Agilent Technologies

87130A
Attenuator/Switch Driver

Operating and Service Guide

Manual part number: 87130-90007
Printed in USA
August 2001
Supersedes: May 2000

Notice

Agilent Technologies, Inc.
1400 Fountaingrove Parkway
Santa Rosa, CA 95403-1799, U.S.A.

NOTE

A serial number label is attached to the rear panel of each instrument. The first six entries are the same for all identical modules; they only change when a change in the electrical or physical functionality is made. The remaining digits are assigned sequentially and are different for each instrument.

This manual applies directly to instruments with the following prefix and above:

US4018

Warranty

Certification

Agilent Technologies, Inc., certifies that this product met its published specifications at the time of shipment from the factory. Agilent Technologies further certifies that its calibration measurements are traceable to the United States National Institute of Standards and Technology (NIST, formerly NBS), to the extent allowed by the Institute's calibration facility, and to the calibration facilities of other International Standards Organization members.

Warranty

This Agilent Technologies system product is warranted against defects in materials and workmanship for a period corresponding to the individual warranty periods of its component products. Instruments are warranted for a period of one year. During the warranty period, Agilent Technologies will, at its option, either repair or replace products that prove to be defective.

Warranty service for products installed by Agilent Technologies and certain other products designated by Agilent Technologies will be performed at Buyer's facility at no charge within Agilent Technologies service travel areas. Outside Agilent Technologies service travel areas, warranty service will be performed at Buyer's facility only upon Agilent Technologies' prior agreement and Buyer shall pay Agilent Technologies' round trip travel expenses. In all other areas, products must be returned to a service facility designated by Agilent Technologies.

For products returned to Agilent Technologies for warranty service, Buyer shall prepay shipping charges to Agilent Technologies and Agilent Technologies shall pay shipping charges to return the product to Buyer. However, Buyer shall pay all shipping charges, duties, and taxes for products returned to Agilent Technologies from another country.

Agilent Technologies warrants that its software and firmware designated by Agilent Technologies for use with an instrument will execute its programming instructions when properly installed on that instrument. Agilent Technologies does not warrant that the operation of the instrument, or software, or firmware will be uninterrupted or error free.

LIMITATION OF WARRANTY. The foregoing warranty shall not apply to defects resulting from improper or inadequate maintenance by Buyer, Buyer-supplied software or interfacing, unauthorized modification or misuse, operation outside of the environmental specifications for the product, or improper site preparation or maintenance.

NO OTHER WARRANTY IS EXPRESSED OR IMPLIED. AGILENT TECHNOLOGIES SPECIFICALLY DISCLAIMS THE IMPLIED

WARRANTIES OR MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

EXCLUSIVE REMEDIES. THE REMEDIES PROVIDED HEREIN ARE BUYER'S SOLE AND EXCLUSIVE REMEDIES. AGILENT TECHNOLOGIES SHALL NOT BE LIABLE FOR ANY DIRECT, INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES, WHETHER BASED ON CONTRACT, TORT, OR ANY OTHER LEGAL THEORY.

YEAR 2000. Agilent Technologies warrants that each Agilent Technologies hardware, software, and firmware product on Agilent Technologies' Corporate Price List (dated July 1, 1998 or later) delivered under the product's contract of sale will be able to accurately process date data (including, but not limited to, calculating, comparing, and sequencing) from, into, and between the twentieth and twenty-first centuries, and the years 1999 and 2000, including leap year calculations, when used in accordance with the product documentation provided that all other products (that is, hardware, software, firmware) used in combination with such Agilent Technologies product(s) properly exchange date data with it. If the agreement requires that specific Agilent Technologies products must perform as a system in accordance with the foregoing warranty, then that warranty will apply to those Agilent Technologies products as a system, and Customer retains sole responsibility to ensure the year 2000 readiness of its information technology and business environment. The duration of this warranty extends through January 31, 2001.

The remedies available under this warranty will be defined in, and subject to, the terms and limitations of the warranties contained in the contract of sale. To the extent permitted by local law, this warranty applies only to branded Agilent Technologies products and not to products manufacture by others that may be sold or distributed by Agilent Technologies. Nothing in this warranty will be construed to limit any rights or remedies provided elsewhere in the contract of sale with respect to matters other than year 2000 compliance.

Assistance

Product maintenance agreements and other customer assistance agreements are available for Agilent Technologies products.

For assistance, call your local Agilent Technologies Sales and Service Office (refer to "Service and Support" on page v).

Service and Support

Any adjustment, maintenance, or repair of this product must be performed by qualified personnel. Contact your customer engineer through your local Agilent Technologies Service Center. You can find a list of local service representatives on the Web at: `www.agilent.com/find/assist`

If you do not have access to the Internet, one of these centers can direct you to your nearest representative:

United States (tel) 1 800 452 4844	**Latin America** (tel) (305) 269 7500 (fax) (305) 269 7599	**Canada** (tel) 1 877 894 4414 (fax) (905) 282-6495	**Europe** (tel) (+31) 20 547 2323 (fax) (+31) 20 547 2390
New Zealand (tel) 0 800 738 378 (fax) (+64) 4 495 8950	**Japan** (tel) (+81) 426 56 7832 (fax) (+81) 426 56 7840	**Australia** (tel) 1 800 629 485 (fax) (+61) 3 9210 5947	

Asia Call Center Numbers

Country	Phone Number	Fax Number
Singapore	1-800-375-8100	(65) 836-0252
Malaysia	1-800-828-848	1-800-801664
Philippines	(632) 8426802 1-800-16510170 (PLDT Subscriber Only)	(632) 8426809 1-800-16510288 (PLDT Subscriber Only)
Thailand	(088) 226-008 (outside Bangkok) (662) 661-3999 (within Bangkok)	(66) 1-661-3714
Hong Kong	800-930-871	(852) 2506 9233
Taiwan	0800-047-866	(886) 2 25456723
People's Republic of China	800-810-0189 (preferred) 10800-650-0021	10800-650-0121
India	1-600-11-2929	000-800-650-1101

Safety and Regulatory Information

Review this product and related documentation to familiarize yourself with safety markings and instructions before you operate the instrument. This product has been designed and tested in accordance with international standards.

WARNING

The WARNING notice denotes a hazard. It calls attention to an operating procedure, practice, or the like that, if not correctly performed or adhered to, could result in personal injury or death. Do not proceed beyond a WARNING notice until the indicated conditions are fully understood and met.

CAUTION

The **CAUTION** notice denotes a hazard. It calls attention to an operating procedure, practice, or the like that, if not correctly performed or adhered to, could result in damage to the product or loss of important data. Do not proceed beyond a **CAUTION** notice until the indicated conditions are fully understood and met.

Instrument Markings

	When you see this symbol on your instrument, you should refer to the instrument’s instruction manual for important information.
	This symbol indicates hazardous voltages.
	The laser radiation symbol is marked on products that have a laser output.
~	This symbol indicates that the instrument requires alternating current (ac) input.
CE	The CE mark is a registered trademark of the European Community. If it is accompanied by a year, it indicates the year the design was proven.
	The CSA mark is a registered trademark of the Canadian Standards Association.
N279	The C-tick mark is a registered trademark of the Spectrum Management Agency of Australia. This signifies compliance with the Australian EMC Framework regulations under the terms of the Radio communications Act of 1992.
1SM1-A	This text indicates that the instrument is an Industrial Scientific and Medical Group 1 Class A product (CISPER 11, Clause 4).

⏚ Safety Earth Ground

This is a Safety Class I product (provided with a protective earthing terminal). An uninterruptible safety earth ground must be provided from the main power source to the product input wiring terminals, power cord, or supplied power cord set. Whenever it is likely that the protection has been impaired, the product must be made inoperative and secured against any unintended operation.

Before Applying Power

Verify that the product is configured to match the available main power source as described in the input power configuration instructions in this manual. If this product is to be powered by autotransformer, make sure the common terminal is connected to the neutral (grounded) side of the ac power supply.

COMPLIANCE WITH GERMAN NOISE REQUIREMENTS

This is to declare that this instrument is in conformance with the German Regulation on Noise Declaration for Machines (Laermangabe nach der Maschinenlaermrerordnung-3.GSGV Deutschland).

Acoustic Noise Emmision/Geraeuschemission	
LpA <70 dB	LpA <70 dB
Operator position	am Arbeitsplatz
Normal position	normaler Betrieb
per ISO 7779	nach DIN 45635 t.19

General Safety Considerations

WARNING

- **This product has been designed and tested in accordance with IEC Publication 1010, Safety Requirements for Electronic Measuring Apparatus, and has been supplied in a safe condition. The instruction documentation contains information and warnings which must be followed by the user to ensure safe operation and to maintain the product in a safe condition.**
- **This is a Safety Class 1 Product provided with a protective earthing ground incorporated in the power cord. The mains plug shall only be inserted in a socket outlet provided with a protective earth contact. Any interruption of the protective conductor inside or outside of the product is likely to make the product dangerous. Intentional interruption is prohibited.**
- **The ON/OFF switch or the detachable power cord is the instrument disconnecting device. It disconnects the mains circuits from the mains supply before other parts of the instrument. Alternately, an externally installed switch or circuit breaker, which is readily identifiable and is easily reached by the operator, may be used as a disconnecting device.**

WARNING

- **This product is designed for use in Installation Category and Pollution Degree 2 per IEC 1010 and 664 respectively.**
- **Install the instrument according to the enclosure protection provided. This instrument protects against finger access to hazardous parts within the enclosure. The instrument does not protect against the ingress of water.**
- **If this product is not used as specified, the protection provided by the equipment could be impaired. This product must be used in a normal condition (in which all means for protection are intact) only.**
- **When installing the product in a cabinet, the convection into and out of the product must not be restricted. The ambient temperature (outside the cabinet) must be less than the maximum operating temperature of the product by 4° C for every 100 watts dissipated in the cabinet. If the total power dissipated in the cabinet is greater than 800 watts forced convection must be used.**

DECLARATION OF CONFORMITY

According to ISO/IEC Guide 22 and CEN/CENELEC EN 45014

Manufacturer's Name: Agilent Technologies, Inc.

Manufacturer's Address: 1400 Fountaingrove Parkway
Santa Rosa, CA 95403-1799
USA

Declares that the product

Product Name: Attenuator/Switch Driver

Model Number: 87130A

Product Options: This declaration covers all options of the above product.

Conform to the following product specifications:

EMC: CISPR 11:1990/EN 55011:1991 Group 1, Class A
IEC 801-2:1984/EN 50082-1:1992 4 kV CD, 8 kV AD
IEC 801-3:1984/EN 50082-1:1992 3 V/m, 27-500 MHz
IEC 801-4:1988/EN 50082-1:1992 0.5 kV sig. lines, 1 kV power lines

Safety: IEC 61010-1:1990 + A1:1992 + A2:1995 / EN 61010-1:1993 +A2:1995
CAN/CSA-C22.2 No. 1010.1-92

Supplementary Information:
The product herewith complies with the requirements of the Low Voltage Directive 73/23/EEC and the EMC Directive 89/336/EEC and carries the CE-marking accordingly.

Santa Rosa, CA, USA   10 April 2000

Greg Pfeiffer/Quality Engineering Manager

For further information, please contact your local Agilent Technologies sales office, agent or distributor.

Typeface Conventions

Italics

- Used to emphasize important information:

  Use this software *only* with the 87130A.

- Used for the title of a publication:

  Refer to the *Agilent 87130A Operating and Service Manual*.

- Used to indicate a variable:

  Type `LOAD BIN` *filename*.

`Instrument Display`

- Used to show on-screen prompts and messages that you will see on the display of an instrument:

  The 87130A will display the message **`CAL1 SAVED`**.

[Keycap]

- Used for labeled keys on the front panel of an instrument or on a computer keyboard:

  Press **[Return]**.

{Softkey}

- Used for simulated keys that appear on an instrument display:

  Press ***{Prior Menu}***.

`User Entry`

- Used to indicate text that you will enter using the computer keyboard; text shown in this typeface must be typed *exactly* as printed:

  Type `LOAD PARMFILE`

- Used for examples of programming code:

  ```
  #endif // ifndef NO_CLASS
  ```

`Path Name`

- Used for a subdirectory name or file path:

  Edit the file *`usr/local/bin/sample.txt`*

Computer Display

- Used to show messages, prompts, and window labels that appear on a computer monitor:

  The **Edit Parameters** window will appear on the screen.

- Used for menus, lists, dialog boxes, and button boxes on a computer monitor from which you make selections using the mouse or keyboard:

  Double-click **EXIT** to quit the program.

Contents

1 Introducing the 87130A Attenuator/Switch Driver

Overview

In this chapter you will find:

- Function, features, and capabilities of the 87130A attenuator/switch driver
- How to unpack and check your instrument
- How to set up a static-free workstation
- How to contact Agilent Technologies for service

Features of the Attenuator/Switch Driver

The Agilent 87130A attenuator/switch driver is a GPIB compatible instrument designed to drive electromechanical switches and step attenuators.

- The standard instrument has a single internal driver board capable of driving up to 31 SPDT switches, or combinations of SPDT and multithrow switches.
- The attenuator/switch driver may be externally connected to a maximum of seven 84940A driver boards and can control and sense switching for up to 248 switches.

The block diagram is shown below. Refer to Figure 6-1 on page 6-3 for a detailed DC Schematic.

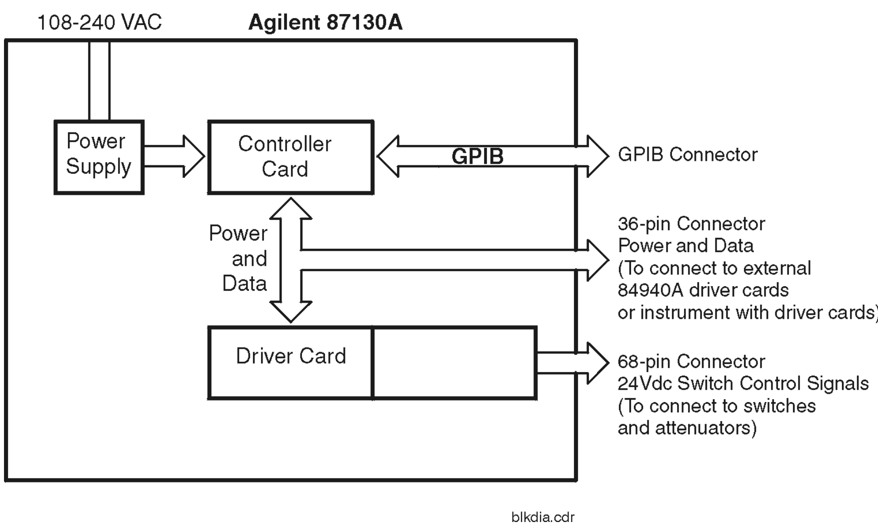


Figure 1-1 87130A Block Diagram

Drive Pulse and Sensing

The attenuator/switch driver can deliver 500 mA, 24 Vdc current pulses to 31 individual switch sections and up to a total of 248 switch sections by the addition of external 84940A driver boards (or driver boards inside externally connected equipment such as switch matrixes). These low impedance pulses can be adjusted for pulse width in order to optimize switching speed. Pulse width and sensing delay can be set from 0.005 to 1.275 seconds.

Sensing Disabled

Each switch coil is internally connected to the + 24 V bias supply. A power transistor on the driver board supplies the ground that will activate the switch coil. The controller assembly actuates the transistor for a predetermined time that is set by the `:WIDTh` command. (Refer to ":WIDTh" on page 4-67.) The default setting is 30 ms.

Sensing Enabled

For switches that can be sensed, the switch coil is internally connected to the + 24 V bias supply via a dc switch that removes the bias from the activated coil after the switch has changed position and applies the bias to the opposite coil. By monitoring the presence of this bias through the opposite coil, the switch controller can determine the switch position.

After the initial 30 ms closure pulse, an additional 20 ms time is allowed for the sense lines to settle. At this time an error and a programmed position check are performed.

The power supply allows the switch driver four switching operations at the same time. This means that at the default setting, seven groups of four switches and one group of three switches will each take 50 ms to switch and verify. This results in a default switching speed of 0.4 seconds for 31 relays with sensing enabled. Refer to "Example Speed Calculation" on page 4-74 for more information.

Compatible Switches and Attenuators

The attenuator/ switch driver is designed to drive Agilent switches and attenuators shown in the tables below.

NOTE

If you are using switches or attenuators made by another company, check their switching characteristic against those specified in Chapter 3, “Specifications”.

All Agilent switches and attenuators have internal clamp diodes to limit reverse EMF energy from the switch solenoid. If other switches are used, this energy must be limited to less than 10 millijoules to prevent damage to the switch driver circuit.

Table 1-1 Compatible Switches

Agilent Model Number	Description	Agilent Model Number	Description
33311A,B,C,D	Terminated SPDT	8765A,B,C,F (Opt 024)	Unterminated SPDT*
33312A,B,C	Terminated transfer	8766K	SP3T
33313A,B,C	5 port switch	8767K	SP4T
33314A,B,C,D (Opt 024)	Unterminated SPDT*	8768K	SP5T
33363K	SP3T	8769K	SP6T
33364K	SP4T	87104A,B,C	SP4T*
33365K	SP5T	87106 A,B,C	SP6T*
33366K	SP6T	87204A,B,C	SP4T
8762A,B,C,F	Terminated SPDT	87206A,B,C	SP6T
8763A,B,C,F	Terminated transfer	87222C,D,E	Transfer switch
8764A,B,C,F	5 port switch	87606B	Matrix switch

* No position verification

Table 1-2 Compatible Attenuators

Agilent Model Number	Description	Agilent Model Number	Description
33320G,H	11 dB, 1 dB steps	8494G,H	11 dB, 1 dB steps
33321G,H,K	70 dB, 10 dB steps	8495G,H,K	70 dB, 10 dB steps
33322G,H	110 dB, 10 dB steps	8496G,H	110 dB, 10 dB steps
33323K	90 dB, 10 dB steps	8497K	90 dB, 10 dB steps
33324K,L	11 dB, 1 dB steps	84904K,L	11 dB, 1 dB steps
33326K,L	90 dB, 10 dB steps	84906K,L	90 dB, 10 dB steps
33327K,L	70 dB, 10 dB steps	84907K,L	70 dB, 10 dB steps

Front Panel Features

The front panel LEDs indicate the status of the 87130A attenuator/switch driver. The front-panel LEDs should turn on and off while the switch driver is performing the self-test (for example, at turn-on).

If the ERROR LED lights at any time other than during self test, an error condition exists in the switch matrix. The switch driver ERROR light indicates it is ready to report one or more error codes. The error codes may be viewed by using the `:ERRor?` command from a controller. Refer to the GPIB command ":ERRor?" on page 4-43 for more information.

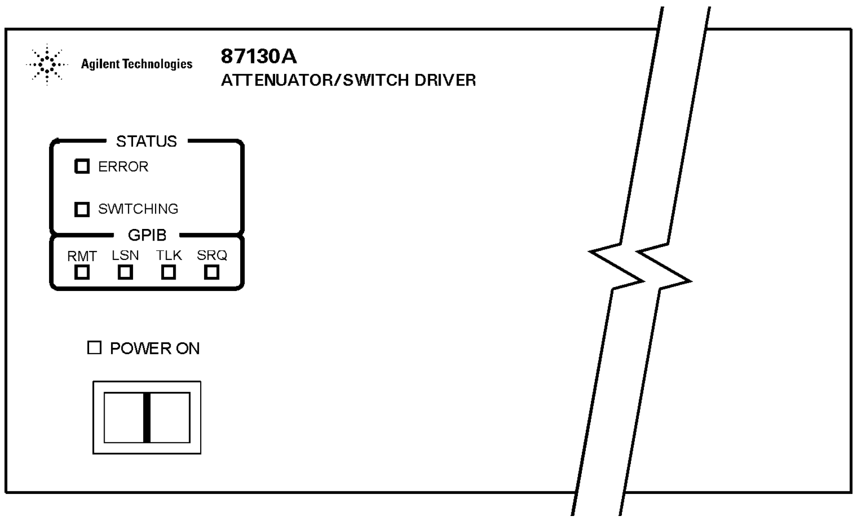


Figure 1-2 87130A Front Panel Features

The user may remotely set the SRQ (service request) state to take place under certain conditions, (for example: completion of an operation or if an error condition occurs). The SRQ LED will only be lit during self test, when it is turned on and off to test the LED.

The other LEDs, RMT (remote), LSN (listen), TLK (talk), and SWITCHING indicate the normal functioning of the switch driver and do not indicate an error condition.

Unpacking Your Instrument

Unpack and inspect the shipping container and its contents thoroughly to ensure that nothing was damaged during shipment. If the shipping container or cushioning material is damaged, the contents should be checked both mechanically and electrically.

WARNING **To avoid hazardous electrical shock, do not perform electrical tests when there are signs of shipping damage to any portion of the outer enclosure (covers, panels, connectors.)**

Table 1-3 87130A Package Contents

Description	Quantity	Part Number
Switch driver	1	87130A
Operating and Service Manual	1	87130-90007
Cable, 68-pin to 68-pin SCSI II, 6 ft.	1	70611-60004

- If the shipping container is damaged, or the cushioning material shows signs of stress, notify the carrier as well as Agilent Technologies. Keep the shipping material for the carrier’s inspection. Refer to Figure 1-3.
- If the contents are damaged or defective, contact your nearest Service Center listed under “Service and Support” on page v. Agilent will arrange for repair or replacement of the damaged or defective equipment. Always refer to your instrument by its full model number and serial number.

Determining Your Module Serial Number

A serial number is attached to a label on the rear panel of the module. The first six entries are the same for all identical modules; they only change when a change in the electrical or physical functionality is made. The remaining entries change sequentially and are different for each module.

Environmental Limitations

The instrument should be stored in a clean, dry environment. The following environmental limitations apply to both shipment and storage:

Temperature	– 40 to + 70° C
Humidity	< 95% relative
Altitude	< 15300 meters (50,000 feet)

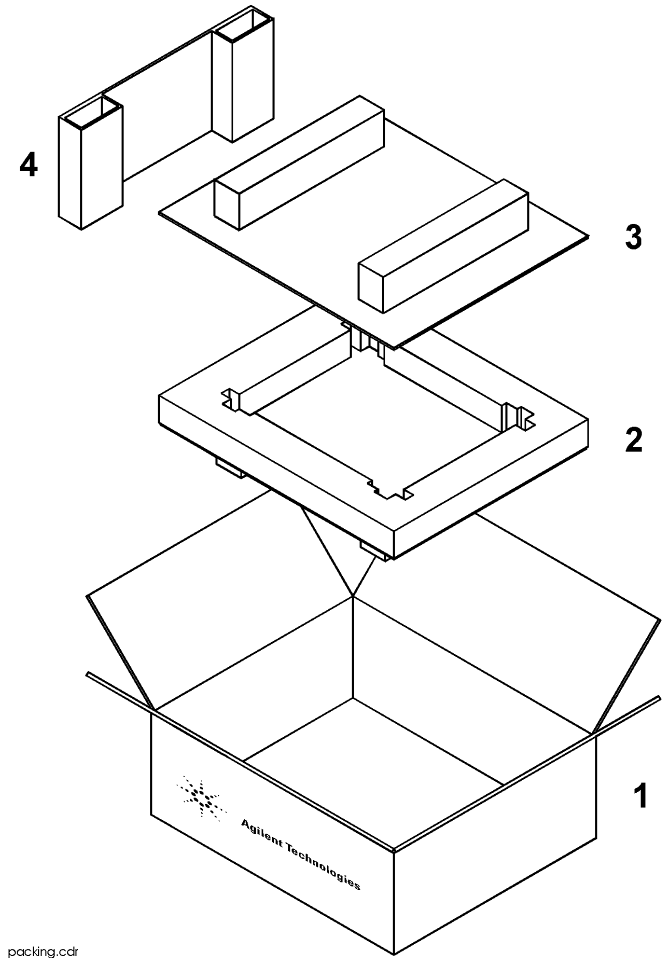


Figure 1-3 Packaging Materials for the 87130A Switch Driver

Item	Quantity	Part Number	Description
1	1	9211-6365	Outer carton
2	1	5181-5515	Foam Insert
3			Foam insert (Part of item 2.)
4	1	5181-5535	Spacer

Before Installing the Attenuator/Switch Driver

Electrostatic discharge (ESD) can damage or destroy electronic components. All work performed on assemblies consisting of electronic components should be done at a static-safe workstation.

An example of a static-safe work station is shown below using two types of ESD protection:

- conductive table mat and wrist strap combination, and
- conductive floor mat and heel strap combination

These methods may be used together or separately. A list of static-safe accessories and their part numbers is given on the following page.

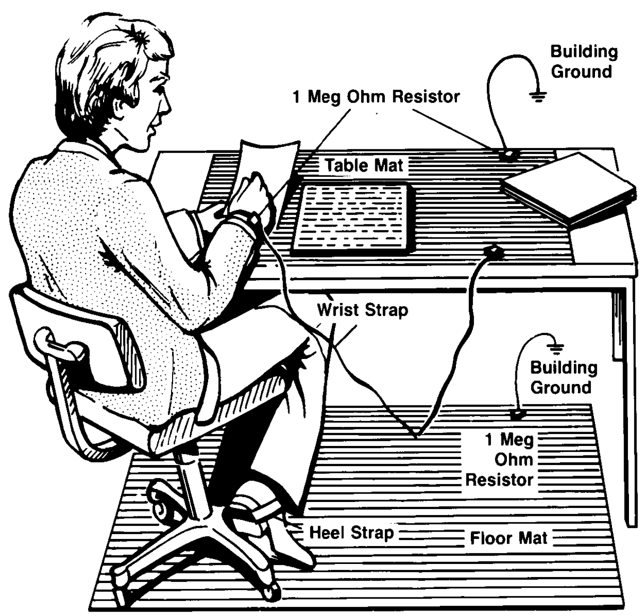


Figure 1-4 Static-Safe Work Station

Reducing ESD Damage

To help reduce the amount of ESD damage that occurs during installation, testing, or servicing instruments use the following guidelines:

- Be sure that all instruments are properly earth-grounded to prevent buildup of static charge.
- Personnel should be grounded with a resistor-isolated wrist strap before touching the center pin of any connector and before removing any assembly from the instrument.
- Before connecting any coaxial cable to an instrument connector for the first time each day, *momentarily* ground the center and outer conductors of the cable.
- Handle all PC board assemblies and electronic components only at static-safe work stations.
- Store or transport PC board assemblies and electronic components in static-shielding containers.
- PC board assembly edge-connector contacts may be cleaned by using a lintfree cloth with a solution of 80% electronics-grade isopropyl alcohol and 20% deionized water. This procedure should be performed at a static-safe work station.

Table 1-4 Static-Safe ESD Accessories

Part Number	Description
9300-0797	Set includes: 3M static control mat 0.6 m x 1.2 m (2 ft x 4 ft) and 4.6 m (15 ft) ground wire. (The wrist-strap and wrist-strap cord are not included. They must be ordered separately.)
9300-0865	Ground wire, 4.6 m (15 ft)
9300-0980	Wrist-strap cord 1.5 m (5 ft)
9300-1367	Wrist-strap, color black, stainless steel, without cord, has four adjustable links and a 7 mm post-type connection.
9300-1308	ESD heel-strap (reusable 6 to 12 months)

Order the above by calling an Agilent Sales and Service Office.

Returning Your Instrument for Service

To obtain servicing information or to order replacement parts, contact your nearest Agilent Technologies Service Center listed under "Service and Support" on page v.

Use the following procedure to return your instrument to Agilent for service:

1. Fill out a service tag and attach it to the instrument. Please be as specific as possible about the nature of the problem.

CAUTION

Damage can result if the original packaging materials are not used. Packaging materials should be anti-static and should cushion the instrument on all sides.

Never use styrene pellets in any shape as packaging materials. They do not adequately cushion the instrument or prevent it from moving in the shipping container. Styrene pellets can also cause equipment damage by generating static electricity or by lodging in fan motors.

2. Place the switch driver in its original packaging materials.

   If the original packaging materials are not available, you can contact an Agilent sales and service office to obtain information on packaging materials or you may use an alternative packing material referred to as "bubble-pack".

   Surround the module with at least 3 to 4 inches of its original packing material or bubble-pack to prevent it from moving in its shipping container.

3. Place the switch driver after wrapping it with packing material, in its original shipping container or a strong shipping container that is made of double-walled corrugated cardboard with 159 kg (350 lb) bursting strength.

   The shipping container must be both large enough and strong enough to accommodate your module and allow at least 3 to 4 inches on all sides for packing material.

4. Seal the shipping container securely with strong nylon adhesive tape.
5. Mark the shipping container "Fragile, Handle with Care" to help ensure careful handling.
6. Retain copies of all shipping papers.

2 Installing the 87130A Attenuator/Switch Driver

Overview

In this chapter you will learn about:

- How to install your switch driver
- How to verify its basic functionality
- How to address your instrument
- How to connect it to a switch matrix

Getting Started

Initial Inspection

1. Unpack and inspect the shipping container and its contents thoroughly to ensure that nothing was damaged during shipment. If the shipping container or cushioning material is damaged, the contents should be checked both mechanically and electrically. A procedure for checking the electrical performance is given in Chapter 4, Verification.

   - If the shipping container is damaged, or the cushioning material shows signs of stress, notify the carrier as well as Agilent Technologies. Keep the shipping material for the carrier's inspection. Refer to Figure 1-3.

   - If the contents are damaged or defective, contact your nearest Service Center listed under "Service and Support" on page v. Agilent will arrange for repair or replacement of the damaged or defective equipment.

Preparing for Use

2. Use the following properties of the attenuator/switch driver to plan your system configuration.

Power requirements

The internal power supply adjusts automatically to the input line voltage. See table 3-2 on page 3-3 for additional information.

Power cord

In accordance with international safety standards, a three-wire power cable is provided with this instrument. When it is connected to an appropriate ac power receptacle, this cable grounds the instrument cabinet. The type of power cable plug shipped with each instrument depends on the country of destination.

Fuses

The 87130A is shipped with a 3A fuse (F3) installed in the + 24 Vdc line and a 3A fuse (F2) in the + 5 Vdc line. The 1 A, 250 V power line fuse is located inside the AC input module.

GPIB Addressing

3. Use the five-bit binary address switches located on the rear panel of the instrument to change the GPIB address.

   ❍ The 87130A has a factory preset address of 9. There are 32 possible addresses. The switch labeled with a one is the least significant bit.

   ❍ Addresses 0 and 31 are typically reserved for GPIB functions and should not be used. IEEE-488.1 limits the number of addressable elements (instruments) to 16.

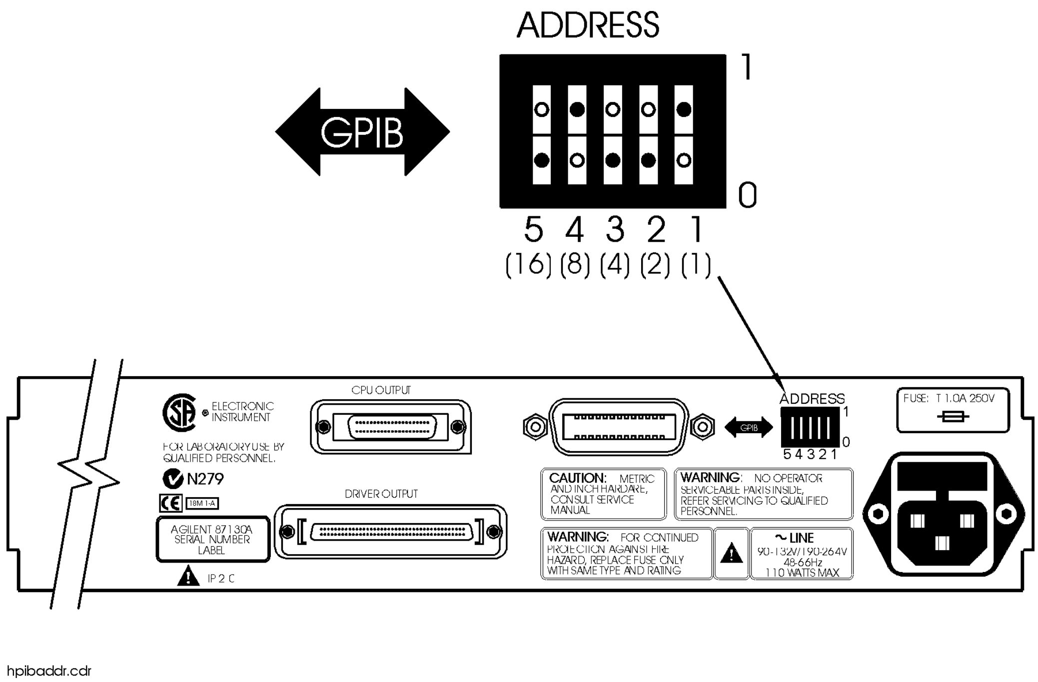


Figure 2-1 87130A GPIB Address Switch (Default 9 shown)

Connecting Switch Drivers to Switches and Attenuators

Driver Boards

The standard 87130A attenuator/switch driver has a single internal driver board capable of driving 31 switches. The attenuator/switch driver may also be connected to a maximum of seven external 84940A driver board which can control and sense switching states for up to 217 additional switches.

The internal driver card is terminated with a 68-pin SCSI II type connector for connecting external switches. The 84941A distribution board should be used to connect the switch driver to switches and attenuators.

- ❍ The distribution board has 31 4-pin black output connectors numbered J1 to J31 (silkscreened on the circuit side of the PCA), in addition to 31 mating cables which allow a cable harness to be quickly assembled to connect to relays. Refer to Figure 2-6 for pin wiring that determines an OPEN or CLOSE condition on each switch.
- ❍ Each relay (switch) is referred to as a *channel* by the switch driver. Each channel has its own unique address. The switch driver begins numbering channels at 0 instead of 1. Switch one, wired to J1 on driver card 1, would have a channel address of 100.

Using the Internal Driver

1. Connect the internal driver board of the switch driver which is terminated with a 68-pin SCSI II type connector (driver output) to an 84941A distribution board. Use the six foot cable with two male 68-pin SCSI II type connectors that is shipped with the 87130A.

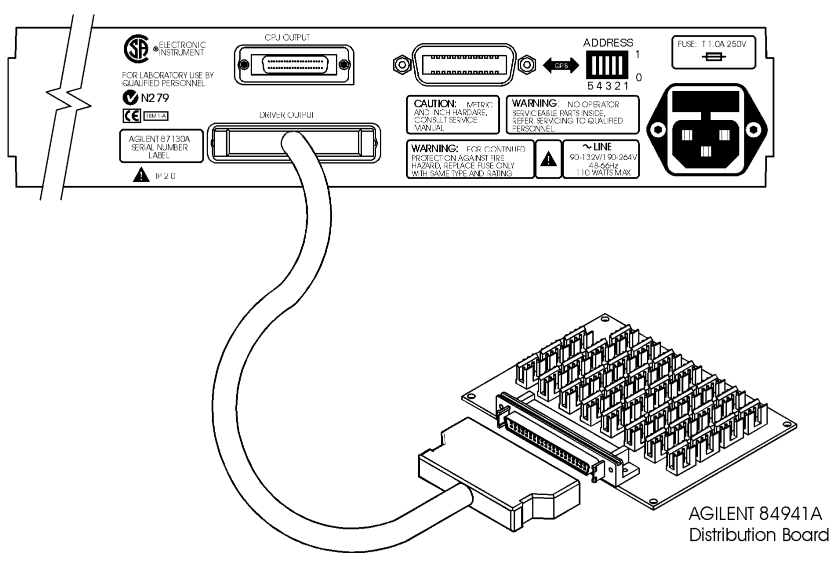


Figure 2-2 Typical Operating Setup Using Internal Driver

Using External Drivers

A standard switch driver can control up to seven external 84940A driver cards.

- Each driver card has 31 4-pin black output connectors numbered J1 to J31 (silkscreened on the circuit side of the PCA) which connect to relays.
- Each relay is referred to as a channel by the switch driver. Therefore, there are a total of 248 relays (channels) that can be driven from a single switch driver.
- Each card must have a unique address. (Refer to Figure 2-10). The internal driver card is set to card 1. On card 1, J1 to J31 correspond to channels 100 to 130 on your switch driver channel menu. Card 2 would correspond to channels 200 to 230; card 3, 300 to 330, and so forth up to card 8, 800 to 830. All of these channels are set with the drive enabled.

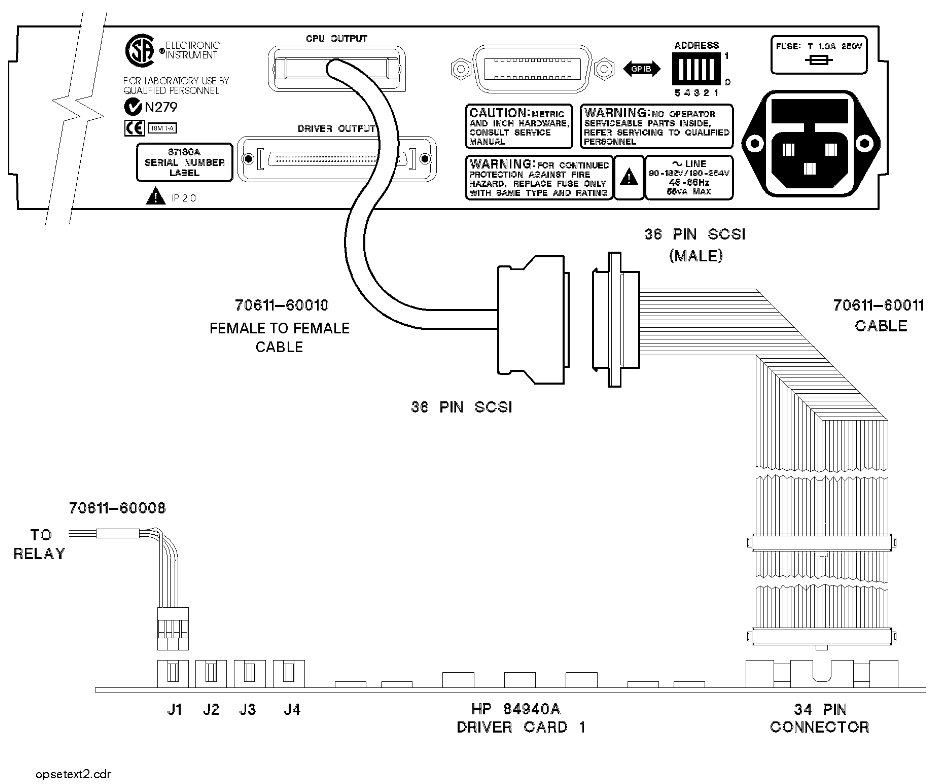


Figure 2-3 Typical Operating Setup Using External Drivers

CAUTION

Do not connect or disconnect relays from 84940A external driver cards with prefixes prior to US4016 while the attenuator/switch driver line switch is turned on. An unintentional short between the + 24 V wire and the driver outputs may result in a catastrophic driver board failure.

Although these driver cards will function properly when driven by the 87130A, they are only specified to 800 mA maximum per group of four relays (200 mA per relay section); however, the + 24 V power supply from the 87130A provides 3 A of dc current.

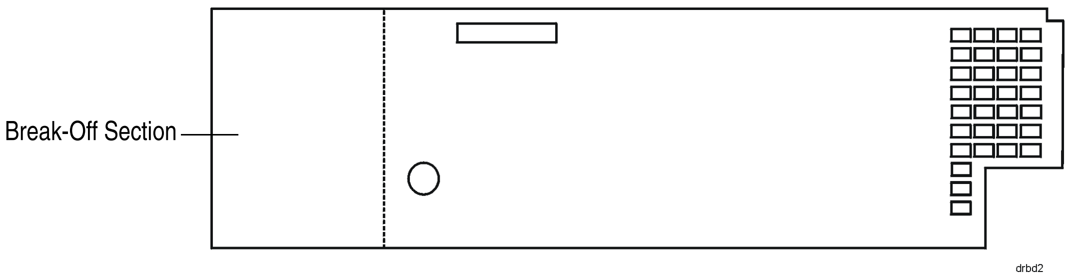


Figure 2-4 84940A External Driver Card with Prefixes Prior to US4016

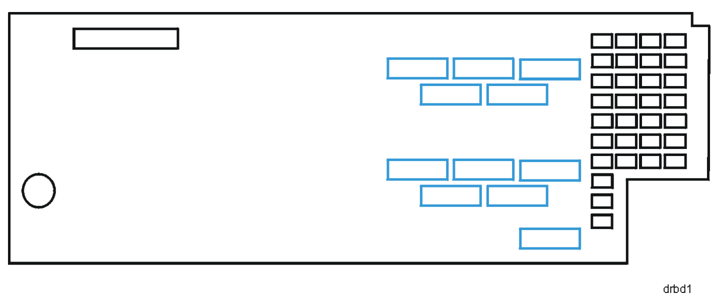


Figure 2-5 84940A External Driver Card with Prefixes US4016 and Above

The 84940A driver board includes the following items:

Description	Quantity	Part Number
Driver board	1	84940A
Cable, 36-pin to 36-pin SCSI, female to female, 5 feet, 28 AWG	1	70611-60010
Cable, 34-pin to 36-pin SCSI, 18 inches, 28 AWG	1	70611-60011
Ribbon cable kit, 36-pin to 34-pin, 6 feet, 28 AWG	1	70611-60013

Wiring Channel Connectors

When installing the switch driver, it is imperative to know which wires will cause an OPEN or CLOSE condition on each switch.

- An OPEN condition is defined as the black wire from J1 pin 1 is active-to-common (+ 24 Vdc red wire).
- A CLOSE condition is defined as the white wire from J1 pin 3 is active-to-common (+ 24 Vdc red wire).

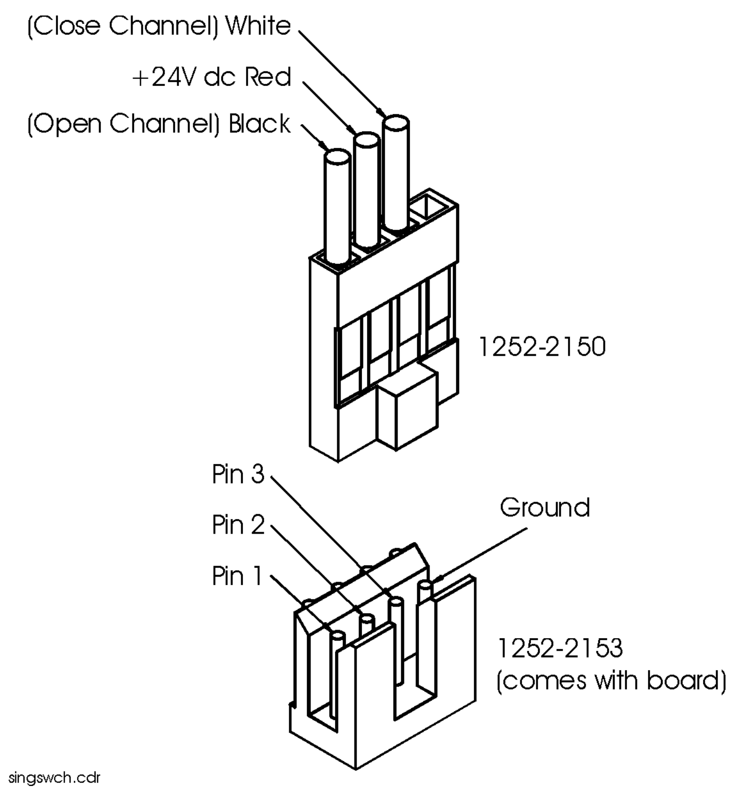


Figure 2-6 Typical Single Switch Channel Connector

Connecting Multiple Driver Cards

The cards are numbered from 1 to 8; the relays on each card are numbered from 0 to 30. Each relay is referred to as a channel by the switch driver. Therefore, there are a total of 248 relays (channels) that can be driven from a single switch driver.

In a single enclosure, place connectors (part number 1251-7090) on ribbon cables (part number 70611-60013) to daisy chain driver cards.

To reliably install the 34-pin connector to the ribbon cable use the following 3M™ tools. (To order from 3M™, call 1-800-225-5373).

Item	3M™ Part Number
Platen	3442-1A
Locator plate	3443-94
Hand press	3540

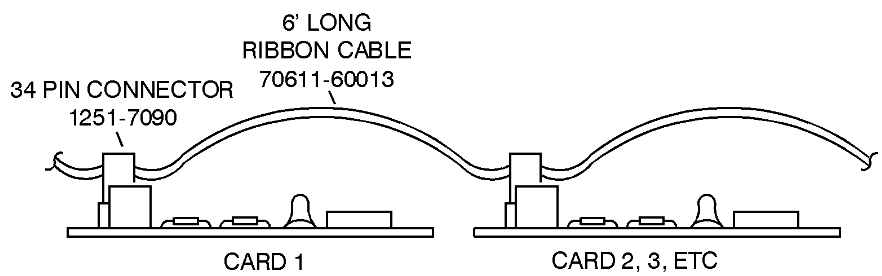


Figure 2-7 Daisy Chain of Driver Cards in Single Enclosure

Use the cables shown below to connect 84940A external cards to expand drive capability in different enclosures.

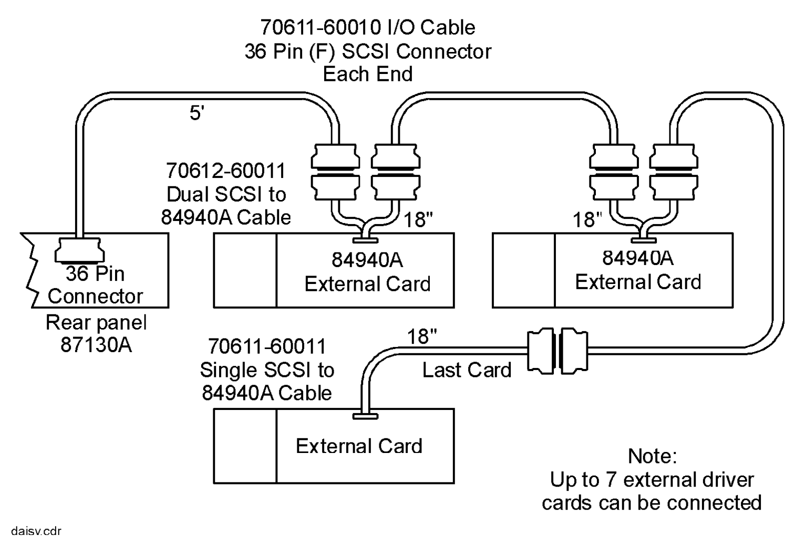


Figure 2-8 Daisy Chain of Driver Cards in Different Enclosures

Connecting Attenuators

Connect attenuator cables using a Viking connector and a ten pin connector. A typical connection of four section attenuators is shown below.

When connecting attenuators

- A CLOSE position should add attenuation.
- An OPEN position should remove attenuation.

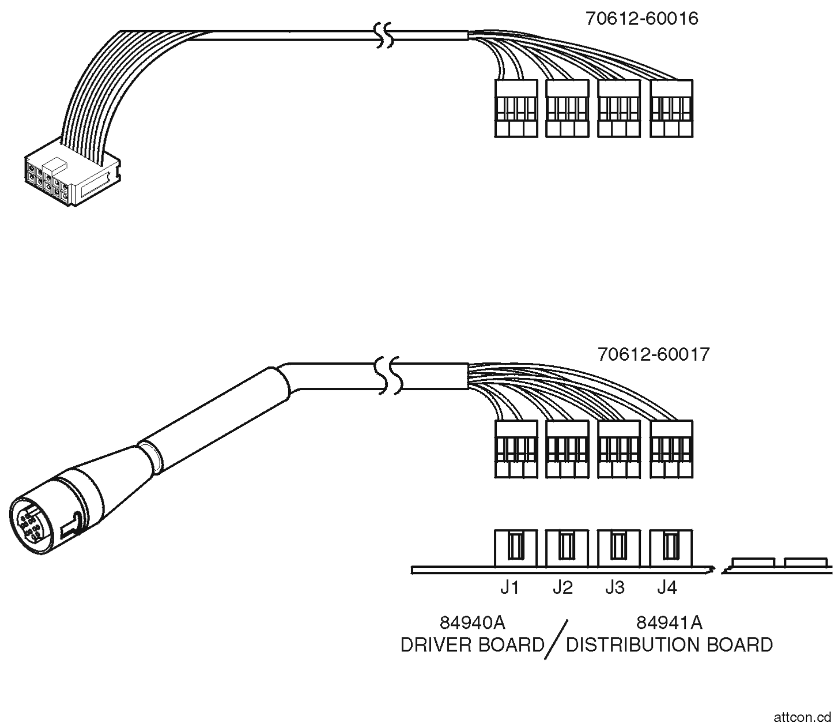


Figure 2-9 Typical Attenuator Cables Connected to an 84940A

Optimizing Switching Speed

To increase the speed at which your switch matrix operates, refer to the table below to determine which four relays, when connected, will be on the same drive lines.

a. Refer to Figure 2-6 to wire your relays into the arbitrary positions of OPEN and CLOSE.

b. Refer to the section "Example Speed Calculation" on page 4-74 for an explanation on calculating and minimizing overall switching time.

Switching speed is a function of pulse widths, sensing delays, the state of the chosen channels, the sequence of relays driven and the power supply recovery time. Pulse widths, sensing delays, and which channels are opened or closed are determined by the user, and cannot be predicted here.

NOTE

The channel number must be preceded by the driver card number. Channels connected to driver card 1 would be numbered 100 to 130; card 2, 200 to 230; card 3, 300 to 330, and so forth up to card 800 to 830. All of these channels are set with the drive enabled.

Table 2-1 Relay Drive Sequence

Drive Line	Connector Locator	Channel List
1	J1, J2, J3, J4	00, 01, 02, 03
2	J5, J6, J7, J8	04, 05, 06, 07
3	J9, J10, J11, J12	08, 09, 10, 11
4	J13, J14, J15, J16	12, 13, 14, 15
5	J17, J18, J19, J20	16, 17, 18, 19
6	J21, J22, J23, J24	20, 21, 22, 23
7	J25, J26, J27, J28	24, 25, 26, 27
8	J29, J30, J31	28, 29, 30

NOTE

The maxium Power Supply Recovery Time should only be required when driving multiple external driver boards with longer interconnect cables. A significant switching speed advantage can be realized if this value is reduced from the 200 msec default. See the command called "TRIGger" on page 4-62 and the "Example Speed Calculation" on page 4-74.

Driver Card Address

Set the 4-bit DIP switch on the 84940A driver assembly card to each address as shown in the figure below. (S1 “up” is open or away from the PC board.)

Each card must have a unique address setting. The internal driver is set to card 1. Card 1 shown below is the factory default setting.

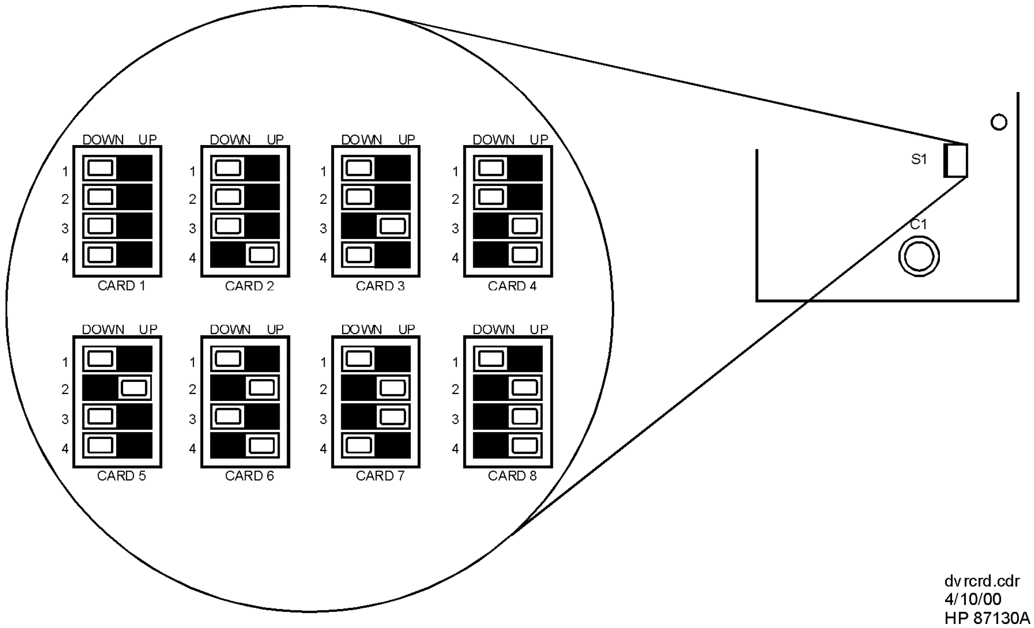


Figure 2-10 Eight Driver Card Addresses

It is impossible to predict the exact configuration of your particular switch matrix. It is assumed that each 84940A driver assembly will be in a separate grounded switch matrix box.

Driver Cable and Switch Cable Length Limitations

When you connect multiple driver boards and switches at a distance from the 87130A, voltage drop limitations due to switch drive requirements, switch quiescent current, drive transistor drop, cable resistance, and LED current must be taken into account.

Agilent “24 volt” switches are guaranteed to work with a minimum drive voltage of 20 volts. The 87130A puts out a minimum of 22.5 V, and the open drain DMOS output drivers of each channel on the driver board have a drop of 1.0 V. Thus 1.5 V is left for the total voltage drop for the driver board cables and switch wires.

For example, a seventh external driver board, “fully loaded” with seven 87104A switches (maximum 350 mA quiescent current plus 400 mA actuating current) located at the end of the sequence of 70611-60010, 70611-60011, and 70612-60011 cables of #28 AWG wire size, at a total cable length of 32.8 feet from the 87130A would have a voltage of 20.3 volts available at the driver board. (21.5 V - (750 mA X 0.065 ohms per foot X 32.8 feet X 0.75)).*

This leaves 0.3 V that can be dropped in the wires from the board to the switches. Thus, if each switch has 400 mA actuating plus 50 mA quiescent current, a combined length of 16.6 feet of #26 AWG wire would be the maximum length permissible to meet switch specifications. (450 mA X 0.04 ohms per foot X 16.6 feet = 0.3 V) Any LED current must also be added to these calculations.

Special longer lengths of heavier-gauge driver (68 pin) and CPU (36 pin) cables are available. Refer to “Service and Support” on page v for ordering information.

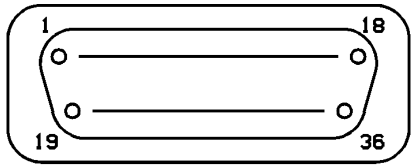
* This calculation makes two assumptions:

(1) There are no other devices which consume quiescent current connected to the driver boards between the 87130A and the seventh driver board.

(2) The factor 0.75 in this equation is used to calculate an “equivalent” cable length for forward and return path since there are two + 24 V lines in parallel and 4 return lines in parallel.

Pin Functions for 36-Pin I/O Data Cable

- The standard switch driver has a high density male, 36-pin SCSI II type connector.
- The standard I/O data cable is a five-foot 28 AWG cable with two female, 36-pin SCSI II type connectors.

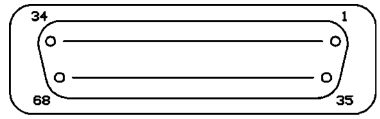


standio.cdr

Table 2-2 Standard 36-Pin (Male) SCSI II Type Connector Pin Functions

Pin	Function	Pin	Function
1	Return	19	D6, Data Line
2	Return	20	D7, Data Line
3	NC	21	D8, Data Line
4	NC	22	D9, Data Line
5	NC	23	D10, Data Line
6	NC	24	D11, Data Line
7	+ 5 Vdc	25	D12, Data Line
8	+ 5 Vdc	26	D13, Data Line
9	+ 24 Vdc	27	D14, Data Line
10	+ 24 Vdc	28	NC
11	Return	29	NC
12	Return	30	Register CLR
13	D0,Data Line	31	Store
14	D1,Data Line	32	I/O
15	D2,Data Line	33	Return
16	D3,Data Line	34	Return
17	D4,Data Line	35	NC
18	D5,Data Line	36	NC

Pin Functions for 68-pin Driver Output Connector



- The 87130A has a rear-panel 68-pin connector for driving attached switches. The standard output cable is a six-foot 28 AWG cable with two male 68-pin SCSI II type connectors.
- When you wire the switch driver to the switches, use the following table to define an OPEN or CLOSE position.

Table 2-3 Rear Panel 68-Pin (Female) SCSI II Type Connector Pin Functions

Pin	Function	Pin	Function
1	Return	35	Return
2	Channel 0, Open	36	Channel 0, Close
3	Channel 1, Open	37	Channel 1, Close
4	Channel 2, Open	38	Channel 2, Close
5	Channel 3, Open	39	Channel 3, Close
6	Channel 4, Open	40	Channel 4, Close
7	Channel 5, Open	41	Channel 5, Close
8	Channel 6, Open	42	Channel 6, Close
9	Channel 7, Open	43	Channel 7, Close
10	Channel 8, Open	44	Channel 8, Close
11	Channel 9 Open	45	Channel 9, Close
12	Channel 10, Open	46	Channel 10, Close
13	Channel 11, Open	47	Channel 11, Close
14	Channel 12, Open	48	Channel 12, Close
15	Channel 13, Open	49	Channel 13, Close
16	Channel 14, Open	50	Channel 14, Close
17	Channel 15 Open	51	Channel 15, Close
18	Channel 16, Open	52	Channel 16, Close
19	Channel 17, Open	53	Channel 17,Close
20	Channel 18, Open	54	Channel 18, Close
21	Channel 19, Open	55	Channel 19, Close
22	Channel 20, Open	56	Channel 20, Close
23	Channel 21, Open	57	Channel 21, Close
24	Channel 22, Open	58	Channel 22, Close
25	Channel 23, Open	59	Channel 23, Close
26	Channel 24, Open	60	Channel 24, Close
27	Channel 25, Open	61	Channel 25, Close
28	Channel 26, Open	62	Channel 26, Close
29	Channel 27, Open	63	Channel 27, Close
30	Channel 28, Open	64	Channel 28, Close
31	Channel 29, Open	65	Channel 29, Close
32	Channel 30, Open	66	Channel 30, Close
33	+ 24 Vdc	67	+ 24 Vdc
34	Return	68	Return

3 Specifications

Overview

Performance specifications are the performance standards or limits against which the 87130A can be tested. The specifications are organized into two categories:

- Measurement related specifications which describe warranted performance for the 87130A over the temperature range of 0 to + 55 °C after one hour of continuous operation, unless otherwise noted.
- Characteristics which provide useful (typical) but non-warranted functional and performance information for the 87130A.

Performance Specifications

Table 3-1 87130A Electrical Specifications

Electrical Specifications	
Drive Capacity - 87130A	248 relays, when mated with seven external 84940A daisy chained driver cards. Each 84940A can drive up to 31 relays. The equivalent of one 84940A driver card is installed within the 87130A.
Voltage	+ 24 + 3.0 / – 1.5 Vdc
Current Pulses	1600 mA maximum per four relay group 400 mA per relay (typically 500 mA maximum) *Pulse width is adjustable for 5 ms to 1275 ms ± 5 ms, in 5 ms steps.*
Load Inductance[1]	Typically < 500 mH
Load Capacitance	Typically < 0.01 µF
Switching Speed	Sensing delay is adjustable, per relay, from 5 to 1275 ms ± 5 ms. Pulse width is also adjustable, per relay, from 5 to 1275 ± 5 ms. Power Supply RecoveryTime is adjustable from 0 to 200 msec Refer to Chapter 6, "Troubleshooting." The final switching speed is a function of pulse widths, sensing delays, the sequence of relays driven, the state of the chosen channels, and the Power Supply Recovery Time.
Remote Programming	All functions are GPIB programmable except the line switch and bus address. All functions are programmable to conform with IEEE 488.2-1987 Standard Commands for Programmable Instruments (SCPI). The 87130A can output over the interface almost all settings, error/malfunction codes and operational status codes.
Interface to Controller	GPIB
Interface to External Driver Cards	36-pin SCSI II type
Interface to Relays	68-pin SCSI II type
Hardware Limits	Each open collector driver IC can drive only one channel (a maximum of four switches) at a time to avoid exceeding package dissipation limits.

1. Refer to "Compatible Switches and Attenuators" on page 1-4 if you are using switches or attenuators made by another company.

Table 3-2 87130A Environmental Specifications

Environmental Specifications	
Temperature	
Operating	0 to + 55 °C
Non-operating	– 40 to 70 °C
Humidity	
Operating and	
Non-operating	80% relative humidity up to 31 °C decreasing linearly to 50% relative humidity at 40 °C
Altitude	
Operating and non-operating	5600 meters (15,000 feet)
Environmental Compatibility	Radiated and conducted emission is in compliance with CISPR Pub 11/1990, Group 1, Level A
Environmental Qualification Test	
Humidity	5 day, 25 to 40 °C, 50 to 95% relative humidity
Vibration	a. Operating: MIL-PRF-28800F, Class 3, par. 4.5.5.3.1 (random, 10 to 500 Hz, 0.21 g rms)
	b. Non-operating: swept sine, 5 to 500 Hz, 0.5g, 15 min/axis, 3 axis
	c. Non-operating: MIL-PRF-28800F, Class 3, par. 4.5.5.3.1 (random, 10 to 500 Hz, 2.1 g rms)
Shock	a. Non-operating, 170 g, 1/2 sine 2ms, 1 drop/face, 6 faces
	b. Non-operating, 30 g, trapezoidal, 28 ms, 1 drop/face, 6 faces
Environmental Conditions	This product is designed for indoor use in Installation Category II and Pollution Degree 2 per IEC 1010 and IEC 664, respectively. Enclosure protection is IP 2 0 according to IEC 529.
Line Voltage	100 to 240 Vac
Power Consumption	110 Watts MAX
Weight	6.2 kg (13.7 lb)
Dimensions	10.2 cm (h) x 45.7 cm (w) X 55.9 cm (d) 4 in. x 18 in. x 22.5 in

4 Remote Operation

Overview

In this chapter you will learn about programming the 87130A using a controller:

- How to set up the switch driver and start programming groups and paths for switches
- How to set switch delay, pulse width, and sensing
- How to sense switch status
- How to store and retrieve switch parameters via remote interface
- How to perform more complicated tasks using a combination of these four basic functions

You will also find:

- A command tree of SCPI commands
- An alphabetical list of common commands
- An alphabetical list of SCPI commands
- Three programming examples:
  - Save memory
  - Restore memory
  - Speed calculation

Programming

Standard Commands

The instrument command language is Standard Commands for Programmable Instruments (SCPI).

The programming examples and information in this chapter use the SCPI format. SCPI follows IEEE 488.2-1987 Codes, Formats, Protocols and Common Commands. Commands are sent over an GPIB bus which follows IEEE 488.1.

If you are already familiar with Standard Commands for Programmable Instruments (SCPI) programming techniques, go to the section "Example Speed Calculation" on page 4-74 for switching speed information. The alphabetical listing of commands and command tree can be used for your own applications.

Language

The programming examples in this manual are written in HP BASIC 5.0 for GPIB.

HP BASIC handles some of the redundant miscellaneous overhead associated with IEEE Standard 488.1 (GPIB). For instance, when a BASIC OUTPUT statement is used (by the active controller) to send data to an GPIB device, a sequence of commands and data are sent over the bus. The HP BASIC OUTPUT statement causes more than just the output of data to take place.

```
OUTPUT 709 "Data"
```

1. The unlisten command is sent.
2. The talker's address command is sent (the address of the computer).
3. The listener's address command (09) is sent.
4. The data bytes "D", "a", "t", and "a" are sent.
5. Terminators CR and LF are sent.

All bytes are sent using the GPIB's interlocking handshake to ensure that the listener has received each byte.

For controllers that are using a programming language other than HP BASIC, additional steps may have to be added to the program examples given in this manual. For more information, refer to IEEE Standard 488.1 (GPIB) and IEEE Standard 488.2-1987 Codes, Formats, Protocols and Common Commands.

Programming Syntax

Talking to the Switch Driver

In general, computers acting as controllers communicate with the switch driver by passing messages over a remote interface using the I/O statements provided in the instruction set of the controller's host language. Therefore, the messages for programming the switch driver described in this manual, will normally appear as ASCII character strings imbedded inside the I/O statements of your controller's program.

For example, the HP 9000 Series 300 BASIC and PASCAL language systems use the `OUTPUT` statement for sending program messages to the switch driver, and the `ENTER` statement for receiving response messages from the switch driver.

Messages are placed on the bus by using an output command and passing the device selector, program message, and terminator. Passing the device selector ensures that the program message is sent to the correct interface and instrument.

Example

The following query command reads out the firmware datecode:

```
OUTPUT <device selector>;":SYSTEM:VERSION?"
```

where <device selector> represents the address of the device being programmed.

Programming Conventions

The programming examples in this manual are written in HP Basic 5.0 for an GPIB controller compatible system.

- The actual `OUTPUT` command used when programming is dependent on the controller and the programming language being used.
- Angular brackets "< >," in this manual, enclose words or characters that symbolize a program code parameter or a bus command.
- Information that is displayed in quotes represents the actual message that is sent across the bus. The message terminator (NL or EOI) is the only additional information that is also sent across the bus.
- On most controllers, it is not necessary to type in the actual <terminator> at the end of the program message. These controllers automatically supply the program message terminator when the return key is pressed.

Addressing the Switch Driver

Since GPIB can address multiple devices through the same interface card, the device selector passed with the program message must include not only the correct interface code, but also the correct instrument address.

Interface Select Code (Selects Interface)

Each interface card has a unique interface select code. This code is used by the controller to direct commands and communications to the proper interface. The default is typically 7 for GPIB controllers.

Instrument Address (Selects Instrument)

Each instrument on an GPIB bus must have a unique instrument address between decimal 0 and 30. The address must not be the address of the controller. (Refer to Chapter 2, “Installing the 87130A Attenuator/Switch Driver.”) The device address passed with the program message must include *both* the correct instrument address *and* the correct interface select code.

Example

DEVICE SELECTOR = (Interface Select Code x 100) + (Instrument Address)

If the instrument address for the switch driver is 9 and the interface select code is 7, when the program message is passed, the routine performs its function on the instrument at device selector 709.

For the switch driver, the instrument address is typically set to 9 at the factory. *The program examples in this manual assume the switch driver is set to device address 709.*

Program Message Syntax

To program the switch driver over the bus, you must have an understanding of the command format and structure expected by the switch driver.

The switch driver is remotely programmed with program messages. These are composed of sequences of program message units, with each unit representing a program command or query.

A program command or query is composed of a sequence of functional elements that include separators (a blank space which is required to separate the program mnemonic from the program data), headers, program data, and terminators. These elements are sent to the switch driver over the system interface as a sequence of ASCII data messages.

Commands

A command is composed of a header, any associated data, and a terminator. The header is the mnemonic or mnemonics that represent the operation to be performed by the switch driver. The different types of headers are discussed in the following paragraphs.

Compound Command Header

Compound command headers are a combination of two or more program mnemonics. The first mnemonic selects the subsystem, and the last mnemonic selects the function within that subsystem. Additional mnemonics appear between the subsystem mnemonic and the function mnemonic when there are additional levels within the subsystem that must be transversed. The mnemonics within the compound message are separated by colons.

Example To execute a single function within a subsystem:

:<subsystem>:<function><separator><program data><terminator>

```
ROUTE:GROUP <group name>:AUTOSELECT:OFF;
```

Example To transverse down a level of a subsystem to execute a subsystem within that subsystem:

:<subsystem>:<subsystem>:<function><separator><program data>
<terminator>

```
ROUTE:GROUP:LABEL "Atten 0 to 110 dB by 10 dB steps";
```

Selecting Multiple Subsystems

You can send multiple program commands and program queries for different switch driver subsystems on the same line by separating each command with a semicolon.

Example The colon following the semicolon enables you to enter a new subsystem.

:<subsystem>:<function><separator><data>;
<function><separator><data><terminator>

```
ROUTE:DRIVE:OFF:ALL;:SYSTEM:VERSION?
```

Common Command Header

Common command headers control IEEE 488.2 functions within the switch driver (such as clear status, etc.). Their syntax is:

*<command header><terminator>

No space or separator is allowed between the asterisk and the command header.

Example

`*CLS` is an example of a common command header.

```
*CLS; ROUTE:DRIVE:ON (@100,102,104,106,....);
```

Common commands used by the switch driver are explained in more detail in the “Common Command Reference” later in this chapter.

Program Header Options

Program headers can be sent using any combination of uppercase or lowercase ASCII characters.

Both program command and query headers may be sent in either longform (complete spelling), shortform (abbreviated spelling), or any combination of longform and shortform.

NOTE

ONLY the longform or shortform of a command will be accepted by the switch driver. Either of the following examples read out the firmware datecode:

`SYSTEM:VERSION?` – longform

`SYST:VERS?` – shortform

- Programs written in longform are easy to read and are almost self-documenting.
- The shortform syntax conserves the amount of controller memory needed for program storage and reduces the amount of I/O activity. The shortform abbreviation is given for each command in the section “SCPI Command Reference” on page 4-26.

Program Data

Program data is used to convey a variety of types of parameter information related to the command header. At least one space must separate the command header or query header from the program data.

<program mnemonic><separator><data><terminator>

When a program mnemonic or query has multiple data parameters, a comma separates sequential program data.

Example

<program mnemonic><separator><data>,<data><terminator>

```
ROUTE:DELAY .02,(@101,103,105);
```

Character Program Data

Character program data is used to convey parameter information as alpha or alphanumeric strings.

Example

```
ROUTE:VERIFY:ON:ALL
```

The `:VERIFY` function is specified to be `ON` for `ALL` channels.

Numeric Program Data

Some command headers require program data to be a number.

Example

```
ROUTE:DELAY .03,(@101,103,105)
```

where the `:DELAY` function is specified to be 30 ms on channels 101, 103, and 105.

Program Message Terminator

The program codes within a data message are executed after the program message terminator is received. The terminator may be either an NL (New Line) character, an EOI (End-Or-Identify) asserted, or a combination of the two. All three ways are equivalent. Asserting EOI sets the GPIB EOI control line low on the last byte of the data message. The NL character is an ASCII linefeed (decimal 10).

Query Command

Command headers immediately followed by a question mark (?) are queries. Query commands are used to find out how the switch driver is currently configured. After receiving a query, the switch driver interrogates the requested function and places the answer in its output queue. The output message remains in the queue until it is read or another command is issued. When read, the message is transmitted across the bus to the designated listener (typically a controller).

Example

The query `ROUTE:PATH:VALUE? <path name>` places the value of the named path in the output queue. In conjunction with this, the controller input statement:

```
ENTER <device selector>;Values$
```

passes the value across the bus to the controller and places it in the BASIC variable “Values$”.

Query commands are also used to get results of switch status made by the switch driver, with the query actually activating the switch.

Example

```
ROUTe:CLOSE? <channel spec>
```

instructs the driver to sense the status of the switch and place the result in the output queue.

The output queue must be read before the next program message is sent.

Example

When the query

```
ROUTE:VERIFY:ON?
```

is sent, that query must be followed with a program statement like,

```
ENTER 709;Verify$
```

to read the result of the query and place the result in a BASIC variable (Verify$).

Sending another command before reading the result of the query will cause the output buffer to be cleared and the current response to be lost. This will also generate an error in the error queue.

Programming the Switch Driver

Initialization

To make sure the bus and all appropriate interfaces are in a known state, begin every program with an initialization statement.

Example

`CLEAR 709` ! initializes the interface of the driver.

Then initialize the switch driver to a preset state. For example:

`OUTPUT 709;"*RST"` ! initializes the instrument to a preset state.

The actual commands and syntax for initializing the switch driver are discussed in the section "Common Commands Reference" on page 4-12. Refer to the controller manual for information on initializing the interface.

Setting Up the Switch Driver

A typical switch driver setup would set the drive (ON or OFF) paths, delay time, sensing (ON or OFF), and pulse width. Some typical examples of the commands sent to the driver are:

```
OUTPUT 709;"*CLS;ROUTE:DRIVE:ON (@100,102,104,106,....);"
OUTPUT 709;"ROUTE:DRIVE:OFF (@101,103,105,107,....);"
OUTPUT 709;"ROUTE:VERIFY:ON (@100,102,104,106,....);"
OUTPUT 709;"ROUTE:WIDTH .04,(@100,102,104,106,....);"
OUTPUT 709;"ROUTE:DELAY .03,(@100,102,104,106,....);"
```

Receiving Information from the Switch Driver

After receiving a query (command header followed by a question mark), the switch driver interrogates the requested function and places the answer in its output queue. The answer remains in the output queue until it is read or another command is issued. When read, the message is transmitted across the bus to the controller.

The input statement for receiving a response message from an instrument's output queue typically has two parameters; the device address and a format specification for handling the response message.

Example

To read the result of the query command

```
:GROUP:LABEL?
```

you would execute the statement:

```
10  OUTPUT 709;"ROUT:GROUP:LABEL? GROUP1"
20  ENTER 709;Setting$
```

where `GROUP1` represents the name of the desired group. This would enter the current label of the group in the string variable Setting$.

Example All results for queries sent in a program message must be read before another program message is sent.

When you send the query:`ROUTe:CLOSE? (@101)`

you must follow that query with the program statement:

```
ENTER 709;Sense$
```

to read the result of the query and place the result in a variable (SENSE$).

- Sending another command before reading the result of the query will cause the output buffer to be cleared and the current response to be lost. This will also cause an error to be placed in the error queue.
- Executing an `ENTER` statement before sending a query will cause the controller to wait indefinitely.

NOTE

- The actual `ENTER` program statement used when programming is dependent on the programming language being used.
- The format specification for handling the response message is dependent on both the controller and the programming language.

String Variables

If you want to observe the headers for queries, you must bring the returned data into a BASIC string variable. Reading queries into string variables is simple and straightforward, requiring little attention to formatting.

Example

```
ENTER 709;Result$
```

places the output of the query in the string variable `Result$`.

The output of the switch driver may be either numeric or character data depending on what is queried. Refer to the specific commands for the formats and types of data returned from queries.

For the example programs, assume that the device being programmed is at device selector 709. The actual address will vary according to how you have configured the bus for your own application.

Example

This example shows the data being returned to a string variable:

```
10 DIM Rang$[40]
20 OUTPUT 709;"ROUTE:VERIFY:OFF:ALL;"
30 OUTPUT 709;"ROUTE:VERIFY:OFF? (@101:105);"
40 ENTER 709;Rang$
50 PRINT Rang$
60 END
```

After running this program, the controller displays a list of 1's or 0's separated by commas for every channel in the list.

```
1,1,1,1,0
```

Instrument Status

Status registers track the current status of the switch driver. By checking the instrument status, you can find out whether an operation has been completed, whether the switch driver is receiving triggers, and query for command and execution errors. Refer to the command *ESR? (Event Status Register Query) on page 4-15 for more information.

Common Commands Reference

The common commands used in this instrument are shown in the following table.

- The common commands control some of the basic instrument functions, such as instrument identification and reset and how status is read and cleared.
- The common commands are defined by the IEEE 488.2 standard and are common to all instruments that comply with this standard.

Table 4-1 IEEE 488.2 Common Commands

Command	Command Name
*CLS	Clear Status Command
*ESE	Event Status Enable Command
*ESE?	Event Status Enable Query
*ESR?	Event Status Register Query
*IDN?	Identification Query
*OPC	Operation Complete Command
*OPC?	Operation Complete Query
*RST	Reset Command
*SRE	Service Request Enable Command
*SRE?	Service Request Enable Query
*STB?	Read Status Byte Query
*TST?	Self-Test Query
*WAI	Wait-to-Continue Command

*CLS (Clear Status)

Syntax

```
*CLS
```

Description

The `*CLS` (clear status) common command clears the status data structures, including the device defined error queue. This command also clears `*OPC` and `*OPC?`.

If the `*CLS` command immediately follows a PROGRAM MESSAGE TERMINATOR, the output queue and the MAV bit will be cleared.

Example Command

```
OUTPUT 709;"*CLS"
```

*ESE (Event Status Enable)

Syntax

`*ESE` *mask*

`*ESE?`

Description

The `*ESE` command sets the Standard Event Status Enable Register bits. This register contains a mask value for the bits to be enabled in the Standard Event Status Register. A one in the Standard Event Status Enable Register will enable the corresponding bit in the Standard Event Status Register; a zero will disable the bit.

Refer to the table below for the information about the Standard Event Status Enable Register bits, bit weights, and what each bit masks. Valid number range is 0 to 255.

The `*ESE` query returns the current contents of the register.

Table 4-2 Event Status Enable Register Bit Definitions

Bit	Weight	Enables
7	128	PON- Power ON
6	64	(not used)
5	32	CME- Command Error
4	16	EXE- Execution Error
3	8	DDE- Device Dependent Error
2	4	QYE- Query Error
1	2	(not used)
0	1	OPC- Operation Complete

Example Command

```
OUTPUT 709;"*ESE 64"
```

Example Query

```
OUTPUT 709;"*ESE?"
ENTER 709; Event
PRINT Event
```

*ESR? (Event Status Register Query)

Syntax

`*ESR?`

Description

The `*ESR` query returns the contents of the Standard Event Status Register.

The table shows each bit in the Event Status Register and the bit weight. When you read the Event Status Register, the value returned is the total bit weights of all bits that are high at the time you read the byte. The register is cleared to 0 on a `*CLS` and after `*ESR?` is executed.

Refer to the command *STB (Status Byte) on page 4-20 to learn how the ESR is reported through the Status Byte.

Table 4-3 Event Status Register Bit Definitions

Bit	Weight	Name	Condition
7	128	PON	1 = an OFF to ON transition has occurred
6	64	URQ	(not used) always 0
5	32	CME	0 = no command errors 1 = a command error has been detected
4	16	EXE	0 = no execution errors 1 = an execution error has been detected
3	8	DDE	0 = no device dependent errors 1 = a device dependent error has been detected
2	4	QYE	0 = no query errors 1 = a query error has been detected
1	2	RQC	(not used) always 0
0	1	OPC	0 = operation is not complete 1 = operation is complete

Example Query

```
OUTPUT 709;"*ESR?"
ENTER 709; Event
PRINT Event
```

*IDN (Identification Number)

Syntax

```
*IDN?
```

Description

The `*IDN` query allows the instrument to identify itself. It returns a string such as:

```
HEWLETT-PACKARD,87130A,US12345678,950713
```

Where 950713 is the firmware version number and US12345678 is the serial number.

Example Command

```
DIM Id$[72]
OUTPUT 709;"*IDN?"
ENTER 709;Id$
PRINT Id$
```

*OPC (Operation Complete)

Syntax

```
*OPC
*OPC?
```

Description

The `*OPC` and `*OPC?` commands are used to synchronize remote interface software to internal module events.

- The `*OPC` (operation complete) command will cause the instrument to set the operation complete bit in the Standard Event Status Register when any switching operations that were in process at the time the `*OPC` command was received have completed.
- `*OPC` is also used to signal the end of `MEM:SAVE` operation.
- `*OPC?` causes a 1 to be put into the output buffer when any switching operations that were in process at the time the `*OPC?` command was received have completed.

If no switching operations were in process at the time the command was sent, the response will be generated immediately. Hence `*OPC` or `*OPC?` should only be sent after an operation has been initiated.

Example Command

```
OUTPUT 709;"*OPC"
```

Example Query

The following sequence is correct, because the OPC command is sent *after* the operation is initiated:

```
OUTPUT 709; "ROUT:CLOS (@1(1,3,5,7,9));*OPC?"
ENTER 709;A
PRINT A
```

The following sequence is incorrect, because the OPC command is sent *before* the operation is initiated:

```
*OPC?;ROUT:CLOSE (@1(1,3,5,7,9));
```

*RST (Reset)

Syntax

```
*RST
```

Description

`*RST` is equivalent to a power up condition for the switch hardware.

All relays for which DRIVE is ON are set to the positions determined by `ROUTe:PFAil.` For any relays not in either the `ROUTe:PFAil:OPEN` or `ROUTe:PFAil:CLOSE` list, the positions which are stored in the “last state” list in RAM are used to set the initial switch position. The “last state” list contains the programmed positions of the switch hardware that existed the last time a `MEM:SAVE` command or a `SAVE TO EEROM` keypress took place.

The setting of the switches during `*RST` or power up is done with VERIFY turned OFF, to get all the relays and sense lines into a known state. VERIFY is then turned on for any switches in the VERIFY list.

`*RST` affects only the switches themselves and does not affect the configuration data stored in RAM (DRIVE and VERIFY lists, drive and delay times, etc).

The **[IP]** or **[Instr Preset]** key does a `*RST` operation, as does the `*TST?` command.

Example Command

```
OUTPUT 709;"*RST"
```

NOTE

The power supply recovery time (see `TRIG:SEQ:DEL` on page 4-62) will be reset to the default value of 200 msec if the *RST command is issued.

*SRE (Request Enable)

Syntax

```
*SRE mask
*SRE?
```

Description

The `*SRE` command sets the Service Request Enable Register bits. This will indicate whether or not the device has at least one reason for requesting service. A one in the Service Request Enable Register will enable the corresponding bit in the Status Byte Register; a zero will disable the bit.

Refer to the table below for the bits in the Service Request Enable Register and what they mask. Legal number range is 0 to 255.

- At power up the SRE register is 0.
- The `*SRE` query returns the current value.

Table 4-4 Service Request Enable Register

Bit	Weight	Enables
7	128	SCPI Operation Summary Bit
6	64	RQS - Request Service
5	32	ESR - Event Status Register
4	16	MAV - Message Available
3	8	SCPI Questionable Summary Bit
2	4	Not used
1	2	Not used
0	1	Not used

*STB (Status Byte)

Syntax

```
*STB?
```

Description

The `*STB` query returns the current value of the instrument's status byte. Refer to the table below for the definitions of the bits in the status byte.

Table 4-5 Status Byte Bit Definitions

Bit	Weight	Name	Condition
7	128	OPER	0 = no operation status events have occurred 1 = an operation status events has occurred
6	64	RQS/MSS	0 = instrument has no reason for service 1 = instrument is requesting service
5	32	ESR	0 = no event status events have occurred 1 = an enabled event status condition has occurred
4	16	MAV	0 = no output messages are ready 1 = an output message is ready
3	8	QUES	0 = no questionable conditions have occurred 1 = a questionable condition has occurred
2	4	__	always 0
1	2	__	always 0
0	1	__	always 0

Example Query

```
OUTPUT 709;"*STB?"
ENTER 709;Value
PRINT Value
```

Refer to the command STATus on page 4-60 for more information on the OPERATION register and summary bit.

*TST? (Test)

Syntax

```
*TST?
```

Description

`*TST?` causes all relays to cycle through both of their positions (first all the CLOSE paths are set; then all the OPEN paths), and then get placed in the appropriate power up positions. Refer to *RST (Reset) on page 4-18.

All relays for which sensing is enabled (`VERIFY:ON`) are checked for proper operation each time they are switched. Unused relays (`DRIVE:OFF`) are neither switched nor checked.

The result of the test will be placed in the output queue. A 0 indicates that the test passed and a non-zero value indicates the test failed.

Example Query

```
OUTPUT 709;"*TST?"
ENTER 709;Result$
PRINT VAL(Result$)
```

*WAI

Syntax

```
*WAI
```

Description

The `*WAI` command causes the instrument to wait for all pending GPIB operations to finish before processing any further commands.

Example

```
OUTPUT 709;"*WAI"
```

Hierarchy

Table 4-6 Command Tree

ROUTE			
	:CLOSe		
	:OPEN		
	:PATH		
		:DEFine	
		:CATalog	
		:LABel	
		:VALue	
		:DELete	:ALL
	:GROUP		
		:NAME	
		:CATalog	
		:ADD	
		:REMove	
		:DEFine?	
		:LABel	
		:AUTOselect	
			:ON
			:OFF
		:DELete	
		:DELete	:ALL

Table 6-6. Command Tree (continued)

```
ROUTE
               :PFAil
                                   :CLOSe
                                   :OPEN
                                   :DELete
               :VERify
                                   :ON
                                   :OFF
                                                 :ALL
               :DRIVe
                                   :ON
                                   :OFF
                                                 :ALL
               :WIDth
               :DELay

               :SERialnumber[?]
               :MODelnumber[?]
               :EEROM
                                   :CYCles?
```

Table 6-6. Command Tree (continued)

```
MEMory
             :DELete
             :INITialize
             :SAVE
             :FREE?
STATus
             :OPERation
                                :[EVENt]?
                                :CONDition?
                                :ENABle[?]
                                :PTRansition
                                :NTRansition
             :QUEStionable
                                :[EVENt]?
                                :CONDition?
                                :ENABLe[?]
SYSTem
             :VERSion?
             :ERRor?
TRIGger
             :SEQuence
                                :DELay[?]
```

NOTE

A colon (:) must be used in front of the `ROUTE`, `DIAGnostics`, `MEMory`, etc. commands if that command is not the first item in a command string. (The colon is optional if the command is the first in the string.)

SCPI Command Reference

Channel Lists

The 87130A can control up to seven different external driver cards, each of which can drive up to 31 different relays. The cards are numbered from 1 to 8; the relays on each card are numbered from 0 to 30. Each relay is referred to as a *channel* by the switch driver. Therefore, there are a total of 248 relays (channels) that can be driven from a single switch driver.

In order to realize the capability of the switch driver, many of the commands listed in the “SCPI Command Reference” utilize a language construct called a channel list. A single remote command may specify single or multiple relays by means of this channel list.

The syntax for channel lists is as follows:

`(@channel number, channel number,...,)`

or

`(@channel number: channel number,),`(a range)

or

`(@card number, (channel number, channel number,...,))`

or

`(@card number, (channel number: channel number,))`

or

`(@)` empty channel list

The card number must always be sent, either as the card number parameter or as part of a channel number (or range). When sent as part of a channel number, the card number is multiplied by 100 and added to the channel number. For example, 214 would mean channel 14 on card 2.

Example

`(@101,2(0:5),3(1,3,5),406:410)`

This means channel 1 on card 1, channels 0 through 5 on card 2, channels 1, 3 and 5 on card 3, and channels 6 through 10 on card 4.

SCPI Commands

The following pages list all of the SCPI compound command program mnemonics used to program this instrument.

:ADD

Syntax

```
ROUTE:GROUP:ADD <group name>,<path name>
```

Description

This command adds an existing path to the end of an existing group. The group name and path name must have been previously defined using `GROUP:NAME and PATH:DEF`. A path may be added to a group in several places by issuing this command several times. Only one path can be added for each issuance of `ADD`.

Example Command

```
ROUTE:GROUP:ADD ATTEN,ATTEN_14;
```

A previously defined path `ATTEN_14` is added to group `ATTEN`. Refer to the query `:DEFine? <group name>` to list all paths in a group.

:AUTOselect

Syntax

```
                          [:ON]
ROUTe:GROUP:AUTOselect[?] {      } <group name>
                          :OFF
```

Description

This turns the current Auto Select state for the group on or off.

Example Command

```
ROUTE:GROUP:AUTO:ON ATTEN;
```

This turns the current Auto Select state for the group `ATTEN` on.

```
ROUTE:GROUP:AUTO:OFF ATTEN;
```

This turns the current Auto Select state for the group `ATTEN` off.

Example Query

```
ROUTE:GROUP:AUTO? ATTEN;
```

or

```
ROUTE:GROUP:AUTO:ON? ATTEN;
```

This queries the current autoselect state for the group. If the current state of autoselect for group `ATTEN` is ON, a 1 will be returned.

```
ROUTE:GROUP:AUTO:OFF? ATTEN;
```

If the current state of autoselect for group `ATTEN` is `OFF`, a 1 will be returned.

:CATalog?

Syntax

```
        ┌ :PATH  ┐
ROUTe  <          > :CATALOG?
        └ :GROUP ┘
```

Description

Returns a list of groups (up to 16) *or* all defined paths in the module.

Example Query

```
ROUTE:GROUP:CATALOG?
```

This query returns a list of all of the group names, in order from 1 to 16, separated by commas.

```
ROUTE:PATH:CATALOG?
```

This query returns a list of all the defined paths in the module, separated by commas.

:CLOSe

Syntax

```
ROUTe:CLOSe {<path name>    }
            {<channel list> }

ROUTe:PFail:CLOSe[?] {<path name>    }
                     {<channel list> }
```

Description

Each channel has a CLOSE or OPEN position. On Agilent relays, the CLOSE path is the path between the input terminal labeled 2 on the relay and the input terminal labeled C. It is recognized that CLOSE and OPEN are arbitrary for this type of switch; they are, however, in keeping with the SCPI language specification.

Example Command

```
ROUTe:CLOSe (@101,2(0:5),3(1,3,5),406:410);
```

Sending the above command causes channel 1 on card 1, channels 0 through 5 on card 2, channels 1, 3 and 5 on card 3, and channels 6 through 10 on card 4 to be closed.

- Channels must have `DRIVe:ON` to be closed or they will be ignored.
- During any switching operation (OPEN or CLOSE) the settling bit in the OPER status register is set (1). It is cleared (0) when the operation completes.

Example Query

```
ROUTE:CLOSE? (@101,103,105);
```

Sending the query (question mark) causes the channels in the channel list parameter to be checked for closed channels. The readback is a list of 1's and 0's separated by commas, one for each channel in the list. A 1 is sent if the specified channel is closed; otherwise a 0 is sent.

Devices for which sensing is on (`VERify:ON`) read back the position in which they were sensed the last time a switching operation took place.

Devices with sensing off simply read back the currently programmed state (which, if they haven't been switched since power up, will be the state they were set to at power up). Devices with `DRIVE:OFF` read back the last value to which they were set.

Example Command

```
ROUTE:CLOSE ATTEN_14;
```

Sending the above command causes the set of switch OPENs and CLOSEs defined by the PATH (refer to :PATH on page 4-55) with name ATTEN_14 to be executed. The first group of switch settings in the PATH is interpreted as CLOSE settings and the second group as OPEN settings. The ΧΛΟΣΕ settings are all executed first, followed by the OPEN settings.

Example

If ATTEN_14 had been defined as:

```
ROUTE:PATH:DEF ATTEN_14,(@101,102),(@103,104);
```

when that path is sent by ROUTE:CLOSE ATTEN_14, switches 101 and 102 will first be closed, and then switches 103 and 104 will be opened.

The query form is not available when using a path name, due to the potential for confusion between the first and second groups in the path.

NOTE

If you are configuring hardware for switching systems, keep in mind that CLOSE settings are executed before OPEN settings when a path is sent.

For example, multistage attenuators should be set up so that a CLOSE operation always adds attenuation and an OPEN operation removes attenuation. This ensures that in moving from one attenuation setting to another, the intermediate stage (after the CLOSEs and before the OPENs) is a stage representing higher attenuation and thus avoids signal spikes that could damage sensitive hardware.

Example Command

```
ROUTE:PFAIL:CLOSE (@101,2(0:5),3(1,3,5));
```

The ROUTe:PFAil:CLOSe command lists the channels desired to be closed on power up or after *RST or *TST?. The channel list has the same restrictions as those for the ROUTE:CLOSE command. Sending the command in the example above causes channel 1 on card 1, channels 0 through 5 on card 2, and channels 1, 3 and 5 on card 3 to be closed on power up.

```
ROUTe:PFAil:CLOSE ATTEN_14;
```

Sending the above command causes the set of switch OPENs and CLOSEs defined by the PATH with name ATTEN_14 to be added to the PFAIL list. The first group of switch settings in the PATH is interpreted as CLOSE settings and the second group as OPEN settings.

Example Query

```
ROUTE:PFAIL:CLOSE? (@101,205);
```

The inclusion of a question mark causes a readback of the power up state of the requested channels as a list of 1's and 0's separated by commas. A 1 means the channel is in the `PFA:CLOS` list. A 0 means that it is not.

- When querying the `PFAil` state, the `PFA:OPEN` list must be checked as well to determine whether the power up state for a given channel is programmed at all.
- If a relay is not in the `PFAil:OPEN` list or the `PFAil:CLOSe` list, its power up state is determined by the last save stored to EEROM for that relay.

:CYCLes?

Syntax

```
DIAGnostics:EERom:CYCLes?
```

Description

This query causes the 87130A to read back the number of times to which the EEROM has been written. If this number exceeds 10,000 the EEROM should be replaced. If the EEROM has never been written to, then 0 is returned.

Example Command

```
DIAG:EEROM:CYCLES?
```

:DEFine

Syntax

```
ROUTe:PATH:DEFine <path name>,<channel list> [,<channel list>]
ROUTe:GROUP:DEFine? <group name>
ROUTe:PATH:DEFine? <path name>
```

Description

Under the `PATH` subsystem, this command is used to define or redefine the switch settings that make up a path.

- This command effectively "creates" a path by assigning the path name to one of the 256 internal path registers (if no register is available, a memory error will be declared). No other command referencing that path name may be sent before the `DEFine` command is sent.
- A path name is any collection of up to 12 uppercase letters (lowercase letters are automatically uppercased), numbers, or underscore characters, starting with a letter.
- If the path name already exists, the old settings (both `CLOSE` and `OPEN`) will be erased and the new settings established from the new channel list.
- The channel lists used by `PATH:DEF` follow all the normal rules for channel lists, and may contain any combination of switches from one or more driver cards. The second channel list is optional; if not sent it will be treated as empty. The empty channel list (@) may be sent for either parameter.
- If a channel is included in both of the channel lists in a path, no error is declared, but the channel will be removed from the first list and only retained in the second.
- The interpretation of the data in a path depends on how it is used. If sent using `ROUTE:CLOSE <path name>` or by the manual interface, the first channel list is a CLOSE list and the second an OPEN list. If sent using `ROUTE:OPEN <path name>`, the first channel list is an `OPEN` list and the second a `CLOSE` list.

Example Command

```
ROUTE:PATH:DEF ATTEN_14,(@101,2(0:5)),(@102);
```

This command defines a path whose name is `ATTEN_14` whose first channel list affects channel 1 on card 1 and channels 0 through 5 on card 2, and whose second channel list affects channel 2 on card 1.

Example Query

```
ROUTE:PATH:DEFine? ATTEN_14;
```

The query form returns a path description as two channel lists separated by a comma. It can be sent back by appending it to a `PATH:DEF` command to recreate the path. For the example command above, the response should look like:

```
(@101,2(0:5)),(@102)
```

Example Query

```
ROUTE:GROUP:DEF? ATTEN;
```

This query returns a list of all of the path names in the group `ATTEN,` in order, separated by commas.

:DELay

Syntax

```
ROUTe:DELay:<delay time>,{<channel>  }
                         {<path name>}
```

Description

This commands sets the delay time in seconds required to validate the sense lines on a relay for which sensing will be used. The drive signal will be held on the relay for this amount of time after the pulse width requirement (refer to :WIDTh on page 4-67) has been satisfied.

The delay time may be set in 5 ms increments up to 1275 ms. The delay time defaults to 20 ms when memory is initialized. The delay parameter may be an integer or real number.

NOTE

The `:DELete` and the `:DELay` shortform is the same. The `:DELete` command applies only in syntax with other subsystems and not directly to channel lists.

Example Command

```
ROUTE:DELAY .02,(@101,103,105);
OUT:DEL 20ms,(@101,103,105);
```

In the above example, the delay time is set to 20 ms for channels 1, 3, and 5.

```
ROUTE:DELAY .02,ATTEN_14;
```

This command causes the drive to the set of relays (defined by the `ROUTe:PATH` command) with path name `ATTEN_14` to be set to 20 ms If the path includes two channel lists, all relays in both list are affected.

Example Query

```
ROUTE:DELAY? (@101,103,105);
```

In this case, the sense delay for channels 101, 103 and 105 is read back, with the values separated by commas. For example, if all three are set to 20 ms, then the readback is:

```
+2.000E-02,+2.000E-02,+2.000E-02
```

NOTE

The query form is not available when using a path name due to the potential for confusion between the first group and the second in the path.

:DELete

Syntax

```
ROUTE { :PATH  } :DELete { <path name>  }
      { :GROUP }         { <group name> }
                         { [:ALL]       }
```

Description

This command deletes:

- All data associated with the specified path or group and frees up the path storage register.
- All channels from the PFAIL list.

This command sets memory to an initial state.

NOTE

The :DELete and the :DELay shortform is the same. The :DELete command applies only in syntax with other subsystems and not directly to channel lists from ROUTe.

Example Command

- `ROUTE:PATH:DELETE ATTEN_14;`

This deletes the path with pathname ATTEN_14 and all data in it.

- `ROUTE:PATH:DELETE:ALL;`

This deletes all paths.

- `ROUTE:GROUP:DEL ATTEN;`

This deletes all data associated with the group ATTEN. The group name is set to the default (refer to MEM:DELETE).

- `ROUTE:GROUP:DEL:ALL;`

This deletes all data associated with all the groups. The group names are set to the default (refer to MEM:DELETE).

- `ROUTe:PFAil:DELete;`

This command removes all data from the PFAIL:OPEN and PFAIL:CLOSE lists.

- `MEMory:DELete;`

`MEMory:DELete` erases all data from CMOS RAM, by filling it with zeroes, and then sets it to an initial state. That state is as follows:

- ❍ The power fail channel lists are empty (`ROUT:PFA:CLOS` and `ROUT:PFA:OPEN`).
- ❍ Sensing `(VERIFY)` is `OFF` for all devices.
- ❍ The `ROUT:DRIVE:ON` list has channels 0 through 30 on card 1 used and all other channels unused.
- ❍ The `WIDTH` is set to 30 ms pulse width; `DELAY` is set to 20 ms for all 256 devices.
- ❍ The group names are defaulted to `GROUP1`, `GROUP2`, and so on through `GROUP16`.
- ❍ The path `VALues` are defaulted to the path register number, 1–256.
- ❍ The `GROUP` and `PATH` registers are empty.

If you also wish to delete the EEROM data, this command should be followed by a `MEM:SAVE` command to copy this state to the EEROM.

This command does not affect the “last switch state” area in the RAM image, even though there is a “last switch state” stored in the EEROM, because the last state must always the match the actual last state of the switches. Nor does it affect the model number and serial number.

:DRIVe

Syntax

ROUTe:DRIVe { [:ON] | :OFF } :ALL

ROUTe:DRIVe { [:ON] | :OFF } [?]<channel list>

ROUTe:DRIVe { [:ON] | :OFF } :<pathname>

Description

There is a list of relays considered unused or "not there" by the firmware. Unused channels are not driven even if included in a channel list or path and are not checked for proper sense line state and cannot generate errors. Turning `:DRIVE:OFF` for a channel adds it to the Unused List.

NOTE

In systems without CMOS RAM it is necessary to execute a write to EEROM to ensure that the `DRIVe` data will survive a power cycle. Refer to the `MEM:SAVE` command.

Example Command

- `ROUTe:DRIVe:ON (@101,103,105);`

This command removes channels 1, 3, and 5 on card 1 from the Unused List.

- `ROUTE:DRIVE:OFF (@101,103,105);`

This command adds channels 1, 3, and 5 on card 1 to the Unused List.

- `ROUTE:DRIVE:OFF ATTEN_14;`

This command causes the set of relays (defined by the `ROUTe:PATH` command) with name `ATTEN_14` to be added to Unused List.

If the path includes two channel lists, all relays in both lists are affected.

- `ROUTE:DRIVE:ON:ALL;`

This turns drive on for all channels.

- `ROUTE:DRIVE:OFF:ALL;`

Drive is turned off for all channels; that is, all channels are "unused".

Example Query

- `ROUTE:DRIVE:ON? (@101,103,105);`

This command returns a list of 1's and 0's, separated by commas, depending on whether drive is on or off for the indicated channels.

If it is on for channels 101 and 105 and off for 103, the switch driver will return:

`1,0,1`

- `ROUTE:DRIVE:OFF? (@101,103,105)`

This command returns a list of 1's and 0's, separated by commas, depending on whether drive is on or off for the indicated channels.

If it is on for channels 101 and 105 and off for 103, the switch driver will return:

`0,1,0`

The query form is not available when using a path name, due to the potential for confusion between the first group and the second in the path.

:EERom

Syntax

```
DIAGnostics:EERom:CYCLes?
```

Description

This function allows EERom information to be read out. (Refer to :CYCLes? on page 4-33.)

:ERRor?

Syntax

```
SYSTem:ERRor?
```

Description

As SCPI specifies, this reads out the full error number and error description for the first error in the error queue. It can be issued repeatedly until the queue is empty (indicated by **`0,"No error"`**).

All possible error numbers with their descriptions are listed below.

Command Errors

These set the Cmd Err bit in ESR.

```
-100,Command error
-100,Command error;SCPI unused invalid character
-101,Invalid character;bad type Syntax error
-103,Invalid separator
-104,Data type error
-105,GET not allowed
-108,Parameter not allowed
-108,Parameter not allowed;invalid
-109,Missing parameter
-112,Program mnemonic too long
-113,Undefined header
-121,Invalid character in number
-123,Exponent too large
-124,Too many digits
-128,Numeric data not allowed
-131,Invalid suffix
-138,Suffix not allowed
-141,Invalid character data
-148,Character data not allowed
-150,String data error
-151,Invalid string data
-158,String data not allowed
-161,Invalid block data
-168,Block data not allowed
-170,Expression error;too long
-171,Invalid expression
-178,Expression data not allowed
```

-181,Invalid outside macro definition

-183,Invalid inside macro definition

Execution Errors

These set the Exec Err bit in ESR.

-200,Execution error

-222,Data out of range

-223,Too much data

-270,Macro error

-272,Macro execution error

-273,Illegal macro label

-276,Macro recursion error

-277,Macro redefinition not allowed

Device Specific Errors

These set the Cmd Err bit in ESR.

-310,System error

-310,System error;SCPI internal

-310,System error;no memory

-310,System error;formatter

777,Queue Overflow

1001,Sense error;<17 hex digits>

This error is generated when an apparently impossible state of the sense lines from one or more relays is detected. The first of the 17 hex digits represents the card number on which the failure was detected; the rest represent a 64-bit binary number which indicates which of the 32-channels experienced failures.

Each channel has two associated bits; the leftmost indicates that the error was detected on the CLOSed side of the relay; the rightmost that the error was detected on the OPEN side. A failure is indicated with a 1. The least significant (rightmost) two bits are channel 0, the most significant (leftmost) are channel 31. If more than one card experiences failures then more than one error will be reported.

1002,Memory capacity exceeded

An attempt has been made to store more data than will fit in the 16 Kbyte nonvolatile memory area.

1003,Timer unstable

Instability has been detected in the 6840 timer chip, so the operating system cannot run reliably.

`1004,EEROM data invalid`

Corruption has been detected in the EEROM; it needs to be replaced, or, if brand new, it needs to have `MEM:SAVE` executed once.

`1006,Channel timeout <17 hex digits>`

This error is generated when a relay apparently fails to switch, based on the detected state of the sense lines. The 17 hex digits indicate which card and which of the 32 channels experienced failures just as for error 1001. Each channel has two associated bits; the leftmost indicates that the error was detected on the CLOSED side of the relay; the rightmost that the error was detected on the OPEN side. A failure is indicated with a 1.

- A **`Channel timeout`** without an accompanying **`Sense error`** indicates that the sense lines were in a valid state, but it was the wrong state.
- A **`Channel timeout`** with a **`Sense error`** indicates that both sense lines appeared to be at 0 V.
- A **`Sense error`** without a **`Channel timeout`** means both sense lines appeared to be at 24 V.

`1007,Label too long`

A path or group label was more than 32 characters long.

`1008,Nonexistent group`

An attempt was made to use a group name which was not previously set up with a GROUP:NAME command.

`1009,Group already exists`

An attempt was made to name a group with a name already in use by another group.

`1010,Nonexistent path`

An attempt was made to use a path name which was not previously set up with a `PATH:DEF` command.

`4000,Divide by Zero`
`4001,Float Overflow`
`4002,Float Underflow`
`4003,Logarithm Error`
`4004,Integer Overflow`
`4005,Square Root Error`

Query Errors

These set the Query Err bit in ESR.

`-400,Query error`
`-410.Query INTERRUPTED`
`-420,Query UNTERMINATD`
`-430,Query DEADLOCKED`

:FREE?

Syntax

```
MEMory:Free?
```

Description

This is a query which returns the number of bytes that remain in RAM for storing configuration data, followed by the number of bytes initially available. The two quantities are separated by commas. For a brand new system there are around 13,000 bytes initially available.

The group names and titles, power fail, verify and drive lists, and device switching times are saved in a fixed size area of memory, and available RAM is unaffected by changing this data.

For the rest of the data, it is allocated as needed. For any given PATH, one or more of the eight cards in the 87130A will be represented. It takes nine bytes to store the complete state of a card and only those cards actually referenced in a given path are saved.

Path titles take up the number of characters in title, and path names take up the number of characters in the name. Every path added to a group takes up one byte. It is up to the user to allocate this memory as appropriate; for example, if a lot of path data is going to be used, path names and titles can be kept short to conserve space.

:GROUP

Syntax

```
                  ⎧ :NAME           ⎫
                  ⎪ :CATALOG?       ⎪
                  ⎪ :ADD[?]         ⎪
ROUTE: GROUP:     ⎨ :REMOVE[?]      ⎬
                  ⎪ :DEFine[?]      ⎪
                  ⎪ :LABEL[?]       ⎪
                  ⎪ :AUTOselect[?]  ⎪
                  ⎩ :DELete[:ALL]   ⎭
```

Description

The `GROUP` subsystem allows grouping of paths to customize the manual interface to the 87130A.

A “group” is an ordered collection of up to 256 paths. Paths can be collected into meaningful groups using the `GROUP` command. The 87130A can store up to 16 groups. Each group may be defined and labeled.

NOTE

In systems without CMOS RAM it is necessary to execute a write to EEROM after configuring custom groups to ensure that the group data will survive a power cycle. Refer to the `MEM:SAVE` command.

:INITialize

Syntax

```
MEMory:INITialize
```

Description

When this command is issued, RAM is initialized according to the following algorithm:

1. RAM is initialized to the state described in `MEMory:DELete`. This command essentially erases any changes that have been made to RAM since the last power cycle.
2. The model number is initialized to 87130A. The serial number is initialized to USXXXXXXXX.

   When equipment is manufactured by Agilent Technologies, it is given a unique serial number. A serial number label is attached to the rear panel of the module. The first six entries are the same for all identical modules; they only change when a change in the electrical or physical functionality is made. The remaining digits are assigned sequentially and are different for each instrument.
3. If the EEROM is not defective, its data is downloaded into RAM, which cancels the effect of steps 1 and 2. If the EEROM is faulty, no download is performed.

This initialization algorithm is the same algorithm used at power up to initialize RAM, except that at power up, before step three is performed, the “last state” in RAM is set to all relays OPEN. Hence, in the case of a failed EEROM, “last state” defaults to all relays OPEN.

:LABel[?]

Syntax

```
ROUTe  :PATH   :LABEL  {<path name> }  "<label>";
       :GROUP          {<group name>}
```

Description

This command specifies a label (32 characters max) to be used when labeling the group on manual interface screens. Any character may be used within the quotes as long as its value is between 32 and 127. These values are treated as ASCII characters.

Example Command

`ROUTE:PATH:LABEL ATTEN_14,"14 dB ATTEN";`

The above commands assigns the label `14 dB ATTEN` to the previously defined path with the pathname `ATTEN_14`.

Example Query

`:LABel? <path name>`

`ROUTE:PATH:LABEL? ATTEN_14;`

The query form returns the programmed label:

`14 dB ATTEN`

Example Command

`ROUTE:GROUP:LABEL ATTEN,"Attenuation";`

The above commands assigns the label `Attenuation` to the group with the group name `ATTEN`.

Example Query

`:LABel? <group name>`

`ROUTE:GROUP:LABEL? ATTEN;`

The query form returns the programmed label:

`Attenuation`

MEMory

Syntax

$$\texttt{MEMory}\left\{\begin{array}{l}\texttt{:DELete}\\ \texttt{:INITialize}\\ \texttt{:SAVE}\\ \texttt{:FREE?}\end{array}\right\}$$

Description

The `MEMory` subsystem is used to delete, initialize RAM, and save EEROM information to the controller.

:NAME

Syntax

```
ROUTE:GROUP:NAME <number>,<group name>
```

Description

The groups are numbered from 1 to 16. They may be named or renamed using this command. An attempt to name a group using a name already in use for another group will result in an error.

A group name is any collection of up to 12 uppercase letters (lowercase letters are automatically uppercased), numbers, or underscore characters, starting with a letter.

Refer to the `MEM:DELETE` command description for the default group names assigned when memory is initialized or a group is deleted.

Example Command

```
ROUTE:GROUP:NAME 1,ATTEN;
```

This command associates the name `ATTEN` with group 1 for programming purposes.

:OPEN

Syntax

```
ROUTe:OPEN[?] {<path name>   }
              {<channel list>}

ROUTe:PFail:OPEN[?] {<path name>   }
                    {<channel list>}
```

Description

Each channel has a CLOSE or OPEN position. On Agilent relays, the OPEN path is the path between the input terminal labeled 1 on the relay and the input terminal labeled C. It is recognized that CLOSE and OPEN are arbitrary for this type of switch; they are, however, in keeping with the SCPI language specification.

Example Command

```
ROUTE:OPEN (@101,2(0:5),3(1,3,5),406:410);
```

During any switching operation (OPEN or CLOSE) the settling bit in the OPER status register is set (1). It is cleared (0) when the operation completes.

Sending the above command causes channel 1 on card 1, channels 0 through 5 on card 2, channels 1, 3 and 5 on card 3, and channels 6 through 10 on card 4 to be opened. Channels must be part of the drive list (`DRIVE:ON`) to be opened or they will be ignored.

Example Query

```
ROUTE:OPEN? (@101,103,105);
```

Sending the query (optional question mark) causes the channels in the channel list parameter to be checked for opened channels. The readback is a list of 1's and 0's separated by commas, one for each channel in the list. A 1 is sent if the specified channel is opened, otherwise a 0 is sent. Although this command is not strictly necessary (`ROUTE:CLOSE?` is sufficient), it is included for completeness.

Devices for which sensing is on, read back the position in which they were sensed the last time a switching operation took place. Devices with sensing off simply read back the currently programmed state (which will be the state they were set to at power up if they haven't been switched since power up). Devices with `DRIVE:OFF` read back the last value to which they were set.

It is possible to combine OPEN and CLOSE in a single command since they are both part of the ROUTe subsystem. For example:

```
ROUTE:CLOSE (@406:410);OPEN (@202);
```

This command will close channels 6 through 10 on card 4 and open channel 2 on card 2.

Example Command

```
ROUTE:OPEN ATTEN_14;
```

Sending the above command causes the set of switch OPENs and CLOSEs defined by the PATH with name ATTEN_14 to be executed. The first group of switch settings in the PATH is interpreted as OPEN settings and the second group as CLOSE settings.

The CLOSE settings are all executed first, followed by the OPEN settings.

For example, if ATTEN had been defined as:

```
ROUTE:PATH:DEF ATTEN_14,(@101,102),(@103,104);
```

then when that path is sent by ROUTE:OPEN ATTEN_14, switches 103 and 104 will first be closed and then switches 101 and 102 will be opened.

NOTE

If you are configuring hardware for switching systems, keep in mind that CLOSE settings are executed before OPEN settings when a path is sent.

For example, multistage attenuators should be set up so that a CLOSE operation always adds attenuation and an OPEN operation removes attenuation. This ensures that in moving from one attenuation setting to another, the intermediate stage (after the CLOSEs and before the OPENs) is a stage representing higher attenuation, and thus avoids signal spikes that could damage sensitive hardware.

Example Command

```
ROUTE:PFAil:OPEN (@101,2(0:5),3(1,3,5));
```

The ROUTe:PFAil:OPEN command lists the channels desired to be opened on power up or after *RST or *TST?. The channel list has the same restrictions as those for the ROUTe:OPEN command. Sending the command in the example above causes channel 1 on card 1, channels 0 through 5 on card 2, and channels 1, 3 and 5 on card 3 to be opened on power up.

```
ROUTE:PFAil:OPEN ATTEN_14;
```

Sending the above command causes the set of switch OPENs and CLOSEs defined by the PATH with name ATTEN_14 to be added to the PFAIL list.

The first group of switch settings in the PATH is interpreted as OPEN settings and the second group as CLOSE settings.

Example Query

```
ROUTE:PFAil:OPEN? (@101,205);
```

The inclusion of a question mark causes a readback of the power up state of the requested channels as a list of 1s and 0s separated by commas.

- A 1 means the channel is in the PFA:OPEN list.
- A 0 means that it is not.

When querying the PFAIL state, the PFA:CLOS list must be checked as well to determine whether the power up state for a given channel is programmed at all.

If a relay is in neither the PFAil:OPEN or PFAil:CLOS lists, its power up state is determined by the last save stored to EEROM for that relay.

The query form is not available when using a path name, due to the potential for confusion between the first group and the second in the path.

:PATH

Syntax

```
                ┌ :DEFine[?]      ┐
                │ :CATalog?       │
ROUTe:PATH     <  :LABel[?]        >
                │ :VALue[?]       │
                └ :DELete[:ALL]   ┘
```

Description

The PATH subsystem allows storing of channel lists to simplify remote access and to customize the manual interface to the 87130A.

- Paths are specified using CLOSE and OPEN channel lists. Each relay contains one CLOSE and one OPEN path. Refer to the command explanations :CLOSe on page 4-30 and :OPEN on page 4-52 for more information.
- A path is defined as a specification of switch positions for a range of switches. Thus it may require one or two channel lists to fully specify a path, depending on the mix of OPENs and CLOSEs in the path.
- The paths can be defined, labeled, and/or sent to the hardware. Each path has a name by which it is referenced for the purpose of programming, which is established by the PATH:DEF command.
- The paths can be collected into meaningful groups using the GROUP command. They can also be sent in place of channel lists by the ROUTE and other commands.

NOTE

In systems without CMOS RAM it is necessary to execute a write to EEROM after configuring custom paths to ensure that the path data will survive a power cycle. Refer to the MEM:SAVE command section.

:PFAil

Syntax

```
                ⎧:CLOSe ⎫
ROUTe:PFAil     ⎨:OPEN  ⎬ ⎧<path name>   ⎫
                ⎩:DELete⎭ ⎩<channel list>⎭
```

Description

The ROUTe:PFAil subsystem of SCPI allows specification of which channels will be closed on a power cycle (or `*RST` or `*TST?)`.

- Channels not specified by ROUTE:PFAIL:CLOSE or ROUTE:PFAIL:OPEN are set during power up by reading the last switch state out of EEROM or CMOS RAM, or if the EEROM data is corrupt, by OPENing the channel.
- Channels not on the drive list (DRIVE:OFF) are not affected at power up even if in the PFAIL list.

NOTE

In systems without CMOS RAM it is necessary to execute a write to EEROM to ensure that the PFAIL lists will survive a power cycle. Refer to the `MEM:SAVE` command section.

:REMove

Syntax

```
ROUTe:GROUP:REMove <group name>,<path name>
```

Description

This command removes all instances of the specified path from a group. The group name and path name must have been previously defined using `GROUP:NAME` and `PATH:DEF`.

Example Command

```
ROUTE:GROUP:REMOVE ATTEN,ATTEN_14;
```

Removes all paths named ATTEN_14 from group ATTEN. Refer to the query `:DEFine? <group name>` to list all paths in a group.

ROUTe

Syntax

Refer to the command tree.

Description

Relay switching and configuration is accomplished by the `ROUTe` command tree.

:SAVE

Syntax

```
MEMory:SAVE
```

Description

This command copies the RAM image to the EEROM. Care should be taken to do this only when necessary, due to the limited life of the EEROM. (Refer to `DIAG:EEROM:CYCLES?`). Because this is time consuming (over a minute in some cases), it is made to turn on the "switching" light while saving. The CALIBRATING bit in the OPER status register is set when a save begins and cleared when it ends. `*OPC` can also be used to detect the end of a save.

The following data will be saved:

- the VERIFY list
- the DRIVE list
- the PFAIL list
- the serial number and model number
- the WIDTH and DELAY times for all switches
- all GROUP data, including group names, titles, AUTOSELECT state
- what PATHs are in each group
- all PATH data, including path names, titles, and values
- what channels are in each PATH

In addition, in the "last state" list will be saved:

- the current state of all switches in the DRIVE list
- the programmed state of all switches not in the DRIVE list

If you know that you have performed a valid `SAVE to the EEROM` (one that was not interrupted by turning off power and which did not generate an error), and you subsequently get an `EEROM invalid` error message, you should replace the EEROM.

STATus

Syntax

```
                     :[EVENt]?
                     :CONDition
STATus:OPERation    {:ENABle[?]         }
                     :PTRansition
                     :NTRansition[?]
```

```
                        :[EVENt]?
STATus:QUEStionable    {:CONDition?}
                        :ENABle[?]
```

Description

The STATus subsystem is fully specified by SCPI. Refer to the following commands: `*STB (Status Byte)`, `*SRE (Request Enable)`, `*ESE (Event Status Enable)`, and `*ESR? (Event Status Register Query)`

- `STATus:OPERation`

In the `STATus:OPERation` subsystem, only the settling bit (bit 1) is implemented by the 87130A; it is set during a switching operation (and when saving to EEROM) and cleared when it completes. The "SWITCHING" LED is on whenever this bit is set. The following commands are applicable:

  - `STATus:OPERation:EVENt`
  - `STATus:OPERation:CONDITION?`
  - `STATus:OPERation:ENABle`
  - `STATus:OPERation:PTRansition[?]`
  - `STATus:OPERation:NTRansition[?]`
  - `STATus:OPERation:PTRansition[?]`

- `STATus:QUEStionable`

The `QUEStionable` susbsytem is required by SCPI but is not used by the 87130A, 70612A,C or 70613A,C. The following commands are implemented:

  - `STATus:QUEStionable:EVENt?`
  - `STATus:QUEStionable:CONDition?`
  - `STATus:QUEStionable:ENABle`

SYSTem

Syntax

```
SYSTEM {:VERSion?
        :ERRor?  }
```

Description

These are SYSTem commands from the SCPI specification.

- `VERSion?`
- `ERRor?`

TRIGger

Syntax

```
TRIGger:SEQuence:DELay <number>
```

Description

This command allows the user to control the 24 V power supply recovery time. Input values are limited to between 0 and 200 msec (200 msec is the default setting). The GPIB command `TRIGger:SEQuence:DELay` will allow entry of a new power recovery time. Values outside the 0 to 200 msec range will return an error.

Example Command

```
TRIG:SEQ:DEL .15
```

This example assigns the value, 150 msec, to the `TRIGger` command.

Example Query

```
TRIG:SEQ:DEL?
```

The query form returns the assigned number. For the example, it would return

```
.15
```

NOTE

The default 200msec `TRIG:SEQ:DEL` value will be reset on instrument power up or if the *RST command is issued.

:VALue

Syntax

```
ROUTe:PATH:VALUE <path name>,<number>;
```

Description

This command specifies a number (integer in the range – 32768 to 32767) to be used when labeling the path on manual interface screens. This number, when entered manually from the user interface, can be used to select paths directly without using the RPG or step keys.

Example Command

```
ROUTE:PATH:VALUE ATTEN_14,14;
```

This example assigns a value of 14 to a path with pathname ATTEN_14.

Example Query

```
ROUTE:PATH:VALUE? ATTEN_14;
```

The query form returns the programmed number. For the example above, it would return

```
+14
```

:VERify

Syntax

```
                {:[ON]}  {:ALL              }
ROUTe:VERify    {      } {<path name>       }
                { OFF  } {<channel list>    }

                {:[ON]}
ROUTe:VERify    {      } [?]<channel list>
                { OFF  }
```

Description

This command adds or removes relays from the “sense list”, the list of relays for which sensing is enabled.

This command only works with relays that have the ability to sense the state of the switch. Refer to the list of Agilent compatible switches and attenuators that have this capability.

NOTE

In systems without CMOS RAM it is necessary to execute a write to EEROM to ensure that the `VERify` data will survive a power cycle. Refer to the `MEM:SAVE` command.

Example Command

```
ROUTE:VERIFY:ON (@101,103,105);
```

This command adds channels 1, 3, and 5 on card 1 to the "sense list" . Due to the nature of sensing relays, enabling this sensing mode of operation may increase switching times, as the sense lines must settle after the switch is thrown. The default sensing delay is 20 ms. Refer to the command `:DELay on page 4-36` to adjust switching time when sensing is enabled.

With sensing on for a given switch, if that switch fails to switch, either on a `ROUTe` command or on `*TST?`, an error is generated. Furthermore, after any switching operation, all of the relays for which sensing is on (and for which `DRIVe` is also on) have their sense lines checked; erroneous values generate errors.

```
ROUTE:VERIFY:OFF (@101,103,105);
```

This command removes channels 1, 3, and 5 on card 1 from the "sense list" .

```
ROUTE:VERIFY:ON ATTEN_14;
```

This command causes the set of switches defined by the PATH with the pathname `ATTEN_14` to be added to (ON) or removed from (OFF) the "sense list. All switches referenced in either channel list in the path are added (ON) or removed (OFF).

```
ROUTE:VERIFY:OFF:ALL;
```

This turns sensing off for all channels.

Example Query

```
ROUTE:VERIFY:ON? (@101,103,105);
```

This command returns a list of 1's and 0's, separated by commas, depending on whether sensing is on or off for the indicated channels. For example, if sensing is on for channels 101 and 105 and off for 103, the switch driver responds with:

```
1,0,1
```

```
ROUTE:VERIFY:OFF? (@101,103,105);
```

This command returns a list of 1's and 0's, separated by commas, depending on whether sensing is off or on for the indicated channels. For example, if it is on for channels 101 and 105 and off for 103, the switch driver responds with:

```
0,1,0
```

The query form is not available when using a path name, due to the potential for confusion between the first group and the second in the path.

:VERsion?

Syntax

```
SYSTem:VERSion?
```

Description

This reads out the firmware datecode.

:WIDTh

Syntax

$$\texttt{ROUTe:WIDTh <pulse width>,} \begin{Bmatrix} \texttt{<channel list>} \\ \texttt{<path name>} \end{Bmatrix}$$

`ROUTe:WIDTh <channel list>`

Description

This command sets the pulse width in seconds required to close a relay. The pulse width may be set in 5 ms increments up to 1275 ms. The pulse width defaults to 30 ms when memory is initialized. The `WIDTh` parameter may be an integer or a real number.

Example Command

```
ROUTE:WIDTH .03,(@101,103,105);
```

In the above example, the pulse width is set to 30 ms for channels 1, 3, and 5.

```
ROUTE:WIDTH .03,ATTEN_14;
```

This command causes the drive with to the set of relays (defined by the `ROUTe:PATH` command) with path name `ATTEN_14` to be set to the specified pulse width. If the path includes two channel lists, all relays in both lists are affected.

Example Query

```
ROUTE:WIDTH? (@101,103,105);
```

In this case, the pulse width for channels 101, 103 and 105 is read back, with the values separated by commas. For example, if all three are set to 30 ms, then the readback is:

+3.000E-02,+3.000E-02,+3.000E-02

The query form is not available when using a path name, due to the potential for confusion between the first group and the second in the path.

Example Programs

The following programs written in Rocky Mountain Basic provide sample programs that may be helpful in programming the 87130A.

Save Memory

In order to use the following program, you must first create a file named `SWDATA`. The following program can be used to read configuration data out of the EEROM so that it can be replaced.

```
10    ! READMEM program. Takes data from 87130A and outputs
       to a file
20    DIM A$[32767]
30    DIM Serialnumber$[10],Modelnumber$[6]
40    DIM Groupnames$(15)[12],Grouptitles$(15)[32]
50    DIM Pathnames$(255)[12],Pathtitles$(255)[32],
          Pathval(255)
60    DIM Groupdata$(15,255)[12],Groupauto(15)
70    COM @Sw,@File
80    MAT Pathnames$= (“”)
90    MAT Groupnames$= (“”)
100   MAT Pathtitles$= (“”)
110   MAT Grouptitles$= (“”)
120   MAT Groupdata$= (“”)
130   ASSIGN @File TO “SWDATA”
140   ASSIGN @Sw TO 709
150   Read_bitmap(“ROUT:VERIFY:ON”)
160   Read_bitmap(“ROUT:DRIVE:ON”)
170   Read_bitmap(“ROUT:PFA:CLOS”)
180   Read_bitmap(“ROUT:PFA:OPEN”)
190   OUTPUT @Sw;”DIAG:SER?”
200   ENTER @Sw;Serialnumber$
210   OUTPUT @File;Serialnumber$
220   OUTPUT @Sw;”DIAG:MOD?”
230   ENTER @Sw;Modelnumber$
240   OUTPUT @File;Modelnumber$
250   Read_bitmap(“ROUT:WIDT”)
260   Read_bitmap(“ROUT:DELAY”)
270   OUTPUT @Sw;”ROUTE:GROUP:CATALOG?”
```

```
280  ENTER @Sw;A$
290  I=-1
300  WHILE LEN(A$)>0
310    Comma=POS(A$,”,”)
320    IF Comma=0 THEN
330      A$=A$&”,”
340      Comma=LEN(A$)
350    END IF
360    I=I+1
370    Groupnames$(I)=A$[1;Comma-1]
380    A$=A$[Comma+1]
390  END WHILE
400  OUTPUT @File;Groupnames$(*)
410  Max_group=I
420  FOR G=0 TO Max_group
430    OUTPUT @Sw;”ROUT:GROUP:LABEL? “&Groupnames$(G)
440    ENTER @Sw;Grouptitles$(G)
450    OUTPUT @Sw;”ROUT:GROUP:AUTOSELECT:ON? “&Groupnames$(G)
460    ENTER @Sw;Groupauto(G)
470    OUTPUT @Sw;”ROUT:GROUP:DEF? “&Groupnames$(G)
480    ENTER @Sw;A$
490    I=-1
500    WHILE LEN(A$)>0
510      Comma=POS(A$,”,”)
520      IF Comma=0 THEN
530        A$=A$”,”
540        Comma=LEN(A$)
550      END IF
560      I=I+1
570      Groupdata$(G,I)=A$[1;Comma-1]
580      A$=A$[Comma+1]
590    END WHILE
600  NEXT G
610  OUTPUT @File;Groupdata$(*)
620  OUTPUT @File;Groupauto(*)
630  OUTPUT @File;Grouptitles$(*)
640  OUTPUT @Sw;”ROUTE:PATH:CATALOG?”
650  ENTER @Sw;A$
660  I=-1
```

```
670   WHILE LEN(A$)>0
680     Comma=POS(A$,”,”)
690     IF Comma=0 THEN
700       A$=A$&”,”
710       Comma=LEN(A$)
720     END IF
730     I=I+1
740     Pathnames$(I)=A$[1;Comma-1]
750     A$=A$[Comma+1]
760   END WHILE
770   OUTPUT @File;Pathnames$(*)
780   Max_path=I
790   FOR P=0 TO Max_path
800     OUTPUT @Sw;”ROUT:PATH:LABEL? “&Pathnames$(P)
810     ENTER @Sw;Pathtitles$(P)
820     OUTPUT @Sw;”ROUT:PATH:VALUE? “&Pathnames$(P)
830     ENTER @Sw;Pathval(P)
840     OUTPUT @Sw;”ROUT:PATH:DEF? “&Pathnames$(P)
850     ENTER @Sw;A$
860     OUTPUT @File;A$
870      ! HAVE TO OUTPUT THIS DATA ON THE FLY, AS IT IS A
           POTENTIALLY HUGE ARRAY
880   NEXT P
890   OUTPUT @File;Pathtitles$(*)
900   OUTPUT @File;Pathval(*)
910   ASSIGN @File TO *
920   END
930   SUB Read_bitmap(S$)
940     COM @Sw,@File
950     DIM Response(31),Bitmap(7,31)
960     FOR I=0 TO 7
970       OUTPUT @Sw;S$&”? (@”&VAL$(I+1)&”00:”&VAL$(I+1)&”31);”
980       ENTER @Sw;Response(*)
990       MAT Bitmap(I,*)= Response
1000    NEXT I
1010    OUTPUT @File;Bitmap(*)
1020  SUBEND
```

Restore Memory

The following program can be used to restore the EEROM state read out by READMEM:

```
10    ! WRITEMEM program. Takes a file written by READMEM and
        sends it to the 87130A.
20    DIM A$[32767]
30    DIM Respond(31),Sense(7,31),Unused(7,31),Pfac(7,31),
      Pfao(7,31),Widt(7,31),Delay(7,31)
40    DIM Serialnumber$[10],Modelnumber$[6]
50    DIM Gpnames$(15)[12],Gptitles$(15)[32]
60    DIM Pathnames$(255)[12},Pathtitles$(255)[32],
      Pathval(255)
70    DIM Groupdata$(15,255)[12],Groupauto(15)
80    COM @File,@Sw
90    MAT Pathnames$= ("")
100   MAT Gpnames$= ("")    ! Group names
110   MAT Pathtitles$= ("")
120   MAT Gptitles$= ("")   ! Group titles
130   MAT Groupdata$= ("")
140   ASSIGN @File TO "SWDATA"
150   ASSIGN @Sw TO 709
160   OUTPUT @Sw;"MEM:DELETE;"
170   OUTPUT @Sw;"ROUT:VERIFY:OFF:ALL;"
180   Getandsend_bmap("ROUT:VERIFY:ON")
190   OUTPUT @Sw;"ROUT:DRIVE:OFF:ALL;"
200   Getandsend_bmap("ROUT:DRIVE:ON")
210   Getandsend_bmap("ROUT:PFA:CLOS")
220   Getandsend_bmap("ROUT:PFA:OPEN")
230   ENTER @File;Serialnumber$
240   OUTPUT @Sw;"DIAG:SER """&Serialnumber$&""";"
250   ENTER @File;Modelnumber$
260   OUTPUT @Sw;"DIAG:MOD """&Modelnumber$&""";"
270   Getandcalc_bmap("ROUT:WIDT")
280   Getandcalc_bmap("ROUT:DELAY")
290   ENTER @File;Gpnames$(*)
300   ENTER @File;Groupdata$(*)
310   ENTER @File;Groupauto(*)
320   ENTER @File;Gptitles$(*)
```

```
330   ENTER @File;Pathnames$(*)
340   FOR I=0 TO 255  !  send path data
350     IF Pathnames$(I)<>”” THEN
360       ENTER @File;A$
370   OUTPUT@Sw;”ROUT:PATH:DEF”&Pathnames$(I)&”,”&A$&”;”
380     END IF
390   NEXT I
400   FOR I=0 TO 15   !  send group data
410     IF Gpnames$(I)<>”” THEN
420       OUTPUT
          @Sw;”ROUT:GROUP:NAME”&VAL$(I+1)&”,”&Gpnames$(I)&”;”
430       IF Groupauto(I) THEN
440         OUTPUT @Sw;”ROUT:GROUP:AUTOSELECT:ON
            “&Gpnames$(I)&”;”
450       ELSE
460         OUTPUT @Sw;”ROUT:GROUP:AUTOSELECT:OFF”
            &Gpnames$(I)&”;”
470       END IF
480       IF Gptitles$(I)<>”” THEN OUTPUT
          @Sw;”ROUT:GROUP:LABEL””&Gpnames$(I)&”,
          “““&Gptitles$(I)&”””;”
490       J=0
500       WHILE Groupdata$(I,J)<>””
510         OUTPUT @Sw;”ROUT:GROUP:ADD
            “&Gpnames$(I)&”,”&””&Groupdata$(I,J)&””&”;”
520         J=J+1
530       END WHILE
540     END IF
550   NEXT I590     IF Pathnames$(I)<>”” THEN
560   ENTER @File;Pathtitles$(*)
570   ENTER @File;Pathval(*)
580   FOR I = 0 to 255
590    IF Pathnames$(I)<>”” THEN I=0 TO 255
600       OUTPUT @Sw;”ROUT:PATH:LAB “&Pathnames$(I)&”,
          “““&Pathtitles$(I)&”””;”
610       OUTPUT @Sw;”ROUT:PATH:VAL”&Pathnames$(I)&”,
          “&VAL$(Pathval(I))&”;”
620     END IF
630   NEXT I
640   ASSIGN @File TO *
```

```
650   END
660   SUB Getandsend_bmap(B$)
670     ! Loads a query response from file and outputs it as a
        channel list
680     COM @File,@Sw
690     DIM Bitmap(7,31),A$[32767]
700     ENTER @File;Bitmap(*)
710     FOR I=0 TO 7
720       A$=””
730       FOR J=0 TO 31
740         IF Bitmap(I,J) THEN A$=A$&”,”&VAL$(100*(I+1)+J)
750       NEXT J
760       IF A$[1;1]=”,” THEN A$=A$[2]
770       IF A$<>”” THEN OUTPUT @Sw;B$&” (@”&A$&”);”
780     NEXT I
790   SUBEND
800   SUB Getandcalc_bmap(B$)
810     ! Loads a query response from a file and outputs it to
          set drive/delay time
820     COM @File,@Sw
830     DIM Bitmap(7,31),A$[32767]
840     ENTER @File;Bitmap(*)
850     FOR I=0 TO 7
860       FOR J=0 TO 31
870         OUTPUT @Sw;B$&””&VAL$(Bitmap(I,J)&”,
            (@”&VAL$(100*(I+1)+J)&”);”
880         IF Bitmap(I,J) THEN A$=A$&”,”&VAL$(100*(I+1)+J)
890       NEXT J
900       IF A$[1;1]=”,” THEN A$=A$[2]
910     NEXT I
920   SUBEND
```

Example Speed Calculation

Switching speed is a function of pulse widths, sensing delays, the state of the chosen channels, the sequence of relays driven and the power suply recovery time. A sample program and timing diagram are provided to help the user minimize switching time, since the user determines pulse widths, sensing delays and which channels are opened or closed.

Table 4-7 shows which connectors (J1 to J31) are on the same drive lines. Refer to the installation instructions (Figure 2-6 on page 2-7) to wire your relay into the arbitrary positions of OPEN and CLOSE.

Table 4-7 Relay Drive Sequence

Drive Line	Connector Locator	Channel List
1	J1, J2, J3, J4	00, 01, 02, 03
2	J5, J6, J7, J8	04, 05, 06, 07
3	J9, J10, J11, J12	08, 09, 10, 11
4	J13, J14, J15, J16	1 2, 13, 14, 15
5	J17, J18, J19, J20	16, 17, 18, 19
6	J21, J22, J23, J24	20, 21, 22, 23
7	J25, J26, J27, J28	24, 25, 26, 27
8	J29, J30, J31	28, 29, 30

The following program, along with Figure 4-1 on page 4-77, can be used to learn how to determine switching speed. It is intended to show how the drive line architecture of the switch driver/driver board(s) and the programmed variables of `:DELay,:WIDTh` and `TRIG:SEQ:DEL` can be used to calculate the total switching time for any switching operation.

Recall that the channel number is a three digit number where the first digit is the driver card number. Channel 130 is channel 30 on driver card 1. Channel 825 is channel 25 on driver card 8.

```
10 DIM Closl$[40]
20 OUTPUT 709:"*RST"
30 OUTPUT 709;"ROUT:DRIV:ON (@100:111);"
40  !
50  !    Drive is set to ON for channels 100 through 111 using
```

```
60  !    a range.
70 OUTPUT 709;"ROUT:DRIV:OFF (@112:130);"
80  !
90  !      Drive is set to OFF for remaining channels on driver
100 !     card 1.Unless channels are part of Drive list, no
110 !     pulse (:WIDTh) is sent.
120 OUTPUT 709;"ROUT:VER:ON (@100:111);"
130 !
140 !      Sensing is ON for channels 100 through 111.
150 !      VERify:ON works at switching time, and errors
160 !      (if they exists) are reported back immediately.
170 !
180 !      Unless channels are part of Verify list no sensing
190        (:DELay) can be valid. In other words,
190 !      you can choose to sacrifice sensing for speed.
200 !
210 !
220 OUTPUT 709;"ROUT:CLOS (@100:111);"
230 !
240 !      This command ensures all channels start in the same
250 !      (CLOSE) state.
260 OUTPUT 709;"ROUT:CLOS? (@100:111);"
270 !
280 !      Queries CLOSe list.
290 !
300 ENTER 709;Closl$
310 PRINT Closl$
320 !
330 !      Switch driver response should look like:
           1,1,1,1,1,1,1,1,1,1,1,1
340 !      This indicates all 12 active channels are in the
350 !      CLOSE) state.
360 PAUSE
```

NOTE

For this example, all relays start at the same (CLOSE) state and have delays and pulse widths to make the calculation easier to follow. In real situations, relays may be in different states. You must programmatically keep track of these relays for your time calculations to be correct.

```
370 DIM Openl$[40]
```

```
380 OUTPUT 709;"ROUT:WIDT .04,(@100,102,104,108);"
390 !
400 !      Pulse (:WIDTh) is set to 40 ms for channels 100,102,
410 !      104, and 108. When :OPEN is sent, 100 and 102
420 !      will OPEN at the same time.
430 !      Channels 104 and 108 will each OPEN at different
440 !      times, because they are connected to different
450 !      drive lines. See the Relay Drive Sequence table
460 !      and Figure 6-1, Timing Diagram.
470 !      In the absence of a pulse width declaration for
480 !      channels 101 and 103, of 30 ms seconds is applied.
490 OUTPUT 709;"ROUT:DEL .015,(@100:103);"
500 !
510 !      Sensing (:DELay) is set to 15 ms for channels 100
520 !      to 103.
530 OUTPUT 709;"ROUT:VER:OFF (@104:107);"
540 !
550 !      Example of sensing sacrificed for speed.
560 !      :DELay is invalid for channels 104, 105, 106, 107.
570 !
580 OUTPUT 709;"ROUT:WIDT 0.05,(@109:111);"
590 !
600 !      Channels 109, 110, 111 set to 50 ms pulse (WIDTh).
610 !
620 OUTPUT 709;"ROUT:DEL 0.025,(@109:111);"
630 !
640 !      Sensing delays for 109, 110, 111 set to 25 ms.
650 !
660 OUTPUT 709;"TRIG:SEQ:DEL 0.02;"
670!
680!       Sets the power supply recovery time to 20 ms.
690!
700 OUTPUT 709:"TRIG:SEQ:DEL?"
710 ENTER 709:Trig
720 PRINT Trig
730!
740!       Queries the power supply recovery time. Response
           should be: 02
750!
760 OUTPUT 709;"ROUT:OPEN (@100:111);"
770 !
```

```
780 !      See timing chart to predict when each relay will
790 !      open.
800 OUTPUT 709;"ROUT:OPEN? (@100:104,108:111);"
810 !
820 !      You turned sensing off for 104 thru 107, remember?
830 !      About OPEN?: you could still query for the entire
840 !      open list for channels 100 to 111. Channels 104 to
850 !      107 would still report back 1,1,1,1.
860 !      The query :OPEN? (or :CLOSe?) queries the channel
870 !      list, not the relay. The switch
880 !      driver reports the state the switch should be in.
890 !
900 ENTER 709;Openl$
910 PRINT Openl$
920 !
930 !      Switch driver should respond with: 1,1,1,1,1,1,1,1,1
940 !
950 END
```

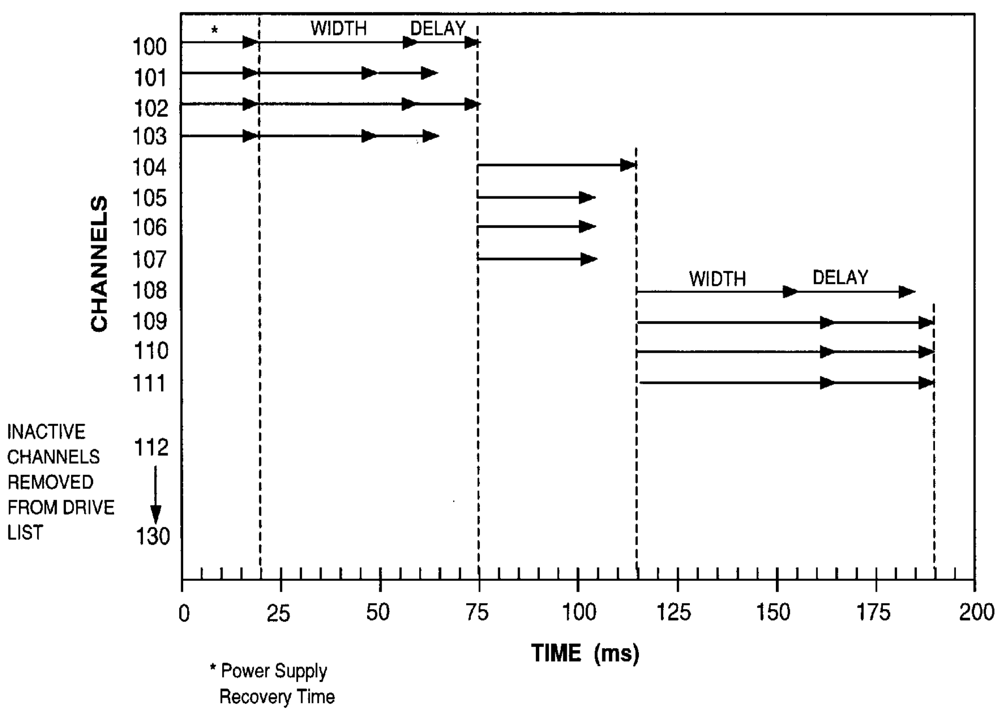


Figure 4-1 Timing Chart

5 Replaceable Parts

Overview

In this chapter you will find:

- Accessories available for the switch driver by part number and description.
- All replaceable parts referenced in chassis and cable assemblies.

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Accessory Boards and Cables

Additional driver boards, interconnect boards, and cables provide expanded capacity, remote switching and everything needed for device connection.

Table 5-1 Accessories

Part Number	Description
11764-60009	Cable (no sensing), 10 pin DIP to 4-pin Berg connectors, 30 inches (used with 87222C,D,E transfer switch)
11764-60010	Cable (sensing), 10 pin DIP to 4-pin Berg connectors, 30 inches (used with 87222C,D,E transfer switch)
70611-60004	Cable, 68-pin to 68-pin SCSI II, 6 feet, 28 AWG
70611-60008	32 cables with connectors, 52 inches, 26 AWG (84940A to switches)
70611-60010	Cable, 36-pin SCSI II to 36 pin SCSI II, shielded, 5 feet, 28 AWG
70611-60011	Cable, ribbon, 36-pin SCSI II to 34-pin, 18 inches, 28 AWG
70611-60013	Cable kit, ribbon 36-pin SCSI to 34-pin
70612-60011	Cable, dual 36-pin SCSI II to 34-pin ribbon, 36 inches, 28 AWG
84940A	Driver board
84941A	Distribution board

Firmware Revisions

Older versions of this instrument may have firmware part numbers different from those listed in Table 5-4 on page 5-8 for U7 and U8. However, the firmware parts listed are the most current versions of the firmware and are the preferred replacement parts. The current firmware versions are backward compatible for all instruments.

Table 5-2 Replaceable Parts - 87130A Chassis Assembly (1)

Part Location	Part Number	Quantity	Description	Reference Designator
1	87130-00009	1	Deck	—
2	87130-00011	1	Power supply shield	—
3	87130-62065	1	Driver board	A2
4	87130-00010	1	PC board bracket assembly	—
5	87130-00008	1	Shield, bottom cover	—
6	87130-60002	1	Controller board	A1
7	87130-00007	1	Shield, top cover	—
8	87130-00002	1	Front sub-panel	—
9	87130-00001	1	Front dress panel	—
10	87130-00004	1	Rear panel	—
11	0515-0458	11	Screw torx metric	—
12	0380-3095	4	Spacer, long	—
13	0380-3094	2	Spacer, short	—
14	0380-2088	2	Spacer	—
15	0515-1851	6	Screw, torx	—
16	0403-0423	6	Bumper foot, 12.5 OD	—
17	0535-0088	7	Nut, plastic locking	—
18	2360-0117	2	Screw, posidrive 6-32 x 0.375 pan head	—
19	7120-4294	2	Label, high voltage	—

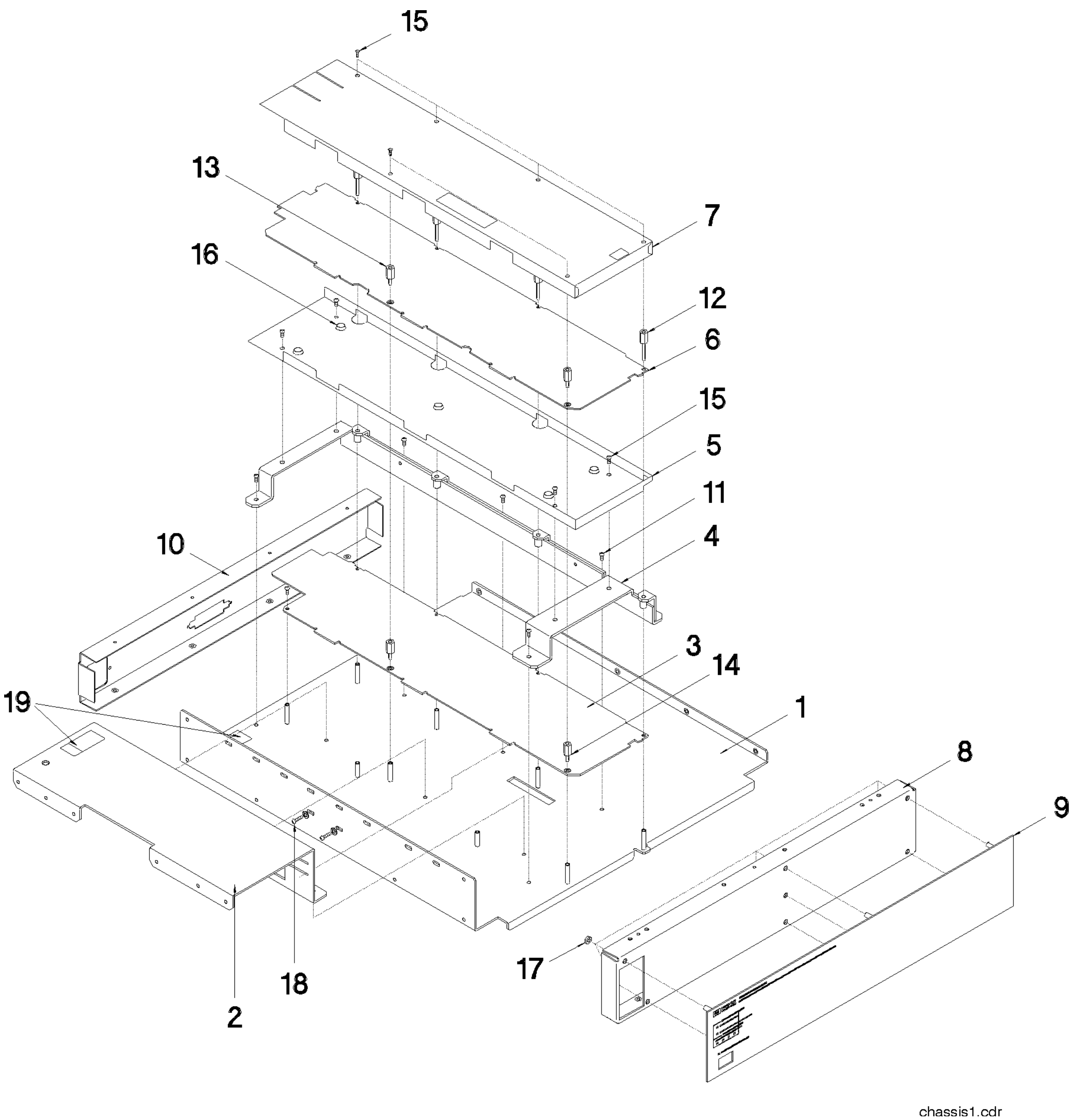

Figure 5-1 87130A Chassis Assembly (1)

Table 5-3 Replaceable Parts - 87130A Chassis Assembly (2)

Part Location	Part Number	Quantity	Description
1	5021-8401	1	Front frame
2	5021-5802	1	Rear frame
3	5021-5887	2	Side strut
4	5041-8802	1	Top trim
5	5063-9226	1	Front handle kit
6	5021-8495	2	Trim, front handle
7	5041-8801	4	Foot, bottom
8	5062-3776	2	Side cover
9	5062-3704	2	Strap handle
10	5041-8819	2	Front cap
11	5041-8820	2	Rear cap
12	5041-8821	4	Rear panel foot
13	5062-3747	1	Bottom cover
14	5062-3735	1	Top cover
15	0515-2036	8	Screw, FH M4 x 0.7 x 10L
16	0515-2039	6	Screw, torx T10 M 3.5 x 0.5x 8L
17	0515-0431	21	Torx pan M3.5 x 0.6 x 6L
18	0515-0458	11	Torx pan M3.5 x 0.6 x 8L
19	2360-0117	2	Screw, posidrive 6-32 x 0.375 pan head
20	0515-1384	4	Torx pan M 5 x0.8 x 10L
21	0515-2044	4	FH 4 x 0.7 x 10L
22	0515-1860	4	Torx pan M3.5 x 0.6 x 10L
23	5063-9212	1	Rack mount kit without front handles 88.1 h (not shown)
24	5063-9214	1	Rack mount kit without front handles 132.6h (not shown)

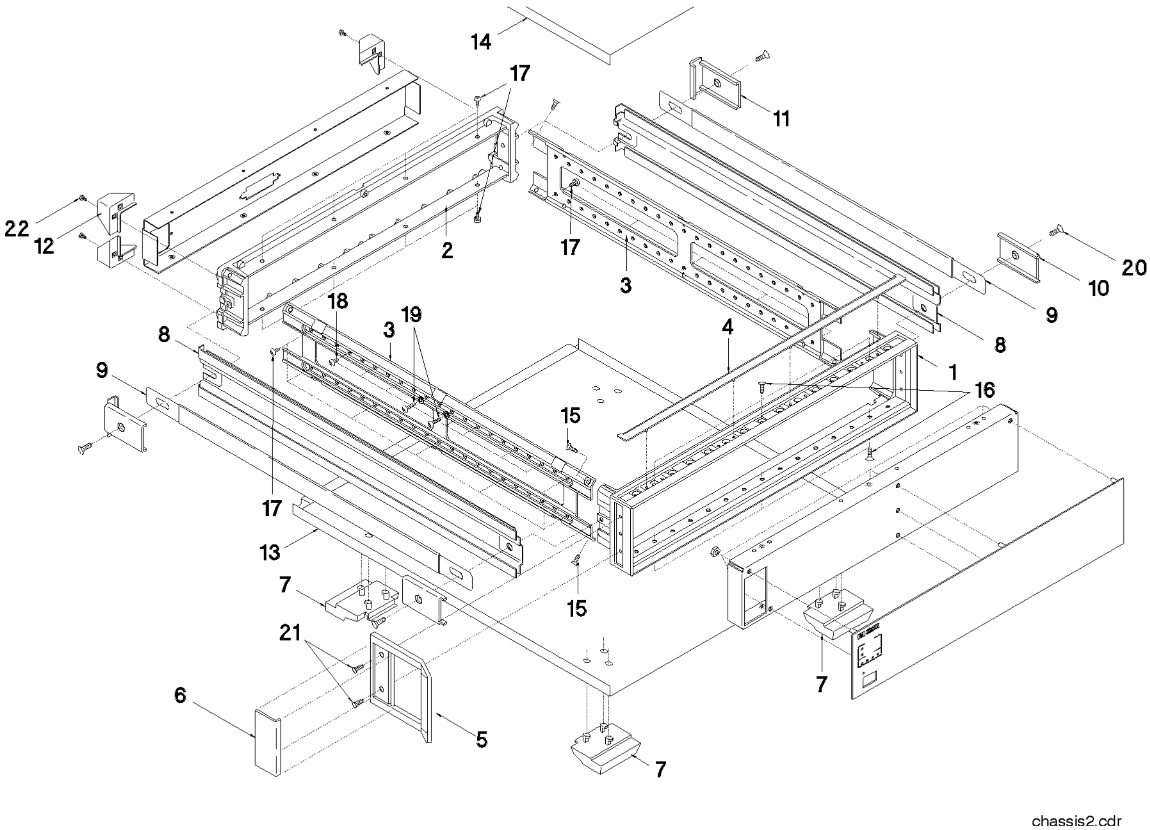

Figure 5-2 87130A Chassis Assembly (2)

Table 5-4 Replaceable Parts - 87130A Cable Assembly

Part Location	Part Number	Quantity	Description	Reference Designator
1	87130-62065	1	Driver board	A2
2	87130-60002	1	Controller board	A1
3	0950-2252	1	Power supply 110 W	A3
4	87130-60001	1	Display board	A4
5	87130-60008	1	GPIB address board	A5
	3101-2325	1	GPIB address switch (part of GPIB address board)	—
6	87130-60007	1	AC line cable assembly	—
	2110-0782	1	Fuse T 1A 250V UL/CSA (part of AC input module)	—
	2110-0674[1]	1	European fuse T 1A 250V IEC (part of AC input module)	—
7	87130-60006	1	34/36-pin SCSI cable	—
8	87130-60005	1	GPIB address cable	W2
9	87130-60004	1	24-pin GPIB cable	W1
10	87130-60003	1	Display cable	W3
11	3101-3008	1	Rocker switch	—
12	0515-1946	2	FH screw M 3.0 x 0.5 x 6 torx	—
13	1252-1900	2	Screw, jack 4-40	—
14	2260-0009		Nut, hex 4-40	—
15	0515-0430		Torx pan M 3.0 x 0.6 x 6	—
16	0515-2028	4	FH screw M 2.5	—
19	0515-0431	2	Torx pan M 3.5 x 0.6 x 6	—
U7	70611-80017	1	EPROM	—
U8	70611-80018	1	EPROM	—
20	2110-0003	1	Fuse 3A 250 V F	—
21	2110-0003	1	Fuse 3A 250V F	—
22	0515-1860	6	FH screw M 3.5 x 0.6 x 10 torx	—

1 Required for 220V options

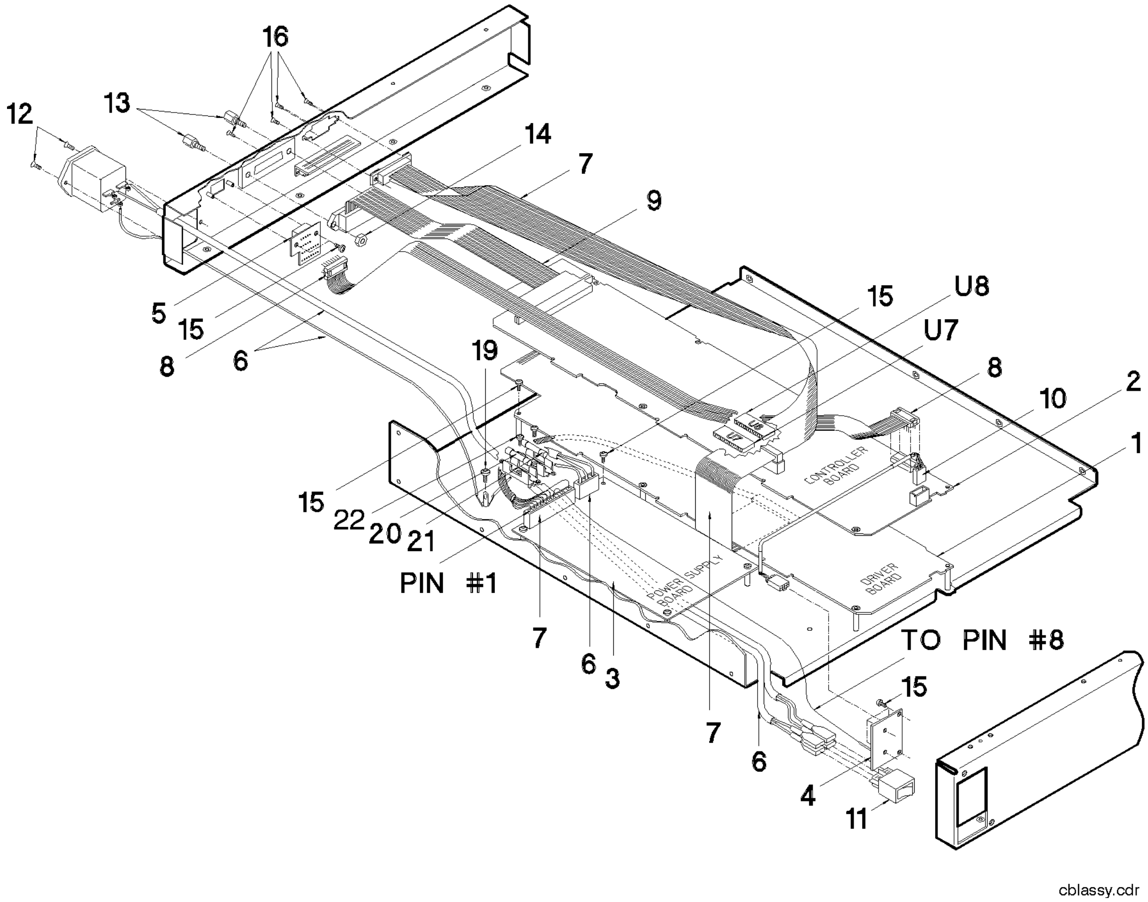

Figure 5-3 87130A Cable Assembly

6 Troubleshooting

Overview

In this chapter you will find:

- How to check the fuses and power supply
- How to set up the EPROM after replacement

Troubleshooting

If your instrument is still in warranty we strongly recommend that you send the entire unit back to Agilent Technologies for repair.

A procedure for checking the fuses and power supply is given on page 6-4.

WARNING

- **To avoid electrical shock, do not perform any servicing unless you are qualified to do so.**
- **Disconnect the product from all voltage sources while it is being opened. The opening of covers or removal of parts may expose dangerous voltages.**
- **The power cord is connected to internal capacitors that may remain live for five seconds after disconnecting the plug from its power supply.**

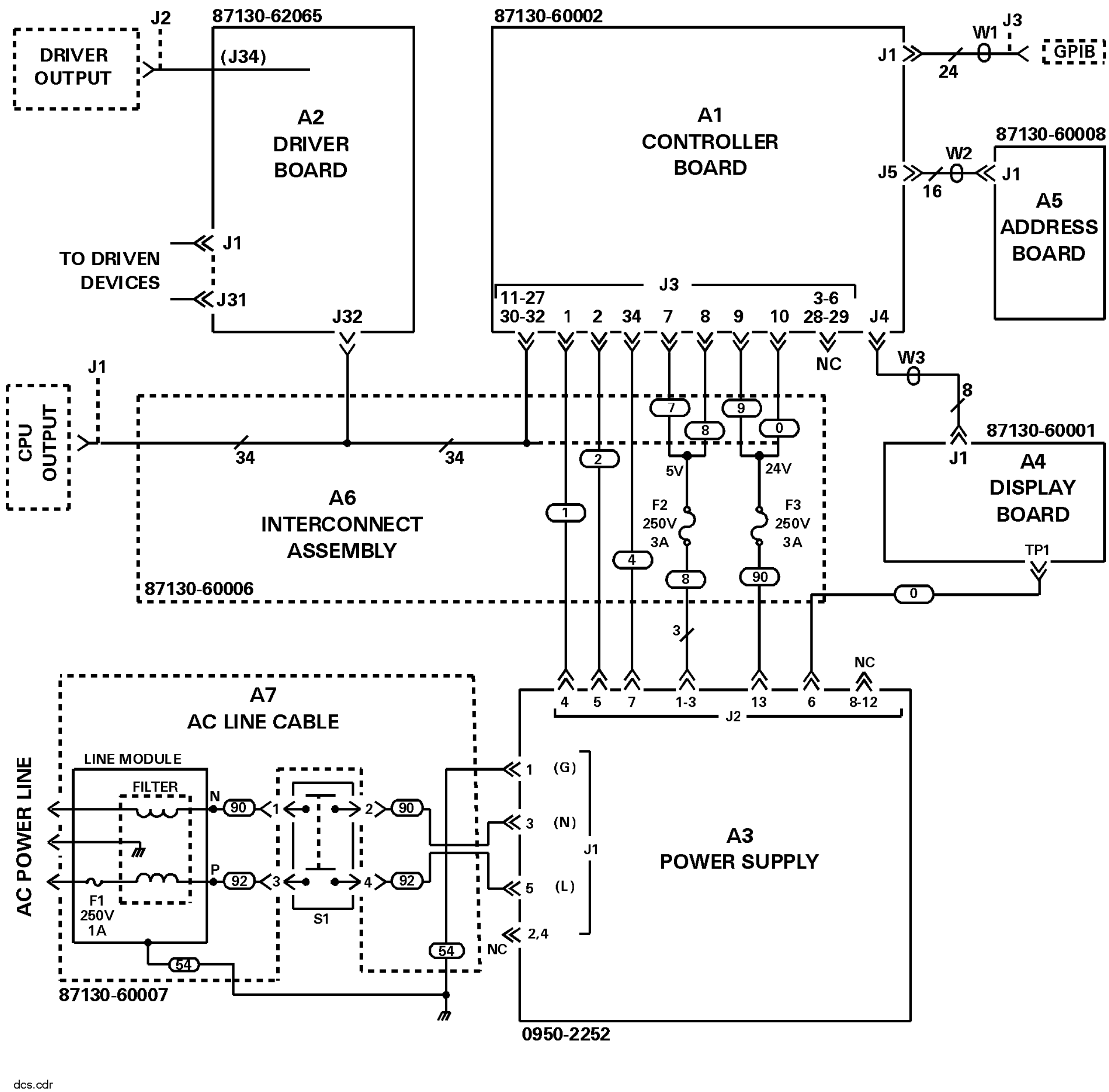

Figure 6-1 87130A DC Schematic

Fuse and Power Supply Check

Fuse Check

If the attenuator/switch driver fails to respond when the power switch is turned on, the power line fuse should be checked. The 1 A, 250 V time delay, power line fuse (part number 2110-0782) is located inside the AC input module.

You will have to remove the top cover of the instrument to check the power supply fuses. Two 3A, 250 V fuses, one with black and white wires (+ 24 Vdc line) attached to the fuse holder and the other with violet and gray wires (+ 5 Vdc line) attached to the fuse holder, are located on the deck, next to the power supply board.

WARNING **For continued protection against fire hazard, replace the power line fuse with the same type and ratings only (1A/250V time delay).**

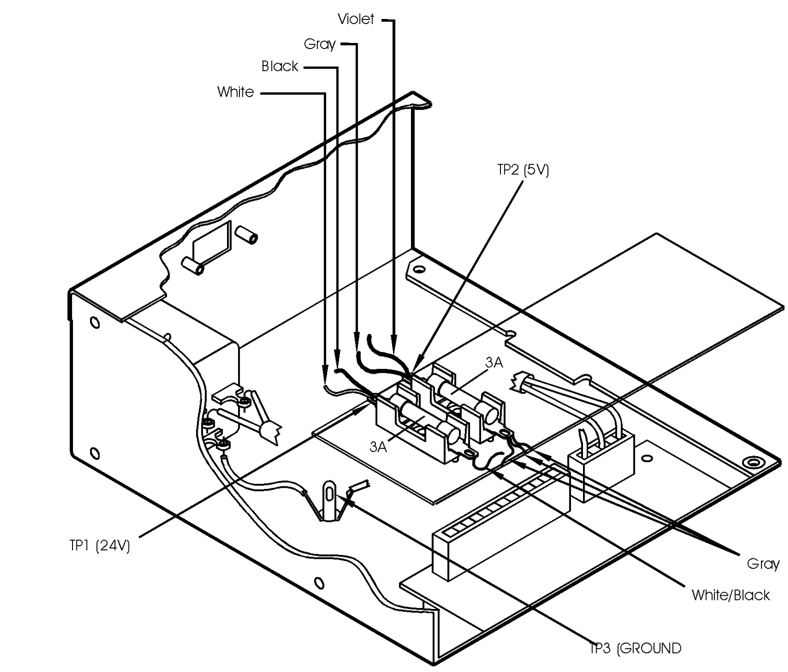

Figure 6-2 Power Supply Test Points

Power Supply Check

The power supply (part number 0950-2252) may be checked by measuring the voltages between TP3 (ground) and the following test points:

TP1	24 V + 10% – 5%
TP2	5.1 V ± 2%

Procedure for Setting Up the EPROM

Use the following procedure to set up the EPROM after the EPROM or the CPU board has been replaced.

- To set up the EPROM from the controller, use the following commands:

`"MEM:DEL;`	Deletes everything in CMOS RAM memory.
`"SYST:ERR?"`	
`READ GPIB FOR ERROR`	Check the error queue (this can be used at any point to read any error back).
`"DIAG:MOD ""87130A"","`	Writes model number of your instrument.
`"DIAG:SER ""US37349017"";"`	Writes the unique serial number of your instrument (example is a typical serial number).
`"ROUTE:DRIVE:ON(@X00:X30)"`	Enables channels* to be engaged.
`"ROUTE:VERIFY:ON(@X00:X30)"`	Turns on sensing. (Can only be used with sensing switches. Do not turn on for non-sensing or non-Agilent switches.)
`"MEM:SAVE;"`	Saves the above configuration to EPROM.

- Cycle power to the 87130A and check the EPROM:

`"*IDN?"`

`READ GPIB`	Reads back the ID of the unit.

The screen should display:

`"HEWLETT-PACKARD,87130A,USXXXXXXXX,950713"` `or something similar`

`"ROUTE:DRIVE:ON?(@X00,X01, X02,X03,X04,X05,X06,X07, X08,X09,X10,X11,X12,X13, X14,X15,X16,X17,X18,X19, X20,X21,X22,X23,X24,X25, X26,X27,X28,X29,X30)"`	Queries X00 through X30
`READ GPIB`	Reads back 1's and 0's for each channel. If VERIFY is ON, it will = 1; if OFF, it will = 0.

* Each channel has its own unique address. The switch driver begins numbering channels at 0 instead of 1. Switch one, wired to J1 on driver card 1, would have a channel address of 100 and so forth up to card 800 to 830.

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