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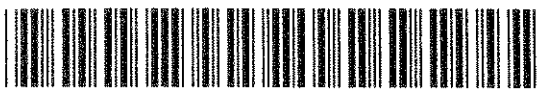
Find the *Keysight / Agilent 44714A* at our website: ***Click HERE***

HP 3852A Data Acquisition/Control Unit

HP 44714A
Stepper Motor Controller/Pulse Output Accessory

Configuration and Programming Manual

Enclosed is the HP 44714A Stepper Motor Controller/Pulse Output Accessory Configuration and Programming Manual. Insert this manual and tab page into the Plug-In Accessories Configuration and Programming Manual's Binder supplied with your HP 3852A Data Acquisition/Control Unit.



44714-90001

HEWLETT PACKARD

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HP 3852A Data Acquisition/Control Unit

HP 44714A
Stepper Motor Controller/Pulse Output Accessory

Configuration and Programming Manual

The HP 44714A Assembly Level Service Manual (Chapter 18 of the HP 3852A Assembly Level Service Manual) is available. Order HP Part Number 03852-90091.

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WARNING, CAUTION, and NOTE Symbols

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

HP 3852A WARNING, CAUTION, and NOTE Symbols

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

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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

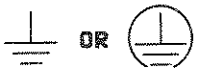
~ LINE — AC line voltage input receptacle.



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.



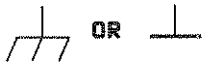
Indicates dangerous voltage – terminals connected to interior voltage exceeding 1000 volts.



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



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



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



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

NOTE

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

CAUTION

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

WARNING

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

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Introduction

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Chapter 1

Introduction

Manual Contents

This manual contains the following:

- **Chapter 1 - Introduction** summarizes manual contents and gives a description of the HP 44714A 3-Channel Stepper Motor Controller/Pulse Output accessory including a block diagram.

- **Chapter 2 - Setting Up the HP 44714A Hardware** provides information on 1) How to set jumpers, connect wires to, and install the accessory terminal module to the component module and 2) How to install the accessory into the HP 3852A mainframe or HP 3852E extender frame.

- **Chapter 3 - Programming the HP 44714A** provides information on programming the Stepper Motor Controller/Pulse Output. You can find programming examples with simplified examples of hardware connections needed in conjunction with the HP 44714A commands used in the programs. An alphabetical listing of all HP 44714A commands and a grouping by function is provided in the "Command Summary" section of this manual. A detailed description of the commands with prerequisites for using the command, parameter definition, programming examples, and power-on and default conditions can be found in the HP 3852A Command Reference Manual (HP P/N 03852-90003).

- **Chapter 4 - Command Summary** summarizes the HP 44714A commands by functional group and provides an aphabetical listing of all commands. A brief description of each command and the syntax is given.

- **Appendix A - Specifications** for the HP 44714A are given in Appendix A.

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Accessory Description

The HP 44714A 3-Channel Stepper Motor Controller/Pulse Output accessory for the HP 3852A can be used for either stepper motor control or general purpose pulse output. The HP 44714A is designed to provide the control signals for all types of stepper motor drivers. You can generate continuous pulses or a fixed number of pulses while you control the pulse width and frequency of the pulses. There are additional features available for controlling stepper motor limits of travel and determining position of the motor. Position can be monitored by using either the internal counter or by physically monitoring position with an optical encoder and the quadrature counter. Two modes of operation are provided 1) Changing frequency of pulses with a fixed pulse width (stepper motor control) and 2) Changing width of pulses with a fixed frequency (pulse output). Figure 1-1 shows the two modes of operation and a simplified block diagram of the HP 44714A.

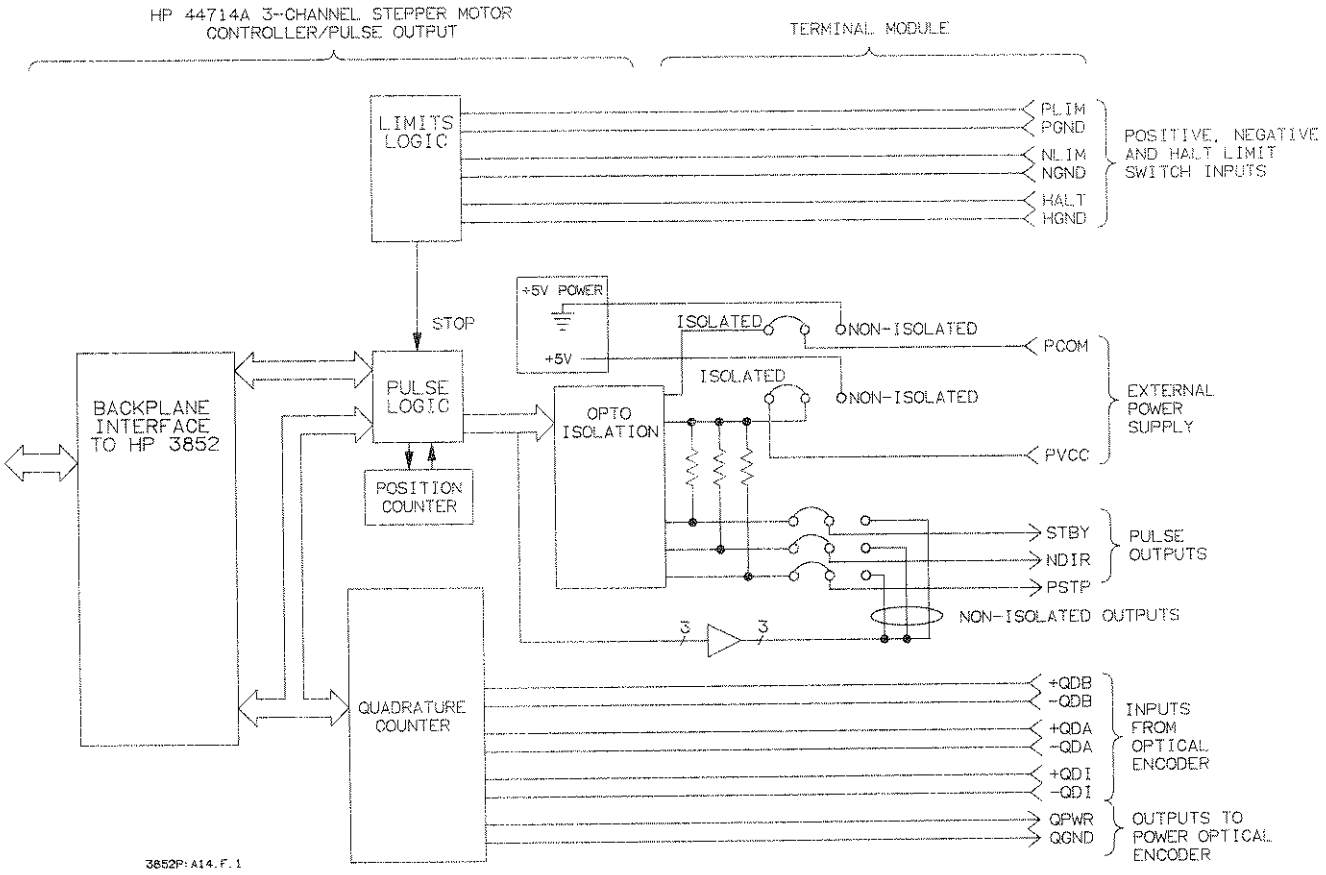


Figure 1-1. Simplified Block Diagram

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Getting Started

You need to perform three tasks to begin using the HP 44714A accessory:

- Define your application
- Set-up the hardware
- Program for stepper motor control or pulse output.

Define Your Application

The HP 44714A can be used for stepper motor control or for general purpose pulse output. You first define the use of the HP 44714A and verify that the specifications of the accessory meet the requirements of your application. For stepper motor control, the HP 44714A connects to a step motor driver. You determine the type of outputs and the logic sense (high-true or low-true) required to control your motor drivers. Additionally, you must determine whether the HP 44714A outputs are to be isolated or non-isolated. For general purpose pulse output, you also determine the type of outputs, the logic sense required, and whether the HP 44714A outputs are to be isolated or non-isolated. Refer to the specifications listed in Appendix A to verify the HP 44714A meets your application requirements.

Set Up the Hardware

All hardware set-up is performed on the terminal module which attaches to the component module. You set jumpers to fit your application and connect your field wiring. Instructions for doing this is provided in Chapter 2 titled "Setting Up the HP 44714A Hardware."

Program the Accessory

You are ready to begin programming the HP 44714A after the hardware is set up and the accessory is installed in a mainframe or extender frame. Programming information is provided in Chapter 3 titled "Programming the HP 44714A". This information is divided into "Programming for Stepper Motor Control" (where controlling frequency or velocity is of primary concern) and "Programming for General Purpose Pulse Output" (where controlling pulse width is of primary concern). Chapter 4 is a summary of HP 44714A commands.

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Chapter 2
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Chapter 2

Setting Up the HP 44714A Hardware

Warnings and Cautions

This section summarizes the WARNINGS and CAUTIONS that apply to the HP 44714A. Review all WARNINGS and CAUTIONS before setting up any of the HP 44714A hardware.



WARNING

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



WARNING

POSSIBLE OPERATOR INJURY. For safety, consider all accessory channels to be at the highest potential applied to any channel.



WARNING

POSSIBLE OPERATOR INJURY OR EQUIPMENT DAMAGE. The terminal module TEST jumper (J581) must be set to the "NORM" position when application wiring is connected. A test pattern of pulses is output by the **TEST** *command when the TEST jumper is in the "TEST" position. An application connected to the module under test conditons can cause uncontrolled motion damaging the equipment and/or injuring the operator.*

CAUTION

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

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Hardware Set-Up Steps ① through ⑦

The HP 44714A accessory physically consists of a component module and a terminal module as shown in Figure 2-1. All hardware set-up and wiring is performed on the terminal module. You connect the terminal module to the component module and install the entire component module/terminal module accessory in a frame. The HP 44714A connects to the mainframe or extender backplane thru edge connector terminals on the component module.

Whether you use the HP 44714A as a stepper motor controller or for general purpose pulse output, you perform the same set-up procedure except for the field wiring. Figure 2-2 illustrates the seven steps required for setting up the HP 44714A hardware (steps 4 and 5 are only required if limit switches are installed (Step 4) or if an optical encoder is connected to the quadrature counter (Step 5). In the text that follows, the steps are denoted by a circle around the step number (i.e. step no. 1 = ①).

① Setting the TEST Jumper

A test jumper is present on the HP 44714A terminal module (see Figure 2-2, Step ①). When the terminal module is connected to your application, the jumper must be in the "NORM" position. Refer to the HP 44714A Service Manual for setting the test jumper to the "TEST" position and testing the HP 44714A.

WARNING

OPERATOR INJURY OR EQUIPMENT DAMAGE. Set the TEST jumper (J581) on the terminal module to the "NORM" position before wiring your application. Refer to the HP 44714A Service Manual for testing of the module with the jumper in the "TEST" position.

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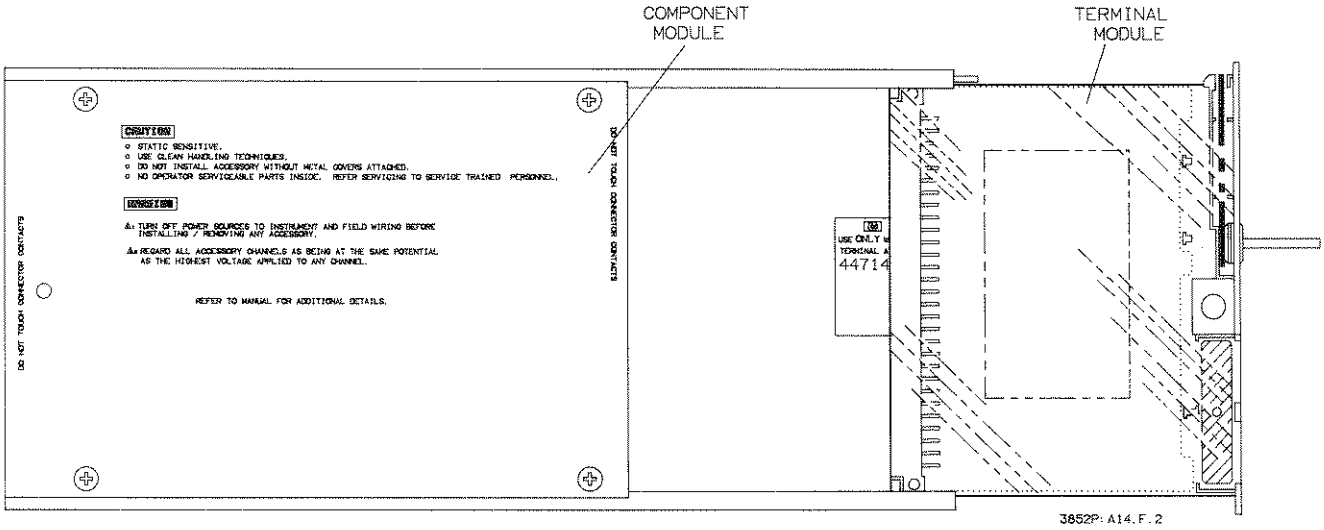


Figure 2-1. HP 44714A Terminal and Component Modules

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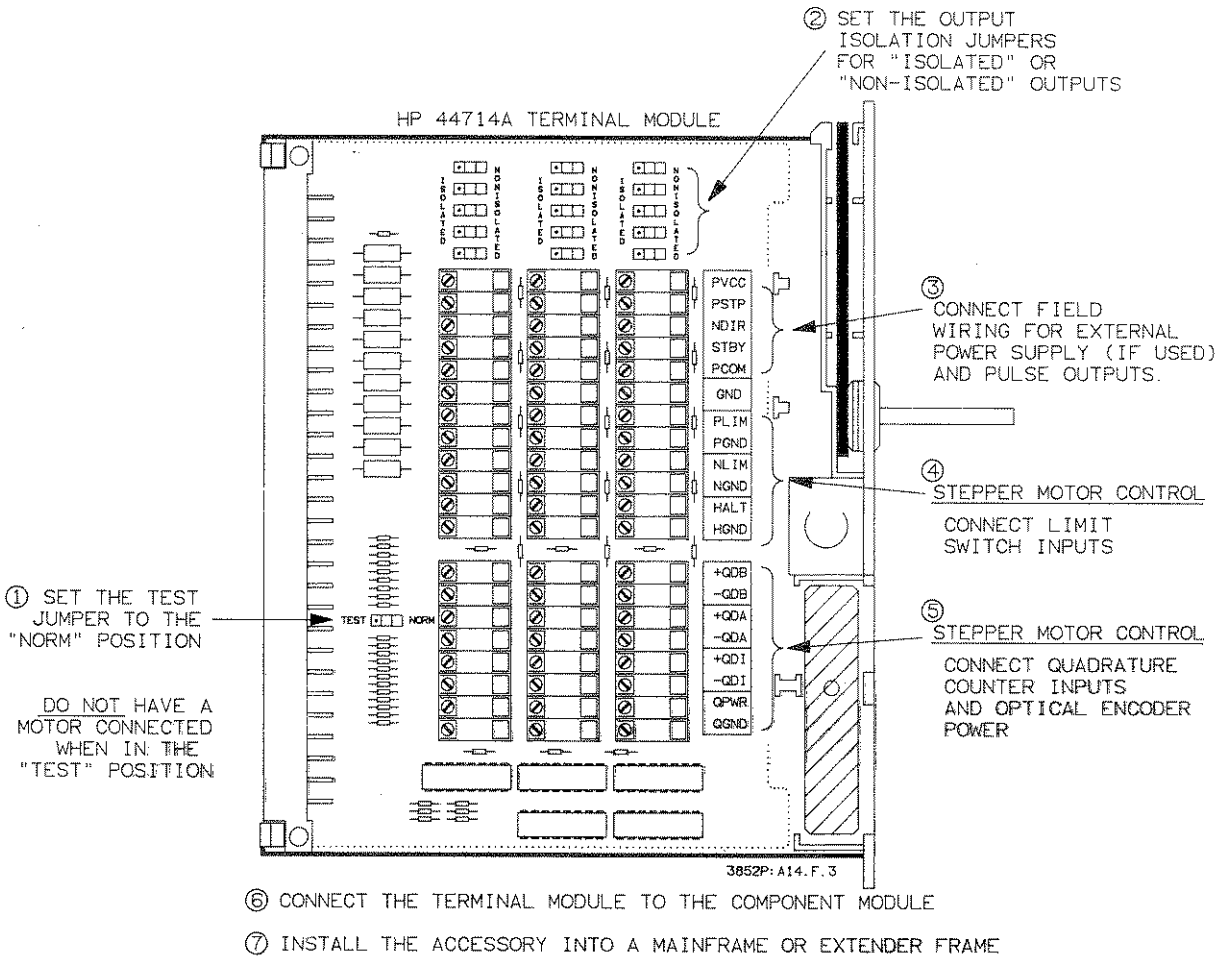


Figure 2-2. HP 44714A Hardware Set-Up Steps

Setting Terminal Module Jumpers

There are five jumpers for each channel (located on the terminal module) that must be set to either the "ISOLATED" or "NON ISOLATED" position. These jumpers provide isolated STBY, NDIR, and PSTP outputs when set to the "ISOLATED" position. All five jumpers for a channel must be set in the same position but some channels can be isolated and others non-isolated. Figure 2-3 shows the isolation jumpers for all three channels. The following sections, including Figures 2-4 and 2-5, illustrate what the isolation and non-isolation modes are and what pull-up resistors are provided. When the jumpers are in the "NON ISOLATED" position, the internal +5V and ground are connected to the pull-up resistors and the STBY, NDIR, and PSTP outputs are routed through buffers instead of through the opto isolators.

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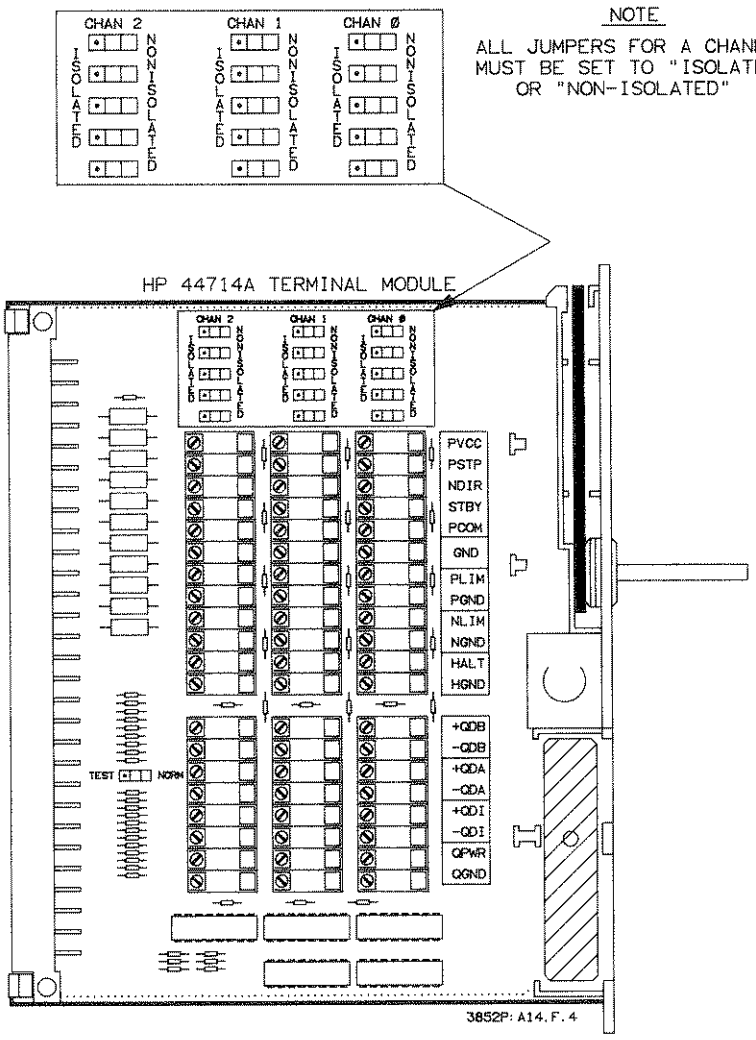


Figure 2-3. Terminal Module Output Isolation Jumpers

Why Use an External Power Supply?

The PVCC and PCOM inputs can be used to power the opto isolation of the pulse output lines with an external power supply. You use an external power supply where your application is in a noisy environment and you are concerned that a power supply glitch may cause an output pulse and move a motor. Operating the HP 44714A in the "ISOLATED" mode with an external power supply can reduce power supply glitches that cause an additional output pulse. Figure 2-4 shows a simplified diagram of output isolation.

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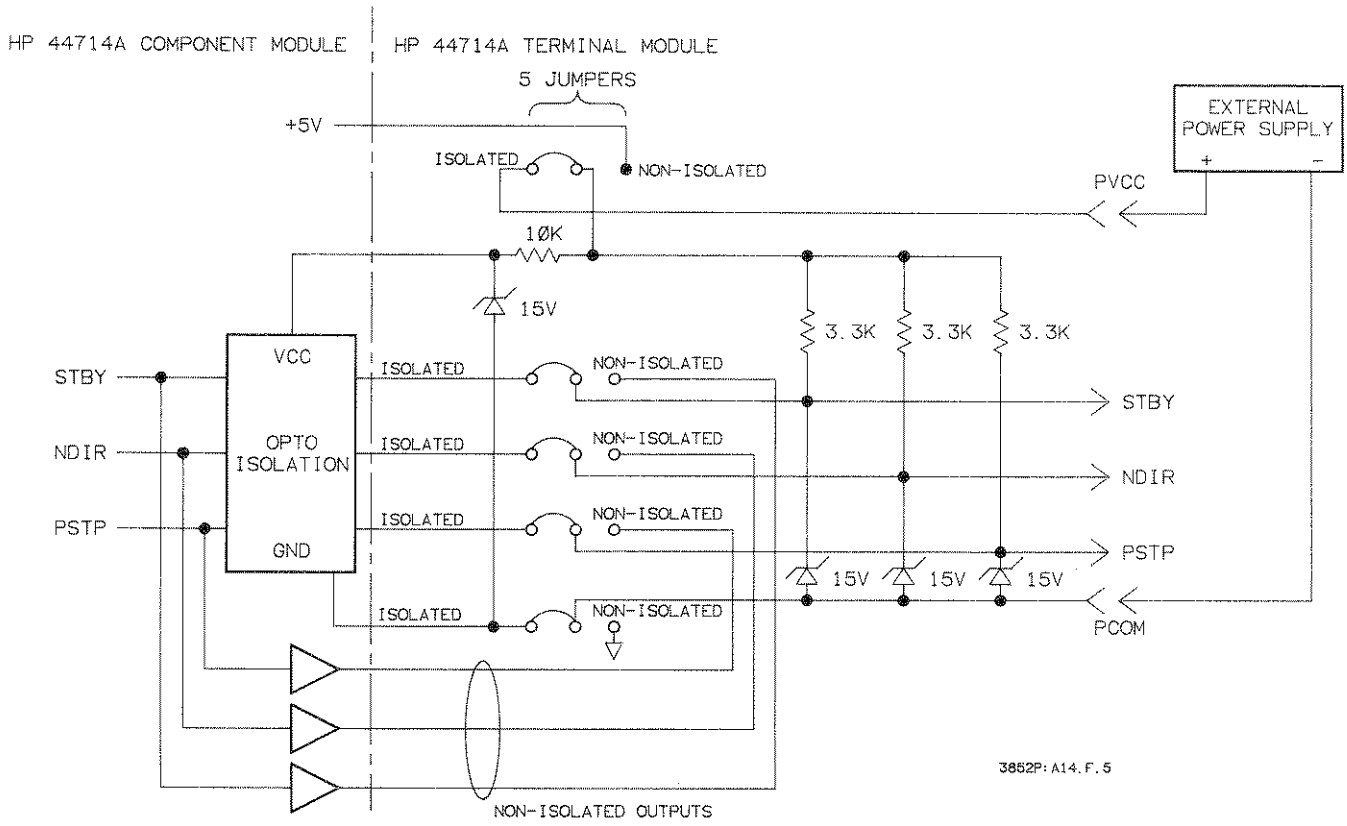
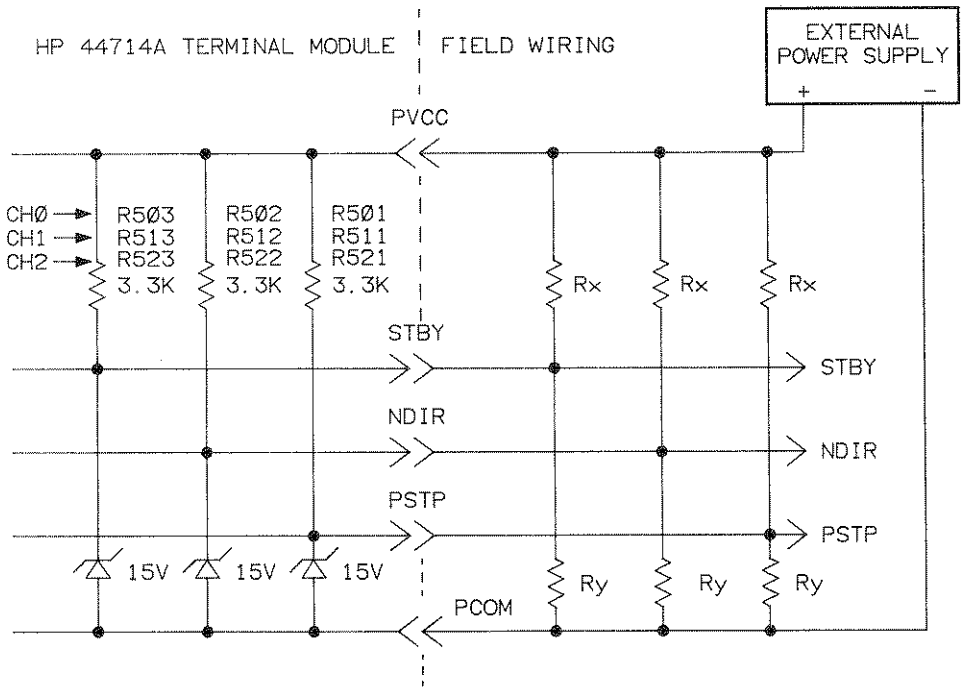


Figure 2-4. Output Isolation Simplified Diagram

Pull-Up Resistors

The pull-up resistors present on the terminal module for the STBY, NDIR, and PSTP outputs have a value that is selected for use with an external +20V power supply to allow a current of 6 mA. For external power supply (isolated) voltages less than +20V, you can decrease the 3.3K pull-up resistance value with external resistors in parallel and still allow 6 mA of current with the lower power supply voltage. Doing this optimizes the performance of the HP 44714A allowing you to achieve the pulse width specifications. Figure 2-5 shows the value of the external resistor needed for different power supply voltages and the resultant parallel combination pull-up resistor value.

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EXTERNAL POWER SUPPLY VOLTAGE	PULL-UP RES. REQUIRED TO ALLOW 6mA	Rx EXTERNAL PARALLEL RESISTOR	Ry OPTIONAL PULL DOWN RESISTOR TO LIMIT HIGH OUTPUT VOLTAGE TO		
			+5V	+1ØV	+15V
+2ØV	3.3K	∞	1.1K	3.3K	1ØK
+15V	2.5K	1ØK	1.2K	5K	∞
+1ØV	1.667K	3.3K	1.6K	∞	X
+5V	833	1.1K	∞	X	X

3852P:A14.F.6

Figure 2-5. Pull-Up Resistor Selection

Wiring the HP 44714A Terminal Module

You make your field wiring connections to the HP 44714A terminal module after you have set the jumpers for each channel. If you are using the HP 44714A for stepper motor control, you may have more field wiring to the terminal module because of limit, halt, and quadrature counter inputs which are not used for general purpose pulse output. The PSTP, NDIR, and STBY pulse ouputs are used in both applications and so are the PVCC and PCOM external power supply inputs for isolating the pulse outputs. Information for these inputs and outputs is presented first. You then find information for using the limit, halt, and quadrature counter inputs for stepper motor control.

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NOTE

Connectors on the terminal module will accept wire sizes up to a maximum of 18 AWG. 18 AWG = 1.02 mm diameter and 0.823 mm² cross sectional area.

③ Wiring the Pulse Outputs

Connections of the PSTP, NDIR, and STBY pulse output lines are dependent on your application. Connections for stepper motor control will be dependent on the type of step motor driver used. Connections for general purpose pulse output depend on the device being driven.

NOTE

If you are controlling stepper motors, refer to the installation instructions supplied with the motor driver you are using between the HP 44714A and the motor for wiring instructions of step/step or step/direction drivers.

Figure 2-2 step ③ identifies the pulse outputs and external power supply inputs.

1. External power supply inputs for isolating the pulse outputs (PVCC and PCOM).

2. PSTP, NDIR, and STBY pulse outputs.

NOTE

For general purpose pulse output, you can use the HALT input for manually stopping the pulse train. Refer to the section titled "Limit and Halt Switch Inputs" for information on using a HALT switch.

③ Wiring the External Power Supply

Whether you use the HP 44714 as a stepper motor controller or for general pulse output, you can isolate the PSTP, NDIR, and STBY pulse outputs by using an external power supply. To use an external power supply, you should have all jumpers for a channel set to the "ISOLATED" position. Figure 2-4 illustrates how an external power supply is connected. Figure 2-2 step ③ shows the PVCC and PCOM connectors on the terminal module.

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NOTE

The remaining set-up procedures apply to stepper motor control or to dc motor control. You can however, use the HALT input for general purpose pulse output.

Additional Wiring for Stepper Motor Control

This section gives you additional information to wire the limit and halt switches and the quadrature counter for stepper motor control. The inputs and outputs described are:

1. Positive and negative limit and halt inputs (PLIM, NLIM, and HALT).

2. Quadrature counter inputs (±QDB, ±QDA, and ±QDI).

3. Optical encoder power supply outputs (QPWR and QGND).

④ Limit and Halt Switch Inputs

You have the ability to limit motor travel in both the positive and negative direction. Limit switches placed in your stepper motor application can provide a hard-wired input to the HP 44714A when a limit is reached. A HALT switch can also provide a hard-wired input to stop operation at any time (i.e. emergency stops). Figure 2-6 shows where positive and negative limit switches and halt switch inputs are made on the terminal module.

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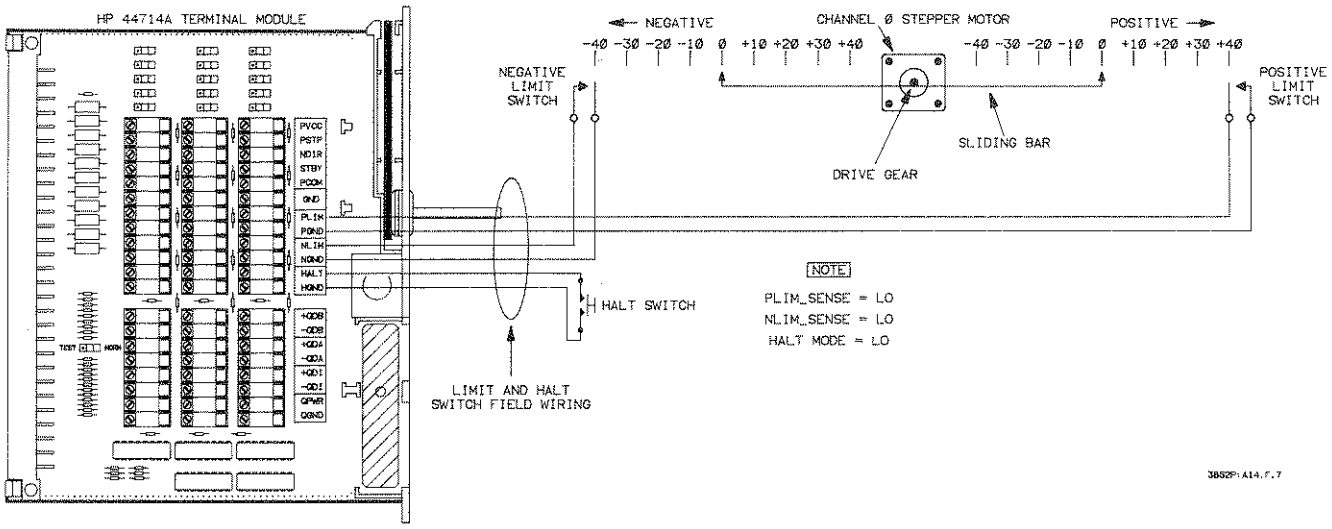


Figure 2-6. Limit and Halt Switch Inputs

(5) Quadrature Counter Inputs and Outputs

Motor shaft movement is physically monitored by attaching a shaft encoder to the motor shaft. Encoder pulses are input to the quadrature counter which keeps track of distance and direction of motion. Figure 2-7 shows a typical shaft encoder connected to the terminal module. Note that power for the encoder is supplied by the HP 44714A via the QPWR and QGND terminals.

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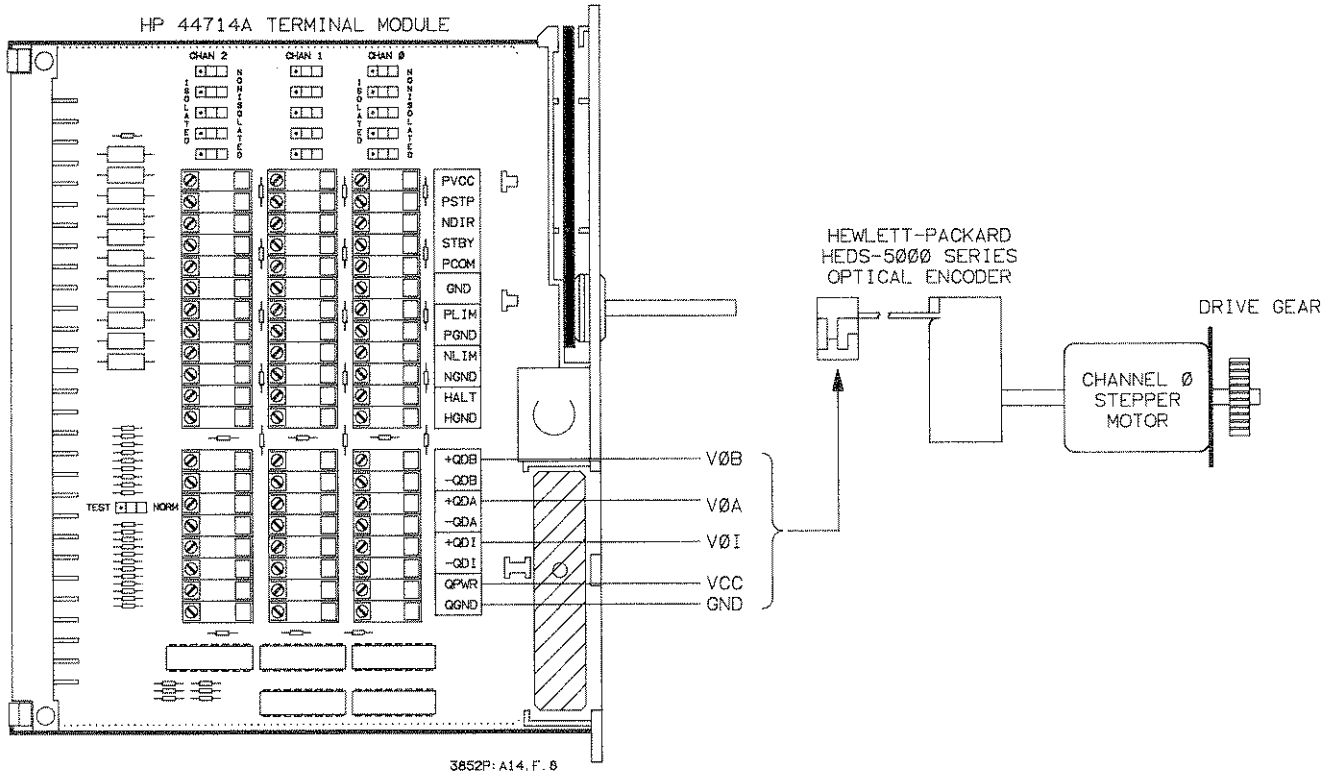
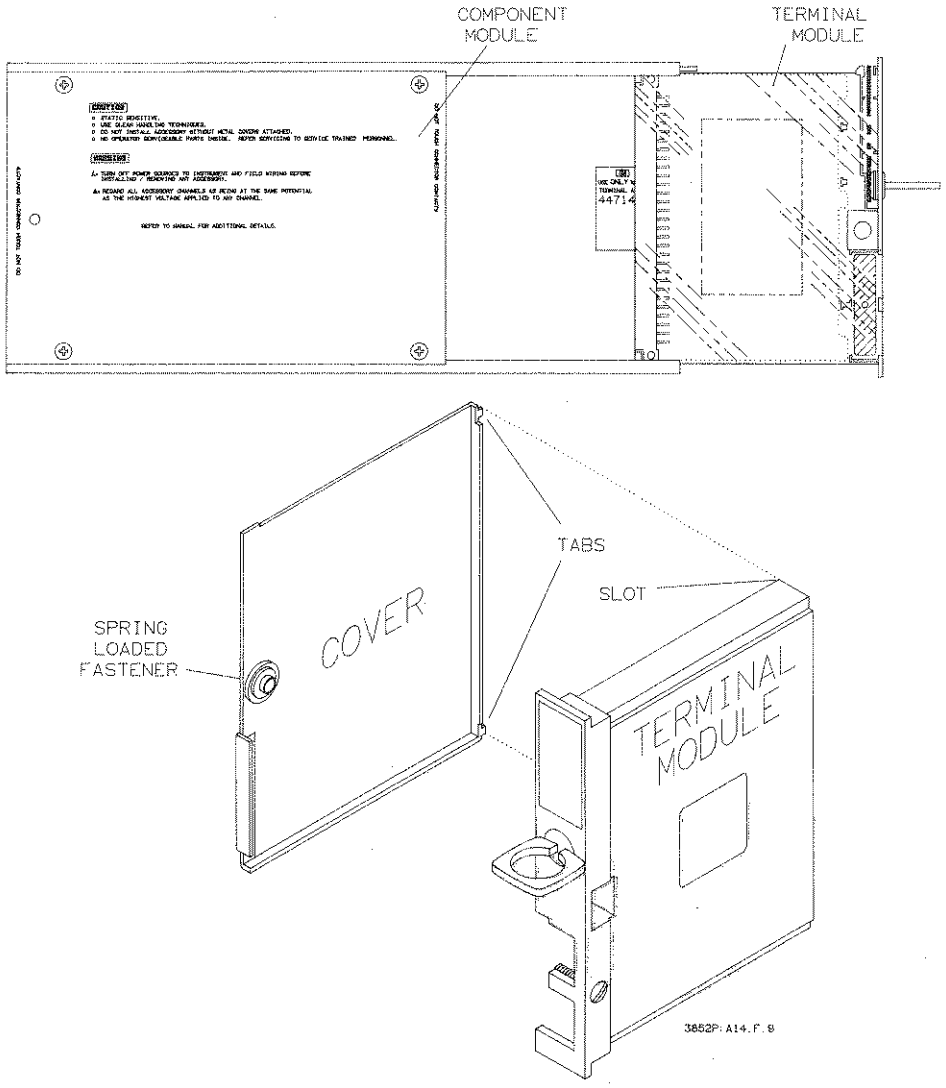


Figure 2-7. Quadrature Counter Inputs/Outputs

⑥ Connecting the Terminal Module to Component Module

After all field wiring is connected to the terminal module, you install the cover and install the terminal module to the component module. Figure 2-8 shows the terminal module with cover and how it is installed on a component module.

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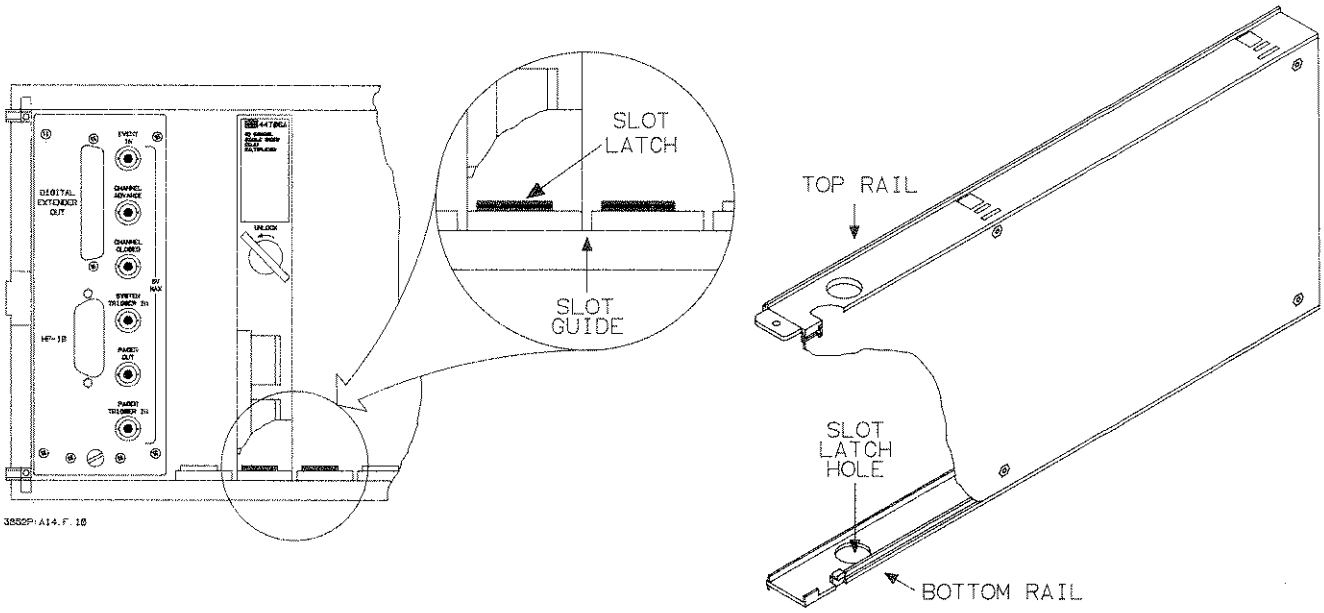
- To remove terminal module cover, seperate terminal module from component module. Use flat-bladed screwdriver to turn spring-loaded fastener 1/4 turn counterclockwise. Lift cover from terminal module.
- To replace terminal module cover, insert tabs on cover into module slots. Lower cover to module, press down on spring-loaded fastener and turn 1/4 turn clockwise to close.
- Connect the terminal module to the component module and turn the locking ring to the right to lock the terminal module to the component module.

Figure 2-8. Accessory Terminal Module with Cover

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Installing the Accessory Into a Frame

Figure 2-9 gives you instructions for installing and removing an HP 44714A accessory from a mainframe or extender frame.



Installing an Accessory

1. Connect the terminal module to the component module and turn the locking ring to the right to lock the terminal module to the component module.

2. Line up the ridges on the top and bottom rails of the accessory with the slot guides to the left of the slot number on the mainframe. Make sure the terminal module cover is facing left.

3. Slide the accessory into the slot and press firmly on the terminal to lock the accessory in the slot. You'll hear a click when the accessory locks.

Removing an Accessory

1. Turn the locking ring to the UNLOCK position and pull on the ring to remove the terminal module. The component module will remain in the slot.

2. To remove the component module, place your right forefinger in the hole in the top rail of the component module and your left forefinger on the slot latch in the bottom rail of the component module.

3. Press down on the slot latch while pulling firmly on the component module. BE CAREFUL—you can easily pinch your left forefinger between the slot latch and the bottom plastic rail of the component module.

Figure 2-9. Installing/Removing an Accessory

Initial Checks

After installing the component and terminal modules for the HP 44714A, turn on power for the mainframe and enter the ID? command from the front panel. At power-on following the ID? command, a 3-Channel Stepper Motor Controller/Pulse Output accessory with terminal module returns "44714A" while the accessory without the terminal module returns "447XXX." If the terminal module is removed after the power-on sequence, subsequent ID? commands will continue to return "44714A."

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If the HP 44714A does not return "44714A" as previously described, first verify that you have mainframe firmware revision 3.0 or greater. Do this by entering the IDN? command and the mainframe returns the revision code. Also, verify you have addressed the correct slot and that the terminal module is installed. If these items are verified and the correct display is not returned, refer to the HP 3852A Assembly Level Service Manual for service procedures.

Hardware set-up is now complete. The accessory's parameters are set to their power-on/reset state which is listed in the beginning of Chapter 3 Programming the Stepper Motor Controller/Pulse Output.

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Chapter 3
Programming the Stepper Motor Controller/Pulse Output

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Chapter 3

Programming the Stepper Motor Controller/Pulse Output

The HP 44714A can be used either as a stepper motor control or for general purpose pulse output. This programming section is divided into two parts to help you effeciently program your application either way:

- Programming For Stepper Motor Control
- Programming For General Purpose Pulse Output

Each section shows the Pulse/Motor Driver Set-Up Commands set-up for the type of application the HP 44714A is used in. Examples of Output Commands are given in each part for the application described. Additionally, some command groups are intended for stepper motor control but can be used in general purpose pulse applications i.e. limit commands, position commands, and quadrature counter commands. A listing of all commands for the HP 44714A plug-in accessory is provided in the last section of this manual titled "Command Summary". Below is a summary of the commands by functional group.

- **PULSE/MOTOR DRIVER SET-UP COMMANDS**
  - STANDBY
  - PULSE
  - PROFILE
  - PSCALE
- **OUTPUT COMMANDS**
  - MOVE
  - SUSTAIN
  - TRIG
  - DELAY
  - HALT SGL
- **INTERRUPT COMMANDS**
  - ENABLE INTR
  - DISABLE INTR
- **LIMIT COMMANDS**
  - HARDLIM
  - HALT
- **POSITION COMMANDS**
  - POS
  - POS?
  - DONE?
- **QUADRATURE COUNTER COMMANDS**
  - QSCALE
  - QINDEX
  - QPOS

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NOTE

The PROFILE command has parameters that are specified to profile frequency for a stepper motor controller and to profile pulse width when used for pulse output use. You can program more effeciently by going to the part of this programming section that deals with the way you intend to use the accessory. The PROFILE command is described for the specified use under each application heading. The remaining PULSE/MOTOR DRIVER SET-UP COMMANDS are discussed under each application heading as they apply to that application.

Power-On/ Reset State

After power-on or when the HP 44714A is reset, all interrupts are disabled. Additionally, command parameters are set to that listed below. It is only necessary to execute a command to change a parameter from the power-on state.

STANDBY
mode = AUTO
sense = HI

PULSE
mode = SS
PSTP__sense = LO
NDIR__sense = LO

PROFILE
mode = FREQ
min = 0 Hz
max = 250 Hz
slope = 500 Hz/sec
pulse width = 50E-6 sec (50 microsec)

PSCALE
scale__factor = 1.0

DELAY
time = 0.000 seconds

TRIG
mode = AUTO

HALT
mode = LO

HARDLIM
Plim__sense = LO
Nlim__sense = LO

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QSCALE *qfactor* = 1.0

QINDEX *mode* = OFF

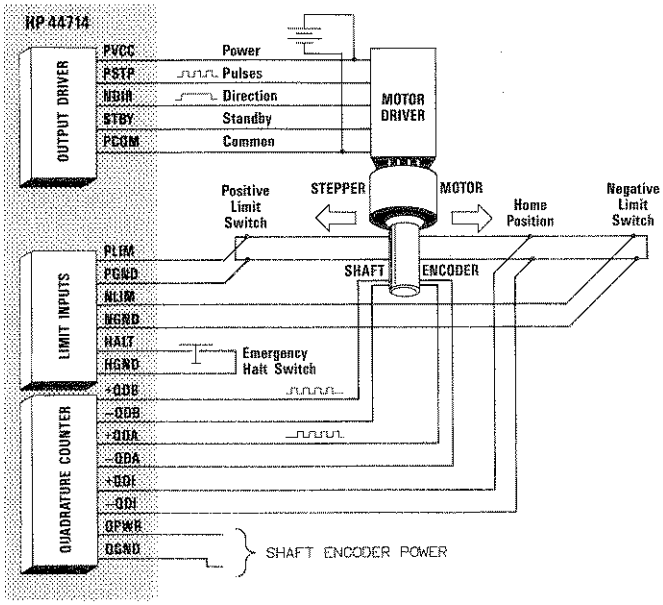
Error Message Summary

A summary of error messages that are generated by the HP 44714A is provided in this section. The error number and a description of each message is given.

ERROR #	MESSAGE	DESCRIPTION
89	"ACCESSORY BUSY"	A move is in progress.
90	"NO ACTION DEFINED"	TRIG SGL encountered without a corresponding MOVE or SUSTAIN command preceeding it.
91	"MUST STOP TO CHANGE DIRECTION"	A running SUSTAIN command must be stopped with HALT or SUSTAIN 0 before a command to reverse direction can be executed.
92	"NOT VALID IN WIDTH MODE"	A MOVE command cannot be executed when the PROFILE command is in the width mode.
93	"TERMINAL CARD TEST JUMPER SET"	Will not execute a MOVE or SUSTAIN command when test jumper is in the "TEST" position.
94	"CANNOT MOVE WHILE STANDBY ON"	Motor cannot move when powered down by STANDBY in the "ON" mode.

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Programming For Stepper Motor Control



The HP 44714A is used as the digital control of a stepper motor driver assembly installed between your HP 3852A/44714A and the stepper motors (See Figure 3-1a). Stepper motor drive assemblies can be of different types. One type has one input for pulses to move the motor and another input to specify CW or CCW movement (direction). The second type has two inputs for pulses to move the motor; one input for CW movement and one input for CCW movement. You can set up the HP 44714A to control either type of stepper motor drive assembly. Figure 3-1b and 3-1c show the two configurations which are discussed further in the section titled "Setting the Pulse Mode and Sense."

There are six groups of commands used for stepper motor control. They are listed below with a brief description of the activities in each group.

1. PULSE/MOTOR DRIVER SET-UP
   a. Set the STANDBY mode/logic sense (set-up for the type of driver used)
   b. Set the PULSE mode (set-up for the type of driver used)
   c. Set the trapezoidal motion PROFILE (specific to your type of motor)
   d. Set the motion scale (specific to your application)
2. PULSE OUTPUT COMMANDS
   a. Stepping a fixed number of times
   b. Stepping the motor indefinitely until commanded to halt

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3. INTERRUPT COMMANDS (optional)
   a. Enable interrupts generated by the HP 44714A
   b. Disable interrupts.
4. LIMITS SET-UP (optional)
   a. Set the hard limits using limit switches
   b. Set the emergency halt limit using a limit switch
5. POSITION SET-UP (optional)
   a. Loading the current position value into memory
   b. Querying the current position value
6. QUADRATURE COUNTER SET-UP (optional)
   a. Setting the counter motion scale
   b. Setting the counter index
   c. Querying the counter position value

Pulse/Motor Driver Set-Up

The pulse output must be set to be compatible with the type of motor driver assembly used. This requires setting the PULSE mode and logic sense to control step/direction or step/step motor drivers. If you intend to power down a motor when it is idle, you must set the correct mode and logic sense for the STANDBY command to make the STBY output compatible with your motor driver. The motion PROFILE and scale factor are also defined for pulse set-up.

Setting the Motor Drive Power Turn-Off Mode and Sense

COMMAND DISCUSSED:

STANDBY [*mode*] [*sense*] [**USE** *ch*]

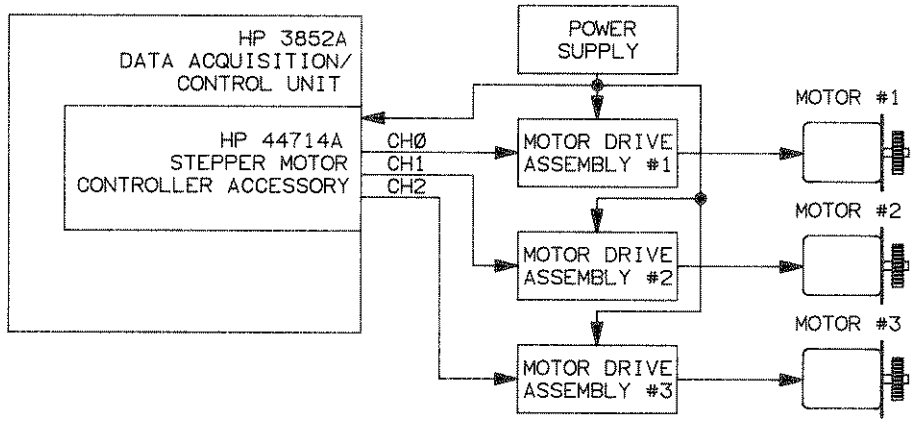
The STANDBY command controls the operating mode and logic sense of the STBYn outputs of the HP 44714A. It is needed only if you intend to us the STBYn output to signal the motor driver to partially or completely remove power from the motor after a move has taken place. This will reduce the load on the power supply when it is not needed and reduce the generation of heat when the motor is sitting idle.

The STANDBY command has three modes; OFF, ON, and AUTO. The sense parameter can be HI or LO. At power-on, the mode is AUTO and the sense is HI. If the STANDBY command is executed without a mode or sense specified, the default is ON with the sense as previously set.

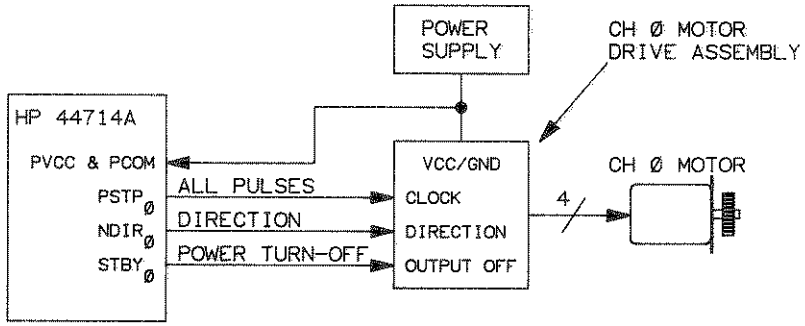
When you specify the STANDBY mode AUTO and the logic sense HI, the STBYn output will be high when the motor is to be idle. When a MOVE or SUSTAIN command is executed and triggered, the STBYn output goes low to allow the motor to be powered up before the pulses are applied to step the motor. After completing the move, the STBYn output goes high after a delay to remove power. The ON and OFF options cause the

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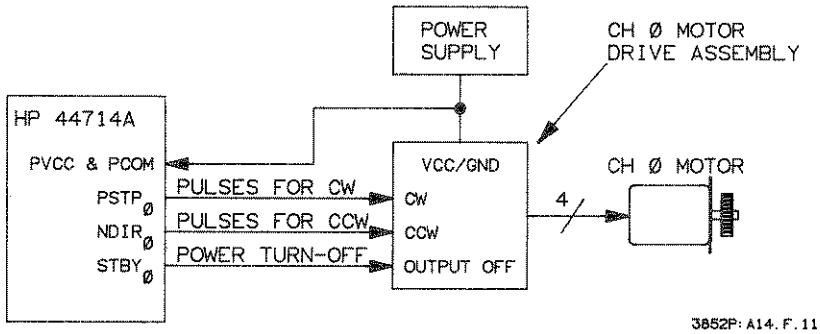
controller to enter and exit the standby mode, respectively (ON = remove power; OFF = apply power). You must check your motor driver specifications for the logic sense (“1” or “0”) required to deenergize the motor.



A. DIGITAL CONTROL OF 3 MOTOR DRIVE ASSEMBLIES



B. PULSE STEP/DIRECTION MODE (CHANNEL Ø SHOWN)



C. PULSE STEP/STEP MODE (CHANNEL Ø SHOWN)

Figure 3-1. Controlling a Stepper Motor

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EXAMPLES: (For a motor driver that deenergizes a motor when STBYn is low)

```
10  OUTPUT 709;"STANDBY AUTO LO"   !Changes sense to LO
20  OUTPUT 709;"MOVE 750 REL"      !Motor power on, a move to 750 takes place,
                                     motor power off

10  OUTPUT 709;"STANDBY ON LO"     !Sense is LO; motor power off
20   *                             !
30   *                             ! other commands
40   *                             !
50  OUTPUT 709;"STANDBY OFF"       !Motor power on
60  OUTPUT 709;"MOVE 750 REL"      !A move to 750 takes place
70  OUTPUT 709;"STANDBY ON"        !Motor power off
```

The AUTO mode satisfies most application needs freeing you from having to program STANDBY on and off. In the AUTO mode, the STANDBY command provides a one second delay in powering off the motor to keep power constantly applied for multiple moves without removing and applying power many times in a short period of time.

Setting the Pulse Mode and Sense

COMMAND DISCUSSED:

PULSE *mode PSTPn__sense* [*NDIR__sense*] [**USE** *ch*]

PARAMETER	VALID ENTRY
mode	SD or SS
PSTPn__sense	HI, LO, LH, or HL
NDIRn__sense	HI, LO, LH, or HL

1. The SD (step/direction) mode causes all pulses to appear at the PSTPn output while the NDIRn output controls direction of motor motion. Direction of motion is specified by using a positive or negative number in the MOVE or SUSTAIN command. See Figure 3-1b.

   The PULSE command establishes which outputs the pulses appear at (PSTPn and NDIRn) and whether the pulses are to be low-high-low or high-low-high. You direct pulses to the PSTPn and NDIRn outputs with the SD and SS mode parameters of the PULSE command.

   Low-high-low pulses are set by declaring the HI or LH option for the PSTPn__sense parameter (LO or HL causes high-low-high pulses). The NDIRn__sense parameter sets the sense for the NDIRn output which will indicate positive moves. For example, if HI is selected for NDIRn__sense, a high on this output will set the motor driver for positive stepper motor motion. If nothing is declared here, the sense defining positive motion is the same as set for PSTPn.

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2. The SS (step/step) mode causes pulses intended for positive motor motion to appear at the PSTPn output while pulses intended for negative motor motion will appear at the NDIRn output. Direction of motion is specified by using a positive or negative number in the MOVE or SUSTAIN command. See Figure 3-1c.

   The PSTPn_sense parameter defines low-high-low or high-low-high pulses for PSTPn as in the SD mode. The NDIRn_sense parameter defines the sense for NDIRn. If the NDIRn_sense is not declared, it is the same as that declared for PSTPn.

Figure 3-3 illustrates the PULSE command used in a program controlling a stepper motor.

Defining a Motion Profile

COMMAND DISCUSSED:

PROFILE *FREQ min max slope pwidth* [**USE** *ch*]

PARAMETER	MEANING
FREQ	frequency profile (versus pulse WIDTH profile used for pulse output)
min	minimum frequency
max	maximum frequency
slope	rate of change between frequencies
pwidth	pulse width of all pulses generated

Stepping motors operate more efficiently by starting step pulses at a frequency the motor can respond to from the idle state and ramping to a higher frequency where the motor will not miss a pulse. To stop the motor, it is more effecient to ramp down from the higher frequency to a frequency that the motor can stop at without advancing a step due to inertia. This type of pulse train is called a trapezoidal motion profile.

The PROFILE command is used to define a trapezoidal motion profile to ensure that the frequency of pulses is not faster than that which the motor can respond to. The frequency specified can be interpreted as motor velocity. The profile dictates a minimum frequency, maximum frequency, and the rate of change when going from one frequency to another within the minimum and maximum. Also defined is the width of the pulses generated. This motion profile dictates the pulse train generated by the MOVE and SUSTAIN commands. A specified frequency not within the min/max window will cause an error to be generated. Figure 3-2 shows typical trapezoidal motion profiles and Figure 3-3 illustrates the use of the PROFILE command in a program controlling a stepper motor.

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The min, max, and slope parameters impose certain operating restrictions. You cannot operate at a frequency less than min or greater than max and a slope of 0 will not allow the frequency to be changed.

PROFILE FREQ Setting Conflicts

A "settings conflict" error is generated if you specify parameters in the PROFILE command which conflict i.e. specifying a pulse width larger than the period of the max frequency. This section lists examples of PROFILE command setting conflicts and describes why the command will cause an error.

COMMAND SYNTAX	SETTINGS CONFLICT
"PROFILE FREQ 100 800 0 25E-6"	slope = 0; min-to-max freq range unattainable
"PROFILE FREQ 0 800 0 25E-6"	min = 0; slope = 0; no pulses can be generated
"PROFILE FREQ 0 0 0 25E-6"	min = max = slope = 0; no pulses can be generated
"PROFILE FREQ 0 1000 500 2E-3"	pwidth larger than period of max frequency
"PROFILE FREQ 500 100 200 2E-3"	min > max

Scaling Motor Motion

COMMAND DISCUSSED:

PSCALE *scale_factor* **[USE** *ch***]**

The PSCALE command specifies the distance one step of the motor (caused by one pulse) will generate. This distance can be a negative or positive number specified in any units you desire (inches, feet, angle of rotation, etc.). You can specify moves including profiles in units of distance instead of number of pulses when you use the PSCALE command. The default scale factor is 1.0. Each channel has a local processor which stores the scale factor for that channel. You must declare a scale factor for each channel where the default factor of 1.0 is not wanted. The scale factor of the PSCALE command affects the PROFILE, POS, and POS? commands. Scaling motor motion with the PSCALE command is illustrated in Figure 3-3, "Sending Pulses To a Motor."

NOTE

When the PSCALE scale_factor is specified as something other than 1, round-off errors can occur in the count contained in the position counter. This is especially true when a scale factor larger than 1 is specified. The examples that follow show how round-off errors are generated and can accumulate.

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PSCALE ROUND-OFF ERROR EXAMPLES:

The two examples that follow show how errors can accumulate using the REL and ABS options of the MOVE command. Refer to the section titled "Sending a Fixed Number of Pulses" for a discussion of the REL and ABS parameters.

```
 5 OUTPUT 709;"USE 400"          !Slot 4 Channel 00
10 OUTPUT 709;"POS 0"            !Set counter to 0
20 OUTPUT 709;"PSCALE 2"         !Set 2 degrees/step
30 OUTPUT 709;"MOVE 1 REL"       !Request 1 degree move (Note 1)
40 OUTPUT 709;"POS?"             !Counter returns 2
50 OUTPUT 709;"MOVE 1 REL"       !Request 1 degree move (Note 1)
60 OUTPUT 709;"POS?"             !Counter returns 4
70 OUTPUT 709;"MOVE 1 REL"       !Request 1 degree move (Note 1)
80 OUTPUT 709;"POS?"             !Counter returns 6
```

Note 1: Although a 1 degree move is requested, the smallest move per step (in degrees as specified by PSCALE) is 2 degrees. The counter can only count in increments of the scale factor specified. Using the REL option, the error continues to accumulate.

```
 5 OUTPUT 709;"USE 400"          !Slot 4 Channel 00
10 OUTPUT 709;"POS 0"            !Set counter to 0
20 OUTPUT 709;"PSCALE 2"         !Set 2 degrees/step
30 OUTPUT 709;"MOVE 1 ABS"       !Request 1 degree move (Note 2)
40 OUTPUT 709;"POS?"             !Counter returns 2
50 OUTPUT 709;"MOVE 2 ABS"       !Request 1 degree move (Note 2)
60 OUTPUT 709;"POS?"             !Counter returns 2
70 OUTPUT 709;"MOVE 3 ABS"       !Request 1 degree move (Note 2)
80 OUTPUT 709;"POS?"             !Counter returns 4
```

Note 2: As illustrated in the previous example using the REL option, the smallest move per step with the ABS option is also 2 (the counter will only count in increments of the scale factor which is 2). In the first MOVE, the request to move to the 1 degree position is divided by the scale factor of 2. The result of 0.5 is rounded up to to 1 and the motor moves one step. The scale factor of 2 degrees/step causes the counter to increment to 2. The second MOVE request places the motor at 2 degrees, the counter is already at 2 and no move takes place. The third MOVE request is for 1 degree which places the motor at 3 degrees. As in the first move, only a 2 degree move can be made and a move of 1 degree is 0.5 steps which rounds up to 1 step incrementing the counter by 2 to a total of 4.

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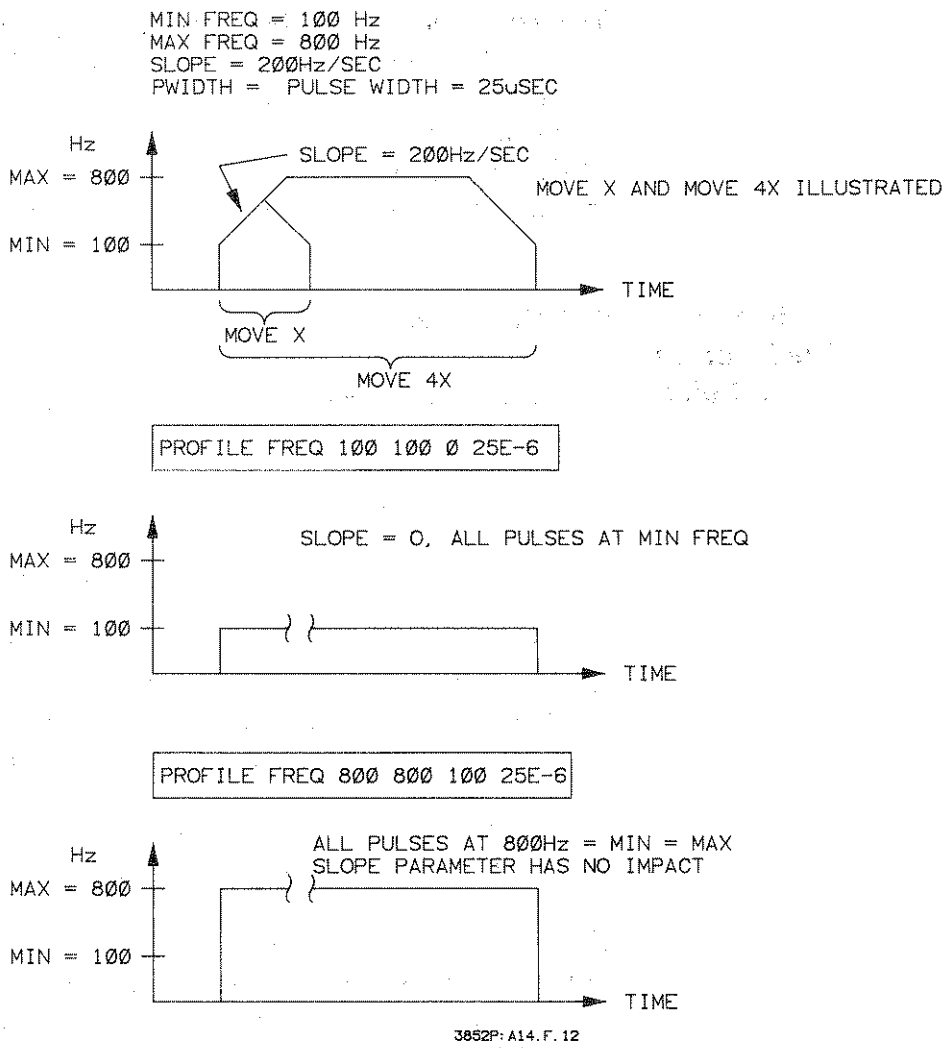


Figure 3-2. Typical Motion Profiles Used By the MOVE and SUSTAIN Commands to Efficiently Control Motor Velocity

Sending Pulses to a Motor

Two commands send pulses to a motor:

MOVE is used to send a fixed number of pulses

SUSTAIN is used to send pulses continuously.

You can choose to trigger either command with the TRIG command or with an external stimulus before pulses are actually generated. If the TRIG mode is *AUTO* (the default), the trigger is automatically generated immediately following the command. Both commands generate pulses as defined by the motion profile you specified in the PROFILE command.

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The motion profile specified must fit the type of stepper motor being controlled. To set up the PROFILE command for stepper motors, you specify the FREQ mode, minimum frequency, maximum frequency, rate of change of frequency, and the pulse width which is fixed until another PROFILE command changes it. You can find a more detailed discussion of the motion profile in the previous section titled "Defining a Motion Profile."

Sending a Fixed Number of Pulses

COMMAND DISCUSSED:

MOVE *distance* [*mode*][*NOWAIT*][**USE** *ch*]

distance	The distance to move (REL) or position to move to (ABS)
mode	REL (relative) or ABS (absolute)
NOWAIT	Allows the acceptance of another command before the move completes (Required if a trigger other than TRIG AUTO is used)

The MOVE command is used to move the motor a fixed number of steps. When triggered, the MOVE command generates a fixed number of pulses determined from the distance you want to move. The number of pulses can vary dependent on the value of the scale factor. In the example of Figure 13, if the slide bar moves 0.1 inches per motor step, you declare a scale factor of 0.1 which will cause 200 pulses to be generated. If a scale factor of 0.2 is specified, the MOVE command will generate only 100 pulses.

The REL and ABS parameters affect the move differently. A REL move means to move a specified distance relative to the current position. An ABS move means to move to the absolute position specified in the MOVE command. For example, a REL move of 10 means to move ten units from the current position. An ABS move of 10 means to move to position 10. If the current position were 90, a move of -80 would take place.

If the PSCALE *scale_factor* is left at 1.0, the distance parameter in the MOVE command corresponds to the number of pulses to be sent.

Sending Pulses Continuously

COMMAND DISCUSSED:

SUSTAIN *velocity* or *width* [*NOWAIT*][**USE** *ch*]

velocity	The frequency of pulses in Hz (PROFILE in FREQ mode)
width	The pulse width in seconds (PROFILE in WIDTH mode)
NOWAIT	Allows the acceptance of another command before the new velocity or width is accepted (required if a trigger other than TRIG AUTO is used)

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The SUSTAIN command sends pulses continuously. When triggered, the command causes pulses to be generated indefinitely until a SUSTAIN *0* command is executed and triggered or a HALT *SGL* command is executed. The start of pulses accelerate to the sustaining velocity at the rate of frequency change specified in the PROFILE command. If the sustaining velocity is greater than the maximum frequency specified in the PROFILE command, the velocity will not exceed the maximum frequency specified. A new SUSTAIN command, that is triggered with a different sustaining velocity, will cause the motor to accelerate or decelerate to the new velocity as specified by the PROFILE command. The actual frequency generated will be limited by the minimum and maximum specified in the PROFILE command. The exception is SUSTAIN 0 which cause the pulses to decelerate to the specified minimum and stop.

No frequencies below the minimum will be generated. For example, if the current frequency is zero and a frequency above the minimum is requested, the generated pulses will begin at the minimum frequency and ramp to the requested frequency. Likewise, if the next frequency requested is 0, the frequency will ramp down to the minimum and then stop.

NOTE A SUSTAIN command with a velocity less than the PROFILE "min" parameter will cause pulses to be generated at the "min" velocity. A SUSTAIN command with a velocity greater than the PROFILE "max" parameter will cause pulses to be generated at the "max" velocity ramping from "min" to "max."

Figure 3-3 illustrates the use of the SUSTAIN command.

Triggering a MOVE or SUSTAIN Command

COMMAND DISCUSSED:

TRIG *mode* **[USE** *ch***]**

MOVE or SUSTAIN commands must be triggered to initiate pulses. The TRIG command is used to generate the trigger and has different trigger modes for you to select from. Trigger modes available are:

HOLD	The trigger is disabled in the HOLD mode.
SYS (1)	The SYS mode connects the mainframe's backplane system trigger as the trigger source.
AUTO (or INT)	The AUTO (INT) mode generates a trigger automatically as the final step in a MOVE or SUSTAIN command (power-on mode).
CHAN0 (1)	The CHAN0 mode connects channel 0 as the trigger source to allow simultaneous moves with channel 0.

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SGL (1) Initiates an immediate trigger. After a SGL trigger is generated, TRIG returns to HOLD.
If a mode is not specified in the command, the default is SGL.

(1) The MOVE and SUSTAIN commands must specify the NOWAIT option for these trigger modes to work. Without NOWAIT, the HP 44714A must complete the MOVE or SUSTAIN command before the next command is recognized. If the next command is a manual trigger, the HP 44714A cannot access the trigger command unless NOWAIT is used.

NOTE

A MOVE or SUSTAIN command, with "NOWAIT" specified, waiting for a SYS, CHAN 0, or SGL trigger can be cancelled by a TRIG HOLD command. If "NOWAIT" is not specified, the command can be cancelled by sending DEVICE CLEAR followed by TRIG HOLD.

The power-on state is AUTO and if a TRIG command is executed without declaring an option, the default option is SGL i.e. OUTPUT 709;"TRIG" is equivalent to OUTPUT 709;"TRIG SGL."

Figure 3-3 illustrates the use of the TRIG command.

Delaying the Trigger

COMMAND DISCUSSED:

DELAY *time* **[USE** *ch***]**

The DELAY command is used to delay the trigger of a MOVE or SUSTAIN command. The delay can be from 0.000 to 65.535 seconds and is settable in one millisecond increments. Once a delay is programmed, all triggers are delayed until the delay is reprogrammed. The DELAY command is illustrated in Figure 3-3.

Halting a Pulse Output

COMMAND DISCUSSED:

HALT *mode* **[USE** *ch***]**

The pulse output can be immediately stopped by sending a HALT command with the *SGL* mode specified. Use of HALT SGL is illustrated in Figure 3-3. Additionally, pulses can be immediately stopped manually by an emergency halt switch connected to the HALTn input which is controlled by the HI/LO and ON/OFF mode parameters of the HALT command. This is discussed further in the section titled "Limiting Motor Motion."

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```
10  OUTPUT 709;"RST 500"
20  OUTPUT 709;"USE 500"              !Slot 5 Channel 00
30  OUTPUT 709;"STANDBY AUTO LO"
40  OUTPUT 709;"PULSE SS HI HI"
50  OUTPUT 709;"PROFILE FREQ 100 800 200 25E-6"
60  OUTPUT 709;"PSCALE 0.1"
```

```
70  OUTPUT 709;"MOVE 20"              !Move auto triggered
80  PAUSE                             !Press CONTINUE to proceed
90  OUTPUT 709;"MOVE -30"             !Move auto triggered
```

```
70  OUTPUT 709;"DELAY 5"              !Delay trigger 5 seconds
80  OUTPUT 709;"TRIG HOLD"
90  OUTPUT 709;"MOVE 20 NOWAIT"       !NOWAIT required for TRIG
100 OUTPUT 709;"TRIG"                 !Single trigger
110 PAUSE                             !Press CONTINUE to proceed
120 OUTPUT 709;"MOVE -30 NOWAIT"
130 OUTPUT 709;"TRIG"                 !Single trigger
140 PAUSE                             !Press CONTINUE to proceed
150 OUTPUT 709;"TRIG AUTO"            !Reset to trigger auto
```

```
160 OUTPUT 709;"SUSTAIN 10"           !Triggered auto
170 OUTPUT 709;"WAIT 10"              !10 second wait
180 OUTPUT 709;"SUSTAIN 50"
190 OUTPUT 709;"WAIT 10"
200 OUTPUT 709;"SUSTAIN 0"            !Stop to change direction
210 OUTPUT 709;"WAIT 10"
220 OUTPUT 709;"SUSTAIN -10"          !Reverse direction
230 OUTPUT 709;"WAIT 10"
240 OUTPUT 709;"HALT SGL"             !Stop
250 END
```

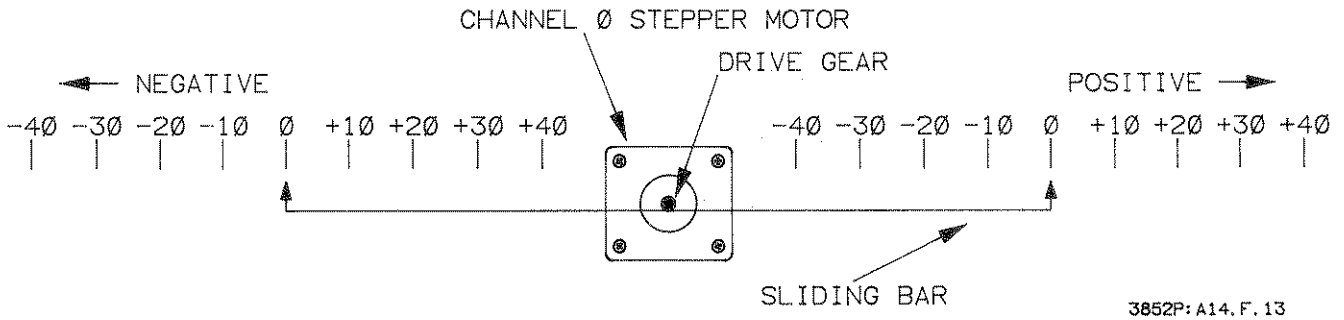


Figure 3-3. Sending Pulses To a Motor

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Selecting Interrupts

Each channel can be enabled to interrupt with the ENABLE INTR [USE ch] command. When enabled, a channel interrupts when:

1. Pulses stop following a MOVE command
2. The specified frequency or pulse width is reached in a SUSTAIN command
3. A hardlimit is reached causing pulses to stop
4. A HALT SGL command is executed stopping pulses
5. The HALT switch is activated stopping pulses

Also, each channel can be prevented from interrupting with the DISABLE INTR [USE ch] command. Refer to Chapter 8 "Using Interrupts" in the HP 3852A Mainframe Configuration and Programming Manual for more information. An example program for servicing an HP 44714A interrupt follows the next two sections titled "Enabling Interrupts" and "Disabling Interrupts."

Enabling Interrupts (ENABLE INTR)

Interrupts can be independently enabled for each channel with the ENABLE INTR command. If more than one channel generates an interrupt, the mainframe services the lowest-numbered channel first, then the next-lowest, etc. The HP 44714A generates an interrupt each time the motor stops or when the specified frequency or pulse width is reached in the SUSTAIN command.

Disabling Interrupts (DISABLE INTR)

Each channel can be independently disabled from generating an interrupt at the end of a move with the DISABLE INTR [USE ch] command. The channel specified by USE ch is the channel with interrupts disabled. The other two channels can still interrupt if enabled.

EXAMPLE: The following program segment and subroutine enables and services an HP 44714A interrupt for slot 4 channel 00.

```
OUTPUT 709;"USE 400"                          !Slot 4 Channel 00
OUTPUT 709;"PROFILE FREQ 0 1200 250 50E-6"    !Set profile for example
OUTPUT 709;"ON INTR CALL INTRUPT"         !Call the subroutine on interrupt
OUTPUT 709;"ENABLE INTR SYS"              !Enable the system interrupt
OUTPUT 709;"ENABLE INTR"                  !Enable the HP 44714A interrupt

OUTPUT 709;"SUB INTRUPT"                  !Subroutine INTRUPT
OUTPUT 709;" BEEP"                        !Action taken on interrupt
OUTPUT 709;" ENABLE INTR"                 !Reenable HP 44714A to interrupt(1)
OUTPUT 709;"SUBEND"                       !End of servicing subroutine

OUTPUT 709;"MOVE 100"                     !Interrupts and beeps after move
```


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```
OUTPUT 709;"WAIT 5"                !5 second pause between moves
OUTPUT 709;"SUSTAIN 1000"          !Interrupts and beeps when 1000 Hz
OUTPUT 709;"WAIT 10"               !Wait
OUTPUT 709;"HALT SGL"              !Interrupts and beeps when pulses halt
```

(1)An enabled interrupt that is serviced is disabled and must be reenabled to be able to interrupt again.

Limiting Motor Motion

COMMANDS DISCUSSED:

HARDLIM *PLIM_sense* [*NLIM_sense*][**USE** *ch*]

HALT *mode* [**USE** *ch*]

Limits of motion can be established for automatically or manually stopping a motor in case of emergency. Limits of motion are determined by use of limit switches which close or open when a limit is reached. You can set up a switch that is operated manually in case of emergency to stop a motor. A halt switch input and two limit switch inputs, one for each direction, are provided for each of the three channels.

Hard Limits

Hard limits are the positive and negative physical limits of your application. Limit switches supply an input for the negative limit and positive limit and connect to the NLIMn and PLIMn inputs respectively. The HARDLIM command sets the logic sense that indicates a hard limit has been reached. Figure 3-4 shows hard limit inputs requiring "LO" sense. The power-on PLIM and NLIM sense is LO and the HARDLIM command is not needed to set this sense. If "HI" sense were required on channel 02 slot 4, send OUTPUT 709;"HARDLIM HI USE 402".

Halt Input

A halt input is available to connect a halt switch to manually stop pulses. Figure 3-4 shows a halt switch connected to the HALTn input that requires a "LO" sense to be set. "HALT LO" is the power-on mode. If a "HI" sense is required (if the HALT switches +5V to the HALTn input), send OUTPUT 709;"HALT HI USE 402" to set the sense high for channel 02 on a module in slot 4.

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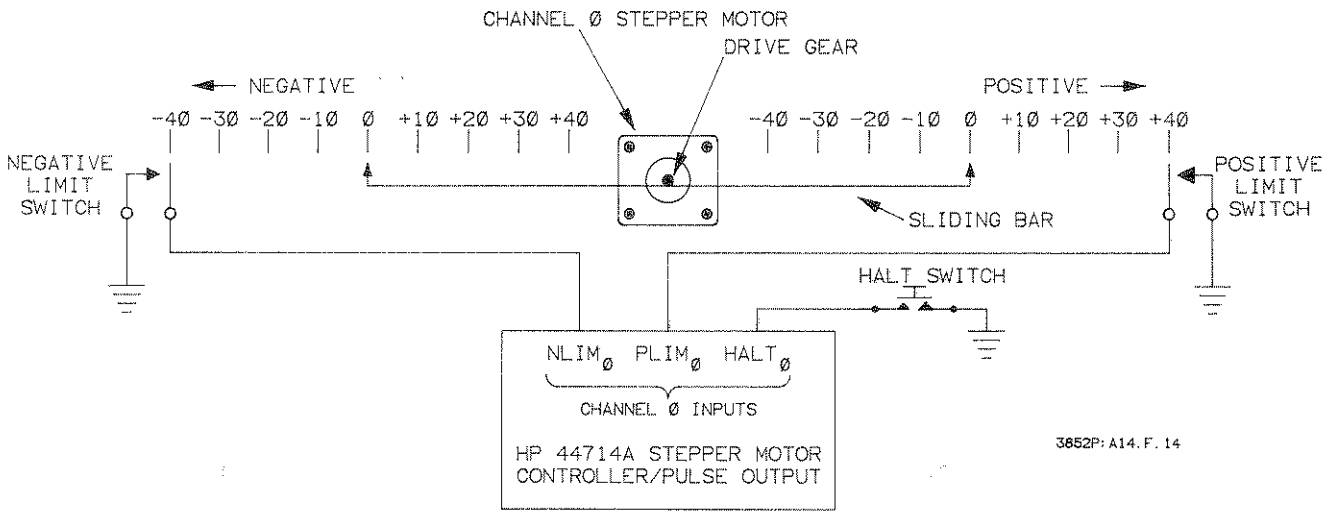


Figure 3-4. Setting Hard Limits and Emergency HALT Capability

Setting and Monitoring Position With the Internal Counter

The internal counter (not the quadrature counter) of the HP 44714A counts the number of pulses that is generated by commands. The counter applies the scale factor and records a position. Distance (as in the MOVE command) specified as a positive number, corresponds to positive motor motion and that specified as a negative number, corresponds to negative motor motion. By accounting for positive or negative motor motion, counting the pulses generated, and applying the scale factor, the counter can keep track of where motor position should be.

Loading a Position Value Into the Counter

COMMAND DISCUSSED:

POS *pos__value* [**USE** *ch*]

The POS command is used to load a position value into the counter corresponding to a reference location the motor is currently set at. This value can be any number from -2,147,483,648 to +2,147,483,647 specified in the units of the PSCALE command. For example, in Figure 13 you step the motor until the pointer aligns with "0" and load 0 with the POS command (or align the pointer with "-10" and load -10 with the POS command etc.). The internal counter will keep track of the pulses causing positive motor motion and those causing negative motor motion, use the scale factor, and keep the position counter updated with current position.

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NOTE

The internal counter does not monitor the motor shaft motion like the quadrature counter does but indicates where the position should be if the motor has not skipped a pulse.

EXAMPLE: Load a position value of 50 for channel 02 slot 4.

```
OUTPUT 709;"POS 50 USE 402"
```

Asking For the Position Value

COMMAND DISCUSSED:

POS? [USE *ch*][*INTO name*] or [*fmt*]

For each channel, the controlling processor can be queried to find out what value the position counter holds by using the POS? command. You can query the counter even while the motor is moving if the NOWAIT option is used in the MOVE or SUSTAIN command.

The POS? command returns a position value that can optionally be placed into the specified variable name or returned in the format specified. If a format is not specified, the value is returned in RASC format (real number). The number can range from -2,147,483,648 to +2,147,483,647.

EXAMPLE: Determine position value of channel 02, slot 4 in LASC format.

```
10  OUTPUT 709;"POS? USE 402 LASC"
20  ENTER 709; value
30  PRINT value
40  END
```

Asking For the Status of a Move

COMMAND DISCUSSED:

DONE? [USE *ch*][**INTO** *name*] or [*fmt*]

With the DONE? command you can determine whether or not a move has completed and, if so, under what conditions. The command returns a number from -3 through +2 which optionally can be placed into the specified variable name or returned in the format specified. The numbers -3 through +2 have the following meaning.

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CODE	MEANING
−3	Waiting for trigger
−2	Running
−1	SUSTAIN Running/Ready for next command
0	Move completed successfully
1	Move aborted because of halt
2	Move aborted because of hard limit

EXAMPLE: Determine if a move on channel 02 slot 4 is complete.

```
10  OUTPUT 709;"DONE? USE 402"
20  ENTER 709; value
30  PRINT value
40  END
```

Monitoring Motor Shaft Movement With the Quadrature Counter

You can use quadrature counter inputs QA, QB, and QI (channels A, B, and Index) for attaching an optical encoder to the HP 44714A and physically monitor the motor shaft movement. Each channel has a positive and negative input that is TTL compatible and has an active switching range of 0 to 15V. The HP 44714A has two outputs (QPWR and QGND) that provide power for the optical encoder. Figure 3-5 shows typical connections to the quadrature counter.

Three commands are used to set up the quadrature counter; QSCALE, QINDEX, and QPOS?.

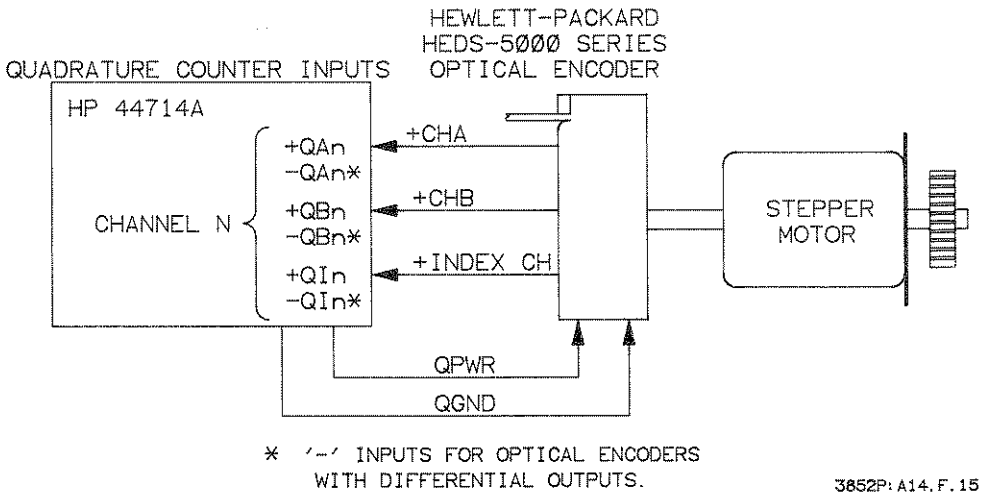


Figure 3-5. Quadrature Counter Connections From An Optical Encoder

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Scaling the Quadrature Counter

COMMANDS DISCUSSED:

QSCALE *qfactor* **[USE** *ch***]**

QSCALE scales each motor step to specify the distance the motor travels per quadrature count (in whatever units you choose). The distance can be a positive or negative number and allows you to determine position in units of distance instead of quadrature counts. This scale factor, called *qfactor*, is stored in the local processor that controls the indicated channel. The power-on default is 1.0. When a QPOS? command is executed, the value returned will be scaled by the *qfactor* and must be interpreted in the units of the *qfactor*.

EXAMPLE: Set the scale of the channel 02 slot 4 quadrature counter to be 0.5.

```
OUTPUT 709;"QSCALE 0.5 USE 402"
```

Indexing the Quadrature Counter

COMMAND DISCUSSED:

QINDEX *mode* **[USE** *ch***]**

The quadrature counter is indexed with the QINDEX command. To index the counter means to reset it to zero and specify when counting is to commence. Indexing can be turned off with the OFF option. The power-on state is OFF. You have two other options for indexing; ONCE and SGL. The default is SGL (i.e. send QINDEX without an option and QINDEX SGL is set).

QINDEX ONCE

The quadrature counter is reset when the command is executed but the counter does not begin counting until the first index pulse is recieved. An encoder that outputs a pulse every revolution causes the counter to begin counting on the first pulse and all following index pulses are ignored. A "home position" switch can be set at the "zero" position to provide the index pulse and initiate counting. The following example illustrates this.

Example: Reset the channel 02 slot 4 counter and initiate counting when the motor passes through the "home position". A "home position" switch connected between +QI and QPWR as shown in Figure 3-6. When the motor steps through the "home position," the switch closes during that step and generates a pulse with the leading edge starting the counter. Executing the following QINDEX command resets the counter and counting begins when the motor steps through the "home position."

```
OUTPUT 709:"QINDEX ONCE USE 402"
```


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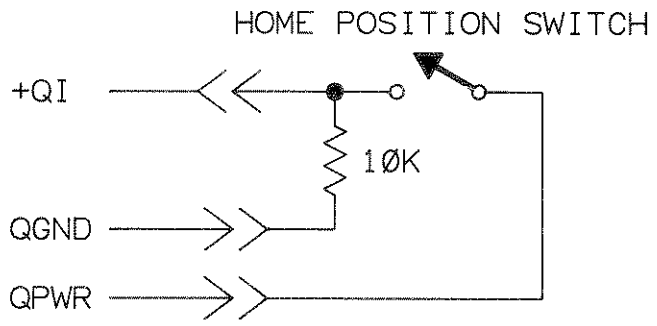


Figure 3-6. QINDEX ONCE With Home Position Switch

QINDEX SGL

The quadrature counter is reset immediately and begins counting immediately when a QINDEX SGL command is executed. QINDEX then returns to the OFF state. The counter is not reset on any following index pulses but continues to keep count of the number of quadrature pulses (positive and negative). This feature lends itself to stepping the motor to position something at a stop (call this "zero") and then resetting the quadrature counter to "zero" to agree with the pointer.

Example: Set the channel 02 slot 4 motor to the "zero" position, reset the counter, and begin counting immediately.

```
OUTPUT 709;"QINDEX SGL USE 402"
```

The counter is reset on execution of the QINDEX command and on the next MOVE or SUSTAIN command providing motion, the counter begins counting.

Asking For Quadrature Counter Value

COMMAND DISCUSSED:

QPOS? [**USE** *ch*][*INTO name*] or [*fmt*]

For each channel, the controlling processor can be queried to find out what value the quadrature counter holds by using the QPOS? command. You can query the counter even while the motor is moving if the NOWAIT option is used in the MOVE or SUSTAIN command.

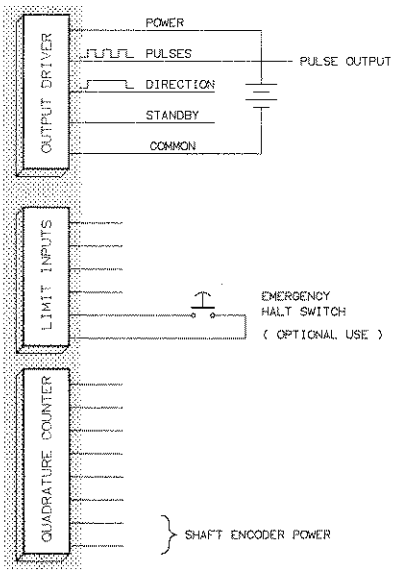
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The QPOS? command returns a value that can optionally be placed into the specified variable name or returned in the format specified. If a format is not specified, the value is returned in RASC format (real number). The number can range from -2,147,483,648 to +2,147,483,647 and will rollover from the maximum positive number to the maximum negative number and vice versa.

EXAMPLE: Determine the quadrature counter value of channel 02, slot 4 in DASC format.

```
10  OUTPUT 709;"QPOS? USE 402 DASC"
20  ENTER 709; value
30  PRINT value
40  END
```

Programming For General Purpose Pulse Output



This section deals with applications that primarily require control of pulse width (pulse width modulation) and secondly, changing of frequency. For general purpose pulse output, all inputs and outputs of the HP 44714A are active but all of them might not be used. Unless you control dc motors, you probably will not use Limit Commands, Position Commands, or Quadrature Counter Commands. Three groups of commands actively used in general purpose pulse output are:

1. PULSE SET-UP
   a. Set the pulse mode (establish outputs the pulses will appear at)
   b. Set the pulse width profile and period
2. PULSE OUTPUT COMMANDS
   a. Sending pulses indefinitely until commanded to halt

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3. INTERRUPT COMMANDS
   a. Enabling the HP 44714A to interrupt
   b. Disabling the interrupts

Setting Up the Pulse Output

COMMAND DISCUSSED:

PULSE *mode PSTP__sense* [*NDIR__sense*][**USE** *ch*]

PARAMETER	VALID ENTRY
mode	SD or SS
PSTP__sense	HI, LO, LH, or HL
NDIR__sense	HI, LO, LH, or HL

Setting up the pulse output establishes the output terminals that pulses appear at (PSTPn and NDIRn) and whether the pulses are to be low-high-low or high-low-high.

1. The SD (step/direction) mode causes all pulses to appear at the PSTPn output while the NDIRn output is one logic level for positive numbers and the other logic level for negative numbers specified in an output command. You specify which level is high and which is low with the PSTP__sense and NDIR__sense.

See Figure 3-7a.

Low-high-low pulses are set by declaring the HI or LH option for the PSTPn__sense parameter (LO or HL causes high-low-high pulses). The NDIRn__sense parameter sets the sense for the NDIRn output which will indicate positive numbers specified in an output command. For example, if HI is selected for NDIRn__sense, this output will be high during the output of pulses specified as a positive number. If nothing is declared here, the sense defining positive numbers is the same as set for PSTPn.

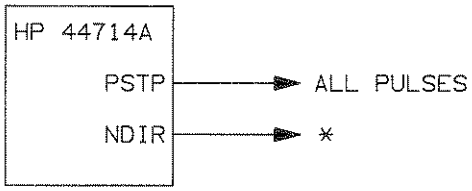
2. The SS (step/step) mode causes pulses for positive numbers to appear at the PSTPn output while pulses for negative numbers will appear at the NDIRn output.

See Figure 3-7b.

The PSTPn__sense parameter defines low-high-low or high-low-high pulses for PSTPn. The NDIRn__sense parameter defines the sense for NDIRn. If the NDIRn__sense is not declared, it is the same as that declared for PSTPn.

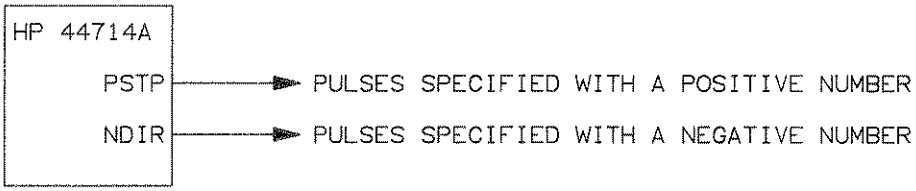
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a) PULSE STEP/DIRECTION MODE.



* Pulse specified with a positive number cause NDIR to be a high or low logic level (settable). Pulse specified with a negitive number cause NDIR to be the opposite logic level.

b) PULSE STEP/STEP MODE.



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Figure 3-7. Setting Up the Pulse Output With the PULSE Command

Defining a Pulse Profile

COMMAND DISCUSSED:

PROFILE *WIDTH min max slope period* **[USE** *ch***]**

PARAMETER	MEANING
WIDTH	pulse width profile (versus FREQ profile used for motor control)
min	minimum pulse width in seconds i.e. .001 or 1E-3
max	maximum pulse width
slope	rate of change going from one width to another
period	period or repetition rate of pulses

A pulse profile specifies a pulse width range (minimum to maximum) and a rate of change for going from one width to another. You also control the period of the pulses with the pulse profile. This pulse profile dictates the pulse train generated by the SUSTAIN command. SUSTAIN initiates the pulses when triggered and specifies the pulse width while the period is controlled by the PROFILE command. Figure 3-8 shows a typical trapezoidal pulse profile.

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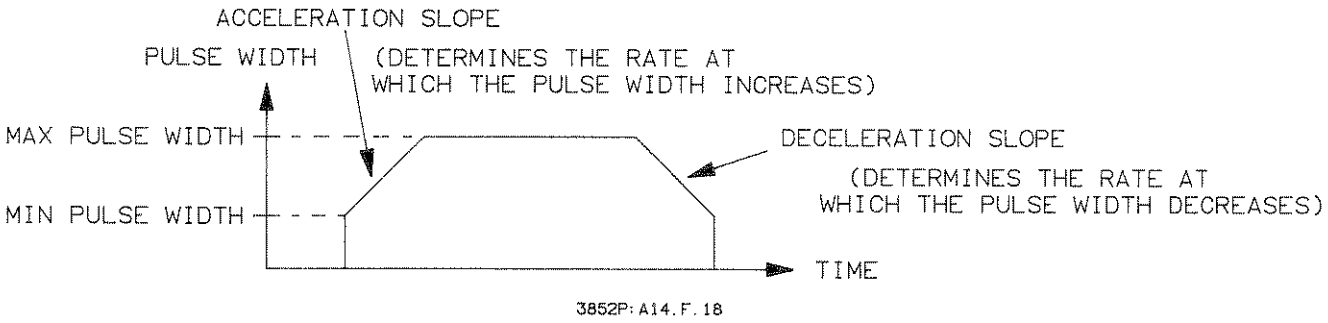


Figure 3-8. Typical Trapezoidal Pulse Width Profile Used By the SUSTAIN Command

PROFILE WIDTH Setting Conflicts

A "settings conflict" error is generated if you specify parameters in the PROFILE command which conflict i.e. specifying a period smaller than the max pulse width. This section lists examples of PROFILE command setting conflicts and describes why the command will cause an error.

COMMAND SYNTAX	SETTING CONFLICT
"PROFILE WIDTH 1E-6 10E-6 0 .1E-3"	slope = 0; min-to-max width range unattainable
"PROFILE WIDTH 0 10E-6 0 .1E-3"	min = 0; slope = 0; no pulses can be generated
"PROFILE WIDTH 0 0 0 .1E-3"	min = max = slope = 0; no pulses can be generated
"PROFILE WIDTH 1E-3 10E-3 1E-3 9E-3"	period < max width
"PROFILE WIDTH 5E-3 1E-3 1E-3 10E-3"	min > max

Pulse Output Commands

The SUSTAIN command is used to set up a pulse output and must be triggered with the TRIG command to initiate action. This section describes the SUSTAIN command, the TRIG command, and the DELAY command for delaying the trigger.

SUSTAIN Command

COMMAND DISCUSSED:

SUSTAIN *width* [*NOWAIT*][**USE** *ch*]

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The SUSTAIN command, when triggered, causes pulses to be generated indefinitely until a SUSTAIN 0 command is executed and triggered or a HALT SGL command is executed. The period of pulses is specified by the PROFILE command and must be used in conjunction with the SUSTAIN command. The SUSTAIN command specifies the final pulse width and initiates the pulse train while the PROFILE command specifies the period of the pulse train. Use of the SUSTAIN and PROFILE commands is illustrated in Figure 3-9. NOTE A SUSTAIN command with a width less than the PROFILE "min" parameter will cause pulses to be generated at the "min" width. A SUSTAIN command with a width greater than the PROFILE "max" parameter will cause pulses to be generated at the "max" width ramping from "min" to "max."

TRIG Command

COMMAND DISCUSSED:

TRIG *mode* [**USE** *ch*]

The SUSTAIN command is triggered to initiate pulses with the TRIG command. You can trigger automatically with the AUTO option and a trigger is generated as the final step in the SUSTAIN command. You use the SYS option to declare the HP 3852A mainframe backplane system trigger as the trigger source. Simultaneous moves of all three channels are made by triggering channels 1 and 2 off of channel 0 using the CHAN0 option. You can generate an immediate trigger with the SGL option and once generated, TRIG returns to HOLD. The power-on state is AUTO and if a TRIG command is executed without declaring an option, the default option is SGL. Use of the TRIG command is illustrated in Figure 3-9.

NOTE

You must specify the NOWAIT option in the SUSTAIN command if you use **TRIG** *HOLD in conjunction with another mode other than AUTO. If NOWAIT is not specified, the SUSTAIN command will be locked into a wait state preventing it from accepting another command.*

DELAY Command

COMMAND DISCUSSED:

DELAY *time* [**USE** *ch*]

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The triggering of a SUSTAIN command can be delayed with a DELAY command. The delay can be from 0.000 to 65.536 seconds and is settable in one millisecond increments.

Figure 3-9 demonstrates the use of the PROFILE, SUSTAIN, DELAY, and TRIG commands to establish and change pulse widths and frequency of pulses.

Selecting Interrupts

Each channel can be enabled to interrupt with the ENABLE INTR [USE ch] command. When enabled, a channel interrupts when:

1. Pulses stop following a MOVE command
2. The specified frequency or pulse width is reached in a SUSTAIN command
3. A hardlimit is reached causing pulses to stop
4. A HALT SGL command is executed stopping pulses
5. The HALT switch is activated stopping pulses

Also, each channel can be prevented from interrupting with the DISABLE INTR [USE ch] command. Refer to Chapter 8 "Using Interrupts" in the HP 3852A Mainframe Configuration and Programming Manual for more information. An example program for servicing an HP 44714A interrupt follows the next two sections titled "Enabling Interrupts" and "Disabling Interrupts".

Enabling Interrupts (ENABLE INTR)

Interrupts can be independently enabled for each channel with the ENABLE INTR command. If more than one channel generates an interrupt, the mainframe services the lowest-numbered channel first, then the next-lowest, etc. The HP 44714A generates an interrupt each time the motor stops or when the specified frequency or pulse width is reached in the SUSTAIN command.

Disabling Interrupts (DISABLE INTR)

Each channel can be independently disabled from generating an interrupt at the end of a move with the DISABLE INTR [USE ch] command. The channel specified by USE ch is the channel with interrupts disabled. The other two channels can still interrupt if enabled.

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EXAMPLE: The following program segment and subroutine enables and services an HP 44714A interrupt for slot 4 channel 00.

```
OUTPUT 709;"USE 400"                          !Slot 4 Channel 00
OUTPUT 709;"PROFILE WIDTH 1E-3 10E-3 5E-3 20E-3"  !Set width profile
OUTPUT 709;"ON INTR CALL INTRUPT"             !Call the subroutine on interrupt
OUTPUT 709;"ENABLE INTR SYS"                  !Enable the system interrupt
OUTPUT 709;"ENABLE INTR"                      !Enable the HP 44714A interrupt

OUTPUT 709;"SUB INTRUPT"                      !Subroutine INTRUPT
OUTPUT 709;" BEEP"                            !Action taken on interrupt
OUTPUT 709;" ENABLE INTR"                     !Reenable HP 44714A to interrupt(1)
OUTPUT 709;"SUBEND"                           !End of servicing subroutine

OUTPUT 709;"SUSTAIN 2E-3"                     !Interrupts and beeps when 2 mS reached
OUTPUT 709;"WAIT 10"                          !Wait
OUTPUT 709;"HALT SGL"                         !Interrupts and beeps when pulses halt
```

(1)An enabled interrupt that is serviced is disabled and must be reenabled to be able to interrupt again.

STANDBY Command

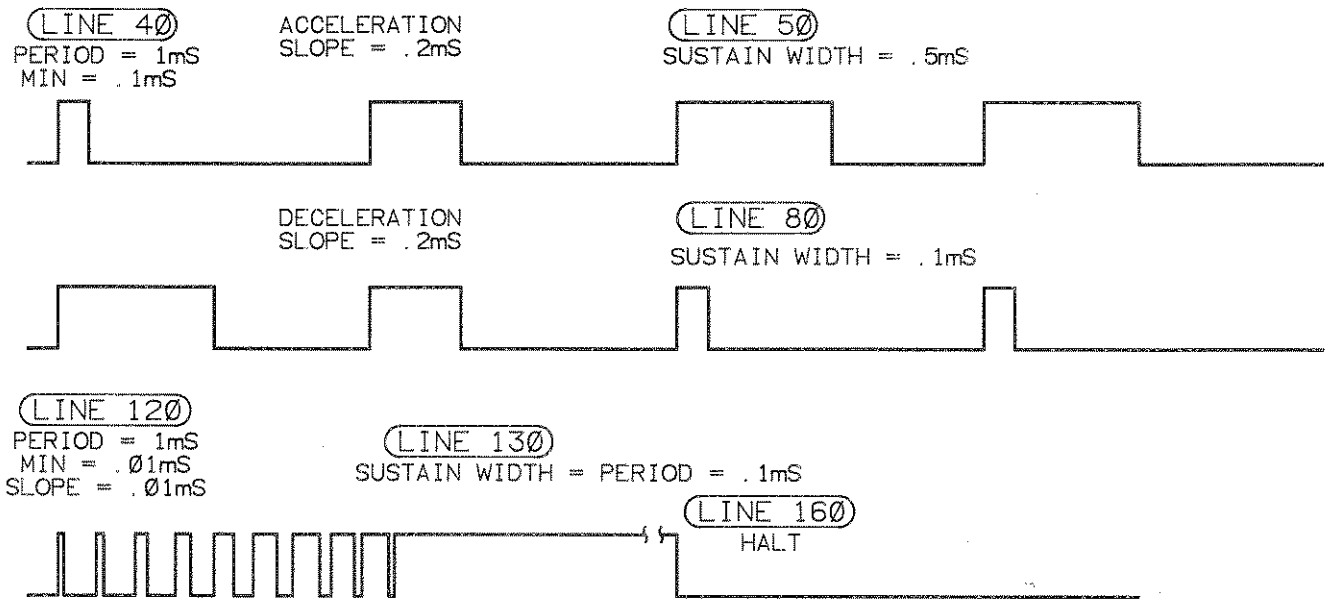
COMMAND DISCUSSED:

STANDBY [*mode*][*sense*][**USE** *ch*]

The primary purpose of the STANDBY command is to set up the STBYn output for powering down a stepper motor between moves. However, the STBYn output may find application in general purpose pulse output where STBYn changes state when a pulse train is present. The opposite state is present when no pulses are output. When you specify the STANDBY mode ON and the logic sense HI, the STBYn output will be high when no pulses are output. When a MOVE or SUSTAIN command is executed and triggered, the STBYn output goes low. After all pulses are sent, the STBYn output goes high. Figure 3-10 illustrates the STBYn output for HI sense and LO sense.

The power-on defaults are AUTO and HI. If a STANDBY command is executed and a mode is not specified, the default is ON. If a sense is not declared, the sense remains unchanged.

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NOTE

THE 'PROFILE WIDTH' AND 'SUSTAIN' COMMANDS ARE USED TOGETHER TO CONTROL THE PULSE WIDTH.

1. PROFILE sets the pulse width limits and waveform period.
2. SUSTAIN specifies the pulse width.

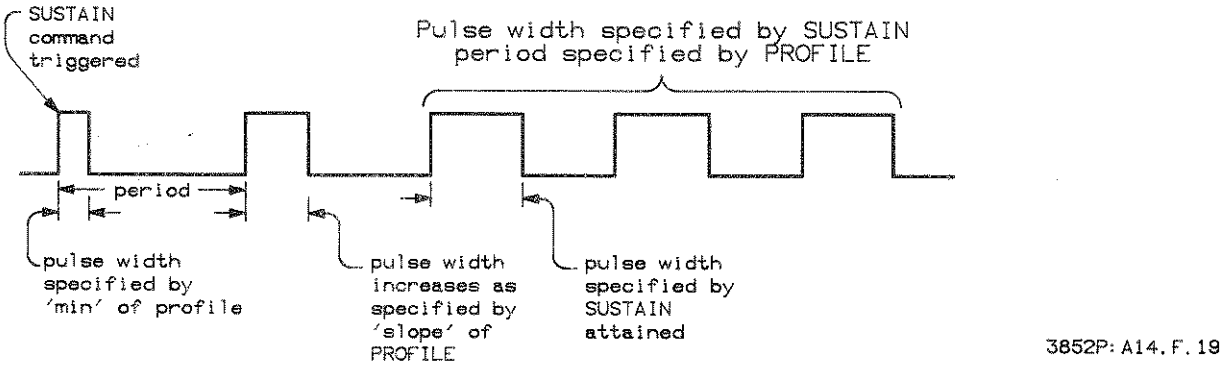


Figure 3-9. Changing Pulse Width and Frequency

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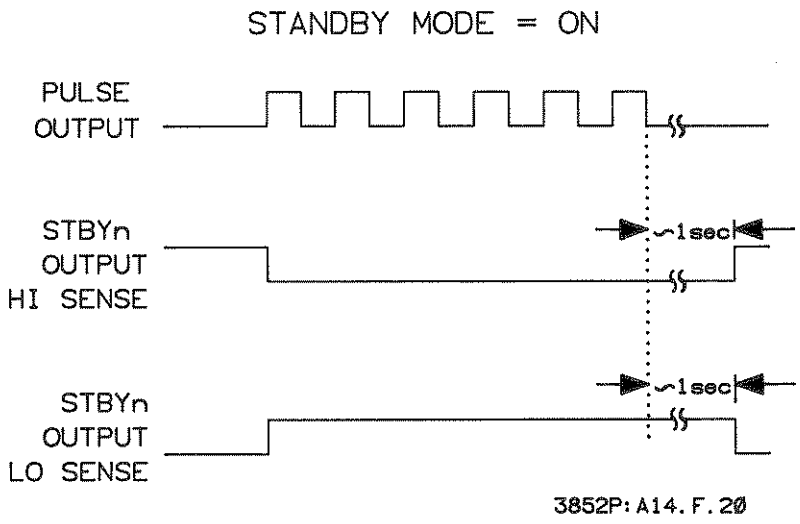


Figure 3-10. Standby Output (STBYn) HI sense and LO sense

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Chapter 4
Command Summary

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Chapter 4

Command Summary

This section summarizes the HP 44714A commands discussed previously in this manual. For a tutorial on each of these commands, refer to the section titled "Programming the Stepper Motor Controller/Pulse Output." For detailed reference information on each command in the summary, refer to the HP 3852A Command Reference Manual.

Commands by Function

PULSE/MOTOR DRIVER SET-UP COMMANDS
STANDBY
PULSE
PROFILE
PSCALE

OUTPUT COMMANDS
MOVE
SUSTAIN
TRIG
DELAY
HALT SGL

LIMITS COMMANDS
HARDLIM
HALT

POSITION COMMANDS
POS
POS?
DONE?

QUADRATURE COUNTER COMMANDS
QSCALE
QINDEX
QPOS?

INTERRUPT COMMANDS
ENABLE INTR
DISABLE INTR

TEST COMMAND
TEST

Alphabetical Listing

DELAY

Causes the selected trigger to be delayed by the time specified. Delays the triggering of the MOVE and SUSTAIN commands.

Syntax: DELAY *time* **[USE** *ch***]**

DISABLE INTR

Disables the interrupts that occur when a move is completed.

Syntax: DISABLE INTR [USE *ch***]**

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DONE?

Queries the controller to determine if a move has completed and if so, under what conditions the move terminated. A code (-3 to +2) is returned indicating how the move completed.

Syntax: DONE? [**USE** *ch*][**INTO** *name*] or [*fmt*]

ENABLE INTR

Clears and then enables the interrupts that occur when a move is completed or a SUSTAIN has reached final frequency or width.

Syntax: ENABLE INTR [**USE** *ch*]

HALT

Specifies the conditions under which a stepper motor is to be brought to an abrupt stop. For general purpose pulse output, specifies the conditions under which pulses abruptly stop.

Syntax: HALT *mode* [**USE** *ch*]

HARDLIM

Determines how the positive (PLIMn) and negative (NLIMn) hard limit inputs will operate. When a limit switch is activated in the positive direction, further positive motion is prohibited but negative motion is allowed. The opposite case occurs when the negative limit switch is activated.

Syntax: HARDLIM *PLIMn_sense* [*NLIMn_sense*][**USE** *ch*]

MOVE

Specifies a distance to be moved and determines the number of pulses required for the move (the parameters of the PROFILE command and the scale factor of the PSCALE command are used to calculate the number pulses required).

Syntax: MOVE *distance* [*mode*][*NOWAIT*][**USE** *ch*]

POS

Loads a position value, in units specified by the PSCALE command, in the internal position counter. This allows you to set the counter to any value corresponding with current position.

Syntax: POS *pos_value* [**USE** *ch*]

POS?

Requests the current position value present in the internal position counter.

Syntax: POS? [**USE** *ch*][*INTO name*] or [*fmt*]

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PROFILE

Defines a trapizoidal motion profile that specifies the velocity range, acceleration/deceleration, and pulse width of pulses generated by the MOVE and SUSTAIN commands.

Syntax: **PROFILE** *FREQ min_freq max_freq slope pwidth* **[USE** *ch*]
or **PROFILE** *WIDTH min_width max_width slope period* **[USE** *ch*]

PSCALE

Specifies the distance of motion that one step of the motor causes.

Syntax: **PSCALE** *scale_factor* **[USE** *ch*]

PULSE

Sets which outputs the pulses appear at and whether the pulses are positive going or negative going.

Syntax: **PULSE** *mode PSTP_sense* [*NDIR_sense*][**USE** *ch*]

QINDEX

Specifies how the quadrature counter is to be indexed (resets the counter).

Syntax: **QINDEX** *mode* **[USE** *ch*]

QPOS?

Requests the current position value present in the quadrature counter.

Syntax: **QPOS? [USE** *ch*][**INTO** *name*] or [*fmt*]

QSCALE

Specifies the distance of motion that one quadrature count corresponds to. The scale factor (qfactor) can be in any units desired i.e. inches, angle of rotation, etc.

Syntax: **QSCALE** *qfactor* **[USE** *ch*]

STANDBY

Used to remove power from a stepper motor when the motor is sitting idle.

Syntax: **STANDBY** [*mode*][*sense*][**USE** *ch*]

SUSTAIN

When triggered, generates pulses continuously at the velocity or pulse width specified. The velocity or pulse width must be within the min and max limits specified in the PROFILE command.

Syntax: **SUSTAIN** *velocity* or *width* [*NOWAIT*][**USE** *ch*]

TEST

Initiates a pass/fail self test.

Syntax: **TEST** *slot*

TRIG

Determines how a move specified by a MOVE or SUSTAIN command is triggered. The move is not initiated until triggered.

Syntax: **TRIG** *mode* **[USE** *ch*]

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Appendix A
Specifications

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HP 44714A Specifications A-1

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Appendix A

Specifications

Introduction

The specifications for the HP 44714A are the performance characteristics of the module which are certified. These specifications are listed in this appendix and are the performance standards or limits against which the module is tested.

Any changes in specifications due to manufacturing changes, design, or traceability to the National Bureau of Standards will be covered in a manual change supplement.

HP 44714A Specifications

Output Characteristics

Trapezoidal motion profiles:

- Continuous stream of pulses (SUSTAIN)
- Set number of pulses (MOVE)

PULSE OUTPUT TERMINALS

PVCC	(+5 to +42V relative to PCOM)*
PSTP	(Positive/Step output channel)
NDIR	(Negative/Direction output channel)
STBY	(removes power when no output)
PCOM	(common return)

*Supplied by the user (isolated operation) or supplied by the module (non-isolated operation).

Isolation:

(Channels are isolated from each other. PVCC, PSTP, NDIR, and STBY outputs on each channel have a common return.)

Between outputs (PSTP,NDIR,STBY) and common (PCOM):	15V
Between channels:	42V
Between channel and ground:	42V

Stepper Motor Configurations:

Two outputs per channel - PSTP & NDIR. These outputs can be configured in one of two modes:

- PSTP - outputs pulses
  NDIR - determines direction

- PSTP - pulses for one direction (e.g. CW)
  NDIR - pulses for other direction (e.g. CCW)

	Maximum	Resolution
Pulse Rate	10 kHz	2.5 μHz**
Pulse Rate of Change	1 MHz/sec	25 mHz/sec
Pulse Width	65.535 msec	1 μsec
Pulse Width Rate of Change	1 sec/sec 1 sec/sec	1 μsec/sec 1 μsec/sec

**An average pulse rate can be selected to this resolution, but period elements will be based on a 1 μsec time base.

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	Jitter	Accuracy
Pulse rate	1 μsec	0.01%
Pulse width	1 μsec	0.01% ± 200 nsec***

***Applies to non-isolated outputs (otherwise 0.01% ± 1 μsec)

Total number output pulses/channel in MOVE mode: ±2,147,483,647

Input Characteristics

Quadrature counter:

- TTL compatible
- +5V (180 mA) or 0 to 15 V with an external power supply available
- Differential inputs (0 to +15V) are filtered for noisy environments

The minimum time interval between any pulse edge on channel QDA to any pulse edge on channel QDB of a particular channel is 2 μsec.

Limit Switch Inputs:

- Schmitt trigger inputs filter noise and sense input state
- Causes an immediate halt of output pulses

Limit Switch Characteristics:

The limit switch inputs are TTL compatible and require a >50 μsec pulse width. The accessory supplies +5V and a 10 kohm pull-up resistor for switch closure sensing.

	Counter	Limit switches
Maximum input voltage	15 V	5 V
Maximum input current	3.5 mA	−1 mA
Thresholds		
Vlow(max)	0.5 V	1.0 V
Vhigh(min)	2.5 V	3.85 V
Number of counts	2,147,483,647	n/a
Counter accuracy	0.5 counts	n/a

Supplemental Characteristics

This section contains characteristics that are intended to provide information useful in applying the system by giving typical or nominal, but non-warranted performance parameters.

RESPONSE TIMES:

Command over HP-IB to start/stop pulses	35 msec
Command from a subroutine to start/stop pulses	10 msec
Backplane trigger to start pulses	150 msec
Limit switch to stop pulses	100 msec

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