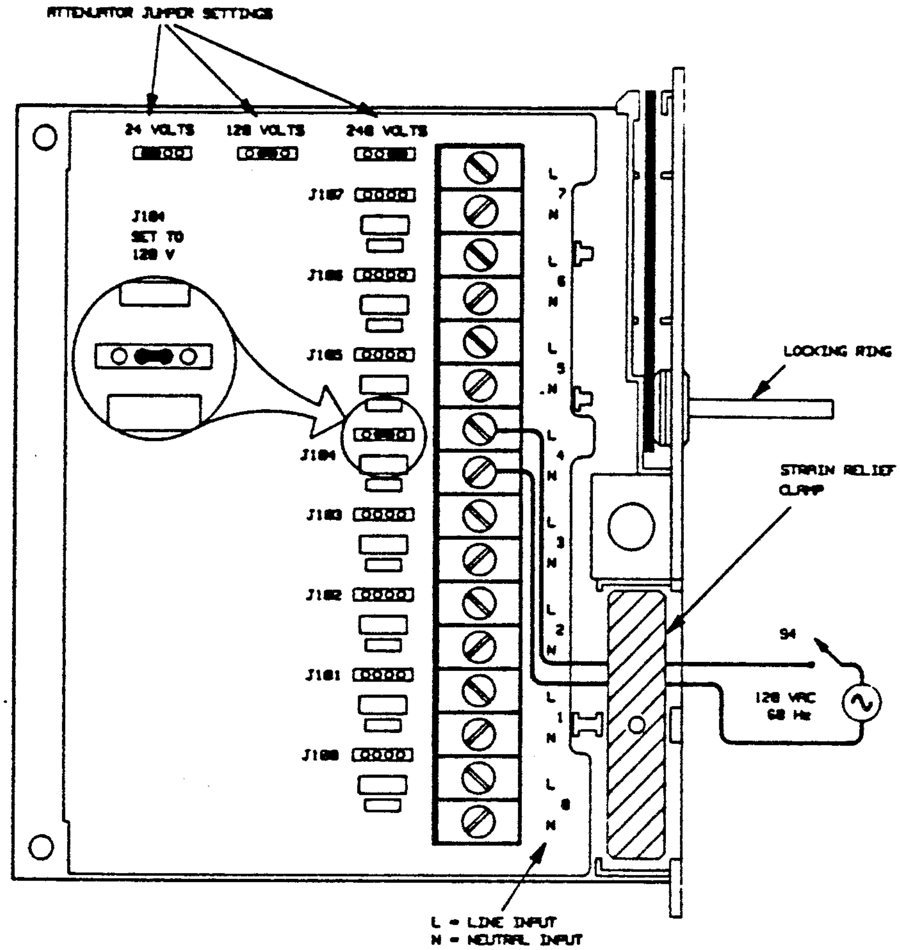


Figure 13-21. Reading/Zeroing AC ON Counts

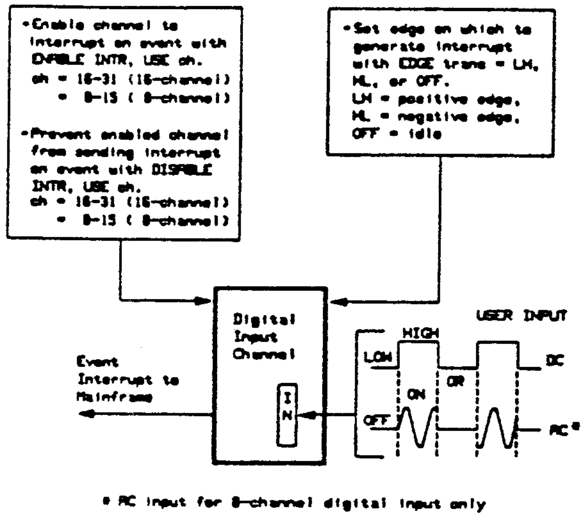


Figure 13-22. Enabling Event Interrupts

NOTE

1. A channel can be enabled for event interrupts, counter interrupts, or both. Refer to "Enabling Counter Interrupts" to program a channel for counter interrupts.

2. The RST slot (reset) command disables all channels from sending event interrupts and/or counter interrupts.

3. 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.

4. 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 disabled when serviced.

5. Interrupts can be processed by the mainframe, or an interrupt signal can be sent to the controller for processing. Refer to the HP 3852A Configuration and Programming Manual for details.

Enabling a Channel for Event Interrupts

Two commands are required to enable a channel for event interrupt: EDGE *trans*, USE *ch* and ENABLE INTR, USE *ch*. EDGE *trans* sets the edge (positive or negative) on which to interrupt. EDGE LH sets positive edges, and EDGE HL sets negative edges. ENABLE INTR, USE *ch*, with *ch* = 16-31 (8-15 for the 8-channel digital input) enables the channel to interrupt when a programmed edge is detected.

For example, to enable channel 3 of a 16-channel digital input in slot 2 of the mainframe to interrupt on positive edges, EDGE LH sets the channel to detect positive edges. ENABLE INTR, USE 219 enables channel 3 to generate an (event) interrupt on the first positive edge. (To enable channel 3 of an 8-channel digital input in this slot, use ENABLE INTR, USE 211).

Disabling Event Interrupts on a Channel

A channel which has been enabled for event interrupts can be disabled from sending the interrupt with DISABLE INTR, USE *ch*, where *ch* = 16-31 (8-15 for the 8-channel digital input). Since a channel can be enabled for event and counter interrupts, this does NOT disable any counter interrupts on the channel.

Servicing Event Interrupts From a Channel

Whether or not the DISABLE INTR, USE *ch* command is used, an event interrupt which is detected and serviced by the mainframe is automatically cleared and disabled. This means that any events (programmed edges) after the first event will not generate another interrupt unless the channel is re-enabled with another ENABLE INTR, USE *ch* command.

For example, if the channel in Figure 13-23 is programmed to detect positive edges and enabled for event interrupts, event (edge) 1 will generate an event interrupt. When the interrupt from event 1 has been serviced, the interrupt is cleared and disabled.

Therefore, event 2 will not generate an interrupt unless another ENABLE INTR, USE *ch* command is sent before event 2 occurs. Also, event 2 (and all following events) will not generate an interrupt if the mainframe has not serviced the interrupt from event 1.

Figure 13-23. Servicing Event Interrupts

Example: Interrupt on Switch Opening

You want to generate an interrupt to the mainframe if switch S5 opens. One way to do this is to connect the switch to channel 5 of a 16-channel digital input in slot 3 of the mainframe and enable the channel to generate an interrupt whenever a negative edge occurs. Figure 13-24 shows a configuration diagram.

Figure 13-24. Interrupt on Switch Opening

NOTE

1. The following program shows the interrupt signal being processed by the mainframe. However, the controller can also process interrupts. Refer to the example "Interrupt on Burst" for a way to process interrupts with an HP 200 Series or HP 300 Series controller.

2. Since there are many ways to structure subroutines to generate control signals, see the HP 3852A Configuration and Programming Manual for guidelines.

.
.

```
120  !
130  !Enable channel 5 of a 16-channel digital input in
140  !slot 3 of mainframe  to interrupt on negative edge.
150  !
160  OUTPUT 709; "USE 321"
170  OUTPUT 709; "EDGE HL; ENABLE INTR"
180  !
190  !Define subroutine INTR_1 as interrupt subroutine:
200  !
210  OUTPUT 709; "SUB INTR_1"
220  OUTPUT 709; "DISP 'Interrupt on Ch 321'"
230  OUTPUT 709; "SUBEND"
240  !
250  !Enable mainframe to process interrupt:
260  !
270  OUTPUT 709; "ON INTR CALL INTR_1"
280  OUTPUT 709; "ENABLE INTR; ENABLE INTR SYS"
```

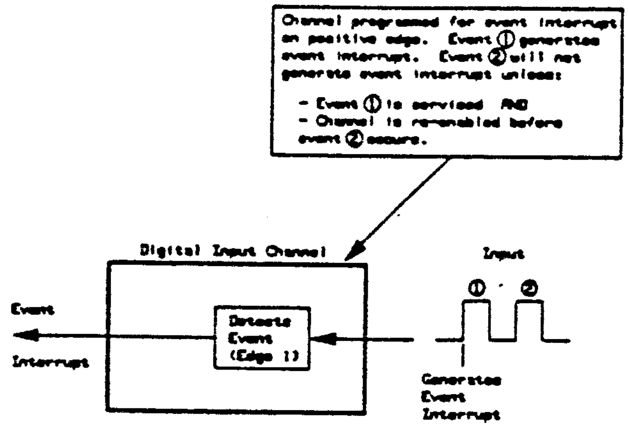


Figure 13-23. Servicing Event Interrupts

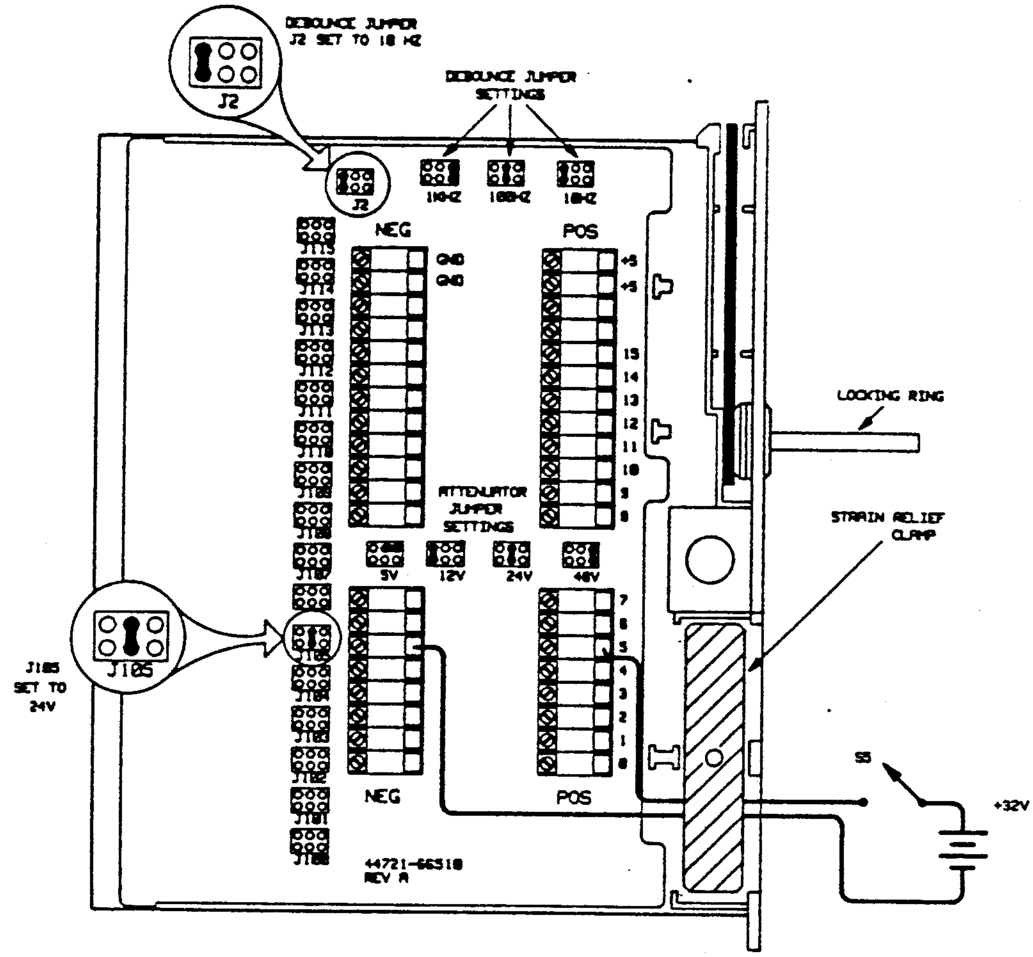


Figure 13-24. Interrupt on Switch Opening

.
.

When an event interrupt occurs on the channel, a typical display on the front panel is:

```
Interrupt on Ch 321
```

Example: Interrupt on Burst

Following an event interrupt, the next event will not generate an interrupt unless the channel is reenabled before the event occurs. This can cause events to be missed by the controller. This example shows a way to count the number of events following an interrupt so that the number of events can be determined.

You want to monitor a digital channel which typically 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 the bursts generally last about 1 to 2 seconds.

To detect the noise bursts, you want to generate an interrupt when the burst begins (first positive pulse) and count the number of pulses in the burst. By doing this, you'll know how many pulses were in the burst even though only the first pulse generated an interrupt.

One way to do this is to connect the input to channel 5 of a 16-channel digital input in slot 1 of the mainframe, enable the channel for event interrupts, and set the channel to count positive edges. See Figure 13-25 for a configuration diagram.

Figure 13-25. Interrupt on Burst

The following program enables channel 5 of a 16-channel digital input in slot 1 of the mainframe for event interrupts and sets the channel to count positive pulses. The readout following the program shows the number of counts in the burst. For an 8-channel digital input, modify line 160 to OUTPUT 709; "ENABLE INTR, USE 113".

NOTE

This program sets an HP 200 Series or HP 300 Series controller to process the interrupt. Interrupts can also be handled by the mainframe. Refer to the example "Interrupt on Switch Opening" for a way to enable the mainframe to handle interrupts.

.
.

```
100 !
110 !Enable channel 5 of a 16-channel digital input
120 !in slot 1 of mainframe for event interrupt.
130 !Set channel to count positive edges.
```

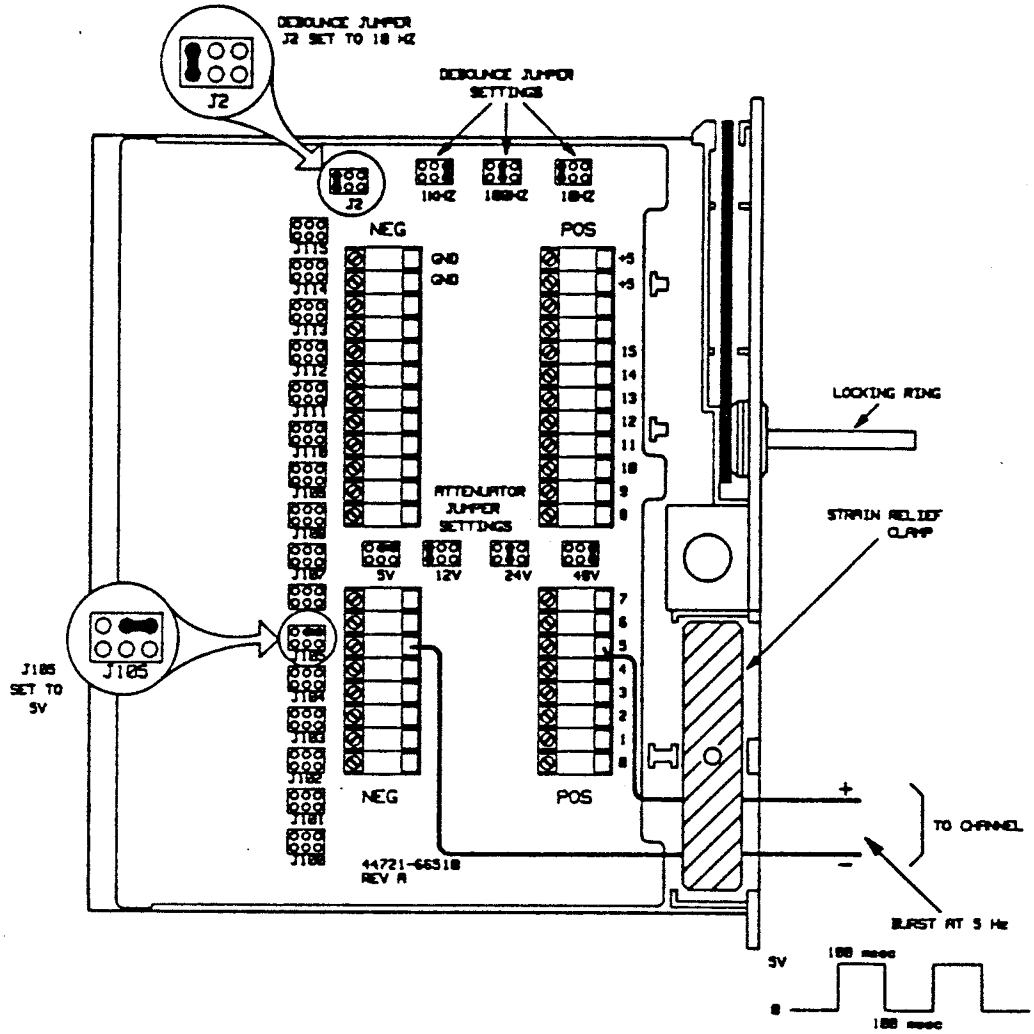


Figure 13-25. Interrupt on Burst

```
140 !
150 OUTPUT 709; "USE 105"
160 OUTPUT 709; "EDGE LH, ENABLE INTR"
170 !
180 !Enable controller to process interrupt:
190 !
200 ON INTR 7 CALL INTR_2
210 ENABLE INTR 7;2
220 !
230 !Enable mainframe to send interrupt to controller:
240 !
250 OUTPUT 709; "RQS INTR; RQS ON"
260 OUTPUT 709; "ENABLE INTR; ENABLE INTR SYS"
                    .
                    .

500 SUB INTR_2
520 OUTPUT 709; "CHREAD 105"
530 ENTER 709; Burst
540 PRINT "Burst Pulses on Channel 105 = ";Burst
550 SUBEND
```

When an interrupt occurs, if the burst contains 100 pulses (positive edges), a typical readout is:

```
Burst Pulses on Channel 105 = 100
```

Enabling Counter Interrupts

A fourth programming function for the digital inputs is to enable counter interrupts. Each channel can be independently enabled to generate an interrupt signal to the mainframe 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. See Figure 13-26 for a summary of commands for this function.

Figure 13-26. Enabling Counter Interrupts

NOTE

1. A channel can be enabled for event interrupts, counter interrupts, or both. Refer to "Enabling Event Interrupts" to program a channel for event interrupts.

2. The RST slot (reset) command disables all channels from sending event interrupts and counter interrupts.

3. 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.

4. If a channel generates an event and a counter interrupt, the counter interrupt is serviced first, then the event interrupt. Each interrupting channel is automatically disabled when serviced.

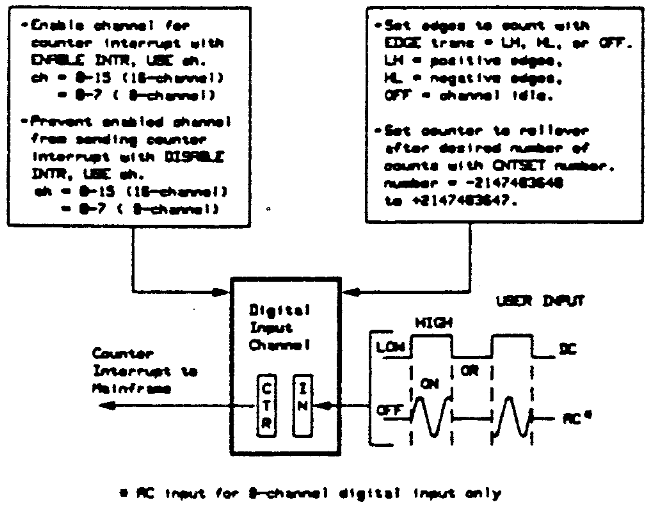


Figure 13-26. Enabling Counter Interrupts

5. Counter interrupts can be processed by the mainframe or can be sent to a controller for processing. Refer to the HP 3852A Configuration and Programming Manual for Details.

Enabling a Channel for Counter Interrupts

Each channel of a digital input can be enabled to send an interrupt signal to the mainframe when the channel counter overflows from -1 to 0. Two commands are required to enable a channel for counter interrupt: EDGE *trans*, USE *ch* and ENABLE INTR, USE *ch*. In addition, CNTSET *number* can be used to preset the counter.

EDGE *trans* sets the channel to count positive or negative edges. EDGE LH sets positive edges, EDGE HL sets negative edges, and EDGE OFF sets the channel to idle (the power-on state). ENABLE INTR, USE *ch*, with *ch* = 0-15 (0-7 for the 8-channel digital input) enables the channel to generate a counter interrupt when the channel counter rolls over.

For example, to enable channel 3 of a 16-channel digital input in slot 2 of the mainframe to interrupt on counter rollover, use EDGE LH, USE 203 to count positive edges and use ENABLE INTR, USE 203 to enable the channel for counter interrupt.

Presetting the Channel Counter

You can use the CNTSET *number* command to preset the counter so that an interrupt can be generated after a specified number of counts. The range of CNTSET *number* is from -2147483648 to + 2147483647, with default value = 0.

Without a preset value, the count sequence is from 0 to 2147483647 counts. With the next count, the counter goes to -2147483648 and counts to -1. With the next count, the counter rolls over to 0 and (if enabled) the channel generates a counter interrupt. Therefore, without preset, the channel requires 4294967296 counts to generate a counter interrupt. At maximum frequency (500 Hz), this requires about 93.3 days.

However, you can preset a channel to interrupt after a desired number of counts with the CNTSET command. To do this, first decide how many counts are required to generate counter rollover. Then, compute *number* from the following equations, where count = desired number of counts to cause counter rollover.

```
number = -counts                   (counts <= 2147483648)
number = 4294967296 - counts       (counts > 2147483648)
```

For example, to cause counter rollover after 1000 counts, since c = 1000 is <= 2147483648, *number* = -counts = -1000. To cause counter rollover after 3,000,000,000 counts, *number* = 4284967296 - 3000000000 = 1294967296.

Disabling Counter Interrupts on a Channel

You can prevent a channel enabled for counter interrupts from generating an interrupt by using the DISABLE INTR, USE *ch* command with *ch* = 0-15 (0-7 for the 8-channel). Since a channel can be enabled for both event and counter interrupts, this does NOT disable any event interrupts on the channel.

Servicing Counter Interrupts From a Channel

Whether or not a DISABLE INTR command has been sent to the channel, when a counter interrupt signal 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 re-enabled with another ENABLE INTR, USE *ch* command.

For example, assume the channel in Figure 13-27 is programmed to count positive edges and enabled for counter interrupts. Also, assume that edge 1 causes the channel counter to roll over to zero and generate a counter interrupt.

When the interrupt has been serviced by the mainframe, the interrupt is cleared and disabled. Therefore, edge 2 will not generate an interrupt unless another ENABLE INTR, USE *ch* 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.

Figure 13-27. Servicing Counter Interrupts

Example: Interrupt After Ten Switch Closures

You want to send an interrupt to the mainframe after switch S2 has closed ten times. One way to do this is to connect a 9V source through S2 to channel 2 of a 16-channel digital input in slot 1 of the mainframe and enable the channel to generate a counter interrupt after S2 has closed ten times. Figure 13-28 shows a configuration diagram.

Figure 13-28. Interrupt After Ten Switch Closures

The following program enables channel 2 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. Since the channel will generate a counter interrupt only when the counter resets from -1 to 0, line 300 presets the channel counter so that it will reset after ten counts (ten switch closures).

As shown in the program, there are three steps to generate a control signal to user circuitry. The first step is to enable the channel to generate an interrupt signal to the mainframe. The second step is to enable the mainframe to send an interrupt to the controller. The third step is to program the controller (through a subroutine or other means) to perform some action to output a control signal to the user system.

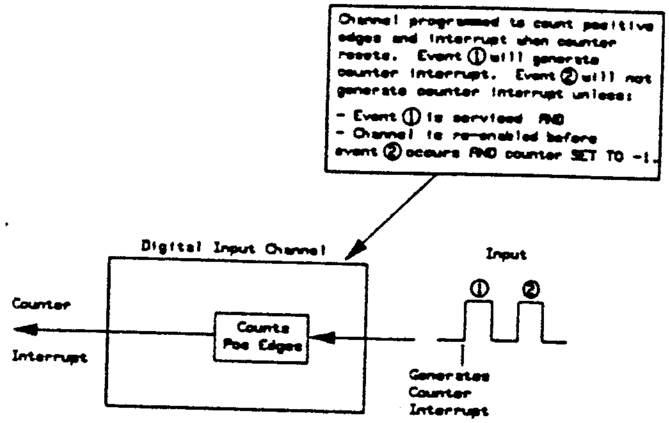


Figure 13-27. Servicing Counter Interrupts

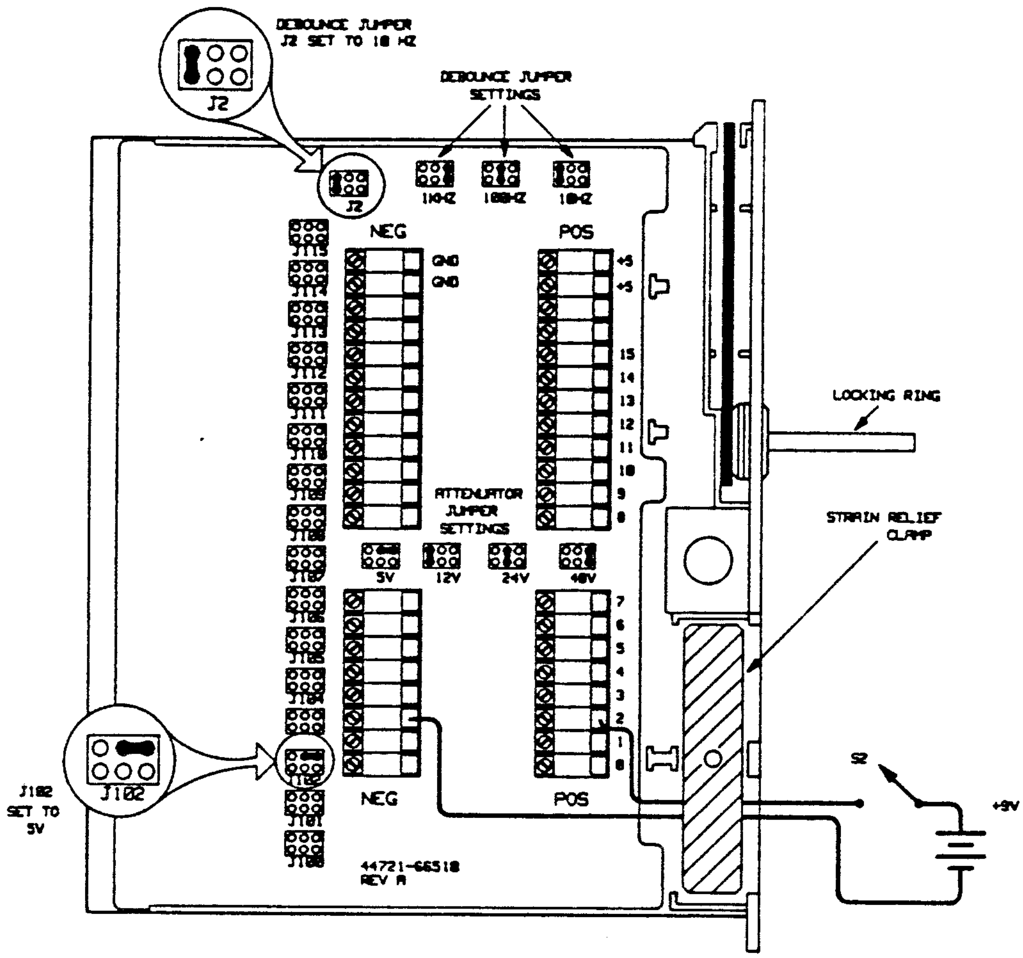


Figure 13-28. Interrupt After Ten Switch Closures

NOTE

1. The following program sets the controller to process the interrupt signal. The mainframe can also process interrupts. Refer to the example "Interrupt on Switch Opening" in the "Enabling Event Interrupts" section for a way to set HP 200 Series or HP 300 Series controllers to handle interrupts.

2. Since there are many ways to structure subroutines, see the HP 3852A Configuration and Programming Manual for guidelines.

```
220  !
230  !Set channel 2 of 16-channel digital input in slot
240  !1 of mainframe to send interrupt to mainframe
250  !after ten switch closures (ten counts).
250  !
260  OUTPUT 709; "USE 102"
270  OUTPUT 709; "EDGE LH; CNTSET -10; ENABLE INTR"
280  !
290  !Enable controller to process interrupt:
300  !
310  ON INTR CALL INTR_3
320  ENABLE INTR 7;2
330  !
340  !Enable mainframe to send interrupt to controller.
350  !
360  OUTPUT 709; "RQS INTR; RQS ON"
370  OUTPUT 709; "ENABLE INTR; ENABLE INTR SYS"
                    .
                    .
500  SUB INTR_3
510  DISP "10 closures on channel 102"
520  SUBEND
```

After 10 switch closures on channel 102, a typical display is:

```
10 closures on channel 102
```

Chapter 14
HP 44724A
16-Channel Digital Output

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HP 44724A

Introduction

This chapter 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 chapter has four sections: Introduction, Specifications, Configuring the Digital Output, and Programming the Digital Output.

- **Introduction** contains a chapter overview, describes the digital output, and shows a suggested getting started sequence.
- **Specifications** lists specifications for the digital output.
- **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 programatically 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.

Defining 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 <= 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 Table 14-1, "Digital Output Specifications" for voltage and current limitations.

Configuring 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 "Configuring the Digital Output" for example field wiring diagrams and procedure to check the digital output ID.

Programming the Digital Output:

The third step is to program the digital output channels to control the devices connected. Refer to "Programming the Digital Output" to program the accessory for two primary programming functions: reading channel states and writing to channels.

Specifications

Table 14-1 lists specifications for the digital output.

Table 14-1. Digital Output Specifications

OFF State Voltage Range:	0 to 55 VDC
OFF State Leakage Current:	0.25 mA @ 55 VDC
Maximum Sink Current:	500 mA DC per channel
Inductive Load Protection:	On component module
Max Current, Reverse Polarity:	500 mA DC per channel
TTL Compatability:	200 mA for Vout <0.4 VDC
ON State Resistance:	<1.5 ohm
Fuse Protection:	1A on terminal module
Max Switching Rate: *	1 kHz
Isolation Between Channels:	250 V rms (354 V peak)
Channel-to-Chassis Isolation:	250 V rms (354 V peak)

* = maximum rate channel can switch from OFF to ON state and back to OFF state or vice-versa. Actual rate determined by firmware times.

Configuring the Digital Output

This section 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 "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 14-1 shows the terminal module with the cover removed.

⚠ 1

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 and extenders, to all installed accessories, and to all external devices connected to the mainframe, extenders or accessories.

⚠ 2

WARNING

For safety, consider all accessory channels to be at the highest voltage applied to any channel.

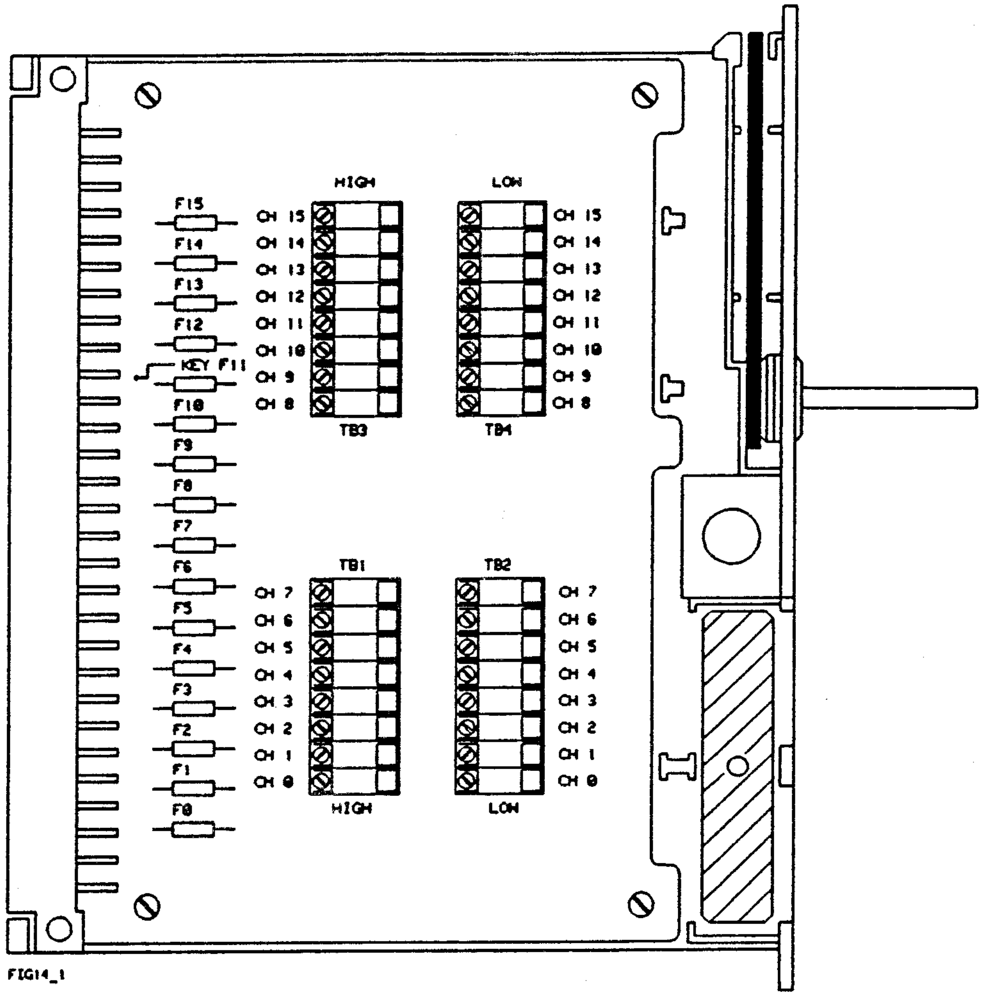

Figure 14-1. Digital Output Terminal Module

As shown in Figure 14-1, 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 14-2 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).

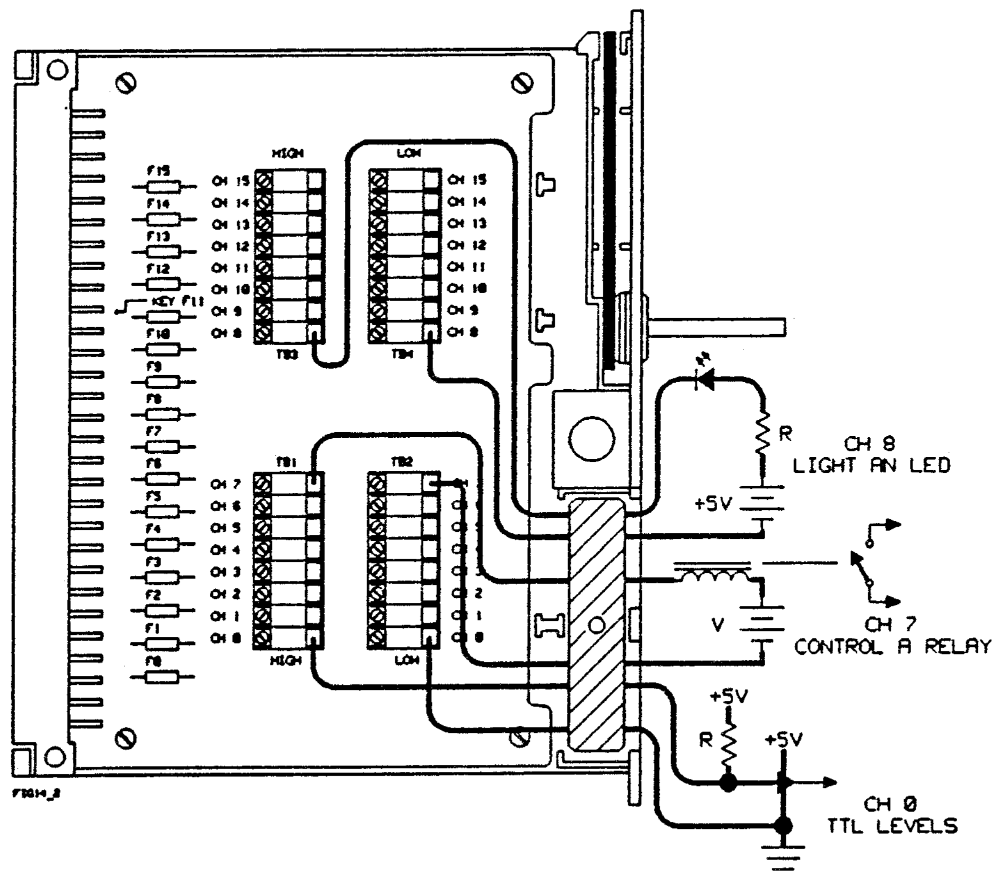

Figure 14-2. Typical Field Wiring Connections

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 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 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"
20 ENTER 709; A
30 DISP A
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 "Programming the Digital Output" to program the digital output for your application.

Programming the Digital Output

The digital output has two primary programming functions: reading channel states and writing to channels. This section shows how to program the accessory for these functions. It includes a description of each function, applicable commands for the function, and programming examples. Each example includes a connection diagram, sample program, and (where applicable) typical readouts for assumed conditions.

The section also lists the titles of the example programs (refer to "Example Program Titles"), includes a discussion of digital output channel bit patterns vs. decimal values (refer to "Decimal Values vs. Bit Patterns"), and summarizes commands for the digital output (refer to "Command Summary").

NOTE

The example programs use HP-IB address 709 and specific slot and channel numbers. Program syntax and data returns apply to HP 200 Series and HP 300 Series 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 digital output for the function. Table 14-2 lists the titles of the example programs.

Table 14-2. Example Program Titles

Example	Description	Commands
Reading Channel States		
Reading LED Status	Reads state of channels to determine LED on/off status.	READ, CLOSE?
Writing to Channels		
Opening/ Closing Relays	Writes data to channels to open or close relays connected to the channels.	OPEN, CLOSE
Controlling TTL Logic	Writes 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.

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 14-3 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 14-3 to provide output range 0 to 65535. The range of values shown in Table 14-3 is -32768 to +32767.

Table 14-3. 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 open (OFF), 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    16384+8192+4096+2048
   of 2's Complement:    +1024+512+256+128+64
   (Table 14-3)          +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

An alphabetical summary of commands which apply to the digital output follows. Refer to the HP 3852A Command Reference Manual for a complete description of these commands.

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.

The READ *slot* command reads the programmed state of all channels in the specified slot. The CLOSE? *ch list* command reads the state of all channels specified by *ch list*. Two examples follow to show how to use the READ and CLOSE? commands.

NOTE

The READ and CLOSE? 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 device connected to the channel.

Example: Reading LED Status

You want 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 14-3 for a configuration diagram.

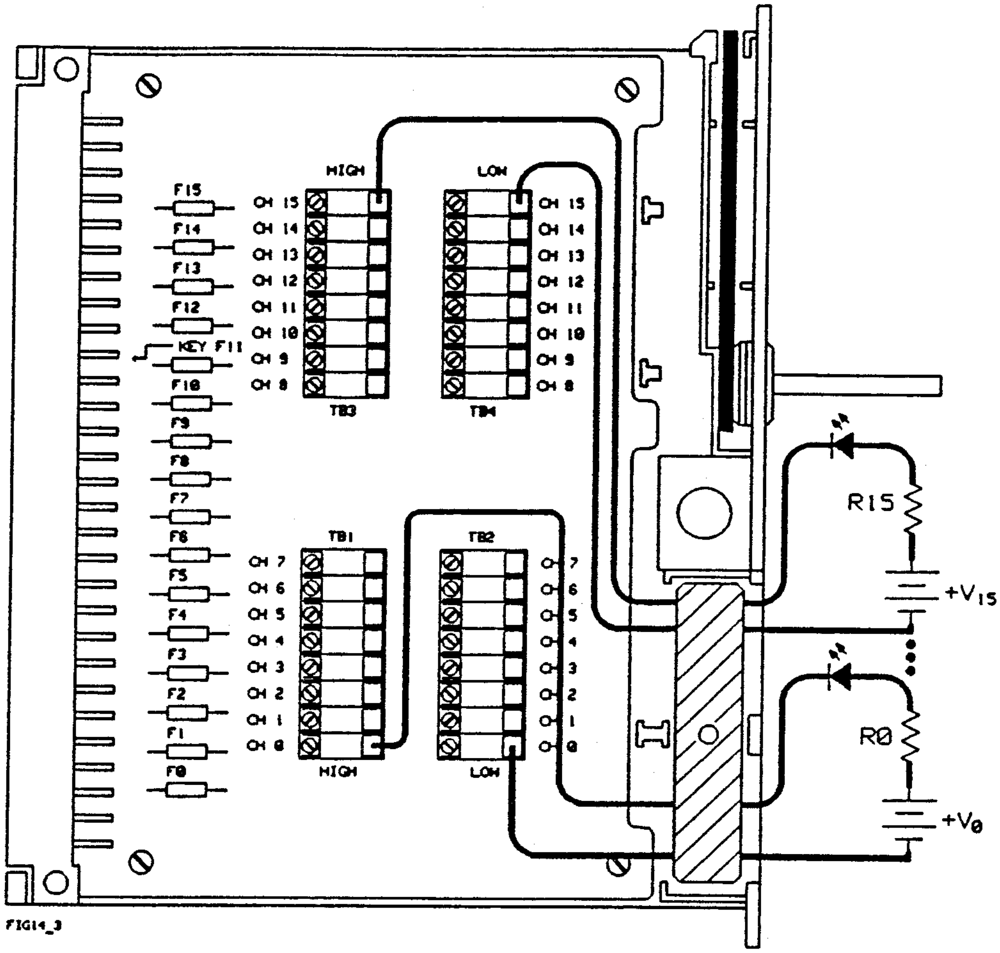

Figure 14-3. Example: Reading LED Status

Two program segments follow to show how to use the READ and CLOSE? commands. to determine LED on/off status. The first segment uses the READ command and the second segment uses the CLOSE? command.

Reading LED Status Using READ Command

This program uses the READ command to read state of all channels of digital output in slot 1 of mainframe.

```
                .
                .
60  OUTPUT 709; "READ 100"           !Read state of slot 1
70  ENTER 709; State1
80  PRINT "LED on/off Status = ";State1
90  END
```

If, for example, channels 0, 5, and 9 are closed (ON), READ returns 545, where 545 is the decimal value of channel bit pattern 0000 0010 0010 0001. A typical readout for this bit pattern is:

```
LED on/off Status =  545
```

Reading LED Status Using CLOSE? Command

This program uses the CLOSE? command to read programmed states of all channels of digital output in slot 2 of mainframe.

```
        .
        .

200  INTEGER State2 (0:15)
210  OUTPUT 709; "CLOSE? 200-215"
220  ENTER 709; State2 (*)
230  PRINT "LED States = ";State2 (*)
240  END
```

For example, with channels 2, 5, and 13 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

You want to 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. Figure 14-4 shows typical connections to a digital output in slot 4 of the mainframe. A program segment using the OPEN and CLOSE commands follows.

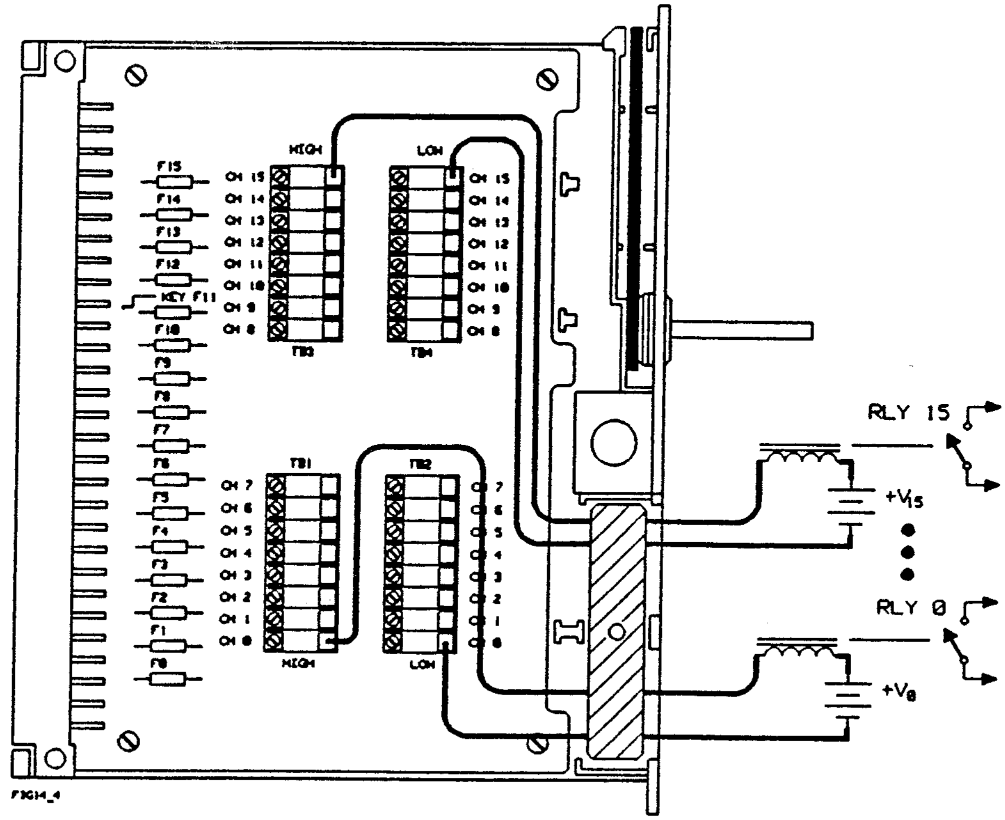

Figure 14-4. Opening/Closing Relays

This program uses the CLOSE command to close relays in channels 0 and 3 through 6 and uses the OPEN command to open relays in remaining channels of a digital output in slot 4 of mainframe.

```
        .
        .
170 OUTPUT 709; "CLOSE 400, 403-406"
180 OUTPUT 709; "OPEN 401, 402, 407-415"
        .
        .
```

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* 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 14-3 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* 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

You want to use 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. Figure 14-5 shows a typical connection diagram.

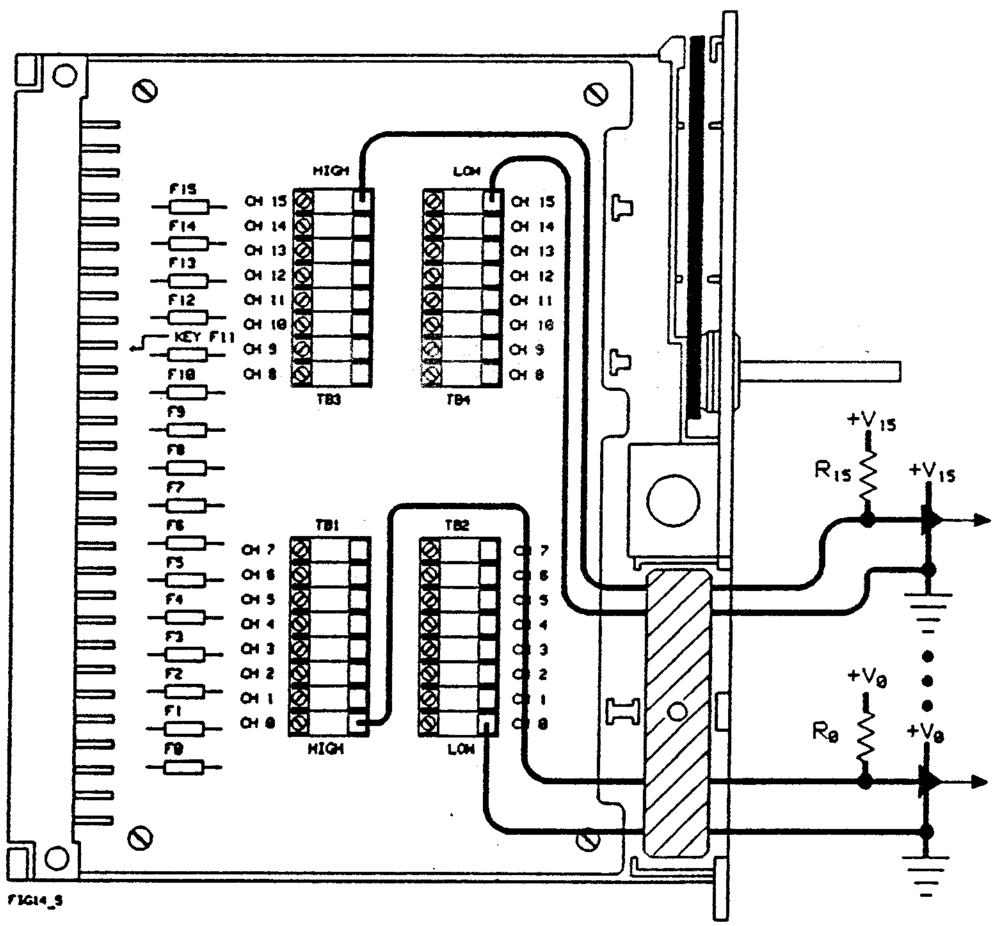

Figure 14-5. Controlling TTL Logic

Two example program segments follow. The first program segment uses the WRITE command to set all channels of a digital output. The second program segment uses the CHWRITE command to set the state of channels 5 and 13 only.

Using WRITE Command to Set All Channels

This program uses WRITE to set TTL high for channels 0, 3, and 5 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"
              .
              .
```

Using CHWRITE to Set Channels 5 and 13 Only

This program uses the CHWRITE command to set TTL low in channel 5 and set TTL high in channel 13 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 5.
100  OUTPUT 709; "CHWRITE 413,1"  !Set TTL high in channel 13.
               .
               .
```

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Chapter 15
HP 44725A 16-Channel General Purpose Switch

Chapter 15

16-Channel General Purpose Switch

HP 44725A

Introduction

This chapter provides configuration, installation, and programming information for the HP 44725A 16-Channel General Purpose Switch accessory. For additional information on the overall data acquisition and control unit and related programming commands, refer to the HP 3852A Data Acquisition/Control Unit, Installation and Programming Manual, Part Number 03852-90001.

The HP 44725A 16-Channel General Purpose Switch (GP switch) Accessory provides 16 channels of moderate voltage level switching (up to 30 VDC or 42V peak AC). 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 actually reprogrammed.

At power-down all switches return to the Normal Closed (NC) position.

The following describes the getting started sequence for the GP switch accessory:

- **Determine Your Application.** Determine the required configuration, current required for each output channel, and total current requirement. Refer to the "Specifications" section, below, for specific current limitations per channel and for the overall accessory.
- **Configure the terminal Card.** Connect your application external wiring to the terminal module in the required configuration.
- **Install and Checkout.** Install the accessory in either the mainframe or an extender and ensure that it is operating properly.
- **Program the Accessory.** Program the accessory registers to meet your application requirements.

Specifications

Specifications for the HP 44725A 16-Channel General Purpose Switch are provided in Table 15-1.

Table 15-1. Accessory Specifications

16 channels of Form C (break-before-make) switching relays

Switching Characteristics:
Vmax: 30V DC or 42V Peak AC
Imax: 1.5A DC and RMS AC per channel, or total accessory current is < 24 amps^2, where total accessory current = the sum of I^2 for each channel.*

Minimum load: 100 uA 100 uV DC **

Output Status Readback: Latches can be read back

Response Time: < 15 ms

Switching Rate: Limited to 3 per second to protect contacts

Switch Life: 10^6 Contact Closures at Full Load;
10^8 Contact Closures at Minimum Load

Thermal Offset: 5 uV

Total Resistance: 175 mohms

Isolation:
DC: 10^9 ohms across switch, channel-to-channel, channel-to-earth
AC: 10 pf open contacts, 5 pf channel-to-channel, 30 pf channel-to-earth

Operating Environment: (HP Class B)
Temperature: 0°C to +55°C
Humidity: 40°C @ 5% to 95% RH
Altitude: 4600 meters (15,000 ft.)

*< Total current load for the accessory must be < 24 Amps^2 (e.g., channel 0 through 7 @ 1.5 Amps each = 2.25 Amps^2 each, for an accessory total I^2 of 18 Amps^2).

** Required for contact cleaning

Configuring the General Purpose Switch

WARNING

Possible voltage hazard to personnel! Only qulaified service-trained personnel who are aware of the hazards should configure the GP switch accessory.

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.

Configure the GP switch by connecting your application field wiring to the terminal module. There are no jumpers or configuration switches on either the GP switch module or the terminal module that require setting.

Field Wiring

WARNING

Possible voltage hazard to personnel! Disconnect all field wiring leads from source voltage before configuring the terminal module.

To configure the GP switch connect all user application wiring to the normally open (NO), common(C), and normally closed (NC) terminal blocks (Figure 15-1). as required.

Figure 15-2 provides simplified examples of field configuration for load switching. Block diagram examples for configuring voltage switching and matrix switching are also provided in Figure 15-3.

Position all field wiring leads under the module strain relief clamp, leaving a small amount of slack on the terminal side of the clamp. Tighten the clamp, ensuring that all interconnecting wires are held firmly in place (see Figure 15-1).

RFI Filter Requirements

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).

Relay Contact Protection

Maximum relay switching life (see Table 15-1) can be expected without external contact protection circuitry unless switching inductive loads.

CAUTION

When switching inductive loads, provide external contact protection circuitry to limit the peak induction kick at switching to the maximum peak voltage specifications shown in Table 15-1.

NOTE

Once gold (Au) plated silver-cadmium oxide (AgCdO) relay contacts have been used to switch moderate power (<10A) 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.

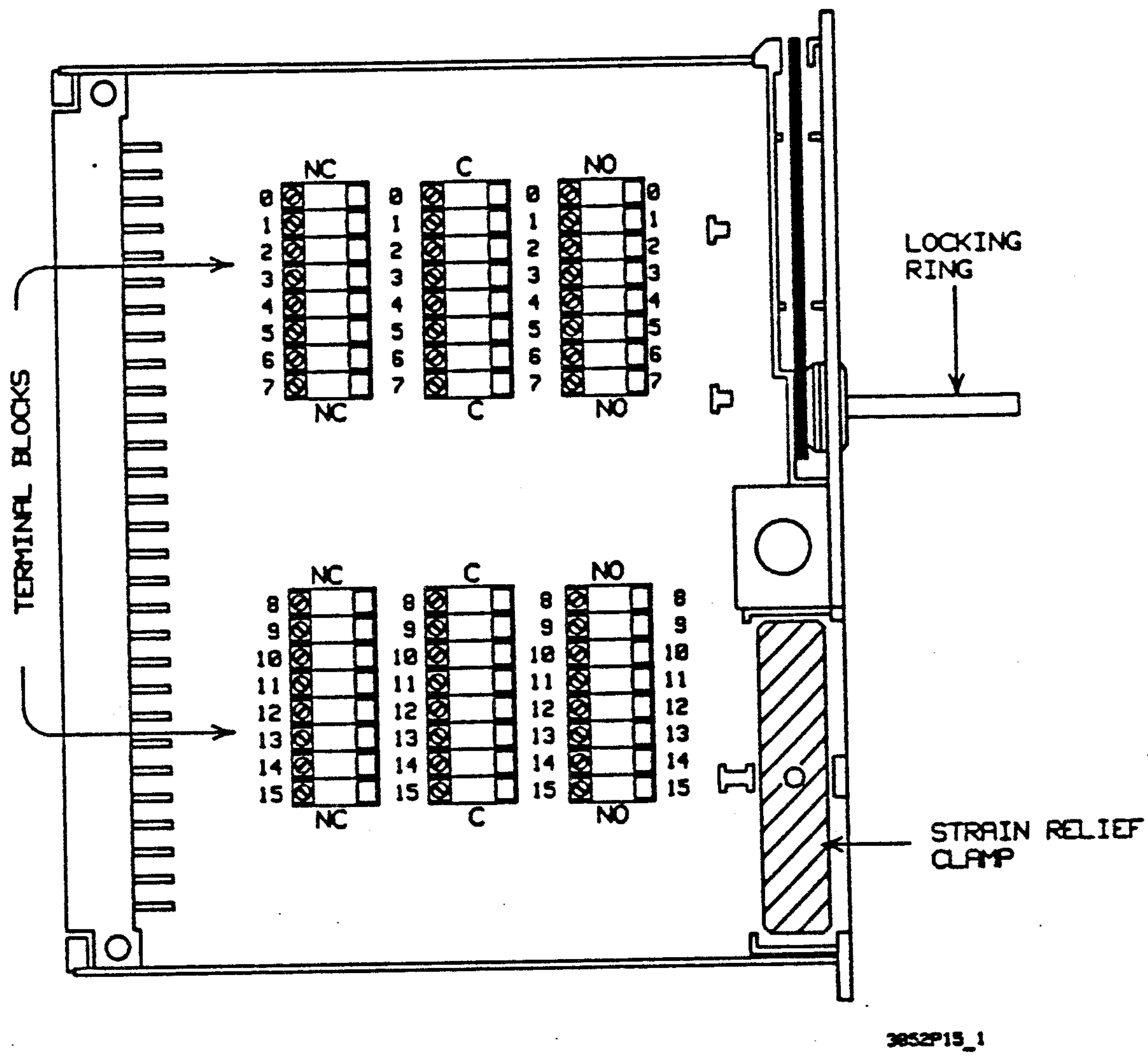


Figure 15-1. Terminal Block Wiring Layout

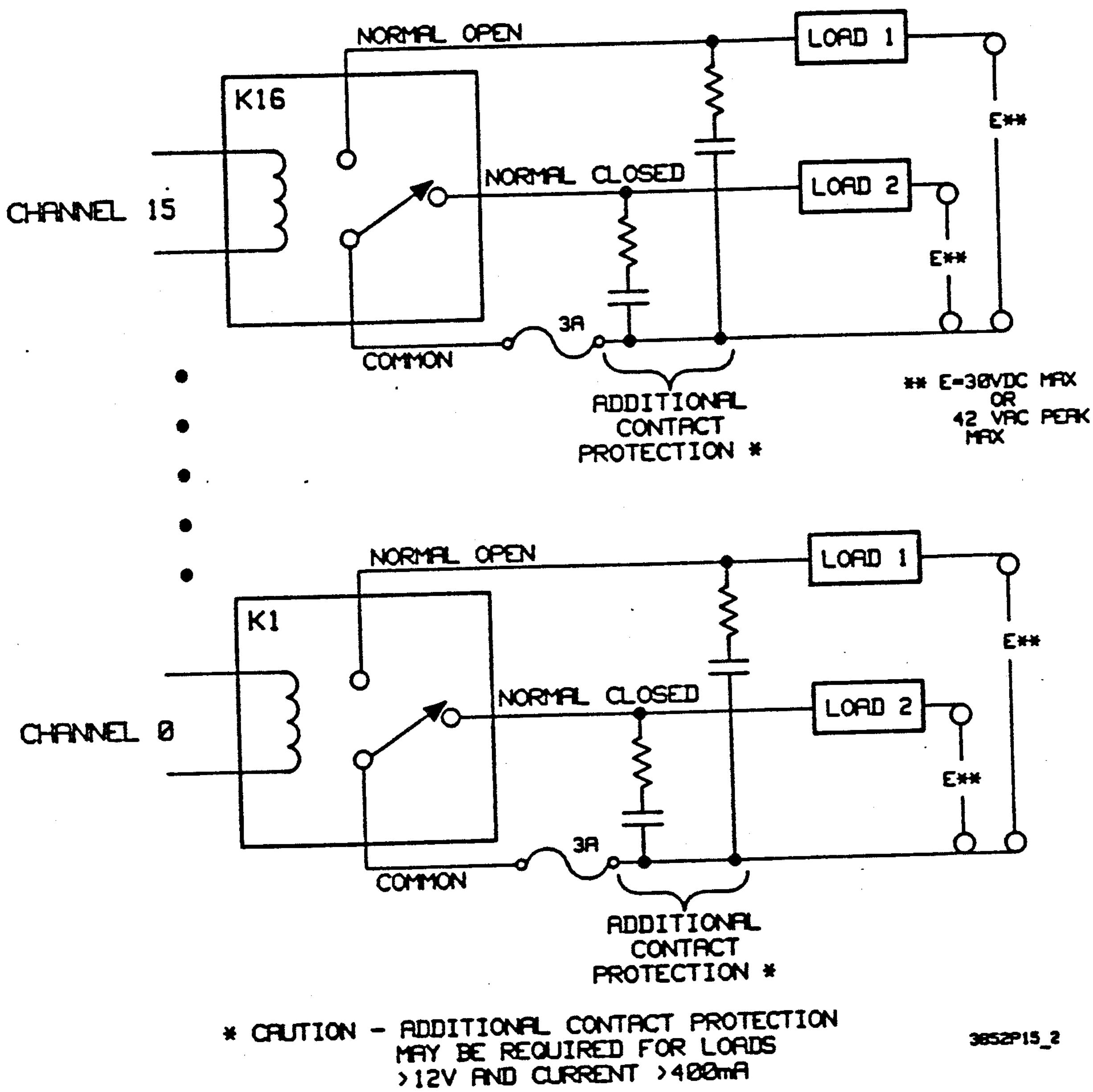


Figure 15-2. Load Switching Block Diagram

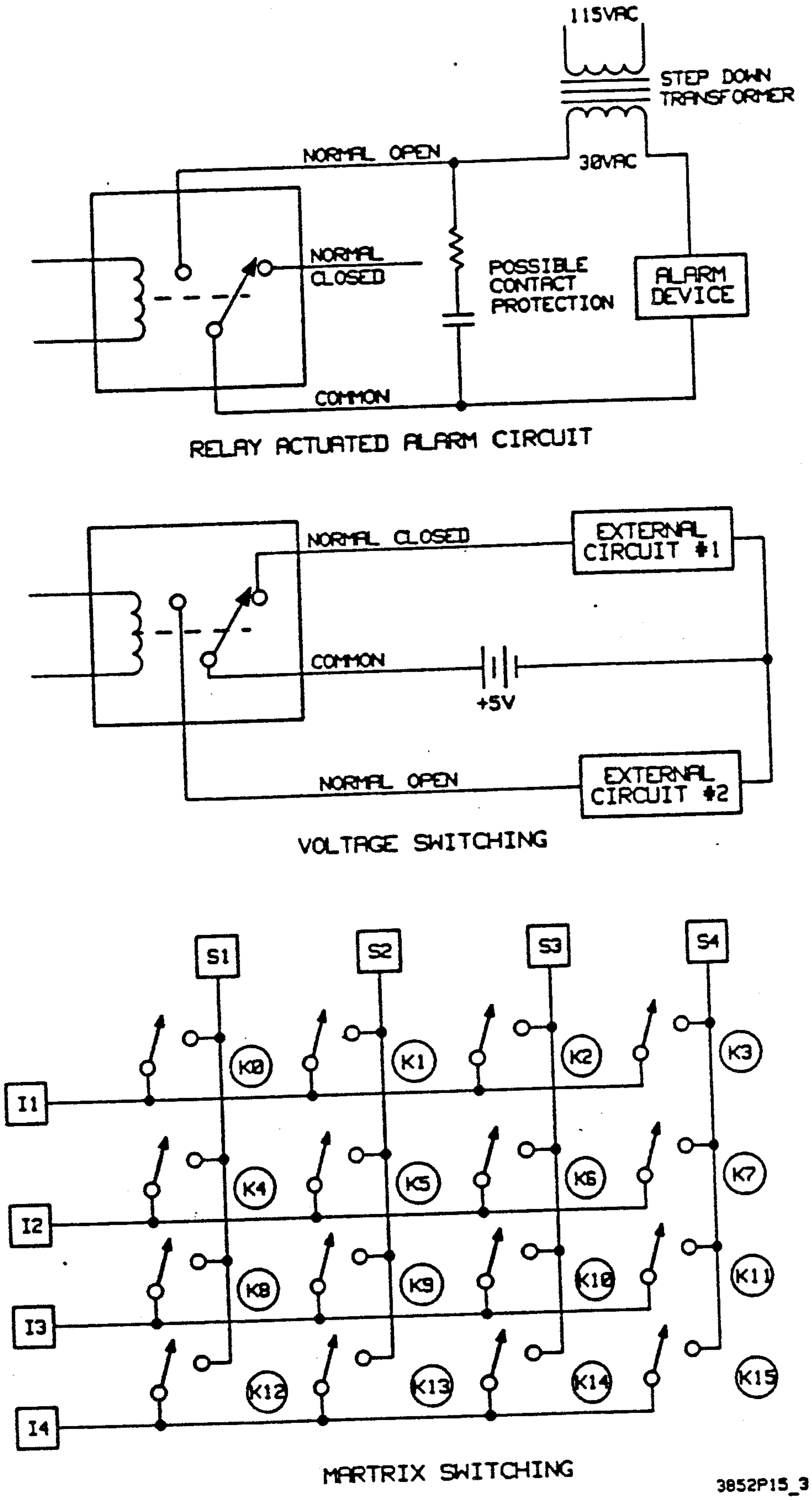


Figure 15-3. Additional Switching Examples

Safety Requirements

WARNING

⚠ 2

Danger to personnel or equipment may exist if the GP switch fails during control of a critical process or function. Always use redundant switching when configuring your application to prevent danger to personnel or damage to equipment.

See Figure 15-4 for a simplified block diagram showing redundant switching control. The Redundancy Failure Indicator (Figure 15-4) will illuminate if the redundant control (Overtemp Control) relay NO contacts become fused together and the Overtemp Control relay deenergizes.

Installation and Checkout

WARNING

⚠ 1

Possible voltage hazard to personnel! Only qualified, service-trained personnel who are aware of the hazards should install the accessory.

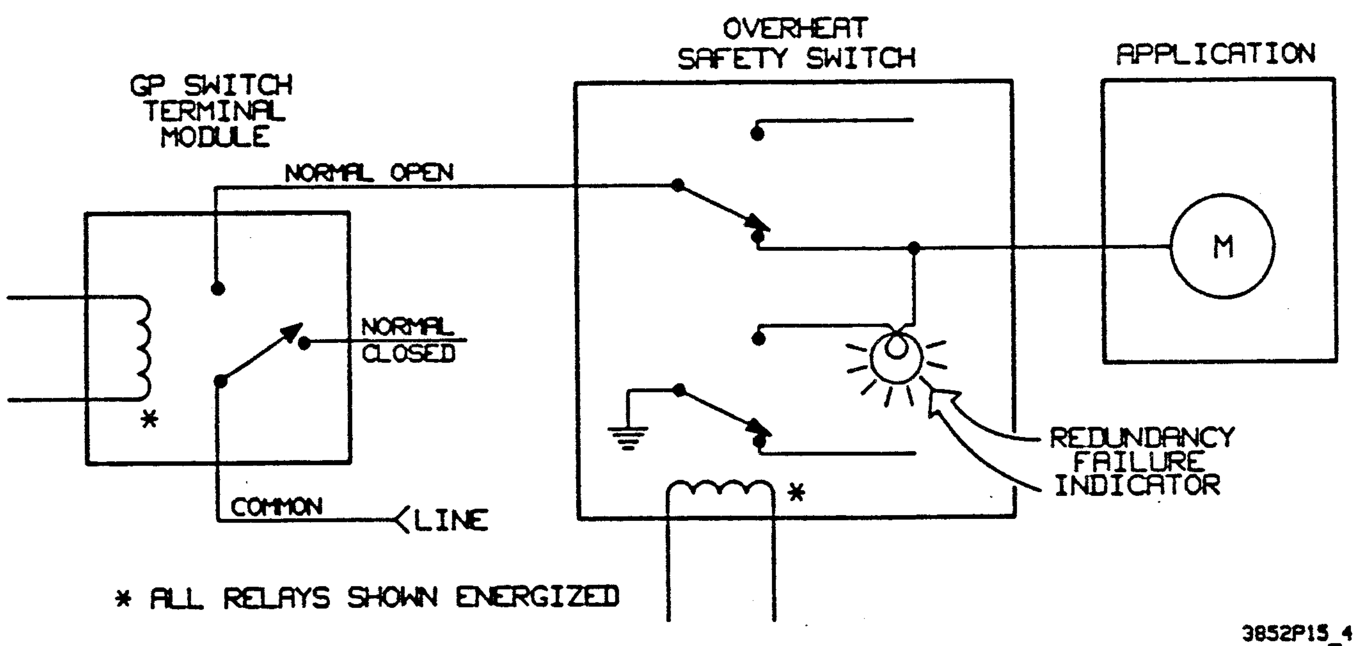


Figure 15-4. Redundant Switching Control, Simplified Block Diagram

CAUTION

Damage to accessory components can result from static discharge or excessive voltage. Use static-free handling methods when installing, removing, or reconfiguring the accessory.

Ensure that the terminal module is properly connected to the GP switch module and install the accessory in the desired slot.

NOTE

Refer to Chapter 1 of this manual for installation and removal procedures.

To check proper installation of the GP switch accessory, enter the following programming sequence (the GP switch is installed in slot 4 of the mainframe for this example):

```
100  OUTPUT 709;"ID? 0400"
110  ENTER 709; Ident$
120  PRINT "Accessory in Slot 4 =  ";Ident$
130  END
```

If the GP switch is properly installed in slot 4 of the mainframe, the message "`Accessory in Slot 4 = 44725A`" will be returned to the CRT and front panel display. If the terminal module is not connected to the GP switch module, the message "`Accessory in Slot 4 = 447XXX`" will be returned.

Addressing an empty accessory slot will return " `000000`" to the CRT and the front panel display.

- If the accessory returns an incorrect product identification number, first ensure that the correct terminal module is connected to the GP switch module. If the accessory still returns an incorrect product number, refer to the HP 3852A installation and programming manual for procedures to return the GP switch accessory to Hewlett-Packard.

- If the accessory returns the correct ID, refer to Programming The General Purpose Switch, below.

Programming The General Purpose Switch

This section describes the programming commands used by the relay actuator, and provides general programming examples for the accessory.

For additional information on the following GP switch commands, and other commands that apply to the complete system, refer to the HP 3852A Data Aquisition/Control System Command Reference Manual.

Programming Commands

Table 15-2 provides a summarized list of the programming commands used with the GP switch accessory. Refer to the command reference manual for complete parameter information and prerequisites for command use.

Table 15-2. Command Summary List

CHWRITE ***ch,data***

Write data to channel specified by ***ch. Data*** programs channel to open or closed state.

CLOSE ***ch list***

Programs channels specified by ***ch list*** to closed state.

CLOSE? ***ch list***

Queries the programmed state of all channels specified by ***ch list.***

ID? ***slot***

Reads identity of accessory installed in slot specified by ***slot***

OPEN ***ch list***

Programs all channels s specified by ***ch list*** to OFF state.

READ ***slot***

Read the programmed state of all channels specified in ***slot.***

RST ***slot***

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

WRITE ***slot,number***

Writes programming data to the accessory specified in ***slot. Number*** is decimal equivalent of binary bit value required to program channels to open (0) or closed (1).

Programming Examples

Table 15-3 provides a list of program examples, showing the program name, function of each program, and the related GP switch commands used.

NOTE

Channel switch positions are as follows:

NC = WRITE 0 = CHANNEL OPEN = OFF
NO = WRITE 1 = CHANNEL CLOSED = ON

Table 15-3. Example Program Summary

Program Name	Function	Related Commands
Initial Programming	Verify slot location of accessory, reset accessory to power-on state, program channels to desired state, verify actual programmed state of all channels.	ID?, RST, WRITE, READ
Close Channels	Close desired channels as selected, and return the programmed status of each channel listed (to verify the CLOSE command).	CLOSE, CLOSE?
Open Channels	Open selected channels by two different methods.	OPEN, CHWRITE

Using the READ/ WRITE Commands

When using the READ and WRITE commands from the controller CRT or mainframe front panel, you must remember that HP 200 Series and HP 3852A mainframe controllers transmit and receive data only in decimal format and that all card cage accessories communicate only in a binary data format. This requires that the WRITE command *number* parameter be entered as the decimal equivalent of a desired channel programming binary data pattern. Conversely, the READ command returns data to either controller display as the decimal equivalent of the binary data pattern showing the current programmed state of all accessesory channels in the slot addressed.

To determine the decimal equivalent of a binary channel control data pattern for channel programming, or to convert a binary data pattern to its decimal equivalent, refer to Table 15-4. As shown at the bottom of the table, a binary "1" will program a channel to CLOSE and a binary "0" will program a channel to OPEN. Channel numbers are determined by bit position from the lease significant bit (LSB), where the LSB is channel 0 and the MSB is channel 15.

In order to communicate with all sixteen channels of the GP switch, channel programming decimal equivalent numbers used by the WRITE and READ commands include both positive and negative signed integers. Positive decimal values range from 0 to 32767 (Table 15-4) when channels 0 through 14, respectively, are programmed to the CLOSED ("1") state. The channel control decimal equivalent becomes a negative integer when channel 15 only (-32768) or channel 15 and any combination of channels 14 through 0 (-32768 plus any positive weighted integers) are programmed to a binary "1" (CLOSED) state.

The following provides an example of how to determine a positive decimal equivalent (channel 15 programmed to binary "0") for channels 0 through 14 programmed to any combination of OPEN or CLOSED; binary "0"s and "1"s. As the example shows, mearly add the positive decimal weighted value of each binary "1" in the channel control bit pattern to obtain the decimal equivalent integer. The decimal equivalent interger is then used as the *number* parameter in the WRITE command:

Channel Number:	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
Channel Control Bit Pattern:	0	0	1	0	0	0	0	0	0	1	1	0	1	0	1	0	LSB

Decimal Equivalent: 8192 + 64 + 32 + 8 + 2 = 8298

The above example shows that channel 13 (the decimal 8196 weighted bit), channel 6 (the decimal 64 weighted bit), channel 5 (the decimal 32 weighted bit), channel 3 (the decimal 8 weighted bit), and channel 1 (the decimal 2 weighted bit) are programmed to the CLOSED ("1") state (Table 15-4).

To determine a negative decimal equivalent (channel 15 programmed to CLOSED; "1"), add the negative decimal weighted value of the channel 15 binary "1" (-32768) to all other positive weighted decimal equivalent values in the channel control bit pattern (Table 15-4), as shown in the following example:

Channel Number:	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
Channel Control Bit Pattern:	1	0	1	0	0	0	0	0	0	1	1	0	1	0	1	0	LSB

Decimal Equivalent: -32768 + 8192 + 64 + 32 + 8 + 2 = -24470

The above example shows that channel 15 (the decimal -32768 weighted bit), channel 13 (the decimal 8196 weighted bit), channel 6 (the decimal 64 weighted bit), channel 5 (the decimal 32 weighted bit), channel 3 (the decimal 8 weighted bit), and channel 1 (the decimal 2 weighted bit) are programmed to the CLOSED ("1") state (Table 15-4).

Table 15-4 Decimal/Binary Pattern Conversion Table

	Channel Number—	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	Wtd Dec Value—	−32768	16384	8192	4096	2048	1024	512	256	128	64	32	16	8	4	2	1
Decimal Value	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	.																
	.																
	.																
	32766	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
	32767	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	−32768	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	−32767	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	.																
	.																
	.																
	−2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
	−1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Note

To compute the decimal value for any channel bit pattern, add the Weighted Decimal Values of the "1" bits in the channel bit pattern. For example, bit pattern 0000 0000 0010 1110 = 32 + 8 + 4 + 2 = 46. Bit pattern 1000 0000 0010 1110 = −32768 + 32 + 8 + 4 + 2 = −32722

Initial Programming

NOTE

The following programming examples use HP-IB address 709, and hypothetical slot and channel numbers for illustrative purposes only. Program syntax and data returns apply to HP 200 series controllers. To use a different controller, modify the syntax and data returns as required.

In the following example, the "ID? 0100" command queries the identification of the accessory installed in slot 1 of the mainframe.

- If the GP switch is properly installed in slot 1, the message "Accessory ID = 44725A" will be printed on the CRT display.
- If the GP switch is, for some reason, not installed in slot 1, the message "Incorrect Accessory or Slot" will be printed on the CRT and display and the program will stop.

The command "RST 0100" resets the accessory located in slot 1 to the power-on condition.

The command "WRITE 100,41" writes the decimal equivalent (41) of the channel control bit pattern (00101001) required to close channel 0,3, and 5 in slot 1 (Table 15-4).

The "READ 100" command then reads the programmed state of all channels in accessory slot 1 of the mainframe (100), and returns "Channel Status = 41" to the CRT and display. Refer to Table 15-4 to convert decimal 41 to the equivalent channel control bit pattern.

```
20  OUTPUT 709;"ID? 0100"
30  ENTER 709;Gpswitch$
40  PRINT "Accessory ID =";Gpswitch$
50    IF Gpswitch$ <> " 44725A" THEN
60          PRINT "Incorrect Accessory or Slot"
70    ELSE
80    OUTPUT 709;"RST 0100"
90    OUTPUT 709;"WRITE 100,41"
100   OUTPUT 709;"READ 100"
110   ENTER 709;Chanstat
120   PRINT "Channel Status = ";Chanstat
130   END IF
140 END
```

Close Channels

The following example uses the command CLOSE to program all accessory channels specified in command parameter *ch list* to the close state.

The command CHWRITE is used to program a specific channel (command parameter *ch*) to the close state (command parameter *data*).

```
        .
        .
220   OUTPUT 709;"CLOSE 201,305,504"
        .
        .
        .
374   OUTPUT 709;"CHWRITE 403,1"
        .
        .
```

The command string "CLOSE 201,305,504" programs slot 2-channel 1, slot 3-channel 5, and slot 5-channel 4 to the close state.

The command string "CHWRITE 403,1" programs only the channel specified (slot 4-channel 3) to the close (1) position.

Open Channels

The following example uses the command OPEN to program all accessory channels specified in command parameter *ch list* to the open state.

The command CHWRITE is used to program a specific channel (command parameter *ch*) to the open state (command parameter *data*).

```
        .
        .
220   OUTPUT 709;"OPEN 201,305,504"
        .
        .
        .
374   OUTPUT 709;"CHWRITE 403,0"
        .
        .
```

The command string "OPEN 201,305,504" programs slot 2-channel 1, slot 3-channel 5, and slot 5-channel 4 to the open state.

The command string "CHWRITE 403,0" programs only the channel specified (slot 4-channel 3) to the open (0) position.

Chapter 16

HP 44727A/B/C
4-Channel DACs

Contents

Chapter 16
HP 44727A/B/C 4-Channel DACs

Chapter 16
4-Channel DACs
HP 44727A/B/C

Introduction

This chapter shows how to configure and program the HP 44727A 4-Channel Voltage Digital-to-Analog Converter (VDAC), the HP 44727B 4-Channel Current Digital-to-Analog Converter (IDAC), and the HP 44727C 2-Channel Voltage; 2-Channel Current Digital-to-Analog Converter (VDAC/IDAC). Refer to the HP 3852A Configuration and Programming Manual for additional information on the acessories.

NOTE

The HP 44727A, HP 44727B, and HP 44727C versions are the same plug-in accessory. The only difference among the three versions is the settings of the switches and jumpers on the modules.

The chapter has five sections: Introduction, Specifications, Configuring Voltage Channels, Configuring Current Channels, and Programming DAC Channels.

- **Introduction** contains a chapter overview, describes the DACs, and shows suggested steps to get started.
- **Specifications** lists specifications for the DACs.
- **Configuring Voltage Channels** shows how to configure DAC channels for voltage output.
- **Configuring Current Channels** shows how to configure DAC channels for current output.
- **Programming DAC Channels** shows how to program DAC channels for voltage or current outputs. It includes a summary of the commands for the DACs and some example programs.

DAC Description

Depending on channel configuration, a DAC can output analog voltages and/or currents. Each DAC channel can be independently programmed to output voltage or current. As factory configured, the VDAC has four voltage channels, the IDAC has four current channels, and the VDAC/IDAC has two voltage and two current channels.

Each channel can be independently reconfigured from voltage to current or current to voltage by moving jumpers on the terminal module, but reconfigured channels may require recalibration to maintain accuracy. DAC voltage channels have remote sense capabilities to provide accurate voltages at the test point.

Each channel can be set to one of four ranges: 0 volts to +10 volts, -10 volts to + 10 volts, 0 to 20 mA, or 4 to 20 mA. Due to mainframe power supply limitations, there is a limit on the number of DACs which can be installed.

An important feature of the DACs is monotonicity. Monotonicity guarantees that the output will never change in a direction other than that programmed. For example, if a voltage channel is set for a 5 mV output and then programmed for a 10 mV output, the actual output will never be less than 5 mV. Or, if a current channel is set for a 5 mA output and then programmed for a 2 mA output, actual output will not be greater than 5 mA.

Getting Started

There are three main steps to configure and program a DAC channel for your application. This section summarizes these three steps and defines the section of the chapter which describes these steps.

- Define Your Application.
- Configure DAC Channels.
- Program DAC Channels.

Defining Your Application:

The first step is to define your application and select the devices to be connected to the DAC. Typically, you can use voltage output channels to control voltage across a load or to test the load resistance value. Voltage output range is switch-selectable from 0 VDC to + 10.235 VDC or from -10.235 VDC to +10.235 VDC.

You can use current output channels to control devices such as proportional control valves, as long as the compliance voltage does not exceed 12 volts. Current output range is switch-selectable for 0 to 20 mA or 4 to 20 mA.

NOTE

When selecting devices to be connected, refer to Table 12-1, "DAC Specifications" for voltage and current limitations.

Configuring DAC Channels:

The next step is to configure each channel of the DAC for the mode (voltage or current) and range required and connect the devices to the terminal module. Refer to "Configuring Voltage Channels" to configure channels for voltage output. Refer to "Configuring Current Channels" to configure channels for current output.

Programming DAC Channels:

The third step is to program each DAC channel to be used to the voltage or current output level required to control the devices connected to the channels. Refer to "Programming DAC Channels" to program DAC channels for voltage or current outputs.

Specifications

Table 16-1 lists the specifications for the DACs. Voltage Configuration specifications refer to channels configured for voltage output. Current Configuration specifications refer to channels configured for current output.

Table 16-1. DAC Specifications

General:

Ordering Configuration:

HP 44727A	Channels 0-3 = Voltage Output
HP 44727B	Channels 0-3 = Current Output
HP 44727C	Channels 0-1 = Voltage Output, Channels 2-3 = Current Output

All versions use the same component module and terminal module. Only difference among the three versions is switch and jumper settings.

Maximum number of DACs: 4 per mainframe or extender with 20 mA output on each channel.

Voltage Configuration:

Item	Specification (0-55 deg C)	See Note
1. Resolution		
0 - 10.235 V (12 bits)	2.5 mV	[1]
0 +/- 10.235 V (13 bits)	2.5 mV	
2. Accuracy		
a) 90 days, 18-28 deg C		
0 - 10 volt range	+/-(0.050% rdg + 2.5 mV)	[2]
0 +/- 10 volt range	+/-(0.050% rdg + 2.5 mV)	[2]
b) 1 year, 18-28 deg C		
0 - 10 volt range	+/-(0.075% rdg + 2.5 mV)	[2]
0 +/- 10 volt range	+/-(0.075% rdg + 2.5 mV)	[2]
3. Temperature coefficient (both ranges)	+/-(0.035 mV + 0.002% rdg)/deg C	[3]
4. Max output current all ranges (rated accuracy)	<= 20 mA	
5. Load regulation (0-20 mA)	<0.6 mV	
6. Max IR drop allowed for	<1.5 volts	[4]

source leads (for rated accuracy with remote sense)		
7. Settling time (rated accuracy)	<75 msec	
8. Ripple and noise (10 Hz - 100 kHz bandwidth)	<2.5 mV rms	
9. Isolation and protection Ch to ch, ch to chassis	>170 max abs volts	[5]
CURRENT CONFIGURATION:		
1. Resolution (13 bits)		
0-20 mA range	2.5 uA	
4-20 mA range	2.5 uA	
2. Accuracy (0 to 600 ohm load, all ranges)		
a) 90 days, 18-28 deg C	+/-(0.050% rdg + 5 uA)	
b) 1 year, 18-28 deg C	+/-(0.075% rdg + 5 uA)	
3. Temperature coefficient	+/-(0.3 uA + 0.003%)/ deg C	[6]
4. Compliance voltage (all ranges)	<12 volts	
5. Load regulation (2.5 to 12 volts)	<2 uA	[7]
6. Settling time (rated accuracy)	<75 msec	
7. Ripple and noise (600 ohm load, 10 Hz - 100 kHz bandwidth)	<7.5 uA	
8. Isolation and protection Ch. to ch., ch. to chassis	>170 V	[8]

Notes:

[1] 0 to 10.235 volt range is same as 0 to +/-10.235 volt range, but is locked to positive volts only.

[2] Implies <2.5 ohms in sense leads.

[3] Add to accuracy for temperatures outside 18-28 deg C.

Table 16-1. DAC Specifications (cont'd)

[4] Maximum of 75 ohms in both output leads for full output current of 20 mA.

[5] Isolation range of output.

[6] Add to accuracy for temperatures outside 18-28 deg C.

[7] Rated accuracy for a load change of 125 to 600 ohms.

[8] Isolation range of output.

Configuring Voltage Channels

Each DAC channel can be independently configured for voltage or current output. This section shows how to configure a channel for voltage output. Refer to "Configuring Current Channels" to configure channels for current output.

NOTE

If you don't need to reconfigure a voltage channel, skip "Setting Switches/Jumpers" and go to "Field Wiring Connections". However, even if you don't reconfigure a channel, to ensure that all channels are set for your application you should check the switch and jumper settings before using the DAC. See Figure 16-1 for voltage channel switch/jumper settings.

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 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.

There are three steps to configure a DAC channel for voltage output. See Figure 16-1 for switch and jumper settings and terminal locations. The circled numbers in Figure 16-1 refer to a suggested sequence to configure channel 3.

- Set switches/jumpers.
- Connect field wiring.
- Install/checkout DAC.

To begin configuring a voltage channel, remove the metal shield from the digital-to-analog component module. Then, remove the cover from the terminal module. If the DAC is installed in the mainframe or in an extender, refer to the HP 3852A Configuration and Programming Manual to remove the accessory. Figure 16-1 shows the two modules with shield and cover removed.

Figure 16-1. Configuring Voltage Channels

Setting Switches/ Jumpers

To configure a channel for voltage output, set the Mode/Range Switch (S1); the Sense Amplifier Jumper; the Voltage/Current Jumper (J101, J201, J301, or J401); and the Sense/Current Jumper (J102, J202, J302, or J402) for voltage output.

Setting Mode/Range Switch

The Mode/Range Switch S1, located on the Digital-to-Analog Converter Module, sets the channel voltage range to the 0 to 10V or the -10V to 10V range. Use the S1 switch settings in Table 16-2 to set the range for each voltage channel, where OPEN = away from the PC board and CLOSED = next to the PC board (see Figure 16-1).

Table 16-2. S1 Settings - Voltage Output Channels

	Ch 3		Ch 2		Ch 1		Ch 0	
S1 Position #	1	2	3	4	5	6	7	8
0 to 10V	C	C	C	C	C	C	C	C
-10V to 10V	C	O	C	O	C	O	C	O

C = CLOSED, O = OPEN

Setting Sense Amplifier Jumper

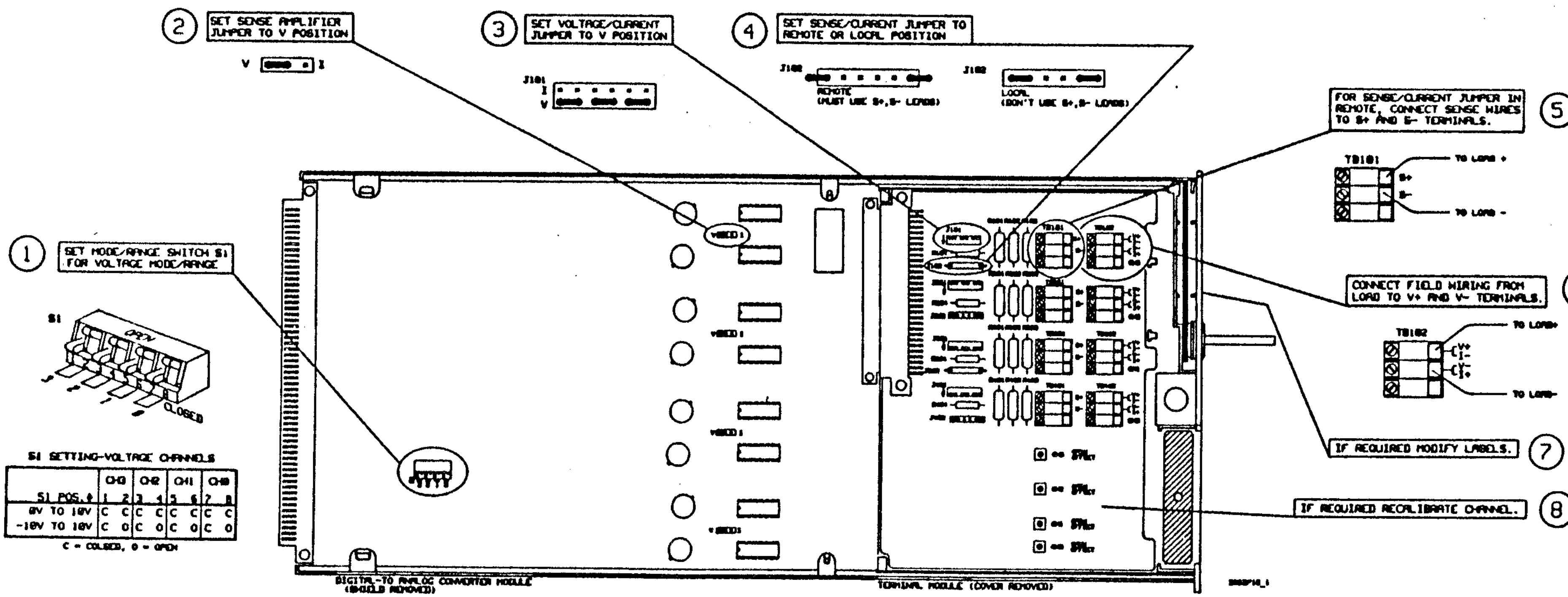


Figure 16-1. Configuring Voltage Channels

Set the channel Sense Amplifier Jumper located on the Digital-to-Analog Converter Module to the V position by placing the jumper plug over the center and left-side pins of the channel jumper. The jumper at the top of Figure 16-1 sets channel 3, and the jumper at the bottom sets channel 0.

Setting Voltage/Current Jumper

Each channel has a Voltage/Current Jumper (J101 for channel 3, J201 for channel 2, J301 for channel 1, and J401 for channel 0). Set the jumpers to the V position to configure required channels to voltage output (see Figure 16-1).

Setting Sense/Current Jumper

In Figure 16-1, the two settings of the Sense/Current Jumper for voltage channels are shown as REMOTE or LOCAL (this labeling does not appear on the terminal module). For voltage channels, set the Sense/Current Jumper (J102 for channel 3, J202 for channel 2, J302 for channel 1, or J402 for channel 0) to REMOTE or LOCAL as required.

In LOCAL, the channel uses internal sensing and field wiring connections to the S+ and S- terminals (on TB101 for channel 3, TB 201 for channel 2, TB 301 for channel 1, or TB401 for channel 0) are NOT required. In REMOTE position, you will need to connect field wiring to the S+ and S- terminals. Some guidelines for using remote sensing follow.

Remote sensing is especially valuable when a constant, accurate voltage is required at the load. To see the advantages of remote sensing, consider the simplified circuit in Figure 16-2 (a) which does not use remote sense leads. Note that the load voltage (V_R) is less than the programmed voltage (V_{VDAC}) due to voltage (IR) losses in the leads (V_l).

However, with remote sensing (see Figure 16-2 (b)) the DAC channel outputs additional voltage (V) to compensate for the voltage loss in the leads. Thus, the load voltage V_R = the programmed voltage, as long as the voltage drop in each lead is <0.75 volts (1.5 volts total loss in the leads).

Therefore, if you need a very accurate voltage across the load and/or you use long leads to connect the load to a voltage channel, set the Sense/Current Jumper to the REMOTE position. Otherwise, set the jumper to the LOCAL position.

NOTE

When the Sense/Current Jumper is set to the REMOTE position, sense wires must be connected to the S+ and S- leads. If leads are not connected, the channel output will arbitrarily go to -10.235V or +10.235V, regardless of the programmed output.

Figure 16-2. Remote Sensing

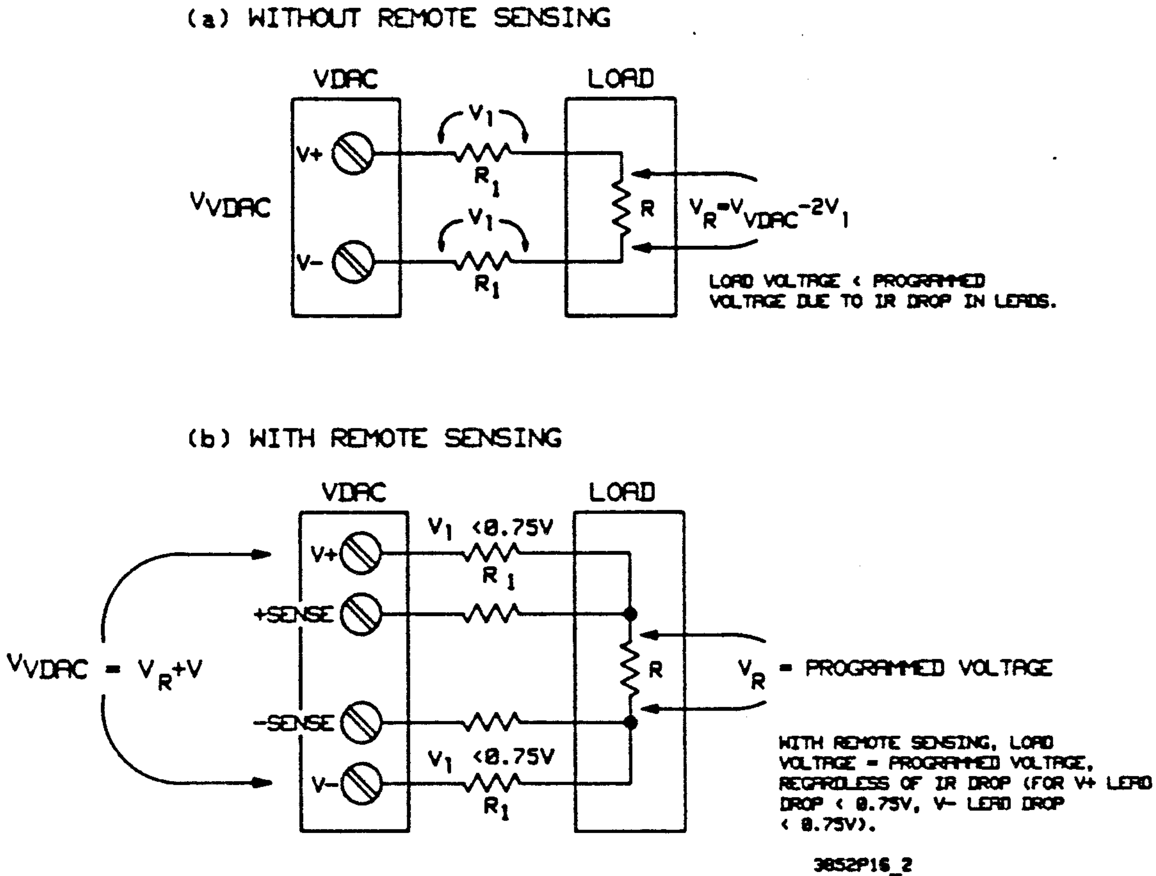


Figure 16-2. Remote Sensing

Connecting Field Wiring

When required channels have been configured for voltage output, connect field wiring from the load to the V+ and V- terminals on TB102 (channel 3); TB202 (channel 2); TB302 (channel 1); or TB402 (channel 0).

If the Sense/Current Jumper is set to the REMOTE position, connect sense leads to the S+ and S- terminals on TB101 (channel 3); TB201 (channel 2); TB301 (channel 1); or TB401 (channel 0).

NOTE

If the channel Sense/Current Jumper is set to LOCAL, skip "Connecting Sense Wiring" and go to "Typical Field Wiring Connections".

Connecting Sense Wiring

When the Sense/Current Jumper is set to REMOTE, connect sense wires from the load to the S+ and S- terminals on TB101 (channel 3); TB201 (channel 2); TB301 (channel 1); or TB401 (channel 4). Twist each pair of sense leads for some immunity from stray magnetic fields.

If you use a shield on the sense lines, do not use the shield as one of the sensing conductors. Tie one end of the shield to the - side of the load and leave the other end disconnected. In general, connect the shield as close as possible to the - side of the load.

Since channels are isolated from each other and from ground, loads up to +/- 170 V peak can be connected to the DACs. However, for rated voltage accuracy, resistance in the sense leads must be < 2.5 ohms in each lead. Figure 16-3 shows typical sense wire connections to channel 3.

Typical Field Wiring Connections

When the sense wires (if required) have been connected, connect field wires from the load to the V+ and V- terminals on TB102 (channel 3); TB202 (channel 2); TB302 (channel 1); or TB402 (channel 0).

When connecting field wiring, route all field wires under the strain relief clamp and tighten the clamp screw to reduce the chances of wires being pulled out of connectors. Figure 16-3 shows typical sense and field wire connections to channel 3.

Figure 16-3. Voltage Channel Field Wiring

Modifying DAC Labels

When all required channels have been configured for voltage output, modify the DAC labels (as required) to identify the reconfigured channels. Refer to the HP 3852A Configuration and Programming Manual to modify the DAC labels.

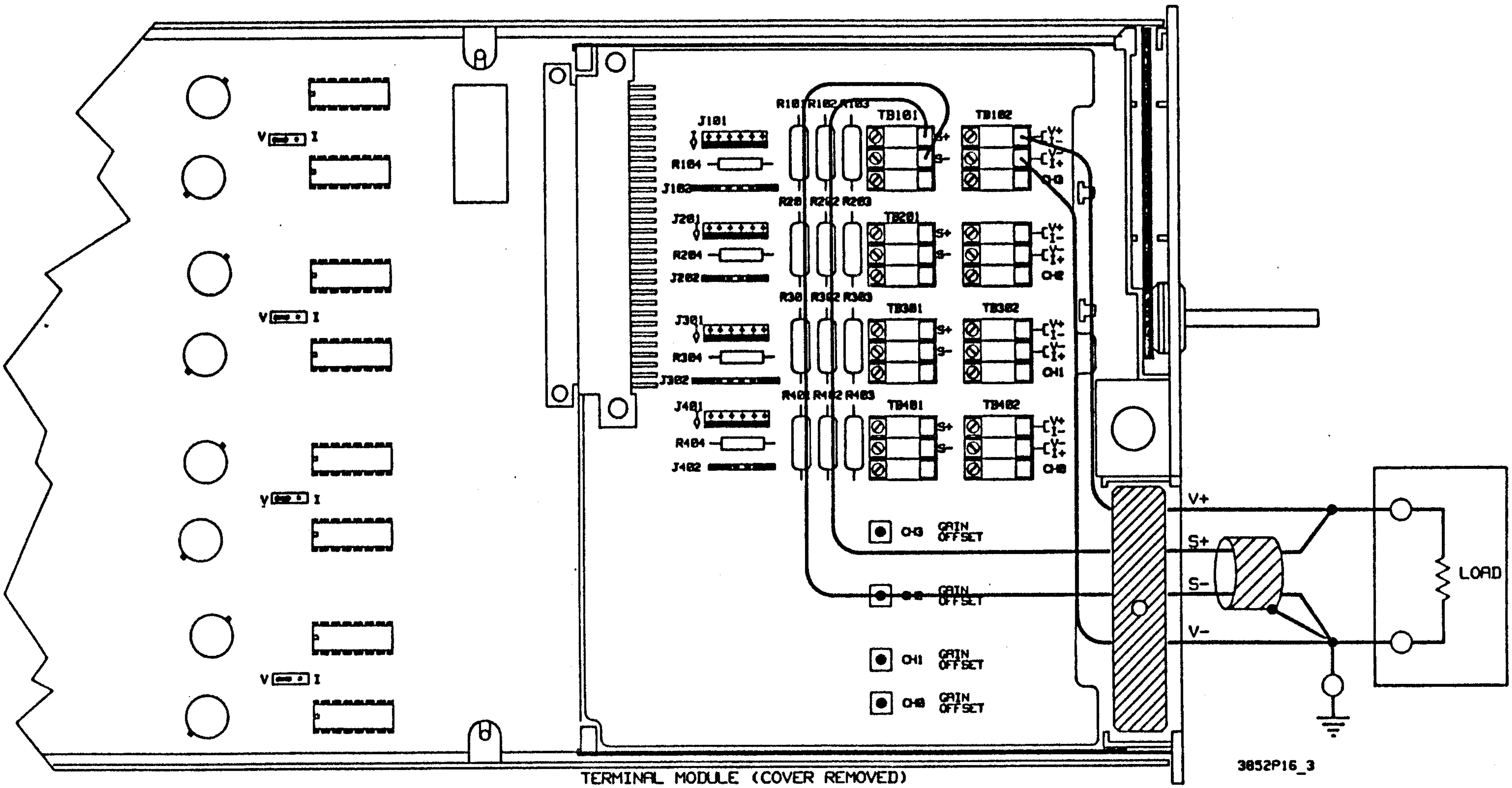


Figure 16-3. Voltage Channel Field Wiring

Installation/ Checkout

When all voltage channels have been configured and field wiring connected, install the DAC in a desired slot in the mainframe or in an extender. However, before you install the DAC, you may have to recalibrate the channels to ensure rated voltage accuracy.

Recalibrating Voltage Channels

If a channel is reconfigured from current output to voltage output, the channel must be recalibrated to ensure rated voltage accuracy. Recalibration is not required if the channel is changed from the 0 to 10V range to the -10V to + 10V range (or vice-versa) nor is recalibration required if reduced voltage accuracy is acceptable.

NOTE

A calibration tool (GC No. 8721) is shipped with each DAC. Refer to the HP 3852A Assembly Level Service Manual for calibration procedures.

Installing the DAC

When all required channels have been reconfigured and recalibrated (as required), replace the digital-to-analog converter module shield and the terminal module cover, connect the two modules together, and install the DAC in a desired slot. Refer to the HP 3852A Configuration and Programming Manual to install the DAC.

CAUTION

To avoid excessive power drain on the instrument power supply, do not install more than four DACs in the mainframe or in an extender if maximum current is to be drawn from each channel.

Checking DAC ID

When the DAC is installed, send the ID? command to check the accessory ID. At power-on, a VDAC, IDAC, or VDAC/IDAC returns 44727X, while a DAC with the terminal module removed returns 447XXX. (Note that if the terminal module is removed after power-on, the DAC still returns 44724X).

For example the following program determines the identity of an accessory in slot 4 of the mainframe. A DAC in this slot returns 44727X.

```
10 OUTPUT 709; "ID? 400"
20 ENTER 709; A
30 DISP A
40 END
```

If the DAC does not return 44727X, be sure you have addressed the proper slot and the terminal module is installed. If the correct slot was addressed and terminal module was properly installed but 44727X was not returned, refer to the HP 3852A Assembly Level Service Manual for service procedures.

This completes configuration for voltage channels. If you need to configure current channels, refer to "Configuring Current Channels". If not, refer to "Programming DAC Channels" to program voltage channel outputs.

Configuring Current Channels

This section shows how to configure DAC channels for current output. Refer to "Configuring Voltage Channels" to configure channels for voltage output.

NOTE

If you don't need to reconfigure a channel, skip "Setting Switches/Jumpers" and go to "Connecting Field Wiring". However, even if you don't reconfigure a channel, to ensure the channels are set for your application you should check the switch and jumper settings before using the DAC. See Figure 16-4 for current channel switch/jumper settings.

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 and extenders, to all installed accessories, and to all external devices connected to the mainframe, extenders or accessories.

WARNING

For safety, consider all accessory channels to be at the highest voltage applied to any channel.

There are three steps to configure DAC channels to current output. See Figure 16-4 for switch and jumper settings and terminal locations. The circled numbers in Figure 16-4 refer to a suggested sequence to configure channel 3.

- Set switches/jumpers.
- Connect field wiring.
- Install/checkout DAC.

To begin configuring current channels, remove the metal shield from the digital-to-analog component module. Then, remove the cover from the terminal module. If the DAC is installed in the mainframe or in an extender, refer to the HP 3852A Configuration and Programming Manual to remove the accessory.

Figure 16-4 shows the two modules with shield and cover removed.

Figure 16-4. Configuring Current Channels

Setting Switches/ Jumpers

To configure a channel for current output, set the Mode/Range Switch (S1); the Sense Amplifier Jumper; the Voltage/Current Jumper (J101, J201, J301, or J401); and the Sense/Current Jumper (J102, J202, J302, or J402) for current output mode.

Setting Mode/Range Switch

The Mode/Range Switch S1, located on the Digital-to-Analog Component Module, sets each channel for one of two current ranges: 0 to 20 mA or 4 to 20 mA. To set a channel to the 0 to 20 mA range or the 4 to 20 mA range, use the S1 switch settings in Table 16-3, where OPEN = away from the PC board and CLOSED = next to the PC board (see Figure 16-4).

Table 16-3. S1 Settings - Current Output Channels

	Ch 3		Ch 2		Ch 1		Ch 0	
S1 Position #	1	2	3	4	5	6	7	8
0 to 20 mA	O	C	O	C	O	C	O	C
4 to 20 mA	O	O	O	O	O	O	O	O

O = OPEN, C = CLOSED

Setting Sense Amplifier Jumper

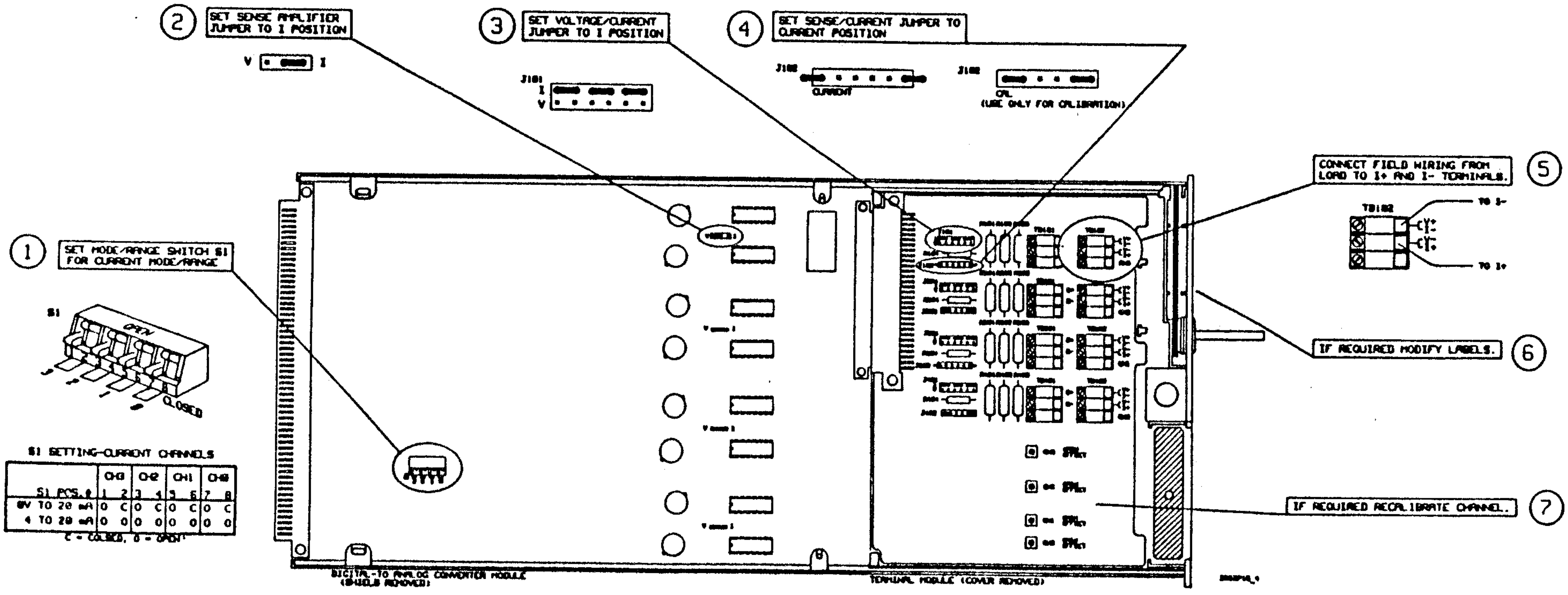
Set the channel Sense Amplifier Jumper (on the the Digital-to-Analog Converter Module) to the I position by placing the jumper plug over the center and right-side pins of the channel jumpers (see Figure 16-4). The jumper at the top of Figure 16-4 sets channel 3, and the jumper at the bottom sets channel 0.

Setting Voltage/Current Jumper

Set the channel Voltage/Current Jumper (J101 for channel 3, J201 for channel 2, J301 for channel 1, or J401 for channel 0) to the I position to configure channels to current output. See Figure 16-4 for jumper settings.

Setting Sense/Current Jumper

In Figure 16-4, the two positions of the Sense/Current Jumper are shown as CURRENT and CAL (these labels are not on the terminal module). For current channels, set the Sense/Current jumper (J102 for channel 3; J202 for channel 2; J302 for channel 1; or J402 for channel 0) to the CURRENT position as shown in Figure 16-4.



S1 SETTING-CURRENT CHANNELS

S1 POS. #	CH3 1	CH3 2	CH2 3	CH2 4	CH1 5	CH1 6	CH0 7	CH0 8
0V TO 20 mA	O	C	O	C	O	C	O	C
4 TO 20 mA	O	O	O	O	O	O	O	O

C = CLOSED, O = OPEN

Figure 16-4. Configuring Current Channels

NOTE

Be sure the Sense/Current jumper is set to the CURRENT position. If the jumper is in the CAL position, the current output is unspecified and probably will not match the programmed value.

Connecting Field Wiring

When the channel switches and jumpers have been set for current output, connect field wiring to the I+ and I- terminals on TB102 (channel 3); TB202 (channel 2); TB302 (channel 1); or TB402 (channel 0). However, before you connect leads to the channels, it is important to consider the channel compliance voltage.

Channel Compliance Voltage

The compliance voltage for a DAC channel is 12 volts, which means that the total voltage drop from channel high to channel low must be less than 12 volts. See Figure 16-5. Since compliance voltage = total circuit resistance times output current, maximum load resistance for a 20 mA output is 600 ohms and may be less if lead resistance is relatively high.

For example, in Figure 16-5 if R_l = lead resistance = 0.5 ohms in each lead and R_L = load resistance = 600 ohms, total circuit resistance = 601 ohms and compliance voltage V_c = 12.2V which exceeds allowable limits.

Figure 16-5. Compliance Voltage

Typical Field Wiring Connections

When you have verified that total circuit resistance (including lead resistance) will not cause the channel voltage to exceed the compliance voltage of 12 volts, connect field wiring from the load to the I+ and I- terminals. Figure 16-6 shows typical connections to channel 3. When connecting 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 connectors.

Figure 16-6. Current Channel Field Wiring

Modifying DAC Labels

When all required channels have been configured for current output, modify the DAC labels (as required) to identify the reconfigured channels. Refer to the HP 3852A Configuration and Programming Manual to modify the labels.

Installation/ Checkout

After reconfiguring the channel and connecting field wiring, install the DAC in a desired slot in the mainframe or in an extender. However, before you install the DAC, you may need to recalibrate the channel to ensure rated current accuracy.

Recalibrating Current Channels

If a channel is reconfigured from voltage output to current output, the channel must be recalibrated to ensure rated current accuracy. Recalibration is NOT required if the channel is changed from the 0 to 20 mA range to the 4 to 20 mA

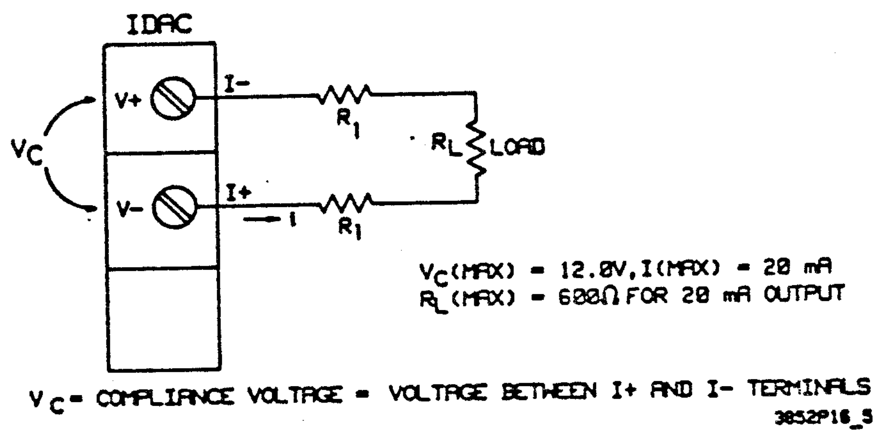


Figure 16-5. Compliance Voltage

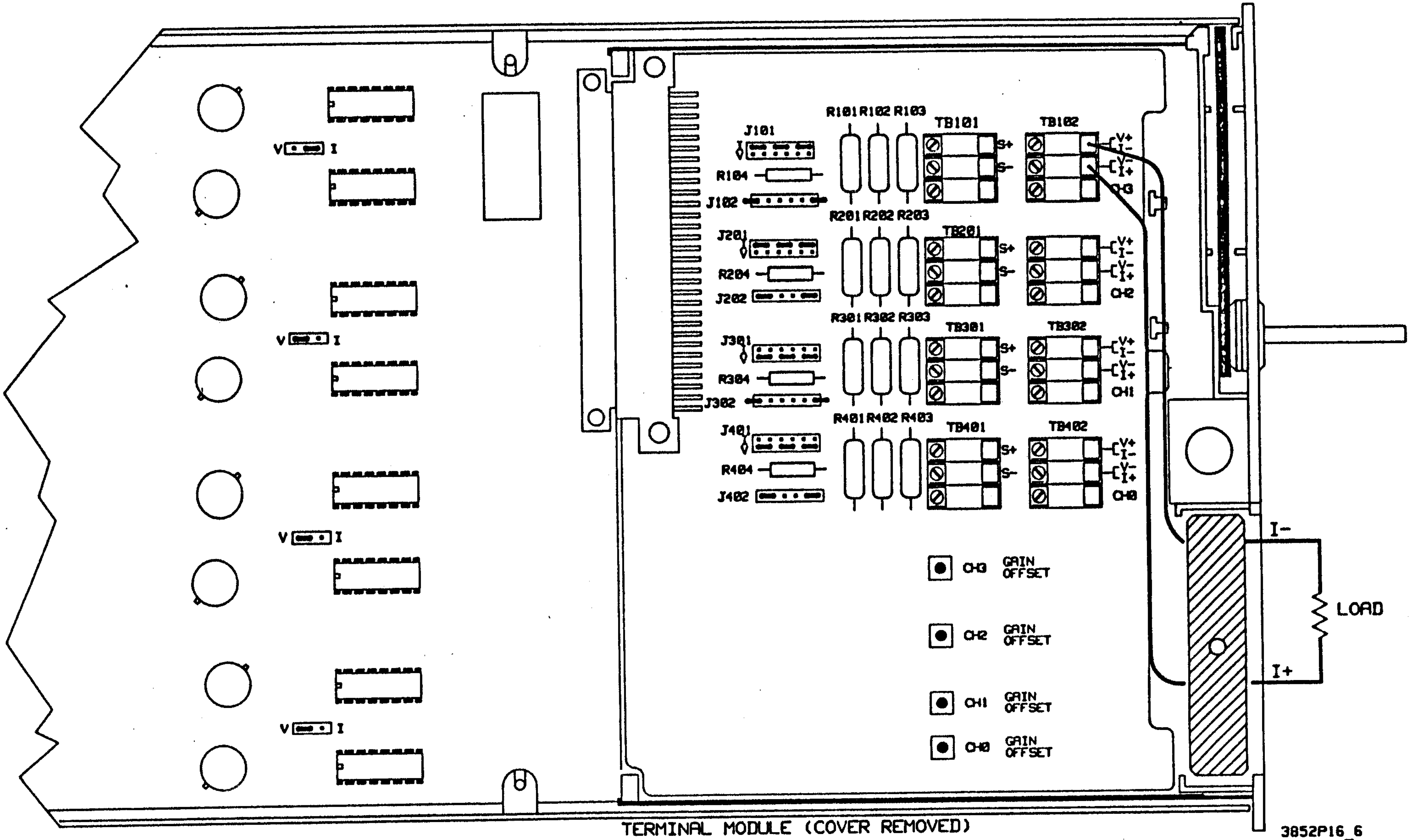


Figure 16-6. Current Channel Field Wiring

range (or vice-versa) nor is recalibration required if reduced current accuracy is acceptable.

NOTE

A calibration tool (GC No. 8721) is shipped with each DAC. Refer to the HP 3852A Assembly Level Service Manual for calibration procedures.

Installing the DAC

When all required channels have been configured and recalibrated (as required), replace the digital-to-analog converter module shield and terminal module cover, connect the two modules together, and install the DAC in a desired slot. Refer to the HP 3852A Configuration and Programming Manual to install the DAC.

CAUTION

To avoid excessive power drain on the instrument power supply, do not install more than four DACs in the mainframe or in an extender if maximum current is to be output from each channel.

Checking DAC ID

When the DAC is installed, send the ID? command to check the accessory ID. After power-on, a VDAC, IDAC, or VDAC/IDAC returns 44727X, while a DAC with the terminal module removed returns 447XXX. (Note that if the terminal module is removed after power-on, the DAC still returns 44727X).

For example, the following program determines the identity of an accessory in slot 4 of the mainframe. A DAC in this slot returns 44727X.

```
10 OUTPUT 709; "ID? 400"
20 ENTER 709; A
30 DISP A
40 END
```

If the accessory does not return 44727X, be sure you have addressed the proper slot and the terminal module is installed. If the correct slot was addressed and terminal module was properly installed but 44727X was not returned, refer to the HP 3852A Assembly Level Service Manual for service procedures.

This completes configuration for current channels. If you need to configure voltage channels, refer to "Configuring Voltage Channels". If not, refer to "Programming DAC Channels" to program current channel outputs.

Programming DAC Channels

There are two main programming functions for the DACs: setting voltage outputs and setting current outputs. Depending on the channel configuration, each DAC channel can be independently programmed to provide a voltage or a current output.

This section shows how to use the APPLY DCV, APPLY DCI, and APPLY PERC commands to program the output from a DAC channel. Refer to "Programming Voltage Channels" to set the voltage level from a voltage channel. Refer to "Programming Current Channels" to set the current level from a current channel.

The section also includes a summary of the commands which apply to the the DACs (refer to "Command Summary"), a summary of the equations to compute the APPLY *number* parameters for each range (refer to "APPLY Parameter Equations"), and a way to reduce the programming time for the DAC (refer to "Reducing Programming Time").

NOTE

1. At power-on or after a RST (reset) command, each DAC channel is an open circuit with no output and remains open until an APPLY command is sent to the channel. After an APPLY command is sent, the channel remains closed until a RST command is received or power is recycled.

2. Normal settling time for a DAC channel is 75 msec. When a DAC channel is programmed, the mainframe waits the entire 75 msec before proceeding with any other action. You can, however, program the DAC to a settling time of about 0.85 msec, which reduces waiting time to about 2 msec. Refer to "Reducing Programming Time" for details.

3. The example program lines in the chapter use specific slot and channel numbers. Program syntax applies to HP 200 Series and HP 300 Series controllers. If you use a different controller, modify the syntax as required. Modify addresses as required for the slots and channels you use.

Command Summary

Three commands are used to set DAC channel output levels: APPLY DCV for voltage channels, APPLY DCI for current channels, or APPLY PERC for either voltage or current channels. Refer to Table 16-4 for a command summary. Refer to the HP 3852A Command Reference Manual for a complete description of these commands.

Table 16-4. DAC Commands

APPLY DCI *ch, number*

Apply Current to DAC Output.
Set current level specified by *number* on
current channel specified by *ch*.
number = output current in amps.

APPLY DCV *ch, number*

Table 16-4. DAC Commands (cont'd)

Apply Voltage to DAC Output.
Set voltage level specified by *number* on voltage channel specified by *ch*.
number = output voltage in volts.

APPLY PERC *ch, number*

Apply Percentage Output.
Set percentage of full voltage output (for voltage channels) or percentage of full current output (for current channels).

ID? *slot*

Check Accessory ID.
Checks identity of accessory in slot specified by *slot*. DACs return 44727X.

RST *slot*

Reset DAC.
Resets DAC in slot specified by *slot* to power-on condition.

APPLY Parameter Equations

As noted, the APPLY DCV, APPLY DCI, and APPLY PERC commands are used to program DAC channels. Each APPLY command has the form APPLY xxx *ch, number*, where *number* is the parameter to set the channel voltage or current output. Although each command uses *number*, the parameter value depends on the range and mode (voltage or current) set for the channel.

For convenience, Table 16-5 summarizes the equations to compute *number* for the APPLY DCV, APPLY DCI, and APPLY PERC commands for each four channel range. The table also includes the range of values for *number*.

Table 16-5. APPLY number Parameters vs. Channel Ranges

	-10V to 10V	0 to 10V	0 to 20 mA	4 to 20 mA
APPLY DCV	n = V n = -10.235 to 10.235	n = V n = 0 to 10.235	------	------
APPLY DCI	------	------	n = I n = 0 to 0.0201675	n = I n = 0.004 to 0.0201675
APPLY	n = 10V	n = 10V	$n = \left(\frac{I}{.02}\right)100$	$n = \left(\frac{I-.004}{.016}\right)100$

Table 16-5. APPLY number Parameters vs. Channel Ranges (cont'd)

PERC	n = -102.35 to 102.35	n = 0 to 102.35	n = 0 to 100.8375	n = 0 to 101.046875

n = APPLY *number* parameter.
V = Channel output voltage in volts.
I = Channel output current in amps.

Reducing Programming Time

When a DAC channel is programmed with an APPLY command, it normally requires 75 msec for the output voltage to reach 99.925% of the programmed value. (A DAC channel can reach 80% of its programmed value in 14 to 16 msec). When the APPLY command is sent, the mainframe microprocessor waits the entire 75 msec before performing any other actions.

The amount of time the mainframe must wait is stored in a register on the DAC. However, by using the SWRITE command you can reset the waiting time to be as low as about 2 msec. To reprogram a DAC to decrease the time the mainframe microprocessor waits, send two SWRITE commands: SWRITE *slot*, 2, 13 followed by SWRITE *slot*, 6, xx, yy where *slot* = slot DAC is in.

In the second SWRITE command, xx = least significant byte and yy = most significant byte. To compute wait time, use wait time = (819.2 usec)*D where D/256 = yy with remainder xx. The ranges of xx and yy are:

```
Ranges:  0 <= yy < 256      (default =  0)
         1 <= xx < 256      (default = 91)
```

<u>Example: Set 10 msec Wait Time</u>

For example, if desired wait time = 10 msec, D = 10 msec/819.2 usec = 12.2, and xx and yy are computed by:

$$\frac{D}{256} = \frac{12.2}{256} = \underset{yy}{0} \text{ remainder } \underset{xx}{12}$$

Therefore, the two commands to set 10 msec wait time are SWRITE *slot*, 2, 13 followed by SWRITE *slot*, 6, 12, 00. Typical program lines for a DAC in slot 2 of the mainframe are:

```
        .
        .
110 OUTPUT 709; "SWRITE 200, 2, 13"
120 OUTPUT 709; "SWRITE 200, 6, 12, 00"
        .
        .
```

Programming Voltage Channels

A primary programming function for the DACs is to program voltage channels for voltage output levels. This section shows how to set voltage channel output levels using the APPLY DCV or APPLY PERC commands. Refer to "Programming Current Channels" to program current channels for current outputs.

Each DAC voltage channel has two output voltage ranges: 0 to 10.235 volts or -10.235 volts to +10.235 volts in increments of 2.5 mV. For either range, you can set the channel voltage output level with APPLY DCV or APPLY PERC commands.

Using APPLY DCV

Use APPLY DCV *ch, number* to program voltage channel outputs from -10.235 volts to + 10.235 volts in increments of 2.5 mV. The range of *number* is -10.2350 to +10.2350, but for *number* <0, the channel must be set to the -10V to 10V range.

Channel output voltage can be changed only in increments of 2.5 mV. If *number* is set for a value other than a multiple of 2.5 mV, the channel outputs the voltage nearest to the programmed value. To program a channel for voltage output using APPLY DCV, use *number* = V where V is the desired output voltage in volts.

Example: Using APPLY DCV on Voltage Channels

To output -5.000 volts from channel 3 of a DAC in slot 2 of the mainframe, *number* = V = -5.000 (channel must be set for the -10V to 10V range). To output 6.125 volts from this channel, *number* = V = 6.125. (channel can be set to either voltage range). Typical program lines are:

```
120 !
130 !Output -5 volts (-10V to 10V range only).
140 !
150 OUTPUT 709; "APPLY DCV 203,-5.000"
                    .
                    .
210 !
220 !Output 6.125 volts (either voltage range).
230 !
240 OUTPUT 709; "APPLY DCV 203, 6.125"
```

Using APPLY PERC

Use APPLY PERC *ch, number* to output a percentage of the maximum voltage output (-10.235 volts to +10.235 volts). The range of APPLY PERC *number* is -102.35 to +102.35, but for *number* <0, the channel must be set to the -10V to 10V range.

Channel output voltage can be changed only in increments of 2.5 mV. If *number* is set for a value other than a multiple of 2.5 mV, the channel outputs the voltage closest to the value. To program a channel for voltage output using APPLY PERC, use *number* = 10*V, where V = desired output voltage in volts.

Example: Using APPLY PERC on Voltage Channels

For example, to output 5.0025 volts from channel 3 of a DAC in slot 1 of the mainframe, *number* = 10*V = 50.025 (channel can be set for either voltage range). To output -3.1750 volts from this channel, *number* = 10*V = -31.75 (channel must be set for -10V to 10V range). Typical program lines are:

```
10  !
20  !Output 5.0025 volts (either voltage range).
30  !
40  OUTPUT 709; "APPLY PERC 103, 50.025"
                .
                .
220 !
230 !Output -3.1750 volts (-10V to 10V range only).
240 !
250 OUTPUT 709; "APPLY PERC 103, -31.75"
```

Programming Current Channels

A second primary programming function for the DACs is to set the output current levels for current channels. This section shows how to use these two commands to program current channels. Refer to "Programming Voltage Channels" to program voltage channel outputs.

The DACs have two output current ranges, 0 to 20 mA and 4 to 20 mA. For either range, you can program the current output level with the APPLY DCI or APPLY PERC command.

Using APPLY DCI

Use the APPLY *ch, number* command to program current channel outputs from 0 to 0.0201675 A (on the 0 to 20 mA range) or from 0.004 to 0.0201675 A (on the 4 to 20 mA range) in increments of 2.5 uA. The range of *number* = 0 to 0.0201675, but for *number* < 0.004, the channel must be set to the 0 to 20 mA range.

To program a channel for current output with the APPLY DCI command, compute the value of *number* from *number* = I, where I is the desired output current in Amps. Channel output can be changed only in increments of 2.5 uA. If the value of number is set to other than a multiple of 2.5 uA, the channel outputs the current level closest to the value.

<u>Example: Using APPLY DCI on Current Channels</u>

To output 0.003 Amps from channel 3 of a DAC in slot 2 of the mainframe using the APPLY DCI command, *number* = I = 0.003 (channel must be set to the 0 to 20 mA range). To output 0.01 Amps from this channel, *number* = I = 0.01 (channel can be set to either current range). Typical program lines are:

```
120 !
130 !Output 0.003 amps (0 to 20 mA range only).
140 !
150 OUTPUT 709; "APPLY DCI 203, .003"
                .
                .
300 !
310 !Output 0.01 amps (either current range).
320 !
330 OUTPUT 709; "APPLY DCI 203, .01"
```

Using APPLY PERC

Use APPLY PERC *ch, number* to program current channel outputs from 0 to 0.0201675 A (on the 0 to 20 mA range) or from 0.004 to 0.0201675 A (on the 4 to 20 mA range), in increments of 2.5 uA. For current channels, the range of APPLY PERC *number* depends on the channel range.

Channel outputs can be changed only in increments of 2.5 uA. If the value of *number* is set to other than a multiple of 2.5 uA, the channel outputs the current level closest to the value.

Using APPLY PERC on 0 to 20 mA Channels

To program a current channel set to the 0 to 20 mA range using the APPLY PERC command, compute APPLY PERC *number* from the following equation where I = desired output current in Amps. The range of *number* for the 0 to 20 mA range is 0 to 100.8375.

$$\text{APPLY PERC number} = \left(\frac{I}{.020}\right) * 100 \qquad \text{[0 to 20 mA range]} \quad \text{[I in Amps]}$$

<u>Example: Using APPLY PERC on 0 to 20 mA Channels</u>

To output 0.005 Amps from channel 3 of a DAC in slot 1 of the mainframe, when the channel is set to the 0 to 20 mA range, APPLY PERC *number* = (.005/.020) x 100 = 25.0000. A typical program line is:

```
10   !
20   !Output 0.005 Amps (0 to 20 mA range only).
30   !
40   OUTPUT 709; "APPLY PERC 103, 25".
```

Using APPLY PERC on 4 to 20 mA Channels

To program a current channel set for the 4 to 20 mA range using the APPLY PERC command, compute APPLY PERC *number* from the following equation where I = desired output current in Amps. The range of APPLY PERC *number* = 4 to 101.046875 for the 4 to 20 mA range.

$$\text{APPLY PERC number} = \left(\frac{I - .004}{.016}\right) * 100 \qquad \text{[4 to 20 mA range]} \quad \text{[I in Amps]}$$

Example: Using APPLY PERC on 4 to 20 mA Channels

To output 0.014 Amps on channel 2 of a DAC in slot 1 of the mainframe, when the channel is set for the 4 to 20 mA range, APPLY PERC *number* = [(.014 -.004)/.016]*100 = 62.5. A typical program line is:

```
10  !
20  !Output 0.014 Amps (4 to 20 mA channel only).
30  !
40  OUTPUT 709; "APPLY PERC, 102, 62.5"
              .
              .
```

Chapter 17
HP 44728A
8-Channel Relay Actuator

Contents

Chapter 17
HP 44728A 8-Channel Relay Actuator

Chapter 17

HP 44728A 8-Channel Relay Actuator

Introduction

This chapter provides configuration, installation, and programming information for the HP 44728A 8-Channel Relay Actuator accessory. For additional information on the overall data acquisition and control unit and related programming commands, refer to the HP 3852A Data Acquisition/Control Unit, Installation and Programming Manual, Part Number 03852-90001.

The HP 44728A 8-Channel Relay Actuator Accessory (relay actuator) consists of an interconnected relay actuator module and terminal module. The relay actuator provides eight channels of moderate level AC (up to 250V) and DC (up to 30V) power level switching for on/off control of external devices.

All switches are break-before-make, SPDT Form C high-voltage relays. Each relay (one for each channel) can be individually programmed, with accessory memory holding the relay in its programmed state until reprogrammed.

At power-down all relays return to the Normal Closed (NC) deenergized position.

The following describes the getting started sequence for the relay actuator accessory:

- **Determine Your Application.** Determine the required configuration, current required for each output channel, and total current requirement. Refer to the "Specifications" section, below, for specific current limitations per channel and for the overall accessory.
- **Configure the terminal Card.** Connect your application external wiring to the terminal module in the required configuration
- **Install and Checkout.** Install the accessory in either the mainframe or an extender and ensure that it is operating properly.
- **Program the Accessory.** Program the accessory registers to meet your application requirements.

Specifications

Specifications for the HP 44728A 8-Channel Relay Actuator are provided in Table 17-1.

Table 17-1. Accessory Specifications

8 Channels of Form C (break-before-make) Switching Relays

Switching Characteristics:
Vmax: 30V DC or 250V AC (RMS)
Imax: 2A DC and 3A AC (RMS) per channel, or total accessory current $< 26A^2$ where total accessory current = the sum of I for each channel.

Output Status Readback: Latches can be read back

Response Time: <15 ms

Switching Rate: Limited to 30 per minute under maximum load

Switch Life: 10^5 cycles at full load

Isolation:
Snubber Leakage Current: <= 1.0 mA per channel @ 60 Hz, 250 VAC
DC: $> 10^9$ ohms channel-to-channel, channel-to-earth
AC: < 10 pf channel-to-channel, < 25 pf channel-to-earth

Operating Environment: (HP Class B)
Temperature: 0°C to +55°C
Humidity: 40°C @ 5% to 95% RH
Altitude: 4600 meters (15,000 ft.)

* Total current load for the accessory must be $<26A^2$ (e.g., channel 0 through 7 @ 1.5 Amps each, for an accessory I^2 total of 1.5^2 X 8 channels = $18A^2$).

Configuring the Relay Actuator

WARNING

⚠ 1

Possible voltage hazard to personnel! Only qulaified service-trained personnel who are aware of the hazards should configure the relay actuator accessory.

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.

Configure the relay actuator by connecting your application field wiring to the terminal module. There are no jumpers or configuration switches on either the relay actuator module or the terminal module that require setting.

Field Wiring

WARNING

⚠ 1

Possible voltage hazard to personnel! Disconnect all field wiring leads from source voltage before configuring the terminal module.

To configure the relay actuator connect all user application wiring to the normally open (NO), common(C), and normally closed (NC) terminal blocks (Figure 17-1), as required.

Figure 17-2 provides simplified examples of field configuration for load switching. Block diagram examples for configuring voltage switching and matrix switching are also provided in Figure 17-3.

Position all field wiring leads under the module strain relief clamp, leaving a small amount of slack on the terminal side of the clamp. Tighten the clamp, ensuring that all interconnecting wires are held firmly in place (see Figure 17-1).

RFI Filter Requirements

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).

Relay Contact Protection

Built-in relay protection (varistors) limits relay contact voltage (Vc) to 350V, preventing secondary arcs from starting. No additional contact protection is required to meet the switch life specifications as shown in Table 17-1. Switch life under full load (Table 17-1) can, however, be extended by the addition of external contact protection circuitry.

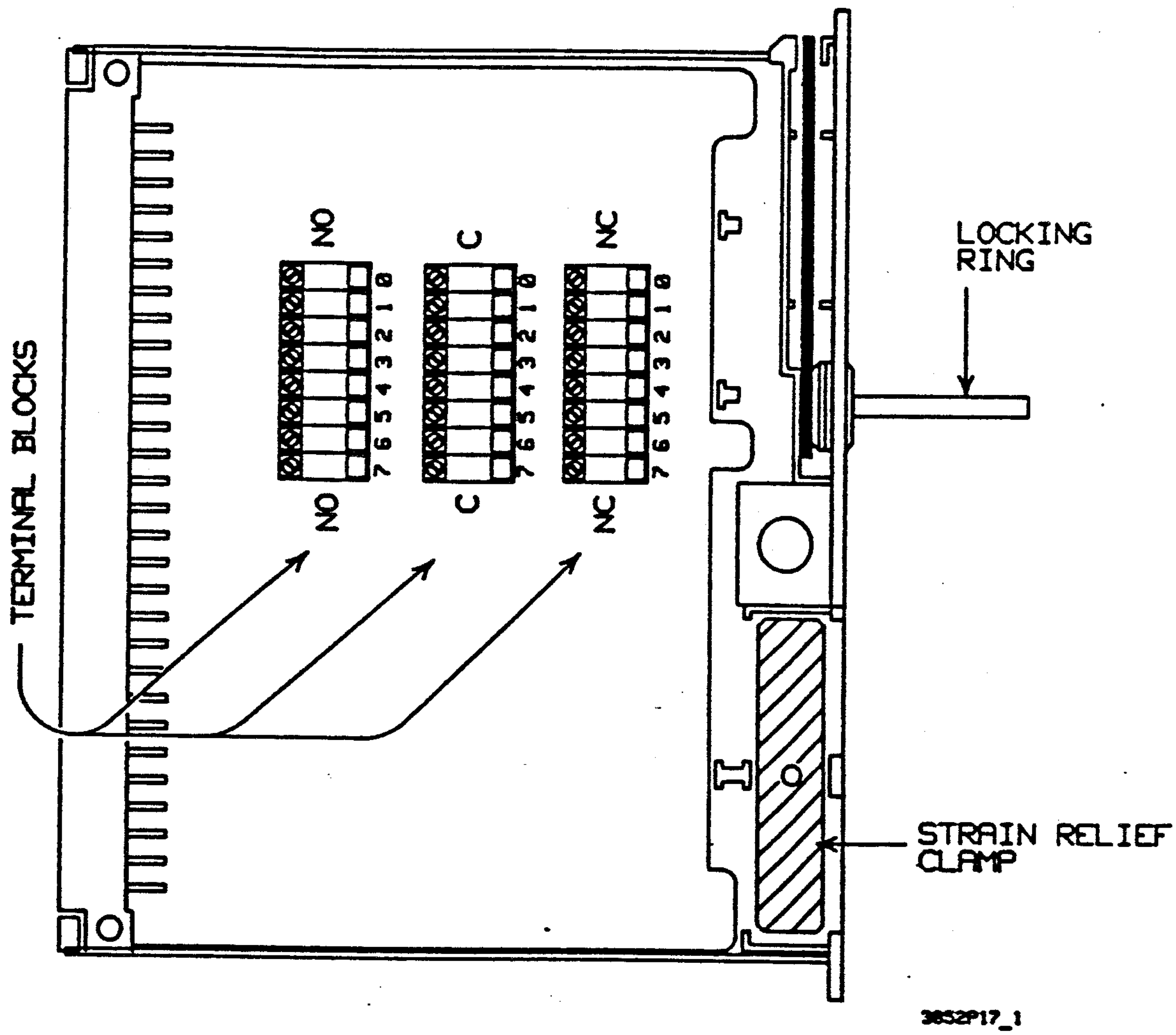


Figure 17-1. Terminal Block Wiring Layout

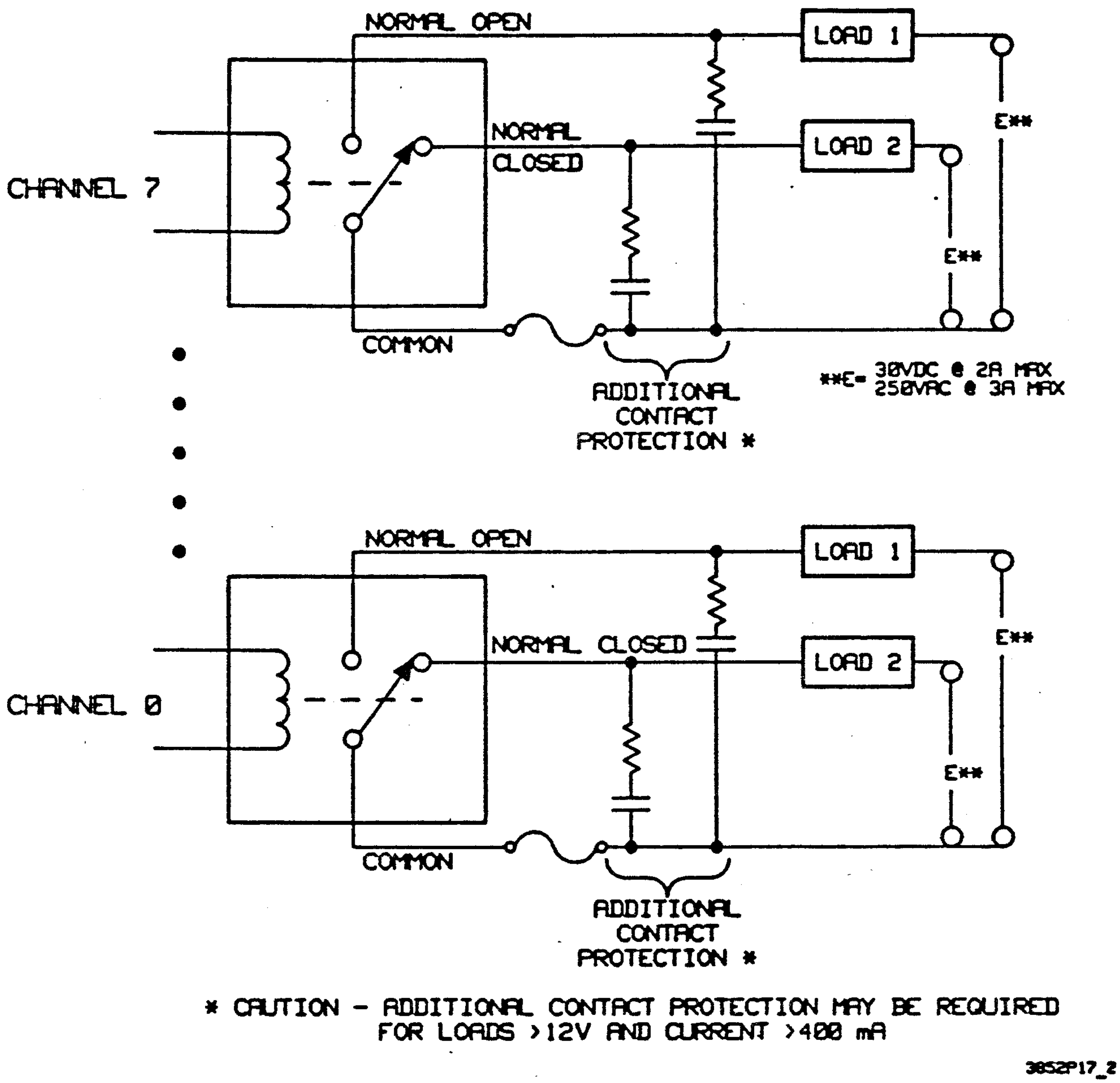


Figure 17-2. Load Switching Block Diagram

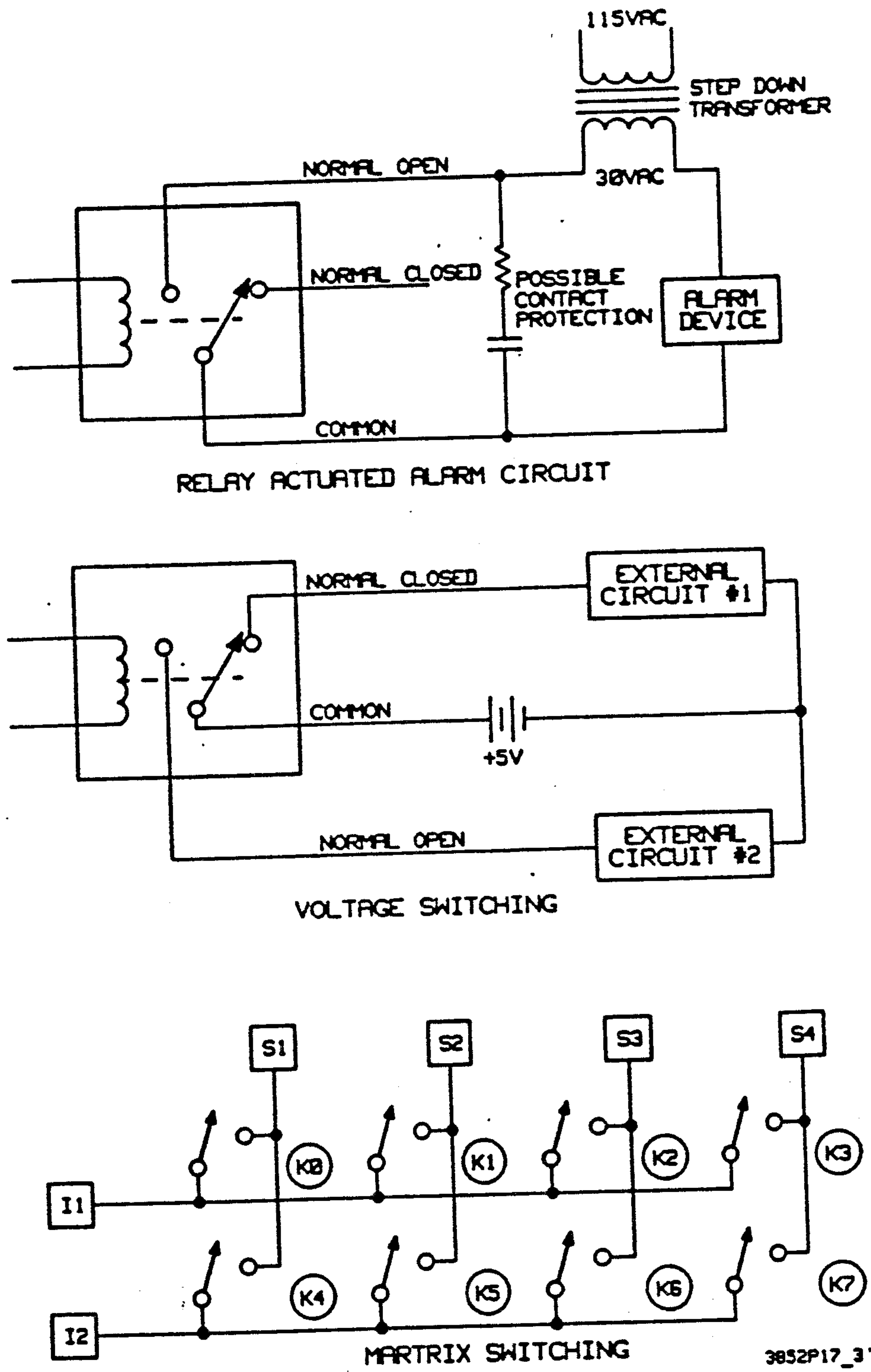


Figure 17-3. Additional Switching Examples

Safety Requirements

WARNING

Danger to personnel or equipment may exist if the relay actuator fails during control of a critical process or function. Always use redundant switching when configuring your application to prevent danger to personnel or damage to equipment.

WARNING

Some applications loads may remain activated following channel relay opening due to snubber circuit leakage current. Up to 1 mA @ 250 VAC leakage current (less at smaller voltages) can flow through the snubber circuit that parallels each channel relay when that relay is open.

See Figure 17-4 for a simplified block diagram showing redundant switching control. The Reduncancy Failure Indicator (Figure 17-4) will illuminate if the redundant control relay NO contacts become fused together and the relay deenergizes.

Installation and Checkout

WARNING

Possible voltage hazard to personnel! Only qualified, service-trained personnel who are aware of the hazards should install the accessory.

CAUTION

Damage to accessory components can result from static discharge or excessive voltage. Use static-free handling methods when installing, removing, or reconfiguring the accessory.

Ensure that the terminal module is properly connected to the relay actuator module and install the accessory in the desired card cage slot. Refer to Chapter 1 of this manual for installation and removal procecures.

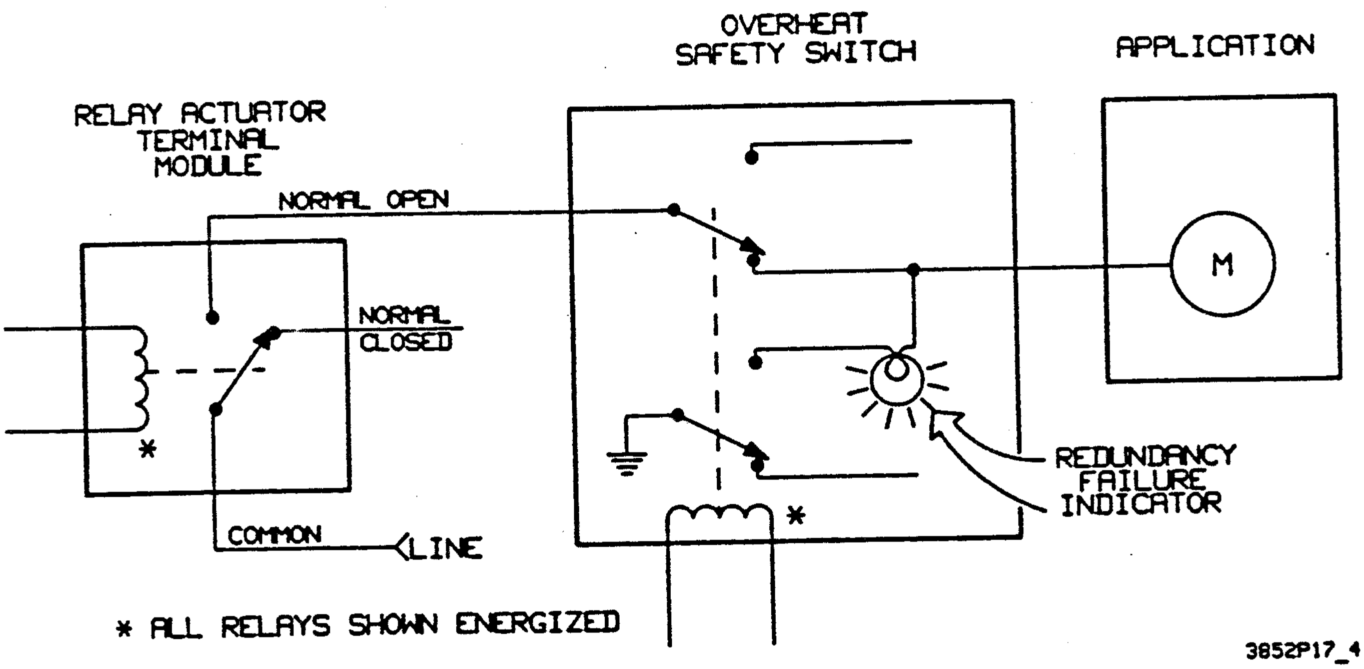


Figure 17-4. Redundant Switching Control, Simplified Block Diagram

To check proper installation of the relay actuator accessory, enter the following programming sequence (the relay actuator is installed in slot 4 of the mainframe for this example):

```
100  OUTPUT 709;"ID? 0400"
110  ENTER 709; Ident$
120  PRINT "Accessory in Slot 4 = ";Ident$
130  END
```

If the relay actuator is properly installed in slot 4 of the mainframe, the message "Accessory in Slot 4 = 44728A" will be returned to the CRT display and front panel display. If the terminal module is not connected to the relay actuator module, the message "Accessory in Slot 4 = 447XXX" will be returned.

Addressing an empty accessory slot will return " 000000" to the CRT and front panel display.

- If an incorrect product identification number is returned, first ensure that the correct terminal module is connected to the relay actuator module. If the accessory still returns an incorrect product number, refer to the HP 3852A Mainframe Configuration and Programming manual for procedures to return the relay actuator accessory to Hewlett-Packard.

- If the accessory returns the correct ID, refer to Programming The Relay Actuator, below.

Programming The Relay Actuator

This section describes the programming commands used by the relay actuator, and provides general programming examples for the accessory.

For additional information on the following relay actuator commands, and other commands that apply to the complete system, refer to the HP 3852A Data Aquisition/Control System Command Reference Manual.

Programming Commands

Table 17-2 provides a summarized list of the programming commands used with the relay actuator accessory. Refer to the command reference manual for complete parameter information and prerequisites for command use.

Table 17-2. Command Summary List

CHWRITE ***ch,data***

Write data to channel specified by *ch*. *Data* programs channel to open or closed state.

CLOSE ***ch list***

Programs channels specified by *ch list* to closed state.

CLOSE? ***ch list***

Queries the programmed state of all channels specified by *ch list*.

ID? ***slot***

Reads identity of accessory installed in slot specified by *slot*

OPEN ***ch list***

Programs all channels s specified by *ch list* to OFF state.

READ ***slot***

Read the programmed state of all channels specified in *slot*.

RST ***slot***

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

WRITE ***slot,number***

Writes programming data to the accessory specified in *slot*. *Number* is decimal equivalent of binary bit value required to program channels to open (0) or closed (1).

Programming Examples

Table 17-3 provides a list of program examples, showing the program name, function of each program, and the related relay actuator commands used.

NOTE

Channel switch positions are as follows:

NC = WRITE 0 = CHANNEL OPEN = OFF
NO = WRITE 1 = CHANNEL CLOSED = ON

Table 17-3. Example Program Summary

Program Name	Function	Related Commands
Initial Programming	Verify slot location of accessory, reset accessory to power-on state, program channels to desired state, verify actual programmed state of all channels.	ID?, RST, WRITE, READ
Close Channels	Close desired channels as selected, and return the programmed status of each channel listed (to verify the CLOSE command).	CLOSE, CLOSE?
Open Channels	Open selected channels by two different methods.	OPEN, CHWRITE

Using the READ/ WRITE Commands

Channel programming data sent to, or received from, any card cage accessory by the WRITE and READ commands, must be applied at the accessory as a binary data pattern.

As the HP 200 Series and HP 3852A mainframe controllers transmit and receive data only in decimal format, the WRITE command *number* parameter must be entered as the decimal equivalent of the required binary data pattern. Conversely, the READ command returns data to the controller CRT and mainframe front panel display as the decimal equivalent of the channel control binary bit pattern showing the programmed state of all accessesory channels in that slot.

To determine the decimal equivalent of a particular binary bit pattern for channel programming, refer to Table 17-4, Decimal-Value-to-Bit-Pattern Conversion. As shown at the bottom of the table, a binary "1" will close a channel and a binary "0" will open a channel. Channel numbers are determined by position from the lease significant bit (LSB), where the LSB is channel 0 and the MSB is channel 7.

Decimal values range from 0 (all channels OFF) to 255 (all channels ON). Refer to the following for an example of determining the decimal value for a binary bit pattern between 0 and 255.

Channel Number:	7 6 5 4 3 2 1 0
Channel Control Binary Bit Pattern:	0 1 1 0 1 0 1 0
Decimal Equivalent:	64 + 32 + 8 + 2 = 106

The above shows that channel 6 (the decimal 64 weighted bit), channel 5 (the decimal 32 weighted bit), channel 3 (the decimal 8 weighted bit), and channel 1 (the decimal 2 weighted bit) are programmed to the ON (closed = NO) state (see Table 17-4).

NOTE

The following programming examples use HP-IB address 709, and hypothetical slot and channel numbers for illustrative purposes only. Program syntax and data returns apply to HP 200 series controllers. To use a different controller, modify the syntax and data returns as required.

Initial Programming

In the following example, the "ID? 0100" command queries the identification of the accessory installed in slot 1 of the mainframe.

- If the relay actuator is properly installed in slot 1, the message "Accessory ID = 44728A" will be printed on the CRT display.
- If the relay actuator is, for some reason, not installed in slot 1, the message "Incorrect Accessory or Slot" will be printed on the CRT and display and the program will stop.

The command "RST 0100" resets the accessory located in slot 1 to the power-on condition.

The command "WRITE 100,41" writes the decimal equivalent (41) of the channel control bit pattern (00101001) required to close channel 0,3, and 5 in slot 1 (Table 17-4, below).

The "READ 100" command then reads the programmed state of all channels in accessory slot 1 of the mainframe (100), and returns "Channel Status = 41" to the CRT and display. Refer to Table 17-4, below, to convert decimal 41 to the equivalent channel control bit pattern.

```
20  OUTPUT 709;"ID? 0100"
30  ENTER 709;Relayact$
40  PRINT "Accessory ID =";Relayact$
50    IF Relayact$ <>" 44728A" THEN
60          PRINT "Incorrect Accessory or Slot"
70    ELSE
80    OUTPUT 709;"RST 0100"
90    OUTPUT 709;"WRITE 100,41"
100   OUTPUT 709;"READ 100"
110   ENTER 709;Chanstat
120   PRINT "Channel Status = ";Chanstat
130   END IF
140 END
```

Table 17-4. Decimal-Value-to-Bit-Pattern Conversion

Decimal Value	7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	0	Channel Control Bit Pattern
1	0	0	0	0	0	0	0	1	
.	.							.	
.	.							.	
.	.							.	
254	1	1	1	1	1	1	1	0	
255	1	1	1	1	1	1	1	1	

(Columns 7–0: Channel Number)

0 = Open (NC), 1 = Closed (NO)

Close Channels

In the following example the command "CLOSE 402,407" closes channels 2 and 7 in slot 4 of the mainframe. The "CLOSE? 402,407" command then queries the programmed state of channels 2 and 7.

```
100  OUTPUT 709;"CLOSE 402,407"
110  OUTPUT 709;"CLOSE? 402,407"
120  ENTER 709;Chan1,Chan2
130  PRINT "Chan 2 & 7 Status =  ";Chan1;" ";Chan2
140  END
```

The message "`Chan 2 & 7 Status = 1 1`" will then be returned to the CRT display, showing that channels 2 and 7 are now programmed in a closed state (1 = closed, 0 = open).

Open Channels

The following example uses the command OPEN to program all accessory channels specified in command parameter *ch list* to the open state.

The command CHWRITE is used to program a specific channel (command parameter *ch*) to the open state (command parameter *data*).

```
      .
      .
220  OUTPUT 709;"OPEN 201,305,504"
      .
      .
      .
374  OUTPUT 709;"CHWRITE 403,0"
      .
      .
```

The command string "OPEN 201,305,504" programs slot 2-channel 1, slot 3-channel 5, and slot 5-channel 4 to the open state.

The command string "CHWRITE 403,0" programs only the channel specified (slot 4-channel 3) to the open (0) position.

Chapter 18

HP 44729A
8-Channel Power Controller

Contents

Chapter 18
HP 44729A 8-Channel Power Controller

Chapter 18

HP 44729A 8-Channel Power Controller

Introduction

This chapter provides a description, specifications, configuration, and programming information for the HP 44729A 8-Channel Power Controller accessory. For additional information on the overall mainframe refer to the HP 3852A Data Acquisition/Control Unit, Installation and Programming Manual.

The HP 44729A 8-Channel Power Controller (power controller) accessory provides eight channels of programmable AC line voltage (12 to 250 VAC) switching and distribution.

Load switching for each channel is provided by a hybrid mechanical relay and silicon controlled recitfier (SCR) circuit. This design provides switching at very close to zero current, minimum switching noise (RFI), extended relay life, and minimum power dissipation.

Switching relays are SPST Form A, with contacts normally open (NO). Only the hot (H) output lead from the terminal module (Figure 18-1, TB3) is switched, with the neutral (N) output lead always connected to the AC main input. Relay contact protection is provided by a built-in snubber network, with no additional protection required.

The following describes the getting started sequence for the power controller accessory:

- **Determine Your Application.** Determine the required configuration, current required for each channel, and total power requirement. (Refer to the "Specifications" section, below.)
- **Configure the Accessory.** Connect your application external wiring to the terminal module. (refer to "Configuring The Power Controller, below).
- **Install and Checkout.** Install the accessory in either the mainframe or an extender and ensure that it is operating properly. (Refer to "Configuring The Power Controller, below)
- **Program the Accessory.** Program the accessory to meet your application requirements (refer to the "Programming The Power Controller", below).

Specifications

Specifications for the HP 44729A 8-Channel Power Controller are provided in Table 18-1.

Table 18-1. Accessory Specifications

Off-state voltage range: 9 to 250 VAC

Off-state leakage: 0.5 mA @ 250 VAC

Maximum load: 2.5 amps each for 8 channels (20 amps max);
or 3 amps each for 5 channels, with a total of
1 amp total for last three channels (16 amps max)

On-state resistance: 125 mohms maximum @ 3 A
200 mohms maximum @ 100 mA

Non-repetitive surge current: 50 amps

Recommended switching speed: 2 operations per minute *

Response time: 6 to 30 msec turn-on
14 to 34 msec turn-off

Fuse protection: 4 amp fuse each channel

Isolation between channels: Neutral common to all channels

Isolation channel-to-chassis: 354 Volts peak

Operating Environment: Temperature: 0° to +55°C
Humidity: 40°C @ 5% to 95% RH
Altitude: 4600 meters (15,000 ft.)

* *Switching speeds > 3 per minute may require external filtering to comply with VDE standard 0875 conducted RFI limits. Speeds up to 10 per second are possible but not recommended due to reduced component life.*

Configuring the Power Controller

WARNING

Possible voltage hazard to personnel! Only qualified service-trained personnel who are aware of the hazards should configure the power controller accessory.

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.

Configure the power controller by connecting your application field wiring to the terminal module. There are no jumpers or configuration switches on either the power controller module or the terminal module that require setting.

Field Wiring

WARNING

Possible voltage hazard to personnel! Disconnect line voltage input leads from line source before connecting them to the line source terminal board TB2 on the terminal module. Also disconnect this line voltage source when connecting your field wiring to output terminal board TB3. (See Figure 18-1, Field Wiring Interconnect Diagram.)

To configure the terminal module, connect the input AC line voltage leads to the respective H (hot) and N (neutral) terminal screws on terminal board TB2 (see Figure 18-1). Ensure that the AC main input will support the sum of the loads to be connected to the power controller accessory. (see Table 18-1).

Connect all field wiring leads to their respective H (hot) and N (neutral terminal) screws for the desired channel on terminal board TB3 (Figure 18-1).

Position all field wiring leads under the module strain relief clamp, leaving a small amount of slack on the terminal side of the clamp. Tighten the clamp, ensuring that all interconnecting wires are held firmly in place (Figure 18-1).

RFI Filter Requirements

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). Insert the filter between the AC power main and the accessory terminal module.

Safety Requirements

WARNING

Danger to personnel or equipment may exist if the power controller fails during control of a critical process or function. Always use redundant switching when configuring your application to prevent danger to personnel or damage to equipment.

See Figure 18-2 for a simplified block diagram showing redundant switching control. This diagram provides a simplified illustration of duplicate switching control for a critical application. If the Over-Temp Control (Figure 18-2) fails to operate properly (relay contacts on hot line fuse together), the Redundancy Failure Indicator will illuminate.

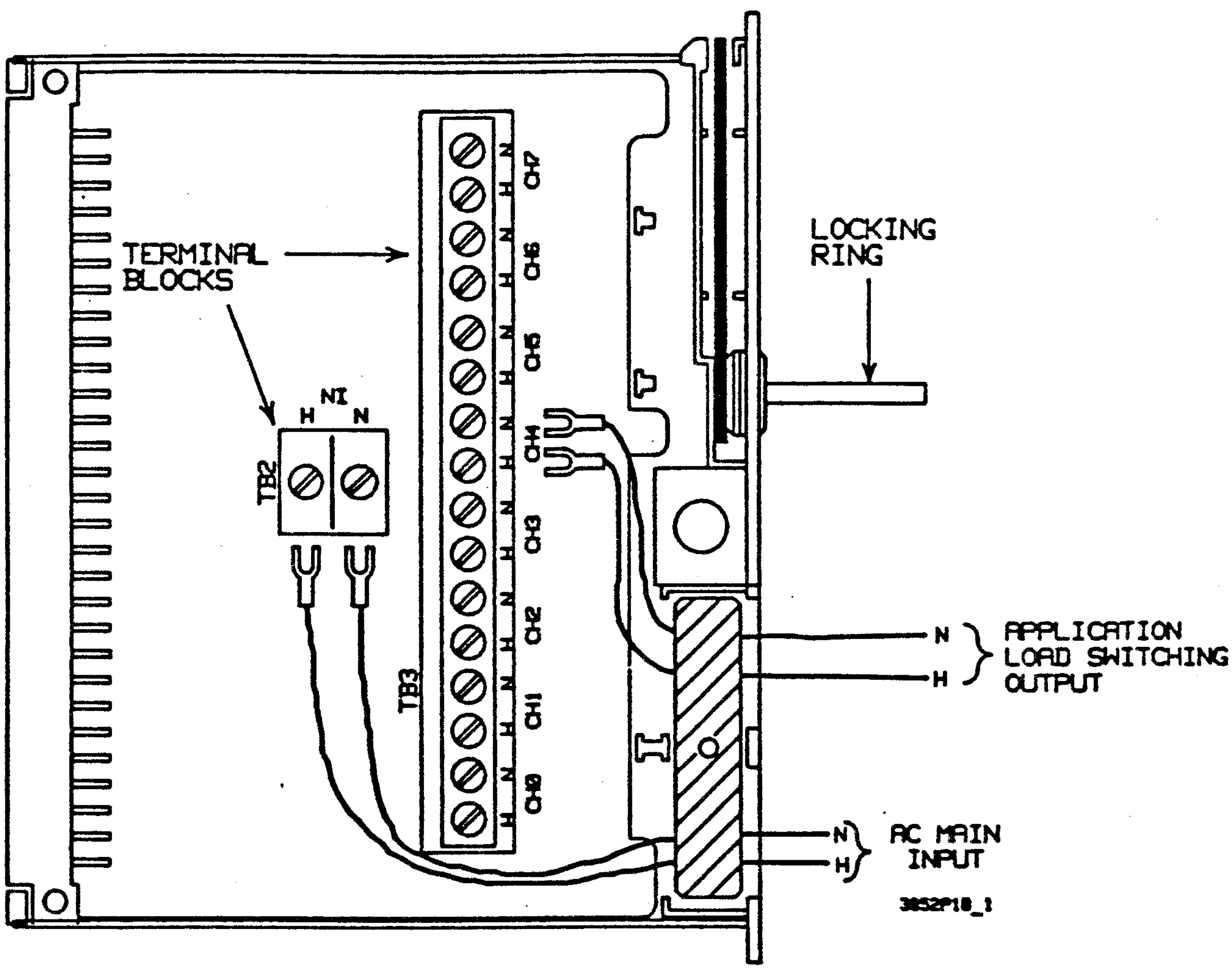


Figure 18-1. Field Wiring Interconnect Diagram

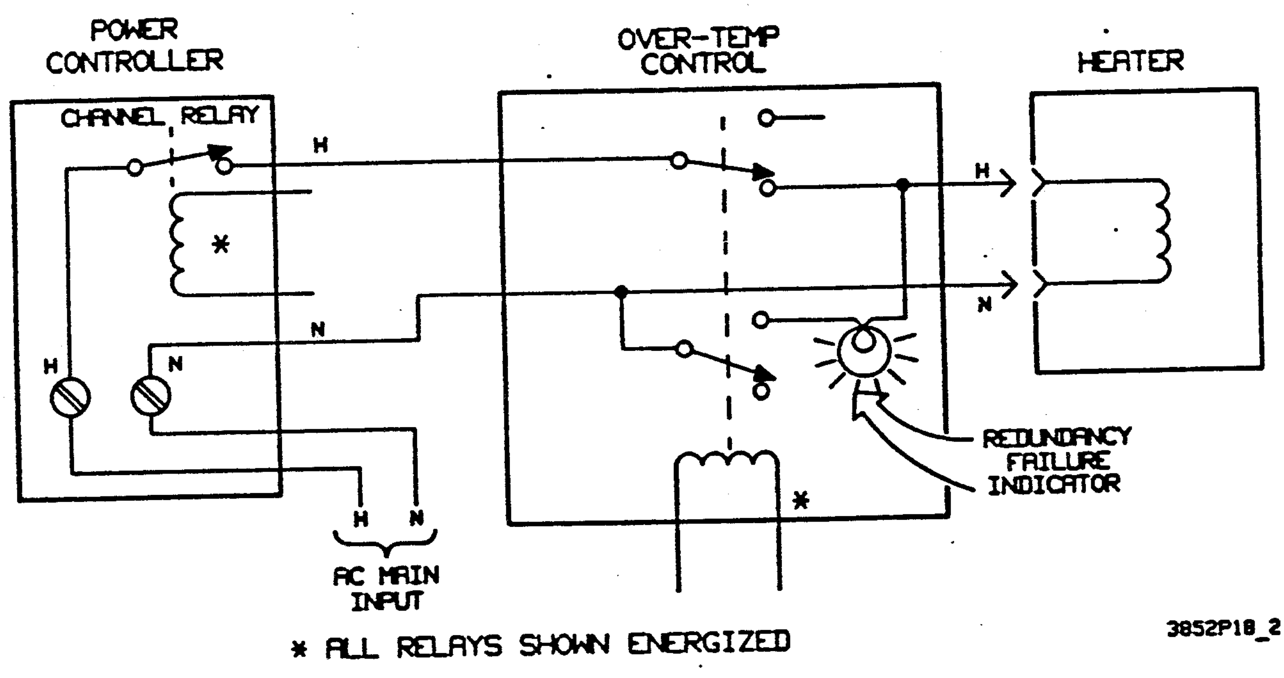


Figure 18-2. Redundant Switching Control, Simplified Block Diagram

Installation and Checkout

△ 1

△ 2

WARNING

Possible voltage hazard to personnel! Only qualified, service-trained personnel who are aware of the hazards should install the accessory.

CAUTION

Damage to accessory components can result from static discharge or excessive voltage. Use static-free handling methods when installing, removing, or reconfiguring the accessory.

Ensure that the terminal module is properly connected to the power controller module and install the accessory in the desired slot.

NOTE

Refer to Chapter 1 of this manual for installation and removal procedures.

To check proper installation of the power controller accessory, enter the following programming sequence (the power controller is installed in slot 4 of the mainframe for this example):

```
100  OUTPUT 709;"ID? 0400"
110  ENTER 709; Ident$
120  PRINT "Accessory in Slot 4 = ";Ident$
130  END
```

If the power controller is properly installed in slot 4 of the mainframe, the message "`Accessory in Slot 4 = 44729A`" will be returned to the CRT and front panel display. If the terminal module is not connected to the power controller module, the message "`Accessory in Slot 4 = 447XXX`" will be returned.

Addressing an empty accessory slot will return "`000000`" to the CRT and mainframe front panel display.

- If an incorrect product identification number is returned, first ensure that the correct terminal module is connected to the power controller module. If the accessory still returns an incorrect product number, refer to the HP 3852A installation and programming manual for procedures to return the power controller accessory to Hewlett-Packard.

- If the accessory returns the correct ID, refer to Programming The Power Controller, below.

Programming The Power Controller

This section describes the programming commands used by the power controller, and provides general programming examples for the accessory.

For additional information on the following power controller commands, and other commands that apply to the complete system, refer to the HP 3852A Data Aquisition/Control System Command Reference Manual.

Programming Commands

Table 18-2 provides a summarized list of the programming commands used with the power controller accessory. Refer to the command reference manual for complete parameter information and prerequisites for command use.

Table 18-2. Command Summary List

CHWRITE ***ch,data***

Write data to channel specified by *ch. Data* programs channel to open or closed state.

CLOSE ***ch list***

Programs channels specified by *ch list* to closed state.

CLOSE? ***ch list***

Queries the programmed state of all channels specified by *ch list.*

ID? ***slot***

Reads identity of accessory installed in slot specified by *slot*

OPEN ***ch list***

Programs all channels s specified by *ch list* to OFF state.

READ ***slot***

Read the programmed state of all channels specified in *slot.*

RST ***slot***

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

WRITE ***slot,number***

Writes programming data to the accessory specified in *slot. Number* is decimal equivalent of binary bit value required to program channels to open (0) or closed (1).

Programming Examples

Table 18-3 provides a list of program examples, showing the program name, function of each program, and the related power controller commands used.

NOTE

Channel switch positions are as follows:

NC = WRITE 0 = CHANNEL OPEN = OFF
NO = WRITE 1 = CHANNEL CLOSED = ON

Table 18-3. Example Program Summary

Program Name	Function	Related Commands
Initial Programming	Verify slot location of accessory, reset accessory to power-on state, program channels to desired state, verify actual programmed state of all channels.	ID?, RST, WRITE, READ
Close Channels	Close desired channels as selected, and return the programmed status of each channel listed (to verify the CLOSE command).	CLOSE, CLOSE?
Open Channels	Open selected channels by two different methods.	OPEN, CHWRITE

Using the READ/ WRITE Commands

Channel programming data sent to, or received from, any card cage accessory by the WRITE and READ commands, must be applied at the accessory as a binary data pattern.

As the HP 200 Series and HP 3852A mainframe controllers transmit and receive data only in decimal format, the WRITE command *number* parameter must be entered as the decimal equivalent of the required binary data pattern. The READ command returns data to the controller CRT and mainframe front panel display as the decimal equivalent of the channel control binary bit pattern showing the programmed state of all accessesory channels in that slot.

To determine the decimal equivalent of a particular binary bit pattern for channel programming, refer to Table 18-4, Decimal-Value-to-Bit-Pattern Conversion. As shown at the bottom of the table, a binary "1" will close a channel and a binary "0" will open a channel. Channel numbers are determined by position from the lease significant bit (LSB), where the LSB is channel 0 and the MSB is channel 7.

Decimal values range from 0 (all channels OFF) to 255 (all channels ON). Refer to the following for an example of determining the decimal value for a binary bit pattern between 0 and 255.

Channel Number:	7 6 5 4 3 2 1 0
Channel Control Binary Bit Pattern:	0 1 1 0 1 0 1 0
Decimal Equivalent:	64 + 32 + 8 + 2 = 106

The above shows that channel 6 (the decimal 64 weighted bit), channel 5 (the decimal 32 weighted bit), channel 3 (the decimal 8 weighted bit), and channel 1 (the decimal 2 weighted bit) are programmed to the ON (closed = NO) state (see Table 18-4).

NOTE

The following programming examples use HP-IB address 709, and hypothetical slot and channel numbers for illustrative purposes only. Program syntax and data returns apply to HP 200 series controllers. To use a different controller, modify the syntax and data returns as required.

Initial Programming

In the following example, the "ID? 0100" command queries the identification of the accessory installed in slot 1 of the mainframe.

- If the power controller is properly installed in slot 1, the message "Accessory ID = 44729A" will be printed on the CRT display.
- If the power controller is, for some reason, not installed in slot 1, the message "Incorrect Accessory or Slot" will be printed on the CRT and front panel display and the program will stop.

The command "RST 0100" resets the accessory located in slot 1 to the power-on condition.

The command "WRITE 100,41" writes the decimal equivalent (41) of the channel control bit pattern (00101001) required to close channel 0,3, and 5 in slot 1 (Table 18-4, below).

The "READ 100" command then reads the programmed state of all channels in accessory slot 1 of the mainframe (100), and returns "Channel Status = 41" to the CRT and display. Refer to Table 18-4, below, to convert decimal 41 to the equivalent channel control bit pattern.

```
20  OUTPUT 709;"ID? 0100"
30  ENTER 709;Powercon$
40  PRINT "Accessory ID =";Powercon$
50    IF Powercon$ <>" 44729A" THEN
60          PRINT "Incorrect Accessory or Slot"
70    ELSE
80    OUTPUT 709;"RST 0100"
90    OUTPUT 709;"WRITE 100,41"
100   OUTPUT 709;"READ 100"
110   ENTER 709;Chanstat
120   PRINT "Channel Status = ";Chanstat
130   END IF
140 END
```

Table 18-4. Decimal-Value-to-Bit-Pattern Conversion

Decimal Value	Channel Number 7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	0	Channel Control Bit Pattern
1	0	0	0	0	0	0	0	1	
.	.							.	
.	.							.	
.	.							.	
254	1	1	1	1	1	1	1	0	
255	1	1	1	1	1	1	1	1	

0 = Open (NC), 1 = Closed (NO)

Close Channels

In the following example the command "CLOSE 402,407" closes channels 2 and 7 in slot 4 of the mainframe. The "CLOSE? 402,407" command then queries the programmed state of channels 2 and 7.

```
100  OUTPUT 709;"CLOSE 402,407"
110  OUTPUT 709;"CLOSE? 402,407"
120  ENTER 709;Chan1,Chan2
130  PRINT "Chan 2 & 7 Status =  ";Chan1;" ";Chan2
140  END
```

The message "`Chan 2 & 7 Status = 1 1`" will then be returned to the CRT display, showing that channels 2 and 7 are now programmed in a closed state.

Open Channels

The following example uses the command OPEN to program all accessory channels specified in command parameter *ch list* to the open state.

The command CHWRITE is used to program a specific channel (command parameter *ch*) to the open state (command parameter *data*).

```
     .
     .
220  OUTPUT 709;"OPEN 201,305,504"
     .
     .
     .
374  OUTPUT 709;"CHWRITE 403,0"
     .
     .
```

The command string "OPEN 201,305,504" programs slot 2-channel 1, slot 3-channel 5, and slot 5-channel 4 to the open state.

The command string "CHWRITE 403,0" programs only the channel specified (slot 4-channel 3) to the open (0) position.

Contents

Chapter 19
HP 44736A Breadboard

Chapter 19
Breadboard
HP 44736A

Introduction

This chapter shows how to configure and program the HP 44736A Breadboard Accessory. The chapter has five sections: Introduction, Specifications, Configuring the Breadboard, Programming the Breadboard, and Replaceable Parts.

- **Introduction** contains a chapter overview, a description of the accessory, warranty information, and shows suggested steps to get started.
- **Specifications** lists the specifications, the dimensions of the accessory, and the component height and protrusion restrictions.
- **Configuring the Breadboard** contains information on the backplane signals, designing backplane interface circuitry, using the Identity Register, and hints on mounting components.
- **Programming the Breadboard** contains information on register programming and reading the accessory identity.
- **Replaceable Parts** includes the mechanical breakdown of the accessory, assembly and disassembly information, and the replaceable parts list for the accessory.

Description

In contrast to the other HP 3852A plug-in accessories, the HP 44736A provides a "breadboard" for design engineers or technicians to custom-design circuitry for use with the mainframe and HP 3853A Extender. You can use the breadboard for specialized applications which haven't been satisfied by the available plug-in accessories.

The breadboard accessory consists of two modules: a breadboard module and a terminal module. The breadboard module contains no circuitry and is intended for your designed circuitry. This module makes the actual connections to the HP 3852A/HP 3853A backplanes. The removable terminal module attaches to the breadboard module and contains 35 screw terminals for connecting external wiring to the breadboard.

Warranty Information

The breadboard warranty (located at the front of this manual) is different than the standard Hewlett-Packard warranty for the HP 3852A and the other plug-in accessories. While Hewlett-Packard is responsible for defects in materials and workmanship of the blank circuit boards and supplied hardware, Hewlett-Packard is not responsible for the performance of your designed circuits. In addition, Hewlett-Packard is not responsible for damage or improper operation of the HP 3852A, HP 3853A, or other plug-in accessories when the breadboard is installed.

Getting Started

To use the breadboard for your application, you will need to:

- Define your application.
- Design and mount your circuitry.
- Program the accessory for your application.

Define Your Application

The first step is to define your application and determine if the breadboard can meet the requirements of your application. The breadboard provides a connection to the backplane signals available on the mainframe and extender. Three power supplies are available through the backplane connector: a regulated supply (+5 VDC), a positive unregulated supply (+17.4 to +22.0 VDC), and a negative unregulated supply (-17.4 to -31.0 VDC). Refer to "Specifications" for the maximum component height and protrusion restrictions, maximum power dissipation, operating temperature range, and power supply specifications.

Design and Mount Your Circuitry

The next step is to design the circuits that you will mount on the breadboard for your application. Refer to "Configuring the Breadboard" for a description of the backplane signals that are available, design suggestions, backplane timing diagrams, information on designing backplane interface circuitry, and hints on mounting components on the accessory.

Program the Accessory

If your breadboard is being designed to connect to the backplane bus, the third step is to program the accessory for your application. The breadboard can be controlled over the backplane bus using read and write registers. Refer to "Programming the Breadboard" for information on register programming using the SREAD (register read) and SWRITE (register write) commands, and information on reading the accessory identity using the ID? command.

Specifications

Specifications are the performance standards or limits against which the accessory may be tested. The specifications for the breadboard are shown below.

Maximum Component Height: 16.9 mm (0.66 in.)

Maximum Component Lead Length: 3 mm (0.118 in.)

Maximum Power Dissipation: 7 watts per slot*

Operating Temperature: 0 - 55°C, non-condensing;
Relative Humidity to 95%

Unregulated Voltage Available: +17.4 to +22.0 VDC (+21 VDC nominal);
-17.4 to -31.0 VDC

Regulated Voltage Available: +5 VDC (+4.8 to +5.25 VDC)

*This includes power drawn from all power supply lines plus externally supplied power dissipated by the circuitry on the accessory.

Figure 19-1 shows the dimensions of the space available for components and the component height and protrusion (lead length) restrictions. Note that the component height and lead length restrictions are determined by the metal shields that surround the breadboard.

NOTE

The metal shields should never be eliminated as they provide RF shielding and structural support to the accessory.

Figure 19-1. Dimensions and Component Height/Protrusion Restrictions

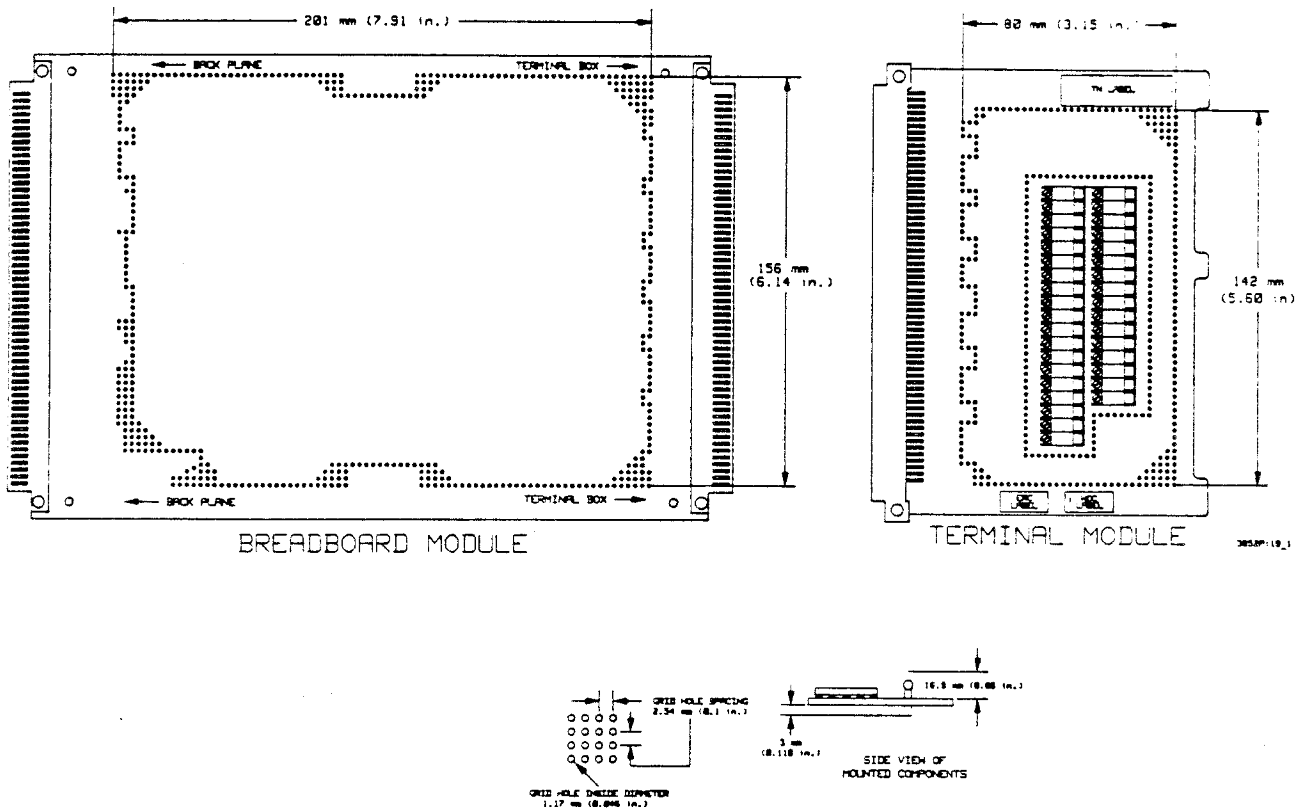


Figure 19-1. Dimensions and Component Height/Protrusion Restrictions

Configuring the Breadboard

This section includes information on the backplane signals, designing backplane interface circuitry, using the Identity Register, and hints on mounting components to the accessory. Refer to "Programming the Breadboard" for information on register programming and reading the accessory identity.

NOTE

Before designing or mounting any backplane interface circuits to the breadboard, familiarize yourself with all backplane signals described in this section. Also, see the following list for precautions and suggestions:

- Observe all WARNINGS and CAUTIONS in this chapter.
- Be sure to observe all power supply and power dissipation limits.
- Observe the component height and protrusion restrictions.
- Keep in mind that other plug-in accessories will share the same backplane signals as your breadboard.

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.*

⚠ 2 *For safety, consider all channels on the accessory to be at the highest voltage applied to any channel.*

WARNING

The HP 3852A and the HP 3853A internal analog buses interconnect the multiplexer accessories and voltmeter accessories to form one circuit. To protect against 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 below 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:

Instrument/Accessory	Maximum Allowable Peak Voltage
HP 3852A Mainframe	350V
HP 3853A Extender	350V
HP 44701A Integrating Voltmeter	350V
HP 44702A/B High-Speed Voltmeter	42V
20-Channel Relay Multiplexers	170V
60-Channel Relay Multiplexer	42V
All FET Multiplexers	42V
All other accessories - no connection to analog bus	

If the analog extender cable is NOT connected between the mainframe and the extenders, each instrument is considered as a separate analog circuit.

The mainframe and extender backplanes consist of 74 lines including power supply lines, ground lines, and logic signal lines which control the plug-in accessories. The breadboard connects into the backplane, as do the other plug-in accessories, to bring the signals to the circuitry on the accessory. Figure 19-2 shows the backplane 74-pin connector with the pin numbers and names shown. Refer to "Backplane Signals" for a complete description of each line.

CAUTION

The connector diagram shown in Figure 19-2 applies ONLY to the connectors in slots 0 through 7 of the mainframe and slots 0 through 9 of the Extender. To avoid possible damage to the instrument and the breadboard, NEVER install the breadboard in any other slot (e.g., the slots reserved for the controller module and power module should NOT be used).

Figure 19-2. HP 3852A/HP 3853A Backplane Connector

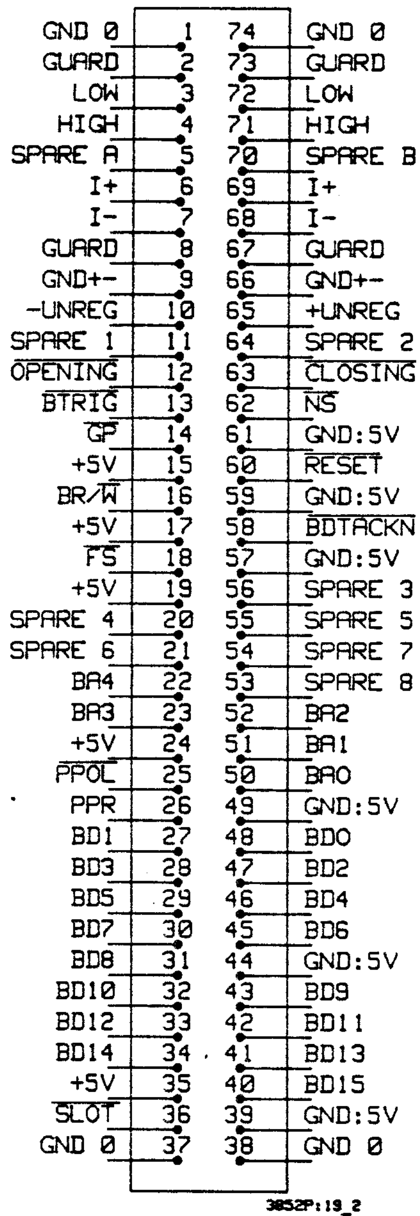


Figure 19-2. HP 3852/3853A Backplane Connector

The breadboard consists of a breadboard module and a removable terminal module as shown in Figure 19-3. Field wiring from your application will connect to the terminal module and the signals will be sent to your designed circuitry located on the breadboard module.

Figure 19-3. HP 44736A Breadboard Accessory

The breadboard module contains no circuitry and is intended for your custom-designed circuitry. This module connects into the backplane to enable you to access the signals which control the plug-in accessories and pass data to and from the mainframe.

The terminal module consists of 35 screw terminals (numbered 1 through 35) for connecting external field wiring to the accessory. When connecting field wiring to the terminal module, route the wires through the strain relief clamp and tighten the clamp screw to reduce the chance of wires being pulled from the screw terminals.

NOTE

As shipped from the factory, the screw terminals are not soldered into the terminal module circuit board. A piece of foam rubber in included inside the terminal module to hold the screw terminals in place during shipment.

Figure 19-4 shows the backplane lines as they appear on the edge of breadboard module circuit board that plugs into the backplane. For those lines that will be used most often (e.g., power supplies and grounds), multiple holes are provided for easy access. The chassis/safety ground lines (GND 0) connect to the sheet metal and chassis ground bus traces are available along the edges of the circuit board as shown in Figure 19-4.

Figure 19-4. Breadboard Module Signal Layout

Backplane Signals

The backplane lines shown in Figures 19-2 and 19-4 can be grouped into four categories: Ground Lines, Power Supply Lines, Analog Lines, and Logic/Control Lines. Table 19-1 lists all 74 backplane lines with pins numbers and which of the four categories the line belongs. This section also includes a technical description of the backplane lines.

NOTE

Before designing or mounting any backplane interface circuitry, familiarize yourself with all backplane lines discussed in this section.

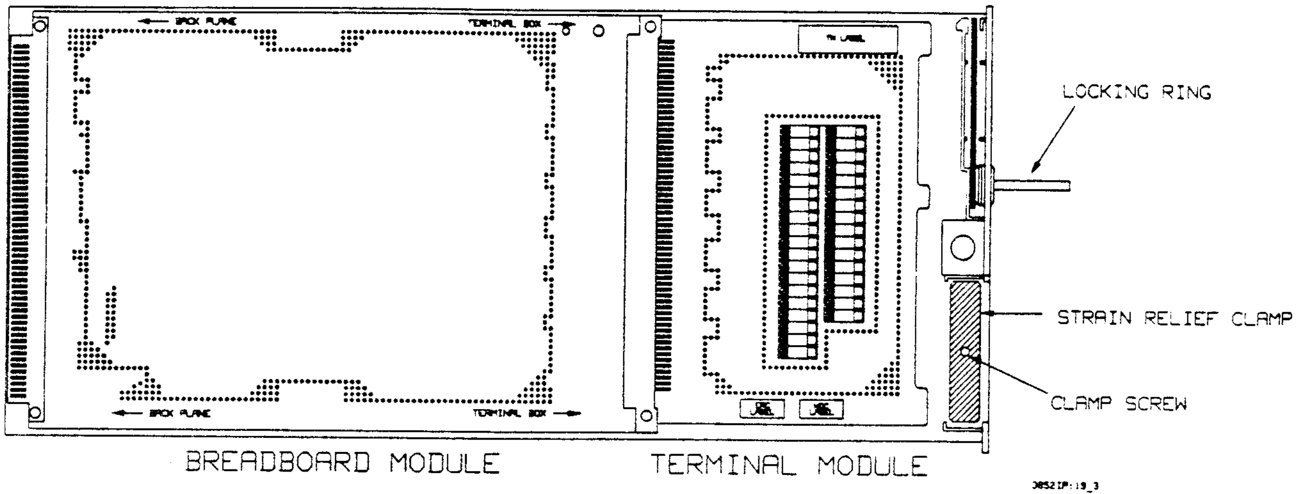


Figure 19-3. HP 44736A Breadboard Accessory

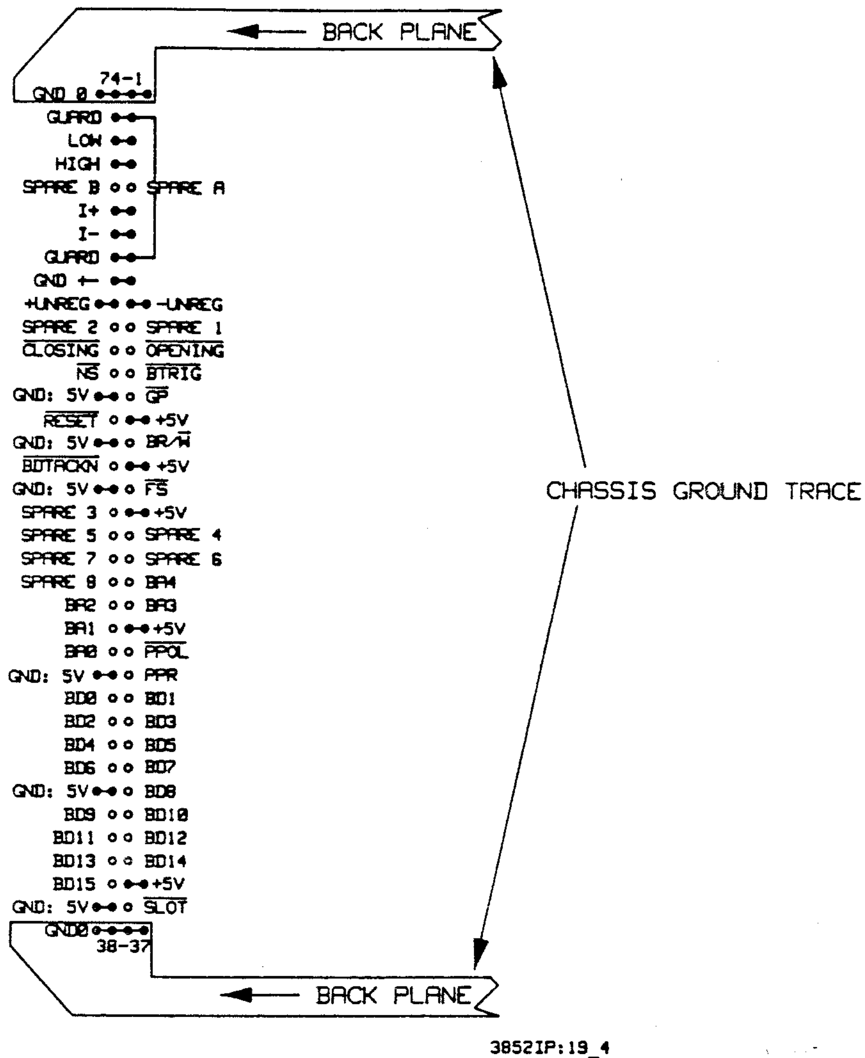


Figure 19-4. Breadboard Module Signal Layout

Table 19-1. Summary of Backplane Signal Categories

Line Name	Pin Number	Category	Line Name	Pin Number	Category
GND 0	1	Ground	GND 0	38	Ground
GUARD	2	Analog	GND: 5V	39	Ground
LOW	3	Analog	BD15	40	Logic/Control
HIGH	4	Analog	BD13	41	Logic/Control
SPARE A	5	*	BD11	42	Logic/Control
I+	6	Analog	BD9	43	Logic/Control
I-	7	Analog	GND: 5V	44	Ground
GUARD	8	Analog	BD6	45	Logic/Control
GND +-	9	Ground	BD4	46	Logic/Control
-UNREG	10	Power Supply	BD2	47	Logic/Control
SPARE 1	11	*	BD0	48	Logic/Control
$\overline{\text{OPENING}}$	12	Logic/Control	GND: 5V	49	Ground
$\overline{\text{BTRIG}}$	13	Logic/Control	BA0	50	Logic/Control
$\overline{\text{GP}}$	14	Logic/Control	BA1	51	Logic/Control
+5V	15	Power Supply	BA2	52	Logic/Control
BR/$\overline{\text{W}}$	16	Logic/Control	SPARE 8	53	*
+5V	17	Power Supply	SPARE 7	54	*
$\overline{\text{FS}}$	18	Logic/Control	SPARE 5	55	*
+5V	19	Power Supply	SPARE 3	56	*
SPARE 4	20	*	GND: 5V	57	Ground
SPARE 6	21	*	$\overline{\text{BDTACKN}}$	58	Logic/Control
BA4	22	Logic/Control	GND: 5V	59	Ground
BA3	23	Logic/Control	$\overline{\text{RESET}}$	60	Logic/Control
+5V	24	Power Supply	GND: 5V	61	Ground
$\overline{\text{PPOL}}$	25	Logic/Control	$\overline{\text{NS}}$	62	Logic/Control
PPR	26	Logic/Control	$\overline{\text{CLOSING}}$	63	Logic/Control
BD1	27	Logic/Control	SPARE 2	64	*
BD3	28	Logic/Control	+UNREG	65	Power Supply
BD5	29	Logic/Control	GND +-	66	Ground
BD7	30	Logic/Control	GUARD	67	Analog
BD8	31	Logic/Control	I-	68	Analog
BD10	32	Logic/Control	I+	69	Analog
BD12	33	Logic/Control	SPARE B	70	*
BD14	34	Logic/Control	HIGH	71	Analog
+5V	35	Power Supply	LOW	72	Analog
$\overline{\text{SLOT}}$	36	Logic/Control	GUARD	73	Analog
GND 0	37	Ground	GND 0	74	Ground

* These lines don't actually fall into any of the categories shown but they are discussed in the "Logic/Control Lines" category in this chapter.

Ground Lines

GND 0 -- Pins 1, 74, 37, 38

Electrostatic discharge (ESD) path and safety ground. These are the four corner pins on the backplane connector and ALL four should be used. This ground is tied to the accessory sheet metal cover and to chassis ground. Along the outer edges of the breadboard module printed circuit board, chassis ground bus traces are provided for easy access to this line (see Figure 19-4).

GND +- -- Pins 9, 66

Return path for currents drawn from the unregulated voltage supply lines (+UNREG, -UNREG).

GND: 5V -- Pins 61, 59, 57, 49, 44, 39

Return path for the currents drawn from the +5 VDC power supply. It is recommended that you use all six pins provided on the backplane to pick up this ground.

NOTE

All ground lines are connected together and to safety ground in the mainframe and extender power supply modules. Use all grounds provided and tie GND 0 to the accessory sheet metal covers to help minimize electrostatic discharge (ESD) susceptibility and radio frequency interference (RFI).

Power Supply Lines

+5V -- Pins 15, 17, 19, 24, 35

+5 Volt Logic Supply.

```
Output Voltage:  +4.8 VDC to +5.25 VDC
Ripple and Noise:  < 100 mV peak-to-peak
Maximum Load Per Slot:  3.1 watts (included as part of +UNREG load rating)
Maximum Capacitive Load Per Slot:  10 µF
Current Supplied to Short Circuit:  9A max.
Maximum Non-Transient Value on Malfunction:  +6.25V
```

+UNREG -- Pin 65

Positive Unregulated Voltage Supply.

```
Output Voltage:  +17.4 VDC to +22.0 VDC  (+21 VDC nominal)
Ripple and Noise:  < 0.5V peak-to-peak
Maximum Load Per Slot:  4.6 watts (1.5 x (5V power used))*
Maximum Capacitive Load Per Slot:  1000 µF
Maximum Allowed Surges Per Slot:  0.0025 Coulomb/transient
Current Supplied to Short Circuit:  4.5A max.
Maximum Value on Malfunction:  +25V
```

* = If no 5V power is used, 4.6 watts may be drawn from +UNREG, but if the maximum of 3.1 watts of 5V power is used, none may be drawn from +UNREG.

-UNREG -- Pin 10

Negative Unregulated Voltage Supply.

```
Output Voltage:  -17.4 VDC to -31.0 VDC
Maximum Load Per Slot:  1.2 watts
Maximum Capacitive Load Per Slot:  1000 µF
Maximum Current Supplied to Short Circuit:  2.5A max.
Maximum Value on Malfunction:  -40V
```

Analog Lines

The analog lines are used by the voltmeter accessories when making measurements. The HP 44701A Integrating Voltmeter uses the HIGH, LOW, and GUARD terminals for measuring voltages and the I+ and I- lines to source current when making resistance measurements. When making resistance measurements, voltage sense is done on the HIGH and LOW lines. The HP 44702A/B High-Speed Voltmeter measures differentially on the HIGH and LOW lines and the GUARD line is tied to chassis at the voltmeter.

Voltages to ±350 volts peak with respect to chassis may be present on the analog lines. For safety, you MUST handle the analog lines in accordance with International Electrotechnical Commission (IEC 348) standards, which includes maintaining 2 mm metal-to-metal spacing between lines even if they aren't used.

NOTE

The path resistance from slot 0 to the analog extender connector (located on the power supply module) on the High, Low, I+, and I- lines is approximately 1Ω. The path resistance for the Guard line is approximately 0.1Ω.

All plug-in accessories that connect to the analog bus require high-impedance designs in order to maintain the high impedance specifications of each accessory.

HIGH -- Pins 4, 71

High Common. Connects to HI terminal of voltmeter accessory.

LOW -- Pins 3, 72

Low Common. Connects to LO terminal of voltmeter accessory.

GUARD -- Pins 2, 73, 8, 67

Guard Common. Connects to GUARD terminal of voltmeter accessory. If an HP 44702A/B High-Speed Voltmeter is installed, this line is tied to chassis ground (GND 0).

I+ -- Pins 6, 69

Current Source. Connects to current source HI terminal of voltmeter accessory.

I- -- Pins 7, 68

Current Source Return Path. Connects to current source LO terminal of voltmeter accessory.

Logic/Control Lines

This section describes the backplane logic and control lines. Refer to "Backplane Timing Diagrams" for the read/write, reset, and multiplexer break-before-make synchronization timing diagrams.

$\overline{\text{OPENING}}$ -- Pin 12 (Input/Output for Multiplexers)

Opening Strobe. This is an open-collector line which is used in conjunction with the CLOSING line to ensure break-before-make switching on multiplexer channels. When a command is executed to open an accessory channel, a low signal is output from the accessory to the OPENING line to indicate that a channel is in the process of opening.

When a command is executed to close a multiplexer channel, it is stored on the multiplexer until the state of the OPENING line is determined. If the OPENING line is high (indicating that all other channels in the system are finished opening), the channel is closed and a low signal is output from the accessory to the CLOSING line. If the OPENING line is low (indicating that there are channels in the process of opening), the channel closure is delayed until the OPENING line returns high.

The requirements for the OPENING line are:

```
VIH max. @ IIH = 3.7V @ 1 µA
VIL min. @ IIL = 0.9V @ 1 µA

VOL max. @ IOL = 0.5V @ 13 mA
Leakage Current when Disabled = 15 µA max.
```

NOTE

A Schmitt Trigger input must be used for waveshaping purposes if this line is to be used as an input to a measurement accessory.

$\overline{\text{CLOSING}}$ -- Pin 63 (Input to Voltmeters/Output from Multiplexers)

Closing Strobe. This is an open-collector line used by the multiplexer accessories to indicate that a channel is in the process of closing. This line is the counterpart to the OPENING line.

NOTE

For scanning operations, a voltmeter accessory can be set to trigger on the low-to-high transition of the CLOSING line.

The requirements for the CLOSING line are:

```
VIH max. @ IIH = 3.7V @ 1 µA
VIL min. @ IIL = 0.9V @ 1 µA

VOL max. @ IOL = 0.5V @ 13 mA
Leakage Current when Disabled = 15 µA max.
```

NOTE

A Schmitt Trigger input must be used for waveshaping purposes if this line is to be used as an input to a measurement accessory.

$\overline{\text{BTRIG}}$ -- Pin 13 (Input to Accessory)

Backplane Hardware Trigger. This is the backplane trigger input to the plug-in accessories. A low signal (at least 500 nS in length) is generated by the mainframe when it receives a TRG command. This line is required only for those accessories which use this triggering command.

The requirements for the BTRIG line are:

VIH max. @ IIH = 3.7V @ 1 µA
VIL min. @ IIL = 0.9V @ 1 µA
Capacitance Limit = 15 pF

$\overline{\text{GP}}$ -- Pin 14 (Output from Accessory)

General purpose interrupt output. This is an open-collector line which is set low to interrupt the mainframe.

The requirements for the GP line are:

VOH max. @ IOH = 5.5V @ 100 µA

$\overline{\text{NS}}$ -- Pin 62 (Output from HP 44701A)

Normal scan interrupt output from an HP 44701A Integrating Voltmeter. This is an open-collector line which is set low to interrupt the mainframe. This line is dedicated for use with the HP 44701A and should not be used with the breadboard.

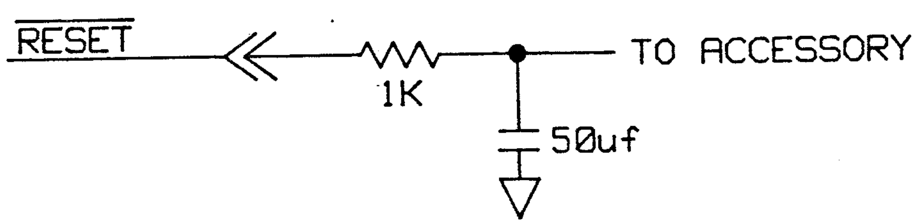
$\overline{\text{FS}}$ -- Pin 18 (Output from HP 44702A/B)

Fast scan interrupt output from an HP 44702A/B High-Speed Voltmeter. This is an open-collector line which is set low to interrupt the mainframe. This line is dedicated for use with the HP 44702A/B and should not be used with the breadboard.

$\overline{\text{RESET}}$ -- Pin 60 (Input to Accessory)

Backplane reset input to the plug-in accessories. This line will be pulled low for at least 50 µS to perform a backplane reset. The reset operation should place the breadboard in a state that is as safe as possible for the breadboard and the user connections (e.g., zero outputs, high-impedance state, all channels disconnected from the backplane, etc.).

If power is applied to the mainframe or extender when a plug-in accessory is being installed, a glitch on this line could reset the backplane. To prevent a possible unwanted reset, install a low pass RC filter using a 1 kΩ series resistor (minimum) and a 50 µF capacitor to ground on the input to the accessory as shown below.



The requirements for the RST line are:

```
VIH max. @ IIH =  3.7V @ 4 µA
VIL min. @ IIL =  0.9V @ 4 µA
```

BR/W -- Pin 16 (Input to Accessory)

Backplane read/write direction control. A high signal from the mainframe on this line enables the read function; a low signal enables the write function. This line is used in conjunction with the BDTACKN and SLOT lines to handshake data on the data lines (refer to "Backplane Timing Diagrams").

The requirements for the BR/W line are:

```
VIH max. @ IIH = 3.7V @ 1 µA
VIL min. @ IIL = 0.9V @ 1 µA
Capacitance Limit = 15 pF
```

BDTACKN -- Pin 58 (Output from Accessory)

Bus Handshake Line. This is an open-collector line used for read and write operations. An error will occur on the microprocessor bus if this line isn't set low within 1 mS after the slot select line (SLOT) goes low. BDTACKN must be released when the SLOT line goes high. On a read operation, data must be valid no later than 300 nS after BDTACKN is set low and must remain valid until SLOT goes high (refer to "Backplane Timing Diagrams").

The requirements for the BDTACKN line are:

```
VOH max. @ IOH = 5.5V @ 100 µA
```

SLOT -- Pin 36 (Input to Accessory)

Slot select input to the plug-in accessories. There is a unique slot select line from the mainframe to each backplane slot. The mainframe selects a specific slot for communication by asserting a low signal on the SLOT line of the appropriate slot.

The requirements for the SLOT line are:

```
VIH max. @ IIH = 3.7V @ 4 µA
VIL min. @ IIL = 0.9V @ 4 µA
Capacitance Limit = 50 pF
```

PPOL -- Pin 25 (Input to Accessory)

Parallel Poll Slots. This is a parallel poll request to all slots. The line is pulled low by the mainframe to query which slot is interrupting. The accessory's response to the parallel poll comes on the PPR line.

The requirements for the PPOL line are:

```
VIH max. @ IIH = 3.7V @ 4 µA
VIL min. @ IIL = 0.9V @ 4 µA
Capacitance Limit = 15 pF
```

PPR -- Pin 26 (Output from Accessory)

Slot Response to Parallel Poll. This open-collector output line is required only if the accessory has interrupt capability. To respond affirmatively to the parallel poll (i.e., confirm that the interrupt initiated from this slot), the accessory pulls this line low while PPOL is low. On the backplane, each PPR line is tied to the data line (BD) corresponding to the slot number (e.g., in slot 0 of the mainframe/extender, PPR is tied to data line BD0; in slot 1, PPR is tied to BD1, etc.).

NOTE

The minimum amount of time from the parallel poll request (PPOL low) to the parallel poll response (PPR low) is 300 nSec.

The requirements for the PPR line are:

```
VOL max. @ IOL = 0.5V @ 3 mA
```

BA4-BA0 -- Pins 22, 23, 52, 51, 50 (Input to Accessory)

Register Address Select Lines. Example: To select register 6, these lines would have the following logic:

BA4	BA3	BA2	BA1	BA0
0	0	1	1	0

The requirements for the address lines are:

```
VIH max. @ IIH = 3.7V @ 1 µA
VIL min. @ IIL = 0.9V @ 1 µA
Capacitance Limit = 15 pF
```

BD15-BD0 -- 40, 34, 41, 33, 42, 32, 43, 31, 30, 45, 29, 46, 28, 47, 27, 48

Bi-directional (input/output) tri-state data bus lines. Data is transferred between the HP 3852A and the plug-in accessories on these lines.

The requirements for the data lines are:

```
VIH max. @ IIH = 3.7V @ 1 µA
VIL min. @ IIL = 0.9V @ 1 µA

VOH min. @ IOH = 4.0V @ 100 µA
VOL max. @ IOL = 0.5V @ 3 mA
Capacitance Limit = 25 pF
```

SPARE -- 5, 70, 11, 64, 56, 20, 55, 21, 54, 53

All lines labeled "SPARE" are not used. However, spare lines which have the same label are connected to one another (e.g., Pin 5 - "SPARE A" is common to all slots on the backplane).

Designing Circuitry

This section includes information on designing circuitry for use with the breadboard. Design suggestions, backplane timing diagrams, and information on designing read/write registers is included in this section.

Design Suggestions

The following includes suggestions to be used when designing circuitry for the breadboard. Information on buffering the data bus, switching inductive loads, and switching high-voltages and power is included.

Buffering the Data Bus

The data bus drive capability is limited and the data bus lines may require buffering depending on your application. If the data direction is always from the HP 3852A to the breadboard (write operation), data latches can be placed directly on the data bus as shown in Figure 19-5.

Figure 19-5. Data Bus Configuration for Write Operation

Whenever the data direction is from the breadboard to the HP 3852A (read operation), the data bus should be buffered using a tri-state device such as the 74HC245. A typical data bus configuration for a read operation is shown in Figure 19-6.

Figure 19-6. Data Bus Configuration for Read Operation

Switching Inductive Loads

If your application involves switching inductive loads, contact protection (arc suppression) circuits may be required. These suppression circuits serve to minimize radio frequency interference (RFI), voltage and current surges, and relay contact breakdown.

The following simplified design equations for a resistive-capacitive (RC) arc suppression network will provide adequate protection in most cases. However, since the R and C values involve parameters difficult to determine precisely (such as the type of relay used, wiring capacitance, etc.), tests should be performed to determine the effectiveness in actual circuits. The design equations are only

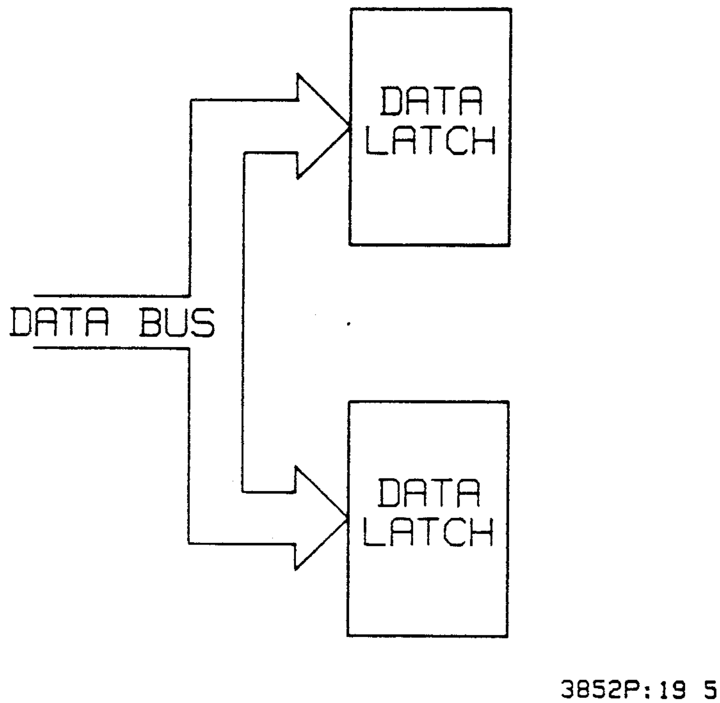


Figure 19-5. Data Bus Configuration for Write Operation

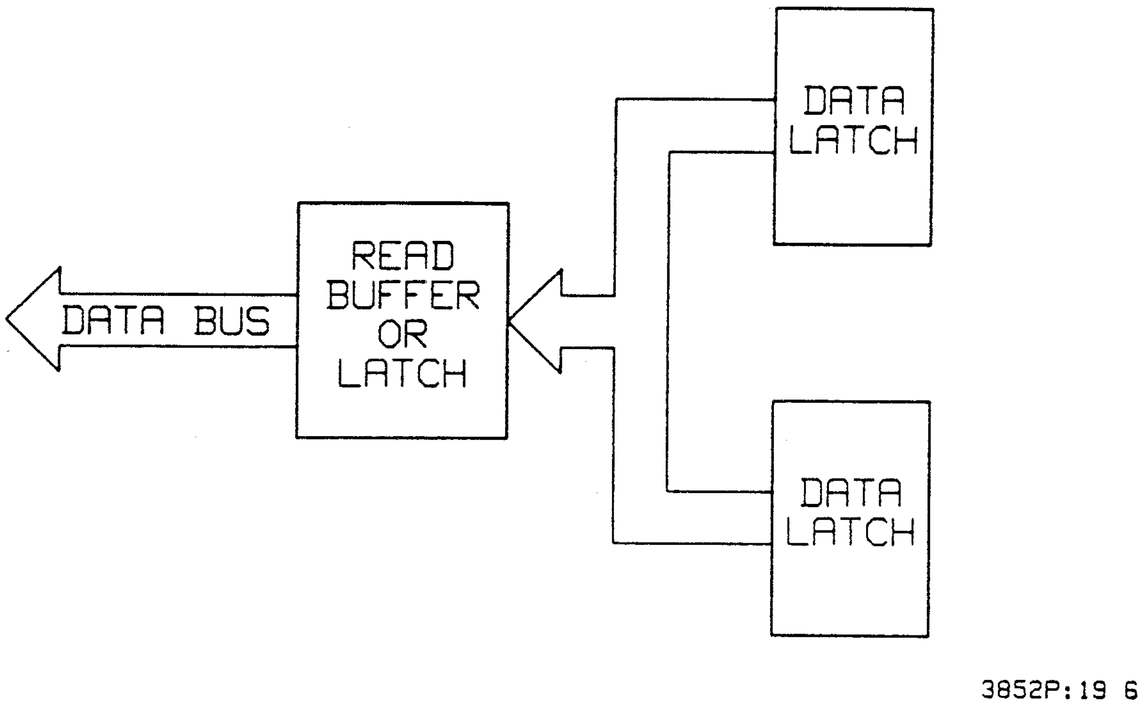


Figure 19-6. Data Bus Configuration for Read Operation

guidelines and are not warranted. Figure 19-7 shows a typical arc suppression circuit.

- R is selected as a compromise between two values. The minimum value for R is determined by the maximum acceptable relay contact current. Thus, the minimum value for R is Vp/I, where Vp is the peak value of the supply voltage and I is the relay current. The maximum value for R is usually equal to the load resistance, RL. Therefore, the limits on R are: $Vp/I < R < RL$.
- To compute the value of C, use the equation: $C \geq ((Io/300)^2 \times L)$, where L is the load inductance, Io is the current through L just before the relay opens, and C is the total circuit capacitance.

Figure 19-7. Typical Arc Suppression Circuit

Switching High-Voltage and Power

To minimize interference caused by high-voltage switching, maintain maximum isolation between the switched voltages and the HP 3852A logic circuitry, and choose relays which have a low contact-to-coil capacitance.

To ensure compliance with applicable standards for Electromagnetic Interference, circuits should be constructed using good RF practice, such as ensuring that all connections are enclosed by shields connected to local earth grounds via low-impedance paths.

When your application involves bringing the power line onto the circuit board, the power line may require a transient suppression circuit to minimize interference with the HP 3852A. A typical transient protection circuit is shown in Figure 19-8.

Figure 19-8. Transient Protection Circuit

Backplane Timing Diagrams

The following section contains timing information and the timing diagrams for the read/write operation, the reset operation, opening/closing multiplexer channels, and scanning multiplexer channels.

Read/Write Operation

The SREAD and SWRITE commands are used to read and write data to and from the breadboard. When using the SREAD and SWRITE commands, the read and write timing diagrams are important. See Figure 19-9 for these timing diagrams. Refer to "Programming the Breadboard" for more information on the SREAD and SWRITE commands.

Figure 19-9. Read/Write Timing Diagrams

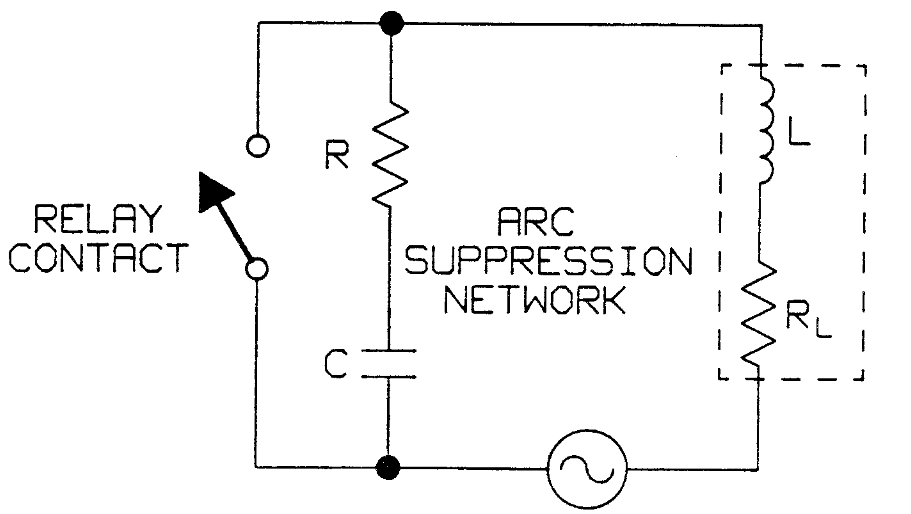


Figure 19-7. Typical Arc Suppression Circuit

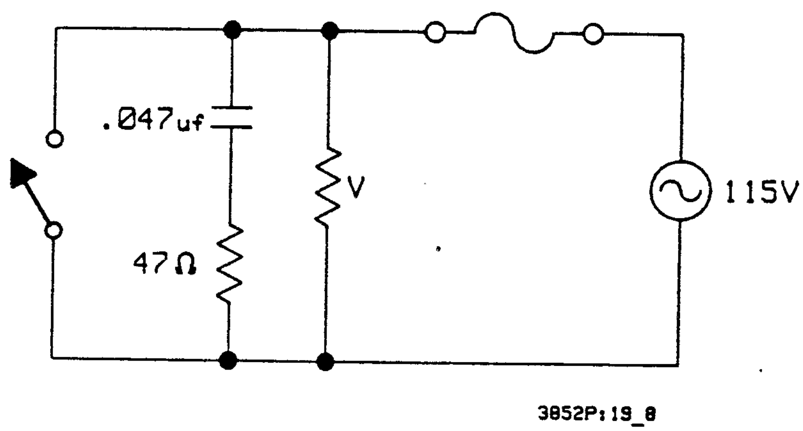
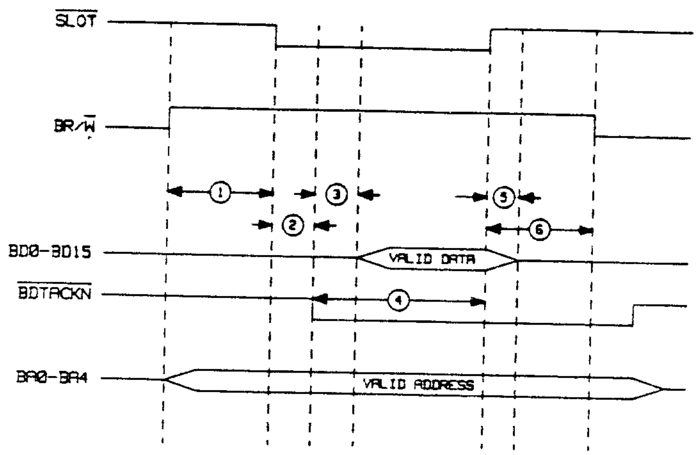


Figure 19-8. Transient Protection Circuit

READ



① ADDRESS VALID, BR/$\overline{\text{W}}$ TO $\overline{\text{SLOT}}$ LOW= 90nSec MIN.

② $\overline{\text{SLOT}}$ LOW TO $\overline{\text{BDTACKN}}$ LOW= 1mSec MAX.

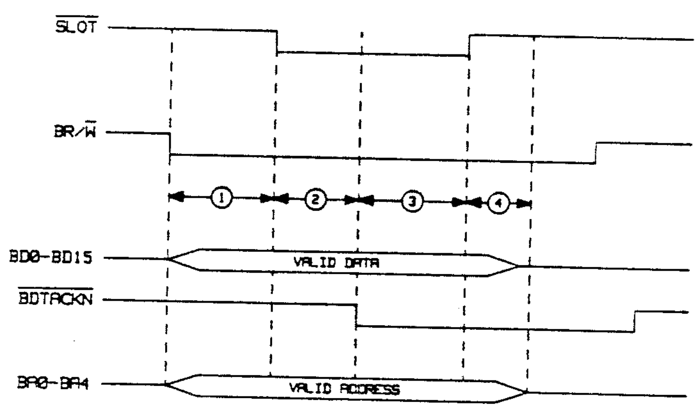
③ $\overline{\text{BDTACKN}}$ LOW TO DATA VALID= 300nSec MAX.

④ $\overline{\text{BDTACKN}}$ LOW TO $\overline{\text{SLOT}}$ HIGH= 750nSec MIN.

⑤ $\overline{\text{SLOT}}$ HIGH TO DATA INVALID= 0nSec MIN.

⑥ $\overline{\text{SLOT}}$ HIGH TO BR/$\overline{\text{W}}$ LOW= 90nSec MIN.

WRITE



① ADDRESS VALID/DATA VALID, BR/$\overline{\text{W}}$ TO $\overline{\text{SLOT}}$ LOW= 90nSec MIN.

② $\overline{\text{SLOT}}$ LOW TO $\overline{\text{BDTACKN}}$ LOW= 1mSec MAX.

③ $\overline{\text{BDTACKN}}$ LOW TO $\overline{\text{SLOT}}$ HIGH= 750nSec MAX.

④ $\overline{\text{SLOT}}$ HIGH TO DATA INVALID/ADDRESS INVALID= 90nSec MIN.

3852P:19_9

Figure 19-9. Read/Write Timing Diagrams

When an accessory is addressed, the SLOT line goes true (to the low state). The register number is specified by the address lines (BA4-BA0). For example, to specify register 6, the address lines would have the following logic:

BA4	BA3	BA2	BA1	BA0
0	0	1	1	0

When the SREAD command is executed, the BR/W line is high to enable the read function. When the SWRITE command is executed, the BR/W line goes low to enable the write function. The data bus lines (BD15-BD0) are common to all accessories installed in the same mainframe or extender.

Reset Operation

The reset operation should place the breadboard in a state that is as safe as possible for the breadboard and the user connections (e.g., zero outputs, high-impedance state, all channels disconnected from backplane, etc.). Figure 19-10 shows the timing diagram for the reset operation.

Figure 19-10. Reset Timing Diagram

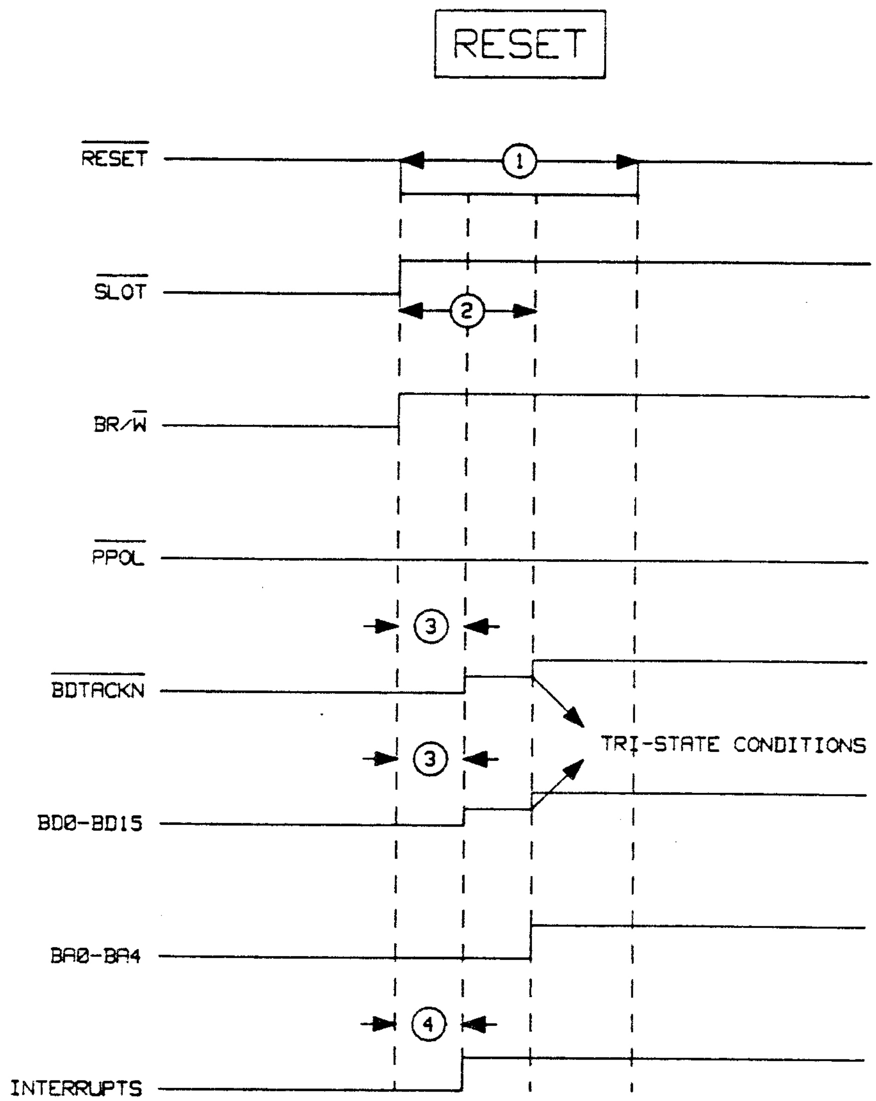
Opening/Closing Multiplexer Channels

The OPENING and CLOSING lines are used to achieve break-before-make switching action on the multiplexer accessories. The lines are open-collector and can be pulled low by any multiplexer accessory to indicate that switching action is taking place. Figure 19-11 shows the timing diagram for break-before-make (BBM) switching action.

Figure 19-11. Break-Before-Make Timing Diagram

Channels are opened on the multiplexer accessories through the use of an OPEN register. Once the proper data to accomplish the desired channel opening is determined, that data is written to the specified register. The data affects the channel state accordingly and a low signal is output from the OPENING line.

Channels are closed through the use of a CLOSE register. Once the proper data to accomplish the desired channel closing is determined, that data is written to the specified register. The command is stored by the multiplexer until the state of the OPENING line is determined. If the OPENING line is high (indicating that all channels in the system are finished opening), the channel is closed and a low signal is output from accessory to the CLOSING line. If the OPENING line is low (indicating that there are channels in the process of opening), the close command is delayed until the OPENING line returns high. This process ensures break-before-make switching on all channels in the system.



(1) RESET LOW TO RESET HIGH= 50uSec MIN., ∞ MAX.

(2) RESET LOW TO BACKPLANE LINES HIGH= 10uSec MAX.

(3) RESET LOW TO TRI-STATE DATA BUS/BDTACKN LINES= 1uSec MAX.

(4) RESET LOW TO CLEAR INTERRUPTS= 1uSec MAX.

Figure 19-10. Reset Timing Diagram

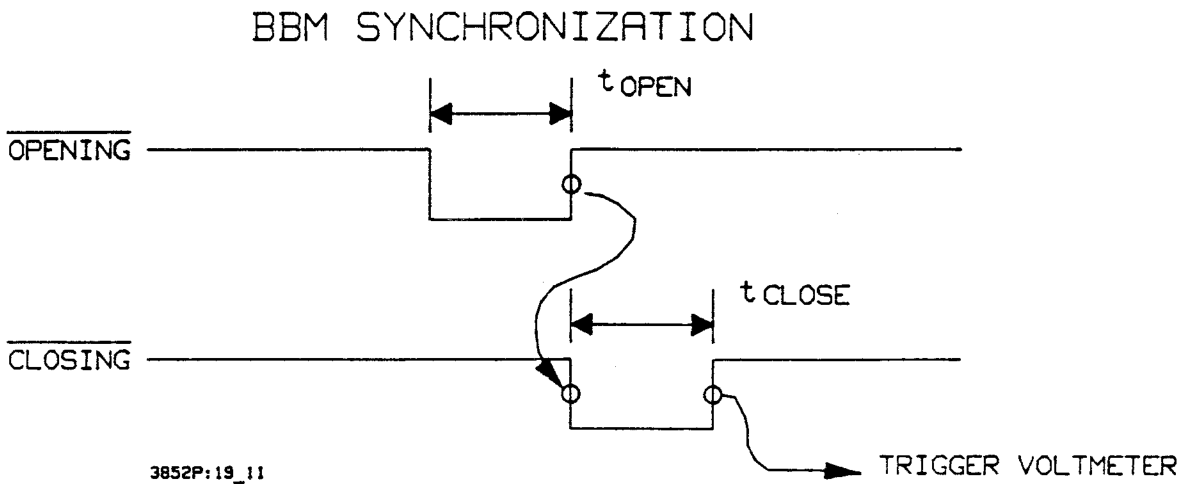


Figure 19-11. Break-Before-Make Timing Diagram

Scanning Multiplexer Channels

Scanning with the multiplexer accessories is also accomplished with the OPEN and CLOSE registers. Scanning operations combine simple OPEN and CLOSE commands in sequence to scan through a series of channels while maintaining break-before-make switching.

In a typical scanning operation, a voltmeter accessory is set to trigger on the rising edge of the CLOSING line as shown in Figure 19-11. As the scan starts, a command is issued to close the first channel in the sequence. The accessory receives the command, notes that the OPENING line is high, and begins closing the channel immediately. The CLOSING line is pulled low and returns high when the channel is closed. The low-to-high transition of the CLOSING line triggers the voltmeter accessory to take a reading.

When the mainframe receives the Scan Advance signal, the scan is advanced to the next channel. An OPEN command is then issued to the old channel and a CLOSE command is issued to the new channel. The OPEN command is executed immediately by the multiplexer and is followed by an OPENING pulse to the backplane. The CLOSE command is stored by the accessory and is executed when the OPENING line returns high. A CLOSING pulse is then sent and the voltmeter is triggered on the low-to-high transition of the line. The process continues until the scan list is complete.

Designing Read/Write Registers

The breadboard can be controlled on the backplane bus using read and write registers. Figure 19-12 shows a typical read and write circuit using two of the backplane address lines (BA1, BA0). You can, however, implement as many as 32 read and 32 write registers using all five available address lines. Table 19-2 includes suggested design components with the manufacturer's part numbers and the Hewlett-Packard part numbers shown.

NOTE

For the existing plug-in accessories, high-speed CMOS (HC) components have been used in most cases because of their low power dissipation and high speed.

Figure 19-12. Typical Read and Write Register Circuit

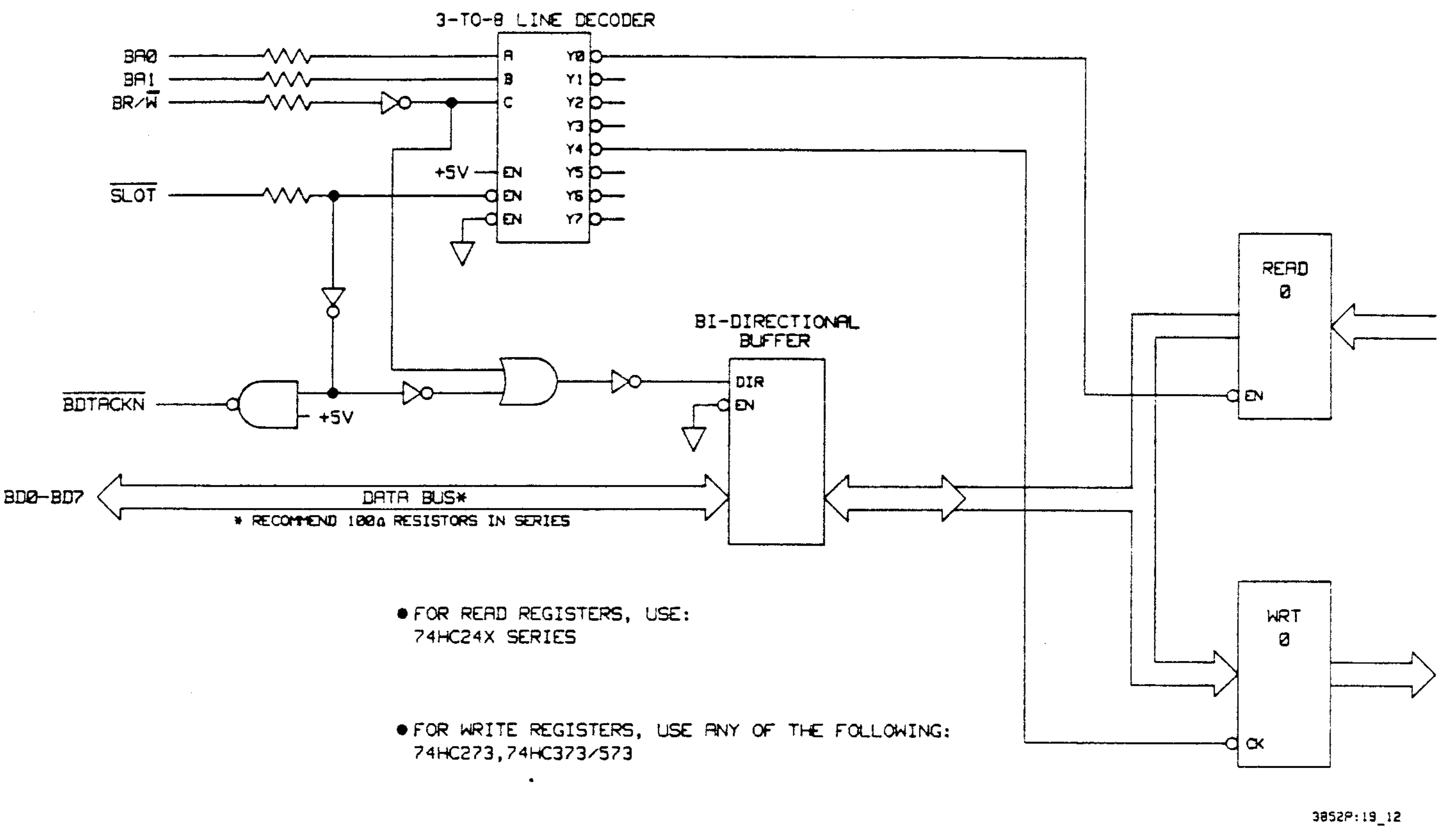


Figure 19-12. Typical Read and Write Register Circuit

Table 19-2. Suggested Parts for Custom Design

Description	Mfg Part No.	HP Part No.	CD	HP Factory Reference
3-to-8 Line Decoders	74HC138	1820-3079	0	IC-74HC138N
Octal Buffers	74HC240	1820-3299	6	IC-74HC240N
	74HC244	1820-3297	4	IC-DIG MC74HC244
	74HC245	1820-3330	6	IC-74HC245N
Octal Latch	74HC273	1820-3399	7	IC MC74HC273N
	74HC573	1820-3790	2	IC-74HC573N

To order a part listed in Table 19-2, quote the Hewlett-Packard part number, the desired quantity, the check digit (abbreviated CD), and the HP Factory Reference. Address the order to the nearest Hewlett-Packard Sales Office (addresses are provided in the back of the Mainframe Configuration and Programming Manual).

Using the Identity Register

As mentioned, the breadboard can be controlled from the backplane bus using read and write registers. If your design requires that you use the backplane logic and control lines, you must implement at least one read register. This register, called the Identity Register, enables the mainframe to identify which accessory is installed, and therefore, which commands are valid for that accessory. The Identity Register is read at power-up and after a RST (reset) command and must be addressable as read register 0.

Each plug-in accessory has a unique Identity Register code which enables the mainframe to identify the accessory. This code is made up of 8 bits and has two parts: a component module identifier and a terminal module identifier. The component module identifier is five bits (bits 7 through 3) and the terminal module identifier is three bits (bits 2 through 0).

Table 19-3 shows the codes that have been reserved for use with the breadboard. These codes will be used when you are designing the circuitry for the Identity Register. The first (left) column shows the binary bit patterns for the component module identifier (bits 7 through 3). The second column shows the binary bit patterns for the terminal module identifier (bits 2 through 0). The third column shows the decimal identity register code for the accessory with and without the terminal module. Refer to the example entitled "Determining Identity Register Codes" to see how the identity register codes are determined and how they are implemented on the Identity Register.

NOTE

Table 19-3 shows the values that are available for use with the breadboard. All other codes are reserved for other accessories and should not be used with the breadboard.

For the typical plug-in accessory, the terminal module identifier code "000" is used to represent the accessory with the terminal module connected and "111" is used to represent the accessory with the terminal module disconnected.

Table 19-3. Identity Register Assignments

Component Module Identifier b7-b3	Terminal Module Identifier b2-b0	Identity Register Code	Breadboard Terminal Module Configuration
01111	000	120	Connected
01111	111	127	Disconnected
10000	000	128	Connected
10000	111	135	Disconnected
10001	000	136	Connected
10001	111	143	Disconnected
10010	000	144	Connected
10010	111	151	Disconnected
10011	000	152	Connected
10011	111	159	Disconnected

Example: Determining Identity Register Codes

This example shows how the Identity Register codes shown in Table 19-3 are determined. The procedure has three steps:

- Determine the Component Module Identifier.
- Determine the Terminal Module Identifier.
- Determine the Identity Register Code.

Determine the Component Module Identifier

The first step is to determine the component module identifier for the accessory. Choose any value from Table 19-3. For this example, we will use 01111.

Determine the Terminal Module Identifier

The next step is to choose a terminal module identifier value using Table 19-3. For the typical accessory, 000 is used to represent the accessory with the terminal module connected and 111 is used to represent the accessory with the terminal module disconnected. For this example, we will use the same conventions.

Determine the Identity Register Code

The final step is to determine the Identity Register code using the component module identifier and terminal module identifier values. The procedure is shown below to determine the codes for the accessory with and without the terminal module.

1. Combine the component module identifier and the terminal module identifier into 8-bit binary patterns.

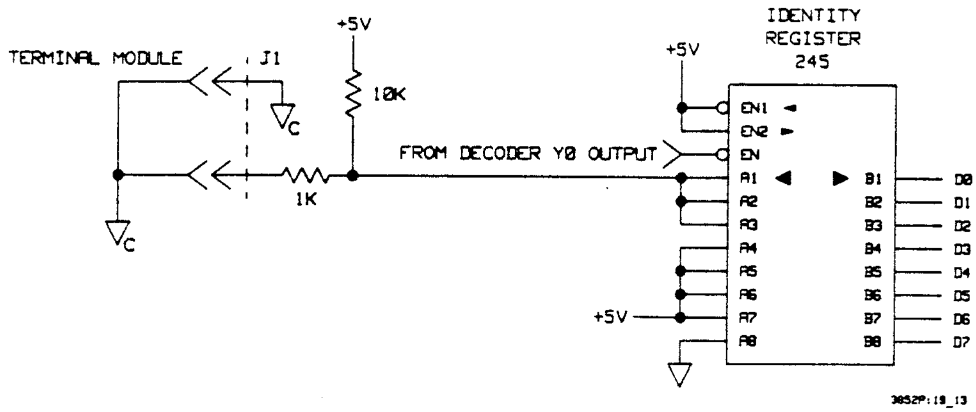
```
Bit Number:    7  6  5  4  3  2  1  0

Bit Pattern:   0  1  1  1  1  0  0  0   (terminal module connected)
Bit Pattern:   0  1  1  1  1  1  1  1   (terminal module disconnected)
```

2. Convert the bit pattern to a decimal value as shown:

```
Decimal Value (terminal module connected):

    01111000 = 64 + 32 + 16 + 8 =  120

Decimal Value (terminal module disconnected):

    01111111 = 64 + 32 + 16 + 8 + 4 + 2 + 1 =  127
```

After determining the identity register codes, the next step is to implement the register circuitry using these codes. Figure 19-13 shows a typical Identity Register circuit using 120 as the code for the accessory with the terminal module connected and 127 with the terminal module disconnected.

Figure 19-13. Typical Identity Register Circuit



	A8	A7	A6	A5	A4	A3	A2	A1
TERMINAL MODULE CONNECTED	0	1	1	1	1	0	0	0
TERMINAL MODULE DISCONNECTED	0	1	1	1	1	1	1	1

Figure 19-13. Typical Identity Register Circuit

Mounting Components

So that the metal shields can be replaced on the breadboard, the maximum component height and protrusion restrictions shown in Figure 19-14 must be observed. As shown, the absolute maximum component height allowed is 16.9 mm (0.66 in.). On the circuit trace side (the reverse side) of the breadboard, the lead lengths are limited to 3 mm (0.118 in.).

Figure 19-14. Component Height/Protrusion Restrictions

Most wire-wrapped components, such as integrated circuit (IC) sockets, will protrude through the breadboard further than the restrictions allow. When using such components make sure to cut the leads to meet the above restrictions.

CAUTION

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

When soldering components on the breadboard, use a soldering iron with a 25 watt (or less) rating and rosin core solder. Use of acid core solder will void the warranty.

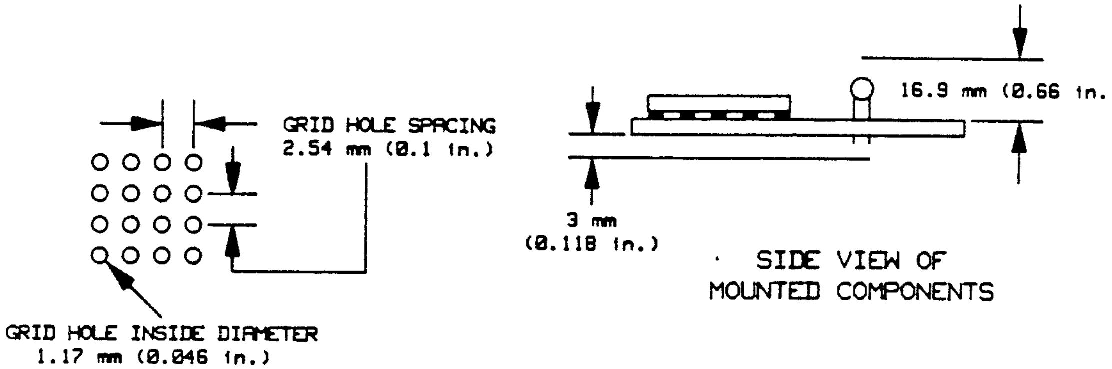


Figure 19-14. Component Height/Protrusion Restrictions

Programming the Breadboard

This section includes information on programming the accessory. Register programming using the SREAD (register read) and SWRITE (register write) commands and information on determining the accessory identity is included in this section.

NOTE

This section assumes that the Identity Register has been implemented as described in "Configuring the Breadboard". If this register is not implemented, the mainframe will not acknowledge that the breadboard is present and programming commands will not be accepted by the accessory.

The programs in this section 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.

Register Programming

The breadboard can be controlled from the backplane bus using registers and the SREAD and the SWRITE commands. This section includes information on using these commands to read and write data to and from registers that you have implemented on the breadboard.

Register Reads

The SREAD command is used to read data from a read register on the accessory. The command reads the contents of the register specified by *register* from the slot specified by *slot*. For example, if the breadboard is installed in slot 1 of the mainframe and you want to read the contents of register 0, the command syntax would be: SREAD 100,0.

Command Syntax: **SREAD** *slot, register* [INTO *name*] or [*fmt*]

The register number (*register*) must an integer between 0 and 31. Any values not in this range will cause an "INVALID REGISTER" error. Data returned by the SREAD command is a decimal number (real format) representing a 16-bit binary pattern (unless *fmt* is specified as PACK or IN16) and is in the range -32768 to +32767.

Example: Using the SREAD Command

This example shows how to use the SREAD command to read the contents of register 0. For this example, the accessory is installed in slot 2 of the mainframe.

```
10  OUTPUT 709; "SREAD 200,0"
20  ENTER 709; A
30  PRINT A
40  END
```

Output:

```
46
```

As an example, the decimal number 46 is returned. This value indicates that bits 5, 3, 2, and 1 are in the high state (logical "1"). The sum of the bit values totals 46 (32 + 8 + 4 + 2 = 46). All remaining bits are in the low state (logical "0").

Example: Reading the Identity Register

This example shows how to use the SREAD command to read the contents of the Identity Register on the breadboard. For this example, we will assume that the Identity Register code is 120 with the terminal module and 127 without the terminal module.

The SREAD command reads the Identity Register and returns a decimal representing the 2's complement of a 16-bit binary pattern. Since we are interested only in the lower eight bits, the upper eight bits must be masked (disregarded) in some way. One way to do this is to use the binary "AND" function.

For example, a register bit pattern is shown below. The upper eight bits are marked with an "X" to show that they are irrelevant in this case. Note that when the pattern is binary ANDed with 255, the upper eight bits (no matter what they are) become zero.

```
Register Bit Pattern:         X X X X X X X X 0 1 1 1 1 0 0 0
Mask to clear upper 8 bits:   0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1
Result after binary AND:      0 0 0 0 0 0 0 0 0 1 1 1 1 0 0 0
```

To show how the SREAD command operates in a program, an example is provided. This example shows how to use the SREAD command to read the Identity Register of a breadboard installed in slot 1 of the mainframe. The value entered into the variable "Identity" is binary ANDed (BINAND) with 255 and the decimal result is returned.

```
10  OUTPUT 709; "SREAD 100,0"
20  ENTER 709; Identity
30  PRINT "Accessory = "; BINAND(Identity,255)
40  END
```

Output with the terminal module connected:

```
Accessory = 120
```

Register Writes

The SWRITE command is used to write data to a write register on the accessory. The command writes data (*num list*) to the register specified by *register* on the accessory installed in the slot specified by *slot*. The *num list* parameter can be a list of up to 10 values or the identifier for a real array containing any number of elements.

Command Syntax: **SWRITE** *slot, register, num list*

For example, if the breadboard is installed in slot 1 of the mainframe and you want to write data to register 0, the command syntax would be: SWRITE 100,0, *num list*. The register number (*register*) must be an integer between 0 and 31. Any values not in this range will cause an "INVALID REGISTER" error.

For the SWRITE command, the *num list* parameter must be a real decimal number representing the desired 16-bit binary pattern (if *num list* is not defined as an array). The *num list* range for the SWRITE command is -32768 to +32767.

Example: Using the SWRITE Command

This example shows how to use the SWRITE command to write data to register 0. For this example, the accessory is installed in slot 2 of the mainframe. The program set bits 1, 4, and 7 in register 0. The binary pattern sent to the register is 10010010 which is, 128 + 16 + 2 = 146.

```
10  OUTPUT 709; "SWRITE 200,0,146"
20  END
```

Reading the Accessory Identity

When you have implemented the Identity Register as described in "Configuring the Breadboard" (and used one of the Identity Register codes listed in Table 19-3), you can use the ID? command to determine the accessory identity. This command provides a way to determine, from the HP 3852A front panel or from a controller, in which slot an accessory has been installed. The ID? command will return " 44736A" for the breadboard accessory with the terminal module connected and " 447XXX" if the terminal module is disconnected. If the ID? command is sent to a slot with no accessory installed, " 000000" will be returned.

Command Syntax: ID? [*slot*]

Example: Reading the Accessory Identity

This example shows how to use the ID? command to read the identity of a breadboard installed in slot 2 of the mainframe.

```
10  OUTPUT 709; "ID? 200"
20  ENTER 709; Identity$
30  PRINT Identity$
40  END
```

Output with terminal module connected:

```
44736A
```

Replaceable Parts

Figure 19-15 shows the mechanical breakdown of the breadboard and provides assembly and disassembly information. The parts in Figure 19-15 are cross-referenced (by reference designator) to the replaceable parts shown in Table 19-4.

Figure 19-15. HP 44736A Breadboard Exploded View

Table 19-4. Replaceable Parts

Ref Design.	Description	Qty	Part Number	C D	HP Factory Reference
44736A	Module; breadboard component	1	44736-66201	8	MOD-BREADBOARD
A1	PCA; breadboard component	1	44736-66501	1	PCA-BREADBOARD
A10	PCA; breadboard terminal	1	44736-66510	2	PCA-BRDBD TERM
MP1	Screw; cover	4	0515-1322	4	SCR-FH M3.0X30LK
MP2	Guide rail; top (molded)	1	03852-41201	1	MLD-RAIL,TOP
MP3	Guide rail; bottom (molded)	1	03852-41202	2	MLD-RAIL,BOTTOM
MP4	Cover; left (aluminum)	1	03852-04101	2	0601 CVR-ACC LT
MP5	Cover; right (aluminum)	1	03852-04102	3	0601 CVR-ACC RT
MP6	Label; 44736A comp. module	1	44736-84320	0	LBL-I/O OPTIONS
MP7	(Not Used)				
MP8	Screw; A10 PCA	4	0515-0886	3	SCR-PH M3.0X6 LK
MP9	Terminal box: case, cover latch, and strain relief	1	03852-84410	4	ASSY-TERM,LG OPN
MP10	Label; rear panel of terminal module 44736A	1	44736-84325	5	LBL-ID,TERM ASSY

NOTE

Complete, assembled HP 44736A terminal modules may be ordered through your local HP Sales Office by ordering 44736AT.

The "447xx-662xx" part numbers are replacement component modules only and do not include a terminal module.

To order a part listed in Table 19-4, quote the Hewlett-Packard part number, the desired quantity, the check digit (abbreviated CD), and the HP Factory Reference. Address the order to the nearest Hewlett Packard Sales Office (addresses are provides in the back of the Mainframe Configuration and Programming Manual).

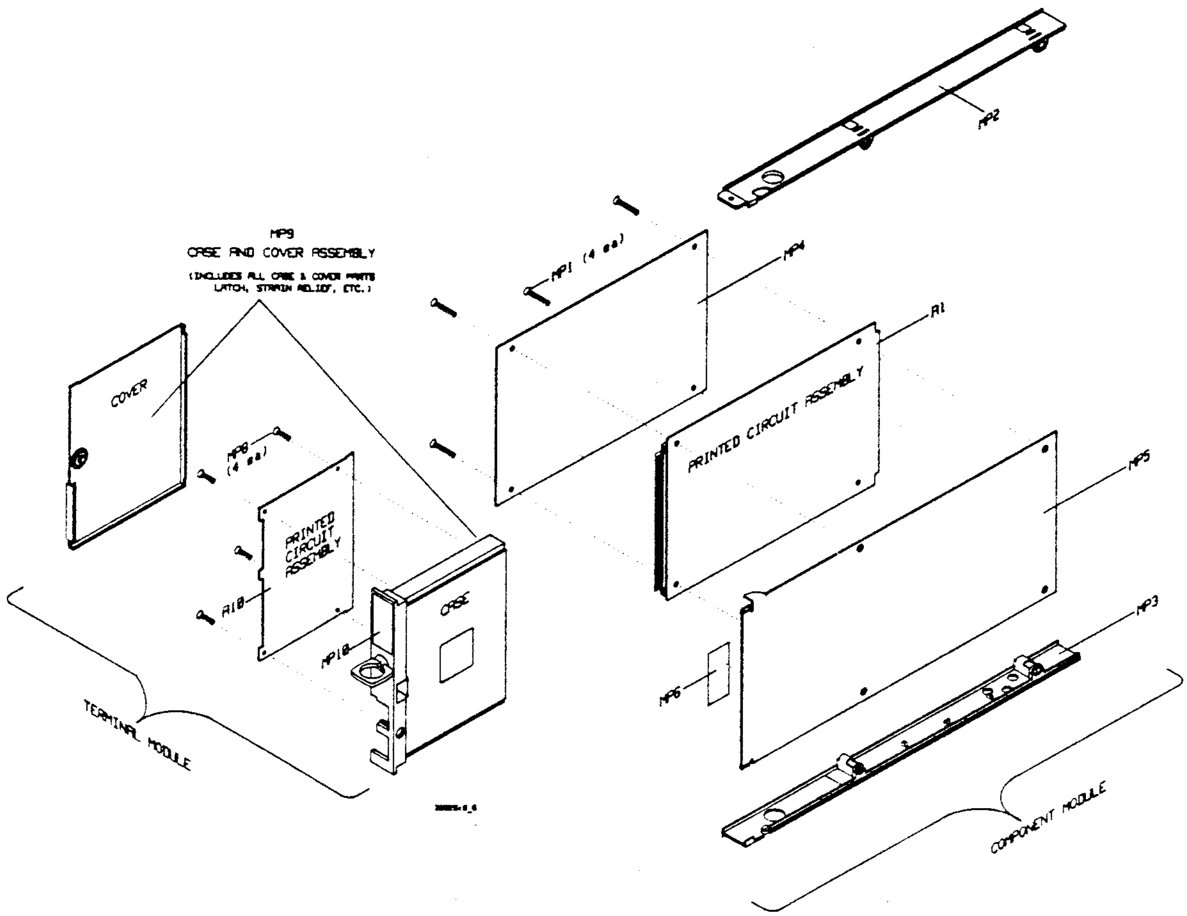


Figure 19-15. HP 44736A Breadboard Exploded View

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Chapter 14 -- HP 44724A 16-Channel Digital Output

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Chapter 17 -- HP 44728A 8-Channel Relay Actuator

Chapter 18 -- HP 44729A 8-Channel Power Controller

Chapter 19 -- HP 44736A Breadboard