Agilent 34980A Multifunction Switch/Measure Unit

User's Guide

Agilent Technologies

Notices

Warranty

Technology Licenses

Restricted Rights Legend

Safety Notices

CAUTION

A **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.

WARNING

A 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.

Additional Safety Notices

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

General

Do not use this products in any manner not specified by the manufacturer. The protective features of this product may be impaired if it is used in a manner not specified in the operation instructions.

Before Applying Power

Verify that all safety precautions are taken. Make all connections to the unit before applying power.

Ground the Instrument

This product is provided with protective earth terminals. To minimize shock hazard, the instrument must be connected to the ac power mains through a grounded power cable, with the ground wire firmly connected to an electrical ground (safety ground) at the power outlet. Any interruption of the protective (grounding) conductor or disconnection of the protective earth terminal will cause a potential shock hazard that could result in personal injury.

Do Not Operate in an Explosive Atmosphere

Do not operate the instrument in the presence of flammable gases or fumes.

Do Not Remove the Instrument Cover

Only qualified, service-trained personal who are aware of the hazards involved should remove instrument covers. Always disconnect the power cable and any external circuits before removing the instrument cover.

Do Not Modify the Instrument

Do not install substitute parts or perform any unauthorized modification to the product. Return the product to an Agilent Sales and Service Office for service and repair to ensure that safety features are maintained.

In Case of Damage

Instruments that appear damaged or defective should be made inoperative and secured against unintended operation until they can be repaired by qualified service personnel.

Safety Symbols

∿	Alternating current
⏚	Frame or chassis terminal
⏻	Standby supply. Unit is not completely disconnected from ac mains when switch is off
⚡	Caution, risk of electric shock
⚠	Caution, refer to accompanying description

If you have questions about your shipment, or if you need information about warranty, service, or technical support, contact Agilent Technologies:

In the United States: (800) 829-4444

In Europe: 31 20 547 2111

In Japan: 0120-421-345

Or go to ww.agilent.com/find/assist for information on contacting Agilent in your country of specific location. You can also contact your Agilent Technologies Representative.

Manufacturer's Name: Agilent Technologies, Incorporated
Manufacturer's Address: 815 – 14th St. SW
                             Loveland, CO 80537
                             USA

Declares under sole responsibility that the product as originally delivered

Product Name: Multifunction Switch / Measure Unit
Model Number: 34980A, 34921A/T, 34922A/T, 34923A/T, 34924A/T,
                    34925A/T, 34931A/T, 34932A/T, 34933A/T, 34937A/T,
                    34938A/T, 34941A, 34942A, 34945A/EXT, 34946A,
                    34947A, 34950A/T, 34951A/T, 34952A/T, 34959A
Product Options: This declaration covers all options of and accessories to
                      the above products

complies with the essential requirements of the following applicable European Directives, and carries the CE marking accordingly:

Low Voltage Directive (73/23/EEC, amended by 93/68/EEC)
EMC Directive (89/336/EEC, amended by 93/68/EEC)

and conforms with the following product standards:

EMC	**Standard**	**Limit**
	IEC 61326-1:1997+A1:1998 / EN 61326-1:1997+A1:1998	
	CISPR 11:1990 / EN 55011:1991	Group 1 Class A
	IEC 61000-4-2:1995+A1:1998 / EN 61000-4-2:1995	4 kV CD, 4 kV AD
	IEC 61000-4-3:1995 / EN 61000-4-3:1995	3 V/m, 80-1000 MHz
	IEC 61000-4-4:1995 / EN 61000-4-4:1995	0.5 kV signal lines, 1 kV power lines
	IEC 61000-4-5:1995 / EN 61000-4-5:1995	0.5 kV line-line, 1 kV line-ground
	IEC 61000-4-6:1996 / EN 61000-4-6:1996	3 V, 0.15-80 MHz, 80% mod
	IEC 61000-4-11:1994 / EN 61000-4-11:1994	Interrupt: 10 ms, 20 ms

Canada: ICES-001:1998
Australia/New Zealand: AS/NZS 2064.1

The product was tested in a typical configuration with Agilent Technologies test systems.

Safety   IEC 61010-1:2001 / EN 61010-1:2001
             Canada: CSA C22.2 No. 61010.1:2004
             USA: UL 61010-1: 2004

Supplementary Information:

This DoC applies to above-listed products placed on the EU market after:

24 May 2005
Date

Ray Corson

Product Regulations Program Manager

For further information, please contact your local Agilent Technologies sales office, agent or distributor,
or Agilent Technologies Deutschland GmbH, Herrenberger Straße 130, D 71034 Böblingen, Germany.

Contents

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Introduction to the 34980A

Agilent Technologies

Front Panel at a Glance

1   On/Standby switch **WARNING**   This switch is standby only. To disconnect the mains from the instrument, remove the power cord.

2   Utility menu contains settings for Remote I/O (LAN, GPIB, and USB), Date and Time, and other system-related instrument parameters

3   Store/recall menu allows you to save and recall up to six instrument setups

4   Control keys directly control module actions

5   Number keypad enters numerical characters

6   Exponent

7   Cancel key exits a menu without saving changes

8   Arrow keys move cursor positions

9   Knob enters alphanumeric characters, selects slots, channels, and navigates menus

10   Enter key steps you through a menu or saves number entries

11   Running a program puts the display into "remote" and disables the front panel keys. Local takes you out of "remote" mode and enables the front panel keys.

12   Configure keys select functions and set function parameters

13   Measure keys execute and monitor measurements. Depending on which measurement key you use, you can have complete/direct control over the switching and measurement operation, or you can have the 34980A automatically control these to capture the desired data.

Rear Panel at a Glance
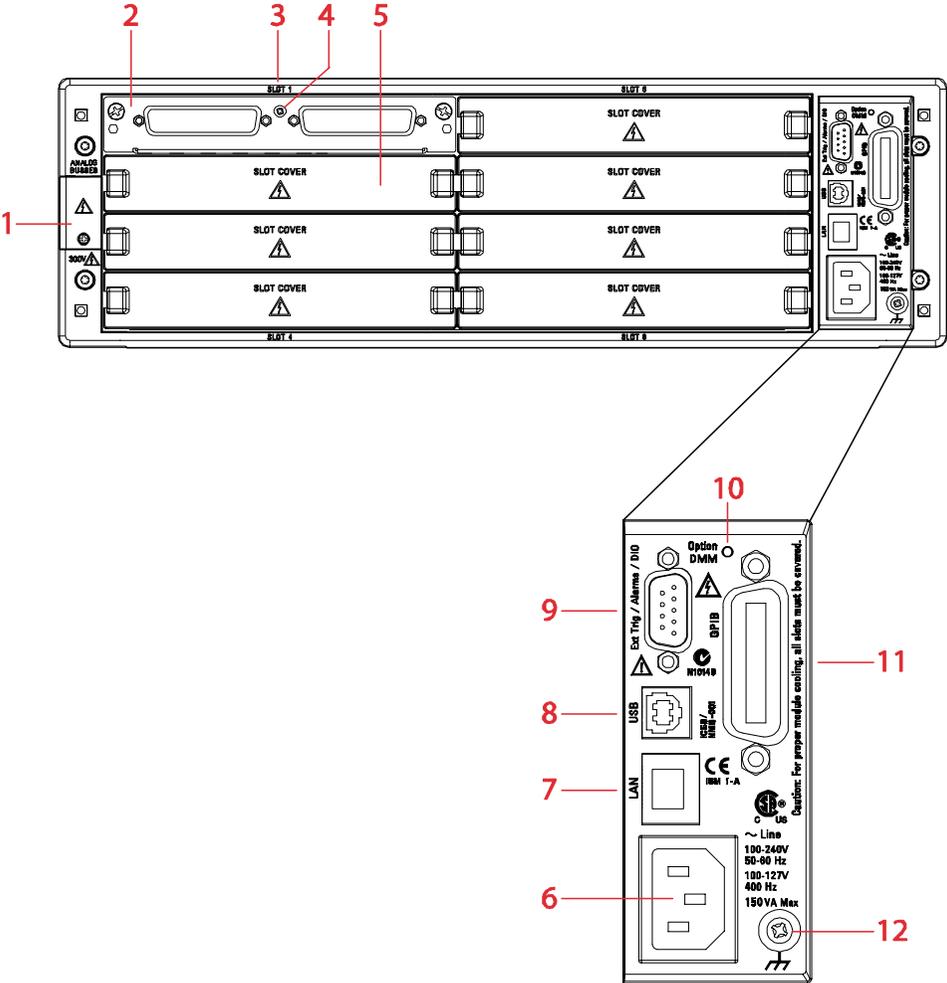
1   Access to Analog Buses (shown with cover installed). For pinout, see page 4.

2   Module installed in slot 1

3   Slot identifier

4   Module ground screw

5   Slot cover over slot 2

6   AC power connector

7   LAN connector (10Base T/100Base Tx)

8   USB 2.0 connector

9   External trigger input. For pinout, see page 4.

10   Internal DMM option mark. If you ordered the internal DMM option, the circle is marked black.

11   IEEE 488.2 GPIB Connector

12   Chassis ground screw

Rear Panel Connector Pinouts

External Trigger/Alarms Connector (Male D-Sub)

Ext Trig / Alarms / DIO

Ext Trig Input /
Chan Adv Input (Pin 6)

Gnd (Pin 9)

Chan Closed Output /
VM Comp Output (Pin 5)

Input
5 V
0 V
> 1 µs

Output
3.3 V
0 V
Approx. 2 µs

Ext Trig / Alarms / DIO

or

Alarm 1 Output (Pin 1)
Alarm 2 Output (Pin 2)
Alarm 3 Output (Pin 3)
Alarm 4 Output (Pin 4)
Gnd (Pin 9)
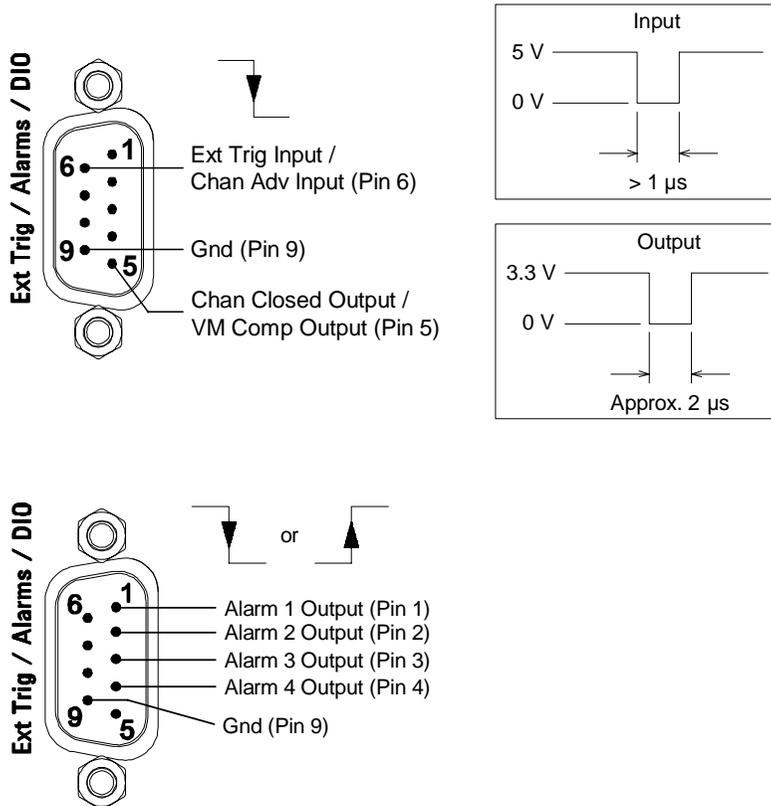
Analog Bus Connector (Female D-Sub)

**ANALOG
BUSSES**

ABus1 HI (Pin 9)
ABus2 HI (Pin 8)
ABus3 HI (Pin 7)
ABus4 HI (Pin 6)

Internal DMM Current Input I (Pin 5)
ABus1 LO (Pin 4)
ABus2 LO (Pin 3)
ABus3 LO (Pin 2)
ABus4 LO (Pin 1)
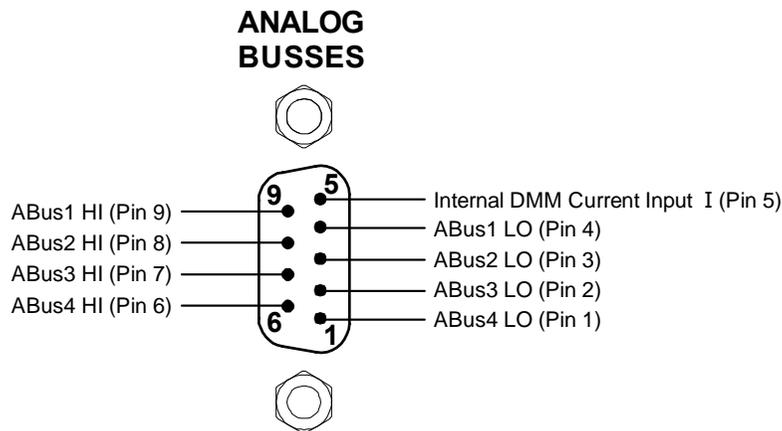
Annunciator Display Indicators
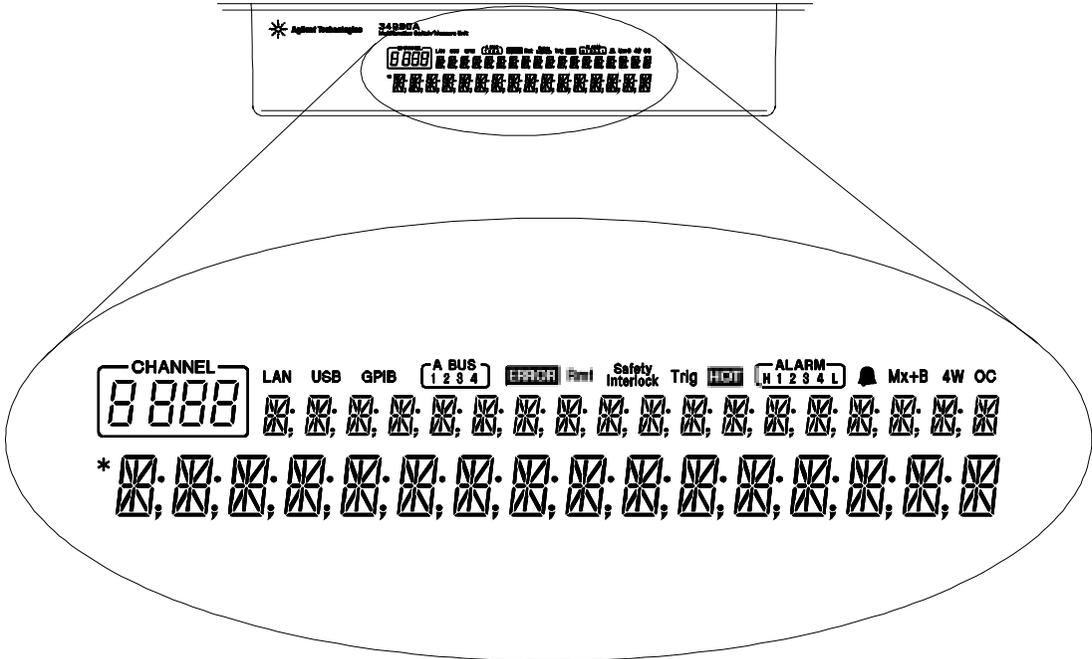
Display Indicator	Definition
LAN	Communicating with the 34980A over LAN.
USB	Communicating with the 34980A over USB.
GPIB	Communicating with the 34980A over GPIB.
ABUS [1234]	Analog Bus Connectivity. Normally, designated ABus connected on any module in mainframe. During scan, if ABus 1 and ABus 2 are indicated, they will be used at some point during the scan.
ERROR	An error has been generated and is in the error queue.
Rmt	Remote. Running a program puts the display into "remote" and disables the front panel keys. Pressing the LOCAL button takes you out of "remote" mode and enables the front panel keys.
Safety Interlock	ABus Safety Interlock. Terminal block or cables have been removed from the D-sub connector of a module. For more information, see page 120 and page 162.
Trig	Waiting for external or manual trigger during scans.
HOT	Over-temperature condition. One or more general purpose (34937A/34938A) modules have reached their over-temperature limits.
ALARM (H1234L)	HI or LO alarm condition has occurred on the indicated alarms.
🔔	Alarms are enabled on the displayed channel.
Mx+B	Scaling enabled on channel. This appears on display after you select scaling function via front panel or remote interface.
4W	4-wire measurement specified on channel. This appears on display after you select the 4-wire function via the front panel or remote interface.
OC	Offset Compensation specified on channel. This appears on display after you have selected the offset compensation function via the front panel or remote interface.
*	Measurement is in progress.

Front Panel Menu Reference

This section gives an overview of the top two levels of menus that you access from the front panel. The menus are designed to automatically guide you through all parameters required to configure a particular function or operation.

Store/Recall   Store and recall instrument states
- Store up to six instrument states in non-volatile memory
- Assign a name to each storage location.
- Recall stored states, power-down state, factory reset state, or preset state

Utility   Configure system-related instrument parameters
- Connecting and configuring to use with LAN, GPIB, or USB
- Set the real time clock and calendar
- Set radix character, thousand separator
- Enable/disable the internal DMM
- Secure/unsecure the instrument for calibration
- Query and update the firmware revisions for the mainframe and modules

Configure Key Group   Set parameters for measurement

DMM
- Set DMM measurement function (AC volts, DC volts, AC current, DC current, 2-wire ohms, 4-wire ohms, temperature, frequency, and period)
- Set function parameters

Channel
- Set channel measurement function (AC volts, DC volts, AC current (34921A only), DC current (34921A only) 2-wire ohms, 4-wire ohms, temperature, frequency, and period
- Set function parameters

Scan
- Set up trigger-in parameters
- Set up sweep count
- Set up sample count

Sequence
- View sequence command string
- Execute sequence
- Delete sequence definitions

Module
- Open all relays
- Clear all measurement functions
- Clear channel labels
- Configure external trigger and clock (34951A)
- Set trace or level mode (34951A)
- Set waveform parameters (34951A)

View

• View errors and alarms

• View the scanned readings from memory

• View errors in the error queue

• Read the number of cycles for the displayed relay (relay maintenance feature)

Advanced

Available at a later firmware release

Alarm

• Select one of four alarms to report alarm conditions on the displayed channel

• Configure a high limit, a low limit, or both for the displayed channel

• Select the slope (rising or falling edge) for the four alarm output lines

Instrument Rack Mounting

Using the optional Agilent Y1130A Rack Mount Kit, you can mount the 34980A in a standard 19-inch rack cabinet. This kit includes rack mount brackets and associated hardware required to forward or reverse mount the instrument in the rack cabinet.

• For *forward* rack mounting (34980A front panel facing the front of the cabinet), use the Agilent standard rack mount kit (part number 5063-9214). For Agilent rack cabinets, use the E3663A Basic Rail Kit (sold separately).

• For *reverse* rack mounting (34980A rear panel facing the front of the cabinet), use the longer brackets (see figure below) with the hardware for the standard rack mount kit. For Agilent rack cabinets, use the E3664AC Third Party Rail Kit (sold separately).
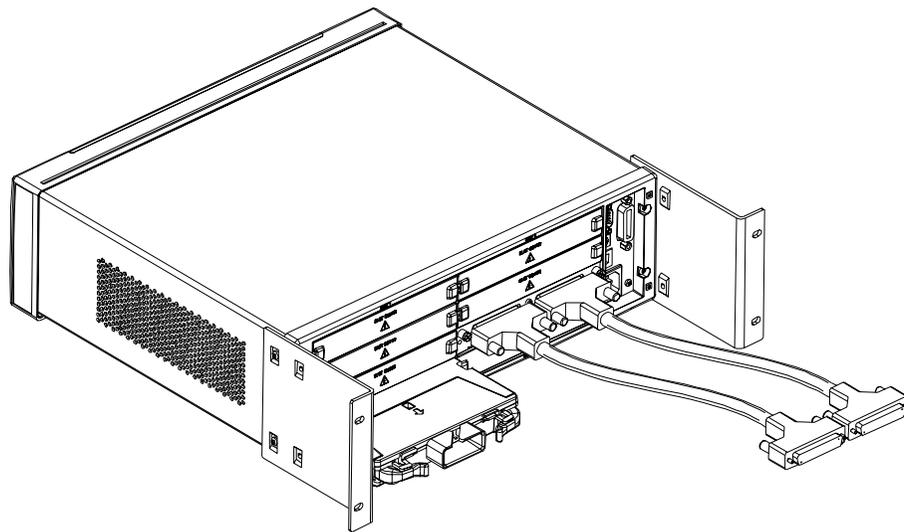
Reverse Rack Mount Orientation (longer brackets used)

425.6 mm (16.76 in)

367.7 mm (14.48 in)

101.9 mm (4.01 in)
or
70.4 mm (2.78 in)
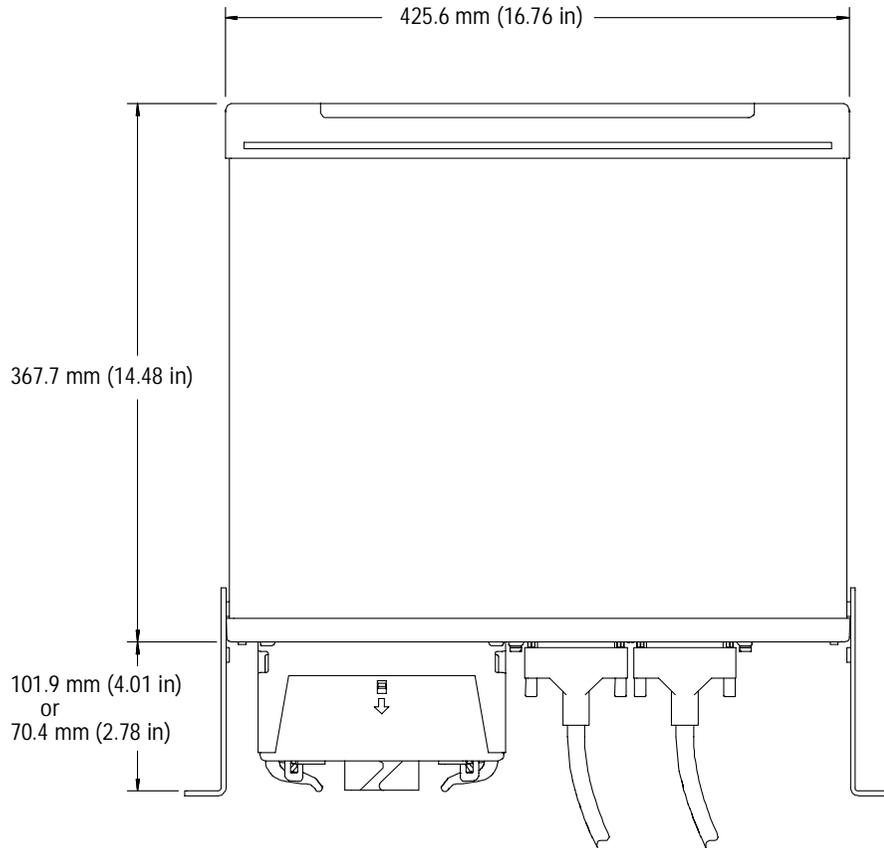
Agilent 34980A Dimensions (shown with Reverse Rack Mount brackets installed)

2

Features and Functions

You will find that this chapter makes it easy to look up all the details about a particular feature of the Agilent 34980A. Whether you are operating the instrument from the front panel or over the remote interface, this chapter will be useful. For information specific to the 34980A plug-in modules, see the later chapters in this manual.

| NOTE | For complete details on the SCPI (Standard Commands for Programmable Instruments) commands, see the *Programmer's Reference* Help file included on the Agilent 34980A *Product Reference CD-ROM.* |

Agilent Technologies

Clearing 34980A Memory

For security reasons, you may want to clear memory in the 34980A. To clear all measurement results from memory, either cycle power to the 34980A or send the `*RST` command. This will also clear the internal DMM settings and all channel configurations, Mx+B scaling constants, and all alarm settings.

The following settings are stored in *non-volatile* memory:

- Optional channel labels
- Real-time system clock setting
- Front-panel number format setting
- GPIB address setting
- LAN settings
- Stored instrument states

To clear the stored instrument states, use the `MEMory:STATe:DELete:ALL` command. To clear non-volatile memory, with the exception of the LAN MAC address and USB ID, use the `SYSTem:SECurity:IMMediate` command.

SCPI Language Conventions

Throughout this guide, the following conventions are used for SCPI command syntax for remote interface programming:

- Braces (**{ }**) enclose the parameter choices for a given command string. The braces are not sent with the command string.

- A vertical bar (**|**) separates multiple parameter choices for a given command string.

- Triangle brackets (**< >**) indicate that you must specify a value for the enclosed parameter. The brackets are not sent with the command string.

- Some parameters are enclosed in square brackets (**[ ]**). This indicates that the parameter is optional and can be omitted. The brackets are not sent with the command string. If you do not specify a value for an optional parameter, the instrument chooses a default value.

Rules for Using a Channel List

Many of the SCPI commands for the 34980A include a *channel list* parameter which allows you to specify one or more channels. From the remote interface, the channel number has the form (**@***sccc*), where *s* is the mainframe slot number (1 through 8) and *ccc* is the channel number. You can specify a single channel, multiple channels, or a range of channels.

The following command closes channel 10 on the module in slot 3.

```
ROUT:CLOS (@3010)
```

The following command closes channels 10, 12, and 15 on the module in slot 2.

```
ROUT:CLOS (@2010,2012,2015)
```

The following command closes channels 5 through 10 (slot 1) and channel 15 (slot 2). When you specify a range of channels, any channels that are invalid will be ignored (no error will be generated) but the first and last channel in the range must be valid.

```
ROUT:CLOS (@1005:1010,2015)
```

The Analog Bus relays (numbered *s*911, *s*912, *s*913, etc.) on the multiplexer and matrix modules are ignored if they are included in a range of channels. An error will be generated if an Analog Bus relay is specified as the first or last channel in a range of channels. For example, the following command closes all valid channels between channel 30 (slot 1) and channel 5 (slot 2). In addition, this command closes Analog Bus relay 911 on the module in slot 1 (Bank 1). Note that although the specified range of channels includes the other Analog Bus relays, they are ignored and are not closed by this command.

```
ROUT:CLOS (@1030:2005,1911)
```

The following command will generate an error since the Analog Bus relays cannot be specified as the first or last channel in a range of channels (none of the channels will be closed).

```
ROUT:CLOS (@1005:1911)   !Generates an error
```

In the following command, since the optional <ch_list> parameter is omitted, the command will be applied to the internal DMM. If the internal DMM is disabled or is not present, an error will be generated.

```
INP:IMP:AUTO ON  !Applies to the internal DMM
```

General Measurement Configuration

This section contains general information to help you configure the instrument for making measurements. Since these parameters are used by several measurement functions, the discussion is combined into one common section. Refer to the later sections in this chapter for more information on parameters that are specific to each measurement function.

Overview of Measurement Modes

Two modes of operation are available with the 34980A, depending on the level of switching and measurement that you wish to directly control: the *Stand-Alone DMM Mode* and the *Scanning Mode*.

Stand-Alone DMM Mode

In the Stand-Alone DMM Mode, the internal DMM makes measurements of whatever signals are present on the Analog Buses. In this mode, you have full control of what channel relays are closed and connected to the appropriate Analog Bus for the measurement. You can route your signals directly to the internal DMM using the 34980A multiplexer and matrix modules, or you can connect to external signals via the *Analog Bus* connector located on instrument's rear panel (see "Analog Buses" on page 16).

Front Panel Operation:

• To configure the most common measurement parameters for the internal DMM, use the DMM (Configure) key.

• To close the desired channel relays and Analog Bus relays, use the Close key. The Analog Bus relays on the multiplexer and matrix modules are numbered s911, s912, s913, etc.

• To auto-trigger the internal DMM and display continuous readings, press the DMM (Measure) key. Press the DMM (Measure) key again to stop taking measurements.

• For additional triggering control and to store DMM readings in memory, use the Scan (Configure) key to set the triggering parameters, and then press and hold the Scan (Measure) key to initiate the DMM measurement. These selections are available only for stand-alone DMM use when a scan list has not been defined (see "Stand-Alone DMM Mode" on page 13).

- To stop storing readings in memory during long measurements, press and hold the Scan (Measure) key.

- To view the readings in memory, use the View key (the readings are not erased when you read them). Each time you initiate a new DMM-only scan, the instrument will clear the previous set of readings from memory.

Remote Interface Operation:

- You can use the MEASure? command without specifying a <ch_list> to quickly take a stand-alone DMM reading. Note, however, that with the MEASure? command, most measurement parameters are set to their default values.

- To close the desired channel relays and Analog Bus relays, use the ROUTe:CLOSe command. The Analog Bus relays on the multiplexer and matrix modules are numbered *s*911, *s*912, *s*913, etc.

- To directly control all measurement parameters or triggering, use the CONFigure, SENSe, and TRIGger commands without specifying a <ch_list> parameter. To initiate the measurement, use the INITiate or READ? command without specifying a <ch_list>. Each time you initiate a new measurement, the instrument will clear the previous set of readings from memory.

- To stop a measurement in progress, use the ABORt command.

- To view the readings in memory, use the FETCh? command (the readings are not erased when you read them).

Scanning Mode

In the Scanning Mode, the 34980A automatically controls a sequence of measurements using the internal DMM, possibly across multiple channels, and stores the results in memory. The 34980A closes and opens the appropriate channel relays and Analog Bus relays required for the sequence. The following general rules apply to the Scanning Mode (for more information on using the Scanning Mode, see "Scanning" on page 43.)

- Any channel that can be "read" by the instrument can also be included in a scan. A scan can also include a read of a digital channel or a read of the totalizer count on the digital modules.

- Before you can initiate a scan, you must set up a scan list to include all desired multiplexer or digital channels. Channels which are not in the scan list are skipped during the scan.

- The Analog Bus relays are automatically opened and closed as required during the scan to connect to the internal DMM for the measurement. For example, all 2-wire measurements use the ABus1 (MEAS) relays for 4-wire measurements, the ABus2 (SENS) relays are used in addition to the ABus1 relays.

- Each time you initiate a new scan, the instrument will clear the previous set of readings from memory.

Front Panel Operation:

- To configure the measurement parameters and add a channel to the scan list, use the Channel (Configure) key.

- To initiate a scan and store all readings in memory, press the Scan (Measure) key. If you press the Scan (Measure) key with no scan list defined, the instrument initiates a DMM-only measurement (see "Stand-Alone DMM Mode" below).

- To stop a scan in progress, press and hold the Scan (Measure) key.

- To view the readings in memory, use the View key (the readings are not erased when you read them).

Remote Interface Operation:

- To define the list of channels to be included in the scan list, use the ROUTe:SCAN command.

- To configure the measurement parameters on the desired channels, use the CONFigure and SENSe commands.

- To initiate a scan and store all readings in memory, use the INITiate or READ? command. Each time you initiate a new scan, the instrument will clear the previous set of readings from memory.

- To stop a scan in progress, use the ABORt command.

- To view the readings in memory, use the FETCh? command (the readings are not erased when you read them).

NOTE	You can use the READ? command in one of three forms depending on which measurement mode you wish to use.

- If you omit the optional <ch_list> parameter and a scan list is <u>not</u> currently defined, the READ? command applies to the internal DMM.

- If you omit the optional <ch_list> parameter and a scan list <u>is</u> currently defined, the READ? command performs a scan of the channels in the scan list.

- If you specify a <ch_list>, regardless of whether a scan list is currently defined, the READ? command performs a "temporary" scan of the specified channels (independent of the present scan list).

NOTE

You can use the MEASure? command in one of two forms depending on which measurement mode you wish to use.

- If you omit the optional <ch_list> parameter, the MEASure? command applies to the internal DMM.

- If you specify a <ch_list>, the MEASure? command performs a "temporary" scan of the specified channels (independent of the present scan list).

Analog Buses

The 34980A provides four 2-wire internal Analog Buses for easier signal routing. You can route your measurements directly to the internal DMM using the 34980A multiplexer and matrix modules, or you can connect to external signals via the *Analog Bus* connector located on the instrument's rear panel (see connector pinout below). Since four 2-wire buses are provided, you can dedicate one bus for use with the internal DMM and use the other three buses for module extensions or additional signal routing between modules.

ANALOG BUSSES

ABus1 HI (Pin 9) —— 9 — 5 —— Internal DMM Current Input Ⅰ (Pin 5)
ABus2 HI (Pin 8) —— —— ABus1 LO (Pin 4)
ABus3 HI (Pin 7) —— —— ABus2 LO (Pin 3)
ABus4 HI (Pin 6) —— —— ABus3 LO (Pin 2)
6 — 1 —— ABus4 LO (Pin 1)
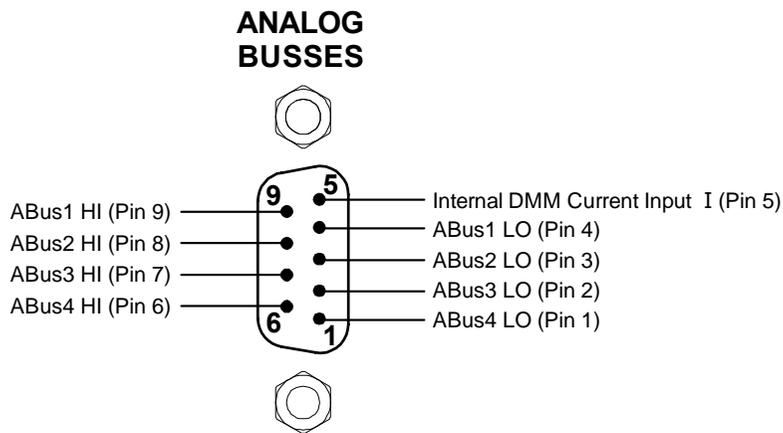
Analog Bus connector (as viewed from rear of instrument)

Measurement Functions

The following table shows which DMM measurement functions are supported by each of the multiplexer modules.

Note that similar considerations must be taken into account on the 34931A, 34932A, and 34933A matrix modules. Since the matrix modules cannot be incorporated into a scan list, you must use the Stand-Alone DMM Mode for these modules.

Function	34921A 40-Ch Arm MUX	34922A 70-Ch Arm MUX	34923A 40-Ch Reed MUX (2-Wire)	34923A 80-Ch Reed MUX (1-Wire)	34924A 70-Ch Reed MUX	34925A 40-Ch FET MUX (2-Wire)	34925A 80-Ch FET MUX (1-Wire)
Voltage, AC/DC	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Current, AC/DC	Yes[1]	No	No	No	No	No	No
Frequency/Period	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Ohms 2-Wire	Yes	Yes	Yes[5]	Yes[5]	Yes[5]	Yes[6]	Yes[6]
Ohms 4-Wire	Yes	Yes	Yes[5]	No	Yes[5]	Yes[6]	No
Thermocouple	Yes[2]	Yes[3]	Yes[3,4]	Yes[3,4]	Yes[3,4]	Yes[3]	Yes[3]
RTD 2-Wire	Yes	Yes	Yes[5]	Yes[5]	Yes[5]	No	No
RTD 4-Wire	Yes	Yes	Yes[5]	No	Yes[5]	Yes[6]	No
Thermistor	Yes	Yes	Yes[5]	Yes[5]	Yes[5]	No	No

[1] Direct current measurements are allowed on channels 41 through 44 only (for all other channels, external shunts are required).

[2] Optional 34921T Terminal Block is required for thermocouple measurements with built-in internal reference junction.

[3] A fixed or external reference junction temperature is required for thermocouple measurement with this module.

[4] Impact of higher offset voltage specification (< 50 μV) must be taken into consideration.

[5] 1 kΩ or higher range used unless 100Ω series resistors are bypassed on module.

[6] 10 kΩ or higher range used for loads over approximately 300Ω due to series resistance of FET channels.

Front Panel Operation: DMM or Channel (Configure) > DMM MEASUREMENT

Use the knob (or numeric keypad) to select the desired channel. Then select the desired measurement function for this channel. You are automatically guided to the next level of the menu where you can configure other measurement parameters (range, integration time, etc.).

Remote Interface Operation: You can select the measurement function using the CONFigure and MEASure? commands. For example, the following command configures the specified channel for dc voltage measurements.

```
CONF:VOLT:DC 10,DEF,(@3001)
```

Measurement Range

You can allow the instrument to automatically select the measurement range using *autoranging* or you can select a fixed range using *manual ranging*. Autoranging is convenient because the instrument decides which range to use for each measurement based on the input signal. For fastest scanning operation, use manual ranging on each measurement (some additional time is required for autoranging since the instrument has to make a range selection).

- Autorange thresholds:

  Down range at: <10% of range
  Up range at: >120% of range

- If the input signal is greater than can be measured on the selected range (manual ranging), the instrument gives an overload indication: "±OVLD" from the front panel or "±9.9E+37" from the remote interface.

- For temperature measurements, the instrument internally selects the range you cannot select which range is used. For thermocouple measurements, the instrument internally selects the 100 mV range. For thermistor and RTD measurements, the instrument autoranges to the correct range for the transducer resistance measurement.

- For frequency and period measurements, the instrument uses one "range" for all inputs between 3 Hz and 300 kHz. The *range* parameter is required only to specify the resolution. Therefore, it is not necessary to send a new command for each new frequency to be measured.

- The `CONFigure` and `MEASure?` commands contain an optional parameter which allows you to specify the range or autoranging.

- The instrument returns to autoranging when the measurement function is changed and after a Factory Reset (`*RST` command). An Instrument Preset (`SYSTem:PRESet` command) or Card Reset (`SYSTem:CPON` command) does *not* change the range setting.

Front Panel Operation: DMM or Channel (Configure) > RANGE

First, select the measurement function on the active channel. You are automatically guided to the next level of the menu where you can select a specific range or autoranging.

Remote Interface Operation: You can select the range using parameters in the `CONFigure` and `MEASure?` commands. For example, the following command selects the 10 Vdc range on the specified channel.

```
CONF:VOLT:DC 10,DEF,(@3001)
```

Measurement Resolution

Resolution is expressed in *number of digits* the internal DMM can measure or display on the front panel. You can set the resolution to 4, 5, or 6 full digits, plus a "½" digit which can be "0" or "1". To increase the measurement accuracy and improve noise rejection, select 6½ digits. To increase the measurement speed, select 4½ digits.

- For ac voltage measurements, the resolution is fixed at 6½ digits. The only way to control the reading rate for ac measurements is by changing the channel delay (see page 56) or by setting the ac filter to the highest frequency limit (see page 37).

- The specified resolution is used for all measurements on the selected channel. If you have applied Mx+B scaling or have assigned alarms to the selected channel, those measurements are also made using the specified resolution. Measurements taken during the Monitor function also use the specified resolution.

- Changing the number of digits does more than just change the resolution of the instrument. It also changes the *integration time*, which is the period the instrument's analog-to-digital (A/D) converter samples the input signal for a measurement. See "Custom A/D Integration Time" on page 20 for more information.

- The CONFigure and MEASure? commands contain an optional parameter which allows you to specify the resolution.

- The instrument returns to 5½ digits when the measurement function is changed and after a Factory Reset (*RST command). An Instrument Preset (SYSTem:PRESet command) or Card Reset (SYSTem:CPON command) does *not* change the resolution setting.

Front Panel Operation: DMM or Channel (Configure) > INTEGRATION > NPLC

First, select the measurement function on the active channel. You are automatically guided to the next level of the menu where you can select a specific resolution.

Remote Interface Operation: Specify the resolution in the same units as the measurement function, not in number of digits. For example, if the function is dc voltage, specify the resolution in volts. For frequency, specify the resolution in hertz.

You can select the resolution using parameters in the CONFigure and MEASure? commands. For example, the following command selects the 10 Vdc range with 4½ digits of resolution on the specified channel.

```
CONF:VOLT:DC 10,0.001,(@3001)
```

The following command selects the 1 A range with 6½ digits of resolution on channel 2041 (current measurements are allowed only on channels 41 through 44 on the 34921A).

```
MEAS:CURR:AC? 1,1E-6,(@2041)
```

You can also select the resolution using the SENSe commands. For example, the following command specifies a 2-wire ohms measurement with 100Ω of resolution on channel 1003.

```
SENS:RES:RES 100,(@1003)
```

Custom A/D Integration Time

Integration time is the period of time the internal DMM's analog-to-digital (A/D) converter samples the input signal for a measurement. Integration time affects the measurement resolution (for better resolution, use a longer integration time) and measurement speed (for faster measurements, use a shorter integration time).

- Integration time is specified in number of *power line cycles* (PLCs). Select from 0.02, 0.2, **1**, 2, 10, 20, 100, or 200 power line cycles. *The default is 1 PLC.*

- Only integral number of power line cycles (1, 2, 10, 20, 100, or 200 PLCs) provide normal mode (line frequency noise) rejection.

- You can also specify integration time directly in seconds (this is called *aperture time*). Select a value between 300 μs and 1 second, with 4 μs resolution.

- The only way to control the reading rate for ac measurements is by changing the channel delay (see "Channel Delay" on page 56) or by setting the ac filter to the highest frequency limit (see "AC Low Frequency Filter" on page 37).

- The specified integration time is used for all measurements on the selected channel. If you have applied Mx+B scaling or have assigned alarms to the selected channel, those measurements are also made using the specified integration time. Measurements taken during the Monitor function also use the specified integration time.

- The following table shows the relationship between integration time, measurement resolution, number of digits, and number of bits.

Relationship between integration time, resolution, digits, and bits

Integration Time	Resolution	Digits	Bits
0.02 PLC	< 0.0001 x Range	4½ Digits	15
0.2 PLC	< 0.00001 x Range	5½ Digits	18
1 PLC	**< 0.000003 x Range**	**5½ Digits**	**20**
2 PLC	< 0.0000022 x Range	6½ Digits	21
10 PLC	**< 0.000001 x Range**	**6½ Digits**	**24**
20 PLC	< 0.0000008 x Range	6½ Digits	25
100 PLC	< 0.0000003 x Range	6½ Digits	26
200 PLC	< 0.00000022 x Range	6½ Digits	26

- The instrument selects 1 PLC when the measurement function is changed and after a Factory Reset (`*RST` command). An Instrument Preset (`SYSTem:PRESet` command) or Card Reset (`SYSTem:CPON` command) does *not* change the integration time setting.

Front Panel Operation: DMM or Channel (Configure) > INTEGRATION > TIME

First, select the measurement function on the active channel. You are automatically guided to the next level of the menu where you can select a specific integration time.

Remote Interface Operation: You can set the integration time using the `SENSe` commands. For example, the following command specifies an aperture time of 2 ms for resistance measurements on channel 2001.

```
SENS:RES:APER 0.002,(@2001)
```

Autozero

When autozero is *enabled* (default), the instrument internally disconnects the input signal following each measurement, and takes a *zero* reading. It then subtracts the zero reading from the preceding reading. This prevents offset voltages present on the instrument's input circuitry from affecting measurement accuracy.

When autozero is *disabled*, the instrument takes one zero reading and subtracts it from all subsequent measurements. It takes a new zero reading each time you change the function, range, or integration time.

- Applies to temperature, dc voltage, resistance, temperature, and dc current measurements only.

- The autozero mode is set indirectly when you set the resolution and integration time. Autozero is automatically turned off when you select an integration time less than 1 PLC.

- The CONFigure and MEASure? commands automatically enable autozero.

- The autozero setting is stored in volatile memory, and does not change when power has been off, after a Factory Reset (*RST command), or after an Instrument Preset (SYSTem:PRESet command).

Front Panel Operation: DMM or Channel (Configure) > AUTO ZERO

Remote Interface Operation: The OFF and ONCE parameters have a similar effect. Autozero OFF does *not* issue a new zero measurement. Autozero ONCE issues an immediate zero measurement.

        [SENSe:]<*function*>:ZERO:AUTO {OFF|ONCE|ON} [,(@<*ch_list*>)]

Trigger Delay

In some applications, you want to allow the input to settle before taking a reading or for pacing a burst of readings. You can add a *trigger delay*, which adds a delay between the trigger signal and the first sample taken by the internal DMM (not used in Scanning Mode). The programmed trigger delay overrides the default trigger delay that the instrument automatically adds to the measurement.
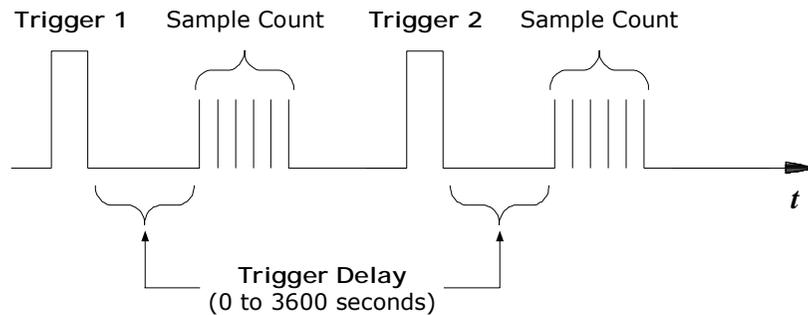
Trigger delay

- The default trigger delay is Automatic (see "Automatic Trigger Delays" on page 24); the instrument determines the delay based on function, range, and integration time.

- If you specify a trigger delay other than Automatic, that same delay is used for all functions and ranges.

- If you have configured the instrument to take more than one reading per trigger (sample count > 1), the specified trigger delay is inserted between the trigger and the first reading in the sample burst.

- The CONFigure and MEASure? commands set the trigger delay to Automatic.

- The instrument selects an automatic trigger delay after a Factory Reset (*RST command). An Instrument Preset (SYSTem:PRESet command) or Card Reset (SYSTem:CPON command) does *not* change the setting.

Automatic Trigger Delays

If you do not specify a trigger delay, the instrument selects a delay for you. The delay is determined by the function, range, integration time, and ac filter setting as shown below.

DC Voltage, Thermocouple, DC Current (for all ranges):

Integration Time	Trigger Delay
PLC > 1	2.0 ms
PLC ≤ 1	1.0 ms

Resistance, RTD, Thermistor (2- and 4-wire):

Range	Trigger Delay (for PLC > 1)	Range	Trigger Delay (for PLC ≤ 1)
100Ω	2.0 ms	100Ω	1.0 ms
1 kΩ	2.0 ms	1 kΩ	1.0 ms
10 kΩ	2.0 ms	10 kΩ	1.0 ms
100 kΩ	25 ms	100 kΩ	20 ms
1 MΩ	30 ms	1 MΩ	25 ms
10 MΩ	200 ms	10 MΩ	200 ms
100 MΩ	200 ms	100 MΩ	200 ms

AC Voltage, AC Current (for all ranges):

AC Filter	Trigger Delay
Slow (3 Hz)	7.0 seconds
Medium (20 Hz)	1.0 second
Fast (200 Hz)	120 ms

Frequency, Period:

AC Filter	Trigger Delay
Slow (3 Hz)	600 ms
Medium (20 Hz)	300 ms
Fast (200 Hz)	100 ms

Digital Input, Totalize:

Trigger Delay
0 seconds

Safety Interlock

The *Safety Interlock* feature prevents connections to the Analog Buses if no terminal block or properly-wired cable is connected to a module (available on multiplexer and matrix modules only).

Normally, if you attempt to connect to the Analog Buses without a terminal block or properly-wired cable connected, an error is generated. You can, however, *temporarily* disable errors generated by the Safety Interlock feature. This simulation mode may be useful during test system development when you may not have connected any terminal blocks or cables to your module.

This feature is available from the remote interface only

CAUTION	The Safety Interlock feature is implemented in hardware on the modules and cannot be circumvented. Regardless of whether the simulation mode is enabled or disabled, all Analog Bus connections are prohibited as long as no terminal block or properly-wired cable is connected to the module.

- The simulation mode applies to the entire mainframe and cannot be selectively used on individual modules.

- When the simulation mode is enabled, the Analog Bus relays will *appear* to close and open as directed. For example, no errors are generated if you close an Analog Bus relay from the front panel, remote interface, or Web Interface. However, remember that the Safety Interlock feature prevents the actual hardware state of the Analog Bus relays from being changed. When you connect a terminal block or cable to the module, the Analog Bus relays will be closed.

- The simulation setting is stored in volatile memory and will be lost when power is turned off. To re-enable the simulation mode after power has been off, you must send the command again.

Remote Interface Operation: `SYSTem:ABUS:INTerlock:SIMulate {OFF|ON}`

User-Defined Channel Labels

You can assign user-defined labels to any channel, including Analog Bus channels on the multiplexer and matrix modules. User-defined channel labels are available for identification purposes *only* and cannot be used in place of a channel number within a command string.

- When shipped from the factory, each channel is assigned a unique factory-default label (cannot be overwritten). From the front panel, the factory-default labels are shown on the upper line of the display (e.g., "MUX CH BANK 1", "MATRIX1 ROW3 COL4", "DIO BYTE 1", etc.). From the Web Interface, the factory-default labels are displayed as the channel number (e.g., "1001", "3020", etc.).

- If desired, you can assign the same user-defined label to multiple channels within the same module or on different modules (i.e., channel labels are not required to be unique).

- You can specify a label with up to 18 characters. You can use letters (A-Z), numbers (0-9), and the underscore character. If you specify a label with more than the allowed 18 characters, it will be truncated (no error is generated).

- From the Web Interface, a limited number of characters can be displayed due to space constraints in the browser window. If the user-defined label it too long to be displayed properly, it will be truncated (no error is generated).

- The instrument keeps a record of what module types are installed in each slot. If a different module type is detected in a specific slot at power on, all user-defined channel labels for that slot are discarded. If an empty slot is detected at power-on, any previously-defined labels for that slot are preserved and will be restored if the same module type is installed later; however, if a module of a different type is installed in that slot, the previously-defined labels will be discarded.

- All user-defined channel labels are stored in non-volatile memory, and do not change when power has been off, after a Factory Reset (`*RST` command), after an Instrument Preset (`SYSTem:PRESet` command), or after a stored state is recalled (`*RCL` command).

Front Panel Operation: Channel (Configure) > CHANNEL LABEL

To define the channel label, press the arrow keys to move the cursor to a specific position and then turn the knob to select the desired letter or number.

To clear the channel label on the selected channel, change each character to "**^**" (starting with the rightmost character) and then press the left arrow key to move to the next character.

To clear all channel labels on the selected module, navigate to:

Module (Configure) > CLEAR LABELS? > YES

Remote Interface Operation: The following command assigns a label ("TEST_PT_1") to channel 3 in slot 1.

```
ROUT:CHAN:LABEL "TEST_PT_1",(@1003)
```

The following command clears the user-defined label previously assigned to channel 3 in slot 1. The channel will now be identified by its factory default label (e.g., "MUX CH BANK 1", "MATRIX1 ROW3 COL4", "DIO BYTE 1", etc.).

```
ROUT:CHAN:LABEL "",(@1003)
```

The following command clears all user-defined channel labels on the module in slot 1. The factory-default labels are assigned to all channels on the module in slot 1.

```
ROUT:CHAN:LABEL:CLEAR:MOD 1
```

The following command clears all user-defined labels on all modules installed in the 34980A. The factory-default labels are assigned to all channels on all installed modules.

```
ROUT:CHAN:LABEL:CLEAR:MOD ALL
```

2-Wire Versus 1-Wire Mode

You can configure the 34923A, 34925A, and 34933A modules for 2-wire (differential) or 1-wire (single ended) measurements. If you change the module configuration, you must cycle power on the 34980A to activate the new setting.

- To determine whether the module is in the 2-wire or 1-wire configuration, check the module description shown on the front panel when the module is selected, or send the `SYSTem:CTYPe?` or `SYSTem:CDEScription?` command. For example, the `SYSTem:CTYPe?` response for the 34923A will be either "34923A" (differential mode) or "34923A-1W" (single-ended mode).

- If you are using terminal blocks with these modules, be sure to use the corresponding 2-wire or 1-wire terminal block.

- The module configuration is stored in non-volatile memory on the module and does not change when you remove the module from the mainframe, after a Factory Reset (`*RST` command), or after an Instrument Preset (`SYSTem:PRESet` command).

Front Panel Operation: Module (Configure) > MODE NEXT POWER-ON

After selecting the 2-wire ("WIRE2") or 1-wire ("WIRE1"), you must cycle power on the 34980A to activate the new setting.

Remote Interface Operation: The following command selects the 1-wire configuration on the module in slot 3. The new configuration will not take effect until you cycle power on the 34980A.

```
SYST:MOD:WIRE:MODE WIRE1,3
```

Analog Bus and Internal DMM Considerations

This section provides important environmental and electrical considerations that can affect mainframe operation.

Environmental Operating Conditions

The 34980A mainframe, including the optional internal DMM, is designed to operate in a temperature range of 0 °C to +55 °C with non-condensing humidity. The maximum humidity is 80% at 40 °C or higher. Do not use in locations where conductive dust or electrolytic salt dust may be present.

The 34980A should be operated in an indoor environment where temperature and humidity are controlled. Condensation can pose a potential shock hazard. Condensation can occur when the instrument is moved from a cold to a warm environment, or if the temperature and/or humidity of the environment changes quickly.

When used in pollution degree 1 conditions, the maximum voltage rating for the Analog Buses is 300V. When used in pollution degree 2 conditions, the maximum voltage rating is 100V. If conditions change, ensure that condensation has evaporated and the instrument has thermally stabilized until pollution degree 1 conditions are restored before turning on power to the equipment.

NOTE	*Pollution Degree 1:* No pollution or only dry, non-conductive pollution occurs. The pollution has no influence (on insulation) (IEC 61010-1 2nd Edition).

NOTE	*Pollution Degree 2:* Normally only non-conductive pollution occurs. Occasionally, a temporary conductivity (leakage current between isolated conductors) caused by condensation can be expected (IEC 61010-1 2nd Edition).

Electrical Operating Conditions

> **WARNING** To avoid electric shock, turn off the 34980A and disconnect or de-energize all field wiring to the modules and the Analog Bus connector before removing any module or slot cover.

Transients

The Analog Buses and the optional internal DMM are designed to safely withstand occasional transient overvoltages up to 1000 Vpeak. Typically, these transient overvoltages result from switching inductive loads or from nearby lightning strikes. The lightning-caused transient overvoltages that may occasionally occur on mains power outlets may be as high as 2500 Vpeak.

> **WARNING** Do not connect the Analog Buses directly to a mains power outlet. If it is necessary to measure a mains voltage or any circuit where a large inductive load may be switched, you must add signal conditioning elements to reduce the potential transients before they reach the Analog Buses.

High Energy Sources

The Analog Buses and the optional internal DMM are designed to handle inputs up to their rated currents or their rated powers, whichever is less. Under certain fault conditions, high energy sources could provide substantially more current or power than the instrument can handle. It is important to provide external current limiting, such as fuses, if the inputs are connected to high-energy sources.

> **CAUTION** Install current limiting devices between high energy sources and the module inputs.

Temperature Measurement Configuration

This section contains information to help you configure the instrument for making temperature measurements. The table below shows the thermocouple, RTD, and thermistor types for which the instrument supports direct measurements.

Temperature transducers supported

Thermocouple Types[*]	RTD Types	Thermistor Types
B, E, J, K, N, R, S, T	R_0 = 49Ω to 2.1 kΩ α = 0.00385 (DIN/IEC 751)[*] α = 0.00391[†]	2.2 kΩ, 5 kΩ, 10 kΩ (YSI 44000 Series)

* Using ITS-90 software conversions.

† Using IPTS-68 software conversions.

Measurement Units

- The instrument can report temperature measurements in °C (Celsius), °F (Fahrenheit), or K (Kelvins). You can mix temperature units on different channels within the instrument and on the same module.

- The CONFigure and MEASure? commands automatically select °C.

- Setting the Mx+B measurement label to °C, °F, or K has *no* effect on the temperature measurement units currently selected.

- The instrument selects Celsius when the probe type is changed and after a Factory Reset (*RST command). An Instrument Preset (SYSTem:PRESet command) or Card Reset (SYSTem:CPON command) does *not* change the units setting.

Front Panel Operation: DMM or Channel (Configure) > TEMPERATURE > UNITS

Remote Interface Operation: UNIT:TEMP {C|F|K}[,(@<ch_list>)]

Thermocouple Measurements

- The instrument supports the following thermocouple types: B, E, J, K, N, R, S, and T using ITS-90 software conversions. *The default is a J-Type thermocouple.*

- Thermocouple measurements require a reference junction temperature. For the reference junction temperature, you can use an internal measurement on the module (34921A only), an external thermistor or RTD measurement, or a known fixed junction temperature.

  - The *internal* reference junction source is valid only on channels 1 through 40 on the 34921A with the 34921T terminal block installed.

  - If you select an *external* reference, the instrument makes thermocouple measurements relative to a previously-stored RTD or thermistor measurement stored in a reference register. To store a reference temperature, first configure a multiplexer channel for an RTD or thermistor measurement. Then assign the measurement from that channel as the external reference. When you initiate a measurement on an external reference channel, the acquired temperature is stored in volatile memory in the reference register. Subsequent thermocouple measurements use the stored temperature as their reference. The temperature remains in memory until you measure a subsequent external reference value in the reference register or remove the mainframe power.

  - If you select a *fixed* reference temperature, specify a value between -20 °C and +80 °C (always specify the temperature in °C regardless of the temperature units currently selected).

- The accuracy of the measurement is highly dependent upon the thermocouple connections and the type of reference junction used. Use a fixed temperature reference for the highest accuracy measurements (you must maintain the known junction temperature). The internal isothermal block reference (34921A only) requires no external wiring but provides lower accuracy measurements than a fixed reference.

- The *thermocouple check* feature allows you to verify that your thermocouples are properly connected for measurements. If you enable this feature, the instrument measures the channel resistance after each thermocouple measurement to ensure a proper connection. If an open connection is detected (greater than 5 kΩ on the 10 kΩ range), the instrument reports an overload condition for that channel (or displays "OPEN T/C" on the front panel).

Front Panel Operation: To select the thermocouple function on the active channel, choose the following items.

    DMM or Channel (Configure) > TEMPERATURE > PROBE TYPE > THERMOCOUPLE

Then, use the knob to select the thermocouple type from the list.

    THERMOCOUPLE TYPE > B | E | J | K | N | R | S | T

If desired, you can enable the thermocouple check feature on the active channel (opens are reported as "OPEN T/C").

    T/C CHECK > OFF | ON

To select the reference junction source for the active channel, choose one of the following items.

    REFERENCE > FIXED | EXT | INT

For an external reference, configure an RTD or thermistor as the external reference channel.

    Channel (Configure) > TEMPERATURE > PROBE TYPE > RTD > . . . USE AS EXT REF?

Remote Interface Operation: You can use the `CONFigure` or `MEASure?` command to select the probe type and thermocouple type. For example, the following command configures channel 3001 for a J-type thermocouple measurement.

```
CONF:TEMP TC,J,(@3001)
```

You can also use the `SENSe` command to select the probe type and thermocouple type. For example, the following command configures channel 2003 for a J-type thermocouple measurement.

```
SENS:TEMP:TRAN:TC:TYPE J,(@2003)
```

The following commands use the `SENSe` command to set a fixed reference junction temperature of 40 degrees (always in °C) on channel 2003.

```
SENS:TEMP:TRAN:TC:RJUN:TYPE,(@2003)
SENS:TEMP:TRAN:TC:RJUN 40,(@2003)
```

The following command enables the thermocouple check feature on the specified channel (opens are reported as "+9.90000000E+37").

```
SENS:TEMP:TRAN:TC:CHECK ON,(@2003)
```

RTD Measurements

- The instrument supports RTDs with α = 0.00385 (DIN/IEC 751) using ITS-90 software conversions or α = 0.00391 using IPTS-68 software conversions. The default is α = 0.00385.

- The resistance of an RTD is nominal at 0 °C and is referred to as R_0. The instrument can measure RTDs with R_0 values from 49Ω to 2.1 kΩ.

- You can measure RTDs using a 2-wire or 4-wire measurement method. The 4-wire method provides the most accurate way to measure small resistances. Connection lead resistance is automatically removed using the 4-wire method.

- For 4-wire RTD measurements, the instrument automatically pairs channel **n** in Bank 1 with channel **n+20** in Bank 2 (34921A, 34923A) or **n+35** (34922A, 34924A) to provide the source and sense connections. For example, make the source connections to the HI and LO terminals on channel 2 in Bank 1 and the sense connections to the HI and LO terminals on channel 22 (or 37) in Bank 2.

Front Panel Operation: To select the 2-wire or 4-wire RTD function for the active channel, choose the following items.

> DMM or Channel (Configure) > TEMPERATURE > PROBE TYPE > RTD|4W RTD

To select the RTD type (α = 0.00385 or 0.00391) for the active channel, choose the following item.

> RTD TYPE > 0.00391|0.00385

To select the nominal resistance (R_0) for the active channel, choose the following item.

> RO > 100 OHM

Remote Interface Operation: You can use the `CONFigure` or `MEASure?` command to select the probe type and RTD type. For example, the following command configures channel 3001 for 2-wire measurements of an RTD with α = 0.00385 (use "85" to specify α = 0.00385 or "91" to specify α = 0.00391).

```
CONF:TEMP RTD,85,(@3001)
```

You can also use the `SENSe` command to select the probe type, RTD type, and nominal resistance. For example, the following command configures channel 1003 for 4-wire measurements of an RTD with α = 0.00391 (channel 1003 is automatically paired with channel 1023 for the 4-wire measurement).

```
SENS:TEMP:TRAN:FRTD:TYPE 91,(@1003)
```

The following command sets the nominal resistance (R_0) to 1000Ω on channel 1003.

```
SENS:TEMP:TRAN:FRTD:RES 1000,(@1003)
```

Thermistor Measurements

The instrument supports 2.2 kΩ (YSI Series 44004), 5 kΩ (YSI Series 44007), and 10 kΩ (YSI Series 44006) thermistors.

Front Panel Operation: To select the thermistor function for the active channel, choose the following items.

DMM or Channel (Configure) > TEMPERATURE > PROBE TYPE > THERMISTOR

To select the thermistor type for the active channel, choose from the following items.

THERMISTOR TYPE > 10K|5K|2.2K

Remote Interface Operation: You can use the CONFigure or MEASure? command to select the probe type and thermistor type. For example, the following command configures channel 3001 for measurements of a 5 kΩ thermistor:

```
CONF:TEMP THER,5000,(@3001)
```

You can also use the SENSe command to select the probe type and thermistor type. For example, the following command configures channel 1003 for measurements of a 10 kΩ thermistor:

```
SENS:TEMP:TRAN:THERM:TYPE 10000,(@1003)
```

Voltage Measurement Configuration

This section contains information to help you configure the instrument for making voltage measurements. The instrument can measure dc and true RMS ac-coupled voltages on the measurement ranges shown below.

100 mV	1 V	10 V	100 V	300 V	Autorange

DC Input Resistance

Normally, the instrument's input resistance is fixed at 10 MΩ for all dc voltage ranges to minimize noise pickup. To reduce the effects of measurement loading errors, you can set the input resistance to greater than 10 GΩ for the 100 mVdc, 1 Vdc, and 10 Vdc ranges.

Applies to dc voltage measurements only.

DC input resistance

Input Resistance Setting	Input Resistance for: 100 mV, 1 V, 10 V ranges	Input Resistance for: 100 V, 300 V ranges
Input Resistance: Auto OFF	10 MΩ	10 MΩ
Input Resistance: Auto ON	> 10 GΩ	10 MΩ

- The `CONFigure` and `MEASure?` commands automatically select AUTO OFF (fixed at 10 MΩ for all ranges).

- The instrument selects 10 MΩ (fixed input resistance on all dc voltage ranges) after a Factory Reset (`*RST` command). An Instrument Preset (`SYSTem:PRESet` command) or Card Reset (`SYSTem:CPON` command) does *not* change the input resistance setting.

Front Panel Operation: DMM or Channel (Configure) > INPUT RESISTANCE

Remote Interface Operation: You can enable or disable the automatic input resistance mode on the specified channels or the internal DMM. With AUTO OFF (default), the input resistance is fixed at 10 MΩ for all ranges. With AUTO ON, the input resistance is set to >10 GΩ for the three lowest dc voltage ranges.

```
[SENSe:]<function>:IMPedance:AUTO {OFF|ON} [,(@<ch_list>)]
```

If you omit the optional <ch_list> parameter, the command applies to the internal DMM.

AC Low Frequency Filter

The instrument uses three different ac filters which enable you to either optimize low-frequency accuracy or achieve faster ac settling times. The instrument selects the *slow* (3 Hz), *medium* (20 Hz), or *fast* (300 Hz) filter based on the input frequency that you specify for the selected channels or the internal DMM.

Applies to ac voltage and ac current measurements only.

AC low frequency filter

Input Frequency	Default Settling Delay	Minimum Settling Delay
3 Hz to 300 kHz (Slow)	7 seconds / reading	1.5 seconds
20 Hz to 300 kHz (Medium)	1 second / reading	200 ms
200 Hz to 300 kHz (Fast)	0.12 seconds / reading	20 ms

- The `CONFigure` and `MEASure?` commands automatically select the 20 Hz (medium) filter.

- The instrument selects the default 20 Hz (medium) filter after a Factory Reset (`*RST` command). An Instrument Preset (`SYSTem:PRESet` command) or Card Reset (`SYSTem:CPON` command) does *not* change the setting.

Front Panel Operation: DMM or Channel (Configure) > AC FILTER

Remote Interface Operation: Specify the lowest frequency expected in the input signal on the specified channels. The instrument selects the appropriate filter based on the frequency you specify (see table above).

```
[SENSe:]VOLTage:AC:BANDwidth {3|20|200} [,(@<ch_list>)]
```

If you omit the optional <ch_list> parameter, the command applies to the internal DMM.

Resistance Measurement Configuration

This section contains information to help you configure the instrument for making resistance measurements. Use the 2-wire method for ease of wiring and higher density or use the 4-wire method for improved measurement accuracy. The measurement ranges shown below.

100Ω	1 kΩ	10 kΩ	100 kΩ	1 MΩ	10 MΩ	100 MΩ	Autorange

Offset Compensation

Offset compensation removes the effects of any dc voltages in the circuit being measured. The technique involves taking the difference between two resistance measurements on the specified channels, one with the current source turned on and one with the current source turned off.

Applies only to 2-wire and 4-wire resistance measurements on the 100Ω, 1 kΩ, and 10 kΩ ranges.

- Four-wire measurements are not allowed on the multiplexer modules configured for the 1-wire (single ended) mode (see page 28).

- For 4-wire resistance measurements, the instrument automatically pairs channel *n* in Bank 1 with channel *n+20* in Bank 2 (34921A, 34923A, 34925A) or *n+35* (34922A, 34924A) to provide the source and sense connections. For example, make the source connections to the HI and LO terminals on channel 2 in Bank 1 and the sense connections to the HI and LO terminals on channel 22 (or 37) in Bank 2.

- The `CONFigure` and `MEASure?` commands automatically disable offset compensation.

- The instrument disables offset compensation after a Factory Reset (`*RST` command). An Instrument Preset (`SYSTem:PRESet` command) or Card Reset (`SYSTem:CPON` command) does *not* change the setting.

Front Panel Operation: DMM or Channel (Configure) > OFFSET COMP

Remote Interface Operation:

```
[SENSe:]FRESistance:OCOMpensated {OFF|ON} [,(@<ch_list>)]
[SENSe:]RESistance:OCOMpensated {OFF|ON} [,(@<ch_list>)]
```

If you omit the optional <ch_list> parameter, the command applies to the internal DMM. For 4-wire measurements, specify the paired channel in Bank 1 (source) as the <ch_list> channel (channels in Bank 2 are not allowed in the <ch_list>).

Current Measurement Configuration

This section contains information to help you configure the instrument for making current measurements on the 34921A multiplexer module. The module has four fused channels for direct dc and ac current measurements on the ranges shown below.

10 mA	100 mA	1 A	Autorange

Current measurements are allowed only on channels 41 through 44 on the 34921A module.

AC Low Frequency Filter

The instrument uses three different ac filters which enable you to either optimize low-frequency accuracy or achieve faster ac settling times. The instrument selects the *slow* (3 Hz), *medium* (20 Hz), or *fast* (300 Hz) filter based on the input frequency that you specify for the selected channels or the internal DMM.

Applies to ac current and ac voltage measurements only.

AC low frequency filter

Input Frequency	Default Settling Delay	Minimum Settling Delay
3 Hz to 300 kHz (Slow)	7 seconds / reading	1.5 seconds
20 Hz to 300 kHz (Medium)	1 second / reading	200 ms
200 Hz to 300 kHz (Fast)	0.12 seconds / reading	20 ms

- The `CONFigure` and `MEASure?` commands automatically select the 20 Hz (medium) filter.

- The instrument selects the default 20 Hz (medium) filter after a Factory Reset (`*RST` command). An Instrument Preset (`SYSTem:PRESet` command) or Card Reset (`SYSTem:CPON` command) does *not* change the setting.

Front Panel Operation: DMM or Channel (Configure) > AC FILTER

Remote Interface Operation: Specify the lowest frequency expected in the input signal on the specified channels. The instrument selects the appropriate filter based on the frequency you specify (see table above).

```
[SENSe:]CURRent:AC:BANDwidth {3|20|200} [,(@<ch_list>)]
```

If you omit the optional <ch_list> parameter, the command applies to the internal DMM.

Frequency Measurement Configuration

This section contains information to help you configure the instrument for making frequency measurements.

Low Frequency Timeout

The instrument uses three different timeout ranges for frequency measurements. The instrument selects the *slow* (3 Hz), *medium* (20 Hz), or *fast* (300 Hz) filter based on the input frequency that you specify with this command for the selected channels.

Applies to frequency measurements only.

Low frequency timeout

Input Frequency	Timeout
3 Hz to 300 kHz (Slow)	1 second
20 Hz to 300 kHz (Medium)	100 ms
200 Hz to 300 kHz (Fast)	10 ms

- The `CONFigure` and `MEASure?` commands automatically select the 20 Hz (medium) filter.
- The instrument selects the default 20 Hz (medium) filter after a Factory Reset (`*RST` command). An Instrument Preset (`SYSTem:PRESet` command) or Card Reset (`SYSTem:CPON` command) does *not* change the setting.

Front Panel Operation: DMM or Channel (Configure) > AC FILTER

Remote Interface Operation: Specify the lowest frequency expected in the input signal on the specified channels. The instrument selects the appropriate timeout based on the frequency you specify (see table above).

    [SENSe:]FREQuency:RANGe:LOWer {3|20|200} [,(@<ch_list>)]

If you omit the optional <ch_list> parameter, the command applies to the internal DMM.

Mx+B Scaling

The scaling function allows you to apply a *gain* and *offset* to readings during a scan or while making measurements in the stand-alone DMM mode. In addition to setting the gain ("M") and offset ("B") values, you can also specify a custom measurement label for your scaled readings (RPM, PSI, etc.). You can apply scaling to any multiplexer channels and for any measurement function. Scaling is not allowed with any of the channels on the digital modules.

- Scaling is applied using the following equation:

  Scaled Reading = (Gain x Measurement) + Offset

- If you change the measurement configuration (function, transducer type, etc.) on a channel or the internal DMM, scaling is turned off on those channels but the gain and offset values are not cleared.

- If you plan to use scaling on a channel which will also use alarms, *be sure to configure the scaling values first*. If you attempt to assign the alarm limits first, the instrument will turn off alarms and clear the limit values when you enable scaling on that channel. If you specify a custom measurement label with scaling, it is automatically used when alarms are logged on that channel.

- If you redefine the scan list, no change will be made to the scaling state or the gain and offset values. If you decide to add a channel back to the scan list, the original gain and offset values are restored.

- You can specify a custom label with up to three characters. You can use letters (A-Z), numbers (0-9), an underscore (_), blank spaces, or the "#" character which displays a degree symbol (°) on the front panel (displayed as a "#" in an output string from the remote interface).

- The maximum value allowed for the gain and offset is ±1E+15.

- The `CONFigure` and `MEASure?` commands automatically set the gain ("M") to 1 and offset ("B") to 0.

- A Factory Reset (`*RST` command) turns off scaling, clears the scaling values on all channels, and sets the custom label to a null string (""). An Instrument Preset (`SYSTem:PRESet` command) does *not* clear the scaling values and does *not* turn off scaling.

Front Panel Operation:

DMM or Channel (Configure) > SCALING > GAIN | OFFSET | UNITS

To define the label on the selected channel, press the arrow keys to move the cursor to a specific position and then turn the knob to select the desired letter or number. To clear the label on the selected channel, change each character to "**^**" (starting with the rightmost character) and then press the left arrow key to move to the next character.

Remote Interface Operation: Use the following commands to set the gain, offset, and custom measurement label.

```
CALC:SCALE:GAIN 1.2,(@1003)
CALC:SCALE:OFFSET 10,(@1003)
CALC:SCALE:UNIT 'PSI',(@1003)
```

After setting the gain and offset values, send the following command to enable the scaling function on the specified channel.

```
CALC:SCALE:STATE ON,(@1003)
```

Scanning

The instrument allows you to combine a DMM (either internal or external) with multiplexer channels to create a *scan*. During a scan, the instrument connects the DMM to the configured multiplexer channels one at a time and makes a measurement on each channel.

Any channel that can be "read" by the instrument can also be included in a scan. This includes any combination of temperature, voltage, resistance, current, frequency, or period measurements on multiplexer channels. A scan can also include a read of a digital channel or a read of the totalizer count on the digital modules. Scanning is allowed with the following modules:

- 34921A through 34925A Multiplexer Modules

- 34950A Digital I/O Module (digital input and counter channels only)

- 34952A Multifunction Module (digital input and totalizer channels only)

Automated scanning is not allowed with the other switching modules. In addition, a scan cannot include a write to a digital channel or a voltage output from a DAC channel. You can, however, write your own program to manually create a "scan" to include these operations.

Rules for Scanning

- Before you can initiate a scan, you must set up a scan list to include all desired multiplexer or digital channels. Channels which are not in the scan list are skipped during the scan. By default, the instrument scans the list of channels in ascending order from slot 1 through slot 8 (channels are reordered as needed). If your application requires non-ordered scanning of the channels in the present scan list, see "Non-Sequential Scanning" on page 60. Measurements are taken only during a scan and only on those channels which are included in the scan list.

- You can store at least 500,000 readings in memory and all readings are automatically time stamped. If memory overflows, a status register bit is set and new readings will overwrite the first (oldest) readings stored. The most recent readings are always preserved. You can read the contents of memory at any time, even during a scan. Reading memory is not cleared when you read it.

- Each time you start a new scan, the instrument clears all readings (including alarm data) stored in reading memory from the previous scan. Therefore, the contents of memory are always from the most recent scan.

- The Analog Bus relays are automatically opened and closed as required during the scan to connect to the internal DMM for the measurement. For example, all 2-wire measurements use the ABus1 (MEAS) relays; for 4-wire measurements, the ABus2 (SENS) relays are used in addition to the ABus1 relays.

- When the scan is initiated, the instrument will open all channels in banks that contain one or more channels in the scan list.

- In order to guarantee that no signals are connected to the Analog Buses prior to the scan, the instrument will open all ABus1 relays (applies to all banks in all slots). In banks that contain channels in the scan list, the instrument will also open all ABus2 relays (regardless of whether 4-wire measurements are involved). If no channels configured for 4-wire measurements are included in the scan list, the state of the ABus2 relays in the non-scanned banks is not altered.

- The state of the ABus3 and ABus4 relays is not altered and these relays remain available for use during the scan. However, be sure to use *CAUTION* when closing these relays on banks involved in the scan. While the scan is running, any signals present on ABus3 and/or ABus4 will be joined with the scanned measurement on ABus1 and ABus2.

- While the scan is running, the instrument prevents use of all channels in banks that contain one or more channels in the specified scan list (these channels are dedicated to the scan). In addition, the instrument prevents use of all ABus1 and ABus2 relays on banks containing channels in the scan list. If one or more channels configured for 4-wire measurements are included in the scan list, then the rules for ABus2 relay operations are extended to the non-scanned banks as well.

- If the ABus1 relay used for current measurements (channel 931 on 34921A only) is not closed prior to the initiation of the scan, the four current channels (channels 41 through 44) are not affected by the scan. However, if the ABus1 relay is closed, the instrument will open the ABus1 relay as well as the four associated current channels in a *make-before-break* fashion.

- When you add a digital read (digital modules) to a scan list, the corresponding channel is dedicated to the scan. The instrument issues a Card Reset to make that channel an input channel (the other channel is not affected).

- While the scan is running, you can perform low-level control operations on any channels on the digital modules that are not in the scan. For example, you can output a DAC voltage or write to a digital channel (even if the totalizer is part of the scan list). However, you cannot change any parameters that affect the scan (channel configuration, scan interval, Card Reset, etc.) while a scan is running.

- If a scan includes a read of the totalizer, the count is reset each time it is read during the scan *only* when the totalizer reset mode is enabled.

- At the end of the scan, the last channel that was scanned will be opened (as well as any Analog Bus relays used during the scan). Any channels that were opened during the scan will remain open at the completion of the scan.

- If you abort a scan that is running, the instrument will terminate any reading in progress (readings are not cleared from memory). If a scan is in progress when the command is received, the scan will not be completed and you cannot resume the scan from where it left off. Note that if you initiate a new scan, all readings are cleared from memory.

- You can use either the internal DMM or an external instrument to make measurements of your configured channels. However, the 34980A allows only one scan list at a time; you cannot scan some channels using the internal DMM and others using an external instrument. Readings are stored in 34980A memory only when the internal DMM is used.

- The Monitor mode is automatically enabled on all channels that are part of the active scan list (see “Monitor Mode” on page 63).

- The present scan list is stored in volatile memory and will be lost when power is turned off or after a Factory Reset (*RST command).

Adding Channels to the Scan List

Before you can initiate a scan, you must set up a scan list to include all desired multiplexer or digital channels. Channels which are not in the scan list are skipped during the scan. By default, the instrument scans the list of channels in ascending order from slot 1 through slot 8 (channels are reordered as needed).

To Build a Scan List From the Front Panel

- To add the active channel to the scan list, press Channel (Configure). Then select the function, range, resolution, and other parameters for this channel. Then add the channel to the scan list by selecting:

    SCAN THIS CHANNEL? > YES

- To remove the active channel from the scan list, select:

    SCAN THIS CHANNEL? > NO

- To remove all channels from the scan list, select:

    Scan (Configure) > CLEAR SCAN LIST? > YES

- To initiate a scan and store all readings in memory, press Scan (Measure). Each time you initiate a new scan, the instrument clears all previously stored readings. If you have not defined a scan list, Scan (Measure) performs an internal DMM scan independent of any channels.

- To stop a scan in progress, press and hold Scan (Measure).

To Build a Scan List From the Remote Interface

- Use the `ROUTe:SCAN` command to define the list of channels in the scan list. To determine what channels are currently in the scan list, use the `ROUTe:SCAN?` query command.

- To add channels to the present scan list, use the `ROUTe:SCAN:ADD` command. To remove channels from the present scan list, use the `ROUTe:SCAN:REMove` command.

- To remove all channels from the scan list, send "`ROUT:SCAN (@)`".

- To initiate a scan, use the `INITiate` or `READ?` command. Measurements are stored in memory. Each time you initiate a new scan, the instrument will clear the previous set of readings from memory.

- To stop a scan in progress, use the `ABORt` command.

Scan Trigger Source

You can configure the event or action that controls the onset of each sweep through the scan list (a *sweep* is one pass through the scan list):

- You can set the instrument's internal timer to automatically scan at a specific interval. You can also program a time delay between channels in the scan list (see "Channel Delay" on page 56).

- You can manually control a scan by repeatedly pressing the Scan (Measure) key from the front panel.

- You can start a scan by sending a software command from the remote interface (MEASure? or INITiate command).

- You can start a scan when an external TTL trigger pulse is received.

- You can start a scan when an alarm event is logged on the channel being monitored.

Interval Scanning

In this configuration, you control the frequency of scan sweeps by selecting a wait period from the start of one trigger to the start of the next trigger (called the *trigger-to-trigger interval*). If the scan interval is less than the time required to measure all channels in the scan list, the instrument will scan continuously, as fast as possible (no error is generated).
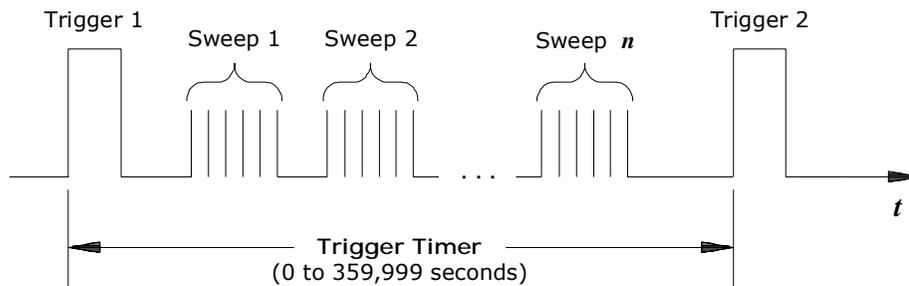
Trigger-to-trigger interval

- You can set the scan interval to any value between 0 seconds and 99:59:59 hours (359,999 seconds), with 1 ms resolution.

- Once you have initiated the scan, the instrument will continue scanning until you stop it or until the trigger count is reached. See "Trigger Count" on page 52 for more information.

- Mx+B scaling and alarm limits are applied to measurements during a scan and all data is stored in volatile memory.

- The CONFigure and MEASure? commands automatically set the scan interval to immediate (0 seconds) and the scan count to 1 sweep.

- The instrument sets the scan interval to immediate (0 seconds) after a Factory Reset (*RST command). An Instrument Preset (SYSTem:PRESet command) or Card Reset (SYSTem:CPON command) does *not* change the setting.

Front Panel Operation: Scan (Configure) > INTERVAL > SCAN INTERVAL

To initiate the scan and store all readings in memory, press the Scan (Measure) key. Between scan sweeps, "WAITING FOR TRIG" will be displayed on the front panel.

Note: To stop a scan, press and hold the Scan (Measure) key.

Remote Interface Operation: The following program segment configures the instrument for an interval scan.

```
TRIG:SOURCE TIMER          Select interval time mode
TRIG:TIMER 5               Set the scan interval to 5 seconds
TRIG:COUNT 2               Sweep the scan list 2 times
INIT                       Initiate the scan
```

Note: To stop a scan, send the ABORt command.

Manual Scanning

In this configuration, the instrument waits for either a front-panel key press or a remote interface command before sweeping through the scan list.

- All readings from the scan are stored in volatile memory. Readings accumulate in memory until the scan is terminated (until the trigger count is reached or until you abort the scan).

- You can specify a trigger count which sets the number of front-panel key presses or scan trigger commands that will be accepted before terminating the scan. See "Trigger Count" on page 52 for more information.

- Mx+B scaling and alarm limits are applied to measurements during a manual scanning operation and all data is stored in volatile memory.

Front Panel Operation: Scan (Configure) > INTERVAL > MANUAL

To initiate the scan and store all readings in memory, press the Scan (Measure) key.

Note: To stop a scan, press and hold the Scan (Measure) key.

Remote Interface Operation: The following program segment configures the instrument for a manual scanning operation.

```
TRIG:SOURCE BUS              Select bus (manual) mode
TRIG:COUNT 2                 Sweep the scan list 2 times
INIT                         Initiate the scan
```

Then, send the `*TRG` (trigger) command to begin each scan sweep. The `*TRG` command will not be accepted unless the internal DMM is in the "wait-for-trigger" state.

Note: To stop a scan, send the `ABORt` command.

Scanning on Alarm

In this configuration, the instrument initiates a scan each time a reading crosses an alarm limit on a channel. You can also assign alarms to channels on the digital modules (34950A and 34952A). For example, you can generate an alarm when a specific bit pattern or bit pattern change is detected on a digital input channel or when a specific count is reached on a totalizer channel.

NOTE	For complete details on configuring and using alarms, refer to "Alarm Limits" on page 68.

- In this scan configuration, you may use the Monitor function to continuously take readings on a selected channel and wait for an alarm on that channel. Channels do not have to be part of an active scan list to be monitored; however, the channel must be configured for a measurement in order to be monitored.

- All readings from the scan are stored in volatile memory. Readings accumulate in memory until the scan is terminated (until the trigger count is reached or until you abort the scan).

- You can specify a trigger count which sets the number of front-panel key presses or scan trigger commands that will be accepted before terminating the scan. See "Trigger Count" on page 52 for more information.

- Mx+B scaling and alarm limits are applied to measurements during a manual scanning operation and all data is stored in volatile memory.

Front Panel Operation: Scan (Configure) > ALARM

To enable the Monitor function, select the desired channel and then press the DMM or Channel (Measure) key. To initiate the scan, press the Scan (Measure) key. When an alarm occurs, the scan starts and readings are stored in memory.

Note: To stop a scan, press and hold the Scan (Measure) key.

You can also configure whether the instrument sweeps through the scan list one time or continuously when an alarm condition is detected:

  Scan (Configure) > ALARM > ALARM TRIG MODE > SINGLE | CONTIN

Remote Interface Operation: The following program segment configures the instrument to continuously scan when an alarm is detected.

```
TRIG:SOURCE ALARM1              Select alarm configuration
TRIG:SOURCE:ALARM CONT          Select continuous scan mode

CALC:LIM:UPPER 10.25,(@1003)    Set upper alarm limit
CALC:LIM:UPPER:STATE ON,(@1003) Enable alarms
OUTPUT:ALARM1:SOURCE (@1003)    Report alarms on Alarm 1

ROUT:MON:CHAN (@1003)           Select monitor channel
ROUT:MON:CHAN:ENABLE ON,(@1003) Enable monitoring on channel
ROUT:MON:STATE ON               Enable monitor mode

INIT                            Initiate the scan
```

Note: To stop a scan, send the `ABORt` command.

External Scanning

In this configuration, the instrument sweeps through the scan list once each time a low-going TTL pulse is received on the rear-panel *Ext Trig Input* line (pin 6).
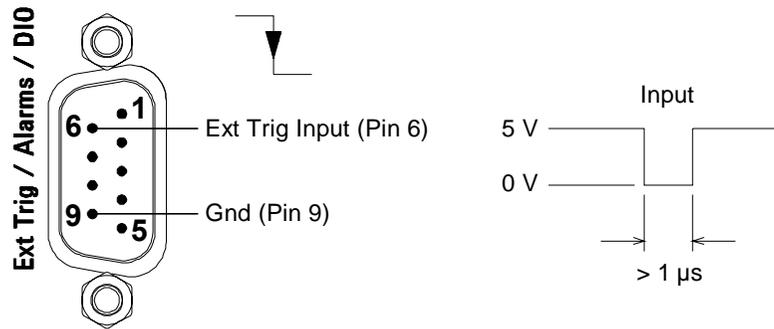
Ext Trig Input connector (as viewed from rear of instrument)

- You can specify a scan count which sets the number of external pulses the instrument will accept before terminating the scan. See "Trigger Count" on page 52 for more information.

- If the instrument receives an external trigger before it is ready to accept one, it will buffer one trigger and then ignore any additional triggers received (no error is generated).

- All readings from the scan are stored in volatile memory. Readings accumulate in memory until the scan is terminated (until the scan count is reached or until you abort the scan).

- Mx+B scaling and alarm limits are applied to measurements during the scan and all data is stored in volatile memory.

Front Panel Operation: Scan (Configure) > INTERVAL > EXTERNAL

To initiate the scan and store all readings in memory, press the Scan (Measure) key. Between scan sweeps, "WAITING FOR TRIG" will be displayed on the front panel. When a TTL pulse is received, the scan starts and readings are stored in memory.

Note: To stop a scan, press and hold the Scan (Measure) key.

Remote Interface Operation: The following program segment configures the instrument for an external scan.

```
TRIG:SOURCE EXT            Select external mode
TRIG:COUNT 2               Sweep the scan list 2 times
INIT                       Initiate the scan
```

Note: To stop a scan, send the `ABORt` command.

Trigger Count

You can specify the number of triggers that will be accepted by the internal DMM before returning to the "idle" state. The trigger count applies to both scanning and stand-alone DMM measurements (with no scan list).

- Select a trigger count between 1 and 500,000 triggers, or continuous.

- You can store at least 500,000 readings in memory and all readings are automatically time stamped. If memory overflows, the new readings will overwrite the first (oldest) readings stored; the most recent readings are always preserved.

- You can specify a trigger count in conjunction with a sample count and a sweep count. The three parameters operate independent of one another, and the total number of readings returned will be the product of the three parameters.

- The `CONFigure` and `MEASure?` commands automatically set the scan trigger count to 1.

- The instrument sets the scan trigger count to 1 after a Factory Reset (`*RST` command). An Instrument Preset (`SYSTem:PRESet` command) or Card Reset (`SYSTem:CPON` command) does *not* change the setting.

Front Panel Operation: Scan (Configure) > SCAN TRIGGER > COUNTED|INFINITE

Remote Interface Operation: `TRIGger:COUNt`

To configure a continuous scan, send `TRIG:COUNT INFINITY`.

Sweep Count

The sweep count sets the number of sweeps per trigger event during a scan (a *sweep* is one pass through the scan list). The front-panel sample annunciator ("*") turns on during each measurement.
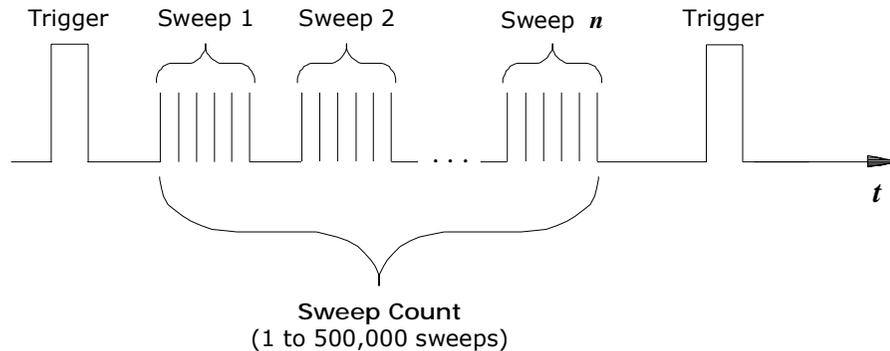
Sweep count

- The sweep count is valid only while scanning. If no channels have been assigned to the scan list, the specified sweep count is ignored (no error is generated).

- You can specify a sweep count in conjunction with a trigger count and a sample count. The three parameters operate independent of one another, and the total number of readings returned will be the product of the three parameters.

- You can store at least 500,000 readings in memory and all readings are automatically time stamped. If memory overflows, the new readings will overwrite the first (oldest) readings stored; the most recent readings are always preserved.

- The CONFigure and MEASure? commands automatically set the sweep count to 1 sweep.

- The instrument sets the sweep count to 1 after a Factory Reset (*RST command). An Instrument Preset (SYSTem:PRESet command) or Card Reset (SYSTem:CPON command) does *not* change the setting.

Front Panel Operation: Scan (Configure) > SWEEP COUNT

Remote Interface Operation: SWEep:COUNt

Sample Count

The sample count sets the number of auto-triggered samples the internal DMM will take per channel per trigger. The sample count applies to both scanning and stand-alone DMM measurements (with no scan list). The front-panel sample annunciator ("*") turns on during each measurement.
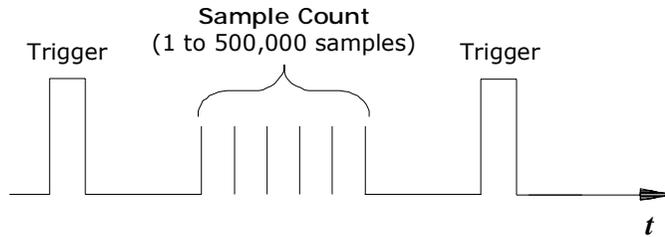
Sample count for Stand-Alone DMM Mode
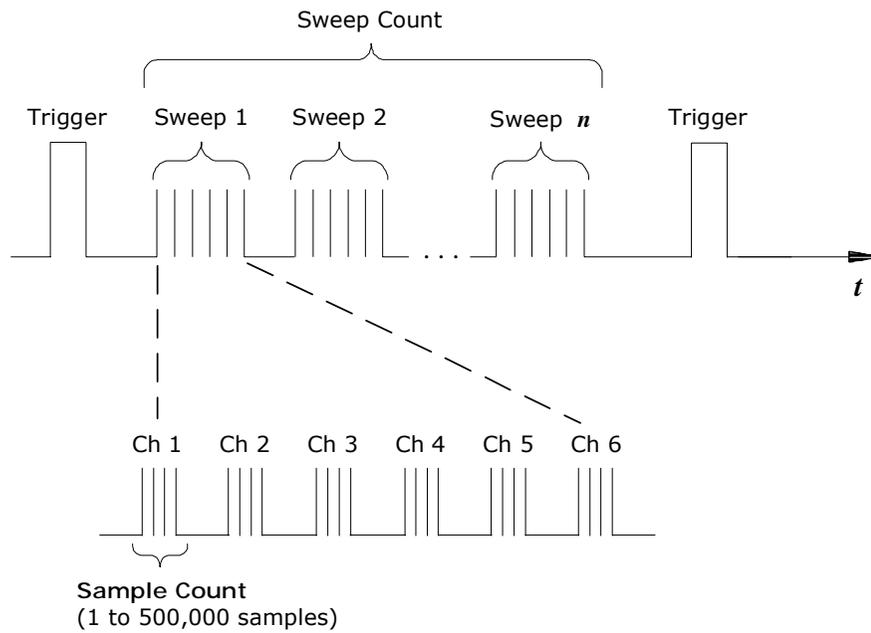
Sample count for Scanning Mode

- For scanning, the specified sample count sets the number of readings per channel (same for all channels in the scan list). If no channels have been assigned to the scan list, the sample count sets the number of readings per trigger for the internal DMM.

- You can specify a sample count in conjunction with a trigger count and a sweep count. The three parameters operate independent of one another, and the total number of readings returned will be the product of the three parameters.

- You can store at least 500,000 readings in memory and all readings are automatically time stamped. If memory overflows, the new readings will overwrite the first (oldest) readings stored; the most recent readings are always preserved.

- The CONFigure and MEASure? commands automatically set the sample count to 1.

- The instrument sets the sample count to 1 after a Factory Reset (*RST command). An Instrument Preset (SYSTem:PRESet command) or Card Reset (SYSTem:CPON command) does *not* change the setting.

Front Panel Operation: Scan (Configure) > SAMPLE COUNT

Remote Interface Operation: SAMPle:COUNt

Channel Delay

You can control the pacing of a scan sweep by inserting a delay between multiplexer channels in the scan list (useful for high-impedance or high-capacitance circuits). The delay is inserted between the relay closure and the actual measurement on the channel, in addition to any delay that will implicitly occur due to relay settling time. The programmed channel delay overrides the default channel delay that the instrument automatically adds to each channel.
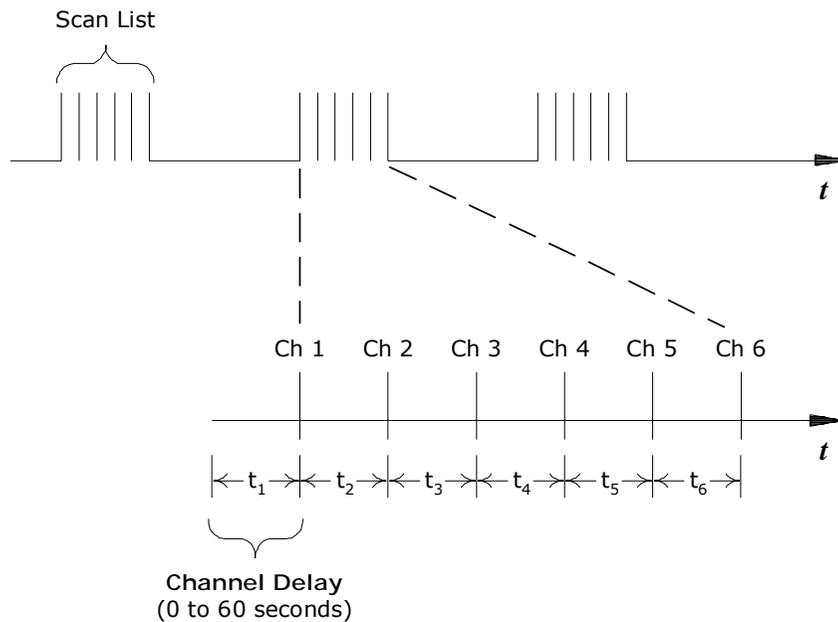
Channel delay

- You can set the channel delay to any value between 0 seconds and 60 seconds, with 1 ms resolution. You can select a different delay for each channel. The default channel delay is automatic; the instrument determines the delay based on function, range, integration time, and ac filter setting (see "Automatic Channel Delays" on page 57).

- You can select a unique delay for every channel on the module.

- The channel delay is valid only while scanning. If no channels have been assigned to the scan list, the specified channel delay is ignored (no error is generated).

- To ensure you are getting the most accurate measurements possible, use care when setting the channel delay less than the default value (automatic). The default channel delay is designed to optimize parameters, such as settling time, for the most accurate measurements.

- The CONFigure and MEASure? commands set the channel delay to automatic. A Factory Reset (*RST command) also sets the channel delay to automatic.

Front Panel Operation: Channel (Configure) > CHANNEL DELAY > TIME

Once you have added the specified channel to the scan list, the channel delay choice will be visible in the menu.

Interface Operation: The following command add a 2-second channel delay to the specified channels.

```
ROUT:CHAN:DELAY 2,(@1003,1013)
```

Automatic Channel Delays

If you do not specify a channel delay, the instrument selects a delay for you. The delay is determined by the delay based on function, range, integration time, and ac filter setting.

DC Voltage, Thermocouple, DC Current (for all ranges):

Integration Time	Channel Delay
PLC > 1	2.0 ms
PLC ≤ 1	1.0 ms

Resistance, RTD, Thermistor (2- and 4-wire):

Range	Channel Delay (for PLC > 1)	Range	Channel Delay (for PLC ≤ 1)
100 Ω	2.0 ms	100 Ω	1.0 ms
1 kΩ	2.0 ms	1 kΩ	1.0 ms
10 kΩ	2.0 ms	10 kΩ	1.0 ms
100 kΩ	25 ms	100 kΩ	20 ms
1 MΩ	30 ms	1 MΩ	25 ms
10 MΩ	200 ms	10 MΩ	200 ms
100 MΩ	200 ms	100 MΩ	200 ms

AC Voltage, AC Current (for all ranges):

AC Filter	Channel Delay
Slow (3 Hz)	7.0 seconds
Medium (20 Hz)	1.0 second
Fast (200 Hz)	120 ms

Frequency, Period:

AC Filter	Channel Delay
Slow (3 Hz)	600 ms
Medium (20 Hz)	300 ms
Fast (200 Hz)	100 ms

Digital Input, Totalize:

Channel Delay
0 seconds

Front Panel Operation: Channel (Configure) > CHANNEL DELAY > AUTO

Once you have added the specified channel to the scan list, the channel delay choice will be visible in the menu.

Interface Operation: The following command enables an automatic channel delay on the specified channels.

```
ROUT:CHAN:DELAY:AUTO ON,(@1003,1013)
```

Selecting a specific channel delay using the `ROUTe:CHANnel:DELay` command (see "Channel Delay" on page 56) disables the automatic channel delay.

Reading Format

During a scan, the instrument automatically adds a time stamp to all readings and stores them in memory. Each reading is stored with measurement units, time stamp, channel number, and alarm status information. From the remote interface, you can specify which information you want returned with the readings (from the front panel, all of the information is available for viewing). The examples below show a reading in *relative* and *absolute* format with all fields enabled.

Relative Format (Default):

```
2.61950000E+01    C,000000000.017,1003,2
```

         1   2   3   4

1	Reading with units (26.195 °C)	**3**	Channel number
2	Time since start of scan (17 ms)	**4**	Alarm limit threshold crossed (0 = No Alarm, 1 = LO, 2 = HI)

Absolute Format:

```
2.61950000E+01    C,2004,11,21,15,30,23.000,1003,2
```

         1   2   3   4   5

1	Reading with units (26.195 °C)	**4**	Channel number
2	Date (November 21, 2004)	**5**	Alarm limit threshold crossed
3	Time of day (3:30:23.000 PM)		(0 = No Alarm, 1 = LO, 2 = HI)
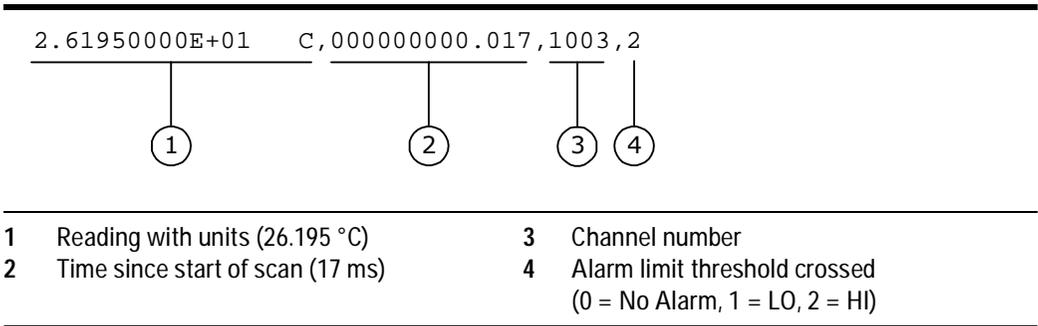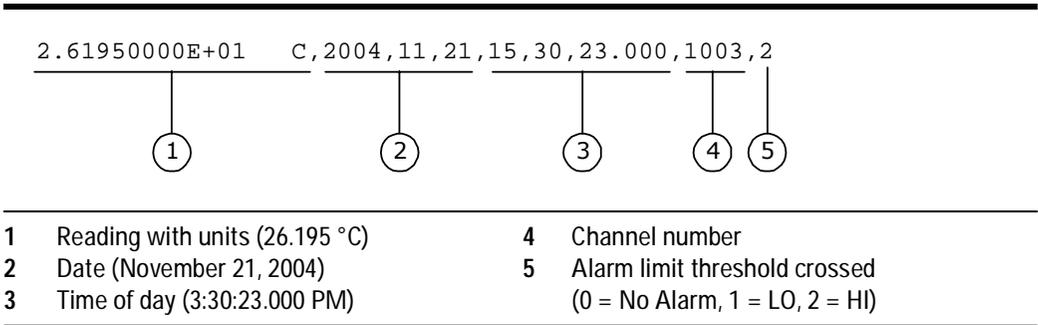
- The reading format applies to all readings being removed from the instrument from a scan; you cannot set the format on a per-channel basis.

- The CONFigure and MEASure? commands automatically turn off the units, time, channel, and alarm information.

- The format settings are stored in volatile memory and will be lost when power is turned off or after a Factory Reset (*RST command).

Remote Interface Operation: Use the following commands to select the reading format.

```
FORMat:READing:ALARm ON
FORMat:READing:CHANnel ON
FORMat:READing:TIME ON
FORMat:READing:TIME:TYPE {ABSolute|RELative}
FORMat:READing:UNIT ON
```

Non-Sequential Scanning

By default, the instrument scans the list of channels in ascending order from slot 1 through slot 8 (channels are reordered as needed). If your application requires non-ordered scanning of the channels in the present scan list, you can use the *non-sequential* scanning mode.

This feature is available from the remote interface only.

- The scanning mode applies to the entire mainframe and cannot be selectively used on individual modules.

- When sequential scanning is enabled (default), the channels in the scan list are placed in ascending order from slot 1 through slot 8. Duplicate channels are not allowed. For example, (@2001,1003,1001,1003) will be interpreted as (@1001,1003,2001).

- When sequential scanning is disabled (OFF), the channels remain in the order presented in the scan list (see exception below). Multiple occurrences of the same channel are allowed. For example, (@2001,2001,2001) and (@3010,1003,1001,1005) are valid and the channels will be scanned in the order presented.

- When you specify a range of channels in the scan list, the channels are always sorted in ascending order, regardless of the scan order setting. Therefore, (@1009:1001) will always be interpreted as 1001, 1002, 1003, etc.

- If you define a scan list with the sequential mode enabled and later disable the mode, the scan list will not be reordered; however, the scan list will be treated as a non-sequential list thereafter.

- If you have defined a scan list with the sequential mode disabled (OFF) and later enable the mode, the channels will be reordered.

- Non-sequential scan lists are not stored as part of the instrument state by the `*SAV` command; in this case, the ordered mode will be enabled and the scan list will be empty when the instrument state is restored (`*RCL` command).

- The scan order setting is stored in volatile memory and the ordered mode will be enabled when power is turned off or after a Factory Reset (`*RST` command).

Remote Interface Operation: `ROUTe:SCAN:ORDered {OFF|ON}`

Viewing Readings Stored in Memory

- During a scan, the instrument automatically adds a time stamp to all readings and stores them in memory. You can read the contents of memory at any time, even during a scan. Reading memory is not cleared when you read it.

- This feature is available from the remote interface only.

- You can store at least 500,000 readings in memory and all readings are automatically time stamped. If memory overflows, a status register bit is set and new readings will overwrite the first (oldest) readings stored. The most recent readings are always preserved.

- Each time you start a new scan, the instrument clears all readings (including alarm data) stored in reading memory from the previous scan. Therefore, the contents of memory are always from the most recent scan.

- The instrument clears all readings from memory after a Factory Reset (`*RST` command), after an Instrument Preset (`SYSTem:PRESet` command), or when mainframe power is cycled.

- The instrument clears all readings from memory when a new scan is initiated, when any measurement parameters are changed (`CONFigure` and `SENSe` commands), and when the triggering configuration is changed (`TRIGger` commands).

- While a scan is running, the instrument automatically stores the minimum and maximum readings and calculates the average for each channel. You can read these values at any time, even during a scan.

- Each reading is stored with measurement units, time stamp, channel number, and alarm status information. From the remote interface, you can specify which information you want returned with the readings (from the front panel, all of the information is available for viewing). See "Reading Format" on page 59 for more information.

- Readings acquired during a Monitor are *not* stored in memory (however, all readings from a scan in progress at the same time are stored in memory).

- The INITiate command stores readings in memory. Use the FETCh? command to retrieve stored readings from memory (the readings are not erased when you read them).

Remote Interface Operation: The following command retrieves stored readings from memory (the readings are not erased).

```
FETCh?
```

Use the following commands to query the statistics on the readings stored in memory for a specific channel or from the internal DMM. These commands do *not* remove the data from memory.

CALC:AVER:MIN? (@3005)	*Minimum reading on channel*
CALC:AVER:MIN:TIME? (@3005)	*Time minimum was logged*
CALC:AVER:MAX? (@3005)	*Maximum reading on channel*
CALC:AVER:MAX:TIME? (@3005)	*Time maximum was logged*
CALC:AVER:AVER? (@3005)	*Average of all readings on channel*
CALC:AVER:COUNT? (@3005)	*Number of readings taken on channel*
CALC:AVER:PTPEAK? (@3005)	*Peak-to-peak (maximum–minimum)*

The following command retrieves the last reading taken on channel 1 on the module in slot 3 during a scan.

```
DATA:LAST? (@3001)
```

The following command clears the contents of statistics memory for the selected channel.

```
CALC:AVER:CLEAR (@3001)
```

Use the following command to determine the total number of readings stored in memory (all channels) from the most recent scan.

```
DATA:POINTS?
```

The following command reads and clears the specified number of readings from memory. This allows you to continue a scan without losing data stored in memory (if memory becomes full, new readings will overwrite the first readings stored). The specified number of readings are cleared from memory, starting with the oldest reading.

```
DATA:REMOVE? 12
```

Monitor Mode

In the Monitor mode, the instrument takes readings as often as it can on a single channel or the internal DMM, even during a scan. This feature is useful for troubleshooting your system before a test or for watching an important signal.

- Any channel that can be "read" by the instrument can be monitored. This includes any combination of temperature, voltage, resistance, current, frequency, or period measurements on multiplexer channels. You can also monitor a digital input channel or the totalizer count on the digital modules. You can also monitor measurements on the internal DMM, independent of any channel measurements.

- Readings acquired during a Monitor are *not* stored in memory but they are displayed on the front panel; however, all readings from a scan in progress at the same time are stored in memory.

- The Monitor mode is equivalent to making continuous measurements on a single channel or the internal DMM with an infinite scan count. Only one channel can be monitored at a time but you can change the channel being monitored at any time.

- A scan in progress always has priority over the Monitor function.

- Channels do *not* have to be part of an active scan list to be monitored; however, the channel must be configured for a measurement in order to be monitored.

- The Monitor mode ignores all trigger settings and takes continuous readings on the selected channel using the IMMediate (continuous) source.

- The Monitor mode is automatically enabled on all channels that are part of the active scan list. If you define the scan list after monitoring has already been enabled, any channels that are not part of the active scan list will be ignored during the monitor operation (no error is generated).

- Mx+B scaling and alarm limits are applied to the selected channel during a Monitor and all alarm data is stored in the alarm queue (which will be cleared if power fails).

- You can monitor a digital input channel or totalizer channel even if the channel is not part of the scan list (the internal DMM is not required either). The count on a totalizer channel is not reset when it is being monitored (the Monitor ignores the totalizer reset mode).

- If a channel that is currently being monitored is manually closed or opened, the Monitor operation will be disabled on that channel.

Front Panel Operation: DMM or Channel (Measure)

For channel monitoring, turn the knob to the desired channel. To stop a Monitor, press the lighted key again.

Remote Interface Operation: Use the following command to select between the channel Monitor mode (default) and the internal DMM monitor mode.

```
ROUTe:MONitor:MODE {CHANnel|DMM}
```

The following program segment selects the channel to be monitored (specify only one channel) and enables the Monitor function.

```
ROUTE:MON:CHAN (@1003)
ROUTE:MON:CHAN:ENABLE ON,(@1003)
ROUTE:MON:STATE ON
```

The following program segment enables the Monitor function on the internal DMM:

```
ROUTE:MON:MODE DMM
ROUTE:MON:STATE ON
```

To read the monitor data from the selected channel or the internal DMM, send the following command. Each reading is returned with measurement units, time stamp, channel number, and alarm status information (see "Reading Format" on page 59).

```
ROUTe:MONitor:DATA?
```

Scanning With External Instruments

If your application doesn't require the built-in measurement capabilities of the 34980A, you can order the mainframe without the internal DMM. In this configuration, you can use the system for signal routing or control applications. If you install a multiplexer plug-in module in the mainframe, you can use the system for scanning with an external instrument. You can connect an external instrument such as a DMM to the multiplexer's COM terminals (see below) or you can connect to the 34980A's analog buses.
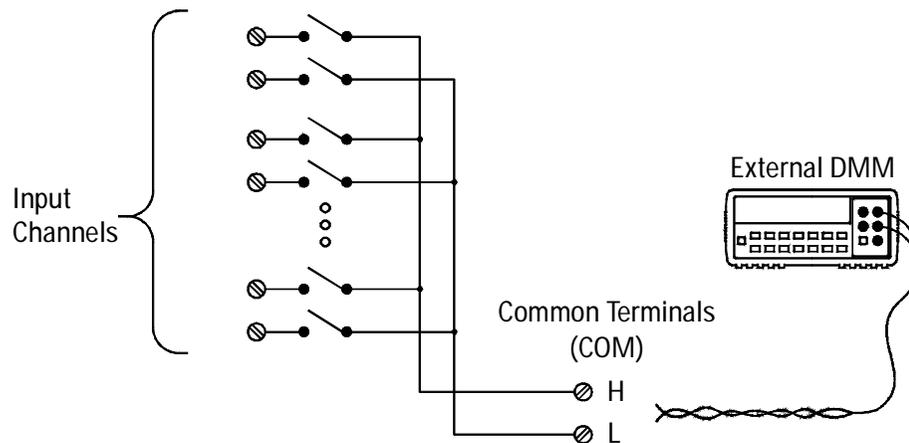
The figure on the following page shows the external connections required to synchronize the scan sequence between the 34980A and an external instrument. The 34980A must notify the external instrument when a relay is closed and fully settled (including channel delay). The 34980A outputs a *Channel Closed* pulse from pin 5 on the rear-panel *Ext Trig* connector. In response, the external instrument must notify the 34980A when it has finished its measurement and is ready to advance to the next channel in the scan list. The 34980A accepts a *Channel Advance* pulse on the *Chan Adv* input line (pin 6).
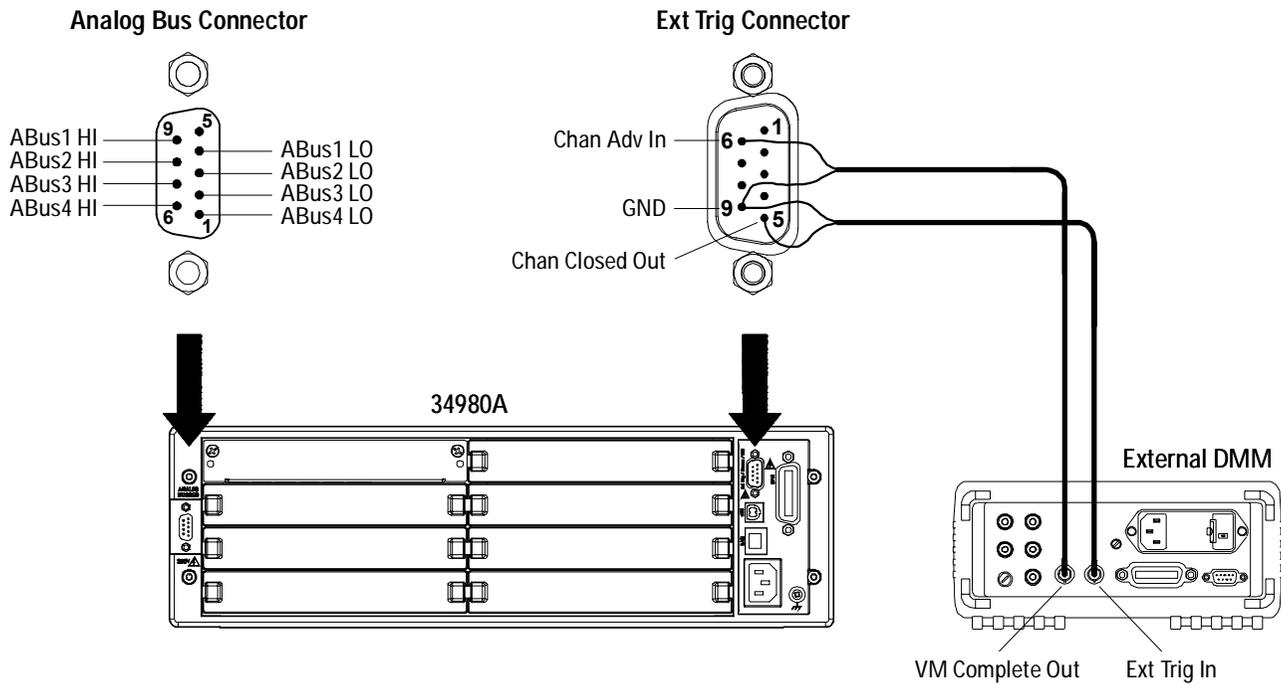
- For an externally-controlled scan, you must either remove the internal DMM from the 34980A or disable it (see "Internal DMM Disable" on page 93). Since the 34980A's internal DMM is not used, readings from multiplexer channels are stored in the external DMM's memory.

- In this configuration, you must set up a *scan list* to include all desired multiplexer or digital channels. Channels which are not in the list are skipped during the scan. By default, the instrument scans the list of channels in ascending order from slot 1 through slot 8 (channels are reordered as needed).

- You can configure the event or action that controls the onset of each sweep through the scan list (a *sweep* is one pass through the scan list). The selected source is used for all channels in the scan list. For more information, refer to "Scan Trigger Source" on page 47.

- You can configure the event or action that notifies the 34980A to advance to the next channel in the scan list. Note that the *Channel Advance* source shares the same sources as the scan trigger. However, an error is generated if you attempt to set the channel advance source to the same source (other than IMMediate) used for the scan trigger.

- You can specify the number of times the instrument will sweep through the scan list. When the specified number of sweeps have occurred, the scan stops. For more information, refer to "Sweep Count" on page 53.

- An externally-controlled scan can also include a read of a digital port or a read of the totalizer count on the digital modules. When the channel advance reaches the first digital channel, the instrument scans through all of the digital channels in that slot (only one channel advance signal is required).

- You can configure the list of channels for 4-wire external scanning without the internal DMM. When enabled, the instrument automatically pairs channel *n* in Bank 1 with channel *n+20* in Bank 2 (34921A, 34923A, 34925A) or *n+35* (34922A, 34924A) to provide the source and sense connections. For example, make the source connections to the HI and LO terminals on channel 2 in Bank 1 and the sense connections to the HI and LO terminals on channel 22 (or 37) in Bank 2.

Front Panel Operation: To select the channel advance source, choose the following items.

> Scan (Configure) > ADVANCE CHANNEL > AUTO | EXT | MANUAL

To initiate the scan and store all readings in memory, press the Scan (Measure) key.

To configure the instrument for 4-wire external scanning, choose the following menu item.

> Channel (Configure) > FOUR WIRE > OFF | ON

Remote Interface Operation: The following program segment configures the instrument for an externally-controlled scan.

```
INST:DMM OFF              Disable internal DMM
ROUT:SCAN (@1001:1020)   Configure scan list
TRIG:SOUR IMM            Set trigger source
TRIG:COUN 5              Set trigger count
ROUT:CHAN:ADV:SOUR EXT   Set channel advance source
INIT                     Initiate the scan
```

To configure the instrument for 4-wire external scanning, send the following command.

```
ROUTe:CHANnel:FWIRe {OFF|ON}, (@<ch_list>)
```

Alarm Limits

The instrument has four alarms which you can configure to alert you when a reading exceeds specified limits on a channel during a scan. You can assign a high limit, a low limit, or both to any configured channel in the scan list. You can assign multiple channels to any of the four available alarms (numbered 1 through 4). For example, you can configure the instrument to generate an alarm on the Alarm 1 output when a limit is exceeded on any of channels 1003, 2025, or 3020.

You can also assign alarms to channels on the digital modules (34950A and 34952A). For example, you can generate an alarm when a specific bit pattern or bit pattern change is detected on a digital input channel or when a specific count is reached on a totalizer channel. With the digital modules, the channels *do not* have to be part of the scan list to generate an alarm. For complete details, see "Using Alarms With the Digital Modules" on page 76.

Alarm data can be stored in one of two locations depending on whether a scan is running when the alarm occurs.

1 If an alarm event occurs on a channel as it is being scanned, then that channel's alarm status is stored in reading memory as the readings are taken. Each reading that is outside the specified alarm limits is logged in memory. You can store at least 500,000 readings in memory during a scan. You can read the contents of reading memory at any time, even during a scan. Reading memory is *not* cleared when you read it.

2 As alarm events are generated, they are also logged in an alarm queue, which is separate from reading memory. This is the only place where non-scanned alarms get logged (alarms during a monitor, alarms generated by the digital modules, etc.). Up to 20 alarms can be logged in the alarm queue. If more than 20 alarm events are generated, they will be lost (only the first 20 alarms are saved). Even if the alarm queue is full, the alarm status is still stored in reading memory during a scan. The alarm queue is cleared by the `*CLS` (clear status) command, when power is cycled, and by reading all of the entries. A Factory Reset (`*RST` command) *does not* clear the alarm queue.

- You can assign an alarm to any configured channel and multiple channels can be assigned to the same alarm number. However, you cannot assign alarms on a specific channel to more than one alarm number.

- When an alarm occurs, the instrument stores relevant information about the alarm in the queue. This includes the reading that caused the alarm, the time of day and date of the alarm, and the channel number on which the alarm occurred. The information stored in the alarm queue is always in absolute time format and is not affected by the `FORMat:READing:TIME:TYPE` command setting.

- You must configure the channel (function, transducer type, etc.) before setting any alarm limits. If you change the measurement configuration, alarms are turned off and the limit values are cleared. Alarms are also turned off when you change the temperature probe type, temperature units, or disable the internal DMM.

- If you plan to use scaling on a channel which will also use Mx+B scaling, *be sure to configure the scaling values first*. If you attempt to assign the alarm limits first, the instrument will turn off alarms and clear the limit values when you enable scaling on that channel. If you specify a custom measurement label with scaling, it is automatically used when alarms are logged on that channel.

- If you redefine the scan list, alarms are no longer evaluated on those channels (during a scan) but the limit values are not cleared. If you decide to add a channel back to the scan list (without changing the function), the original limit values are restored and alarms are turned back on. This makes it easy to temporarily remove a channel from the scan list without entering the alarm values again.

- Each time you start a new scan, the instrument clears all readings (including alarm data) stored in reading memory from the previous scan. Therefore, the contents of reading memory are always from the most recent scan.

- As shown below, alarms are logged in the alarm queue only when a reading crosses a limit, not while it remains outside the limit and not when it returns to within limits.
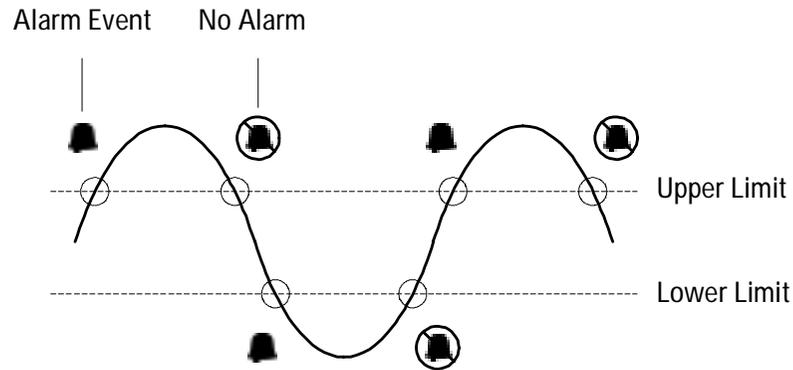
Alarm Event   No Alarm

Upper Limit

Lower Limit

- Four TTL alarm outputs are available on the rear-panel *Alarms* connector. You can use these hardware outputs to trigger external alarm lights, sirens, or send a TTL pulse to your control system.
  You can also initiate a scan sweep (no external wiring required) when an alarm event is logged on a channel. For complete details, refer to "Using the Alarm Output Lines" on page 74.

- The following table shows the different combinations of front-panel annunciators that may appear while using alarms. In addition to being stored in reading memory, alarms are also recorded in their own SCPI status system. You can configure the instrument to use the status system to generate a Service Request (SRQ) when alarms are generated. Refer to the Agilent 34980A *Programmer's Reference* for more information on the Status System.

🔔	An alarm is enabled on the displayed channel.
H 2	The indicated HI or LO limit is being configured on the indicated alarm (shown while in the *Alarm* menu).
⌐ALARM¬ H 2	An alarm has occurred on one or more channels. The behavior of the Alarm Output lines tracks the alarm annunciators on the front panel.
ALARM	The Alarm Output lines have been cleared but alarms remain in the queue.

- The default values for the upper and lower alarm limits are "0". The lower limit must always be less than or equal to the upper limit, even if you are using only one of the limits.

- For details on configuring alarms on the digital modules, see "Using Alarms With the Digital Modules" on page 76.

- A Factory Reset (*RST command) clears all alarm limits and turns off all alarms. An Instrument Preset (SYSTem:PRESet command) or Card Reset (SYSTem:CPON command) does not clear the alarm limits and does not turn off alarms.

Front Panel Operation: Alarm > LOW LIMIT > HIGH LIMIT > THIS CHANNEL ALARM

After selecting the lower and upper limit for the selected channel, assign one of the four alarm numbers. Note that the instrument does not start evaluating the alarm conditions until you exit the *Alarm* menu.

Remote Interface Operation: To assign the alarm number to report any alarm conditions on the specified channels, use the following command (if not assigned, all alarms on all channels are reported on Alarm 1 by default).

```
OUTPUT:ALARM2:SOURCE (@2001,2012)
```

To set the upper and lower alarm limits on the specified channels, use the following commands.

```
CALC:LIMIT:UPPER 5.25,(@2001,2012)
CALC:LIMIT:LOWER 0.025,(@2001,2012)
```

To enable the upper and lower alarm limits on the specified channels, use the following commands.

```
CALC:LIMIT:UPPER:STATE ON,(@2001,2012)
CALC:LIMIT:LOWER:STATE ON,(@2001,2012)
```

Viewing Stored Alarm Data

If an alarm occurs on a channel as it is being scanned, then that channel's alarm status is stored in reading memory as the readings are taken. As alarm events are generated, they are also logged in an alarm queue, which is separate from reading memory. This is the only place where non-scanned alarms get logged (alarms during a monitor, alarms generated by the digital modules, etc.).

- You can store at least 500,000 readings in memory during a scan. You can read the contents of reading memory at any time, even during a scan. Reading memory is *not* cleared when you read it.

- Each time you start a new scan, the instrument clears all readings (including alarm data) stored in reading memory from the previous scan. Therefore, the contents of reading memory are always from the most recent scan.

- Up to 20 alarms can be logged in the alarm queue. If more than 20 alarm events are generated, they will be lost (only the first 20 alarms are saved).

- The alarm queue is cleared by the *CLS (clear status) command, when power is cycled, and by reading all of the entries. A Factory Reset (*RST command) or Instrument Preset (SYSTem:PRESet command) does not clear the alarm queue.

Front Panel Operation: View > ALARMS

From the front panel, you can view the first 20 alarms in the queue. After turning the knob to the desired channel, press the left or right arrow keys to view the alarm reading. Notice that the annunciators indicate which alarm is being viewed.

Note: The alarm queue is cleared when you read the alarms.

Remote Interface Operation: The following command reads data from the alarm queue (one alarm event is read and cleared each time this command is executed).

```
SYSTEM:ALARM?
```

The following is an example of an alarm stored in the alarm queue (if no alarm data is in the queue, the command returns "0" for each field).
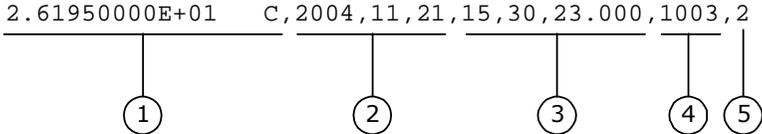
```
2.61950000E+01   C,2004,11,21,15,30,23.000,1003,2
```

1	Reading with Units (26.195 °C)	4	Channel Number
2	Date (November 21, 2004)	5	Alarm Limit Threshold Crossed
3	Time (3:30:23.000 PM)		(0 = No Alarm, 1 = LO, 2 = HI)

The following command retrieves scanned readings and alarm data from reading memory (the readings are not erased).

```
FETCH?
```

Using the Alarm Output Lines

Four TTL alarm outputs are available on the rear-panel *Alarms* connector. You can use these hardware outputs to trigger external alarm lights, sirens, or send a TTL pulse to your control system. You can assign an alarm to any configured channel and multiple channels can be assigned to the same alarm number. Each alarm output line represents the logical "OR" of all channels assigned to that alarm number (an alarm on any of the associated channels will pulse the line).
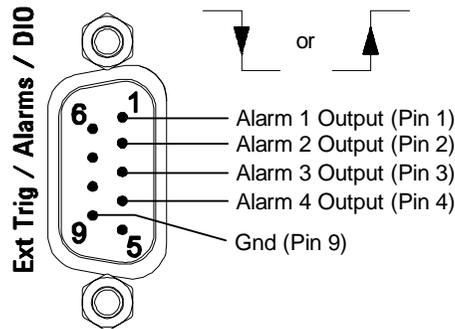
Alarms connector (as viewed from rear of instrument)

You can configure the behavior of the alarm output lines as described below. The behavior of the alarm annunciators on the front panel also tracks the alarm output configuration. The configuration that you select is used for all four alarm output lines. A Factory Reset (`*RST` command) clears all four alarm outputs but does not clear the alarm queue in either configuration.

- *Latch Mode*: In this mode, the corresponding output line is latched true when the first alarm occurs and remains asserted until you clear it by initiating a new scan or cycling power. You can manually clear the output lines at any time (even during a scan) and the alarm data in memory is *not* cleared (however, data is cleared when you initiate a new scan).

- *Track Mode*: In this mode, the corresponding output line is asserted only when a reading crosses a limit and remains outside the limit. When a reading returns to within limits, the output line is automatically cleared. You can manually clear the output lines at any time (even during a scan) and the alarm data in memory is *not* cleared (however, data is cleared when you initiate a new scan). The alarm outputs are also cleared when you initiate a new scan.

- You can control the slope of the pulse from the alarm outputs (the selected configuration is used for all four outputs). In the falling edge mode, 0V (TTL low) indicates an alarm. In the rising edge mode, +5V (TTL high) indicates an alarm. A Factory Reset (`*RST` command) will reset the slope to falling edge.

  Note: Changing the slope of the output lines may cause the lines to change state.

Front Panel Operation:

- To manually clear all four alarm output lines, select:

  Alarm > CLEAR ALARM OUT? > YES | NO

- To select the output configuration for all four output lines, select:

  Alarm > ALARM OUT SIGNAL > TRACK | LATCH

- To configure the slope of all four output lines, select:

  Alarm > ALARM OUT SLOPE > NEGATIVE | POSITIVE

Remote Interface Operation: To clear the specified output lines (or to clear all four lines), use one of the following commands.

```
OUTPUT:ALARM2:CLEAR       Clear alarm output line 2
OUTPUT:ALARM:CLEAR:ALL    Clear all four alarm outputs
```

To select the output configuration for all four output lines, use the following command.

```
OUTPut:ALARm:MODE {LATCh|TRACk}
```

To configure the slope of all four output lines, use the following command.

```
OUTPut:ALARm:SLOPe {NEGative|POSitive}
```

Using Alarms With the Digital Modules

You can configure the instrument to generate an alarm when a specific bit pattern or bit pattern change is detected on a digital input channel or when a specific count is reached on a totalizer channel (34950A and 34952A). These channels *do not* have to be part of the scan list to generate an alarm. Alarms are evaluated continuously as soon as you enable them.

- The channel numbering scheme for the digital input and totalizer channels is shown below (*s* represents the slot number).

	Digital Input Channel Numbering	Totalizer Channel Numbering
34950A	*s*101 through *s*104 *s*201 through *s*204	*s*301, *s*302
34952A	*s*001 through *s*004	*s*005

- Pattern comparisons always start on the lowest-numbered channel in the bank and extend to all channels involved in the channel width.

- Alarms are evaluated continuously on the digital modules, but alarm data is stored in reading memory only during a scan.

- Each time you start a new scan, the instrument clears all readings (including alarm data) stored in reading memory from the previous scan. However, alarm data stored in the alarm queue from the digital modules is not cleared. Therefore, although the contents of reading memory are always from the most recent scan, the alarm queue may contain data that occurred during previous scans or while the instrument was not scanning.

Front Panel Operation:

- To configure an alarm on a digital input channel, choose from the following items and then set the desired patterns for the compare data and mask. Set each bit to "0" or "1".

    Alarm > COMPARE DATA > COMPARE MASK

- You can either specify that an alarm will occur when certain bits change or when a specific pattern is read:

    Alarm > COMPARE FOR > EQUAL | NOT-EQ

- To configure an alarm on a specific totalizer count, select:

    Alarm > TOTALIZER LIMIT

Remote Interface Operation (Digital Input): To assign the alarm number to report any alarm conditions on the specified digital input channels, use the following command.

```
OUTPut:ALARm[1|2|3|4]:SOURce (@<ch_list>)
```

To configure alarms on the specified digital input channel, use the following commands (also see the example on the following page).

```
CALCulate
  :COMPare:TYPE {EQUal|NEQual},(@<ch_list>)
  :COMPare:DATA <data>,(@<ch_list>)
  :COMPare:MASK <mask>,(@<ch_list>)
```

Select `EQUal` to generate an alarm when the data read from the port is equal to `CALC:COMP:DATA` after being masked by `CALC:COMP:MASK`. Select `NEQual` (not equal) to generate an alarm when the data read from the port is not equal to `CALC:COMP:DATA` after being masked by `CALC:COMP:MASK`.

Use `CALC:COMP:MASK` to designate the "don't care" bits. Bits that you set to "0" in the mask are ignored. To enable the specified alarm mode, send the following command.

```
CALCulate:COMPare:STATe ON,(@<ch_list>)
```

Example: *Configuring an Alarm on a Digital Input*

The following program segment sets the digital pattern for the 34950A in slot 3 and then enables the pattern comparison mode. When the data read from the bank is equal to the comparison pattern, an alarm is generated on Alarm 2.

```
CALC:COMP:DATA:WORD #HF6,(@3101)    Set compare pattern (1111 0110)
CALC:COMP:TYPE EQUAL,(@3101)        Generate alarm on match
OUTP:ALARM2:SOUR (@3101)            Enable alarms
CALC:COMP:STAT ON,(@3101)           Enable pattern compare mode
```

Remote Interface Operation (Totalizer): To assign the alarm number to report any alarm conditions on the specified totalizer channels, use the following command.

```
OUTPut:ALARm[1|2|3|4]:SOURce (@<ch_list>)
```

To configure an alarm on a totalizer channel, specify the desired count as the upper limit using the following command.

```
CALCulate:LIMit:UPPer <count>,(@<ch_list>)
```

To enable the upper limit on the specified totalizer channel, use the following command.

```
CALCulate:LIMit:UPPer:STATe ON,(@<ch_list>)
```

Sequences

This section gives information on defining and executing a *sequence*, which is a compiled series of SCPI commands stored in non-volatile memory and identified by a user-defined name. Sequences can be used in a variety of applications, such as creating a signal path from a device-under-test to a measurement device or sequencing relays in a specified order. You can also uses sequences in conjunction with other operations to configure and synchronize complex measurements without having to send the routing commands each time.

The following tables summarizes the commands used to define, execute, and manage sequences. For more information, see the *Programmer's Reference* Help file.

Sequence Definition

ROUTe:SEQuence:DEFine *<name>*, "*<commands>*"	Defines a sequence.
ROUTe:SEQuence:DEFine? *<name>*	Returns sequence definition.

Sequence Execution

ROUTe:SEQuence:ABORT	Terminates currently-running sequence.
ROUTe:SEQuence:BUSY?	Returns "1" if sequence is executing (busy).
ROUTe:SEQuence:RUNNing:NAME?	Returns name of currently-running sequence.
ROUTe:SEQuence:TRIGger[:IMMediate]	Executes specified sequence.
ROUTe:SEQuence:WAIT	Blocks until sequence has completed.

Sequence Management

ROUTe:SEQuence:CATalog?	Returns list of defined sequence names.
ROUTe:SEQuence:DELete:ALL	Deletes all sequences from memory.
ROUTe:SEQuence:DELete[:NAME] *<name>*	Deletes specified sequence from memory.

Alarm Limits

OUTPut:ALARm{1-4}:SEQuence?	Returns sequence associated with alarm.
ROUTe:SEQuence:TRIGger:SOURce *<name>*, *<source>*	Assigns trigger source to sequence.
ROUTe:SEQuence:TRIGger:SOURce? *<name>*	Returns trigger source currently selected.

Defining a Sequence

A sequence defines a series of SCPI commands with an associated name. When the sequence is first defined, the commands are compiled and then stored in a compressed format in non-volatile memory. The following SCPI commands are allowed in a sequence definition (all other commands will generate an error).

```
ABORt
DISPlay:TEXT '<string>'
OUTPut[:STATe] {OFF|0|ON|1}, (@<ch_list>)
ROUTe:CLOSe (@<ch_list>)
ROUTe:CLOSe:EXCLusive (@<ch_list>)
ROUTe:MODule:WAIT {1-8|SLOT1-SLOT8|ALL}
ROUTe:OPEN (@<ch_list>)
ROUTe:OPEN:ABUS [{1-4|ABUS1-ABUS4|ALL}]
ROUTe:OPEN:ALL [{1-8|SLOT1-SLOT8|ALL}]
ROUTe:SEQuence:TRIGger[:IMMediate] <name>
[SENSe:]TOTalize:CLEar:IMMediate (@<ch_list>)
SOURce:CURRent[:LEVel] {<current>|MIN|MAX|DEF}, (@<ch_list>)
SOURce:DIGital:DATA[:{BYTE|1|WORD|2|LWORd|4}] <data>,(@<ch_list>)
SOURce:DIGital:DATA:BIT {0|1}, <bit>, (@<ch_list>)
SOURce:FUNCtion:TRIGger:IMMediate (@<ch_list>)
SOURce:VOLTage[:LEVel] {<voltage>|MIN|MAX|DEF} , (@<ch_list>)
SYSTem:BEEPer
SYSTem:DELay[:IMMediate] <time>
```

- Sequences can be defined from the remote interface only. You can, however, review, execute, and delete sequences from the front panel.

- When a sequence is defined, the specified commands are checked for proper syntax and absolute parameter range limits. If an error is detected during compilation, the entire sequence will be discarded. During compilation, the sequence commands do not have to be valid for the current instrument configuration; this allows you to define sequences without regard to compatibility with the current set of installed modules. More extensive error checking, such as channel range expansion and validation, is performed when the sequence is executed.

- If you define a sequence with a name already in use by another sequence, the new definition will overwrite the previous definition (no error is generated).

- A sequence name can contain up to 30 characters. The first character must be a letter (A-Z), but the remaining 29 characters can be letters, numbers (0-9), or an underscore (_). Blank spaces are not allowed.

- When stored in memory, the user-defined sequence names are converted to all uppercase letters. For example, when stored "MySeq_1" is converted to "MYSEQ_1".

- A sequence may invoke another sequence, but may not invoke itself recursively. In addition, the number of invocations is limited to *four* levels of nesting and this is enforced at the time of execution. Exceeding the limit will abort the sequence and an error will be generated.

- At the time of sequence definition, a sequence may reference another undefined sequence; however, at the time of execution an error will be generated if an undefined sequence is invoked.

- Up to 500 unique sequences can be stored in non-volatile memory. Each sequence is limited to 1024 bytes.

- While a scan is running (see "Scanning" on page 43), the instrument prevents use of all channels in banks that contain one or more channels in the specified scan list (these channels are dedicated to the scan). Therefore, if a sequence attempts to operate a channel in a scanned bank, an error is generated and the entire sequence will be discarded.

- If the command overlap function is enabled, all switching operations within the sequence follow the overlapping rules. If the command overlap function is disabled, all commands within the sequence are processed in a serial fashion in the exact order in which they are received. Note, however, that within a single command containing a <ch_list> parameter (e.g., `ROUT:CLOSE (@1001:1010)`), the order of the individual switch operations is not guaranteed.

Remote Interface Operation: The following command defines a sequence named "MYSEQ_1", which closes several channels on the module in slot 1 and opens a single channel on the module in slot 2.

```
ROUT:SEQ:DEF MYSEQ_1,"ROUT:CLOS (@1001:1009);OPEN (@2001)"
```

Querying the Sequence Definition

Once you have defined a sequence, you can query the definition to review what SCPI commands have been assigned. Although sequences can be defined from the remote interface only, you can review them from the front panel.

- The exact text specified in the original sequence definition is not preserved when the sequence is compressed/stored in memory. Therefore, the string returned may not be identical to the original string, but it will be functionally equivalent. If the specified sequence name is not currently stored in memory, an error is generated.

- The query command always returns the short form of the command header in all upper-case letters (e.g., "ROUT:CLOS" is returned instead of "ROUTE:CLOSE"). Channel numbers and channel range specifiers are returned as they were specified.

Front Panel Operation: Sequence > VIEW

Remote Interface Operation: The following command returns a string containing the SCPI commands assigned to the specified sequence.

```
ROUT:SEQ:DEF? MYSEQ_1
```

The above command returns a string in the form (the quotes are also returned):

```
":ROUT:CLOS (@1001:1009);:ROUT:OPEN (@2001)"
```

Executing a Sequence

After you have defined a valid sequence, you can execute it to process the specified commands. If the specified sequence name is not currently stored in memory, an error will be generated.

- If you attempt to trigger a sequence while one is already executing, the trigger will be placed in a queue. When the trigger queue is full, a "trigger ignored" error will be generated.

- To abort a sequence execution from the remote interface, use the `ROUTe:SEQuence:ABORt` command or a `Device Clear`. When the sequence is terminated, the resultant instrument state will be determined by how of the sequence had been executed when the `ABORt/Device Clear` was received. An `ABORt` command (system abort) executed from within a sequence will not terminate the sequence. The `*RST` and `SYSTem:PRESet` commands will also abort a sequence execution prior to performing their own actions.

- When a sequence is defined, the specified commands are checked for proper syntax and absolute parameter range limits. If an error is detected during compilation, the entire sequence will be discarded. More extensive error checking, such as channel range expansion and validation, is performed when the sequence is executed.

- A sequence may invoke another sequence. but may not invoke itself recursively. In addition, the number of invocations is limited to *four* levels of nesting and this is enforced at the time of execution. Exceeding the limit will abort the sequence and an error will be generated.

- You can also execute a sequence when an alarm condition is reached. See "Executing a Sequence on an Alarm Condition" on page 84 for more information.

- While a scan is running (see "Scanning" on page 43), the instrument prevents use of all channels in banks that contain one or more channels in the specified scan list (these channels are dedicated to the scan). Therefore, if a sequence attempts to operate a channel in a scanned bank, an error is generated and the entire sequence will be discarded.

Front Panel Operation: Sequence > EXECUTE

Although sequences can be defined from the remote interface only, you can execute pre-defined sequences from the front panel.

Remote Interface Operation: The following command executes a sequence named "MYSEQ_1", which closes several channels on the module in slot 1 and opens a single channel on the module in slot 2.

```
ROUT:SEQ:DEF MYSEQ_1,"ROUT:CLOS (@1001:1009);OPEN (@2001)"
ROUT:SEQ:TRIG MYSEQ_1
```

Executing a Sequence on an Alarm Condition

After you have defined a valid sequence, you can configure the instrument to execute a sequence when a reading crosses an alarm limit on a channel. The specified sequence will execute *once* when an alarm occurs on the specified alarm. If the specified sequence name is not currently stored in memory, an error will be generated.

For more information on configuring alarms, see "Alarm Limits" on page 68.

- Assigning a sequence to an alarm will remove any other sequence's association with that alarm, as well as that alarm's association to any other sequence.

- You can assign multiple channels to any of the four available alarms (numbered 1 through 4). For example, you can configure the instrument to generate an alarm on the Alarm 1 output when a limit is exceeded on any of channels 1003, 2005, or 3010. You cannot, however, assign alarms on a specific channel to more than one alarm number.

- The sequence will execute once when an alarm occurs, after which the trigger source will be automatically set to MANual. The sequence will not execute again until the trigger source has been reassigned, the alarm has been cleared, the association of the sequence to the alarm has been re-established, and the alarm condition exists again.

Front Panel Operation: Sequence > TRIGGER > MANUAL|ALARM1–ALARM4

Select MANUAL to remove an association without reassigning it to another alarm.

Remote Interface Operation: To assign the sequence to a specific alarm number, use the following command. Specify the `MANual` parameter to remove an association without reassigning it to another alarm.

```
ROUTe:SEQuence:TRIGger:SOURce <name>,{ALARm1-ALARm4|MANual}
```

The following program segment selects the alarm source and configures the instrument to execute the sequence named "MYSEQ_1" when an alarm is reported on Alarm 1. The Monitor mode is used to evaluate alarm conditions on the selected channel.

```
ROUT:SEQ:DEF MYSEQ_1,"ROUT:CLOS (@1001:1009);OPEN (@2001)"
CALC:LIM:UPP 10.25,(@1003)
CALC:LIM:UPP:STAT ON,(@1003)
OUTP:ALARM1:SOUR (@1003)
ROUT:MON:CHAN (@1003)
ROUT:MON:CHAN:ENAB ON, (@1003)
ROUT:SEQ:TRIG:SOUR MYSEQ_1,ALAR1
ROUT:MON:STAT ON
INIT
```

Deleting Sequences

You can delete sequences from the front panel or over the remote interface. Deleting a sequence also frees up space in non-volatile memory previously allocated for the sequence.

- If you attempt to delete a sequence name that is not currently stored in memory, an error will be generated.

- If you attempt to delete a sequence while it is executing, an error will be generated. To abort a sequence execution, use the `ROUTe:SEQuence:ABORt` command or a `Device Clear`.

- Deleting a sequence will remove its association with an alarm if used (see "Executing a Sequence on an Alarm Condition" on page 84 for more information).

Front Panel Operation: Sequence > DELETE|DELETE ALL

Remote Interface Operation: The following command deletes the sequence named "MYSEQ_1".

```
ROUT:SEQ:DEL MYSEQ_1
```

The following command deletes all sequences from memory.

```
ROUT:SEQ:DEL:ALL
```

Reading the List of Stored Sequences

From the remote interface only, you can read the names of all sequences currently stored in memory.

- When stored in memory, the user-defined sequence names are converted to all uppercase letters. For example, when stored "MySeq_1" is converted to "MYSEQ_1".

- Up to 500 unique sequences can be stored in non-volatile memory. Each sequence is limited to 1024 bytes.

Remote Interface Operation: The following command returns a comma-separated list of sequence names currently stored.

```
ROUT:SEQ:CAT?
```

The above command returns a string in the form:

```
MYSEQ_1,PATH_DUT1,SW_PATH2
```

If no sequence names have been stored, a null string ("") string is returned.

System-Related Operations

This section gives information on system-related topics such as instrument state storage, error conditions, self-test, and front-panel display control. This information is not directly related to making measurements but is an important part of operating the instrument.

Firmware Revision

The mainframe, the internal DMM, and each of the plug-in modules has its own microprocessor. You can query each to determine which version of firmware is installed. For the mainframe, three firmware revision numbers are returned: mainframe revision, boot code revision, and front-panel revision. For the internal DMM and all plug-in modules, one firmware revision number is returned.

Front Panel Operation: Utility > FIRMWARE > REVISIONS

Use the knob to scroll through the revision numbers for the mainframe, internal DMM, and each installed module.

Remote Interface Operation: Use the following command to read the mainframe firmware revision numbers (be sure to dimension a string variable with at least 72 characters).

    *IDN?

The above command returns a string in the form:

AGILENT TECHNOLOGIES,34980A,<*Serial Number*>,**m.mm–b.bb–f.ff–d.dd**

m.mm	= Mainframe revision number
b.bb	= Boot code revision number
f.ff	= Front-panel revision number
d.dd	= Internal DMM revision number

Use the following command to read the firmware revision number of the module in the specified slot (be sure to dimension a string variable with at least 73 characters).

    SYSTem:CTYPe? <*slot*>

This command returns a string in the form:

AGILENT TECHNOLOGIES,<*Model Number*>,<*Serial Number*>,<*Firmware Rev*>

A 10-digit string is returned for the Serial Number field. The Firmware Revision has the form **R.RR** and indicates the revision of firmware currently in use on the specified module.

Product Firmware Updates

As new product features and enhancements become available, you can easily update your mainframe and plug-in module firmware to ensure optimum compatibility.

Front Panel Operation: Utility > FIRMWARE > UPDATE

Once you have downloaded the latest mainframe firmware (see above), use the knob to scroll through the installed modules that require a firmware update. To exit the menu without installing the updates, select CANCEL.

Instrument State Storage

The instrument has five storage locations in non-volatile memory to store instrument states, numbered 1 through 5. You can assign a user-defined name to each of locations 1 through 5.

- You can store the instrument state in any of the five locations, but you can only recall a state from a location that contains a previously stored state.

- The instrument stores the state of all plug-in modules including all channel configurations, scanning setups, and Mx+B scaling values. However, note that only the measurement attributes of the currently-selected function (range, resolution, etc.) will be preserved in the stored states.

- Before recalling a stored state, the instrument verifies that the same plug-in module types are installed in each slot. If a different module type is installed, the instrument will perform the equivalent of a Factory Reset (*RST command) and an error will be generated.

- When shipped from the factory, storage locations 1 through 5 are empty. In addition, the automatic recall mode is disabled (MEMory:STATe:RECall:AUTO OFF command) and a Factory Reset (*RST command) is issued when power is turned on.

- You can name a location from the front panel or over the remote interface but you can recall a named state *only* from the front panel. The name can contain up to 12 characters. The first character *must* be a letter (A-Z), but the remaining 11 characters can be letters, numbers (0-9), or the underscore character ("_"). Blank spaces are not allowed. An error is generated if you specify a name with more than 12 characters.

- A Factory Reset (*RST command) does not affect the configurations stored in memory. Once a state is stored, it remains until it is overwritten or specifically deleted.

Front Panel Operation: Store/Recall > STORE | RECALL | DELETE | RENAME | AUTO

To rename a location, select RENAME. Press the arrow keys to move the cursor to a specific position and then turn the knob to select the desired letter or number. To clear the name of a location, change each character to "^" (starting with the rightmost character) and then press the left arrow key to move to the next character.

To automatically recall a specific location when power is restored, select AUTO. Use the knob to scroll through the available locations containing a stored state.

Remote Interface Operation: Use the following commands to store and recall instrument states.

```
*SAV {1|2|3|4|5}
*RCL {1|2|3|4|5}
```

To assign a user-defined name to a stored state to be recalled from the front panel, see the following example. From the remote interface, you can only recall a stored state using a number (1 through 5).

```
MEM:STAT:NAME 1,TEST_RACK_1
```

To configure the instrument to automatically recall location 2 when power is restored, send the following commands.

```
*SAV 2
MEM:STATE:RECALL:SELECT 2
MEM:STATE:RECALL:AUTO ON
```

Error Conditions

When the front panel ERROR annunciator turns on, one or more command syntax or hardware errors have been detected. A record of up to 20 errors can be stored in the instrument's *error queue*. Each remote interface I/O session (i.e., GPIB, USB, LAN, etc.) has its own interface-specific error queue. Errors appear in the error queue of the I/O session that caused the error (the front panel reports errors from all I/O sessions).

For a complete listing of the error messages, see the Agilent 34980A *Programmer's Reference* Help file, located on the *Product Reference CD-ROM* shipped with the instrument.

- The instrument beeps once each time a command syntax or hardware error is generated.

- A special *global* error queue holds all power-on and hardware-related errors (e.g., over-temperature, Safety Interlock, etc.).

- Errors are retrieved in first-in-first-out (FIFO) order. The first error returned is the first error that was stored. Errors are cleared as you read them. Once you have read all of the interface-specific errors, the errors in the global queue are retrieved.

- Errors are cleared as you read them. When you have read all errors from the interface-specific and global error queues, the ERROR annunciator turns off and the errors are cleared.

- If more than 20 errors have occurred, the last error stored in the queue (the most recent error) is replaced with -350,"Error queue overflow". No additional errors are stored until you remove errors from the queue. If no errors have occurred when you read the error queue, the instrument responds with +0,"No error".

- The front panel reports errors from all I/O sessions as well as the global error queue.

- The interface-specific and global error queues are cleared by the `*CLS` (Clear Status) command and when power is cycled. The errors are also cleared when you read the error queue. The error queue is not cleared by a Factory Reset (`*RST` command) or an Instrument Preset (`SYSTem:PRESet` command).

Front Panel Operation: View > ERROR QUEUE

Use the knob to scroll through the errors. Press the right arrow key to view the text of the error message. All errors are cleared when you exit the menu.

Remote Interface Operation: The following command reads and clears one error from the queue.

    SYSTem:ERRor?

Self-Test

A *power- on* self- test occurs automatically when you turn on the instrument. This limited test assures you that the instrument and all installed plug- in modules are operational. This self- test does *not* perform the extensive self test described below.

A *complete* self- test actually performs a series of internal tests and takes approximately 20 seconds to execute. If all tests pass, you can have high confidence that the instrument and all installed plug- in modules are operational. *This feature is available from the remote interface only.*

- If you have a 34951A Isolated DAC Module installed, the complete self- test will require an additional 15 seconds to complete per DAC module (a memory test is performed).

- The complete self- test will abort if any signals are connected to ABus1 via the rear- panel Analog Bus connector (pins 4, 5, and 9; see "Analog Buses" on page 16). Be sure to disconnect any signals from ABus1 prior to running the self- test.

- If the power- on or complete self- test fails, and error is stored in the error queue. See the Agilent 34980A *Service Guide* for more information on returning the instrument to Agilent for service.

- Following the complete self- test, the instrument issues a Factory Reset (`*RST` command).

Remote Interface Operation: The following command returns "+0" if the self- test is successful or "+1" if it fails.

```
*TST?
```

Front-Panel Display Control

For security reasons or for a slight increase in measurement rates, you may want to turn off the front- panel display. From the remote interface, you can also display up to 18 characters on the upper line of the front- panel display.

- You can disable the front- panel display only by sending a command from the remote interface (i.e., you cannot disable the front panel while in local operation).

- When disabled, the entire front- panel display goes dark and all display annunciators except ERROR, HOT, and Safety Interlock are disabled.

- The front- panel display is automatically enabled when power is cycled, after a Factory Reset (`*RST` command), or after an Instrument Preset (`SYSTem:PRESet` command).

- You can display a message on the front panel by sending a command from the remote interface. The instrument can display up to 18 characters on the upper line of the front-panel display; any additional characters are truncated (no error is generated). You can use letters (A-Z), numbers (0-9), and special characters like "@", "%", "*", etc. Use the "#" character to display a degree symbol (°). Commas, periods, and semicolons share a display space with the preceding character, and are not considered individual characters.

- While a message is displayed on the front panel, readings from a scan or monitor are not sent to the front-panel display.

- Sending a text message to the display overrides the display state; this means that you can display a message even if the display is turned off. In addition, pressing any front-panel key will clear the text message.

Remote Interface Operation: The following command turns off the front-panel display.

```
DISPLAY OFF
```

The following command displays a message on the front panel and turns on the display if currently disabled (the quotes are not displayed).

```
DISPLAY:TEXT "SCANNING ..."
```

To clear the message displayed on the front panel (without changing the display state), send the following command.

```
DISPLAY:TEXT:CLEAR
```

Front-Panel Number Format

The instrument can show numbers on the front-panel display with periods or commas for the decimal point (radix) and thousands separator.

This feature is available from the front panel only.

- The number format is stored in non-volatile memory, and does *not* change when power has been off, after a Factory Reset (`*RST` command), or after an Instrument Preset (`SYSTem:PRESet` command).

- When shipped from the factory, a period is used as the radix character and commas are used for the digits separator (e.g., +1.234,56 VDC).

Front Panel Operation: Utility > MISC. SETTINGS > RADIX|THOUSAND SEPARATOR

Real-Time System Clock

During a scan, the instrument stores all readings and alarms with the current time and date (based on a 24-hour clock).

- When shipped from the factory, the instrument is set to the current time and date for Greenwich Mean Time (GMT).

- The clock setting is stored in non-volatile memory, and does not change when power has been off, after a Factory Reset (`*RST` command), or after an Instrument Preset (`SYSTem:PRESet` command).

Front Panel Operation: Utility > DATE/TIME

Remote Interface Operation: The following commands show how to set the time and date.

```
SYST:TIME 15,30,23.000        Set time to 3:30:23.000 PM
SYST:DATE 2004,11,24          Set date to November 21, 2004
```

Internal DMM Disable

You can scan through the configured channels using either the internal DMM (an optional accessory with the 34980A) or an external instrument. For externally-controlled scans, you must either disable the internal DMM or remove it from the instrument.

- For information on controlling a scan with an external instrument, refer to "Scanning With External Instruments" on page 65.

- With the internal DMM disabled, any command received that is directed to the DMM or requires its use (e.g., configuring a multiplexer channel for a DMM measurement), will generate an error.

- When you change the state of the internal DMM, the instrument issues a Factory Reset (`*RST` command).

- If you ordered the internal DMM, it is enabled when shipped from the factory.

- The internal DMM setting is stored in *volatile* memory and will be enabled (ON) when power is turned off or after a Factory Reset (`*RST` command).

Front Panel Operation: Utility > DMM

Remote Interface Operation: `INSTrument:DMM[:STATe] {OFF|ON}`

Relay Cycle Count

The instrument has a *Relay Maintenance System* to help you predict relay end-of-life. The instrument counts the cycles on each relay in the instrument and stores the total count in non-volatile memory on each relay module. You can use this feature on any of the relay modules and the internal DMM.

- In addition to the channel relays, you can also query the count on the Analog Bus relays and bank relays.

- You can query the state of six relays associated with function selection and isolation on the internal DMM. These relays are numbered K102 through K107.

- You can reset the cycle count on any of the channel relays, Analog Bus relays, or bank relays (allowed only from remote) but the instrument must be unsecured. See "To Unsecure the Instrument for Calibration" on page 95 for more information.

Front Panel Operation: View > RELAY CYCLES

Turn the knob to read the count on the desired channel relay or Analog Bus relay.

Remote Interface Operation: To read the count on either the specified internal DMM relay or module channel relays, send the following commands.

```
DIAG:DMM:CYCLES? 2
DIAG:RELAY:CYCLES? (@1003,1013)
```

To reset the cycle count on the specified module channel relays, send the following command (the instrument must be unsecured).

```
DIAG:RELAY:CYCLES:CLEAR (@1003,1911)
```

SCPI Language Version

The instrument complies with the rules and conventions of the present version of SCPI (*Standard Commands for Programmable Instruments*). You can determine the SCPI version with which the instrument is in compliance by sending a command from the remote interface.

- You can query the SCPI version from the remote interface only.

- The SCPI version is returned in the form "YYYY.V", where "YYYY" represents the year of the version, and "V" represents a version number for that year (for example, 1994.0).

Remote Interface Operation: `SYSTem:VERSion?`

Calibration Overview

This section gives a brief introduction to the calibration features of the instrument and plug-in modules. For a more detailed discussion of the calibration procedures, see the Agilent 34980A *Service Guide*.

Calibration Security

This feature allows you to enter a security code to prevent accidental or unauthorized calibrations of the instrument. The specified code is used to unsecure the mainframe and all installed modules. When you first receive your instrument, it is secured. Before you can calibrate the instrument, you must unsecure it by entering the correct security code.

- The security code is set to "AT34980" when the instrument is shipped from the factory. The security code is stored in non-volatile memory in the mainframe, and does not change when power has been off, after a Factory Reset (`*RST` command), or after an Instrument Preset (`SYSTem:PRESet` command).

- The security code can contain up to 12 characters. The first character must be a letter (A-Z), but the remaining 11 characters can be letters, numbers (0-9), or the underscore character ("_"). Blank spaces are not allowed. You do not have to use all 12 characters but the first character must always be a letter.

To Unsecure the Instrument for Calibration

You can unsecure the instrument from either the front panel or over the remote interface. The instrument is secured when shipped from the factory.

Once you enter a security code, that code must be used for both front-panel and remote operation. For example, if you secure the instrument from the front panel, you must use that same code to unsecure it from the remote interface.

Front Panel Operation: Utility > CALIBRATE > UNSECURE

Remote Interface Operation: To unsecure the instrument, send the following command (the factory security code is shown).

```
CAL:SECURE:STATE OFF,AT34980
```

To Secure the Instrument for Calibration

You can secure the instrument either from the front panel or over the remote interface. The instrument is secured when shipped from the factory.

Once you enter a security code, that code must be used for both front-panel and remote operation. For example, if you secure the instrument from the front panel, you must use that same code to secure it from the remote interface.

Front Panel Operation: Utility > CALIBRATE > SECURE

Remote Interface Operation: To secure the instrument, send the following command (the factory security code is shown).

```
CAL:SECURE:STATE ON,AT34980
```

To Change the Security Code

To change the security code, you must first unsecure the instrument, and then enter a new code. Make sure you have read the security code rules described on before attempting to change the security code.

Front Panel Operation: Utility > CALIBRATE > SET CAL CODE

To change the security code, unsecure the instrument using the old security code. Then go back into the menu and change the code. Changing the code from the front panel also changes the security code as seen from the remote interface.

Remote Interface Operation: To change the security code, unsecure the instrument using the old security code. Then enter the new code as shown below.

```
CAL:SECURE:STATE OFF,AT34980    Unsecure with old code
CAL:SECURE:CODE SN123456789     Enter new code
```

Calibration Count

You can query the instrument to determine how many calibrations have been performed on the entire mainframe, the digital modules, or the internal DMM. Note that your instrument was calibrated before it left the factory. When you receive your instrument, be sure to read the various counts to determine the initial values.

• The calibration count is stored in non-volatile memory in the mainframe, and does not change when power has been off, after a Factory Reset (`*RST` command), or after an Instrument Preset (`SYSTem:PRESet` command).

• The calibration counts increments up to a maximum of 4,294,967,295 after which they roll over to "0". Since the value increments by one for each calibration point, a complete calibration may increase the value by many counts.

• The calibration count is also incremented with calibrations of DAC channels on the 34951A Isolated DAC Module and 34952A Multifunction Module.

Front Panel Operation: Utility > CALIBRATE > COUNT

Remote Interface Operation: `CALibration:COUNt?`

Calibration Message

The instrument allows you to store one message in calibration memory in the mainframe, a digital module, or the internal DMM. For example, you can store such information as the date when the last calibration was performed, the date when the next calibration is due, the instrument's serial number, or even the name and phone number of the person to contact for a new calibration.

- You can record a calibration message *only* from the remote interface and *only* when the instrument is unsecured. You can read the message (mainframe message only) from either the front-panel or over the remote interface. You can read the calibration message whether the instrument is secured or unsecured.

- The calibration message may contain up to 40 characters. From the front panel, you can view 18 characters of the message at a time.

- Storing a calibration message will overwrite any message previously stored in memory.

- The calibration message is stored in non-volatile memory in the mainframe, a digital module, or the internal DMM, and does not change when power has been off, after a Factory Reset (`*RST` command), or after an Instrument Preset (`SYSTem:PRESet` command).

Front Panel Operation: Utility > CALIBRATE > CAL MESSAGE

Remote Interface Operation: The following example shows how to store a message in calibration memory on the module in slot 3.

```
CAL:STRING "CAL: 21 NOV 2005",3
```

Remote Interface Configuration

This section gives information on configuring the instrument for remote interface communication. For more information on the SCPI commands available to program the instrument over the remote interface, see the *Programmer's Reference* Help file included on the Agilent 34980A *Product Reference CD-ROM* shipped with the instrument.

The Agilent 34980A supports GPIB, USB, and LAN interfaces. All three interfaces are enabled at power on. The corresponding front-panel annunciator turns on whenever there is activity on the remote interface.

GPIB Interface   You need only set the GPIB address for the instrument and connect it to your PC using a GPIB cable (sold separately).

USB Interface   There is nothing to configure on your instrument for a USB connection. Just connect the instrument to your PC using a USB 2.0 cable (sold separately).

LAN Interface   By default, DHCP is enabled on the instrument, which may enable network communication over the LAN interface (10BaseT/100BaseTx). You may need to set several configuration parameters as described in the LAN configuration sections that follow. A crossover LAN cable is shipped with your instrument.

NOTE	To easily configure and verify an interface connection between the 34980A and your PC, you can use the Agilent IO Libraries Suite (E2094M Agilent IO Libraries for Windows) or an equivalent.

- Agilent IO Libraries Suite for Windows® 98/2000/ME/XP. For more information and to install this software, see the *Automation-Ready CD*, which is shipped with your 34980A.
- Previous versions of the Agilent IO Libraries for Windows® 98/NT/2000/ME/XP.

NOTE	For more information on connecting instruments to USB, LAN, and GPIB and how to configure and troubleshoot these interfaces, refer to the Agilent *Connectivity Guide.*

If you have installed the Agilent IO Libraries Suite, you can access the guide from the Agilent IO Libraries Control icon.

GPIB Interface

Each device on the GPIB (IEEE-488) interface must have a unique address. You can set the instrument's address to any value between 0 and 30. The address is set to "**9**" when the instrument is shipped from the factory.

- Your computer's GPIB interface card has its own address. Be sure to avoid using the computer's address for any instrument on the interface bus.

- The GPIB address is stored in non-volatile memory, and does not change when power has been off, after a Factory Reset (`*RST` command), or after an Instrument Preset (`SYSTem:PRESet` command).

Front Panel Operation: Utility > REMOTE I/O > GPIB > GPIB ADDRESS

To set the GPIB address, turn the knob (or use the number keypad) to select the desired address.

Remote Interface Operation: `SYSTem:COMMunicate:GPIB:ADDRess`

USB Interface

For the USB interface, no configuration parameters are required to set up the instrument. Connect your instrument to a USB port on your computer. Note that it may take several seconds for the computer to recognize and establish a connection to the instrument.

LAN Interface

By default, DHCP is enabled on the instrument, which may enable network communication over the LAN interface. You may need to set several configuration parameters as described in this section.

34980A Web Browser Interface

The Agilent 34980A provides a Web Interface which is built into the instrument. You can use this interface over LAN for remote access and control of the instrument via a Java®-enabled Web browser, such as Microsoft® Internet Explorer.

To access and use the 34980A Web Interface:

3 Establish a LAN interface connection from your computer to the 34980A.

4 Open your computer's Web browser.

5 Launch the 34980A Web Interface by entering the IP address of your 34980A, or its fully-qualified host name, in the browser address field.

6 Follow the instructions in the 34980A Web Interface's on-line Help.
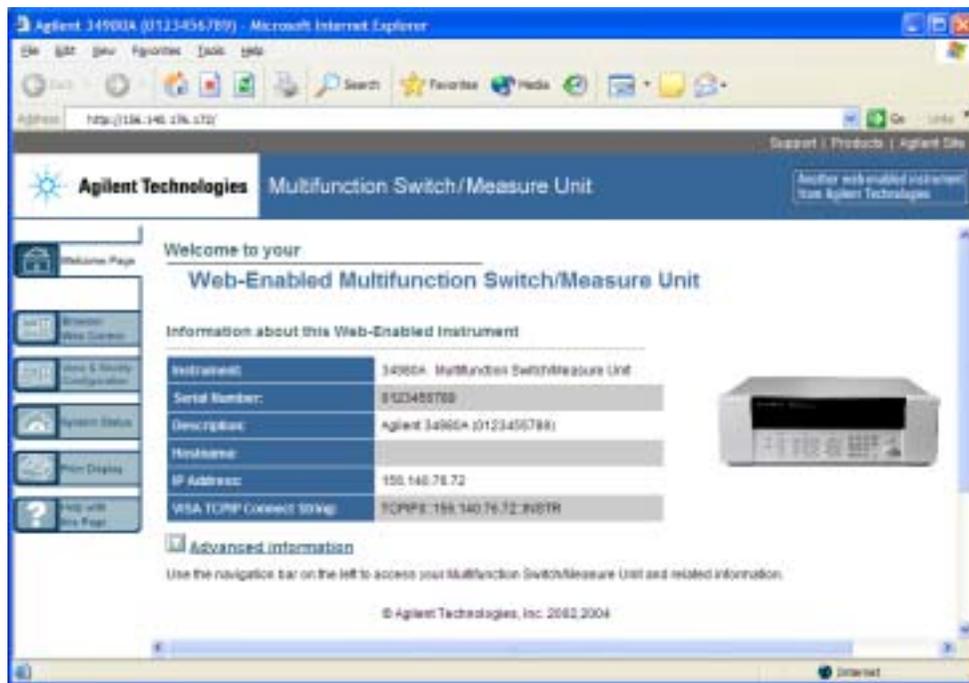
Agilent 34980A Web Interface

If desired, you can control access to the 34980A Web Interface using password protection. As shipped from the factory, no password is set. To set a password (available from the front panel only), navigate to the WEB PASSWORD menu selection from the 34980A front panel.

Utility > REMOTE I/O > LAN > LAN SETTINGS > MODIFY > . . . WEB PASSWORD

DHCP

DHCP (Dynamic Host Configuration Protocol) is a protocol for automatically assigning a dynamic IP address to a device on a network. DHCP is typically the easiest way to configure your instrument for remote communication using the LAN interface.

If you change the DHCP setting, you must cycle power on the 34980A to activate the new setting.

- When DHCP is *enabled* (factory setting), the instrument will try to obtain an IP address from a DHCP server. If a DHCP server is found, it will assign a dynamic IP address, Subnet Mask, and Default Gateway to the instrument.
- When DHCP is *disabled* or unavailable, the instrument will use the static IP address, Subnet Mask, and Default Gateway during power-on.
- If a DHCP LAN address is not assigned by a DHCP server, then a static IP will be assumed after approximately 2 minutes.
- The DHCP setting is stored in non-volatile memory, and does not change when power has been off, after a Factory Reset (`*RST` command), or after an Instrument Preset (`SYSTem:PRESet` command).

Front Panel Operation:

Utility > REMOTE I/O > LAN > LAN SETTINGS > MODIFY > DHCP

Remote Interface Operation:

`SYSTem:COMMunicate:LAN:DHCP {OFF|ON}`

IP Address

An Internet Protocol (IP) Address is required for all IP and TCP/IP communications with the instrument. If DHCP is enabled (factory setting), the specified static IP address is not used. However, if the DHCP server fails to assign a valid IP address, the currently configured static IP address will be used.

If you change the IP address, you must cycle power on the 34980A to activate the new setting.

- The default IP Address for the 34980A is "169.254.9.80".

- Dot-notation addresses ("nnn.nnn.nnn.nnn" where "nnn" is a byte value) must be expressed with care, as most web software on the computer will interpret byte values with leading zeros as octal numbers. For example, "255.255.020.011" is actually equivalent to decimal "255.255.16.9" not "255.255.20.11" because ".020" is interpreted as "16" expressed in octal, and ".011" as "9". To avoid confusion, use only decimal expressions of byte values (0 to 255), with no leading zeros.

  For example, the 34980A assumes that all dot-notation addresses are expressed as decimal byte values and strips all leading zeros from these byte values. Thus, attempting to set an IP address of "255.255.020.011" will become "255.255.20.11" (a purely decimal expression). Be sure to enter the exact expression, "255.255.20.11", in your computer web software to address the instrument. Do not use "255.255.020.011" — the computer will interpret this address differently due to the leading zeros.

- If you are planning to use a static IP address on a Corporate LAN, contact your network administrator to obtain a fixed IP address to be used exclusively for your instrument.

- The IP address is stored in non-volatile memory, and does not change when power has been off, after a Factory Reset (`*RST` command), or after an Instrument Preset (`SYSTem:PRESet` command).

Front Panel Operation:

Utility > REMOTE I/O > LAN > LAN SETTINGS > MODIFY > DHCP OFF >
AUTO IP OFF > IP ADDRESS

Remote Interface Operation:

`SYSTem:COMMunicate:LAN:IPADdress <address>`

Auto-IP

The Auto-IP standard automatically assigns an IP address to the 34980A when on a network that does not have DHCP servers.

If you change the Auto-IP configuration, you must cycle power on the 34980A to activate the new setting.

- Auto-IP allocates IP addresses from the link-local address range (169.254.xxx.xxx).

- From the factory, the Auto-IP setting is enabled.

- The Auto-IP setting is stored in non-volatile memory, and does not change when power has been off, after a Factory Reset (`*RST` command), or after an Instrument Preset (`SYSTem:PRESet` command).

Front Panel Operation:

Utility > REMOTE I/O > LAN > LAN SETTINGS > MODIFY > DHCP OFF > AUTO IP

Remote Interface Operation:

```
SYSTem:COMMunicate:LAN:AUTOip (OFF|ON}
```

Subnet Mask

The instrument uses the Subnet Mask to determine if a client IP address is on the same local subnet. When a client IP address is on a different subnet, all packets must be sent to the Default Gateway. Contact your network administrator to determine if subnetting is being used and for the correct Subnet Mask.

If you change the Subnet Mask, you must cycle power on the 34980A to activate the setting.

- The default Subnet Mask for the 34980A is "255.255.0.0".

- If DHCP is enabled, the specified Subnet Mask is not used. However, if the DHCP server fails to assign a valid IP address, the currently configured Subnet Mask will be used.

- Dot-notation addresses ("nnn.nnn.nnn.nnn" where "nnn" is a byte value) must be expressed with care, as most web software on the computer will interpret byte values with leading zeros as octal numbers. For example, "255.255.020.011" is actually equivalent to decimal "255.255.16.9" not "255.255.20.11" because ".020" is interpreted as "16" expressed in octal, and ".011" as "9". To avoid confusion, use only decimal expressions of byte values (0 to 255), with no leading zeros.

  For example, the 34980A assumes that all dot-notation addresses are expressed as decimal byte values and strips all leading zeros from these byte values. Thus, attempting to set a Subnet Mask of "255.255.020.011" will become "255.255.20.11" (a purely decimal expression). Be sure to enter the exact expression, "255.255.20.11", in your computer web software to address the instrument. Do not use "255.255.020.011" — the the computer will interpret this address differently due to the leading zeros.

- A value of "0.0.0.0" or "255.255.255.255" indicates that subnetting is not being used.

- The Subnet Mask is stored in non-volatile memory, and does not change when power has been off, after a Factory Reset (`*RST` command), or after an Instrument Preset (`SYSTem:PRESet` command).

Front Panel Operation:

Utility > REMOTE I/O > LAN > LAN SETTINGS > MODIFY > DHCP OFF >
AUTO IP OFF > . . . SUBNET MASK

Remote Interface Operation:

`SYSTem:COMMunicate:LAN:SMASk <mask>`

Default Gateway

A Default Gateway address allows the instrument to communicate with systems that are not on the local subnet. Thus, this is the Default Gateway where packets are sent which are destined for a device not on the local subnet, as determined by the Subnet Mask setting. Contact your network administrator to determine if a gateway is being used and for the correct address.

If you change the Default Gateway, you must cycle power on the 34980A to activate the new setting.

- The default for the 34980A is "0.0.0.0" (no gateway, and subnetting is not being used).

- If DHCP is enabled, the specified Default Gateway is not used. However, if the DHCP server fails to assign a valid IP address, the currently configured Default Gateway will be used.

- Dot-notation addresses ("nnn.nnn.nnn.nnn" where "nnn" is a byte value) must be expressed with care, as most web software on the computer will interpret byte values with leading zeros as octal numbers. For example, "255.255.020.011" is actually equivalent to decimal "255.255.16.9" not "255.255.20.11" because ".020" is interpreted as "16" expressed in octal, and ".011" as "9". To avoid confusion, use only decimal expressions of byte values (0 to 255), with no leading zeros.

  For example, the 34980A assumes that all dot-notation addresses are expressed as decimal byte values and strips all leading zeros from these byte values. Thus, attempting to set a Default Gateway of "255.255.020.011" will become "255.255.20.11" (a purely decimal expression). Be sure to enter the exact expression, "255.255.20.11", in your computer web software to address the instrument. Do not use "255.255.020.011" — the computer will interpret this address differently due to the leading zeros.

- The Default Gateway is stored in non-volatile memory, and does not change when power has been off, after a Factory Reset (`*RST` command), or after an Instrument Preset (`SYSTem:PRESet` command).

Front Panel Operation:

Utility > REMOTE I/O > LAN > LAN SETTINGS > MODIFY > DHCP OFF >
AUTO IP OFF > . . . DEFAULT GATEWAY

Remote Interface Operation:

```
SYSTem:COMMunicate:LAN:GATEway <address>
```

Host Name

The Host Name is the host portion of the domain name, which is translated into an IP address.

If you change the Host Name, you must cycle power on the 34980A to activate the new setting.

- The default Host Name for the 34980A is "A-34980A-***nnn***", where ***nnn*** is the instrument's serial number representation.
- If Dynamic Domain Name System (DNS) is available on your network and your instrument uses DHCP, the Host Name is registered with the Dynamic DNS service at power-on.
- If DHCP is enabled, the DHCP server can change the specified Host Name.
- The Host Name is stored in non-volatile memory, and does not change when power has been off, after a Factory Reset (`*RST` command), or after an Instrument Preset (`SYSTem:PRESet` command).

Front Panel Operation:

Utility > REMOTE I/O > LAN > LAN SETTINGS > MODIFY > . . . HOST NAME

Remote Interface Operation:

```
SYSTem:COMMunicate:LAN:HOSTname "<name>"
```

DNS Server

The Domain Name Service (DNS) is an Internet service that translates Domain names into IP addresses. Contact your network administrator to determine if DNS is being used and for the correct address.

If you change the DNS address, you must cycle power on the 34980A to activate the new setting.

- The default DNS Address for the 34980A is "0.0.0.0".

- Dot‑notation addresses ("nnn.nnn.nnn.nnn" where "nnn" is a byte value) must be expressed with care, as most web software on the computer will interpret byte values with leading zeros as octal numbers. For example, "255.255.020.011" is actually equivalent to decimal "255.255.16.9" not "255.255.20.11" because ".020" is interpreted as "16" expressed in octal, and ".011" as "9". To avoid confusion, use only decimal expressions of byte values (0 to 255), with no leading zeros.

  For example, the 34980A assumes that all dot‑notation addresses are expressed as decimal byte values and strips all leading zeros from these byte values. Thus, attempting to set an IP address of "255.255.020.011" will become "255.255.20.11" (a purely decimal expression). Be sure to enter the exact expression, "255.255.20.11", in your computer web software to address the instrument. Do not use "255.255.020.011" — the computer will interpret this address differently due to the leading zeros.

- The DNS address is stored in non‑volatile memory, and does not change when power has been off, after a Factory Reset (`*RST` command), or after an Instrument Preset (`SYSTem:PRESet` command).

Front Panel Operation:

Utility > REMOTE I/O > LAN > LAN SETTINGS > MODIFY > DHCP OFF >
AUTO IP OFF > . . . DNS SERVER

Remote Interface Operation:

`SYSTem:COMMunicate:LAN:DNS <address>`

Domain Name

A domain name is a registered name on the Internet, which is translated into an IP address. *This feature is available from the remote interface only.*

If you change the Domain Name, you must cycle power on the 34980A to activate the new setting.

- If Dynamic Domain Name System (DNS) is available on your network and your instrument uses DHCP, the Domain Name is registered with the Dynamic DNS service at power-on.

- If DHCP is enabled, the DHCP server can change the specified Domain Name.

- The Domain Name is stored in non-volatile memory, and does not change when power has been off, after a Factory Reset (`*RST` command), or after an Instrument Preset (`SYSTem:PRESet` command).

Remote Interface Operation:

```
SYSTem:COMMunicate:LAN:DOMain "<name>"
```

Factory Reset State

The following tables show the state of the instrument after a `*RST` or `SYSTem:CPON` command is executed.

Measurement Configuration	Factory Reset State
Function	DC Volts
Range	Autorange
Resolution	5½ Digits
Integration Time	1 PLC
Input Resistance	10 MΩ (fixed for all DCV ranges)
Channel Labels	No Change
Channel Delay	Automatic Delay
Reading Format	Reading Only (no units, channel, time)
Sample Count	1 Sample per Trigger
Trigger Count	1 Trigger
Trigger Delay	Automatic Delay
Trigger Source	Immediate

Scanning Operations	Factory Reset State
Scan List	Empty
Reading Memory	All Readings are Cleared
Min, Max, and Average	All Statistical Data is Cleared
Sweep Count	1 Sweep
Trigger Interval	1 Second
Monitor in Progress	Stopped

Mx+B Scaling	Factory Reset State
Scaling State	Off
Gain Factor ("M")	1
Offset Factor ("B")	0
Scale Label	Null String (" ")

Alarm Limits	Factory Reset State
Alarm Queue	Not Cleared
Alarm State	Off
HI and LO Alarm Limits	0
Alarm Output	Alarm 1
Alarm Output Configuration	Latched Mode
Alarm Output State	Output Lines are Cleared
Alarm Output Slope	Fail = Low

Module Hardware	Factory Reset State
Multiplexer Modules	All Channels Open 2-Wire/1-Wire Mode: No Change
Matrix Modules	All Channels Open 2-Wire/1-Wire Mode: No Change
GP Modules	All Channels Open
RF Modules	Channels **b**01 and **b**02 Selected (**b**=Bank)
Microwave Modules	34945A: All Channel Drives = Default 34946A: Channels 101 and 201 to COM 34947A: Channels 101, 201, and 301 to COM
System Control Modules	34950A: DIO Ports = Input, Count = 0, Trace Patterns are Cleared 34951A: DACs=0 Vdc, Trace Waveforms Cleared 34952A: DIO Ports=Input, Count=0, DACs=0 Vdc 34959A: DIO Ports=Input, All Relay Channels Open

System-Related Operations	Factory Reset State
Display State	On
Error Queue	Errors Not Cleared
Stored States	No Change
System Date	No Change
System Time	No Change
Temperature Units	°C

Instrument Preset State

The following tables show the state of the instrument after a SYSTem:PRESet command is executed.

Measurement Configuration	Preset State
Function	No Change
Range	No Change
Resolution	No Change
Integration Time	No Change
Input Resistance	No Change
Channel Labels	No Change
Channel Delay	No Change
Reading Format	No Change
Sample Count	No Change
Trigger Count	No Change
Trigger Delay	No Change
Trigger Source	No Change

Scanning Operations	Preset State
Scan List	No Change
Reading Memory	All Readings are Cleared
Min, Max, and Average	All Statistical Data is Cleared
Sweep Count	No Change
Trigger Interval	No Change
Monitor in Progress	Stopped

Mx+B Scaling	Preset State
Scaling State	No Change
Gain Factor ("M")	No Change
Offset Factor ("B")	No Change
Scale Label	No Change

Alarm Limits	Preset State
Alarm Queue	No Change
Alarm State	No Change
HI and LO Alarm Limits	No Change
Alarm Output	No Change
Alarm Output Configuration	No Change
Alarm Output State	Output Lines are Cleared
Alarm Output Slope	No Change

Module Hardware	Preset State
Multiplexer Modules	All Channels Open 2-Wire/1-Wire Mode: No Change
Matrix Modules	All Channels Open 2-Wire/1-Wire Mode: No Change
GP Modules	All Channels Open
RF Modules	Channels **b**01 and **b**02 Selected (**b**=Bank)
Microwave Modules	34945A: All Channel Drives = Default 34946A: Channels 101 and 201 to COM 34947A: Channels 101, 201, and 301 to COM
System Control Modules	34950A: DIO Ports = Input, Count = 0, Trace Patterns are Cleared 34951A: DACs=0 Vdc, Trace Waveforms Cleared 34952A: DIO Ports=Input, Count=0, DACs=0 Vdc 34959A: DIO Ports=Input, All Relay Channels Open

System-Related Operations	Preset State
Display State	On
Error Queue	Errors Not Cleared
Stored States	No Change
System Date	No Change
System Time	No Change
Temperature Units	°C
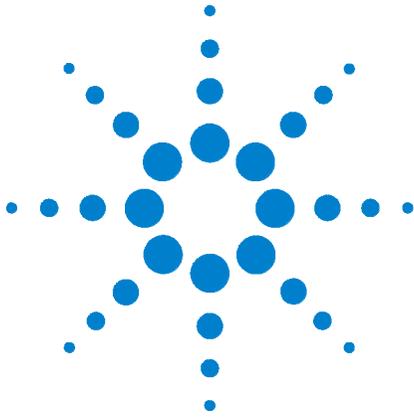
3

Introduction to the Plug-In Modules for the 34980A

Slot and Channel Addressing Scheme

The eight module slots in the 34980A are arranged as shown below.

Slot number indications
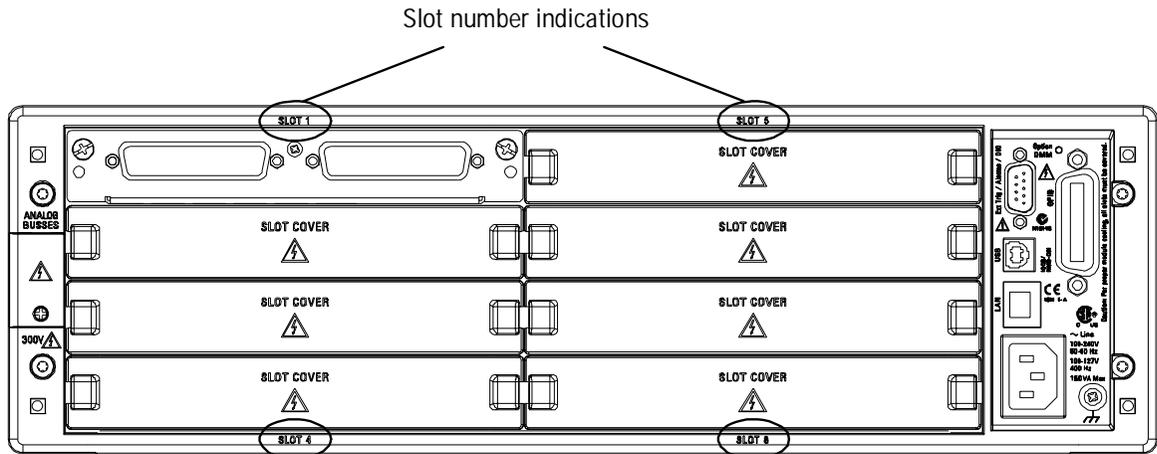
The slot and channel addressing scheme for the 34980A follows the form *sccc* where *s* is the mainframe slot number (1 through 8) and *ccc* is the three-digit channel number. Note that MUX channels numbers are derived differently from matrix modules, and channel numbers for matrix modules are derived differently between 1-wire and 2-wire configuration modes.

Displayed Number...	Means This...	Determined by...
1014	A MUX module is in slot 1, channel of interest is 14. This channel is labeled on the simplified schematics as 014 on Bank 1 of each MUX module.	MUX module channel numbers are determined by the numbers assigned to the switches on each bank. Channel numbers contain three digits.
3921	A MUX or matrix module is in slot 3, channel of interest is 921 (Analog Bus relay on ABus1)	MUX and matrix channel numbers for the Analog Bus relays are determined by the number assigned to the relays.
5304	A 34931A, 34932A, 34933A (2-wire mode) matrix module is in slot 5, crosspoint is row 3, column 4.	Matrix module (in 2-wire mode) channel numbers are derived from the crosspoint or intersection of rows and columns, columns having two digits).
2437	A 34933A matrix module in 1-wire mode is in slot 2, matrix of interest is 4, crosspoint is row 3, column 7.	34933A matrix module (in 1-wire mode) channel numbers are derived from a specific matrix number and the crosspoint or intersection of rows and columns on that matrix.

Interconnection Solutions Overview

Depending on your specific requirements, you can connect your DUT to the 34980A using the following optional interconnection solutions. See the 34980A Product Data Sheet for additional information.

Terminal Blocks Detachable terminal blocks are available for the low-frequency modules and offer a flexible method for connecting external wiring (300V rated). Each terminal block is customized for a specific module (not available for RF and microwave modules).

Ordering Information: 349*xx*T (e.g., 34921T, 34922T, etc.)

Shielded Cables Standard cables are available for 50-pin D-sub and 78-pin D-sub connectors. Depending on the module and your specific requirements, one or two cables may be required per module.

Ordering Information:
   Y1135A (1.5 meters, 50-pin D-sub, 300V)
   Y1136A (3 meters, 50-pin D-sub, 300V)
   Y1137A (1.5 meters, 78-pin D-sub, 300V)
   Y1138A (3 meters, 78-pin D-sub, 300V)

Solder Cup Connector Kits These connector kits are available if you want to build your own custom cables.
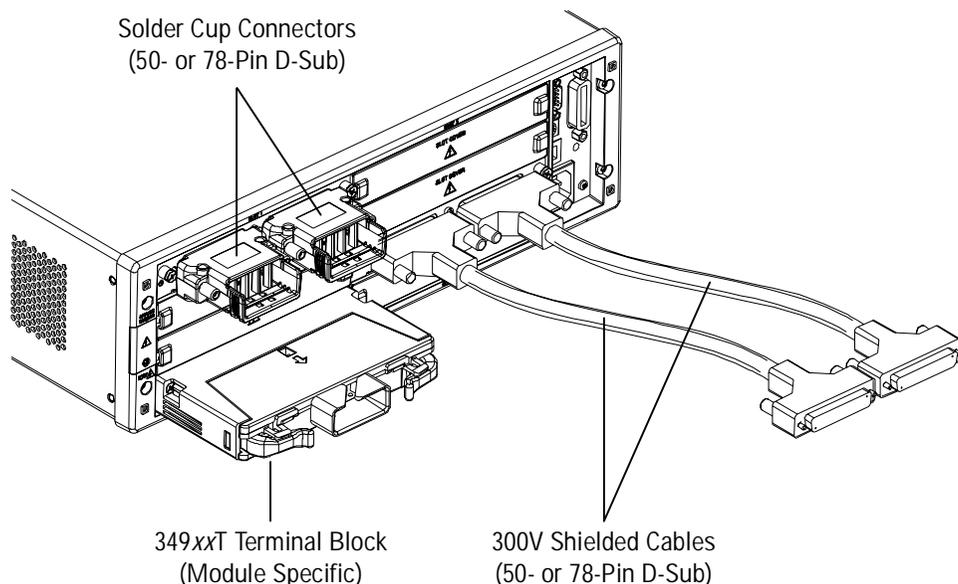
Ordering Information:
   Y1139A (50-pin D-sub female, 125V, for 34921/23/25/31/32/33/37/38)
   Y1140A (78-pin D-sub female, 60V, for 34922/24)
   Y1141A (50-pin D-sub male, 125V, for 34951/52)
   Y1142A (78-pin D-sub male, 60V, for 34950)

Solder Cup Connectors
(50- or 78-Pin D-Sub)

349*xx*T Terminal Block
(Module Specific)

300V Shielded Cables
(50- or 78-Pin D-Sub)

Module Considerations

This section lists important items and actions that can affect the operation of your modules.

General Considerations

NOTE	To reduce wear on the internal DMM relays, wire *like* functions on adjacent channels.

Environmental Operating Conditions

These modules are designed to operate in a temperature range of 0 °C to +55 °C with non-condensing humidity. The maximum humidity is 80% at 40 °C or higher. Do not use in locations where conductive dust or electrolytic salt dust may be present.

These modules should be operated in an indoor environment where temperature and humidity are controlled. Condensation can pose a potential shock hazard. Condensation can occur when the modules are moved from a cold to a warm environment, or if the temperature and/or humidity of the environment changes quickly.

The following table shows maximum voltage ratings for each module. If conditions change, ensure that condensation has evaporated and the instrument has thermally stabilized until pollution degree 1 conditions are restored before turning on power to the equipment.

Module	Pollution Degree 1 Specifications	Pollution Degree 2 Specifications
34921A	40 channels, 300 V rms or DC, 1 A, 60 VA per channel	40 channels, 100V rms or DC, 1 A, 60 VA per channel
34922A	70 channels, 300 V rms or DC, 1 A 60 VA per channel	70 channels, 100 V, 1 A, 60 VA per channel
34923A	20/40/80 channels, 150 Vpeak, 0.5 A, 10 VA per channel	20/40/80 channels, 100 Vpeak, 0.5 A, 10 VA per channel
34924A	70 channels, 150 Vpeak, 0.5 A, 10 VA per channel	70 channels, 100 Vpeak, 0.5 A, 10 VA per channel
34925A	40/80 channels, 80 Vpeak, 50 mA	40/80 channels, 80 Vpeak, 50 mA
34931A	Dual 4x8 matrix, 300 V rms or DC, 1 A, 60 VA per channel	Dual 4x8 matrix, 100 V rms or DC, 1 A, 60 VA per channel
34932A	Dual 4x16 matrix, 300 V rms or DC, 1 A, 60 VA per channel	Dual 4x16 matrix, 100 V rms or DC, 1 A, 60 VA per channel

Module	Pollution Degree 1 Specifications	Pollution Degree 2 Specifications
34933A	Dual/quad 4x8 matrix, 150 Vpeak, 0.5 A, 10 VA per channel	Dual/quad 4x8 matrix, 100 Vpeak, 0.5 A, 10 VA per channel
34937A	28 channels, 300 V rms or DC, 1 A, 60 VA per channel 4 channels, 250 V rms or 30 VDC, 5A, 150 VA per channel	28 channels, 100 V rms or DC, 1 A, 60 VA per channel 4 channels, 100 V rms or 30 VDC, 5A, 150 VA per channel
34938A	20 channels, 250 V rms or 30 VDC, 5 A, 150 VA per channel	20 channels, 100 V rms or 30 VDC, 5 A, 150 VA per channel
34941A	Four channels, 30 V, 0.5 A, 10 W per channel	Four channels, 30 V, 0.5 A, 10 W per channel
34942A	Four channels, 30 V, 0.5 A, 10 W per channel	Four channels, 30 V, 0.5 A, 10 W per channel
34945A	*See 34945A chapter on page 205.*	*See 34945A chapter on page 205.*
34946A	Dual channel, 7 V, 1 W per channel, 4 GHz or 20 GHz	Dual channel, 7 V, 1 W per channel, 4 GHz or 20 GHz
34947A	Triple channel, 7 V, 1 W per channel, 4 GHz or 20 GHz	Triple channel, 7 V, 1 W per channel, 4 GHz or 20 GHz
34950A	64 channels, 5 V, 30 mA Max	64 channels, 5V, 30 mA Max
34951A	4 channels, 16 V, 20 mA	4 channels, 16 V, 20 mA
34952A	32 DIO channels, 42 V, 400 mA, 2 channel DAC, 12 V, 10 mA	32 DIO channels, 42 V, 400 mA, 2 channel DAC, 12 V, 10 mA
34959A	*See 34959A chapter on page 311.*	*See 34959A chapter on page 311.*

NOTE   *Pollution Degree 1*: No pollution or only dry, non-conductive pollution occurs. The pollution has no influence (on insulation) (IEC 61010-1 2nd Edition).

NOTE   *Pollution Degree 2*: Normally only non-conductive pollution occurs. Occasionally, a temporary conductivity (leakage current between isolated conductors) caused by condensation can be expected (IEC 61010-1 2nd Edition).

CAUTION   For proper module cooling, all unused slots must be covered.

Electrical Operating Conditions

> **WARNING**   To avoid electric shock, turn off the 34980A and disconnect or de-energize all field wiring to the modules and the Analog Bus connector before removing any module or slot cover.

Transients

The 34921A, 34922A, 34923A, 34924A, 34925A, 34931A, 34932A, 34933A, 34937A, and 34938A modules are designed to safely withstand occasional transient overvoltages up to 1000 Vpeak. Typically, these transient overvoltages result from switching inductive loads or from nearby lightning strikes. The lightning-caused transient overvoltages that may occasionally occur on mains power outlets may be as high as 2500 Vpeak.

The 34941A, 34942A, 34945A, 34946A, 34947A, 34950A, 34951A, 34952A and 34959A modules are intended for only low-voltage applications, and should not be connected to circuits that may generate or conduct large transient voltages.

> **WARNING**   Do not connect any of the modules directly to a mains power outlet. If it is necessary to measure a mains voltage or any circuit where a large inductive load may be switched, you must add signal conditioning elements to reduce the potential transients before they reach the module or the Analog Buses.

High Energy Sources

These modules are designed to handle inputs up to their rated currents or their rated powers, whichever is less. Under certain fault conditions, high energy sources could provide substantially more current or power than a module can handle. It is important to provide external current limiting, such as fuses, if the module inputs are connected to high-energy sources.

> **CAUTION**   Install current limiting devices between high energy sources and the module inputs.

4

Low Frequency Multiplexer Switch Modules

Low Frequency Multiplexer Switch Modules

All low frequency multiplexer (MUX) switch modules feature two banks of channels that provide broad multiplexing and measuring capabilities. You can connect a MUX to an external instrument, and/or switch multiple analog signals to the internal DMM. With the 34921A, 34922A, 34923A, and the 34924A modules, you can close more than one channel in each bank simultaneously (N:1 configuration). As the 34925A module is protected with overvoltage circuitry, you can close only one channel in each bank at one time (1:N configuration).

And, you can connect multiple MUXes to the built-in Analog Buses, which allow you to scan as many as 560 2-wire (differential) channels or 640 1-wire (single-ended) channels in one 34980A mainframe.

NOTE	**Safety Interlock** The Analog Buses of the 34980A are capable of carrying 300V signals. The MUX and matrix modules have a hardware *Safety Interlock* feature that automatically opens the Analog Bus relays when the associated interlock pins on the D-sub connectors (faceplate) lose continuity. This prevents signals on the Analog Buses from being present on the D-sub connector pins. Optional terminal blocks available from Agilent automatically provide continuity for these interlock pins. If cables are used, you must provide continuity for the interlock pins in your DUT assembly. See the pinout information later in this chapter for the location of interlock pins on each module.

The MUX modules have Analog Bus relays on each of their two banks. Therefore, the interlock pins are present on both the Bank 1 and Bank 2 D-sub connectors on the MUX modules.

Normally, if you attempt to connect to the Analog Buses without a terminal block or cable connected, an error is generated. The `SYSTem:ABUS:INTerlock:SIMulate` command allows you to temporarily disable errors generated by the Safety Interlock feature and enables the simulation mode. Although Safety Interlock errors are suppressed in this mode, the actual Analog Bus relays affected by the Safety Interlock are disabled as long as no terminal block or cable is connected to the module.

Measurement Functions for the MUX Modules

The MUX modules support the DMM measurement functions as shown in the following table.

Function	34921A 40-Ch Arm MUX	34922A 70-Ch Arm MUX	34923A 40-Ch Reed MUX (2-Wire)	34923A 80-Ch Reed MUX (1-Wire)	34924A 70-Ch Reed MUX	34925A 40-Ch FET MUX (2-Wire)	34925A 80-Ch FET MUX (1-Wire)
Voltage, AC/DC	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Current, AC/DC	Yes[1]	No	No	No	No	No	No
Frequency/Period	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Ohms 2-Wire	Yes	Yes	Yes[5]	Yes[5]	Yes[5]	Yes[6]	Yes[6]
Ohms 4-Wire	Yes	Yes	Yes[5]	No	Yes[5]	Yes[6]	No
Thermocouple	Yes[2]	Yes[3]	Yes[3,4]	Yes[3,4]	Yes[3,4]	Yes[3]	Yes[3]
RTD 2-Wire	Yes	Yes	Yes[5]	Yes[5]	Yes[5]	No	No
RTD 4-Wire	Yes	Yes	Yes[5]	No	Yes[5]	Yes[6]	No
Thermistor	Yes	Yes	Yes[5]	Yes[5]	Yes[5]	No	No

[1] Direct current measurements are allowed on channels 41 through 44 only (for all other channels, external shunts are required).

[2] Optional 34921T Terminal Block is required for thermocouple measurements with built-in internal reference junction.

[3] A fixed or external reference junction temperature is required for thermocouple measurement with this module.

[4] Impact of higher offset voltage specification (< 50 μV) must be taken into consideration.

[5] 1 kΩ or higher range used unless 100Ω series resistors are bypassed on module.

[6] 10 kΩ or higher range used for loads over approximately 300Ω due to series resistance of FET channels.

SCPI Programming Examples for the MUX Modules

The programming examples below provide you with SCPI command examples to use for actions specific to the MUX modules.

The slot and channel addressing scheme used in these examples follow the form **sccc** where **s** is the mainframe slot number (1 through 8) and **ccc** is the three-digit channel number. For information on specific MUX channel configurations, refer to the simplified schematics contained in each MUX section of this chapter.

For complete information on the SCPI commands used to program the 34980A, refer to the Agilent 34980A Programmer's Reference contained on the 34980A Product Reference CD. For example programs, also refer to the 34980A Product Reference CD.

Opening and Closing Channels

Example: Closing and opening channels on the armature and reed MUX modules

This command closes the specified channels on a MUX module. If any channel in a bank is defined to be part of the scan list, and a scan is occurring, attempting to close another channel (including Analog Bus channels) within the same bank will result in an error. Channel closures in the other bank are allowed as long as no channels are part of the scan list.

The following commands close and open channels 13 and 15 through 18 in slot 3.

```
ROUTe:CLOSe (@3013,3015:3018)
ROUTe:OPEN (@3013,3015:3018)
```

Example: Closing channels on the FET MUX module   The FET MUX module supports a 1:N type closure, meaning that you can have only one channel per bank closed at a time. The following command closes then automatically opens each channel from 1-19 (Bank 1) in succession, leaving channel 20 closed. Then the command continues closing and opening channels 21 to 39 (Bank 2), then leaving channel 40 closed. At the end, only channels 20 and 40 will be closed, while all other channels will have been closed and then opened. In this process, a channel will open before the next channel in succession closes, making this a "break-before-make" series.

```
ROUTe:CLOSe (@3001:3040)
```

The following command opens the closed channel on Bank 1 of a FET MUX module in slot 3, and closes channel 15 on that bank.

```
ROUTe:CLOSe (@3015)
```

Example: Closing and opening Analog Bus relays   The following command connects the Analog Buses to Bank 1 (via the Analog Bus relays on Bank 1) for a module in slot 3.

```
ROUTe:CLOSe (@3911,3912,3913,3914)
ROUTe:OPEN (@3911,3912,3913,3914)
```

The Analog Bus relays (numbered s911, s912, s913, etc.) on the MUX modules are ignored if they are included in a range of channels. An error will be generated if an Analog Bus relay is specified as the first or last channel in a range of channels. For example, the following command closes all valid channels between channel 30 (slot 1) and channel 5 (slot 2). In addition, this command closes Analog Bus relay 911 on the module in slot 1 (Bank 1). Note that although the specified range of channels includes the other Analog Bus relays, they are ignored and are not closed by this command.

```
ROUTe:CLOSe (@1030:2005,1911)
```

Example: Querying channels for open or close state   The following command returns a 1 (true) or 0 (false) state of channel 036 for a module in slot 3.

```
ROUTe:CLOSe (@3036)
ROUTe:CLOSe? (@3036) !Returns a 1
ROUTe:OPEN? (@3036) !Returns a 0
```

Making Measurements

Example: Making voltage measurements   The following command configures channels 9 and 10 in slot 4 for DC voltage measurements, triggers the internal DMM to scan channels 9 and 10, and returns the reading. The 1 V range is selected with 1 mV resolution.

```
MEASure:VOLTage:DC? 1,0.001, (@4009,4010)
```

Example: Making voltage measurements using INITiate and FETCh?
The following program segment shows how to use the `INITiate` command with the `CONFigure` and `FETCh?` commands. The `ROUTe:SCAN` command puts channels 3 and 8 (of a module in slot 1) into the scan list (and redefines the scan list). The `INITiate` command scans the specified channels, and then sends the readings to memory. The `FETCh?` command transfers the readings from memory to the user.

```
CONFigure:VOLTage:DC 10,0.003,(@1003,1008)
ROUTe:SCAN (@1003,1008)
INITiate
FETCh?
```

Example: Making current measurements   The following command configures channel 43 for a 34921A modules in slot 7 for dc current measurements, triggers the internal DMM to scan the channel, and then sends the reading to the output buffer of the 34980A. The default settings for range (autorange) and resolution (1 PLC) are used for the measurement.

```
MEASure:CURRent:DC? (@7043)
```

Configuring a Module

Example: Configuring a module for 2-wire or 1-wire mode   The following command configures a MUX module in slot 4 for 1-wire mode. Because you can configure only the 34923A and 34925A MUX modules (and the 34933A matrix module) for either 2-wire or 1-wire mode, an error is generated if you send this command to a slot that does not contain one of those three modules. If you are using terminal blocks with these modules, be sure to use the corresponding 2-wire or 1-wire terminal block.

```
SYSTem:MODule:WIRE:MODE WIRE1,4
```

> **NOTE**   When using a command to configure the system, the new configuration does not take effect until you cycle power on the 34980A.

Example: Querying the system for module Identify   The following command returns the identity of the module installed in slot 7.

```
SYSTem:CTYPe? 7
```

> **NOTE**   For the 34923A and the 34925A MUX modules, the query response may include a suffix to indicate a 1-wire configuration. For example, the response for the 34923A will be either "34923A" (differential mode) or "34923A-1W" (single-ended mode).

Querying and Clearing Cycle Count, and Resetting Modules

Example: Querying the cycle count for a relay   The following command returns the cycle count on channel 7 and channel 16 for a MUX module in slot 1.

```
DIAGnostic:RELay:CYCLes? (@1007,1016)
```

> **NOTE**   The 34925A will return 0 for relay counts because the FET relays on that module are non-mechanical and have an undefined lifetime.

Example: Clearing the cycle count for a relay   The following command resets the cycle count to zero on the channels 7 and 16 for a MUX module in slot 1.

```
DIAGnostic:RELay:CYCLes:CLEar (@1007,1016)
```

Example: Resetting module(s) to power-on state   The following command resets a module in slot 4 to its power-on state.

```
SYSTem:CPON 4
```

34921A 40-Channel Armature Multiplexer with Low Thermal Offset

The 34921A 40-Channel Armature Multiplexer (40-Ch Arm MUX) is divided into two banks with 20 latching armature switches (channels 1-20 and 21-40) in each. This module also offers four additional fused relays (channels 41-44) for making AC and DC current measurements with the internal DMM with no external shunts needed. These current channels feature "make-before-break" connections to ensure continuous current flow when switching from one current channel to another. The current fuses are replaceable. Refer to the 34980A Service Guide for specific information about these fuses.

This module also contains nine armature Analog Bus relays (channels 911-914, 921-924, and 931), four on each bank that can connect the bank relays to the system Analog Buses and one that connects the current relays to the current input of the DMM. Through ABus1 and ABus2 you can connect any of the channels to the internal DMM for voltage or resistance measurements. Refer to the simplified schematic on .

NOTE	ABus1 consists of three wires that are used for current and voltage measurements. You cannot measure current and voltage on ABus1 simultaneously.

Using program commands or the mainframe front panel, you can control each of the channel switches individually, and thus configure this module in these modes:

- two independent 20-channel 2-wire MUXes. This configuration requires neither using external wiring nor connecting through the internal Analog Buses.

- one 20-channel 4-wire MUX. This configuration requires neither using external wiring nor connecting through the internal Analog Buses. For 4-wire resistance measurements, the instrument automatically pairs channel n on Bank 1 with channel n+20 (Bank 2) to provide the source and sense connections. Four-wire controls occur only when doing 4-wire measurement operations through the internal DMM, such as MEASure:FRESistance? or scanning a channel previously configured as 4-wire.

- one 40-channel 2-wire MUX. You must use external wiring or connect through the internal Analog Bus relays for this configuration. For example, closing Analog Bus channels 913 and 923 connects Bank 1 and Bank 2 through ABus3. Or, externally you can connect COM1 to COM2 to create this configuration.

Low thermal offset voltage makes the 34921A ideal for low-level signal switching. The 34921T optional terminal block provides a built-in thermocouple reference junction that helps minimize errors due to thermal offset when you measure thermocouples.

This module has capability to scan as many as 100 channels/second using the internal DMM. With the automatic "break-before-make" connection operation, you are assured that no two signals are connected to each other during a scan. When using the module in a non-scanning mode, you can close as many channels as you wish.

This module is safety interlock protected, which means whenever the D-sub connector end of the modules is exposed, the Analog Bus relays automatically open and disconnect from the Analog Bus. For more information, refer to page 120 and page 129.

When power is off, all channel relays maintain state, and the Analog Bus relays open.
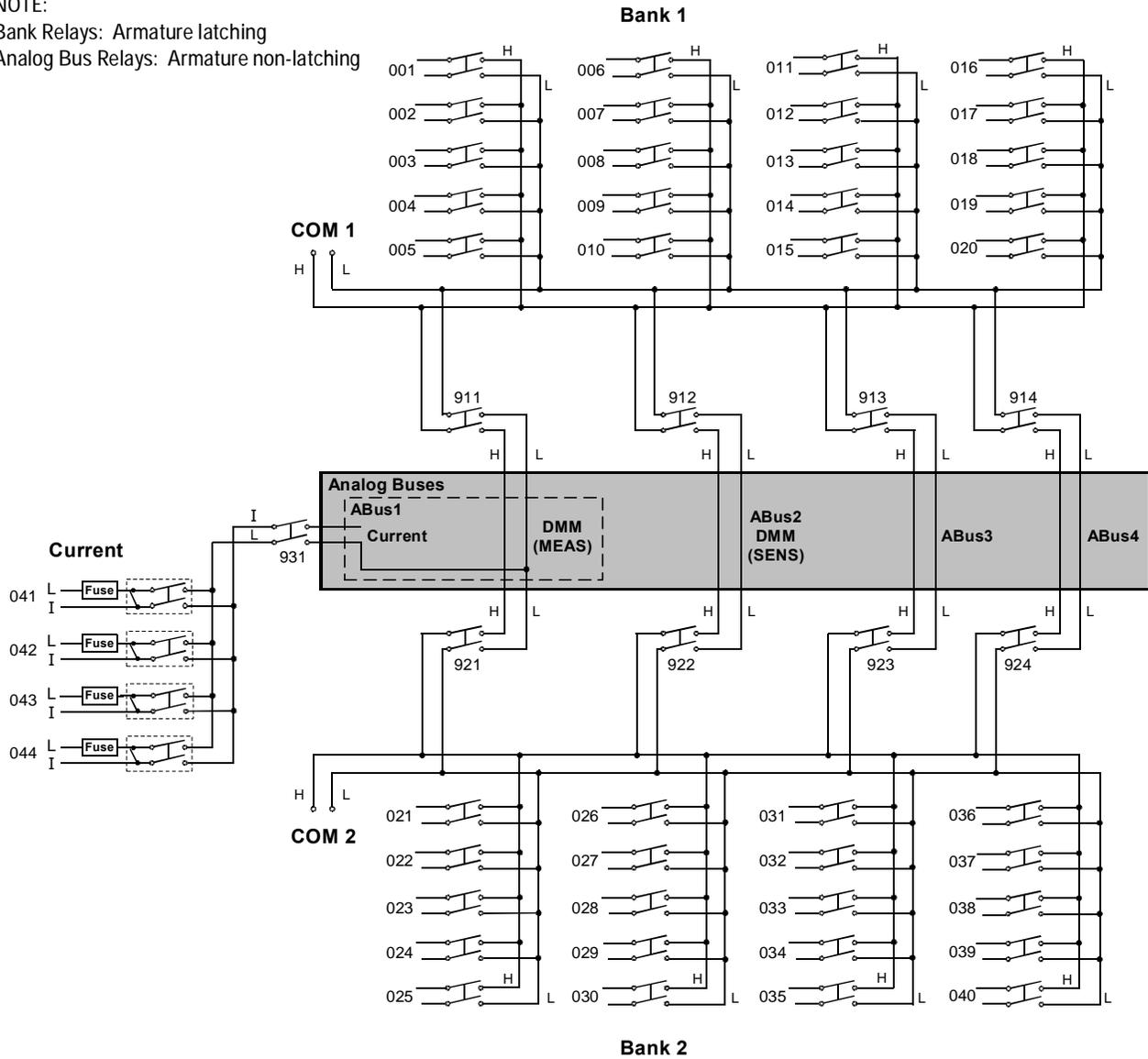
34921A Simplified Schematic

This drawing shows two independent 20-channel 2-wire MUXes.

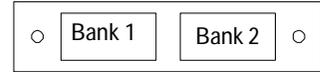NOTE: The three-digit number assigned to each switch represents the channel number.

NOTE:
Bank Relays: Armature latching
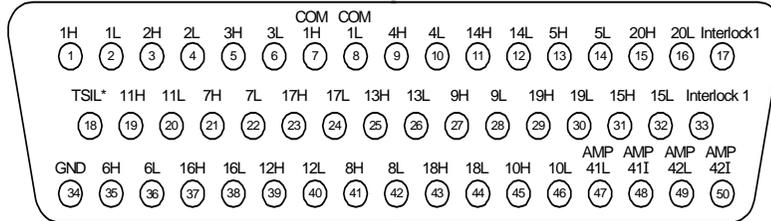Analog Bus Relays: Armature non-latching

Bank 1

Bank 2

34921A D-Sub Connectors

Bank 1

Bank 1 | Bank 2

For orientation, the D-sub connector end of the module is facing you.

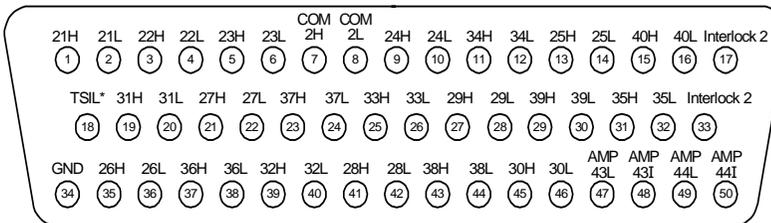*TSIL represents Temperature Sensor Interface Line. This line is used for temperature interface only.

50-Pin D-Sub Male Connector

```
       1H   1L   2H   2L   3H   3L  COM  COM  4H   4L  14H  14L  5H   5L  20H  20L Interlock1
                                    1H   1L
       (1)  (2)  (3)  (4)  (5)  (6)  (7)  (8)  (9) (10) (11) (12) (13) (14) (15) (16) (17)

         TSIL* 11H  11L  7H   7L  17H  17L  13H  13L  9H   9L  19H  19L  15H  15L Interlock 1
         (18) (19) (20) (21) (22) (23) (24) (25) (26) (27) (28) (29) (30) (31) (32) (33)

       GND  6H   6L  16H  16L  12H  12L  8H   8L  18H  18L  10H  10L  AMP  AMP  AMP  AMP
                                                              41L  41I  42L  42I
       (34) (35) (36) (37) (38) (39) (40) (41) (42) (43) (44) (45) (46) (47) (48) (49) (50)
```

WARNING As a safety feature, interlock 1 pins (17 and 33) on Bank 1 must be shorted to enable the Bank 1 Analog Bus relays to close. The optional 34921T terminal block shorts these pins for you. This feature protects inadvertent routing of high voltages from the Analog Bus to the D-sub connector of the module.

Description	Pin	Description	Pin	Description	Pin	Description	Pin	Description	Pin
1H	1	6H	35	11H	19	16H	37	COM1 H	7
1L	2	6L	36	11L	20	16L	38	COM1 L	8
2H	3	7H	21	12H	39	17H	23	Interlock 1	17
2L	4	7L	22	12L	40	17L	24	Interlock 1	33
3H	5	8H	41	13H	25	18H	43	GND	34
3L	6	8L	42	13L	26	18L	44	TSIL*	18
4H	9	9H	27	14H	11	19H	29	AMP 41L	47
4L	10	9L	28	14L	12	19L	30	AMP 41I	48
5H	13	10H	45	15H	31	20H	15	AMP 42L	49
5L	14	10L	46	15L	32	20L	16	AMP 42I	50

Bank 2

*TSIL represents Temperature Sensor Interface Line. This line is used for temperature interface only.

50-Pin D-Sub Male Connector

```
      21H  21L  22H  22L  23H  23L  COM  COM  24H  24L  34H  34L  25H  25L  40H  40L Interlock 2
                                    2H   2L
       (1)  (2)  (3)  (4)  (5)  (6)  (7)  (8)  (9) (10) (11) (12) (13) (14) (15) (16) (17)

         TSIL* 31H  31L  27H  27L  37H  37L  33H  33L  29H  29L  39H  39L  35H  35L Interlock 2
         (18) (19) (20) (21) (22) (23) (24) (25) (26) (27) (28) (29) (30) (31) (32) (33)

       GND  26H  26L  36H  36L  32H  32L  28H  28L  38H  38L  30H  30L  AMP  AMP  AMP  AMP
                                                              43L  43I  44L  44I
       (34) (35) (36) (37) (38) (39) (40) (41) (42) (43) (44) (45) (46) (47) (48) (49) (50)
```

WARNING As a safety feature, interlock 2 pins (17 and 33) on Bank 2 must be shorted to enable the Bank 2 Analog Bus relays to close. The optional 34921T terminal block shorts these pins for you. This feature protects inadvertent routing of high voltages from the Analog Bus to the D-sub connector of the module.

Description	Pin	Description	Pin	Description	Pin	Description	Pin	Description	Pin
21H	1	26H	35	31H	19	36H	37	COM2 H	7
21L	2	26L	36	31L	20	36L	38	COM2 L	8
22H	3	27H	21	32H	39	37H	23	Interlock 2	17
22L	4	27L	22	32L	40	37L	24	Interlock 2	33
23H	5	28H	41	33H	25	38H	43	GND	34
23L	6	28L	42	33L	26	38L	44	TSIL*	18
24H	9	29H	27	34H	11	39H	29	AMP 43L	47
24L	10	29L	28	34L	12	39L	30	AMP 43I	48
25H	13	30H	45	35H	31	40H	15	AMP 44L	49
25L	14	30L	46	35L	32	40L	16	AMP 44I	50

34921T Terminal Block

This terminal block with screw-type connections is labeled with the model number and the abbreviated module name. In addition, space is available on the label for you to write the slot number.

| NOTE	All modules that connect to the internal DMM are interlock protected. This means that when an installed module is exposed (no terminal block or cable is connected), the Analog Bus relays are open and disconnected from the Analog Buses. See for further information.

The 34921T is the only terminal block that provides an isothermal block with temperature reference for thermocouple measurements. The temperature sensor is located on the bottom side of the PC board as shown below. Also shown are two holes that you can use for connecting an external temperature reference to the terminal block.
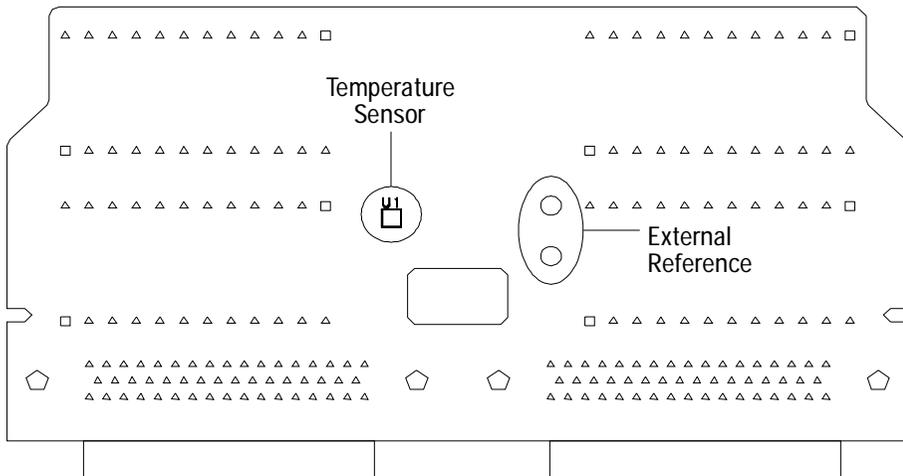
34921T (viewed from bottom side)

CAUTION	When wiring the terminal block via cables to the mainframe, make sure the cables are connected to the correct connector. The cables provide communication and power to the temperature sensor on the 34921T terminal block. If cabling is not correct, an error may occur indicating that the 34921A module is not fully operational.

The 34980A Product Reference CD (shipped with the instrument) contains a 34921T Wiring Log for you to document your wiring configuration for this module. You can open the wiring log file in Microsoft® Excel® or Adobe® Acrobat® format.
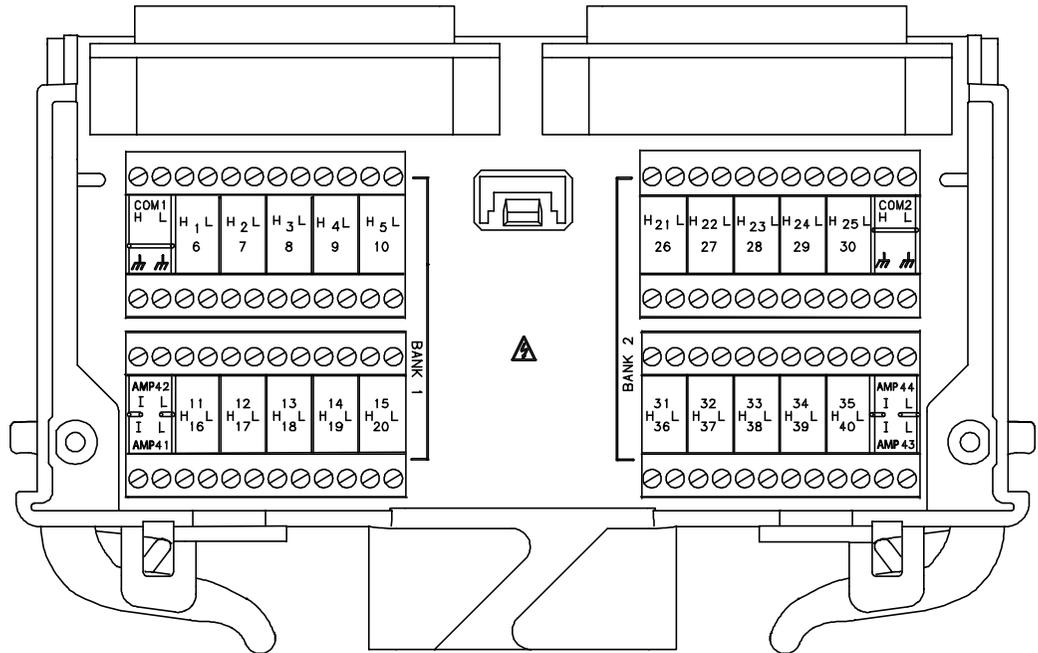
34922A 70-Channel Armature Multiplexer

The high-density 34922A 70-Channel Armature Multiplexer (70-Ch Arm MUX) is divided into two banks with 35 latching armature switches (channels 1-35 and 36-70) in each. This module also contains eight armature Analog Bus relays (channels 911-914 and 921-924), four on each bank that can connect the bank relays to the system Analog Buses. Through ABus1 and ABus2 you can connect any of the channels to the internal DMM for voltage or resistance measurements. Refer to the simplified schematic on page 133.

Using program commands or the mainframe front panel, you can control each of the channel switches individually, and thus configure this module in these modes:

- two independent 35-channel 2-wire MUXes. This configuration requires neither using external wiring nor connecting through the internal Analog Buses.

- one 35-channel 4-wire MUX. This configuration requires neither using external wiring nor connecting through the internal Analog Buses. For 4-wire resistance measurements, the instrument automatically pairs channel n on Bank 1 with channel n+35 (Bank 2) to provide the source and sense connections. Four-wire controls occur only when doing 4-wire measurement operations through the internal DMM, such as `MEASure:FRESistance?` or scanning a channel previously configured as 4-wire.

- one 70-channel 2-wire MUX. You must use external wiring or connect through the internal Analog Bus relays for this configuration. For example, closing Analog Bus channels 913 and 923 connects Bank 1 and Bank 2 through ABus3. Or, externally you can connect COM1 to COM2 to create this configuration.

This module has capability to scan as many as 100 channels/second using the internal DMM. With the automatic "break-before-make" connection operation, you are assured that no two signals are connect to each other during a scan. When using the module in a non-scanning mode, you can close as many channels as you wish.

This module is interlock protected, which means whenever the D-sub connector end of the modules is exposed, the Analog Bus relays automatically open and disconnect from the Analog Bus. For more information, refer to page 120 and page 134.
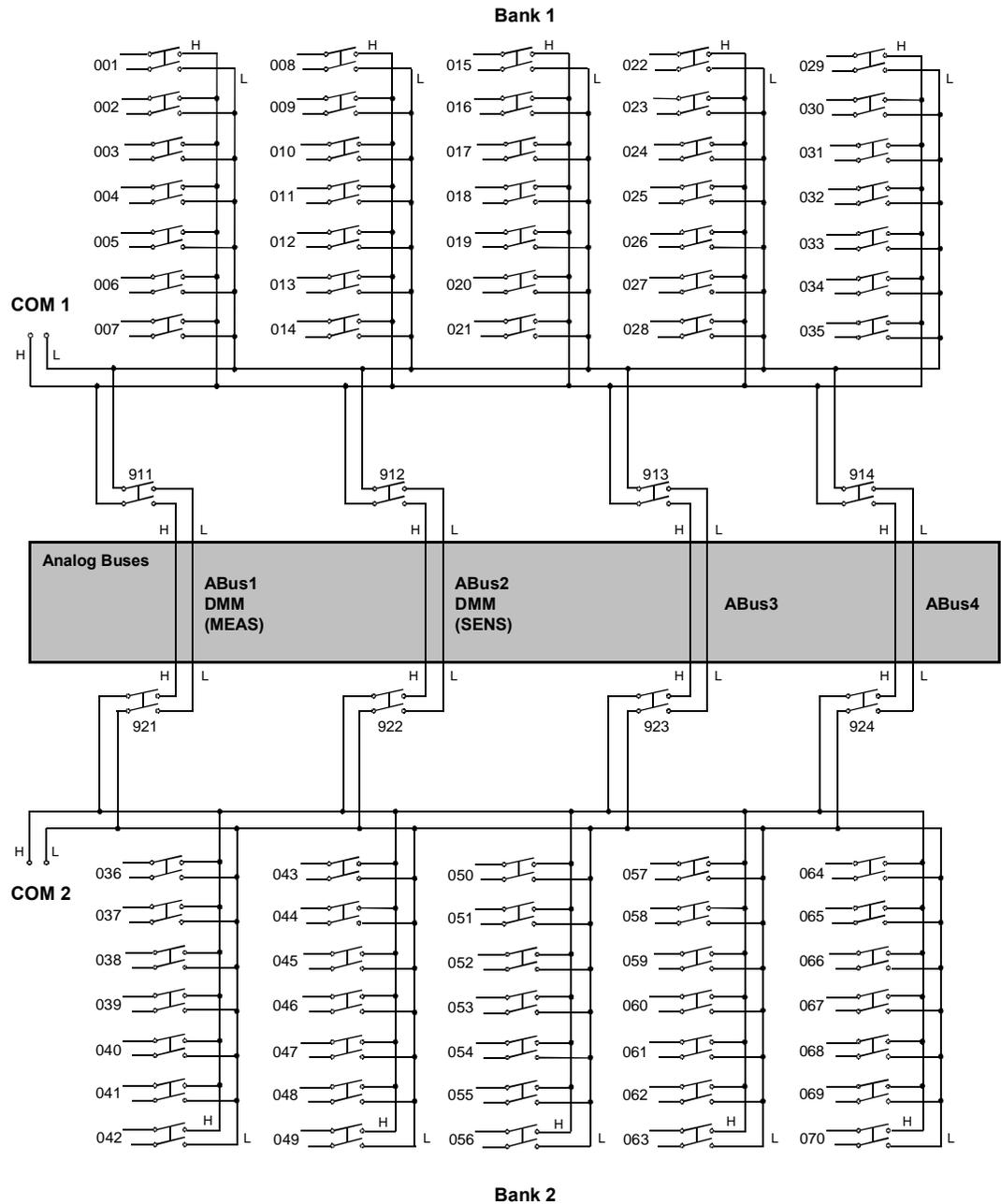
When the power is off, all channel relays maintain state, and the Analog Bus relays open.

34922A Simplified Schematic

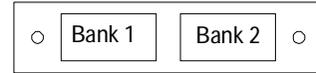This drawing shows two independent 35-channel 2-wire MUXes.

NOTE: The three-digit number
assigned to each switch represents
the channel number.

NOTE:
Bank Relays: Armature latching
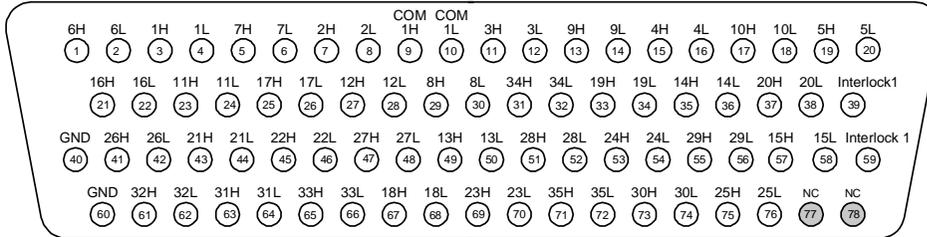Analog Bus Relays: Armature non-latching

Bank 1

COM 1

Analog Buses

ABus1
DMM
(MEAS)

ABus2
DMM
(SENS)

ABus3

ABus4

COM 2

Bank 2

34922A D-Sub Connectors

Bank 1

For orientation, the D-sub connector end of the module is facing you.

78-Pin D-Sub Male Connector

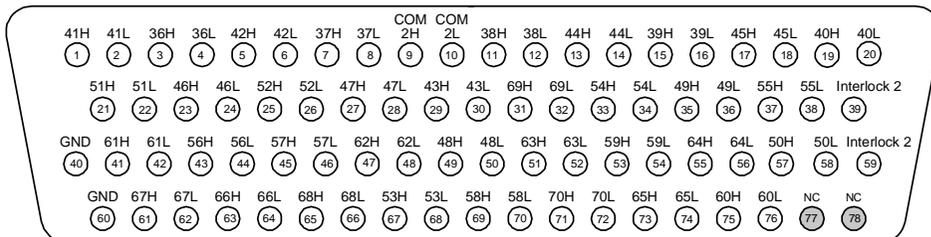| Description	Pin	Description	Pin	Description	Pin	Description	Pin	Description	Pin	Description	Pin
1H	3	8H	29	15H	57	22H	45	29H	55	COM1 H	9
1L	4	8L	30	15L	58	22L	46	29L	56	COM1 L	10
2H	7	9H	13	16H	21	23H	69	30H	73	Interlock 1	39
2L	8	9L	14	16L	22	23L	70	30L	74	Interlock 1	59
3H	11	10H	17	17H	25	24H	53	31H	63	GND	40
3L	12	10L	18	17L	26	24L	54	31L	64	GND	60
4H	15	11H	23	18H	67	25H	75	32H	61	No Connect	77
4L	16	11L	24	18L	68	25L	76	32L	62	No Connect	78
5H	19	12H	27	19H	33	26H	41	33H	65		
5L	20	12L	28	19L	34	26L	42	33L	66		
6H	1	13H	49	20H	37	27H	47	34H	31		
6L	2	13L	50	20L	38	27L	48	34L	32		
7H	5	14H	35	21H	43	28H	51	35H	71		
7L	6	14L	36	21L	44	28L	52	35L	72		

WARNING   As a safety feature, interlock 1 pins (39 and 59) on Bank 1 must be shorted to enable the Bank 1 Analog Bus relays to close. The optional 34922T terminal block shorts these pins for you. This feature protects inadvertent routing of high voltages from the Analog Buses to the D-sub connector of the module.

Bank 2

| ○ | Bank 1 | Bank 2 | ○ |

For orientation, the D-sub connector end of the module is facing you.

78-Pin D-Sub
Male Connector

Description	Pin	Description	Pin	Description	Pin	Description	Pin	Description	Pin	Description	Pin
36H	3	43H	29	50H	57	57H	45	64H	55	COM2 H	9
36L	4	43L	30	50L	58	57L	46	64L	56	COM2 L	10
37H	7	44H	13	51H	21	58H	69	65H	73	Interlock 2	39
37L	8	44L	14	51L	22	58L	70	65L	74	Interlock 2	59
38H	11	45H	17	52H	25	59H	53	66H	63	GND	40
38L	12	45L	18	52L	26	59L	54	66L	64	GND	60
39H	15	46H	23	53H	67	60H	75	67H	61	No Connect	77
39L	16	46L	24	53L	68	60L	76	67L	62	No Connect	78
40H	19	47H	27	54H	33	61H	41	68H	65		
40L	20	47L	28	54L	34	61L	42	68L	66		
41H	1	48H	49	55H	37	62H	47	69H	31		
41L	2	48L	50	55L	38	62L	48	69L	32		
42H	5	49H	35	56H	43	63H	51	70H	71		
42L	6	49L	36	56L	44	63L	52	70L	72		

WARNING

As a safety feature, interlock 2 pins (39 and 59) on Bank 2 must be shorted to enable the Bank 2 Analog Bus relays to close. the optional 34922T terminal block shorts these pins for you. This feature protects inadvertent routing of high voltages from the Analog Buses to the D-sub connector of the module.

34922T Terminal Block

This terminal block with solder-type connections is labeled with the model number and the abbreviated module name. In addition, space is available on the label for you to write the slot number.

NOTE	All modules that connect to the internal DMM are interlock protected. This means that when an installed module is exposed (no terminal block or cable is connected), the Analog Bus relays are open and disconnected from the Analog Buses. See page 120 for further information.

The 34980A Product Reference CD (shipped with the instrument) contains a 34922T Wiring Log for you to document your wiring configuration for this module. You can open the wiring log file in Microsoft® Excel® or Adobe® Acrobat® format.
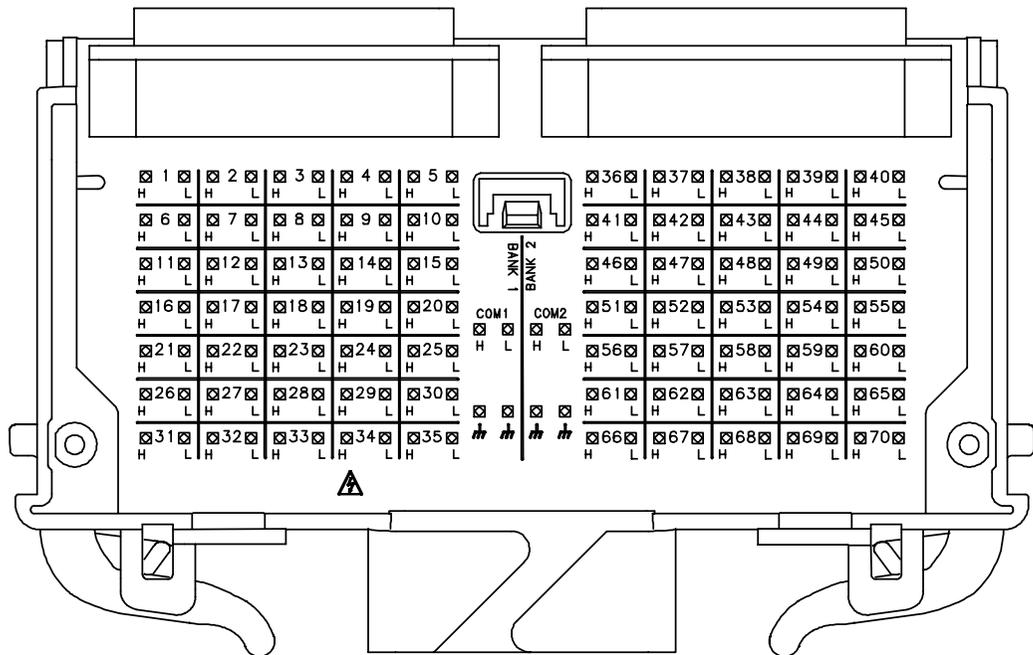
34923A 40/80-Channel Reed Multiplexer

The 34923A 40/80-Channel Reed Multiplexer (40/80-Ch Reed MUX) is divided into two equal banks of non-latching reed switches. This module also contains eight armature Analog Bus relays (channels 911-914 and 921-924), four on each bank that can connect the bank relays to the system Analog Buses. You can connect any of the channels to the internal DMM through ABus1 and ABus2 for voltage or resistance measurements.

Using program commands or the mainframe front panel, you can control each of the channel switches individually, and configure this module for differential (2-wire or 4-wire) or single-ended (1-wire) mode. Refer to the simplified schematics on page 140 and page 143.

If you are using an optional Agilent 349*xx*T terminal block to connect your DUT to this module be sure to use the terminal block that corresponds to your module configuration. Use the 34923T-001 terminal block for 2-wire or 4-wire configuration. Use the 34923T-002 terminal block for 1-wire configuration. Refer to drawings on page 142 and page 145.

You can confirm the mode in which your module is configured by using the `SYSTem:CTYPe? <slot number>` program command. This command returns the identity of the plug-in module in the specified slot.

NOTE	Whenever you change from 2- or 4-wire mode to 1-wire mode, or the reverse, you must cycle power on the 34980A for the configuration to take effect.

Two-Wire Mode

- two independent 20-channel 2-wire MUXes. This configuration requires neither using external wiring nor connecting through the internal Analog Buses.

- one 40-channel, 2-wire MUX. You must use external wiring or connect through the internal Analog Buses for this configuration.

In 2-wire mode, you can close no more than 20 channels simultaneously due to power dissipation. These 20 channels are split 10 to a bank. However, note that Analog Bus relays count half as much as channel relays in that total. For example, with one Analog Bus relay closed, you can close up to a maximum of 19 channel relays. If you try to close more than the allowed number of channels, you will receive an error message.

Four-Wire Mode

This 20-channel 4-wire MUX This configuration requires neither using external wiring nor connecting through the internal Analog Buses. For 4-wire resistance measurements, the instrument automatically pairs channel n on Bank 1 with channel n +20 (Bank 2) to provide the source and sense connections. Four-wire controls occur only when doing 4-wire measurement operations through the internal DMM, such as `MEASure:FRESistance?` or scanning a channel previously configured as 4-wire.

One-Wire Mode

- two independent 40-channel 1-wire MUXes. This configuration requires neither using external wiring nor connecting through the internal Analog Buses.

- one 80-channel 1-wire MUX. You must use external wiring or connect through the internal Analog Bus for this configuration.

NOTE	Because all bank relays supply only HI signals, you can apply a LOW signal through COM1 L or COM2 L when you are making 2-wire resistance measurements in 1-wire mode.

In 1-wire mode, you can close no more than 40 channels simultaneously due to power dissipation. These channels are split 20 to a bank. For example, with one Analog Bus relay closed you can close up to a maximum of 39 channel relays. If you try to close more than the allowed number of channels, you will receive an error message.

In all modes, this module has capability to scan as many as 500 channels/second using the internal DMM. With the automatic "break-before-make" connection operation, you are assured that no two signals are connect to each other during a scan.

This module is interlock protected, which means whenever the D-sub connector end of the modules is exposed, the Analog Bus relays immediately open and disconnect from the Analog Bus. For more information, refer to .

<table>
<tr><td>CAUTION</td><td>Because user-attached reactive loads and backplane parasitic capacitance may result in high in-rush currents, 100 Ω in-rush resistors protect the reed relays from damage and performance degradation. Therefore, you must consider these resistors when you are designing a measurement. Refer to the simplified schematics on page 140 and page 143.</td></tr>
</table>

Lifetime of relays is severely degraded as current or voltage goes up. If higher voltage is being switched, limits on source current are recommended.
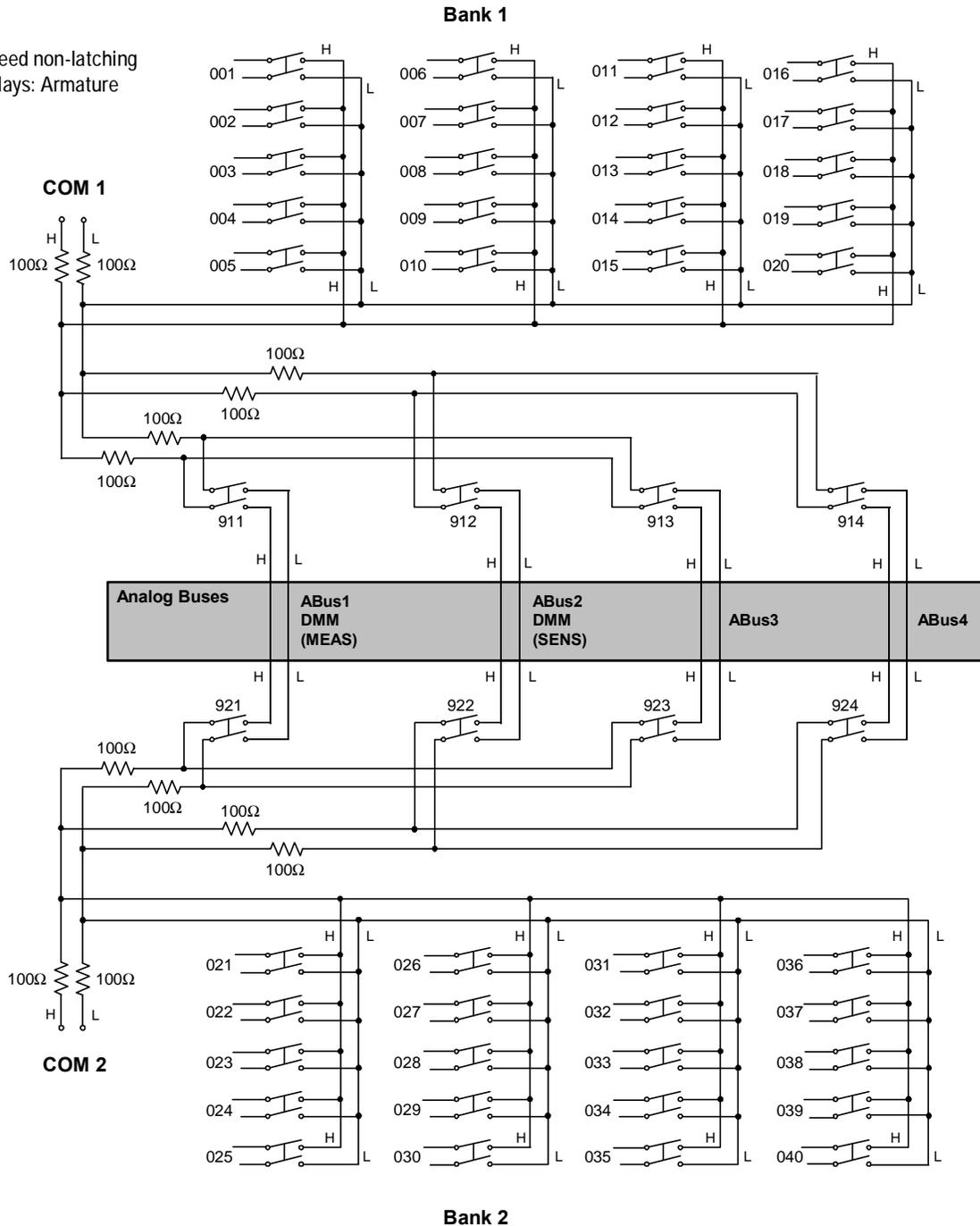
When the power is off, all channel and Analog Bus relays open.
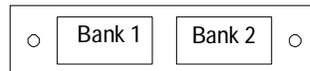
34923A Simplified Schematic for Two- or Four-Wire Mode

This drawing shows two independent 20-channel 2-wire MUXes. To change configuration modes, use the SYSTem:MODule:WIRE:MODE command.

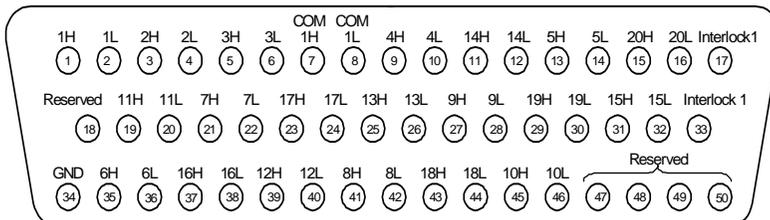NOTE: The three-digit number assigned to each switch represents the channel number.

34923A D-Sub Connectors for Two- or Four-Wire Mode

Bank 1   Bank 2

For orientation, the D-sub connector end of the module is facing you.
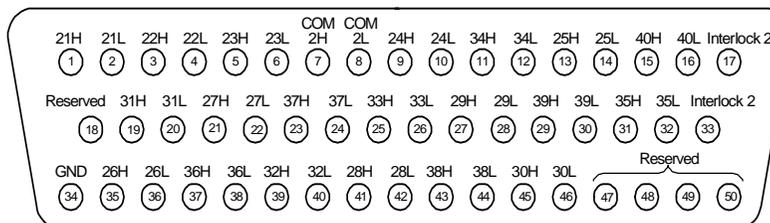
Bank 1

50-Pin D-Sub Male Connector

WARNING As a safety feature, interlock 1 pins (17 and 33) on Bank 1 must be shorted to enable the Bank 1 Analog Bus relays to close. The optional 34923T-001 (for 2-wire) terminal block shorts these pins for you. This feature protects inadvertent routing of high voltages from the Analog Bus to the D-sub connector of the module.

Description	Pin	Description	Pin	Description	Pin	Description	Pin	Description	Pin
1H	1	6H	35	11H	19	16H	37	COM1 H	7
1L	2	6L	36	11L	20	16L	38	COM1 L	8
2H	3	7H	21	12H	39	17H	23	Interlock 1	17
2L	4	7L	22	12L	40	17L	24	Interlock 1	33
3H	5	8H	41	13H	25	18H	43	GND	34
3L	6	8L	42	13L	26	18L	44	Reserved	18
4H	9	9H	27	14H	11	19H	29	Reserved	47
4L	10	9L	28	14L	12	19L	30	Reserved	48
5H	13	10H	45	15H	31	20H	15	Reserved	49
5L	14	10L	46	15L	32	20L	16	Reserved	50

Bank 2

50-Pin D-Sub Male Connector

WARNING As a safety feature, interlock 2 pins (17 and 33) on Bank 2 must be shorted to enable the Bank 2 Analog Bus relays to close. The optional 34923T-001 (for 2-wire) shorts these pins for you. This feature protects inadvertent routing of high voltages from the Analog Buses to the D-sub connector of the module.

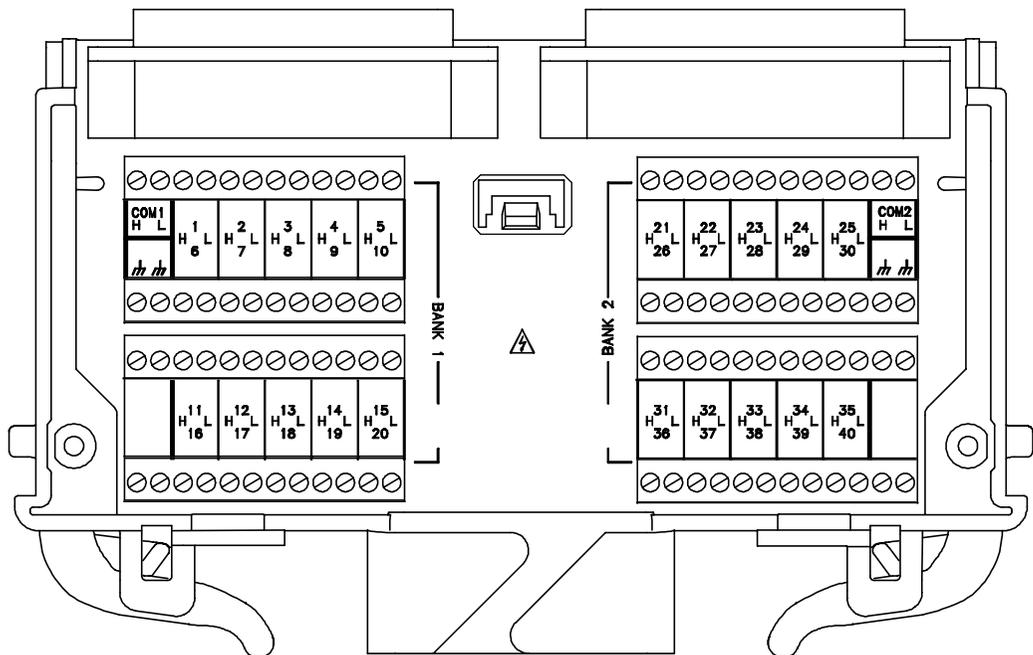| Description	Pin	Description	Pin	Description	Pin	Description	Pin	Description	Pin
21H	1	26H	35	31H	19	36H	37	COM2 H	7
21L	2	26L	36	31L	20	36L	38	COM2 L	8
22H	3	27H	21	32H	39	37H	23	Interlock 2	17
22L	4	27L	22	32L	40	37L	24	Interlock 2	33
23H	5	28H	41	33H	25	38H	43	GND	34
23L	6	28L	42	33L	26	38L	44	Reserved	18
24H	9	29H	27	34H	11	39H	29	Reserved	47
24L	10	29L	28	34L	12	39L	30	Reserved	48
25H	13	30H	45	35H	31	40H	15	Reserved	49
25L	14	30L	46	35L	32	40L	16	Reserved	50

34923T-001 Terminal Block for Two- or Four-Wire Mode

This terminal block with screw-type connections is labeled with the model number and the abbreviated module name. In addition, space is available on the label for you to write the slot number.

NOTE	All modules that connect to the internal DMM are interlock protected. This means that when an installed module is exposed (no terminal block or cable is connected), the Analog Bus relays are open and disconnected from the Analog Buses. See page 120 for further information.

NOTE	If you are using an Agilent terminal block to connect your DUT to this module be sure to use the 34923T-001 terminal block that corresponds to the 2- or 4-wire configuration mode. An error will not be generated if you have installed a terminal block that doesn't match the present module configuration.

The 34980A Product Reference CD (shipped with the instrument) contains a 34923T (2-wire mode) Wiring Log for you to document your wiring configuration for this module. You can open the wiring log file in Microsoft® Excel® or Adobe® Acrobat® format.
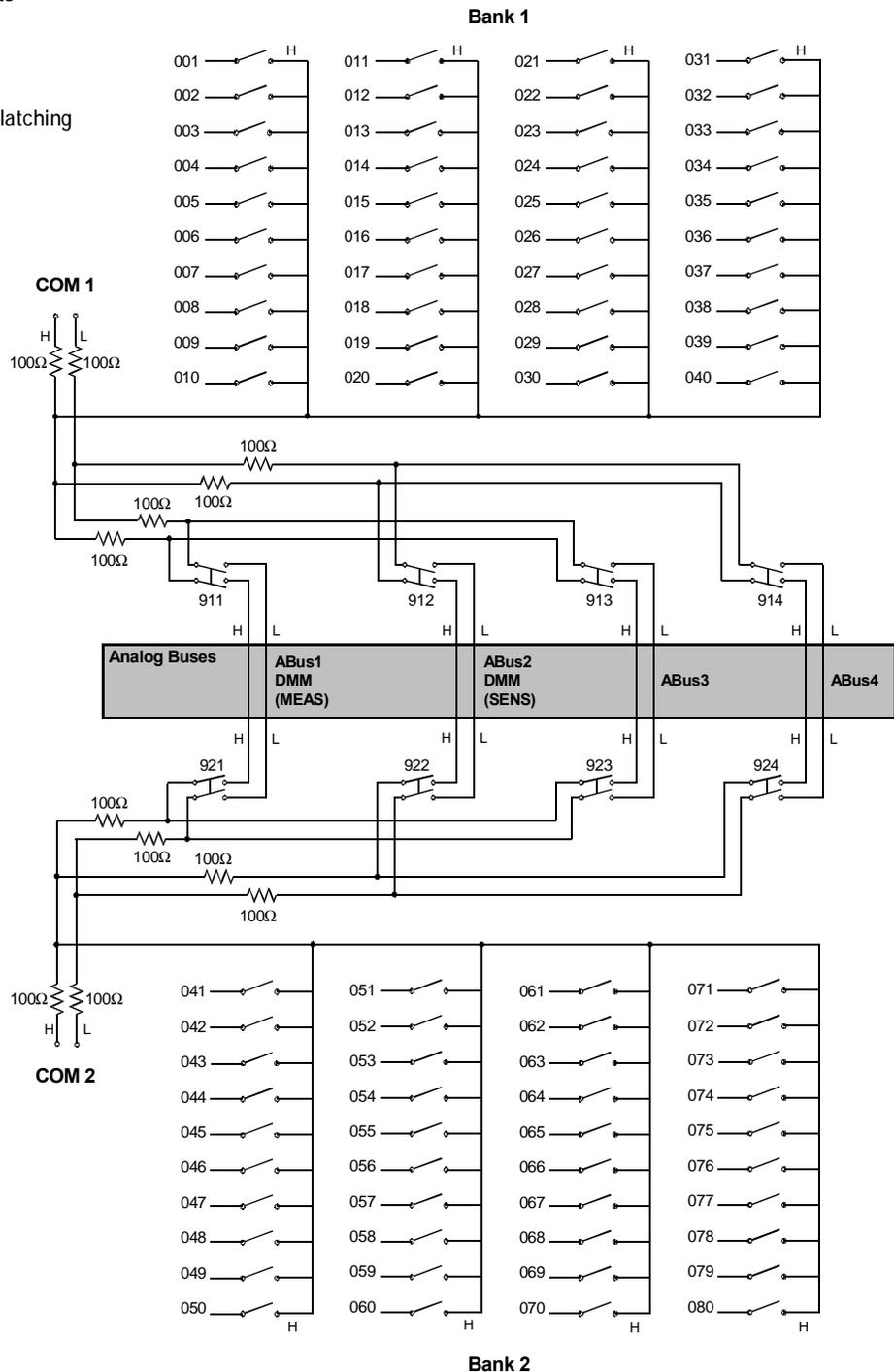
34923A Simplified Schematic for One-Wire Mode

This drawing shows two independent 40-channel 1-wire MUXes. To change configuration modes, use the SYSTem:MODule:WIRE:MODE command.

NOTE: The three-digit number assigned to each switch represents the channel number.

NOTE:
Bank relays: Reed non-latching
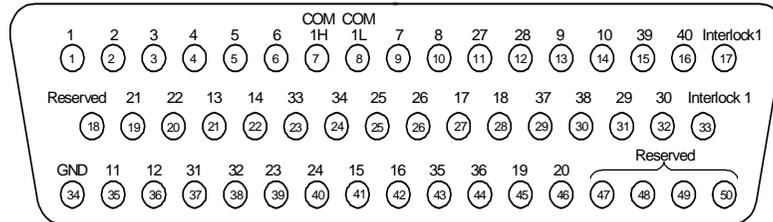Analog Bus relays: Armature non-latching

Bank 1

001 H   011 H   021 H   031 H
002   012   022   032
003   013   023   033
004   014   024   034
005   015   025   035
006   016   026   036
007   017   027   037
008   018   028   038
009   019   029   039
010   020   030   040

COM 1
H L
100Ω 100Ω

100Ω
100Ω 100Ω
100Ω

911   912   913   914
H L   H L   H L   H L

Analog Buses | ABus1 DMM (MEAS) | ABus2 DMM (SENS) | ABus3 | ABus4

H L   H L   H L   H L
921   922   923   924

100Ω
100Ω 100Ω
100Ω

100Ω 100Ω
H L

COM 2

041   051   061   071
042   052   062   072
043   053   063   073
044   054   064   074
045   055   065   075
046   056   066   076
047   057   067   077
048   058   068   078
049   059   069   079
050 H   060 H   070 H   080 H

Bank 2

34923A D-Sub Connectors for One-Wire Mode

Bank 1

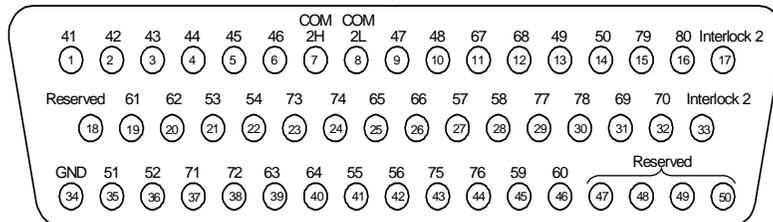For orientation, the D-sub connector end of the module is facing you.

50-Pin D-Sub Male Connector

WARNING As a safety feature, interlock 1 pins (17 and 33) on Bank 1 must be shorted to enable the Bank 1 Analog Bus relays to close. The optional 34923T-002 (for 1-wire) shorts these pins for you. This feature protects inadvertent routing of high voltages from the Analog Bus to the D-sub connector of the module.

Description	Pin	Description	Pin	Description	Pin	Description	Pin	Description	Pin
1	1	11	35	21	19	31	37	COM1 H	7
2	2	12	36	22	20	31	38	COM1 L	8
3	3	13	21	23	39	33	23	Interlock 1	17
4	4	14	22	24	40	34	24	Interlock 1	33
5	5	15	41	25	25	35	43	GND	34
6	6	16	42	26	26	36	44	Reserved	18
7	9	17	27	27	11	37	29	Reserved	47
8	10	18	28	28	12	38	30	Reserved	48
9	13	19	45	29	31	39	15	Reserved	49
10	14	20	46	30	32	40	16	Reserved	50

Bank 2

50-Pin D-Sub Male Connector

WARNING As a safety feature, interlock 2 pins (17 and 33) on Bank 2 must be shorted to enable the Bank 2 Analog Bus relays to close. The optional 34923T-002 (for 1-wire) shorts these pins for you. This feature protects inadvertent routing of high voltages from the Analog Buses to the D-sub connector of the module.

| Description	Pin	Description	Pin	Description	Pin	Description	Pin	Description	Pin
41	1	51	35	61	19	71	37	COM2 H	7
42	2	52	36	62	20	72	38	COM2 L	8
43	3	53	21	63	39	73	23	Interlock 2	17
44	4	54	22	64	40	74	24	Interlock 2	33
45	5	55	41	65	25	75	43	GND	34
46	6	56	42	66	26	76	44	Reserved	18
47	9	57	27	67	11	77	29	Reserved	47
48	10	58	28	68	12	78	30	Reserved	48
49	13	59	45	69	31	79	15	Reserved	49
50	14	60	46	70	32	80	16	Reserved	50

34923T-002 Terminal Block for One-Wire Mode

This terminal block with screw-type connections is labeled with the model number and the abbreviated module name. In addition, space is available on the label for you to write the slot number.

NOTE	All modules that connect to the internal DMM are interlock protected. This means that when an installed module is exposed (no terminal block or cable is connected), the Analog Bus relays are open and disconnected from the Analog Buses. See page 120 for further information.

NOTE	If you are using an Agilent terminal block to connect your DUT to this module be sure to use the 34923T-002 terminal block that corresponds to the 1-wire configuration mode. An error will not be generated if you have installed a terminal block that doesn't match the present module configuration.

The 34980A Product Reference CD (shipped with the instrument) contains a 34923T (1-wire mode) Wiring Log for you to document your wiring configuration for this module. You can open the wiring log file in Microsoft® Excel® or Adobe® Acrobat® format.
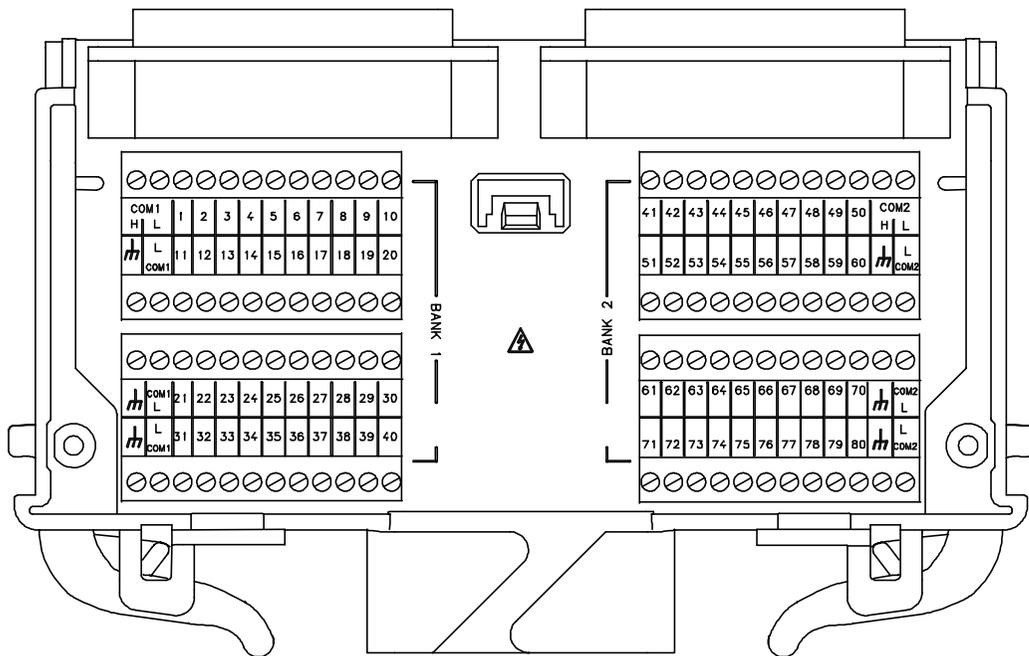
34924A 70-Channel Reed Multiplexer

The high-density 34924A 70-Channel Reed Multiplexer (70-Ch Reed MUX) is divided into two banks with 35 non-latching reed switches (channels 1-35 and 36-70) in each. This module also contains eight armature Analog Bus relays (channels 911-914 and 921-924), four on each bank that can connect the bank relays to the system Analog Buses. Through ABus1 and ABus2 you can connect any of the channels to the system DMM for voltage or resistance measurements. See the simplified schematic on .

Using program commands or the mainframe front panel, you can control each of the channel switches individually, and thus configure this module in the modes listed below.

- two independent 35-channel 2-wire MUXes. This configuration requires neither using external wiring nor connecting through the internal Analog Buses.

- one 70-channel, 2-wire MUX. You must use external wiring or connect through the internal Analog Buses for this configuration.

- one 35-channel 4-wire MUX. This configuration requires neither using external wiring nor connecting through the internal Analog Buses. For 4-wire resistance measurements, the instrument automatically pairs channel n on Bank 1 with channel n+35 (Bank 2) to provide the source and sense connections. Four-wire controls occur only when doing 4-wire measurement operations through the internal DMM, such as `MEASure:FRESistance?` or scanning a channel previously configured as 4-wire.

In 2-wire mode, you can close no more than 20 channels simultaneously due to power dissipation. These 20 channels are split 10 to a bank. However, note that Analog Bus relays count half as much as channel relays in that total. For example, with one Analog Bus relay closed, you can close up to a maximum of 19 channel relays. If you try to close more than the allowed number of channels, you will receive an error message.

In all modes, this module has capability to scan as many as 500 channels/second using the internal DMM. With the automatic "break-before-make" connection operation, you are assured that no two signals are connect to each other during a scan.

> **CAUTION** Because user-attached reactive loads and backplane parasitic capacitance may result in high in-rush currents, 100 Ω in-rush resistors protect the reed relays from damage and performance degradation. Therefore, you must consider these resistors when you are designing a measurement. Refer to the simplified schematic on page 148.

This module is interlock protected, which means whenever the D-sub connector end of the modules is exposed, the Analog Bus relays immediately open and disconnect from the Analog Bus. For more information, refer to .

Lifetime of relays is severely degraded as current or voltage goes up. If higher voltage is being switched, limits on source current are recommended.

When the power is off, all channel and Analog Bus relays open.
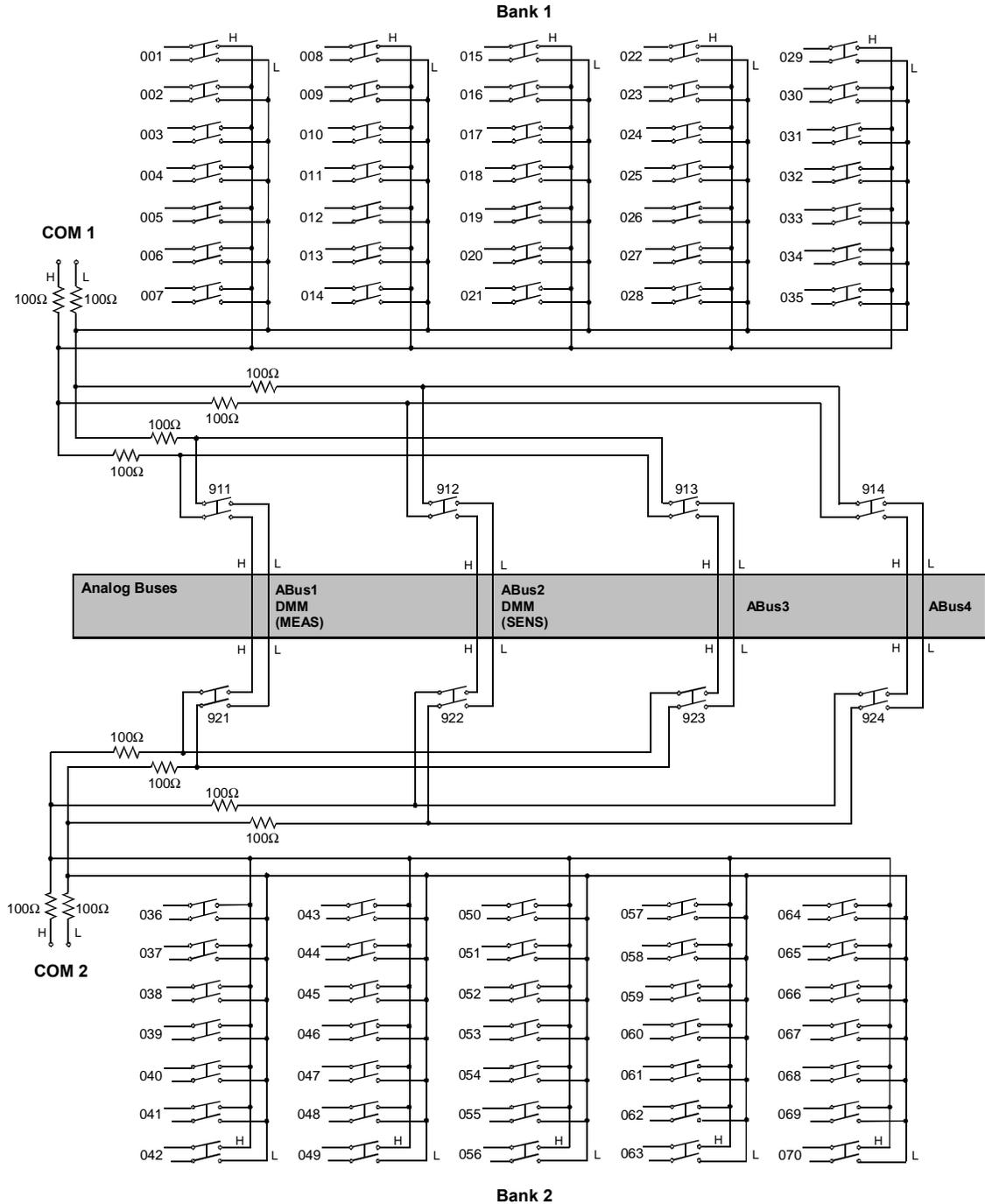
34924A Simplified Schematic

This drawing shows two independent 35-channel 2-wire MUXes.

NOTE: The three-digit number assigned to each switch represents the channel number.

NOTE:
Bank relays: Reed non-latching
Analog Bus relays: Armature non-latching

Bank 1

COM 1

Bank 2

COM 2

34924A D-Sub Connectors

Bank 1

For orientation, the D-sub connector end of the module is facing you.

| Bank 1 | Bank 2 |

78-Pin D-Sub Male Connector

| Description	Pin	Description	Pin	Description	Pin	Description	Pin	Description	Pin	Description	Pin
1H	3	8H	29	15H	57	22H	45	29H	55	COM1 H	9
1L	4	8L	30	15L	58	22L	46	29L	56	COM1 L	10
2H	7	9H	13	16H	21	23H	69	30H	73	Interlock 1	39
2L	8	9L	14	16L	22	23L	70	30L	74	Interlock 1	59
3H	11	10H	17	17H	25	24H	53	31H	63	GND	40
3L	12	10L	18	17L	26	24L	54	31L	64	GND	60
4H	15	11H	23	18H	67	25H	75	32H	61	No Connect	77
4L	16	11L	24	18L	68	25L	76	32L	62	No Connect	78
5H	19	12H	27	19H	33	26H	41	33H	65		
5L	20	12L	28	19L	34	26L	42	33L	66		
6H	1	13H	49	20H	37	27H	47	34H	31		
6L	2	13L	50	20L	38	27L	48	34L	32		
7H	5	14H	35	21H	43	28H	51	35H	71		
7L	6	14L	36	21L	44	28L	52	35L	72		

WARNING   As a safety feature, interlock 1 pins (39 and 59) on Bank 1 must be shorted to enable the Bank 1 Analog Bus relays to close. The optional 34924T terminal block shorts these pins for you. This feature protects inadvertent routing of high voltages from the Analog Buses to the D-sub connector of the module.

Bank 2

Bank 1 | Bank 2

For orientation, the D-sub connector end of the module is facing you.

78-Pin D-Sub
Male Connector

Description	Pin	Description	Pin	Description	Pin	Description	Pin	Description	Pin	Description	Pin	Description	Pin
36H	3	43H	29	50H	57	57H	45	64H	55	COM2 H	9
36L	4	43L	30	50L	58	57L	46	64L	56	COM2 L	10
37H	7	44H	13	51H	21	58H	69	65H	73	Interlock 2	39
37L	8	44L	14	51L	22	58L	70	65L	74	Interlock 2	59
38H	11	45H	17	52H	25	59H	53	66H	63	GND	40
38L	12	45L	18	52L	26	59L	54	66L	64	GND	60
39H	15	46H	23	53H	67	60H	75	67H	61	No Connect	77
39L	16	46L	24	53L	68	60L	76	67L	62	No Connect	78
40H	19	47H	27	54H	33	61H	41	68H	65		
40L	20	47L	28	54L	34	61L	42	68L	66		
41H	1	48H	49	55H	37	62H	47	69H	31		
41L	2	48L	50	55L	38	62L	48	69L	32		
42H	5	49H	35	56H	43	63H	51	70H	71		
42L	6	49L	36	56L	44	63L	52	70L	72		

WARNING   As a safety feature, **interlock 2 pins (39 and 59) on Bank 2 must be shorted to enable the Bank 2 Analog Bus relays to close. The optional 34924T terminal block shorts these pins for you. This feature protects inadvertent routing of high voltages from the Analog Buses to the D-sub connector of the module.**

34924T Terminal Block

This terminal block with solder-type connections is labeled with the model number and the abbreviated module name. In addition, space is available on the label for you to write the slot number.

NOTE	All modules that connect to the internal DMM are interlock protected. This means that when an installed module is exposed (no terminal block or cable is connected), the Analog Bus relays are open and disconnected from the Analog Buses. See page 120 for further information.

The 34980A Product Reference CD (shipped with the instrument) contains a 34924T Wiring Log for you to document your wiring configuration for this module. You can open the wiring log file in Microsoft® Excel® or Adobe® Acrobat® format.
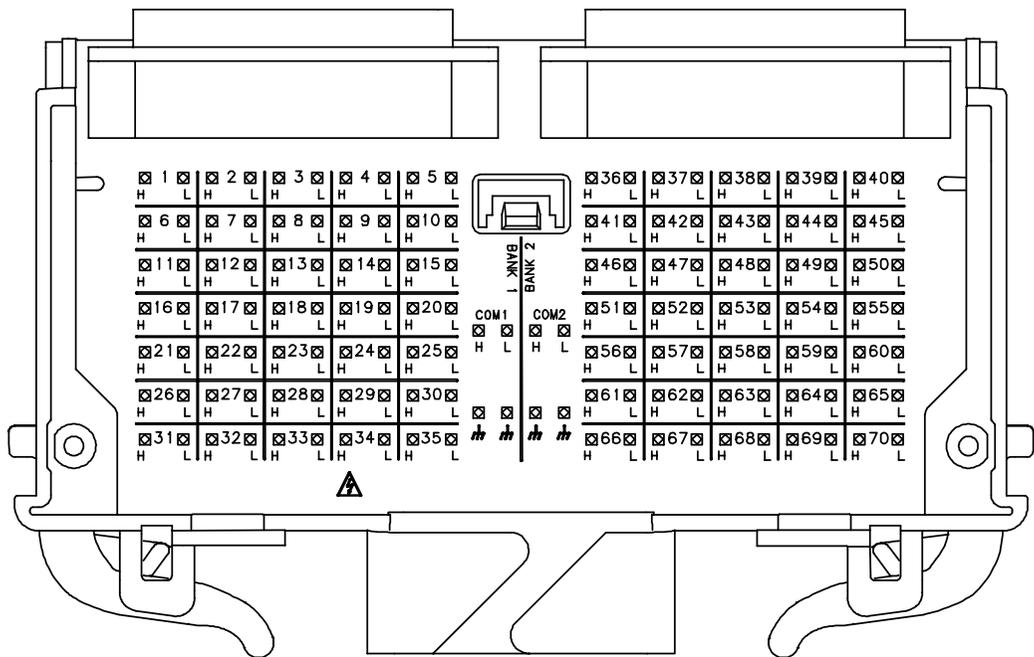
34925A 40/80-Channel Optically-Isolated FET Multiplexer

The 34925A 40/80- Channel Optically- Isolated FET Multiplexer (40/80- Ch FET MUX) module is a high- speed and high- density FET MUX for high throughput production test. This module is divided into two equal banks of non- latching FET switches. This module also contains four armature Analog Bus relays. Through ABus1 and ABus2 you can connect any of the channels to the internal DMM for voltage or resistance measurements. When the power is off, all channel and Analog Bus relays open.

Using program commands or the mainframe front panel, you can control each of the FET channel switches individually, and configure this module for differential (2- wire or 4- wire) or single- ended (1- wire) mode. Refer to the simplified schematics on page 155 and page 158.

If you are using an Agilent 349xxT terminal block to connect your DUT to this module, be sure to use the terminal block that corresponds to your module configuration mode. Use the 34925T- 001 terminal block for differential mode (2- wire or 4- wire configuration). Use the 34925T- 002 terminal block for single- ended mode (1- wire configuration). Refer to drawings on page 157 and page 160.

You can confirm the mode in which your module is configured by using the `SYSTem:CTYPe? <slot number>` program command. This command returns the identity of the plug- in module in the specified slot.

NOTE	Whenever you change from 2- or 4-wire mode to 1-wire mode, or the reverse, you must cycle power on the 34980A for the configuration to take effect.

Two-Wire

• two independent 20- channel 2- wire MUXes. This configuration requires neither using external wiring nor connecting through the internal Analog Bus relays.

• one 40- channel, 2- wire MUX. You must use external wiring or connect through the Analog Bus relays to for this configuration.

Four-Wire

- one 20-channel 4-wire MUX. This configuration requires using neither external wiring nor connecting through the internal Analog Buses. For 4-wire resistance measurements, the instrument automatically pairs channel n on Bank 1 with channel n+20 (Bank 2) to provide the source and sense connections. Four-wire controls occur only when doing 4-wire measurement operations through the internal DMM, such as `MEASure:FRESistance?` or scanning a channel previously configured as 4-wire.

One-Wire

- two independent 40-channel 1-wire MUXes. This configuration requires neither using external wiring nor connecting through the Analog Bus relays.

- one 80-channel 1-wire MUX. You must use external wiring or connect through the Analog Bus relays for this configuration.

NOTE	Because all bank relays supply only HI signals, you can apply a LOW signal through COM1 L or COM2 L when you are making 2-wire resistance measurements in 1-wire mode.

Interlock Protection

This module is interlock protected, which means whenever the D-sub connector end of the modules is exposed, the Analog Bus relays immediately open and disconnect from the Analog Buses. For more information, refer to .

Overvoltage Protection

This module also features high voltage detection (< 100 V) and current limiting circuitry to protect the FET relays. This circuitry senses current flows from input overvoltages. These overvoltages may come from either the MUX input or from the Analog Buses. In addition, each channel is also protected from input overvoltages with a resistor.

When overvoltage is detected, all relays (Analog Bus and FET) are opened. While in the overvoltage state, any attempts to close any Analog Bus or FET switch, results in an error status response from the module.

Once in the overvoltage state, you must restore normal module operation with one of these actions:

- using the `SYSTem:CPON <slot>` command. This affects only the module specified.

- using the `*RST` command. This command resets the mainframe and all installed modules to the Factory configuration. This affects all installed modules.

- cycling system power. This affects all installed modules.

If the overvoltage situation is not resolved, clearing the overvoltage will result in a new overvoltage event occurring immediately.
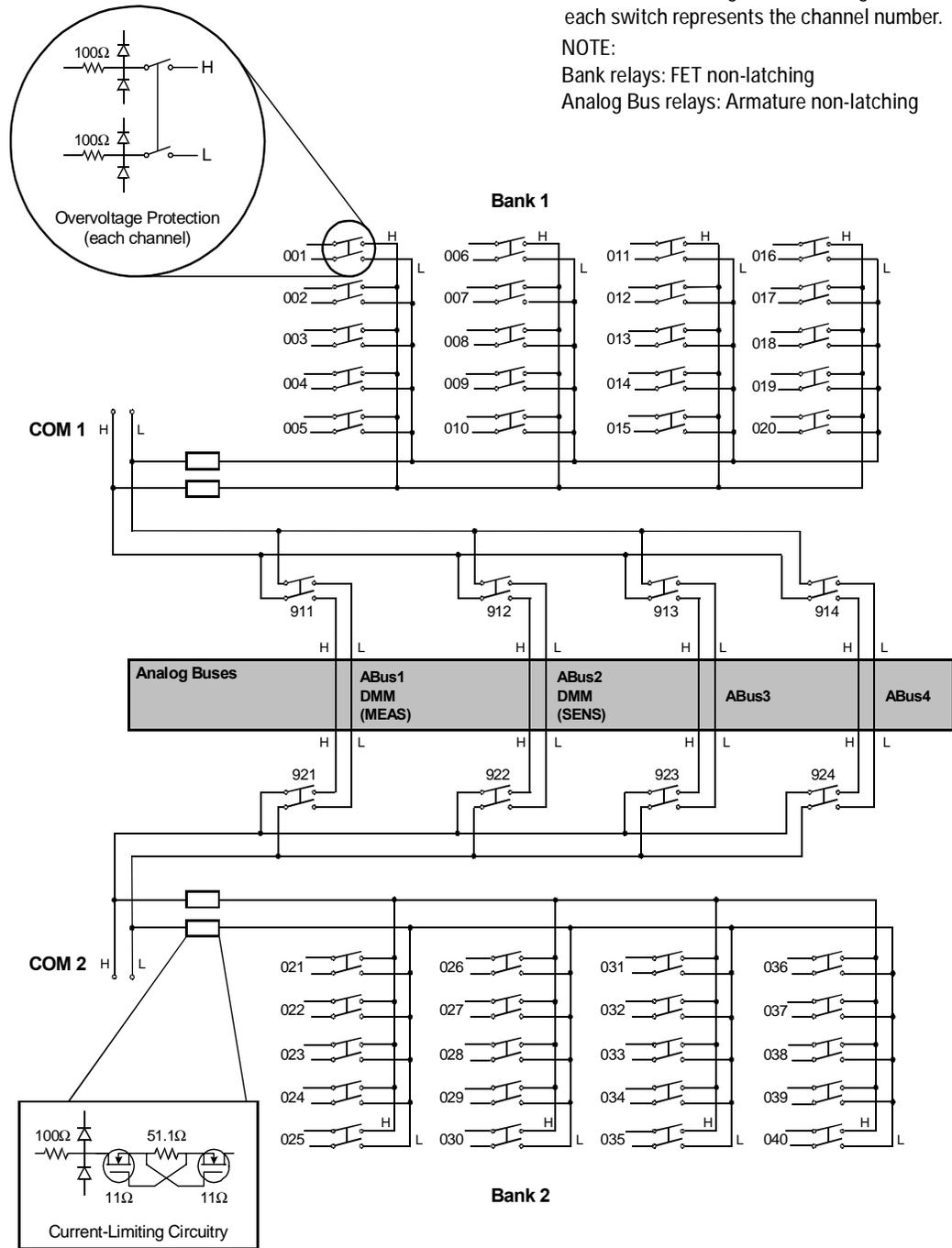
Further FET protection is assured only as one channel in each bank is closed at any time. Thus this module will operate as only a 1:N MUX module. For more information about FET channel closures, refer to page 122.

34925A Simplified Schematic for Two- or Four-Wire Mode

This drawing shows two independent 20-channel 2-wire MUXes. To change configuration modes, use the SYSTem:MODule:WIRE:MODE command.

NOTE: The three-digit number assigned to each switch represents the channel number.

NOTE:
Bank relays: FET non-latching
Analog Bus relays: Armature non-latching

Overvoltage Protection (each channel)

Bank 1

COM 1

Analog Buses   ABus1 DMM (MEAS)   ABus2 DMM (SENS)   ABus3   ABus4

COM 2

Current-Limiting Circuitry

Bank 2

34925A D-Sub Connectors for Two- or Four-Wire Mode

Bank 1

| ○ | Bank 1 | Bank 2 | ○ |

For orientation, the D-sub connector
end of the module is facing you.

50-Pin D-Sub
Male Connector

WARNING As a safety feature, interlock 1 pins (17 and 33) on Bank 1 must be shorted to enable the Bank 1 Analog Bus relays to close. The optional 34925T-001 (for 2-wire) terminal block shorts these pins for you. This feature protects inadvertent routing of high voltages from the Analog Bus to the D-sub connector of the module.

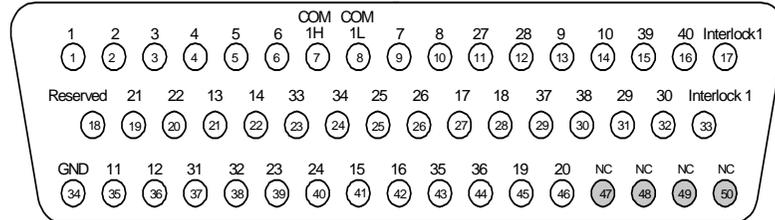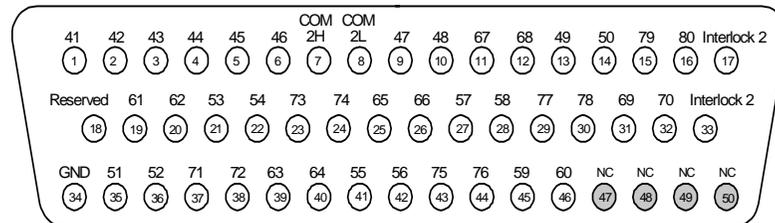| Description	Pin	Description	Pin	Description	Pin	Description	Pin	Description	Pin
1H	1	6H	35	11H	19	16H	37	COM1 H	7
1L	2	6L	36	11L	20	16L	38	COM1 L	8
2H	3	7H	21	12H	39	17H	23	Interlock 1	17
2L	4	7L	22	12L	40	17L	24	Interlock 1	33
3H	5	8H	41	13H	25	18H	43	Reserved	18
3L	6	8L	42	13L	26	18L	44	GND	34
4H	9	9H	27	14H	11	19H	29	No Connect	47
4L	10	9L	28	14L	12	19L	30	No Connect	48
5H	13	10H	45	15H	31	20H	15	No Connect	49
5L	14	10L	46	15L	32	20L	16	No Connect	50

Bank 2

50-Pin D-Sub
Male Connector

WARNING As a safety feature, interlock 2 pins (17 and 33) on Bank 2 must be shorted to enable the Bank 2 Analog Bus relays to close. The optional 34925T-001 (for 2-wire) terminal block shorts these pins for you. This feature protects inadvertent routing of high voltages from the Analog Buses to the D-sub connector of the

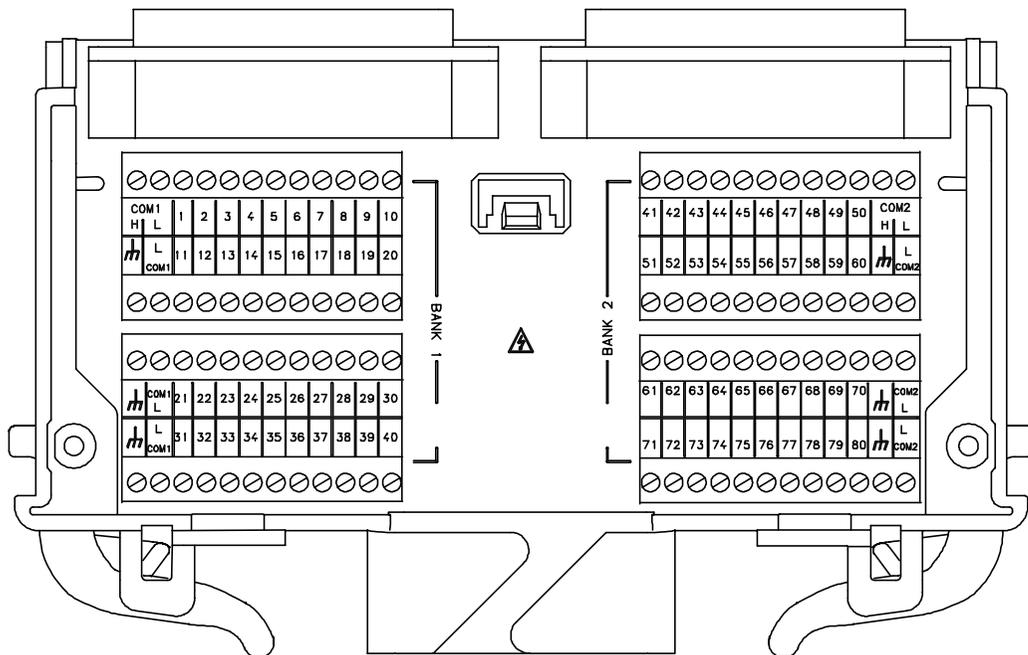| Description	Pin	Description	Pin	Description	Pin	Description	Pin	Description	Pin
21H	1	26H	35	31H	19	36H	37	COM2 H	7
21L	2	26L	36	31L	20	36L	38	COM2 L	8
22H	3	27H	21	32H	39	37H	23	Interlock 2	17
22L	4	27L	22	32L	40	37L	24	Interlock 2	33
23H	5	28H	41	33H	25	38H	43	Reserved	18
23L	6	28L	42	33L	26	38L	44	GND	34
24H	9	29H	27	34H	11	39H	29	No Connect	47
24L	10	29L	28	34L	12	39L	30	No Connect	48
25H	13	30H	45	35H	31	40H	15	No Connect	49
25L	14	30L	46	35L	32	40L	16	No Connect	50

34925T-001 Terminal Block for Two- or Four-Wire Mode

This terminal block with screw-type connections is labeled with the model number and the abbreviated module name. In addition, space is available on the label for you to write the slot number.

NOTE	All modules that connect to the internal DMM are interlock protected. This means that when an installed module is exposed (no terminal block or cable is connected), the Analog Bus relays are open and disconnected from the Analog Buses. See page 120 for further information.

NOTE	If you are using an Agilent terminal block to connect your DUT to this module be sure to use the 34925T-001 terminal block that corresponds to the 2- or 4-wire configuration mode. An error will not be generated if you have installed a terminal block that doesn't match the present module configuration.

The 34980A Product Reference CD (shipped with the instrument) contains a 34925T (2-wire mode) Wiring Log for you to document your wiring configuration for this module. You can open the wiring log file in Microsoft® Excel® or Adobe® Acrobat® format.
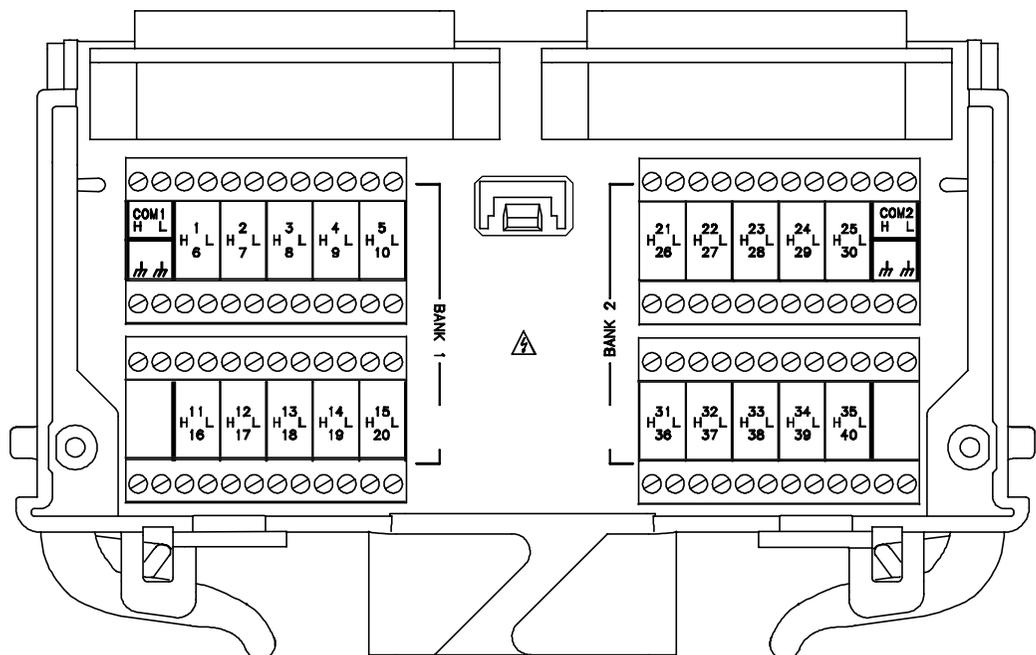
34925A Simplified Schematic for One-Wire Mode

This drawing shows two independent 40-channel, 1-wire MUXes. To change configuration modes, use the SYSTem:MODule:WIRE:MODE command.

NOTE: The three-digit number assigned to each switch represents the channel number.

NOTE:
Bank relays: FET non-latching
Analog Bus relays: Armature non-latching
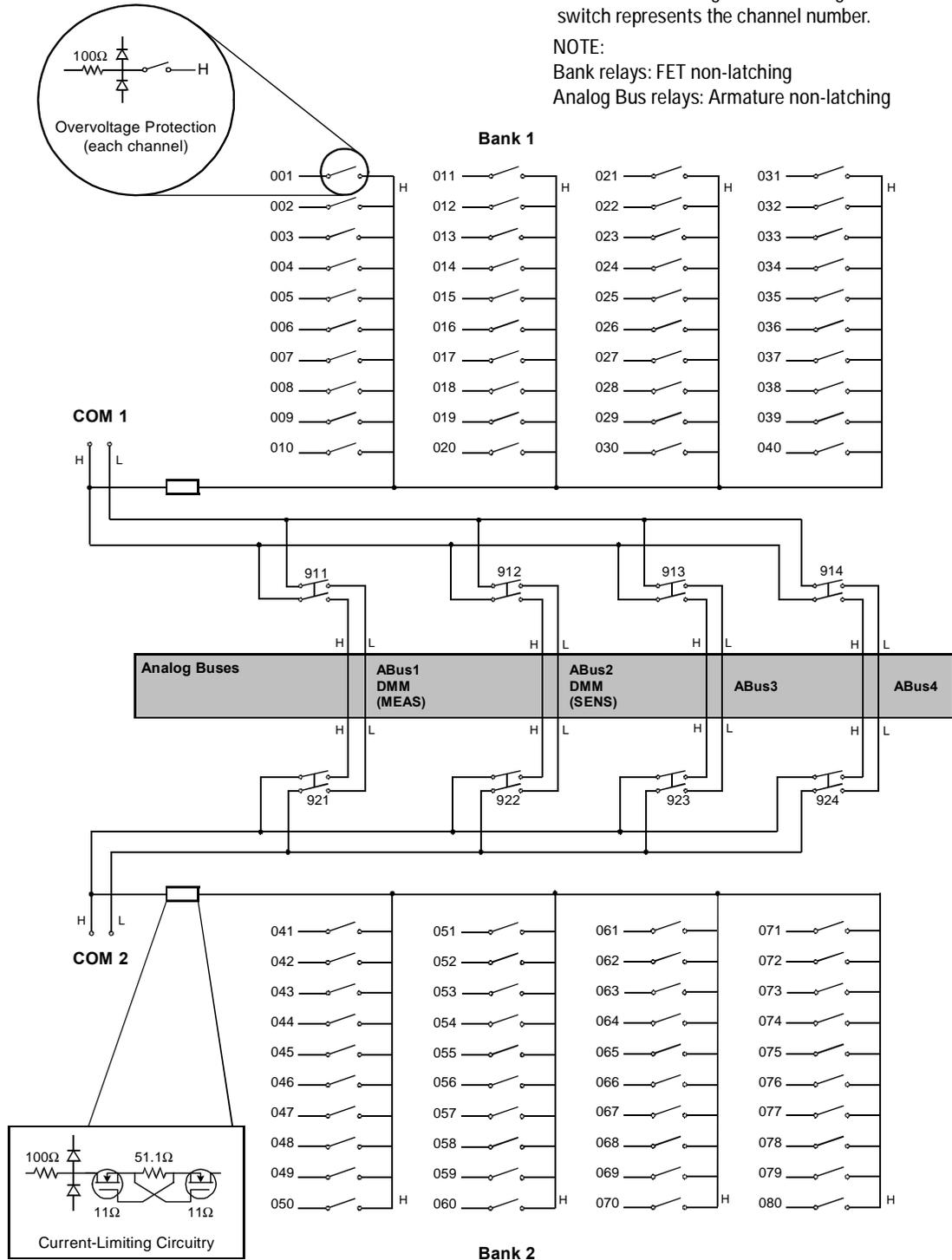
34925A D-Sub Connectors for One-Wired Mode

Bank 1   Bank 2   ○

For orientation, the D-sub connector end of the module is facing you.

Bank 1

```
            COM  COM
 1   2   3   4   5   6   1H   1L   7   8   27  28   9   10  39  40  Interlock1
(1) (2) (3) (4) (5) (6) (7)  (8) (9)(10)(11)(12)(13)(14)(15)(16) (17)

Reserved 21  22  13  14  33  34  25  26  17  18  37  38  29  30  Interlock 1
(18)(19)(20)(21)(22)(23)(24)(25)(26)(27)(28)(29)(30)(31)(32)(33)

GND  11  12  31  32  23  24  15  16  35  36  19  20  NC  NC  NC  NC
(34)(35)(36)(37)(38)(39)(40)(41)(42)(43)(44)(45)(46)(47)(48)(49)(50)
```

50-Pin D-Sub Male Connector

WARNING As a safety feature, interlock 1 pins (17 and 33) on Bank 1 must be shorted to enable the Bank 1 Analog Bus relays to close. The optional 34925T-002 (for 1-wire) terminal block shorts these pins for you. This feature protects inadvertent routing of high voltages from the Analog Bus to the D-sub connector of the module.

Description	Pin	Description	Pin	Description	Pin	Description	Pin	Description	Pin
1	1	11	35	21	19	31	37	COM1 H	7
2	2	12	36	22	20	32	38	COM1 L	8
3	3	13	21	23	39	33	23	Interlock 1	17
4	4	14	22	24	40	34	24	Interlock 1	33
5	5	15	41	25	25	35	43	Reserved	18
6	6	16	42	26	26	36	44	GND	34
7	9	17	27	27	11	37	29	No Connect	47
8	10	18	28	28	12	38	30	No Connect	48
9	13	19	45	29	31	39	15	No Connect	49
10	14	20	46	30	32	40	16	No Connect	50

Bank 2

```
            COM  COM
41  42  43  44  45  46  2H   2L  47  48  67  68  49  50  79  80  Interlock 2
(1) (2) (3) (4) (5) (6) (7)  (8) (9)(10)(11)(12)(13)(14)(15)(16) (17)

Reserved 61  62  53  54  73  74  65  66  57  58  77  78  69  70  Interlock 2
(18)(19)(20)(21)(22)(23)(24)(25)(26)(27)(28)(29)(30)(31)(32)(33)

GND  51  52  71  72  63  64  55  56  75  76  59  60  NC  NC  NC  NC
(34)(35)(36)(37)(38)(39)(40)(41)(42)(43)(44)(45)(46)(47)(48)(49)(50)
```

50-Pin D-Sub Male Connector

WARNING As a safety feature, interlock 2 pins (17 and 33) on Bank 2 must be shorted to enable the Bank 2 Analog Bus relays to close. The optional 34925T-002 (for 1-wire) terminal block shorts these pins for you. This feature protects inadvertent routing of high voltages from the Analog Buses to the D-sub connector of the

Description	Pin	Description	Pin	Description	Pin	Description	Pin	Description	Pin
41	1	51	35	61	19	71	37	COM2 H	7
42	2	52	36	62	20	72	38	COM2 L	8
43	3	53	21	63	39	73	23	Interlock 2	17
44	4	54	22	64	40	74	24	Interlock 2	33
45	5	55	41	65	25	75	43	Reserved	18
46	6	56	42	66	26	76	44	GND	34
47	9	57	27	67	11	77	29	No Connect	47
48	10	58	28	68	12	78	30	No Connect	48
49	13	59	45	69	31	79	15	No Connect	49
50	14	60	46	70	32	80	16	No Connect	50

34925T-002 Terminal Block for One-Wire Mode

This terminal block with screw-type connections is labeled with the model number and the abbreviated module name. In addition, space is available on the label for you to write the slot number.

NOTE	All modules that connect to the internal DMM are interlock protected. This means that when an installed module is exposed (no terminal block or cable is connected), the Analog Bus relays are open and disconnected from the Analog Buses. See page 120 for further information.

NOTE	If you are using an Agilent terminal block to connect your DUT to this module be sure to use the 34925T-002 terminal block that corresponds to the 1-wire configuration mode. An error will not be generated if you have installed a terminal block that doesn't match the present module configuration.

The 34980A Product Reference CD (shipped with the instrument) contains a 34925T (1-wire mode) Wiring Log for you to document your wiring configuration for this module. You can open the wiring log file in Microsoft® Excel® or Adobe® Acrobat® format.

5

Matrix Switch Modules

Agilent Technologies

Matrix Switch Modules

The matrix switch modules for the 34980A offer a convenient way for you to connect multiple instruments to multiple points on your DUT. For a lower cost and better specification alternative, you can connect both matrix and multiplexer (MUX) modules.

Although flexible, it is possible to connect more than one source at the same time with a matrix. Make sure that dangerous or unwanted conditions are not created by these connections.

The family of matrix switch modules consists of:

- the 34931A with two (dual) matrices of latching armature switches. Each matrix is organized in a 4-row by 8-column configuration.

- the 34932A with two (dual) matrices of latching armature switches. Each matrix is organized in a 4-row by 16-column configuration.

- the 34933A, with non-latching reed switches, which you can configure for:

  - differential (2-wire) mode, which has two (dual) matrices. Each matrix is organized in a 4-row by 8-column configuration.

  - single-ended (1-wire) mode, which has four (quad) matrices. Each matrix is organized in a 4-row by 8-column configuration.

<table>
<tr>
<td>

NOTE

</td>
<td>

Safety Interlock   The Analog Buses of the 34980A are capable of carrying 300V signals. The matrix modules have a hardware *Safety Interlock* feature that automatically opens the Analog Bus relays when the associated interlock pins on the D-sub connectors (faceplate) lose continuity. This prevents signals on the Analog Buses from being present on the D-sub connector pins. Optional terminal blocks available from Agilent automatically provide continuity for these interlock pins. If cables are used, you must provide continuity for the interlock pins in your DUT assembly. See the pinout information later in this chapter for the location of interlock pins on each module.

The matrix modules have Analog Bus relays on Bank 2 only. Therefore, the interlock pins are present on only the Bank 2 D-sub connectors.

Normally, if you attempt to connect to the Analog Buses without a terminal block or cable connected, an error is generated. The `SYSTem:ABUS:INTerlock:SIMulate` command allows you to temporarily disable errors generated by the Safety Interlock feature and enables the simulation mode. Although Safety Interlock errors are suppressed in this mode, the actual Analog Bus relays affected by the Safety Interlock are disabled as long as no terminal block or cable is connected to the module.

</td>
</tr>
</table>

SCPI Programming Examples for the Matrix Modules

The programming examples below provide you with SCPI command examples to use for actions specific to the matrix switch modules.

The slot and channel addressing scheme used in these examples follow the general form **sccc** where **s** is the mainframe slot number (1 through 8) and **ccc** is the three-digit channel number. Channel numbers for the matrix modules are derived as follows:

Two-wire mode: The channel numbers for the 34931A, 34932A, and the 34933A (2-wire mode) are derived from the crosspoint or intersection of rows and columns, columns having two digits. See the example below.

Displayed Channel	Means This...
5304	A 34931A, 34932A, 34933A (2-wire mode) matrix module is in slot 5, crosspoint is row 3, column 4. It might be easy to remember this channel configuration as "srcc" (**s**lot, **r**ow, **c**olumn, **c**olumn)

One-wire mode: The channel numbers for the 34933A (in 1-wire mode) are derived from a specific matrix number and the crosspoint or intersection of rows and columns on that matrix. See the example below.

Displayed Channel	Means This...
2437	A 34933A matrix module in 1-wire mode is in slot 2, matrix of interest is 4, crosspoint is row 3, column 7. It might be easy to remember this channel configuration as "smrc" (**s**lot, **m**atrix, **r**ow, **c**olumn)

For information on specific configurations, refer to the simplified schematics for the matrix modules. The schematics are in this chapter.

For complete information on the SCPI commands used to program the 34980A, refer to the Agilent 34980A Programmer's Reference contained on the 34980A Product Reference CD. For example programs, also refer to the 34980A Product Reference CD.

Opening and Closing Channels

Example: Closing and opening matrix channels (34931A, 34932A, and 34933A in two-wire mode)   The following commands close and open channels 311 and 312 through 315 of a 34932A matrix module in 2-wire mode. This module is in slot 3. The channel number represents the matrix crosspoint of a row (one digit) and a column (two digits). For example, channel 311 represents crosspoint at row 3 and column 11 on a 34932A module.

```
ROUTe:CLOSe (@3311,3312:3315)
ROUTe:OPEN (@3311,3312:3315)
```

Example: Closing and opening matrix channels (34933A in one-wire mode)   The following commands close and open channels 311 and 312 through 315 of the 34933A module in 1-wire mode. The module is in slot 4. The channel number represents the matrix and the matrix crosspoint of a row (one digit) and a column (one digit). For example, channel 311 represents the crosspoint on matrix 3 at row 1, column 1 on a 34933A module in 1-wire mode.

```
ROUTe:CLOSe (@3311,3312:3315)
ROUTe:OPEN (@3311,3312:3315)
```

NOTE	Although the previous two examples show the same channel numbers, the channels are derived differently as determined by a module's configuration mode. See page 163 for channel number derivation.

Example: Closing and opening Analog Bus relays   The following command connects the Analog Buses to Matrix 2 for a module (in 2-wire mode) in slot 3.

```
ROUTe:CLOSe (@3921,3922,3923,3924)
ROUTe:OPEN (@3921,3922,3923,3924)
```

NOTE	For matrix modules in 2-wire mode, only Matrix 2 connects to the the Analog Buses. For the 34933A in 1-wire mode, only Matrix 3 and Matrix 4 connect to the Analog Buses.

The Analog Bus relays (numbered s921, s922, s923, etc.) on the matrix modules are ignored if they are included in a range of channels. An error will be generated if an Analog Bus relay is specified as the first or last channel in a range of channels. For example, the following command closes all valid channels between channel 304 and channel 615 (slot 2). In addition, this command closes Analog Bus relay 911 on the module in slot 1 (Bank 1). Note that although the specified range of channels includes the other Analog Bus relays, they are ignored and are not closed by this command.

```
ROUTe:CLOSe (@2304:2615,1911)
```

Example: Querying channels for open or close state The following command returns a 1 (true) or 0 (false) state of channel 204 for a module in slot 3.

```
ROUTe:CLOSe (@3204)
ROUTe:CLOSe? (@3204) !Returns a 1
ROUTe:OPEN? (@3204) !Returns a 0
```

Configuring a Module

Example: Configuring the 34933A module for 2-wire or 1-wire mode The following command configures a matrix module in slot 4 for 1-wire measurements. Because you can configure only the 34933A (and the 34923A and 34925A MUX modules) for either 2-wire or 1-wire mode, an error is generated if you send this command to a slot that does not contain one of those three modules. If you are using terminal blocks with the 34933A module, be sure to use the corresponding 2-wire or 1-wire terminal block.

```
SYSTem:MODule:WIRE:MODE WIRE1,4
```

> **NOTE** When using a command to configure the system, the new configuration does not take effect until you cycle power on the 34980A.

Example: Querying the system for module Identify The following command returns the identity of the module installed in slot 7.

```
SYSTem:CTYPe? 7
```

> **NOTE** For the 34933A matrix module, the query response may include a suffix to indicate a 1-wire configuration. For example, the response for the 34933A will be either "34933A" (differential mode) or "34933A-1W" (single-ended mode).

Reading Cycle Count and Resetting Modules to Power-On State

Example: Reading the cycle count for a relay The following command returns the cycle count on channels 304 and 308 for a matrix module in slot 3.

```
DIAGnostic:RELay:CYCLes? (@3304,3308)
```

Example: Resetting module(s) to power-on state The following command resets a module in slot 4 to its power-on state.

```
SYSTem:CPON 4
```

Linking Multiple Matrix Modules

You can link multiple matrix modules to form a larger matrix. The following two drawings show two-module connections through rows and columns.

Wiring Multiple 34931A or 34932A Modules

With a 34931A you can combine two matrices to form 8x8 (connecting columns) or 4x16 (connecting rows) configurations. Using two 34932A matrices on a 34932A module, you can create 16x8 (connecting columns) or 4x32 (connecting rows) configurations.

You can connect rows in separate modules using external wiring. Or, using Bank 2 matrices, you can connect through the mainframe Analog Buses. For a clear idea of how matrices are arranged and their connections to the Analog Buses, see the simplified schematics on page 169 (34931A) and page 174 (34932A).

You must use external wiring whenever you connect:

• Rows in Matrix 1 of separate modules

• Rows in Matrix 1 to rows in Matrix 2 on the same or separate modules

• Columns of two matrices on the same or separate modules

You can expand upon these two-module configurations and add up to eight modules to design your own large matrices. From a programming standpoint, each matrix module operates as an independent module regardless of the external connections. When linking modules, the channel numbering scheme remains the same as for single modules.

Wiring Multiple 34933A Modules

You can connect matrices on the 34933A module in a similar fashion to the 34931A. However, the presence of in-rush resistors on the Analog Buses and columns require additional consideration, and you must take care when linking multiple 34933A matrix modules. See the simplified schematics on page 179 and page 183.

Increase number of rows by connecting through columns

Module 1

1
2
3
4

1   2   3   *n* - 1   *n**

• • •

8 or 16 Columns

8 Rows

1   2   3   *n* - 1   *n**

1
2
3
4

Module 2

*n can be 8 or 16

Increase number of columns by connecting through rows

16 or 32 Columns

1   2   3   *n* - 1   *n**   1   2   3   *n* - 1   *n**

• • • •   • • • •

Module 1   Module 2

1
2   Analog
3   Buses
4

1
2
3
4

*n can be 8 or 16

4 Rows
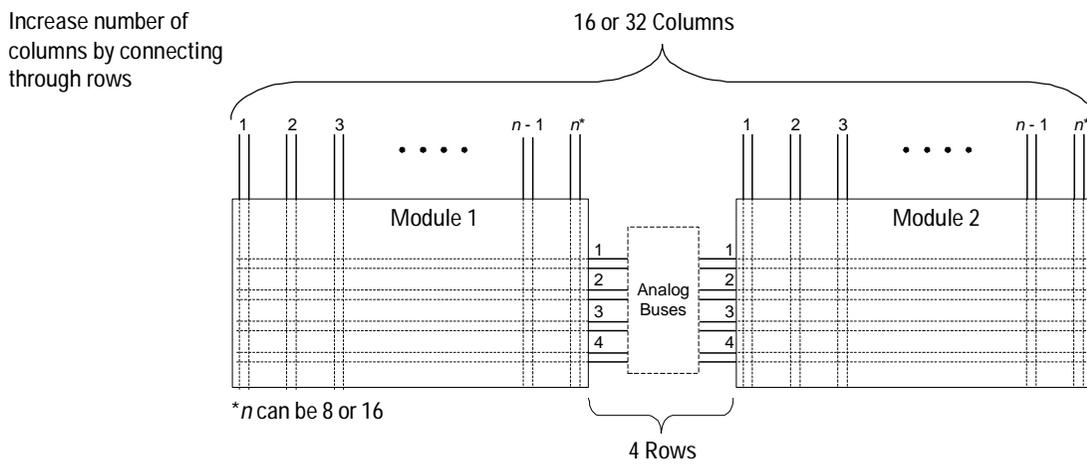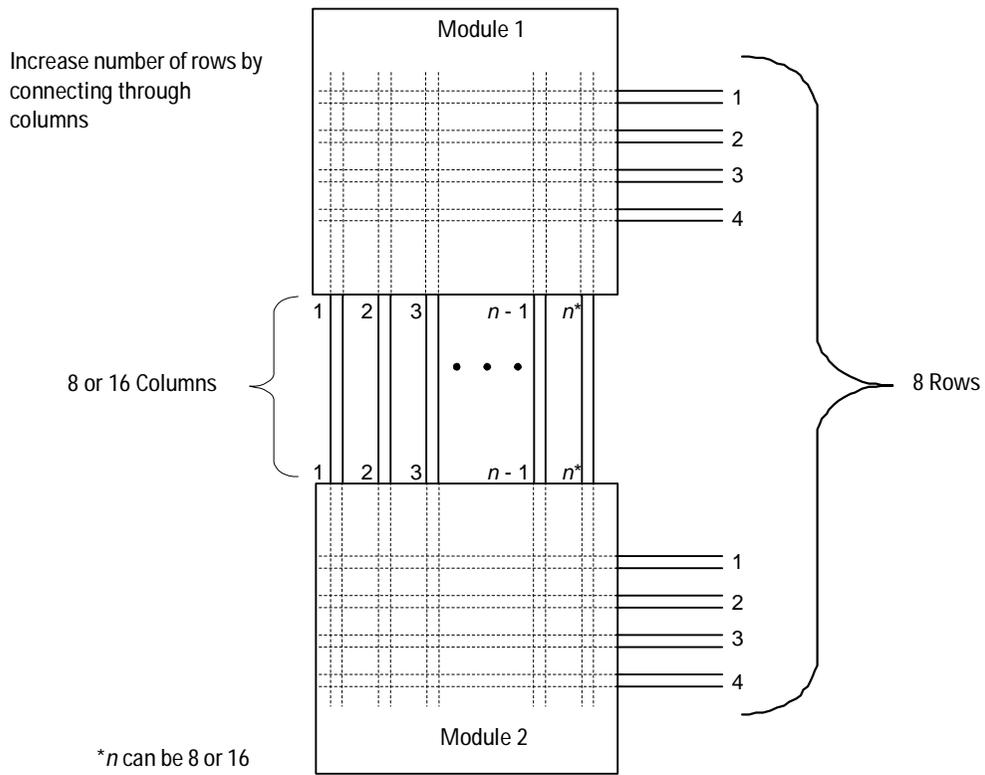
34931A Dual 4x8 Armature Matrix

The 34931A dual 4x8 armature matrix contains two matrices, each with 32 2-wire crosspoint latching armature relays organized in a 4-row by 8-column configuration. Every row and column are made up of two wires each, a high (H) and a low (L). Each crosspoint relay has a unique channel number representing the row and column that intersects to create the crosspoint. For example, channel 304 represent the crosspoint connection between row 3 and column 4 (all columns consisting of two digits; in this case the digits are 04). See the simplified schematic on page 169.

You can connect any combination of inputs and outputs at the same time. However, only Matrix 2 in this module connects to the Analog Buses. By closing channels 921 and 922 you can connect rows 5 and 6 respectively to the internal DMM of the 34980A mainframe for voltage and resistance measurements. You can connect multiple matrix modules externally and/or through the Analog Buses for applications that require large matrices. For information on linking multiple matrices, refer to page 166 of this chapter.

NOTE	When the DMM is scanning, it controls ABus1 and ABus2 relays, which are on Matrix 2. Therefore, consider this behavior when you are connecting matrices.

When the power is off, matrix relays maintain state, and Analog Bus relays open.

34931A Simplified Schematic
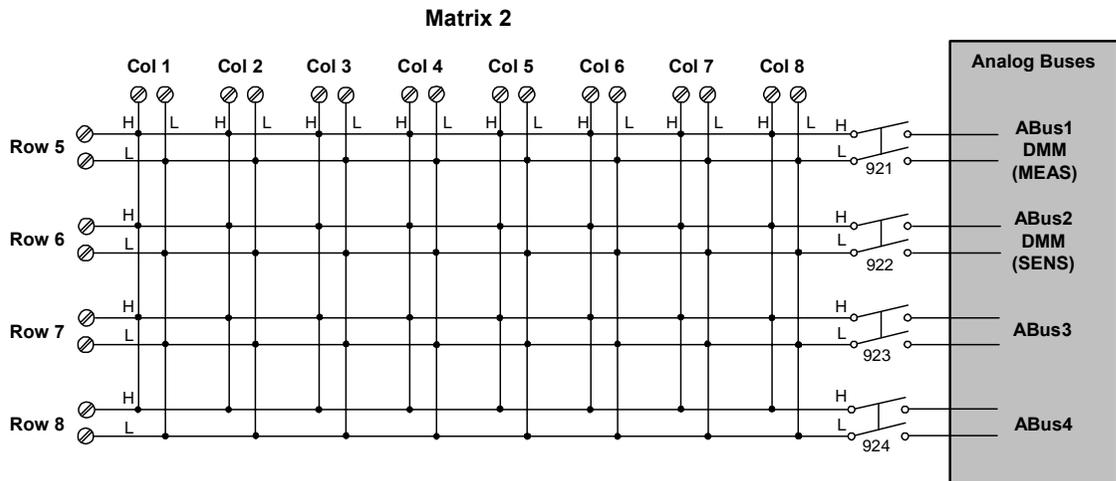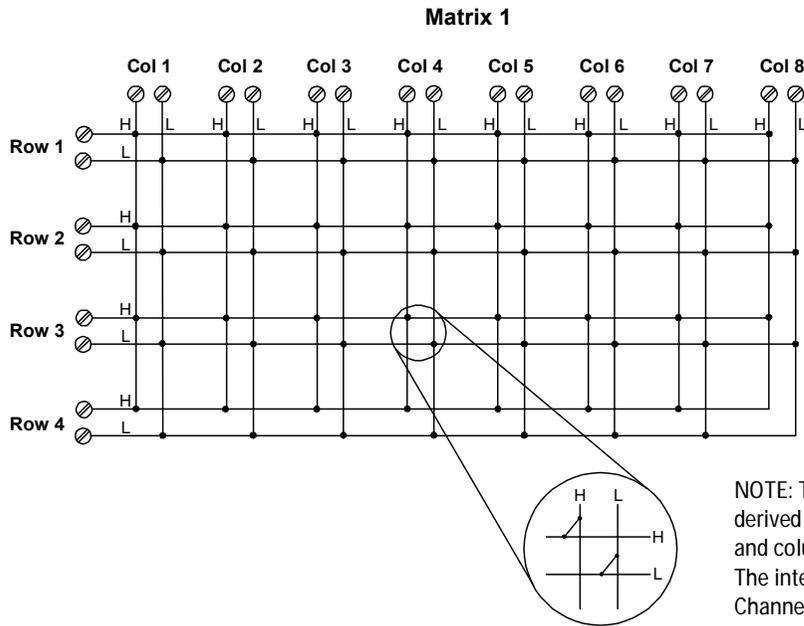
Matrix 1

NOTE: Three-digit channel numbers are derived from the intersection of the rows and columns, columns having two digits. The intersection shown here represents Channel 304 (Row 3, Column 4)

Matrix 2

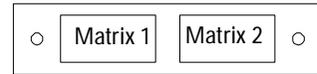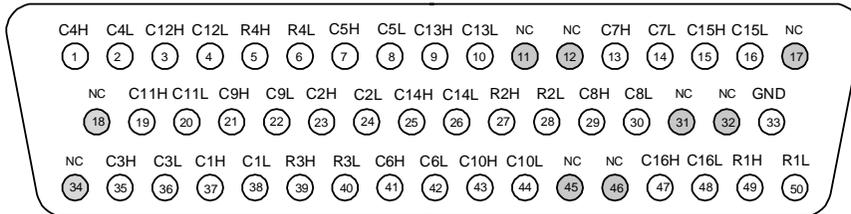NOTE: Matrix 1 and Matrix 2 are electrically separate from one another.

NOTE:
Matrix Relays: Armature latching
Analog Bus Relays: Armature non-latching

34931A D-Sub Connectors

Matrix 1

C4H	C4L	NC	NC	R4H	R4L	C5H	C5L	NC	NC	NC	NC	C7H	C7L	NC	NC	NC
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
NC	NC	NC	NC	NC	C2H	C2L	NC	NC	R2H	R2L	C8H	C8L	NC	NC	GND
18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
NC	C3H	C3L	C1H	C1L	R3H	R3L	C6H	C6L	NC	NC	NC	NC	NC	NC	R1H	R1L
34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
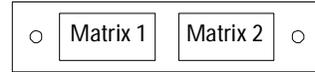
| | Matrix 1 | Matrix 2 | |

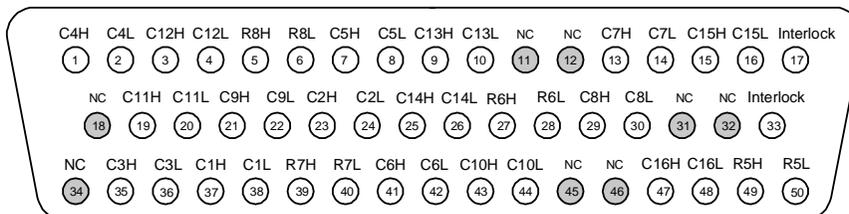For orientation, the D-sub connector end of the module is facing you.
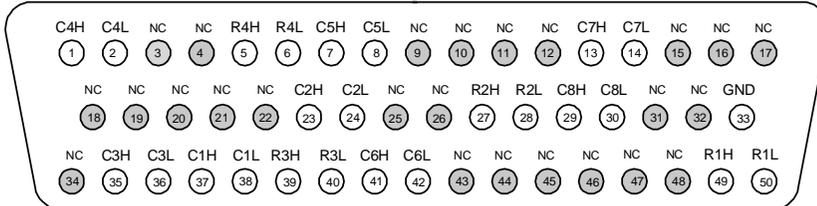
NOTE: In this diagram and the table below, R represents "row," and C represents "column."

50-Pin D-Sub
Male Connector

Description	Pin	Description	Pin	Description	Pin
R1H	49	C2H	23	C7H	13
R1L	50	C2L	24	C7L	14
R2H	27	C3H	35	C8H	29
R2L	28	C3L	36	C8L	30
R3H	39	C4H	1	GND	33
R3L	40	C4L	2	No Connect pins: 3-4, 9-12, 15-22, 25-26, 31-32, 34, and 43-48.	
R4H	5	C5H	7		
R4L	6	C5L	8		
C1H	37	C6H	41		
C1L	38	C6L	42		

Matrix 2
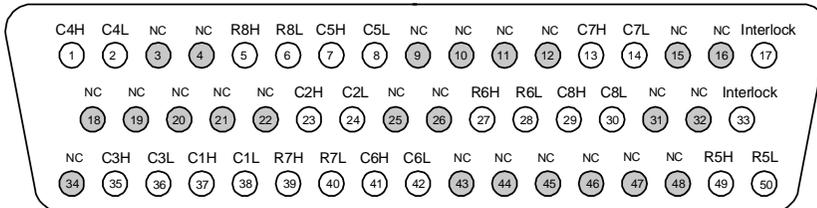
C4H	C4L	NC	NC	R8H	R8L	C5H	C5L	NC	NC	NC	NC	C7H	C7L	NC	NC	Interlock
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
NC	NC	NC	NC	NC	C2H	C2L	NC	NC	R6H	R6L	C8H	C8L	NC	NC	Interlock
18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
NC	C3H	C3L	C1H	C1L	R7H	R7L	C6H	C6L	NC	NC	NC	NC	NC	NC	R5H	R5L
34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50

NOTE: In this diagram and the table below, R represents "row," and C represents "column."

50-Pin D-Sub
Male Connector

WARNING As a safety feature, Interlock pins (17 and 33) must be shorted to enable the Analog Bus relays, which are on Matrix 2, to close. The optional 34931T terminal block shorts these pins for you. This feature protects inadvertent routing of high voltages from the Analog Buses to the D-sub connector of the module.

| Description	Pin	Description	Pin	Description	Pin
R5H	49	C2H	23	C7H	13
R5L	50	C2L	24	C7L	14
R6H	27	C3H	35	C8H	29
R6L	28	C3L	36	C8L	30
R7H	39	C4H	1	Interlock	17
R7L	40	C4L	2	Interlock	33
R8H	5	C5H	7	No Connect pins: 3-4, 9-12, 15-16. 18-22, 25-26, 31-32, 34, 43-48	
R8L	6	C5L	8		
C1H	37	C6H	41		
C1L	38	C6L	42		

34931T Terminal Block

This terminal block with screw-type connections is labeled with the model number and the abbreviated module name. In addition, space is available on the label for you to write the slot number.

NOTE	All modules that connect to the internal DMM are interlock protected. This means that when an installed module is exposed (no terminal block or cable is connected), the Analog Bus relays, which are on Matrix 2, are open and disconnected from the Analog Buses. See page 162 for further information.

The 34980A Product Reference CD (shipped with the instrument) contains a 34931T Wiring Log for you to document your wiring configuration for this module. You can open the wiring log file in Microsoft® Excel® or Adobe® Acrobat® format.

NOTE	On the 34931T terminal block, only two sets of screw terminals are for use with the 34931A module. See the following drawing.

When using the 34931T terminal block, be sure to wire your connections to the two sets of screw terminals closest to the 50-pin D-sub connectors.
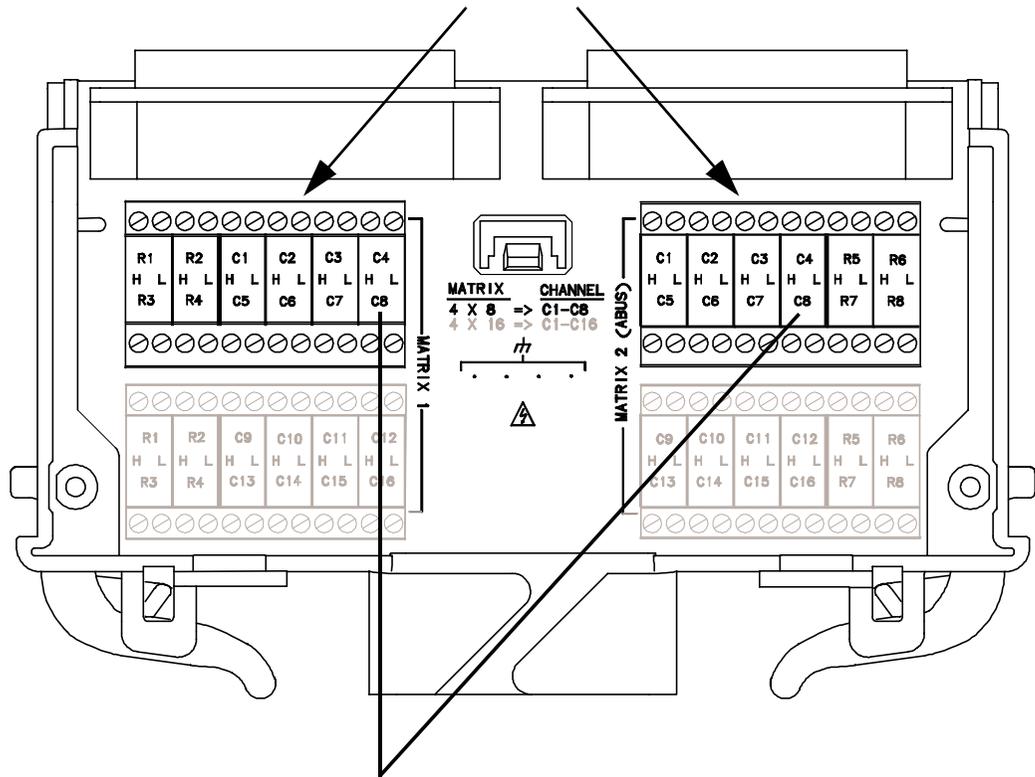
Although columns are numbered the same on Matrix 1 and Matrix 2, they are electrically separate from one another (e.g., Col C8).

34932A Dual 4x16 Armature Matrix

The 34932A dual 4x16 armature matrix contains two matrices, each with 64 2-wire crosspoint latching armature relays organized in a 4-row by 16-column configuration. Every row and column are made up of two wires each, a high (H) and a low (L). Each crosspoint relay has a unique channel number representing the row and column that intersect to create the crosspoint. For example, channel 315 represents the crosspoint connection between row 3 and column 15 (all columns consisting of two digits; in this case the digits are 15). See the simplified schematic on .

You can connect any combination of inputs and outputs at the same time. However, only Matrix 2 in this module connects to the Analog Buses. By closing channels 921 and 922 you can connect rows 5 and 6 respectively to the internal DMM of the 34980A mainframe for voltage and resistance measurements. You can connect multiple matrix modules externally and/or through the Analog Buses for applications that require large matrices. For information on linking multiple matrix modules, refer to of this chapter.

NOTE	When the DMM is scanning, it controls ABus1 and ABus2 relays, which are on Matrix 2. Therefore, consider this behavior when you are connecting matrices.

When the power is off, matrix relays maintain state, and Analog Bus relays open.

34932A Simplified Schematic

Matrix 1

NOTE: Three-digit channel numbers are derived from the intersection of the rows and columns, columns having two digits. The intersection shown here represents Channel 315 (Row 3, Column 15).

Matrix 2

NOTE: Matrix 1 and Matrix 2 are electrically separate from one another.

NOTE:
Matrix Relays: Armature latching
Analog Bus Relays: Armature non-latching

34932A D-Sub Connectors

Matrix 1 | Matrix 2

For orientation, the D-sub connector end of the module is facing you.

Matrix 1

C4H C4L C12H C12L R4H R4L C5H C5L C13H C13L NC NC C7H C7L C15H C15L NC
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17

NC C11H C11L C9H C9L C2H C2L C14H C14L R2H R2L C8H C8L NC NC GND
18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33

NC C3H C3L C1H C1L R3H R3L C6H C6L C10H C10L NC NC C16H C16L R1H R1L
34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50

NOTE: In this diagram and the table below, R represents "row," and C represents "column."

50-Pin D-Sub
Male Connector

Description	Pin	Description	Pin	Description	Pin	Description	Pin	Description	Pin
R1H	49	C2H	23	C7H	13	C12H	3	GND	33
R1L	50	C2L	24	C7L	14	C12L	4	No Connect pins: 11-12, 17-18, 31-32, 34, and 45-46	
R2H	27	C3H	35	C8H	29	C13H	9		
R2L	28	C3L	36	C8L	30	C13L	10		
R3H	39	C4H	1	C9H	21	C14H	25		
R3L	40	C4L	2	C9L	22	C14L	26		
R4H	5	C5H	7	C10H	43	C15H	15		
R4L	6	C5L	8	C10L	44	C15L	16		
C1H	37	C6H	41	C11H	19	C16H	47		
C1L	38	C6L	42	C11L	20	C16L	48		

Matrix 2

C4H C4L C12H C12L R8H R8L C5H C5L C13H C13L NC NC C7H C7L C15H C15L Interlock
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17

NC C11H C11L C9H C9L C2H C2L C14H C14L R6H R6L C8H C8L NC NC Interlock
18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33

NC C3H C3L C1H C1L R7H R7L C6H C6L C10H C10L NC NC C16H C16L R5H R5L
34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50

NOTE: In this diagram and the table below, R represents "row," and C represents "column."

50-Pin D-Sub
Male Connector

WARNING As a safety feature, interlock pins (17 and 33) must be shorted to enable the Analog Bus relays, which are on Matrix 2, to close. The optional 34932T terminal block shorts these pins for you. This feature protects inadvertent routing of high voltages from the Analog Buses to the D-sub connector of the module.

Description	Pin	Description	Pin	Description	Pin	Description	Pin	Description	Pin
R5H	49	C2H	23	C7H	13	C12H	3	Interlock	17
R5L	50	C2L	24	C7L	14	C12L	4	Interlock	33
R6H	27	C3H	35	C8H	29	C13H	9	No connect pins: 11-12, 18, 31-32, 34, and 45-46.	
R6L	28	C3L	36	C8L	30	C13L	10		
R7H	39	C4H	1	C9H	21	C14H	25		
R7L	40	C4L	2	C9L	22	C14L	26		
R8H	5	C5H	7	C10H	43	C15H	15		
R8L	6	C5L	8	C10L	44	C15L	16		
C1H	37	C6H	41	C11H	19	C16H	47		
C1L	38	C6L	42	C11L	20	C16L	48		

34932T Terminal Block

This terminal block with screw-type connections is labeled with the model number and the abbreviated module name. In addition, space is available on the label for you to write the slot number.

<table>
<tr><td>NOTE</td><td>All modules that connect to the internal DMM are interlock protected. This means that when an installed module is exposed (no terminal block or cable is connected), the Analog Bus relays, which are on Matrix 2, are open and disconnected from the Analog Buses. See page 162 for further information.</td></tr>
</table>

The 34980A Product Reference CD (shipped with the instrument) contains a 34932T Wiring Log for you to document your wiring configuration for this module. You can open the wiring log file in Microsoft® Excel® or Adobe® Acrobat® format

Although they have separate screw-type connectors, rows labeled the same on a matrix are electrically connected. Therefore, you can wire the same-matrix rows in two locations.
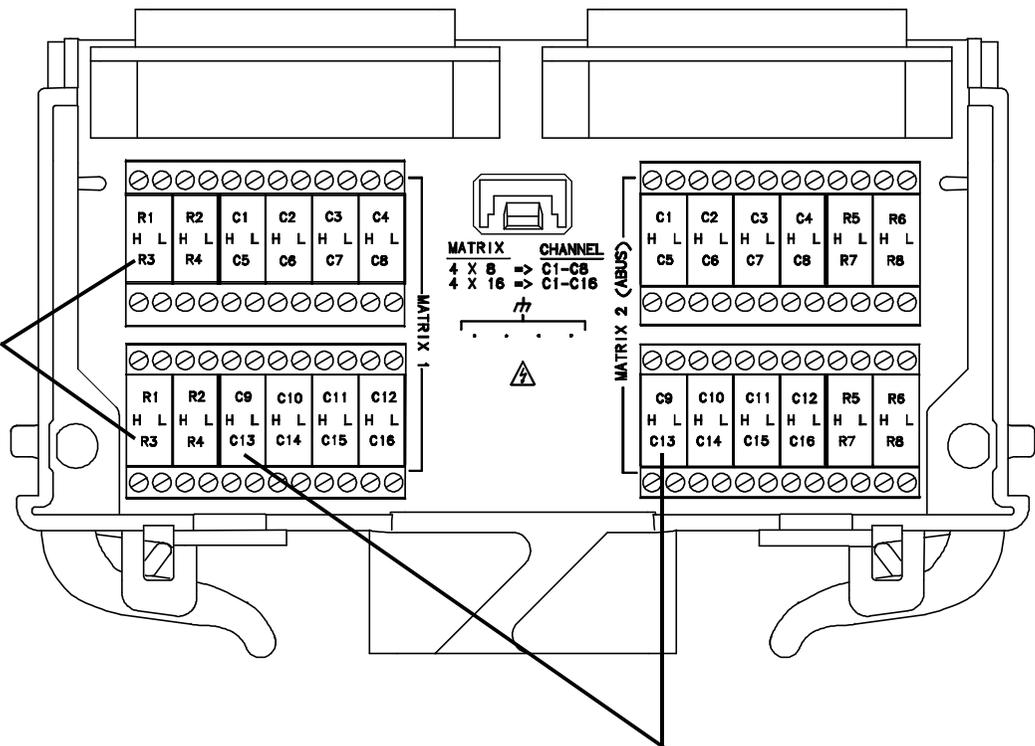
Although columns are numbered the same on Matrix 1 and Matrix 2, they are electrically separate from one another (e.g., Col C13).

34933A Dual/Quad 4x8 Reed Matrix

Using program commands or the front panel of the 34980A, you can configure the 34933A dual/quad 4x8 reed matrix module for differential (2-wire) mode or single-ended (1-wire) mode.

The 34933A module contains 100 Ω in-rush resistors that are used to protect the reed relays from reactive loads. If you have applications where in-rush resistors interfere with measurements, connections are provided on the terminal blocks for you to bypass the in-rush resistors that are located on the columns. See the simplified schematics on page 179 and page 183. However, if you choose to bypass the in-rush resistors, the life of the reed relays that you bypass may be degraded.

Two-Wire Mode

To physically configure the module for 2-wire mode, use the 34933T-001 terminal block, or a compatible standard or custom cable. If using a standard or custom cable, make sure you connect interlock pins 17 and 33 on the Matrix 2 D-sub connector. Refer to the pinout drawing and table on page 180.

In 2-wire mode, the 34933A module contains two matrices, each with 32 2-wire crosspoint non-latching reed relays organized in a 4-row by 8-column configuration. Every row and column are made up of two wires each, a high (H) and a low (L). Each crosspoint relay has a unique channel number representing the row and column that intersect to create the crosspoint. For example, channel 308 represents the crosspoint connection between row 3 and column 08 (all columns consisting of two digits; in this case the digits are 08). See the simplified schematic on page 179.

You can connect any combination of inputs and outputs at the same time. However, only Matrix 2 in 2-wire mode of this module connects to the Analog Buses. By closing channels 921 and 922 you can connect rows 5 and 6 respectively to the internal DMM of the 34980A mainframe for voltage and resistance measurements.

In 2-wire mode, you can close no more than 20 channels simultaneously due to power dissipation. However, note that Analog Bus relays count half as much as channel relays in that total. For example, with one Analog Bus relay closed, you can close up to a maximum of 19 channel relays. If you try to close more than the allowed number of channels, you will receive an error message.

One-Wire Mode

To physically configure the module in 1-wire mode, use the 34933T-002 terminal block, or a compatible standard or custom cable. If using a standard or custom cable, make sure you connect interlock pins 17 and 33 on the Matrix 2 D-sub connector. Refer to the pinout drawing and table on .

In 1-wire mode, the 34933A module contains four matrices (1 through 4), each with 32 1-wire crosspoint non-latching reed relays organized in a 4-row by 8-column configuration. Every row and column has one wire each. Each crosspoint relay has a unique channel number representing the matrix, and the single-wire row and column that intersect to make the crosspoint. For example, channel 218 represents Matrix 2, row 1 and column 8. See the simplified schematic on .

In 1-wire mode, you can close no more than 40 channels simultaneously due to power dissipation. For example, with one Analog Bus relay closed you can close up to a maximum of 39 channel relays. If you try to close more than the allowed number of channels, you will receive an error message.

You can connect any combination of inputs and outputs at the same time. However, only Matrix 3 and Matrix 4 in 1-wire mode of this module connect to the Analog Buses. By closing channels 921 and 922 you can connect rows 1 and rows 2 respectively to the internal DMM of the 34980A mainframe for voltage and resistance measurements.

You can connect multiple matrix modules externally and/or through the Analog Buses for applications that require large matrices. For information on linking multiple matrix modules, refer to of this chapter.

When the power is off, matrix relays and Analog Bus relays open.

34933A Simplified Schematic for Two-Wire Mode

Matrix 1

NOTE:
Matrix Relays: Reed non-latchir
Analog Bus Relays: Armature non-latching

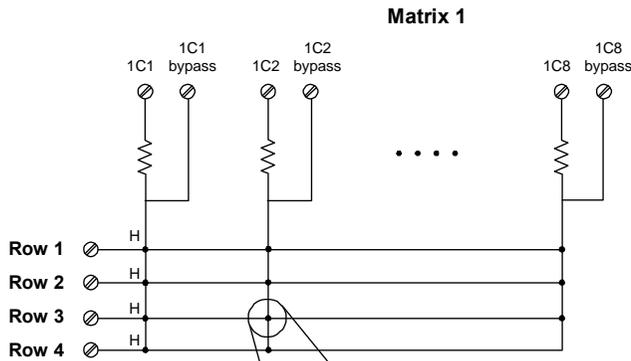NOTE: Although columns are numbered the same on Matrix 1 and Matrix 2, they are electrically separate from one another.

NOTE: All series resistors shown are 100Ω.

NOTE: Three-digit channel numbers are derived from the intersection of the rows and columns, columns having two digits. The intersection shown here represents Channel 308 (Row 3, Column 8).

Matrix 2

Analog Buses

ABus1
DMM
(MEAS)
921

ABus2
DMM
(SENS)
922

ABus3
923

ABus4
924

34933A D-Sub Connectors for Two-Wire Mode
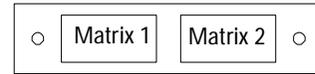
| ○ | Matrix 1 | Matrix 2 | ○ |

Matrix 1

For orientation, the D-sub connector end of the module is facing you.
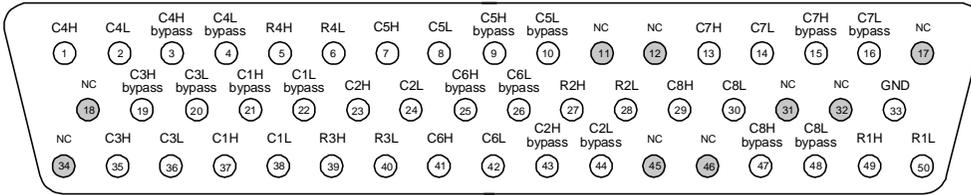
50-Pin D-Sub Male Connector

NOTE:
- In this diagram and the table below, R represents "row," and C represents "column."
- "Bypass" means to bypass the 100Ω in-rush resistor that protects the reed relays.

Description	Pin	Description	Pin	Description	Pin	Description	Pin	Description	Pin	Description	Pin
R1H	49	C1H	37	C5H	7	C1H bypass	21	C5H bypass	9	GND	33
R1L	50	C1L	38	C5L	8	C1L bypass	22	C5L bypass	10	No Connect pins: 11-12, 17-18, 31-32, 34, and 45-46	
R2H	27	C2H	23	C6H	41	C2H bypass	43	C6H bypass	25		
R2L	28	C2L	24	C6L	42	C2L bypass	44	C6L bypass	26		
R3H	39	C3H	35	C7H	13	C3H bypass	19	C7H bypass	15		
R3L	40	C3L	36	C7L	14	C3L bypass	20	C7L bypass	16		
R4H	5	C4H	1	C8H	29	C4H bypass	3	C8H bypass	47		
R4L	6	C4L	2	C8L	30	C4L bypass	4	C8L bypass	48		

Matrix 2
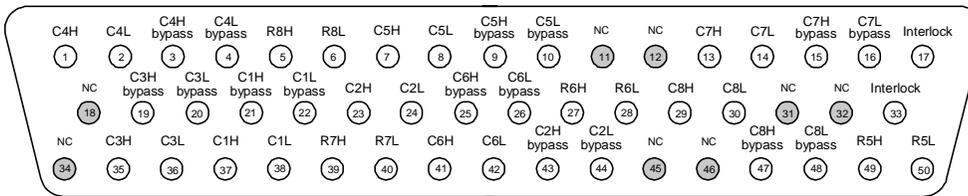
50-Pin D-Sub Male Connector

NOTE:
- In this diagram and the table below, R represents "row," and C represents "column."
- "Bypass" means to bypass the 100Ω in-rush resistor that protects the reed relays.

WARNING As a safety feature, interlock pins (17 and 33) must be shorted to enable the Analog Bus relays, which are on Matrix 2, to close. The optional 34933T-001 (for 2-wire) terminal block shorts these pins for you. This feature protects inadvertent routing of high voltages from the Analog Bus to the D-sub connector of the module.

Description	Pin	Description	Pin	Description	Pin	Description	Pin	Description	Pin
R5H	49	C2H	23	C7H	13	C4H bypass	3	Interlock	17
R5L	50	C2L	24	C7L	14	C4L bypass	4	Interlock	33
R6H	27	C3H	35	C8H	29	C5H bypass	9	No Connect pins: 11-12, 18, 31-32, 34, and 45-46	
R6L	28	C3L	36	C8L	30	C5L bypass	10		
R7H	39	C4H	1	C1H bypass	21	C6H bypass	25		
R7L	40	C4L	2	C1L bypass	22	C6L bypass	26		
R8H	5	C5H	7	C2H bypass	43	C7H bypass	15		
R8L	6	C5L	8	C2L bypass	44	C7L bypass	16		
C1H	37	C6H	41	C3H bypass	19	C8H bypass	47		
C1L	38	C6L	42	C3L bypass	20	C8L bypass	48		

34933T-001 Terminal Block for Two-Wire Mode

This terminal block with screw-type connections is labeled with the model number and the abbreviated module name. In addition, space is available on the label for you to write the slot number.
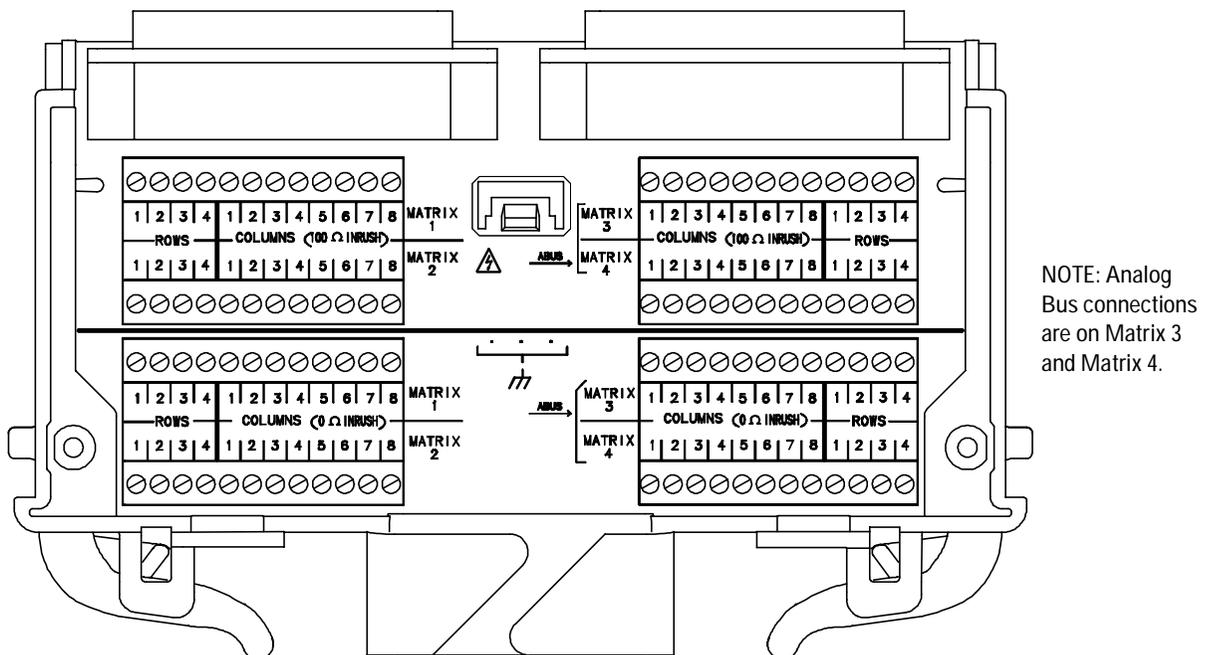
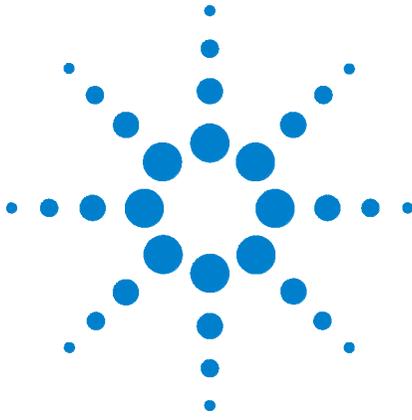| NOTE	All modules that connect to the internal DMM are interlock protected. This means that when an installed module is exposed (no terminal block or cable is connected), the Analog Bus relays, which are on Matrix 2, are open and disconnected from the Analog Buses. See page 162 for further information.

The 34980A Product Reference CD (shipped with the instrument) contains a 34933T (2-wire) Wiring Log for you to document your wiring configuration for this module. You can open the wiring log file in Microsoft® Excel® or Adobe® Acrobat® format

NOTE	If you are using an Agilent terminal block to connect your DUT to this module be sure to use the 34933T-001 terminal block that corresponds to the 2-wire configuration mode. Note that an error will not be generated if you have installed a terminal block that doesn't match the present module configuration.

Although columns are numbered the
same on Matrix 1 and Matrix 2, they are
electrically separate from one another
(e.g., Col C2).
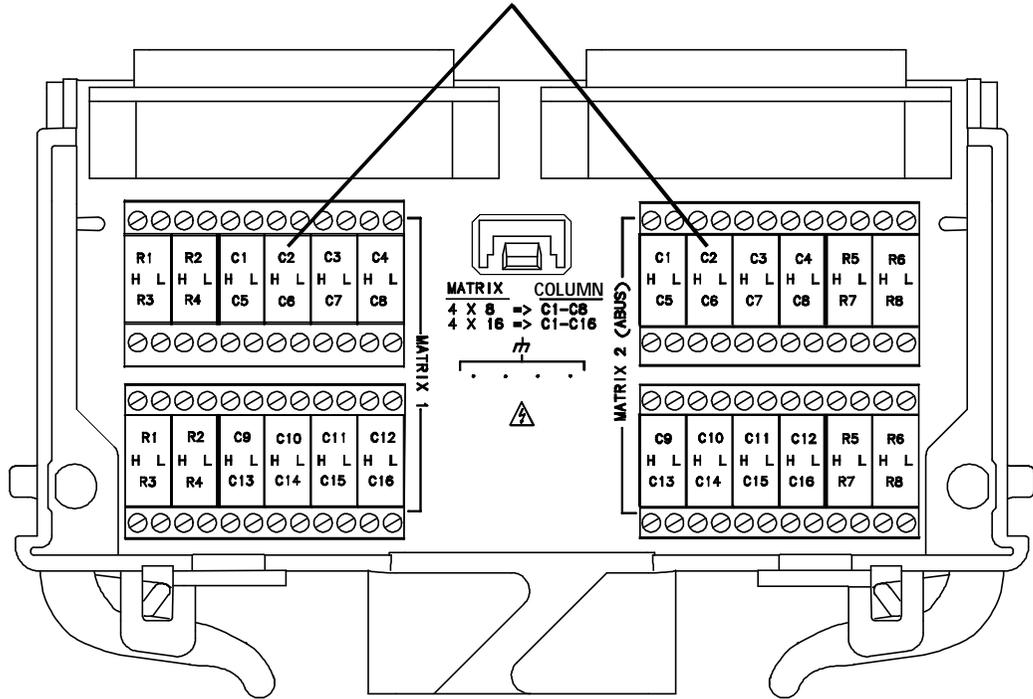
When using the 34933T terminal block for 2-wire mode, access is
provided to the bypass columns through the columns labeled C9 through
C16. Follow this wiring convention shown in the table below for both
matrices.

Terminal marked...	Connects to...	Terminal marked...	Connects to...
C9H	C1Hbypass	C13H	C5H bypass
C9L	C1L bypass	C13L	C5L bypass
C10H	C2H bypass	C14H	C6H bypass
C10L	C2L bypass	C14L	C6L bypass
C11H	C3H bypass	C15H	C7H bypass
C11L	C3L bypass	C15L	CC7L bypass
C12H	C4H bypass	C16H	C8H bypass
C12L	C4L bypass	C16L	C8L bypass

34933A Simplified Schematic for One-Wire Mode

NOTE: Although rows are numbered the same across the matrices, they are electrically separate from one another.

NOTE:
Matrix Relays: Reed non-latching
Analog Bus Relays: Armature non-latching

NOTE: All series resistors shown are 100Ω.

Matrix 1

NOTE: Three-digit channel numbers are derived from a specific matrix number and the intersection of rows and columns on that matrix. The channel shown here is 132 (Matrix 1, Row 3, Column 2.)
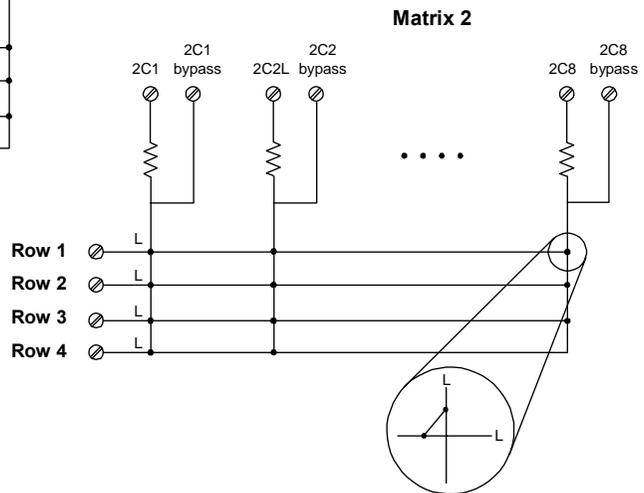
Matrix 2

Channel 218
(Matrix 2, Row 1, Column 8)

Matrix 3

Analog Buses

ABus1
DMM
(MEAS)
921

ABus2
DMM
(SENS)
922

ABus3
923

ABus4
924

Matrix 4
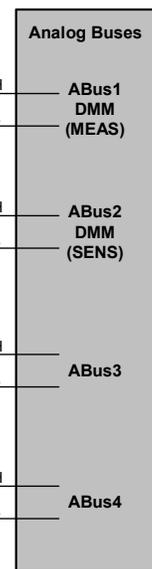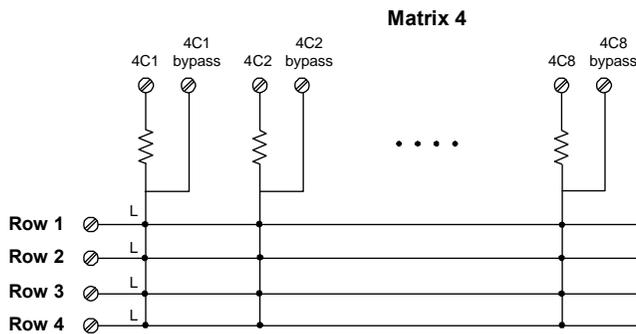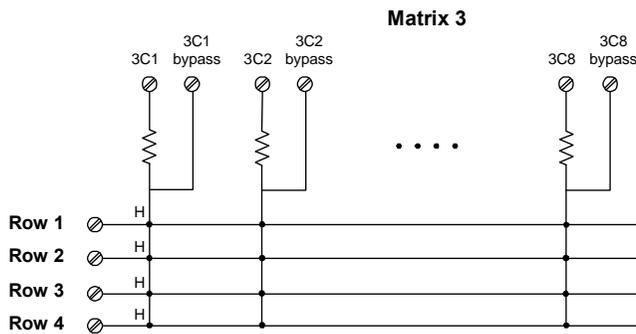
34933A D-Sub Connectors for One-Wire Mode

○ Matrices 1 & 2	Matrices 3 & 4 ○
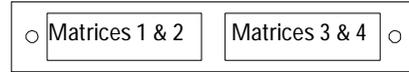
Matrices 1 and 2

For orientation, the D-sub connector end of the module is facing you.
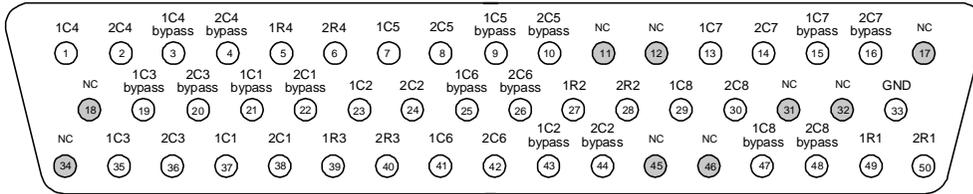
50-Pin D-Sub Male Connector

NOTE: Conventions for these drawings and tables as they relate to pinout information:

- **2R4** means Matrix **2**, **R**ow **4**.
- **1C5** means Matrix **1**, **C**olumn **5**
- **4C2 bypass** means: Matrix **4**, **C**olumn **2**, and the connection bypasses the 100Ω in-rush resistor that protects the reed relays

Description	Pin	Description	Pin	Description	Pin	Description	Pin	Description	Pin
1R1	49	1C2	23	1C7	13	1C4 bypass	3	GND	33
1R2	27	2C2	24	2C7	14	2C4 bypass	4	No connect pins: 11-12, 17-18, 31-32, 34, and 45-46	
1R3	39	1C3	35	1C8	29	1C5 bypass	9		
1R4	5	2C3	36	2C8	30	2C5 bypass	10		
2R1	50	1C4	1	1C1 bypass	21	1C6 bypass	25		
2R2	28	2C4	2	2C1 bypass	22	2C6 bypass	26		
2R3	40	1C5	7	1C2 bypass	43	1C7 bypass	15		
2R4	6	2C5	8	2C2 bypass	44	2C7 bypass	16		
1C1	37	1C6	41	1C3 bypass	19	1C8 bypass	47		
2C1	38	2C6	42	2C3 bypass	20	2C8 bypass	48		

Matrices 3 and 4
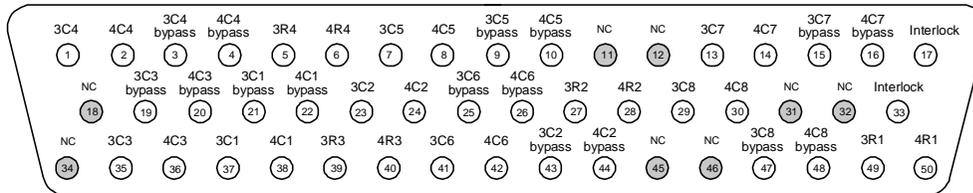
50-Pin D-Sub Male Connector

WARNING As a safety feature, interlock pins (17 and 33) must be shorted to enable the Analog Bus relays, which are on Matrix 2, to close. The optional 34933T-002 (for 1-wire) terminal block shorts these pins for you. This safety feature protects inadvertent routing of high voltages from the Analog Buses to the D-sub connector of the module.

Description	Pin	Description	Pin	Description	Pin	Description	Pin	Description	Pin
3R1	49	3C2	23	3C7	13	3C4 bypass	3	Interlock	17
3R2	27	4C2	24	4C7	14	4C4 bypass	4	Interlock	33
3R3	39	3C3	35	3C8	29	3C5 bypass	9	No connect pins: 11-12, 18, 31-32, 34, and 45-46	
3R4	5	4C3	36	4C8	30	4C5 bypass	10		
4R1	50	3C4	1	3C1 bypass	21	3C6 bypass	25		
4R2	28	4C4	2	4C1 bypass	22	4C6 bypass	26		
4R3	40	3C5	7	3C2 bypass	43	3C7 bypass	15		
4R4	6	4C5	8	4C2 bypass	44	4C7 bypass	16		
3C1	37	3C6	41	3C3 bypass	19	3C8 bypass	47		
4C1	38	4C6	42	4C3 bypass	20	4C8 bypass	48		

34933T-002 Terminal Block for One-Wire Mode

This terminal block with screw-type connections is labeled with the model number and the abbreviated module name. In addition, space is available on the label for you to write the slot number.

| **NOTE** | All modules that connect to the internal DMM are interlock protected. This means that when an installed module is exposed (no terminal block or cable is connected), the Analog Bus relays and current channels are open and disconnected from the Analog Buses. See page 162 for further information. |

The 34980A Product Reference CD (shipped with the instrument) contains a 34933T (1-wire) Wiring Log for you to document your wiring configuration for this module. You can open the wiring log file in Microsoft® Excel® or Adobe® Acrobat® format

| **NOTE** | If you are using an Agilent terminal block to connect your DUT to this module be sure to use the 34933T-002 terminal block that corresponds to the 1-wire configuration mode. Note that an error will not be generated if you have installed a terminal block that doesn't match the present module configuration. |

NOTE: Analog Bus connections are on Matrix 3 and Matrix 4.

6

General Purpose Switch Modules

Agilent Technologies

General Purpose Switch Modules

Use the general-purpose (GP) switch modules in your 34980A mainframe to route signals or control other system devices.

- The 34937A 32-Channel Form C and Form A GP Switch Module provides independent control of 32 latching relays:

  - Twenty-eight Form C relays rated for 1 A at 60 W per channel

  - Four Form A relays rated for 5 A at 150 W per channel.

- For power switching applications, the 34938A 21-Channel 5 A Form A Switch Module offers 20 Form A relays rated for 5 A at 150 W per channel.

Both modules contain armature-latching relays, and you can use these switches for device actuation, digital output, or combined with other switch modules to create flexible switching topologies. You can close multiple channels at the same time. These modules do not connect to the analog buses.
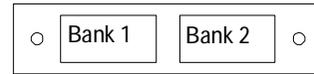
A temperature sensor on these modules triggers system interrupts when high-carry current-induced heat on the modules is excessive and sets the HOT annunciator on the front panel. This over-temperature situation generates an SRQ event when the factory-set 70 $^\circ$C threshold is reached. It is up to the user to determine what, if any, action should be taken.

Reactive loads (those that include significant inductance or capacitance) can cause voltage spikes or current spikes during switching operations. The general purpose modules are designed for switching reactive loads. The optional 34937T and 34938T terminal blocks have solder pads for adding snubber circuits for the 5 A relays to reduce the reactive transients. See the drawings on page 194 and page 197 for the locations of snubber circuit pads and installation information about a snubber circuit.

A hardware jumper on each of the GP modules allows you to define the power-failure states for the modules' 5 A latching relays. Depending on the position of the jumper, the 5 A relays will either open or maintain state when system power failure occurs. When shipped from the factory, the power-fail jumper is in "MAINTAIN" position (all relays maintain their present state when power fails).

NOTE	The 34937A has five 5 A relays, and the 34938A modules has 20 5 A relays

WARNING	Before changing the position of the jumper, remove external connections from the module. Wait five to ten seconds to allow the module's internal capacitors to discharge.

After a five- to ten-second delay, remove the sheet metal cover from the module and move the position of the jumper mounted on the module. See the figure below for the jumper's location on the module.

WARNING	Do not connect either the 34937A or 34938A module directly to a mains power outlet. If it is necessary to switch a mains voltage or any circuit where a large inductive load may be switched, you must add signal conditioning elements to reduce the potential transients before they reach the module or the Analog Buses.
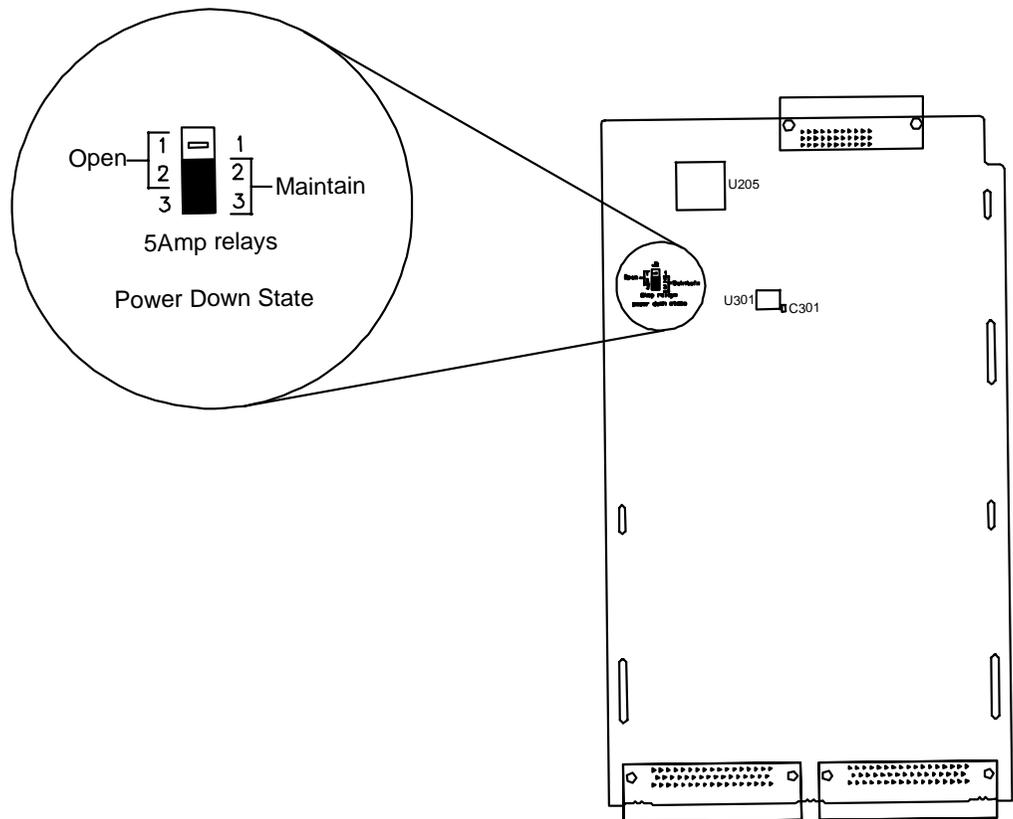
34937A and 34938A SCPI Programming Examples

The programming examples below provide you with SCPI command examples to use for actions specific to the general purpose switch modules.

The slot and channel addressing scheme used in these examples follow the form **sccc** where **s** is the mainframe slot number (1 through 8) and **ccc** is the channel number.

For complete information on the SCPI commands used to program the 34980A, refer to the Agilent 34980A Programmer's Reference contained on the 34980A Product Reference CD. For example programs, also refer to the 34980A Product Reference CD.

Opening and Closing Channels

Example: Closing and opening channels   The first two commands close channel 3 for a module in slot 2, then channel 5 for that module. The last command opens both channel 3 and channel 5.

```
ROUTe:CLOSe (@2003)
ROUTe:CLOSe (@2005)
ROUTe:OPEN (@2003,2005)
```

Example: Querying channels for open or close state   The following command returns a 1 (true) or 0 (false) state of channel 016 for a module in slot 3.

```
ROUTe:CLOSe (@3016)
ROUTe:CLOSe? (@3016) !Returns a 1
ROUTe:OPEN? (@3016) !Returns a 0
```

Reading Jumper State and System Identity

Example: Querying the power-failure state of 5 A relays   The following command returns the position of the power-fail jumper, either "MAIN" (all relays maintain their present state when power fails) or "OPEN" (all relays open when power fails) for a module in slot 4. If this command is sent to a module other than the 34937A or 34938A, "NONE" is returned (no error is generated).

```
SYSTem:MODule:PFAil:JUMPer:AMP5? 4
```

Example: Querying the system for module identify (all modules)   The following command returns the identify of the module installed in slot 7.

```
SYSTem:CTYPe? 7
```

Reading Cycle Count and Resetting Modules to Power-On State

Example: Reading the cycle count for a relay (all switch modules)   The following command returns the relay cycle count on channel 7 and channel 16 for a module in slot 1.

```
DIAGnostic:RELay:CYCLes? (@1007,1016)
```

Example: Clearing the cycle count for a relay (all switch modules)   The following command resets the relay cycle count on channels 7 and 16 for a module in slot 1.

```
DIAGnostic:RELay:CYCLes:CLEar (@1007,1016)
```

Example: Resetting Module(s) to power-on state (all modules)   The following command resets a module in slot 4 to its power-on state.

```
SYSTem:CPON 4
```

34937A 32-Channel GP Switch

The 34937A general-purpose switch module provides independent control of:

- Twenty-eight Form C (DPST) latching relays rated at 1 A
- Four Form A (SPST) latching relays rated at 5 A. You can set the power-failure state for these 5 A relays. See page 188 and page 189.

<table>
<tr><td>NOTE</td><td>A temperature sensor on these modules triggers system interrupts when high-carry current-induced heat on the modules reaches a threshold of 70 ^{0}C.</td></tr>
</table>

34937A Simplified Schematic

NC ●
NO ○   Channel 001 (1A Form C)
COM

NO ○   Channel 029 (5A Form A)
COM

NC ●
NO ○   Channel 028 (1A Form C)
COM

NO ○   Channel 032 (5A Form A)
COM

34937A D-Sub Connectors

Bank 1

Bank 1 | Bank 2

For orientation, the D-sub connector end of the module is facing you.
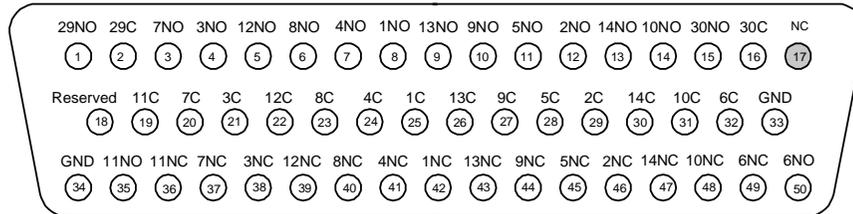
50-Pin D-Sub Male Connector

Channel	Pin	Channel	Pin	Channel	Pin	Channel	Pins	Channel	Pins		
1 NC	42	4 NC	41	7 NC	37	10 NC	48	13 NC	43	30 NO	15
1 Common	25	4 Common	24	7 Common	20	10 Common	31	13 Common	26	30 Common	16
1 NO	8	4 NO	7	7 NO	3	10 NO	14	13 NO	9	Reserved	18
2 NC	46	5 NC	45	8 NC	40	11 NC	36	14 NC	47	GND	33
2 Common	29	5 Common	28	8 Common	23	11 Common	19	14 Common	30	GND	34
2 NO	12	5 NO	11	8 NO	6	11 NO	35	14 NO	13	No Connect	17
3 NC	38	6 NC	49	9 NC	44	12 NC	39	29 NO	1		
3 Common	21	6 Common	32	9 Common	27	12 Common	22	29 Common	2		
3 NO	4	6 NO	50	9 NO	10	12 NO	5				

Bank 2
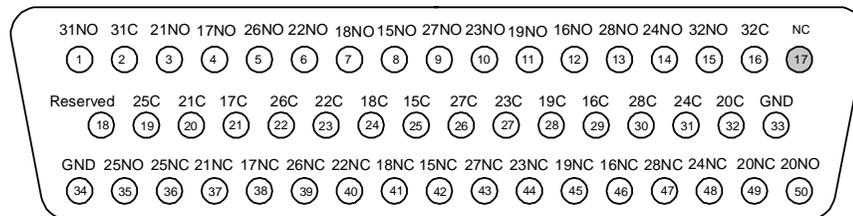
50-Pin D-Sub Male Connector

Channel	Pin	Channel	Pin	Channel	Pin	Channel	Pins	Channel	Pins		
15 NC	42	18 NC	41	21 NC	37	24 NC	48	27 NC	43	32 NO	15
15 Common	25	18 Common	24	21 Common	20	24 Common	31	27 Common	26	32 Common	16
15 NO	8	18 NO	7	21 NO	3	24 NO	14	27 NO	9	Reserved	18
16 NC	46	19 NC	45	22 NC	40	25 NC	36	28 NC	47	GND	33
16 Common	29	19 Common	28	22 Common	23	25 Common	19	28 Common	30	GND	34
16 NO	12	19 NO	11	22 NO	6	25 NO	35	28 NO	13	No Connect	17
17 NC	38	20 NC	49	23 NC	44	26 NC	39	31 NO	1		
17 Common	21	20 Common	32	23 Common	27	26 Common	22	31 Common	2		
17 NO	4	20 NO	50	23 NO	10	26 NO	5				

34937T Terminal Block

This terminal block with screw-type connections is labeled with the model number and the abbreviated module name. In addition, space is available on the label for you to write the slot number.

The 34980A Product Reference CD (shipped with the instrument) contains a 34937T Wiring Log for you to document your wiring configuration for this module. You can open the wiring log file in Microsoft® Excel® or Adobe® Acrobat® format.
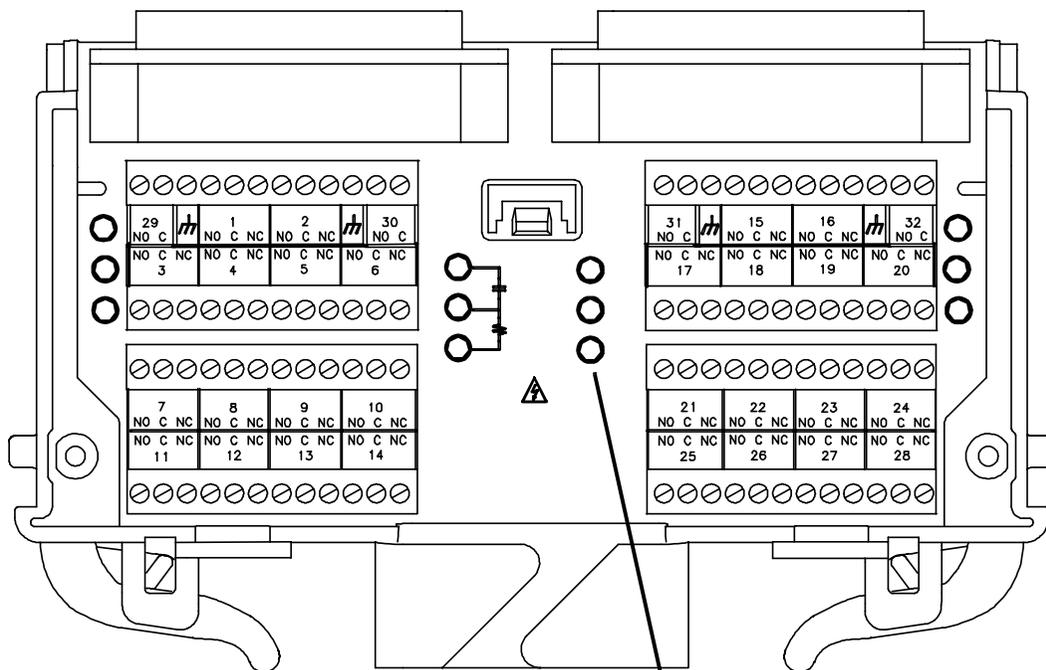
Pads for user-supplied snubber circuity to alleviate reactive transients. The circuits may consist of resistors, capacitors, varistors, or other elements as needed to reduce the switching voltage and current transients inherent in reactive circuits.

34938A 20-Channel High-Current GP Switch

The 34938A high-channel GP switch module provides twenty 5 A Form A relays for general purpose switching needs. You can set the power-failure state for these 5 A relays. See page 188 and page 189.

NOTE	A temperature sensor on these modules triggers system interrupts when high-carry current-induced heat on the modules reaches a threshold of 70 $^{\circ}$C.

34938A Simplified Schematic
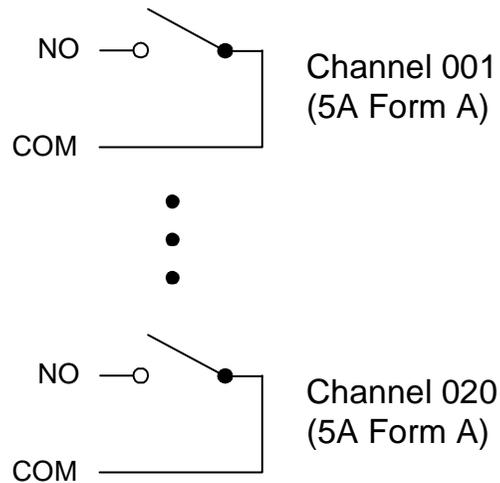
34938A D-Sub Connectors
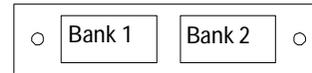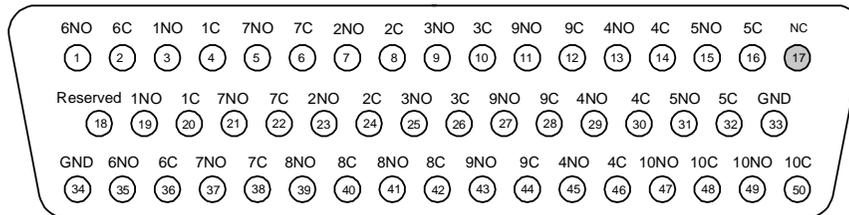
Bank 1

	Bank 1	Bank 2	
○			○

For orientation, the D-sub connector end of the module is facing you.

50-Pin D-Sub
Male Connector

Channel	Pin	Channel	Pin	Channel	Pin	Channel	Pins	Channel	Pins
1NO	3	3NO	25	5NO	31	7NO	37	9NO	43
1Common	4	3Common	26	5Common	32	7Common	38	9Common	44
1NO	19	4NO	13	6NO	1	8NO	39	10NO	47
1Common	20	4Common	14	6Common	2	8Common	30	10Common	48
2NO	7	4NO	29	6NO	35	8NO	41	10NO	49
2Common	8	4Common	30	6Common	36	8Common	42	10Common	50
2NO	23	4NO	45	7NO	5	9NO	11	Reserved	18
2Common	24	4Common	46	7Common	6	9Common	12	GND	33
3NO	9	5NO	15	7NO	21	9NO	27	GND	34
3Common	10	5Common	16	7Common	22	9Common	28	No Connect	17

Bank 2
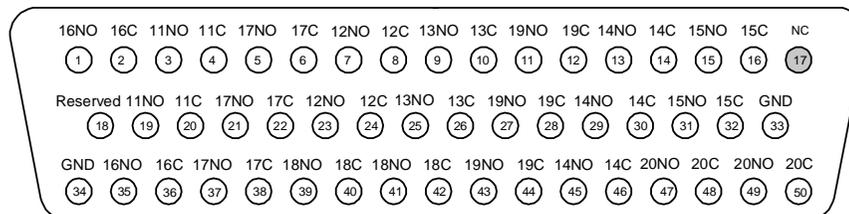
50-Pin D-Sub
Male Connector

Channel	Pin	Channel	Pin	Channel	Pin	Channel	Pins	Channel	Pins
11NO	3	13NO	25	15NO	31	17NO	37	19NO	43
11Common	4	13Common	26	15Common	32	17Common	38	19Common	44
11NO	19	14NO	13	16NO	1	18NO	39	20NO	47
11Common	20	14Common	14	16Common	2	18Common	40	20Common	48
12NO	7	14NO	29	16NO	35	18NO	41	20NO	49
12Common	8	14Common	30	16Common	36	18Common	42	20Common	50
12NO	23	14NO	45	17NO	5	19NO	11	Reserved	18
12Common	24	14Common	46	17Common	6	19Common	12	GND	33
13NO	9	15NO	15	17NO	21	19NO	27	GND	34
13Common	10	15Common	16	17Common	22	19Common	28	No Connect	17

34938T Terminal Block

This terminal block with screw-type connections is labeled with the model number and the abbreviated module name. In addition, space is available on the label for you to write the slot number.

The 34980A Product Reference CD (shipped with the instrument) contains a 34938T Wiring Log for you to document your wiring configuration for this module. You can open the wiring log file in Microsoft® Excel® or Adobe® Acrobat® format.
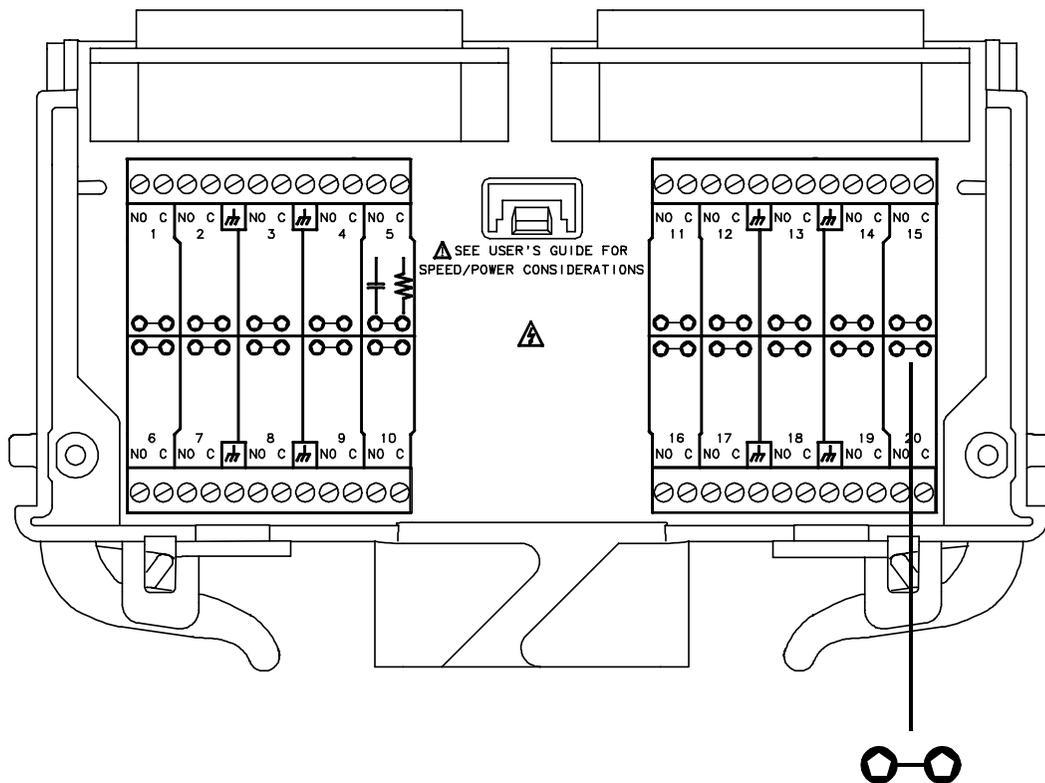
Pads for user-supplied snubber circuity to alleviate reactive transients. The circuits may consist of resistors, capacitors, varistors, or other elements as needed to reduce the switching voltage and current transients inherent in reactive circuits.
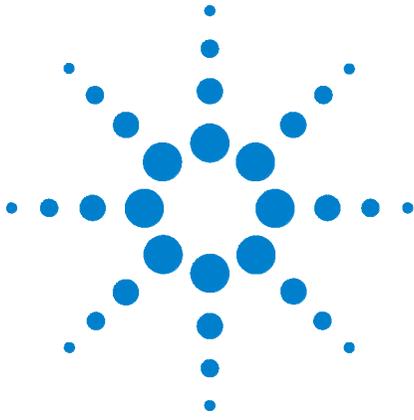
7

RF Multiplexer Switch Modules

Agilent Technologies

34941A and 34942A RF Multiplexer Switch Modules

The 34941A and 34942A Quad 1x4 RF MUX switch modules provide high density RF signal switching with four independent 1x4 multiplexer banks in each module.

The important differences between the two RF MUX modules lie in their characteristic impedance and their use of connectors (connectors are *not* provided with the module). The 34941A, the 50-Ω version, uses SMA connectors. The 34942A, the 75-Ω variation, uses Mini SMB connectors.

Both the 34941A and 34942A modules contain four banks of latching switches. Each bank consists of three form C relays. See the simplified schematic on .

The RF MUX modules do not connect to the analog buses. Instead, all signal connections are made through the visible connectors via external cables. Each visible connector on an RF MUX module is labeled with a number
(11 through 44) that represents a channel you can close program a tic ally, from the front panel, or with the Web UI. When you close a channel on the RF MUX modules you automatically close all relays that create a direct path to the Common of a bank.

With RF MUX switches, you cannot open switches program a tic ally. You can only close a channel. When you close one channel, another channel automatically opens. Therefore, only one channel relay in each bank is closed at any time.

Each bank is chassis-grounded. Alternatively, you can easily isolate a bank from other banks and from chassis ground as well. Refer to for instructions to install insulating washers.

You can connect the banks in this modules and to banks in other RF MUX modules to create a larger switching configuration. For example, you can create up to 1x97 RF MUX in a single 34980A mainframe.

| NOTE | For the 34942A, it is recommended that you use gold-plated straight plug connectors (75Ω Miniature SMB). Because of the space constraints between connectors on this module, right-angle plugs and SMB adapters are not recommended. |

Installing SMA Connectors

When installing SMA connectors on the 34941A module, it is recommend that you tighten them to 0.8 - 1.1 Nm (7-10 in-lbs) of torque.

CAUTION	SMA connectors are easily damaged, especially when tightening a neighboring connector with a wrench. To help prevent damage and contamination, do not remove a connector's protective cap until immediately prior to installing a cable on that connector.

Isolating Connector Banks

You can configure each bank on the RF MUX modules to be either isolated or chassis-grounded. The modules come with chassis-grounded metal shoulder washers installed on all connectors in each bank of relays. If you want to isolate a bank from the other banks and from chassis-ground, you must remove the five metal washers in that bank and replace them with the provided plastic shoulder washers.

To isolate a bank from other banks and chassis-ground, install the provided **plastic** shoulder washers on the connectors in the bank to be isolated. When installing the plastic shoulder washers, use 7 in-lbs of torque.

The 34941A and 34942A are shipped from the factory chassis-grounded with **metal** shoulder washers installed on all connectors in each bank of relays.
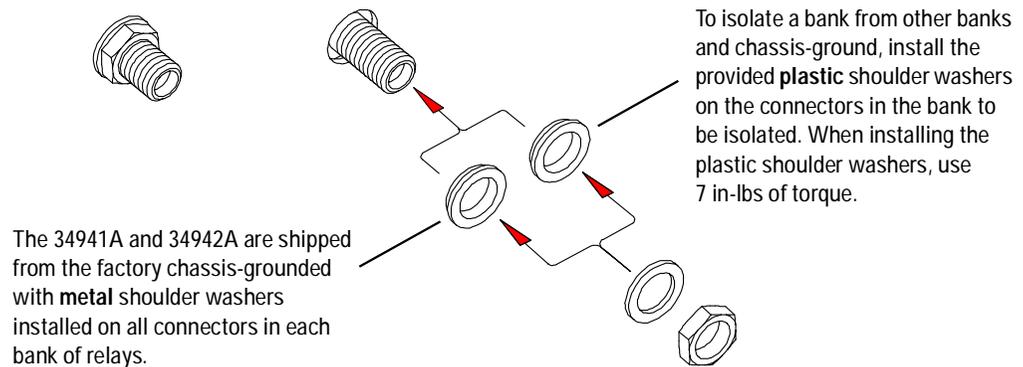
34941A and 34942A SCPI Programming Examples

The programming examples below provide you with SCPI command examples to use for actions specific to the RF MUX switch modules.

The slot and channel addressing scheme used in these examples follow the form **sccc** where **s** is the mainframe slot number (1 through 8) and **ccc** is the channel number. For information on specific configurations, refer to the simplified schematic on .

For complete information on the SCPI commands used to program the 34980A, refer to the Agilent 34980A Programmer's Reference contained on the 34980A Product Reference CD. For example programs, also refer to the 34980A Product Reference CD.

Example: Closing channels   You can only close channels on the RF MUX modules. You cannot open channels. When you close a channel, any already-closed channels automatically open. With this "one-step" operation, the relays switch in the proper order that avoids momentary connection of the wrong input to the multiplexer output. The following command closes channel 03 on Bank 1 of an RF MUX module installed in slot 5.

```
ROUTe:CLOSe (@5103)
```

Example: Querying channels for open or close state   The following commands returns the close or open state of channel 33 of a module installed in slot 5.

```
ROUT:CLOSe? (@5033)
ROUT:OPEN? (@5033)
```

Example: Querying the system for module identify   The following command returns the identify of the module installed in slot 7.

```
SYSTem:CTYPe? 7
```

Example: Reading the cycle count for a relay   On these modules, each bank consists of two *leaf* relays and one *tree* relay (see the simplified schematic on). The module stores the cycle count for each of the three relays on all four banks. The cycle count is the greater of the three values on the specified bank (i.e., reflecting the cycle count for the entire bank). Therefore, the count for Channels 101, 102, 103, and 104 will *always* be equal. The following statement reads back the number of completed cycles for the channels 101 and 202 on a module installed in slot 6.

```
DIAGnostic:RELay:CYCLes? (@6101,6202)
```

Example: Clearing the cycle count for a relay   The following command resets the cycle count on the channels 103 and 201 for a module in slot 1. Note that clearing the cycle count on a specific channel will clear the count on *all* three relays in the corresponding bank.

```
DIAGnostic:RELay:CYCLes:CLEar (@1103,1201)
```

Example: Resetting module to power-on state   The following command resets a module in slot 4 to its power-on state.

```
SYSTem:CPON 4
```

34941A and 34942A Simplified Schematic

Both the 34941A and 34942A modules are configured alike. They each contain four banks of latching switches. Each bank consists of three form C relays.

The front panel of the two RF MUX modules are similar with channel labels in the same positions, the unique product number on the left, and the product description on the right.

8

Microwave Switch/Attenuator Driver

Agilent Technologies

34945A Microwave Switch/Attenuator Driver

The 34945A consists of a plug-in driver interface module (34945A) and one or more external remote modules (34945EXT). The first remote module is electrically attached to the driver module using a provided cable (equipped with 9-pin D-Sub connectors). The first remote module attached to the driver module is referred to as the *master* module. Any additional external remote modules are referred to as *slave* modules.

Additional remote modules (34945EXT) are connected in a daisy-chain fashion using RJ-45 connectors and cables. A cable is provided with each additional remote module. Up to eight remote modules can be controlled by a single 34945A and up to eight 34945As may be installed in a 34980A mainframe. However, the maximum number of 34945EXTs allowed per mainframe is eight in any configuration.

Each remote module is divided into four banks for switch control. Each bank has a connector for a distribution board. The distribution boards provide an electrical connection between the user-supplied microwave switches or attenuators and the remote module. A variety of distribution boards are available that provide the most common connections to Agilent microwave switches and attenuators. A screw terminal distribution board is also available for other devices. A list of the available distribution boards is shown on . The microwave switches or attenuators and the cables connecting them to the distribution boards are not supplied with the 34945A.

The cables and the remote modules allow the microwave switches and attenuators to be located closer to the device under test. This helps to keep the signal transmission paths shorter and corresponding signal losses lower.

Microwave switches and attenuators have larger power requirements than other switch devices. In many cases, the 34980A mainframe is able to power 24 Volt switches or attenuators on the first remote module (master). Any additional remote modules (slaves) require an external power supply since no power is supplied through the expansion bus cable. The first remote module may use either an external power supply or the mainframe power to supply high power devices or devices requiring drive voltages other than 24 Volt. Each remote module has screw terminals for the external power supply connections.

A system configuration is illustrated below. As shown, two driver interface modules are used, one in slot 1 and one is slot 6. Each driver interface is connected to a single remote module. The remote module attached to slot 1 uses an external power supply. The remote module attached to slot 6 is using the internal power supply.
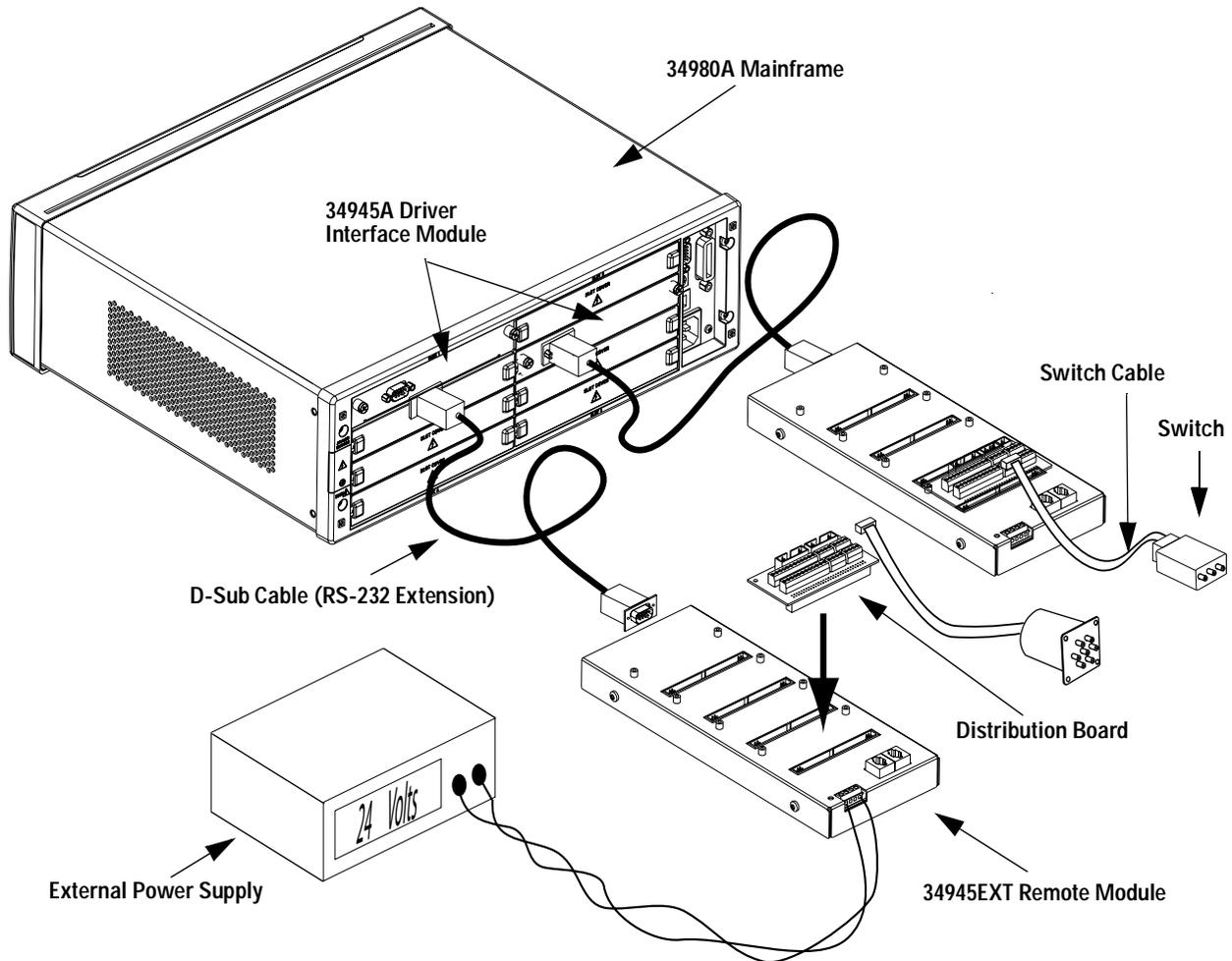
- The first remote module is connected to the driver interface using the provided D-Sub cable. This cable is a fully populated RS-232 extension cable.

- Although only a single distribution board is show in the figure for each remote, each remote module may have up to four distribution boards connected.

- The driver interface can supply 24 V power to the first remote module only.

- The first remote module may also use an external power source.

- Each remote module only supports a single power source.

An alternate system configuration, using multiple remote modules, is illustrated below. As shown, the driver interface module is installed in slot 1. The first remote module, connected via the D-Sub cable, is the *master* remote module. Additional remote modules are connected in a daisy chain fashion using standard ethernet RJ-45 connectors and Cat 5 cable. These remote modules are referred to as *slaves*. The master and first slave remote module are powered from a 24 Volt external power supply. The last slave remote module is powered from a 12 Volt external power supply.
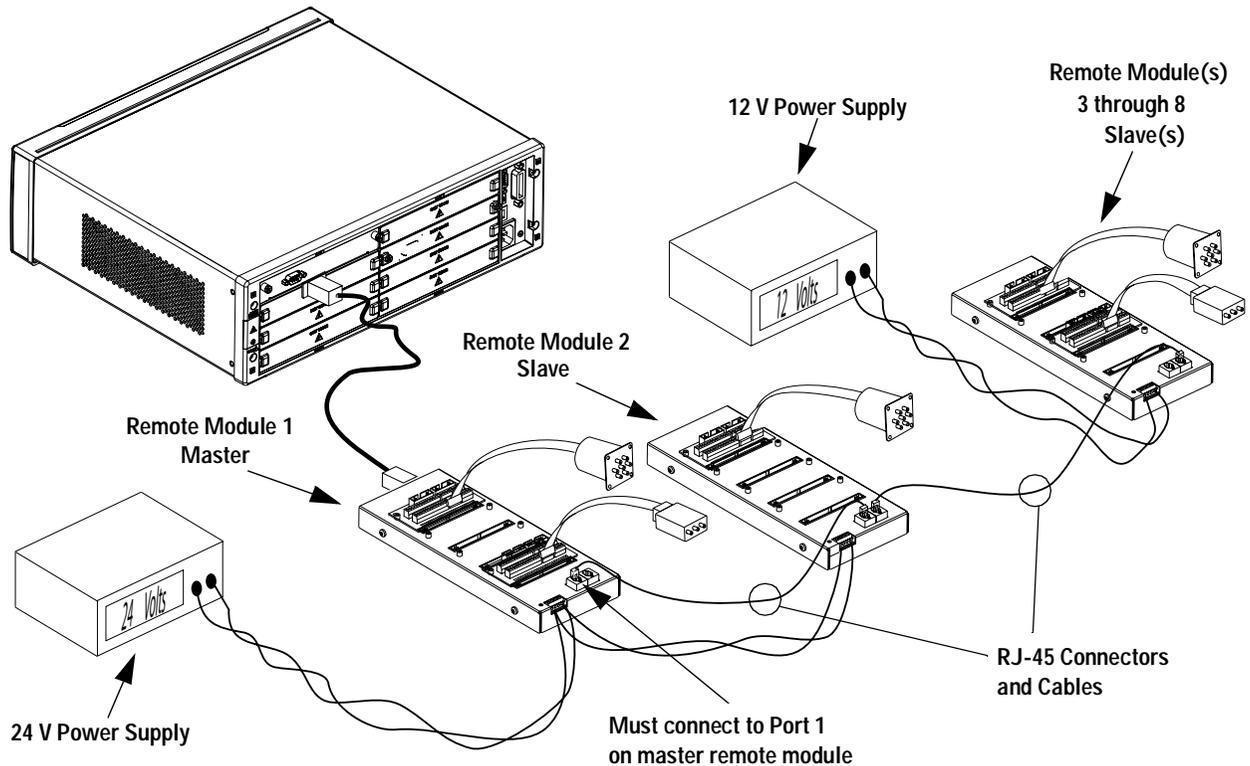
- All slave modules must obtain power from an external power supply. the master remote module may obtain power from the mainframe.

- The Cat 5 Ethernet connecting cable *must* be plugged-in to port 1 on the *master* remote module. Port 1 and Port 2 are interchangeable on all *slaves*.

- Each remote module may be powered by a separate power supply. All distribution boards on each remote module must use the same power supply voltage.

- You may have up to eight 34945EXTs in a system.

A 34945EXT remote module is shown below.
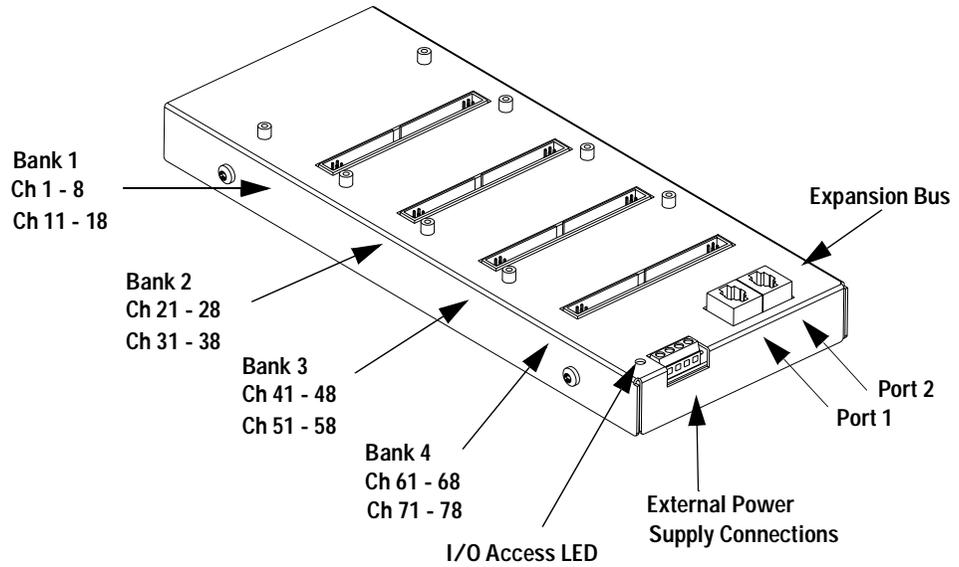
Each 34945EXT has an I/O Access LED used to indicate transactions between the 34980A mainframe and the 34945EXT module. When power is first applied to a 34945EXT module, this LED is continuously illuminated indicating that power has been applied.

After the module has booted, the LED illuminates only intermittently during interactions from the Mainframe.

Should the mainframe encounter problems communicating with the 34945EXT the LED is continuously illuminated.

LED	Meaning
Not Illuminated	Power is not applied to the module or the module is not processing any mainframe commands.
Continuously Illuminated	The 34945EXT is not booted, either due to an internal error or a mainframe error.
Blinking Intermittently	Normal operation during command transactions. Send the `SYSTem:CTYPe:RMODule?` query to initiate a transfer and blink the LED.

NOTE   Always tighten the screws securing the 34945A in the mainframe and the screws on both ends of the D-Sub cable. Incorrect grounding can cause malfunctions of the modules due to electro-static discharge.

Recommended Switches and Attenuators

The recommended Agilent switches and attenuators for use with the 34945A are shown below. Included in the table is the distribution board used for each switch or attenuator.

Switch/Attenuator	Coil Voltage	Connection Type	Drive Options	Distribution Board
N1810UL/TL N1811TL N1812TL	Option 124 24 Vdc	Option 201 D-Sub 9-pin female	Option 402 Position Indicators	Y1150A
87104A/B/C SP4T	24 V	STD 16-pin Ribbon Cable Header	STD direct coil for open drain	Y1151A
87106A/B/C SP6T	24 V	STD 16-pin Ribbon Cable Header	STD direct coil for open drain	Y1151A
87406B 6 port matrix	24 V	STD 16-pin Ribbon Cable Header	STD direct coil for open drain	Y1151A
87204A/B/C SP4T	24 V	STD 16-pin Ribbon Cable Header	STD direct coil for open drain	Y1152A
87206A/B/C SP6T	24 V	STD 16-pin Ribbon Cable Header	STD direct coil for open drain	Y1152A
87606B 3 x 3, 2 x 4, or 1 x 5 matrix	24 V	STD 16-pin Ribbon Cable Header	STD direct coil for open drain	Y1152A
84904K/L M 84906K/L M 849807K/L M Step Attenuators	Option 024 24 V	STD 10-pin Ribbon Cable Header		Y1153A
8494G/H 8495G/H 8496G/H Step Attenuators	Option 024 24 V	STD 12-pin Viking Connector		Y1153A
87222C/D/E Coaxial Transfer Switches	24 V	STD 10-pin Ribbon Cable Header	STD direct coil for open drain and TTL compatible	Y1154A
8762A/B/C/F 8763A/B/C 8764A/B/C	Option 024 24 V	Solder Lugs	STD direct coil for open drain	Y1155A

Power Supplies

The switches and attenuators on the first remote module may be powered from the 34980A or use an external power supply. All additional remote modules must use an external power supply.

Each remote module has a terminal strip used to connect external switch power. The three most common power supply voltages used by the microwave switches and attenuators are:

- 5 Volts
- 15 Volts
- 24 Volts (most common)
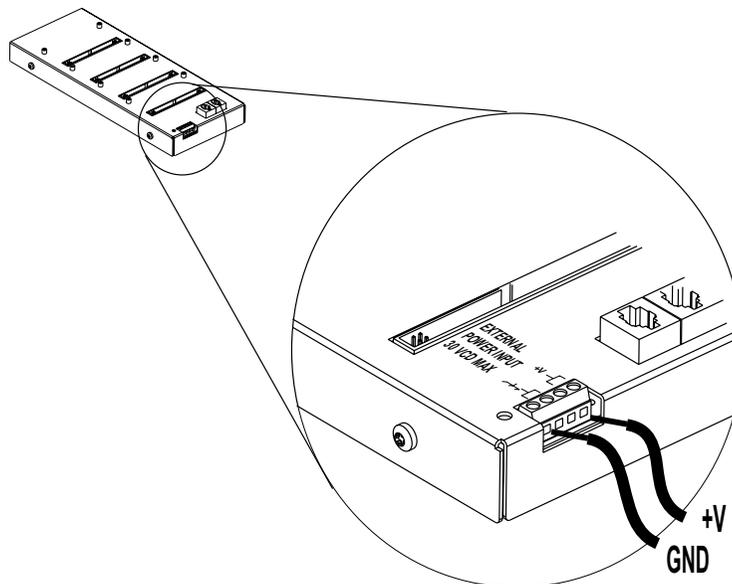
Power Consumption

Each 34945EXT can drive up to 6A continuously using an external power supply. The actual amount of power available for the switches on each 34945EXT module varies with the type of switches being used and the settings for those switches.

- Some switch types consume power even in their quiescent state. Be sure to review the switch data sheets for the switches you are using.
- Set the pulse width to the minimum necessary to activate the switch using the `ROUTe:CHANnel:DRIVe:PULSe:WIDTh` command.
- Add power supply recovery time using the `ROUTe:CHANnel:DRIVe:TIMe:RECovery` command
- Use an external power supply if possible.
- When the drive source for the master remote module is set to internal, each driver interface module may supply up to 6A.

Channel Numbering

The 34945A uses the following channel numbering scheme:

<slot><rem><channel>

where:

slot is the 34980A slot where the 34945A driver interface is installed, and is a single digit in the range of 1 to 8.

rem is the remote module being controlled, and is a single digit in the range of 1 to 8.

channel is the channel number on the remote module.

The *channel* number is two digits spanning channels across each remote module. Channel numbers are shown below (also see the figure on).

Bank	Channels	Channels
Bank 1	1 to 8	11 to 18
Bank 2	21 to 28	31 to 38
Bank 3	41 to 48	51 to 58
Bank 4	61 to 68	71 to 78

The channel numbers are arranged to facilitate the pairing of channels for dual coil switches and attenuators. Dual coil devices require the use of two channels, one for each coil. By pairing the upper and lower channels in each bank, the devices can be controlled using only the lower channel number. For example, when a paired-coil device is installed on bank 1, channels 21 and 31 are paired and are controlled using only channel 21.

For example, the following SCPI command closes channel 5 on the first remote module connected to a 34945A installed in slot 2.

```
ROUT:CLOS (@2105)
```

You can also use a range of channel numbers. You could close all the channels on the first remote module connected to a 34945A installed in slot 2 by sending the following command.

```
ROUT:CLOS (@2101:2178)
```

Note that when single-coil devices are used, the channel numbering is not consecutive across all 16 channels in a bank.

Simple Switch Control

All examples in this chapter make reference to SCPI commands for switch control. Details of these commands and their parameters can be found in the *Programmer's Reference* Help file shipped with your 34980A mainframe.

The switches and attenuators are designed to respond to the SCPI `ROUTe:CLOSe` and `ROUTe:OPEN` commands. For example, to open and close a switch attached to channel 1 on bank 1 of the second remote module attached to a 34945A installed in slot 3 of the mainframe, you could use the following commands (*slot* = 3, *rem* = 2, *channel* = 01).

```
ROUT:OPEN (@3201)
ROUT:CLOS (@3201)
```

Before you can close or open a switch, however, several other parameters must be configured. Each distribution board has a set of factory default parameters designed to support the type of switches intended to be present. These defaults are described in more detail on page 221. Additionally, the drive current source must be selected and configured.

The following commands show a simple command sequence controlling channel 1 of an Agilent N1810 switch (installed on a Y1150A distribution board) of the third remote module attached to a 34945A installed in slot 4 of the mainframe (*slot* = 4, *rem* = 3, *channel* = 01).

```
SYST:RMOD:RES 4
ROUT:RMOD:BANK:PRESET BANK1,(@4300)
ROUT:CHAN:DRIV:CLOS:DEF (@4301)
ROUT:RMOD:DRIV:SOUR INT,(@4300)
ROUT:OPEN (@4301)
<-- other commands -->
ROUT:CLOS (@4301)
```

In the example above, the `SYSTem:RMODule:RESet` command resets the module and disables all drive currents. The next command loads the factory default settings for the distribution board (Y1150A) used to support the Agilent N1810 switch. The default state of switch closed is then configured. When the drive source is set to internal (third remote module only), the switch assumes its default closed state. The configured switch may now be controlled using the `ROUTe:OPEN` and `ROUTe:CLOSe` commands.

> **NOTE**   You must turn off the channel drive before sending the `ROUTe:RMODule:BANK:PRESet` command. Once configured, turn the channel drive back on (`ROUTe:RMODule:DRIVe:SOURce:IMMediate`).

These commands and settings are described in more detail later in this chapter and in the *Programmer's Reference* Help file.

Remote Module Identifiers

A special channel numbering method exists for use with SCPI commands that operate one or more banks of the remote module. This addressing uses a non-existent channel number (00) to indicate the commands are useful for all channel in a bank or all channels on a remote module. The format of this special channel list is specified as:

<slot><rem><00>

where:

slot is the 34980A slot where the 34945A driver interface is installed, and is a single digit in the range of 1 to 8.

rem is the remote module being controlled, and is a single digit in the range of 1 to 8.

channel is non-existent channel number 00 on the remote module.

You may not use this special channel list in a range of channels. The following commands use this form of channel addressing. Refer to the *Programmer's Reference* Help file for more details.

```
ROUTe:RMODule:BANK:DRIVe:MODE
ROUTe:RMODule:BANK:LED:DRIVe:ENABle
ROUTe:RMODule:BANK:LED:DRIVe:LEVel
ROUTe:RMODule:BANK:PREset
ROUTe:RMODule:DRIVe:LIMit
ROUTe:RMODule:DRIVe:SOURce:BOOT
ROUTe:RMODule:DRIVe:SOURce:IMMediate
```

Drive Modes

Each remote module can drive the switches and attenuators using either TTL or open collector drive methods. The TTL drive mode uses a pull-down resistor on the output and drives a TTL high level when asserted. The open collector drive provides a current path to ground when asserted.
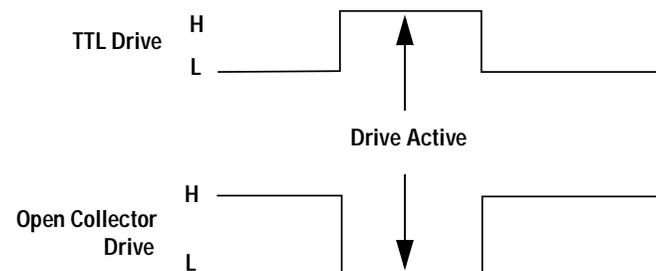
The drive mode is set on a per bank basis using the `ROUTe:RMODule:BANK:DRIVe:MODE` command.

Using Single Drive Switches and Attenuators

Some microwave switches require a single drive. With single drive devices the channel numbering is not consecutive across all channels in a bank (refer to the channel numbering description on).

The 34945A can provide single drive devices with either pulsed or continuous drive current. Settings and parameters for continuous drive mode are given in the next section.

Continuous Drive Current

Driving non-latching devices requires a power supply capable of handling sustained high current requirements. You may only use continuous drive current with channel configured for single drive. Additionally, to prevent power supply loading, care must be taken when operating more than one continuous drive at a time. The actual drive may be configured as either TTL or open-collector operation.

Using Continuous Drive

The diagram below illustrates the continuous drive signals for two channels (switches) and the relationship of the drive parameters to the power supply requirements.
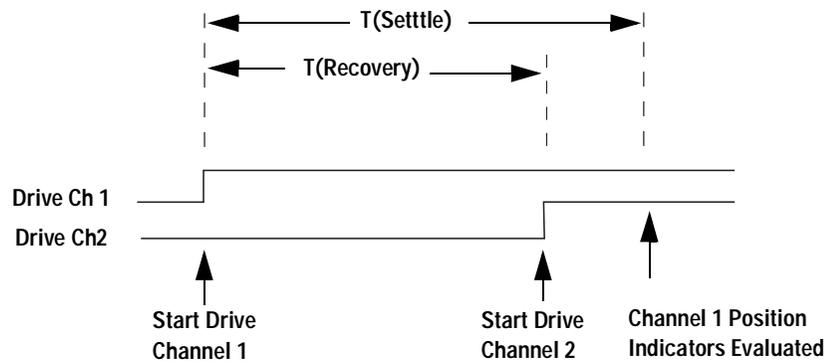
As shown in the diagram, the drive signal is initially applied to channel 1. Drive is applied to channel 2 only after a power supply recovery period has elapsed T(Recovery). The power supply recovery time is set using the the `ROUTe:CHANnel:DRIVe:TIMe:RECovery` command. This parameter may be set individually for each channel or will default to 0.0 ms following either a `SYSTem:RMODule:RESet` or `ROUTe:RMODule:BANK:PRESet` command.

If you are verifying the channel closure (see), you may also specify a T(Settle) parameter. This parameter ensures the switch has had time to change state before the position indicator is evaluated. This parameter may be set individually for each channel or will default to 0.0 ms following either a `SYSTem:RMODule:PRESet` or `ROUTe:RMODule:BANK:PRESet` command.

Using Dual Drive Switches and Attenuators

Many microwave switches and attenuators have a paired drive input. Typically, one drive is electrically connected to the lower channel number in a bank and one connected to a corresponding upper channel number. For example, a dual drive switch should have its 'State A' coil connected to channel 21 and its 'State B' coil connected to channel 31 on bank two.

The 34945A drives dual drive devices in pulsed mode only. Pairing two channels automatically configures the channels to pulsed mode (you must explicitly un-pair the channels before continuous drive mode can be re-enabled). Settings and parameters for pulsed drive mode are given on .

Pairing Channels

With dual drive devices the channels in each bank may be paired (refer to the channel numbering description on). For example, one drive might be 'State A' and one drive 'State B' on a switch. Pairing channels allows settings and control to be shared between the two drives. To pair channels use the `ROUTe:CHANnel:DRIVe:PAIRed:MODE` command. When paired, the lower and upper channel number on a bank are combined. For example, the following command pairs channel 1 and channel 11 on bank 1.

`ROUTe:CHANnel:DRIVe:PAIRed:MODE ON, (@1101)`

You may also pair all channels in a bank by specifying a range of channels:

`ROUTe:CHANnel:DRIVe:PAIRed:MODE ON, (@1101:1108)`

Typically, pairing is performed using the lower channel numbers in the bank. You may set channel parameters using either the lower or upper channel number. The settings will apply to both channels in the pair.

You must have the channel drive turned off before attempting to pair channels. Channel drive is turned off by sending the `ROUTe:RMODule:DRIVe:SOURce OFF` command.

Once a channel is paired, only pulse drive is allowed on that channel.

Setting any of the following parameters applies the setting to both of the paired channels:

- `ROUTe:CHANnel:DRIVe:PULSe:WIDTh`
- `ROUTe:CHANnel:DRIVe:TIMe:RECovery`
- `ROUTe:CHANnel:DRIVe:TIMe:SETTle`
- `ROUTe:CHANnel:VERify:ENABle`

Using Pulse Drive

To use the pulse drive mode, send the
`ROUTe:CHANnel:DRIVe:PULSe:MODE ON` command or pair two channels
with the `ROUTe:CHANnel:DRIVe:PAIRed:MODE` command. The diagram
below illustrates the pulse drive for two channels (switches) and the
relationship of the drive parameters to the power supply requirements.
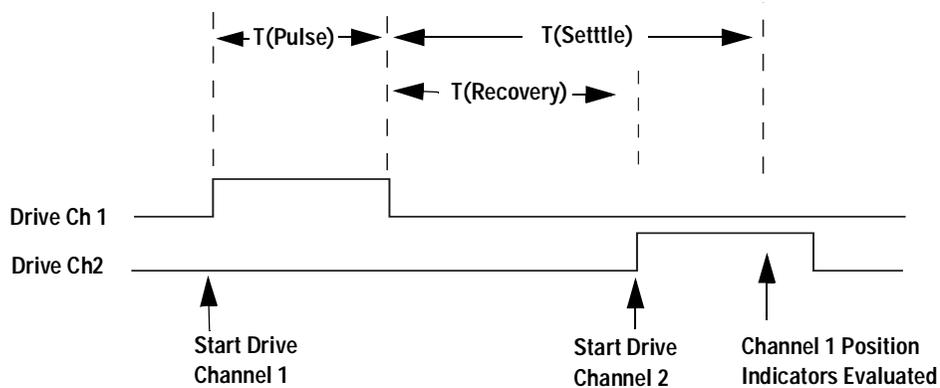
As shown in the diagram, the drive is applied to channel 1 and held for
the T(Pulse) time set using the `ROUTe:CHANnel:DRIVe:PULSe:WIDTh`
command. Drive is applied to channel 2 only after a power supply
recovery period has elapsed T(Recovery). The power supply recovery
time is set using the `ROUTe:CHANnel:DRIVe:TIMe:RECovery` command.
This parameter may be set individually for each channel or will default
to 0.0 ms following either a `SYSTem:RMODule:RESet` or
`ROUTe:RMODule:BANK:PRESet` command.

If you are verifying the channel operation (see page 218), you may also
specify a T(Settle) parameter. During T(Settle) the switch is considered
'busy'. This parameter ensures the switch has had time to change state
before the verification. This parameter may be set individually for each
channel or will default to 0.0 ms following either a `SYSTem:RMODule:RESet`
or `ROUTe:RMODule:BANK:PRESet` command.

Unlike other switch modules, the 34945A will always pulse a channel in
response to a `ROUTe:OPEN` or `ROUTe:CLOSe` command. For example, sending
`ROUTe:CLOSe` to a channel three times in a row will result in three
output pulses.

| NOTE | A single drive channel operating in pulse mode with channel verification (see page 218) turned off (default) will report the channel as 'stateless' and the `ROUTe:CLOSe?` query will return an error. Single drive pulsed channels must have verification enabled (`ROUTe:CHANnel:VERify ON`) to query the channel state using the `ROUTe:CLOSe?` query. |

Long Execution Times

When configuring long channel pulse drive times and/or power supply recovery times, be aware that the results may be long execution times in the mainframe. For example, you can set a channel pulse width of 255 ms and a recovery time of 255 ms. This channel will require 510 ms to open or close. If you set such parameters across all the channels on a remote module then the execution time will be over 30 seconds. The mainframe will display the message LONG OPERATION SLOT *n* BUSY on the display when this is happening.

Be aware, all channel states are driven when the remote module is reset. So, this lengthy execution can occur following a power on, *RST, SYSTem:CPON, SYSTem:PRESet, or ROUTe:RMODule:DRIVe:SOURce command.

Verifying Switch State

Many switches and attenuators have a built-in switch position indicator. This indicator can be used to drive LED position indicators (some position indicator circuits are shown beginning on). Additionally, the 34945A checks the position indicators against the SCPI command last sent to provide verification of switch states.

By default, verification is disabled and the switch state is assumed to be the last open/close state driven. Verification is enabled using the ROUTe:CHANnel:VERify:ENABle command. Enabling verification can cause multiple errors to be generated if the system is incorrectly configured.

If a switch operation appears to have failed, an error is generated at the time the ROUTe:CLOSe or ROUTe:OPEN command is executed. If you send a ROUTe:CLOSe or ROUTe:OPEN command with a channel list (i.e., multiple channels), the verification is performed after all open/close operations have been completed. An error is generated for each channel operation that did not properly verify.

The verification process will affect the operation of the ROUTe:CLOSe? and ROUTe:OPEN? commands. If verification is enabled, these commands will check the actual hardware state of the specified channels, rather than just reporting the presumed state.

When verification is enabled and a remote module is reset, a series of errors will be consolidated and reported as one error.

Verification will slow switching performance on any remote module with one or more verified channels. Additionally, if you have enabled the command overlap function (using the ROUTe:OPERation:OVERlap:ENABle command), the verification will be performed at the end of each close/open operation, before processing the next command.

The state of all verified channels on a remote module is refreshed whenever any channel on that remote module is operated. This helps to ensure the front panel and web based interface have a valid state. Switch state is stored in the mainframe. In contrast, the `ROUTe:OPEN?` and `ROUTe:CLOSe` queries always check the actual hardware state of the switch for verified channels.

For paired operations on the 34945A (using the `ROUTe:CHANnel:DRIVe:PAIRed:MODE` command), when you enable verification on either paired channel verification will be enabled on both channels. In addition, the module checks for complementary position indicators on the lower and upper channels of the pair (i.e., the position indicators should indicate opposite states). If the state of the lower and upper position indicators are found to be in the same state (due to a hardware issue), an error is generated and the state of the lower channel is assumed.

When the paired mode is disabled and pulsed mode is enabled, you cannot query the open/closed state of the associated channels unless verification is enabled. While in this mode (single drive operation), only "close" operations are allowed on the channels ("open" operations are not allowed). In this mode, a close operation provides a single pulse on the specified channel.

If you enable verification on a non-paired (single drive), non-pulsed (continuous drive) channel on the 34945A, the `ROUTe:CLOSe?` and `ROUTe:OPEN?` commands return the state of the verified device, rather than the drive state of the specified channel. It is possible to have such a channel being driven via a `ROUTe:CLOSe` command by the channel position indicators show the channel as open. In these cases, use the `ROUTe:CHANnel:VERify:POSition:STATe?` command to determine exactly which channels are currently being driven.

The `ROUTe:CHANnel:VERify:POLarity` command sets the logic polarity of the verification lines on specific channels. You can specify the polarity as `NORMal` (active high) or `INVerted` (active low).

If you have not enabled verification, you can still query the indicator state of a specific channel using the `ROUTe:CHANnel:VERify:POSition:STATe?` command. This command is useful for channels on which verification is disabled for activities such as debugging or when verification is disabled for performance reasons.

LED Drive

The distribution boards contain a ribbon cable header you can use to connect LEDs to provide a visual indication of switch state. These lines reflect the state of their corresponding channel's position indicator. Some systems use LEDs as a graphical indicator of switch positions.

Use the `ROUTe:RMODule:BANK:LED:DRIVe:LEVel` command to set the drive current for the LEDs. You do not need to provide an external current limiting resistor. This command uses special channel addressing as described in "Remote Module Identifiers" on page 214.

Once the drive current is set, enable the LED drives using the `ROUTe:RMODule:BANK:LED:DRIVe:ENABle` command. This command uses special channel addressing as described in "Remote Module Identifiers" on page 214.

NOTE	The LEDs obtain their power from the remote module power supply. If the `ROUTe:RMODule:DRIVe:SOURce OFF` command has been sent, the LEDs will not operate.

Simplified connections for the position indicators are shown in the diagrams beginning on page 254.

Default and Reset States

The 34945A allows several types of reset and default actions. Most resets rely on states stored in non-volatile memory on the remote modules. Default parameters can be set to ensure the system always returns to a safe state.

SYSTem:RMODule:RESet

This command is the only command that will reset all remote modules connected to a slot to the factory defaults. No determination of the distribution boards present is made. The system is set to the following conditions after executing this command.

ROUTe:RMODule:DRIVe:SOURce:IMMediate	OFF
ROUTe:RMODule:DRIVe:SOURce:BOOT	OFF
ROUTe:RMODule:DRIVe:LIMit	1
ROUTe:RMODule:BANK:DRIVe:MODE	OCOLlector
ROUTe:RMODule:BANK:LED:DRIVe:ENABle	ON
ROUTe:RMODule:BANK:LED:DRIVe:LEVel	5 mA
ROUTe:CHANnel:DRIVe:PAIRed:MODE	OFF
ROUTe:CHANnel:DRIVe:PULSe:MODE	ON
ROUTe:CHANnel:DRIVe:PULSe:WIDTh	15 ms
ROUTe:CHANnel:DRIVe:TIME:RECovery	0.0 seconds
ROUTe:CHANnel:DRIVe:TIME:SETTle	0.0 seconds
ROUTe:CHANnel:DRIVe:OPEN:DEFault	OPEN selected
ROUTe:CHANnel:VERify:ENABle	OFF
ROUTe:CHANnel:VERify:POLarity	NORMal

SYSTem:PRESet, *RST, SYSTem:CPON and Power On

These actions drive the channels to their defined `DEFault` state (using the configuration stored on the remote module) and force the system to recognize new topologies (caused by power or connectivity changes). These actions set the defaults shown in the table on page 221. Two parameters are controllable to ensure safety of operation in the system; the default state for channel closure and the default state for drive enabled.

The default channel state (open or closed) for each channel can be set using either of the following commands.

```
ROUTe:CHANnel:DRIVe:CLOSe:DEFault
ROUTe:CHANnel:DRIVe:OPEN:DEFault
```

NOTE	If a channel is configured for a single drive in pulsed mode, `OPEN` operations are undefined. When these channels are configured to a default state of `OPEN`, no action is taken on these channels.

The drive state can be set as a default using the `ROUTe:RMODule:DRIVe:SOURce:BOOT` command. This command allows you to specify whether the drive current, when present, should be applied to the switches or not. You can set `OFF`, `INTernal`, and `EXTernal` for the default.

The `*RST` command forces a re-evaluation of all connected remote modules, followed by setting all channels to their default states. The system connections and drive states. This is very similar in operation to what occurs at power-up. The `SYSTem:CPON` command performs a reset operation on a 34945A in single slot. `*RST` resets all modules in the mainframe.

ROUTe:RMODule:BANK:PRESet

This command sets a bank to default values that vary according to which distribution board is attached. The following table shows the default states set by `ROUTe:RMODule:BANK:PRESet`.

	Y1150A	Y1151A	Y1152A	Y1153A	Y1154A	Y1155A
ROUT:CHAN:DRIV:PULS:MODE	ON	ON	ON	ON	ON	ON
ROUT:CHAN:DRIV:PULS:WIDT	15 ms	15 ms	15 ms	15 ms	15 ms	15 ms
ROUT:CHAN:PAIR:MODE	ON	OFF	ON	ON	ON	OFF
ROUT:CHAN:DRIV:TIME:REC	0 s	0 s	0 s	0 s	0 s	0 s
ROUT:CHAN:DRIV:TIME:SETT	0 s	0 s	0 s	0 s	0 s	0 s
ROUT:CHAN:VER:ENAB	OFF	OFF	OFF	OFF	OFF	OFF
ROUT:CHAN:VER:POL	NORM	NORM	INV	INV	NORM	NORM
ROUT:RMOD:BANK:DRIV:MODE	OCOL	OCOL	OCOL	OCOL	OCOL	OCOL
ROUT:RMOD:BANK:LED:DRIV	ON	ON	ON	ON	ON	ON
ROUT:RMOD:BANK:LED:LEV	0.005 A	0.005 A	0.005 A	0.005 A	0.005 A	0.005 A
ROUT:CHAN:DRIV:CLOS:DEF	OFF	OFF (except channel 7, 17)	ON	OFF	OFF	OFF
ROUT:CHAN:DRIV:OPEN:DEF	ON	ON (except channel 7, 17)	OFF	ON	ON	ON

This command uses special channel addressing as described in

This command requires the channel drive source be in order to allow execution (`ROUTe:RMODule:DRIVe:SOURce OFF`)

Distribution Boards

Each 34945EXT remote module can hold up to four distribution boards. Distribution boards are designed to support the most common types of Agilent microwave switches and attenuators. The table below shows the distribution boards available and lists the supported switches and attenuators.

Y1150A	Distribution board for up to eight N181x SPDT switches (9-pin Dsub connectors)
Y1151A	Distribution board for two 87104x/106x multiport or 87406B matrix switches
Y1152A	Distribution board for a single 87204x/206x or 87606B switches and two N181x ultra switches
Y1153A	Distribution board for two 84904/5/8x or 8494/5/6 step attenuators
Y1154A	Distribution board for two 87222 transfer switches and up to six N181x SPDT switches
Y1155A	Distribution board with screw terminals for up to 16 switch drives

Specific information for each distribution board and the supported switch types is given in the following sections.

Distribution boards are specialized terminal boards and hold no active electronic components. The distribution boards can be identified by the system (refer to the `SYSTem:CTYPe:RMODule?` and `SYSTem:CDEScription:RMODule?` commands description in the *Programmers Reference* Help file*)*.

Channel drive attributes for each distribution board will be set to the values shown on .

Y1150A

The Y1150A supports the Agilent N181x series microwave switches shown below. Up to eight switches in any combination can be connected to each distribution board.

Agilent Switch	Description
N1810UL	Unterminated latching 3-port (SPDT)
N1810TL	Terminated latching 3-port (SPDT)
N1811TL	Terminated latching 4-port (transfer)
N1812UL	Unterminated latching 5-port

Y1150A Switch Options Supported

(Recommended options are shaded).

Option Name	Option Number	Description and Comments
Frequency Range	various	All options supported
Coil Voltage	105	+5VDC Highest coil current requirement of all coil voltage options. May limit system speed because current capacity limitations. This option draws 600 mA (except N1810UL 300 mA). Therefore, a maximum of 3 (6) devices may be switched simultaneously.
	115	+15VDC
	124	+24VDC (required if using internal power)
DC Connector Type	201	D-Sub 9 pin female
	202	Solder lugs Can use ribbon cables with the Y1150A, or discrete wires with the Y1155A.
RF Performance	various	All options supported
Drive Options	401	TTL/CMOS compatible All switches on the same distribution board must use the same drive mode.
	402	Position indicators (required to use verification feature)
	403	Current interrupts For pulsed operation, current interrupts are not required. May provide system switching speed improvements.

Y1150A Connections

LED Connectors
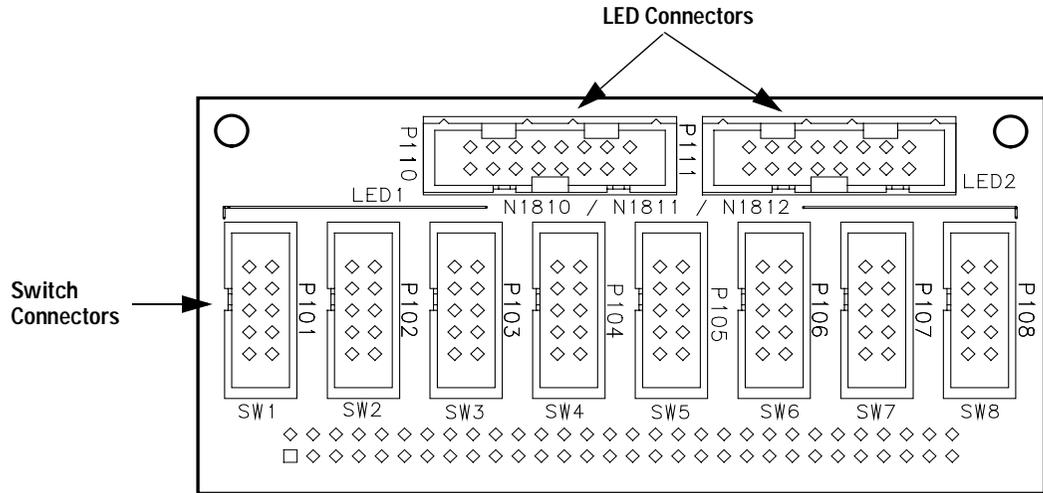
Switch Connectors

Y1150A Switch Connectors SW1 Through SW8

Pin	Use	Pin	Use
1	GND	2	IND B
3	N.C.	4	+VI
5	Drive B	6	IND A
7	Drive A	8	+VI
9	+VR	10	N.C.

+VR is the Voltage source for the Relay

+VI is the Voltage source for the LED Indicator

Distribution Board Connector

Switch Connector

Pin 1

No Connection
To This Pin

Item	Description	Example Part Numbers
Cable Type	9 conductor ribbon cable, 0.050"pitch, 26 or 28 AWG stranded[*]	3M 3801/09 (26 AWG) 3M 3365/09 (28 AWG)
Y1150A Connector	10 pin socket connector, 0.1" x 0.1" pin grid, IDC termination, center polarizing key	3M P/N 89110-0101 AMP P/N 76288-1
Switch Connector	9 pin D-sub male, IDC termination, without threaded insert	3M P/N 8209-6000 AMP P/N 747306-4
Cable Wiring	Y1150A socket connector pin 1 to switch D-sub connector pin 1 (Note: pin 10 of Y1150A connector not used)	

[*] 26 AWG recommended for 5V coil switches

Y1150A Switch Control

All switches are driven in `PAIRed` mode

	State A	State B
SW1	ROUT:OPEN (@xx01)	ROUT:CLOS (@xx01)
SW2	ROUT:OPEN (@xx02)	ROUT:CLOS (@xx02)
SW3	ROUT:OPEN (@xx03)	ROUT:CLOS (@xx03)
SW4	ROUT:OPEN (@xx04)	ROUT:CLOS (@xx04)
SW5	ROUT:OPEN (@xx05)	ROUT:CLOS (@xx05)
SW6	ROUT:OPEN (@xx06)	ROUT:CLOS (@xx06)
SW7	ROUT:OPEN (@xx07)	ROUT:CLOS (@xx07)
SW8	ROUT:OPEN (@xx08)	ROUT:CLOS (@xx08)

Y1150A LED Connectors LED1 and LED2

LED1 Connector				LED2 Connector			
Pin	**Use**	**Pin**	**Use**	**Pin**	**Use**	**Pin**	**Use**
1	+VI	**2**	SW1 - A	**1**	+VI	**2**	SW5 - A
3	+VI	**4**	SW1 - B	**3**	+VI	**4**	SW5 - B
5	+VI	**6**	SW2 - A	**5**	+VI	**6**	SW6 - A
7	+VI	**8**	SW2 - B	**7**	+VI	**8**	SW6 - B
9	+VI	**10**	SW3 - A	**9**	+VI	**10**	SW7 - A
11	+VI	**12**	SW3 - B	**11**	+VI	**12**	SW7 - B
13	+VI	**14**	SW4 - A	**13**	+VI	**14**	SW8 - A
15	+VI	**16**	SW4 - B	**15**	+VI	**16**	SW8 - B

Y1151A

The Y1151A supports up to two of the Agilent microwave switches shown below.

Agilent Switch	Description
87104A/B/C	SP4T 4 port latching
87106A/B/C	SP6T 6 port latching
87406B	6 port matrix

Y1151A Switch Options Supported

(Recommended options are shaded).

Option Name	Option Number	Description and Comments
Frequency Range	letter suffix in model number	All options supported
Coil Voltage	STD (no options)	+24VDC nominal (+20VDC to +32VDC allowed)
DC Connector Type	STD	16 pin ribbon cable header
	100	Solder lugs Can use ribbon cables with the Y1150A, or discrete wires with the Y1155A.
Calibration Certificate	UK6, UKS	All options supported
Drive Options	STD	Direct coil connections for open drain drive
	T24	TTL/CMOS compatible All switches on the same distribution board must use the same drive mode.
	T00 (87406 only)	Solder lugs and TTL/5V CMOS compatible options combined - see comments above.

Y1151A Connections

LED Connectors
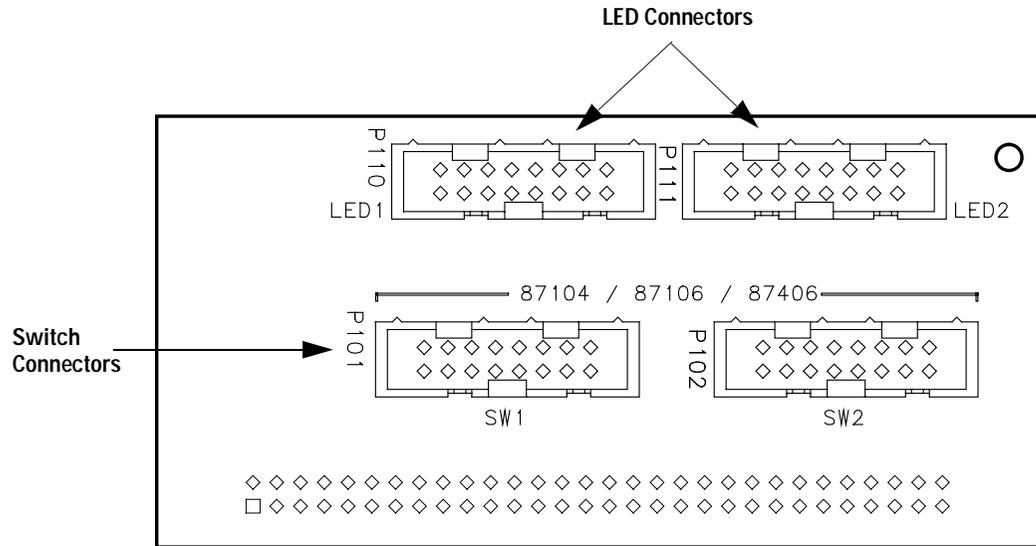
Switch Connectors

Y1151A Switch Connector SW1 and SW2
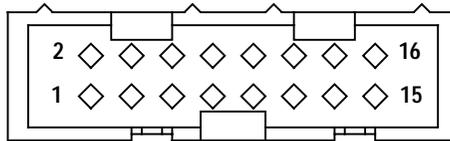
Pin	Use	Pin	Use
1	+VR	2	+VI
3	Path 1	4	IND 1
5	Path 2	6	IND 2
7	Path 3	8	IND 3
9	Path 4	10	IND 4
11	Path 5	12	IND 5
13	Path 6	14	IND 6
15	GND	16	Open All Paths

+VR is the Voltage source for the Relay
+VI is the Voltage source the LED Indicator
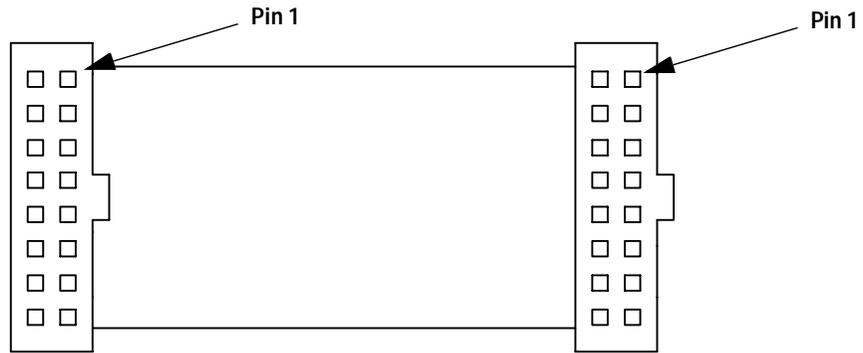
Pin 1

Pin 1

Item	Description	Example Part Numbers
Cable Type	16 conductor ribbon cable, 0.050" pitch, 26 or 28 AWG stranded	3M 3801/16 (26 AWG) 3M 3365/16 (28 AWG)
Y1151A Connector	16 pin socket connector, 0.1" x 0.1" pin grid, IDC termination, center polarizing key	3M P/N 89116-0101 AMP P/N 76288-3
Switch Connector	16 pin socket connector, 0.1" x 0.1" pin grid, IDC termination, center polarizing key	3M P/N 89116-0101 AMP P/N 76288-3
Cable Wiring	Y1151A connector pin 1 to switch connector pin 1	

Y1151A Switch Control

All channels are single drive.

	Path Closed	Path Open
SW1 Path 1	ROUT:CLOS (@xx01)	Close another path or open all
SW1 Path 2	ROUT:CLOS (@xx02)	Close another path or open all
SW1 Path 3	ROUT:CLOS (@xx03)	Close another path or open all
SW1 Path 4	ROUT:CLOS (@xx04)	Close another path or open all
SW1 Path 5	ROUT:CLOS (@xx05)	Close another path or open all
SW1 Path 6	ROUT:CLOS (@xx06)	Close another path or open all
SW1 Open All 1	ROUT:CLOS (@xx07)	
SW2 Open All 1	ROUT:CLOS (@xx08)	

	Path Closed	Path Open
SW2 Path 1	ROUT:CLOS (@xx11)	Close another path or open all
SW2 Path 2	ROUT:CLOS (@xx12)	Close another path or open all
SW2 Path 3	ROUT:CLOS (@xx13)	Close another path or open all
SW2Path 4	ROUT:CLOS (@xx14)	Close another path or open all
SW2 Path 5	ROUT:CLOS (@xx15)	Close another path or open all
SW2 Path 6	ROUT:CLOS (@xx16)	Close another path or open all
SW2 Open All 2	ROUT:CLOS (@xx17)	
SW2 Open All 2	ROUT:CLOS (@xx18)	

Y1151A LED Connectors LED1 and LED2
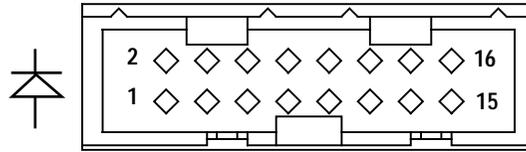
LED1 Connector				LED2 Connector			
Pin	Use	Pin	Use	Pin	Use	Pin	Use
1	+VI	2	SW1 - Path 1	1	+VI	2	SW2- Path 1
3	+VI	4	SW1 - Path 2	3	+VI	4	SW2 - Path 2
5	+VI	6	SW1 - Path 3	5	+VI	6	SW2 - Path 3
7	+VI	8	SW1 - Path 4	7	+VI	8	SW2 - Path 4
9	+VI	10	SW1 - Path 5	9	+VI	10	SW2 - Path 5
11	+VI	12	SW1 - Path 6	11	+VI	12	SW2 - Path 6
13	+VI	14	Not Used	13	+VI	14	Not Used
15	+VI	16	Not Used	15	+VI	16	Not Used

Y1152A

The Y1152A supports one of the 87xxx switches and up to two of the Agilent N181x switches. Supported switches are shown below.

Agilent Switch	Description
87204A/B/C	SP4T 4 port latching
87206A/B/C	SP6T 6 port latching
87606B	6 port matrix
N1810UL	Unterminated latching 3-port (SPDT)
N1810TL	Terminated latching 3-port (SPDT)
N1811TL	Terminated latching 4-port (transfer)
N1812UL	Unterminated latching 5-port

Y1152A Switch Options Supported

(Recommended options are shaded).

Option Name	Option Number	Description and Comments
Frequency Range	letter suffix in model number	All options supported
Coil Voltage	STD (no options)	+24VDC nominal (+20VDC to +32VDC allowed)
DC Connector Type	STD	16 pin ribbon cable header
	100	Solder lugs Can use ribbon cables with the Y1152A, or discrete wires with the Y1155A.
Calibration certificate	UK6, UKS	All options supported
Drive Options	STD	Direct coil connections for open collector drive

Y1152A Connections
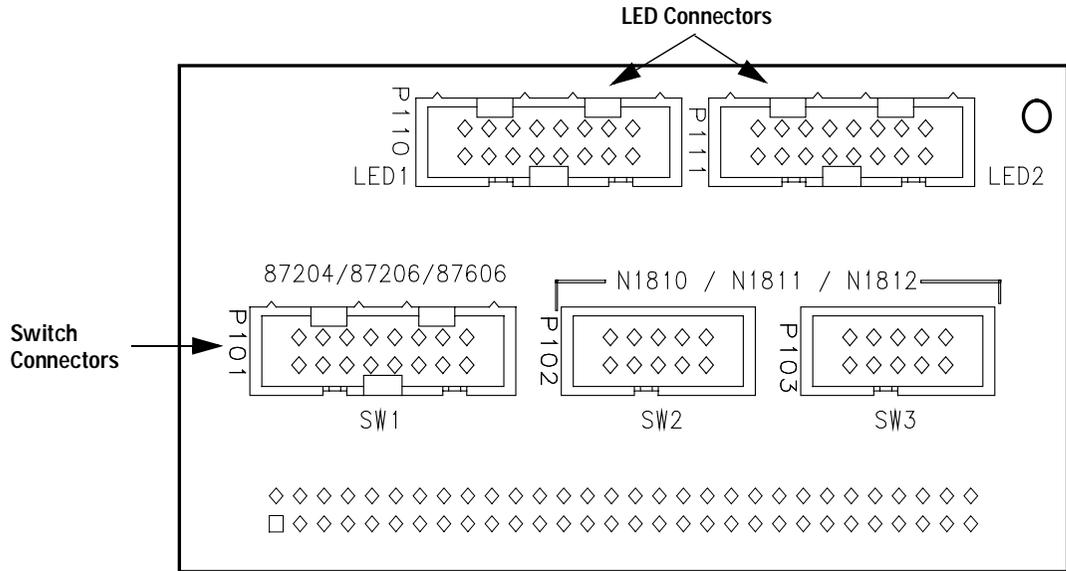
Y1152A Switch connector SW1 (87204/06)
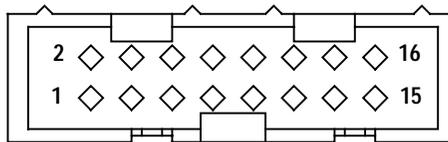
Pin	Use	Pin	Use
1	+VR	2	N.C.
3	Close 1	4	Open 1
5	Close 2	6	Open 2
7	Close 3	8	Open 3
9	Close 4	10	Open 4
11	Close 5	12	Open 5
13	Close 6	14	Open 6
15	GND	16	N.C.

Y1152A Switch Connector SW2 and SW3 (N181x)

Pin	Use	Pin	Use
1	GND	**2**	IND B
3	N.C.	**4**	+VI
5	Drive B	**6**	IND A
7	Drive A	**8**	+VI
9	+VR	**10**	N.C.

+VR is the Voltage source for the Relay
+VI is the Voltage source for the LED Indicator

Distribution Board Connector   **Switch Connector**

No Connection
To This Pin
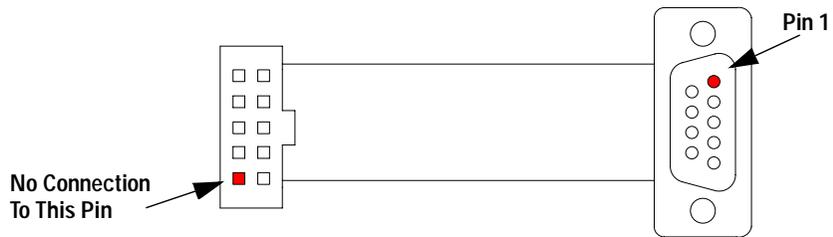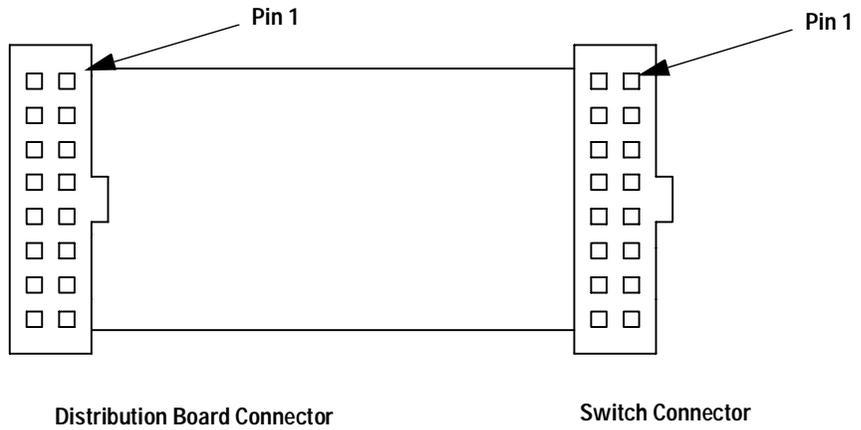
16 Conductor Cable

Item	Description	Example Part Numbers
Cable Type	16 conductor ribbon cable, 0.050" pitch, 26 or 28 AWG stranded	3M 3801/16 (26 AWG) 3M 3365/16 (28 AWG)
Y1152A Connector	10 pin socket connector, 0.1" x 0.1" pin grid, IDC termination, center polarizing key	3M P/N 89116-0101 AMP P/N 76288-3
Switch Connector	16 pin socket connector, 0.1" x 0.1" pin grid, IDC termination, center polarizing key	3M P/N 89116-0101 AMP P/N 76288-3
Cable Wiring	Y1152A connector pin 1 to switch connector pin 1	

9 Conductor Cable

Item	Description	Example Part Numbers
Cable Type	9 conductor ribbon cable, 0.050" pitch, 26 or 28 AWG stranded	3M 3801/09 (26 AWG) 3M 3365/09 (28 AWG)
Y1150A Connector	10 pin socket connector, 0.1" x 0.1" pin grid, IDC termination, center polarizing key	3M P/N 89110-0101 AMP P/N 76288-1
Switch Connector	9 pin D-sub male, IDC termination, without threaded insert	3M P/N 8209-6000 AMP P/N 747306-4
Cable Wiring	Y1152A socket connector pin 1 to switch D-sub connector pin 1 (Note: pin 10 of Y1152A connector not used)	

Y1152A Switch Control

All channels are driven in `PAIRed` mode.

	Path closed*	Path open*
SW1 Path1	ROUT:OPEN (@xx01)	ROUT:CLOS (@xx01)
SW1 Path2	ROUT:OPEN (@xx02)	ROUT:CLOS (@xx02)
SW1 Path3	ROUT:OPEN (@xx03)	ROUT:CLOS (@xx03)
SW1 Path4	ROUT:OPEN (@xx04)	ROUT:CLOS (@xx04)
SW1 Path5	ROUT:OPEN (@xx05)	ROUT:CLOS (@xx05)
SW1 Path6	ROUT:OPEN (@xx06)	ROUT:CLOS (@xx06)
	State A	**State B**
SW2	ROUT:OPEN (@xx07)	ROUT:CLOS (@xx07)
SW3	ROUT:OPEN (@xx08)	ROUT:CLOS (@xx08)

* For switches connected to SW1, note the path closed is accomplished with the `ROUTe:OPEN` command.

Y1152A LED Connectors LED1 and LED2
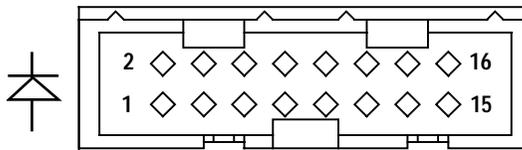
LED1 Connector				LED2 Connector			
Pin	**Use**	**Pin**	**Use**	**Pin**	**Use**	**Pin**	**Use**
1	+VI	**2**	SW1 - Close 1	**1**	+VI	**2**	SW1 - Close 5
3	+VI	**4**	SW1 - Open 1	**3**	+VI	**4**	SW1 - Open 5
5	+VI	**6**	SW1 - Close 2	**5**	+VI	**6**	SW1 - Close 6
7	+VI	**8**	SW1 - Open 2	**7**	+VI	**8**	SW1 - Open 6
9	+VI	**10**	SW1 - Close 3	**9**	+VI	**10**	SW2 - Ind A
11	+VI	**12**	SW1 - Open 3	**11**	+VI	**12**	SW2 - Ind B
13	+VI	**14**	SW1 - Close 4	**13**	+VI	**14**	SW3 - Ind A
15	+VI	**16**	SW1 - Open 4	**15**	+VI	**16**	SW3 - Ind B

Y1153A

The Y1153A supports the attenuators listed below. Up to two of the attenuators may be connected.

Agilent Attenuator	Description
84904K/L	11 dB max, 1 dB steps, 4 sections
84906K/L	90 dB max, 10 dB steps, 4 sections
84907K/L	70 dB max, 10 dB steps, 3 sections
84904M	11 dB max, 1 dB steps, 4 sections
84905M	60 dB max, 10 dB steps, 3 sections
84908M	65 dB max, 5 dB steps, 4 sections
8494G/H	11 dB max, 1 dB steps, 4 sections
8495G/H	70 dB max, 10 dB steps, 3 sections
8496G/H	110 dB max, 10 dB steps, 4 sections

Y1153A Attenuator Options Supported

(Recommended options are shaded).

84904/5/6/7/8

Option Name	Option Number	Description and Comments
Frequency Range	letter suffix in model number	All options supported
RF Connectors	various	All options supported
Coil Voltage	011	+5VDC
	015	+15VDC
	024	+24VDC (required if using internal power)
DC Connector Type	STD	10 pin ribbon cable header
Calibration Certificate	UK6	All options supported

8494/5/6

Option Name	Option Number	Description and Comments
Frequency Range	letter suffix in model number	All options supported
RF connectors	various	All options supported
Coil Voltage	STD	+24VDC
DC connector type	STD	12 pin Viking connector (includes 5 foot cable with Viking connector on one end, no terminations on other end)
	016	Flat Pack - ribbon cable connected to attenuator with 14 pin DIP header on free end. Not recommended.
Calibration certificate	UK6	All options supported

Y1153A Connections
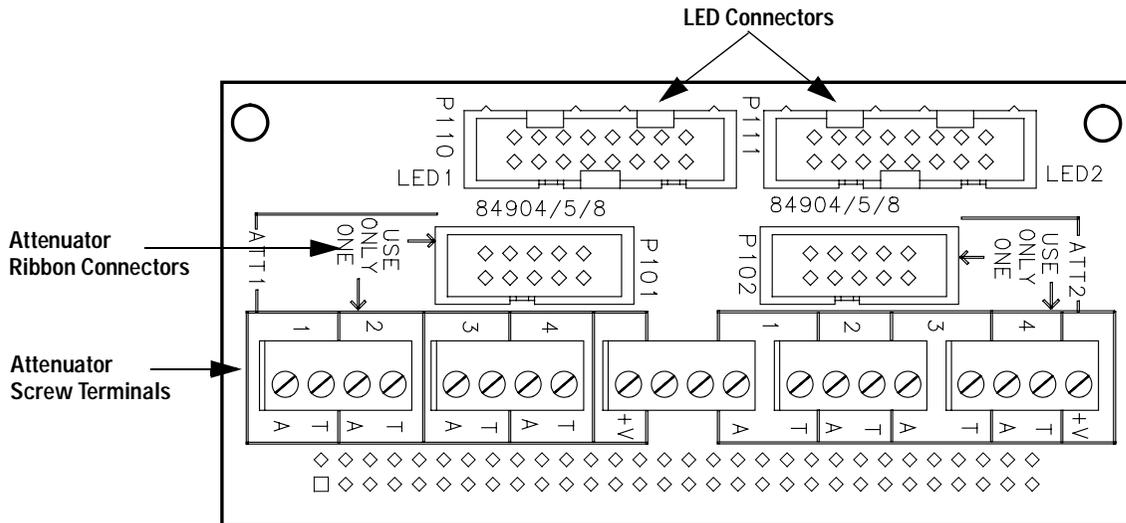
Y1153A Attenuator connector P101 and P102 (84904/5/8)
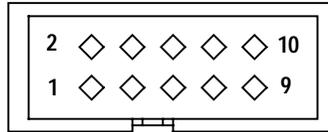
Pin	Use	Pin	Use
1	Section 1 Thru Line	2	Section 1 Atten
3	N.C.	4	Section 3 Thru Line
5	Section 2 Thru Line	6	Section 4 Thru Line
7	Section 4 Atten	8	Section 2 Atten
9	Section 3 Atten	10	+VR

NOTE   You may use either the ribbon cable header or the screw terminals to make connections to the attenuators. You should not use both.

Pin 1
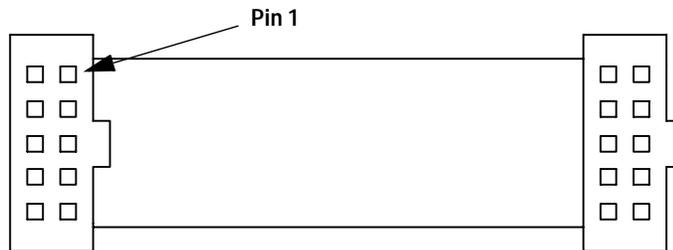
84904/5/6/7/8

Item	Description	Example Part Numbers
Cable Type	10 conductor ribbon cable, 0.050" pitch, 26 or 28 AWG stranded	3M 3801/10 (26 AWG) 3M 3365/10 (28 AWG)
Y1153A Connector	10 pin socket connector, 0.1" x 0.1" pin grid, IDC termination, center polarizing key	3M P/N 89110-0101 AMP P/N 76288-1
Attenuator Connector	10 pin socket connector, 0.1" x 0.1" pin grid, IDC termination, center polarizing key	3M P/N 89110-0101 AMP P/N 76288-1
Cable Wiring	Y1153A connector pin 1 to attenuator connector pin 1	

8494/5/6

Item	Description	Example Part Numbers
Cable Supplied with Attenuator	Cable with Viking connector on attenuator end, bare wires on other end	Agilent 8120-2178
Cable Type	12 conductor round cable, 22 or 24 AWG stranded, 0.25" dia.	
Y1153A Connection	Screw terminals provided on Y1153A distribution cable connection	
Attenuator Connector	12 pin Viking Industries, Inc. circular connector	Viking connector body TNP12-102P contacts TS-100-AU
Cable Wiring	See attenuator manual	

Y1153A Attenuator Control

All channel are operated in PAIRed mode.

	Attenuation Section In	Attenuation Section Out
ATTEN 1 SECTION 1	ROUT:OPEN (@xx01)	ROUT:CLOS (@xx01)
ATTEN 1 SECTION 2	ROUT:OPEN (@xx02)	ROUT:CLOS (@xx02)
ATTEN 1 SECTION 3	ROUT:OPEN (@xx03)	ROUT:CLOS (@xx03)
ATTEN 1 SECTION 4	ROUT:OPEN (@xx04)	ROUT:CLOS (@xx04)
ATTEN 2 SECTION 1	ROUT:OPEN (@xx05)	ROUT:CLOS (@xx05)
ATTEN 2 SECTION 2	ROUT:OPEN (@xx06)	ROUT:CLOS (@xx06)
ATTEN 2 SECTION 3	ROUT:OPEN (@xx07)	ROUT:CLOS (@xx07)
ATTEN 2 SECTION 4	ROUT:OPEN (@xx08)	ROUT:CLOS (@xx08)

NOTE ROUTe:OPEN adds that section's attenuation amount to the overall attenuation. Total attenuation is the sum of the dB amounts for the individual sections switched in.

When all channels open at reset maximum attenuation is set.

Y1153A LED Connectors LED1 and LED2
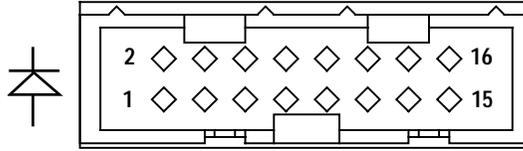
LED1 Connector				LED2 Connector			
Pin	**Use**	**Pin**	**Use**	**Pin**	**Use**	**Pin**	**Use**
1	+VI	**2**	P101 Atten 1	**1**	+VI	**2**	P102 Atten 1
3	+VI	**4**	P101 Thru Line 1	**3**	+VI	**4**	P102 Thru Line 1
5	+VI	**6**	P101 Atten 2	**5**	+VI	**6**	P102 Atten 2
7	+VI	**8**	P101 Thru Line 2	**7**	+VI	**8**	P102 Thru Line 2
9	+VI	**10**	P101 Atten 3	**9**	+VI	**10**	P102 Atten 3
11	+VI	**12**	P101 Thru Line 3	**11**	+VI	**12**	P102 Thru Line 3
13	+VI	**14**	P101 Atten 4	**13**	+VI	**14**	P102 Atten 4
15	+VI	**16**	P101 Thru Line 4	**15**	+VI	**16**	P102 Thru Line 4

Y1154A

The Y1154A supports one of the transfer switches listed below and up to six N181x switches.

Agilent Switch	Description
87222C/D/E	4 port transfer switch
N1810UL	Unterminated latching 3-port (SPDT)
N1810TL	Terminated latching 3-port (SPDT)
N1811TL	Terminated latching 4-port (transfer)
N1812UL	Unterminated latching 5-port

Y1154A Switch Options Supported

(Recommended options are shaded).

Option Name	Option Number	Description and Comments
Frequency Range	letter suffix in model number	All options supported
Coil Voltage	STD (no options)	+24VDC nominal (+20VDC to +32VDC allowed)
DC Connector Type	STD	10 pin ribbon cable header
	100	Solder lugs Can use ribbon cables with the Y1154A, or discrete wires with the Y1155A.
Mounting Bracket	201	All options supported
Calibration Certificate	UK6	All options supported
Drive Options	STD	Direct coil connections for open collector drive and TTL/5V CMOS compatible inputs standard

Y1154A Connections
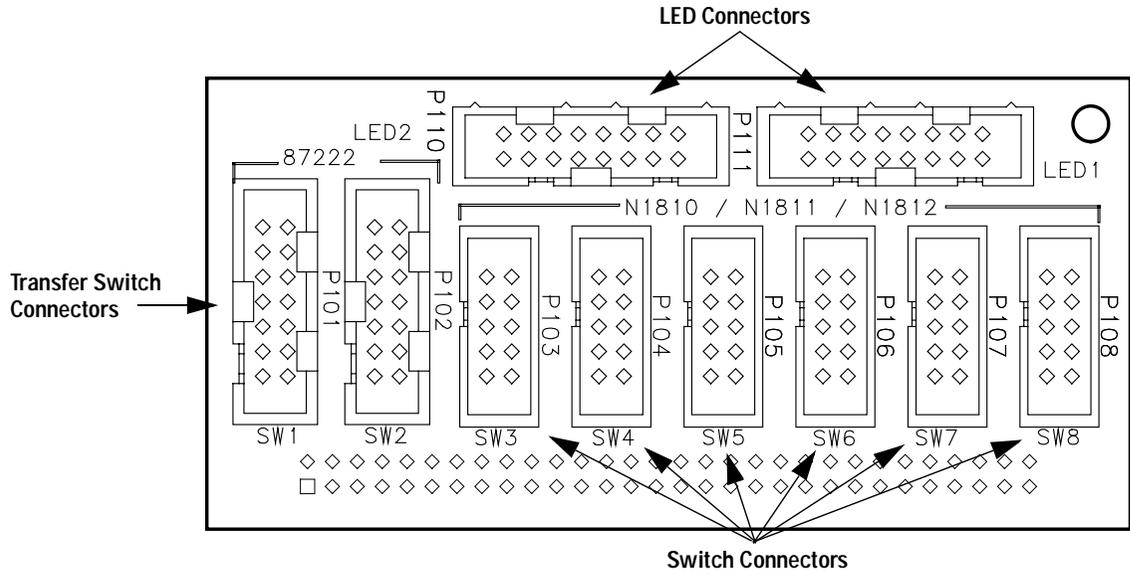
Y1154A Switch connector SW1 and SW2 (87222)
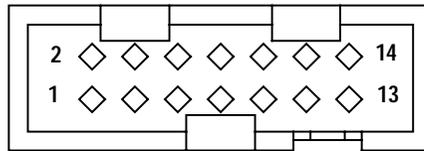
Pin	Use	Pin	Use
1	+VR	2	+VI
3	Drive A	4	Ind A
5	Drive B	6	Ind B
7	N.C.	8	N.C.
9	GND	10	N.C.
11	N.C.	12	N.C.
13	N.C.	14	N.C.

Y1154A Switch connector SW3 Through SW8 (N181x)
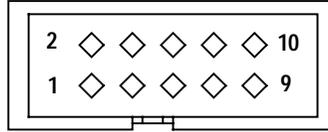
Pin	Use	Pin	Use
1	GND	2	IND B
3	N.C.	4	+VI
5	Drive B	6	IND A
7	Drive A	8	+VI
9	+VR	10	N.C.

+VR is the Voltage source for the Relay
+VI is the Voltage source for the LED Indicator
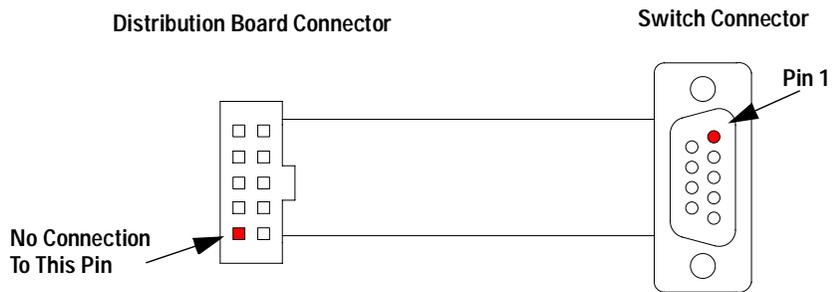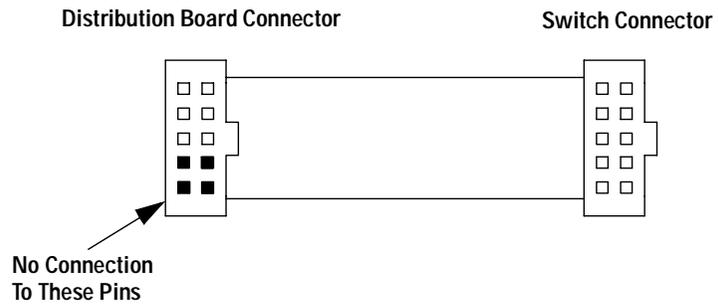
87222 Cable

Item	Description	Example Part Numbers
Cable Type	10 conductor ribbon cable, 0.050" pitch, 26 or 28 AWG stranded	3M 3801/10 (26 AWG) 3M 3365/10 (28 AWG)
Y1154A Connector	14 pin socket connector, 0.1" x 0.1" pin grid, IDC termination, center polarizing key	3M P/N 89114-0101 AMP P/N 76288-2
Switch Connector	10 pin socket connector, 0.1" x 0.1" pin grid, IDC termination, center polarizing key	3M P/N 89110-0101 AMP P/N 76288-1
Cable Wiring	Y1154A connector pin 1 to switch connector pin 1 (Note: pins 11 - 14 of 14 pin connector not used)	

9 Conductor Cable

Item	Description	Example Part Numbers
Cable Type	9 conductor ribbon cable, 0.050" pitch, 26 or 28 AWG stranded	3M 3801/09 (26 AWG) 3M 3365/09 (28 AWG)
Y1154A Connector	10 pin socket connector, 0.1" x 0.1" pin grid, IDC termination, center polarizing key	3M P/N 89110-0101 AMP P/N 76288-1
Switch Connector	9 pin D-sub male, IDC termination, without threaded insert	3M P/N 8209-6000 AMP P/N 747306-4
Cable Wiring	Y1154A socket connector pin 1 to switch D-sub connector pin 1 (Note: pin 10 of Y1154A connector not used)	

Y1154A Switch Control

All channels are operated in PAIRed mode.

	State A	State B
SW1	ROUT:OPEN (@xx01)	ROUT:CLOS (@xx01)
SW2	ROUT:OPEN (@xx02)	ROUT:CLOS (@xx02)
SW3	ROUT:OPEN (@xx03)	ROUT:CLOS (@xx03)
SW4	ROUT:OPEN (@xx04)	ROUT:CLOS (@xx04)
SW5	ROUT:OPEN (@xx05)	ROUT:CLOS (@xx05)
SW6	ROUT:OPEN (@xx06)	ROUT:CLOS (@xx06)
SW7	ROUT:OPEN (@xx07)	ROUT:CLOS (@xx07)
SW8	ROUT:OPEN (@xx08)	ROUT:CLOS (@xx08)

Y1154A LED Connectors LED1 and LED2

LED1 Connector				LED2 Connector			
Pin	**Use**	**Pin**	**Use**	**Pin**	**Use**	**Pin**	**Use**
1	+VI	**2**	SW1 - A	**1**	+VI	**2**	SW5 - A
3	+VI	**4**	SW1 - B	**3**	+VI	**4**	SW5 - B
5	+VI	**6**	SW2 - A	**5**	+VI	**6**	SW6 - A
7	+VI	**8**	SW2 - B	**7**	+VI	**8**	SW6 - B
9	+VI	**10**	SW3 - A	**9**	+VI	**10**	SW7 - A
11	+VI	**12**	SW3 - B	**11**	+VI	**12**	SW7 - B
13	+VI	**14**	SW4 - A	**13**	+VI	**14**	SW8 - A
15	+VI	**16**	SW4 - B	**15**	+VI	**16**	SW8 - B

Y1155A

The Y1155A provides screw terminal connections can support the Agilent switches listed below. Additionally, the screw terminals make it adaptable to most any switch.

Agilent Switch	Description
8762A/B/C	Terminated latching 3-port (SPDT)
8762F	75 ohm terminated SPDT
8763A/B/C	Terminated latching 4-port (transfer)
8764A/B/C	Terminated latching 5-port
Other Switches	Numerous

NOTE   When using the Y1155A, the `ROUTe:RMODule:BANK:PRESet` command's default configuration (see page 223) may not be suitable for the wide variety of switches and devices available. You will need to manually configure the channel drive attributes to ensure safe reset operations of these switch systems.

Y1155A Switch Options Supported

Recommended options are shaded.

Option Name	Option Number	Description and Comments
Frequency Range	Various	All options supported
Coil Voltage	011	+5VDC +5VDC Highest coil current requirement of all coil voltage options. May limit system speed because current capacity limitations. 34945EXT limits total switch current to 2A; opt 011 coils draw 400 mA. Therefore, a maximum of 5 devices may be switched simultaneously.
	015	+15VDC
	024	+24VDC (required if using internal power)
DC Connector Type	STD	solder lugs
RF Performance	various	All options supported
Drive Options	STD	Direct coil connections for open collector drive
	T24	TTL/5V CMOS compatible inputs with +24VDC coils (Note: position indicators do not function; wiring pattern differs from direct drive)
	T15	TTL/5V CMOS compatible inputs with +15VDC coils (Note: position indicators do not function; wiring pattern differs from direct drive)

Y1155A Connections
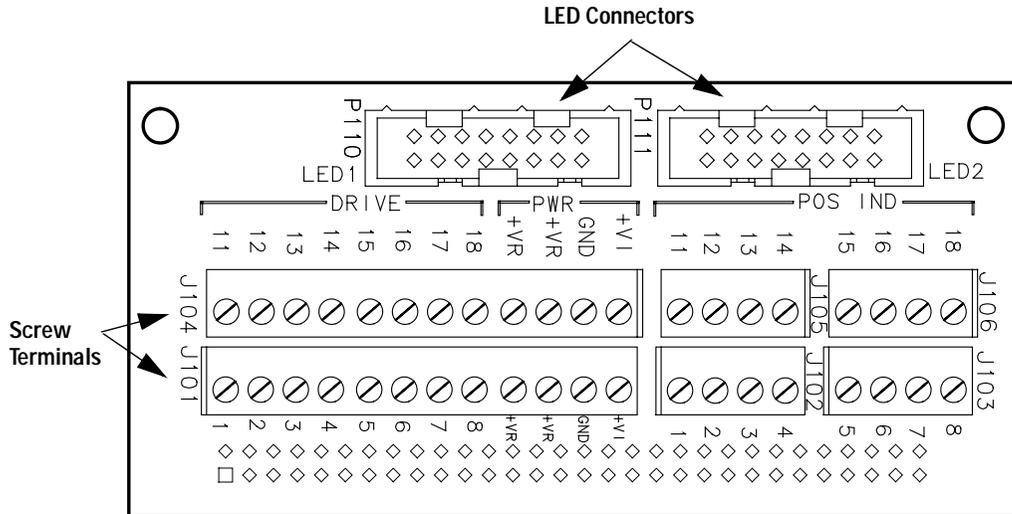
LED Connectors

+VR is the Voltage source for the Relay
+VI is the Voltage source for the LED Indicator

876x Switches

Item	Description
Cable Type	3 wire cable, 24 AWG stranded
Y1155A Connector	Screw terminal connection for wire provided on Y1155A
Switch Connector	Solder wire to switch solder lug
Cable Wiring	Varies with drive option; see switch documentation

Y1155A Switch Control

Paired Operations*

Drive 1	ROUT:OPEN (@xx01)	**Drive 11**	ROUT:CLOS (@xx01)
Drive 2	ROUT:OPEN (@xx02)	**Drive 12**	ROUT:CLOS (@xx02)
Drive 3	ROUT:OPEN (@xx03)	**Drive 13**	ROUT:CLOS (@xx03)
Drive 4	ROUT:OPEN (@xx04)	**Drive 14**	ROUT:CLOS (@xx04)
Drive 5	ROUT:OPEN (@xx05)	**Drive 15**	ROUT:CLOS (@xx05)
Drive 6	ROUT:OPEN (@xx06)	**Drive 16**	ROUT:CLOS (@xx06)
Drive 7	ROUT:OPEN (@xx07)	**Drive 17**	ROUT:CLOS (@xx07)
Drive 8	ROUT:OPEN (@xx08)	**Drive 18**	ROUT:CLOS (@xx08)

* `PAIRed` operation must be configured manually. The `ROUTe:RMODule:BANK:PRESet` does not configure Y1155A channels for `PAIRed` operations.

Unpaired Operations

Drive 1	ROUT:CLOS (@xx01)
Drive 2	ROUT:CLOS (@xx02)
Drive 3	ROUT:CLOS (@xx03)
Drive 4	ROUT:CLOS (@xx04)
Drive 5	ROUT:CLOS (@xx05)
Drive 6	ROUT:CLOS (@xx06)
Drive 7	ROUT:CLOS (@xx07)
Drive 8	ROUT:CLOS (@xx08)
Drive 11	ROUT:CLOS (@xx11)
Drive 12	ROUT:CLOS (@xx12)
Drive 13	ROUT:CLOS (@xx13)
Drive 14	ROUT:CLOS (@xx14)
Drive 15	ROUT:CLOS (@xx15)
Drive 16	ROUT:CLOS (@xx16)
Drive 17	ROUT:CLOS (@xx17)
Drive 18	ROUT:CLOS (@xx18)

Y1155A LED Connectors LED1 and LED2

LED1 Connector				LED2 Connector			
Pin	**Use**	**Pin**	**Use**	**Pin**	**Use**	**Pin**	**Use**
1	+VI	2	SW1 - A	1	+VI	2	SW5 - A
3	+VI	4	SW1 - B	3	+VI	4	SW5 - B
5	+VI	6	SW2 - A	5	+VI	6	SW6 - A
7	+VI	8	SW2 - B	7	+VI	8	SW6 - B
9	+VI	10	SW3 - A	9	+VI	10	SW7 - A
11	+VI	12	SW3 - B	11	+VI	12	SW7 - B
13	+VI	14	SW4 - A	13	+VI	14	SW8 - A
15	+VI	16	SW4 - B	15	+VI	16	SW8 - B

Simplified Connection Diagrams

Single Drive With Separate Position Indicators

The simplified schematic below illustrates the connection for a single drive switch with separate position indicators. The position indicators for this type of switch are independent relay contacts that are mechanically linked to the RF switch position.

Even though this is a single drive switch, each switch state has its own coil. The switch uses internal logic to open all paths except the one being closed.

The RF paths are not shown in the simplified diagram. The coils are driven in open collector mode. The position indicator is set so that a high level indicates an active switch. The logic level of the position indicator can be inverted using the ROUTe:CHANnel:VERify:POLarity command.

The schematic shown is similar to the Agilent 87104A/B/C, 87106A/B/C, and 87406B switches. Many other switches use this technique (both with and without the position indicator).
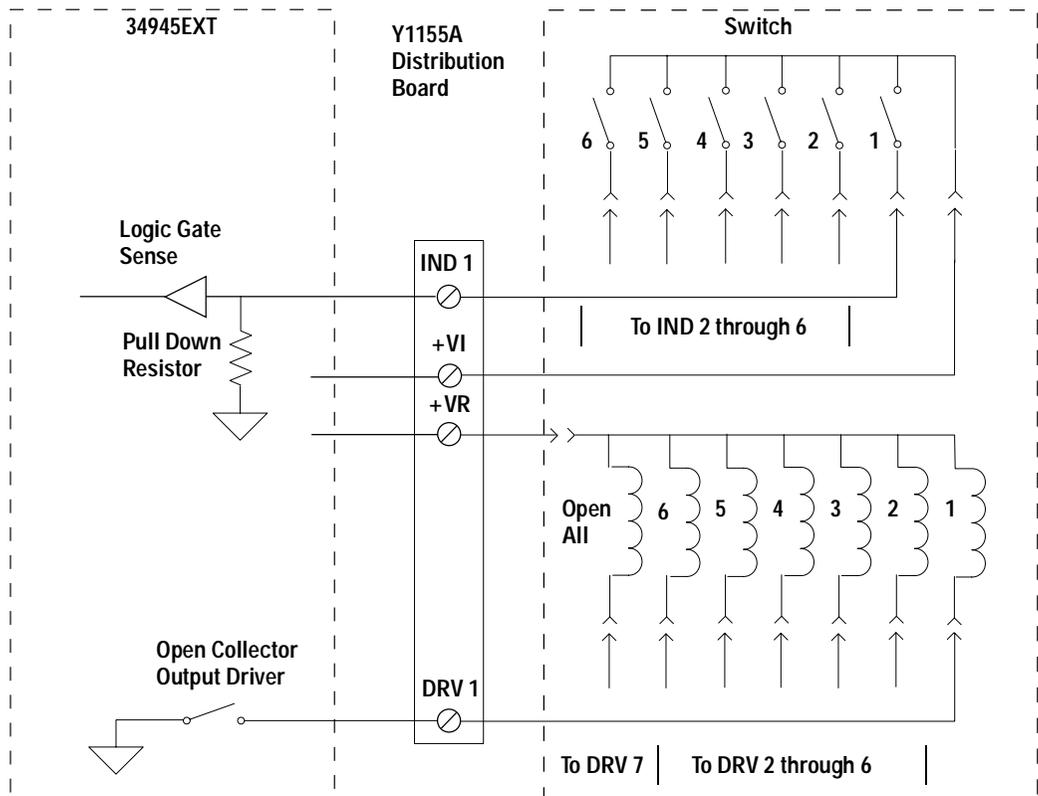
Paired Drive With Separate Position Indicators

The simplified schematic below illustrates the connection for a dual drive switch with separate position indicators. The position indicators for this type of switch are independent relay contacts that are mechanically linked to the RF switch position.

The RF paths are not shown in the simplified diagram. The coils are driven in open collector mode. The position indicator is set so that a high level indicates an active switch. The logic level of the position indicator can be inverted using the ROUTe:CHANnel:VERify:POLarity command.

As shown, Channel 01 was pulsed to close Coil A. The corresponding position indicator also closed. Closing position indicator A opens position indicator B.

The schematic shown is similar to the Agilent N181x series of switches.
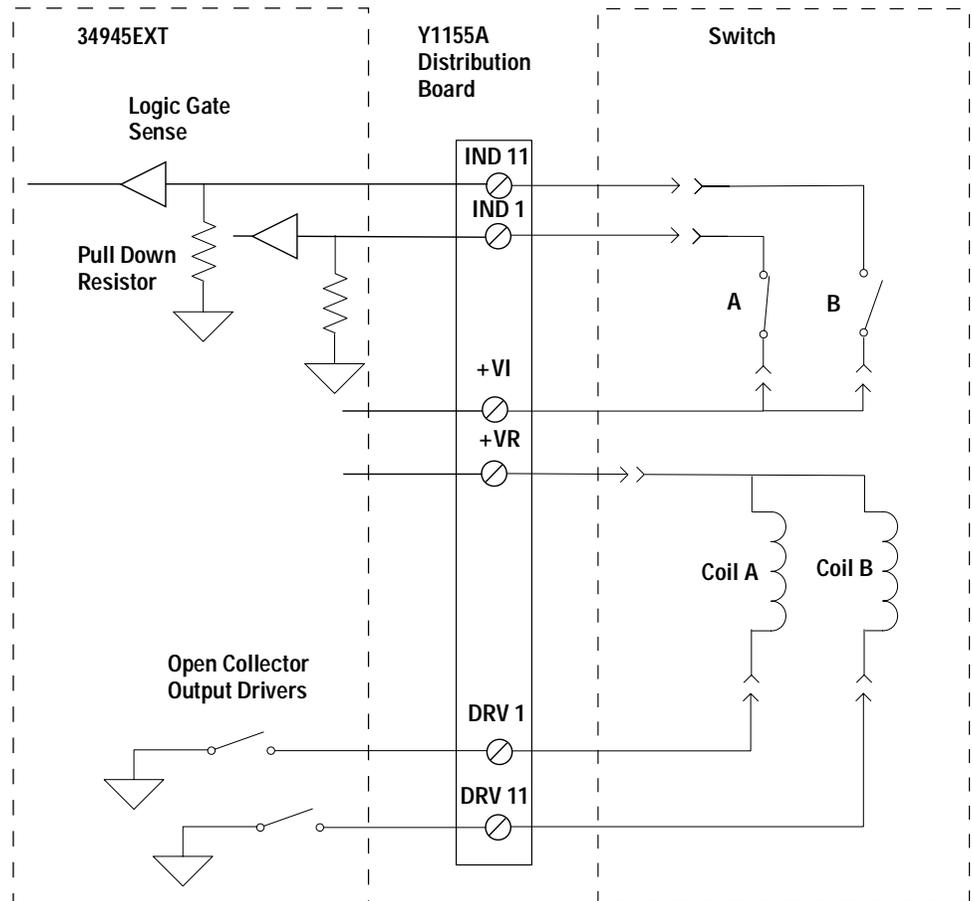
Paired Drive With Combined Position Indicators

The simplified schematic below illustrates the connection for a dual drive switch with an integral position indicator. The position indicators for this type of switch are electrically connected to the device's drive coil. This is a typical arrangement for microwave attenuators. For these types of position indicators, you must make a parallel connection at the distribution board between the channel drive and the indicator input.

With these types of devices, positive voltage is present on the paired coil opposite the position the switch is currently in. Typically you will need to invert the logic level of the position indicator using the ROUTe:CHANnel:VERify:POLarity command.

As shown, Channel 01 was pulsed to close Port 1. The corresponding position indicator also closed.

The schematic shown is similar to the Agilent 876x series of switches and 849x series of step attenuators.
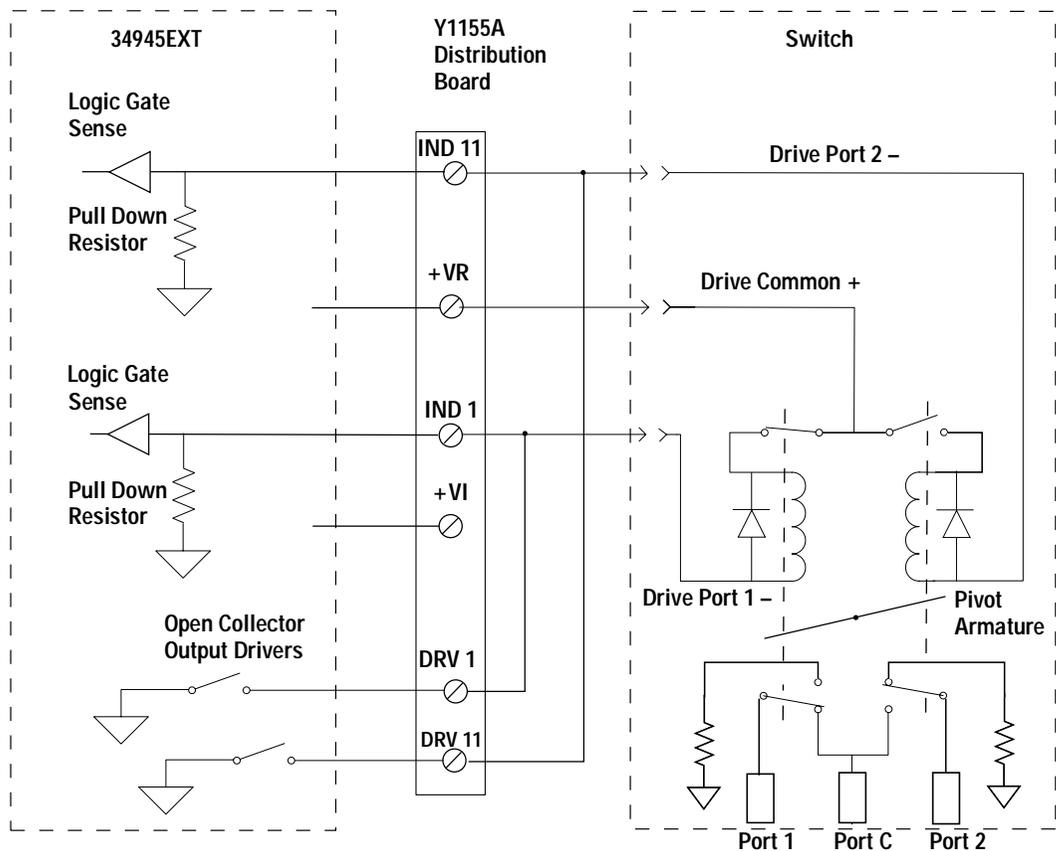
Mounting the Remote Modules

The figure below shows the dimensions of the remote module and the locations of usable mounting holes.

All Mounting Holes are
Metric M4X0.7 Threads
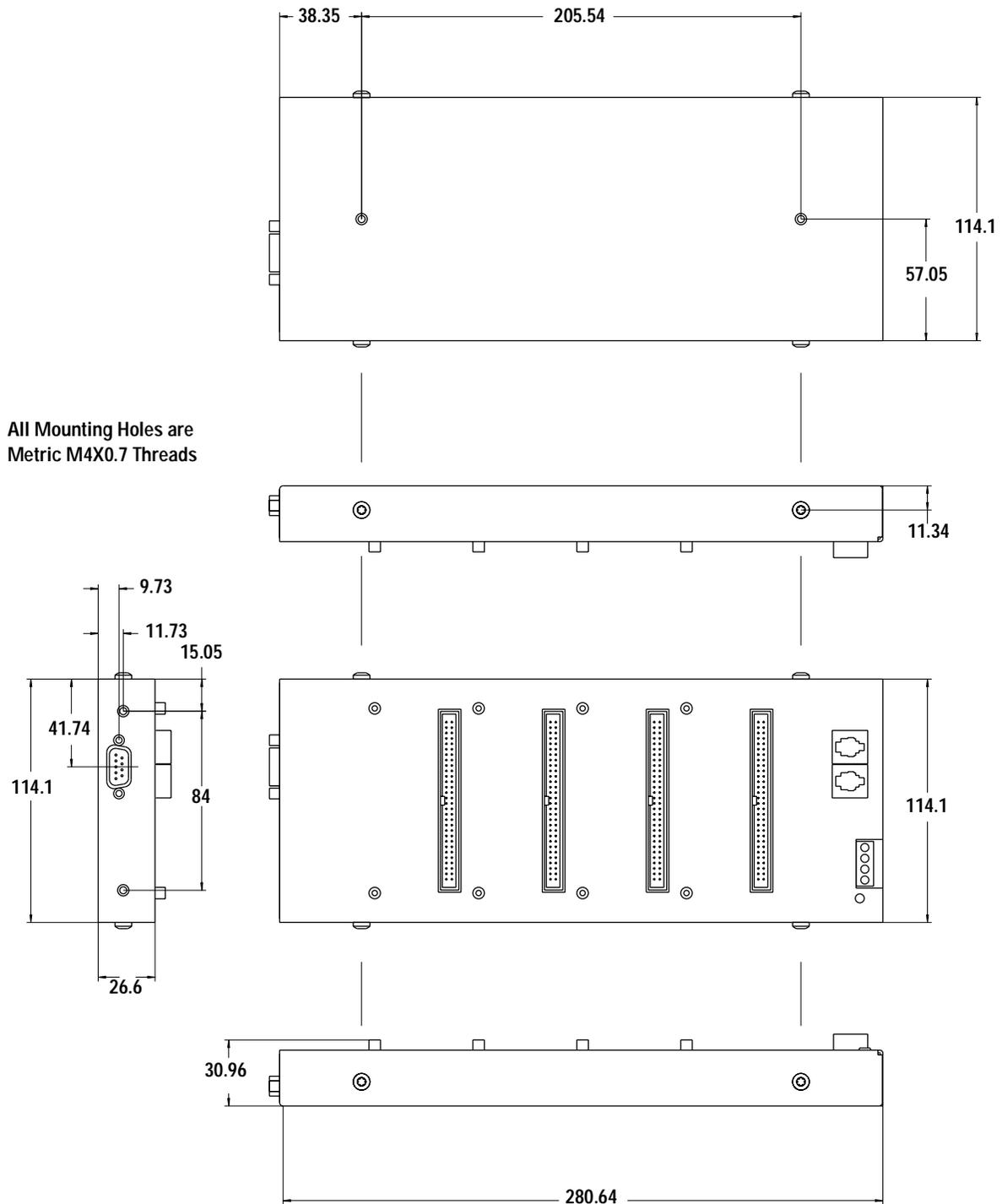
SCPI Programming Examples

These programming examples provide you with SCPI command examples to use for driving the microwave switch modules.

The slot and channel addressing scheme used in these examples follow the form *srcc* where **s** is the mainframe slot number (1 through 8), *r* is the remote module number (1 through 8), and **cc** is the two-digit channel number. For more information about channel numbering, refer to "Channel Numbering" on page 212.

For complete information on SCPI commands, see the *Programmer's Reference* Help file.

Example: Configuring an Agilent N1810UL

The following example illustrate controlling an Agilent N1810UL attached to a Y1150A distribution board. The distribution board is connected to Bank 1 of the first remote module attached to the 34945A installed in slot 1 of the mainframe. This example uses the bank preset (described on page 223).

```
ROUTe:RMODule:DRIVe:SOURce OFF,(@1100)
ROUTe:RMODule:BANK:PRESet BANK1,(@1100)
ROUTe:RMODule:DRIVe:SOURce INT,(@1101)

ROUT:CLOSe (@1101)
```

Example: Configuring a Paired Drive Channel

The following example illustrates the sequence of commands used to configure a paired drive channel. In the example, the 34945A is installed in slot 4 of the mainframe, and operations are directed to channel 1 on remote module 3.

The drive source must be disabled before configuring either the channel pairing or the pulse mode. The channel is then paired and the pulse width set to 15 ms. Power supply recovery time and settling time is then set to 12 ms and 10 ms, respectively. Verify is then enabled. The default behavior for the switches is set to OPEN and TTL drive using an EXTernal power supply. Finally, the channel is closed.

```
ROUTe:RMODule:DRIVe:SOURce OFF,(@4300)
ROUTe:CHANnel:DRIVe:PAIRed ON,(@4301)
ROUTe:CHANnel:DRIVe:PULSe 0.015,(@4301)
ROUTe:CHANnel:DRIVe:TIME:SETTle 0.012,(@4301)
ROUTe:CHANnel:DRIVe:TIME:RECovery 0.010,(@4301)
ROUTe:CHANnel:VERify ON,(@4301)
ROUTe:CHANnel:DRIVe:OPEN:DEFault (@4301)
ROUTe:RMODule:BANK:DRIVe:MODE TTL,BANK1,(@4300)
ROUTe:RMODule:DRIVe:SOURce EXT,(@4300)

ROUT:CLOSe (@4301)
```

Example: Configuring a Single Drive Channel

The following example illustrates the sequence of command to configure a single drive channel with continuous drive. In the example, the 34945A is installed in slot 4 of the mainframe, and operations are directed to channel 1 on remote module 3.

The drive source must be disabled before configuring pulse or paired modes. The channel is then un-paired and the pulse mode disabled (enables continuous drive). Power supply recovery time and settling time is then set to 10 ms and 12 ms, respectively. Verify is then enabled. The switches are set to a CLOSe default state and OCOLlector drive with an EXTernal power supply is selected. The channel is closed. The final query of the channel state involves querying both verified state and whether channel drive is occurring.

```
ROUTe:RMODule:DRIVe:SOURce OFF,(@4300)
ROUTe:CHANnel:DRIVe:PAIRed OFF,(@4301)
ROUTe:CHANnel:DRIVe:PULSe:MODE OFF,(@4301)
ROUTe:CHANnel:DRIVe:TIME:SETTle 0.010,(@4301)
ROUTe:CHANnel:DRIVe:TIME:RECovery 0.012,(@4301)
ROUTe:CHANnel:VERify ON,(@4301)
ROUTe:CHANnel:DRIVe:CLOSe:DEFault (@4301)
ROUTe:RMOD:BANK:DRIVe:MODE OCOLlector,BANK1,(@4300)
ROUTe:RMODule:DRIVe:SOURce EXT,(@4300)

ROUT:CLOSe (@4301)
ROUT:CLOSe? (@4301)
ROUTe:CHANnel:DRIVE:STATe? (@4301)
```

The ROUTe:CHANnel:DRIVE:STATe? query returns a 0 if the channel is not being driven and a 1 if the channel is being driven.
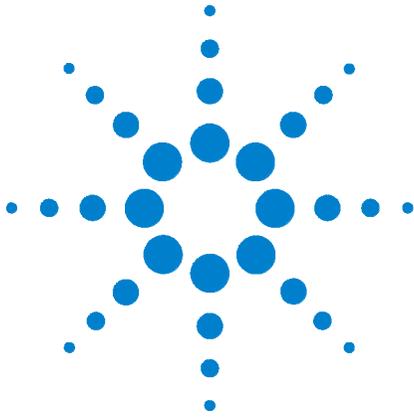
9

Dual/Triple Microwave Switch Modules

34946A and 34947A Dual/Triple Microwave Switch Modules

The 34946A and 34947A modules offer single-pole, double-throw switches in either 4-GHz or 20-GHz options.

The 34946A and 34947A modules do not connect to the analog buses. Instead, all connections are made through the visible SMA connectors via external cables. Each connector on the modules is labeled with a three-digit number that represents a channel you can control programmatically, from the front panel, or with the Web UI.

The 34946A module uses two independent Agilent N1810TL switches. These terminated 3-port 50-ohm switches are designed to maintain impedance matching. The 34947A module contains three independent Agilent N1810UL switches. These higher density 3-port switches are unterminated. For channel configuration on each module, refer to the simplified schematics on .

The 34946A and 34947A modules implement a *verification* feature, which senses the actual hardware state of the specified channels following a `ROUTe:CLOSe` or `ROUTe:OPEN` operation. If a switch operation appears to have failed, an error will be generated at the time the `ROUTe:CLOSe` or `ROUTe:OPEN` command is executed. An error will be generated for each channel operation that did not properly verify. The verification process will slow overall switching performance on the module.

34946A and 34947A SCPI Programming Examples

The programming examples below provide you with SCPI command examples to use for actions specific to the microwave switch modules.

The slot and channel addressing scheme used in these examples follow the form **sccc** where **s** is the mainframe slot number (1 through 8) and **ccc** is the three-digit channel number. For information on specific configurations, refer to the simplified schematics in this chapter.

For complete information on the SCPI commands used to program the 34980A, refer to the Agilent 34980A Programmer's Reference contained on the 34980A Product Reference CD. For example programs, also refer to the 34980A Product Reference CD.

Example: Closing channels   You can use the `ROUTe:CLOSe` to close channels on the microwave switch modules, but these modules do not support the `ROUTe:OPEN` command. You can open channels by closing other channels. With this "one-step" operation, the relays switch in the proper order that avoids momentary connection of the wrong input to the switch output. The following statement closes channel 201 of a microwave switch module installed in slot 5.

`ROUTe:CLOSe (@5201)`

Example: Querying channels for open or close state   The following command returns the open (1) or close (0) state of channel 202 for a module in slot 3.

`ROUTe:CLOSe? (@3202)`

Example: Querying the system for module identify   The following command returns the identify of the module installed in slot 7.

`SYSTem:CTYPe? 7`

Example: Reading the cycle count for a relay   The following command reads back the number of completed cycles for the channel 201 relay of a module installed in slot 6.

`DIAGnostic:RELay:CYCLes? (@6201)`

Example: Clearing the cycle count for a relay   The following command resets the cycle count on channels 201 and 202 for a module in slot 1.

`DIAGnostic:RELay:CYCLes:CLEar (@1201,1202)`

Example: Resetting Module(s) to Power-On State   The following command resets a module in slot 4 to its power-on state.

```
SYSTem:CPON 4
```

Example: Enabling Verification   The following command enables verification on channels 201 and 202 for a module in slot 1. When verification is enabled, the actual hardware state of each relay is sensed for the correct state.

```
ROUTe:CHANnel:VERify:ENABle ON,(@1201,1202)
```

Installing SMA Connectors

When installing SMA connectors, it is recommend that you tighten them to 0.8 - 1.1 Nm (7-10 in-lbs) of torque.

34946A and 34947A Simplified Schematics

The following drawings show the channel configuration for the 34946A and 34947A modules, respectively.

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64-Bit Digital I/O Module with Memory and Counter

34950A 64-Bit Digital I/O Module with Memory and Counter

The 34950A has 64-bits of general-purpose digital I/O grouped in 8-bit channels with programmable polarity, input thresholds, and output levels. The module is segmented into two banks of four 8-bit channels. Each bank has 64 Kb of volatile memory for pattern capture and pattern generation with hardware interrupt capability. Up to three pins of handshaking are available for each bank of 32 bits.

The module also has two 10 MHz frequency counter/totalizer measurement input channels and a programmable clock output for frequency synchronization or general clocking needs.

The digital channels are numbered by bank; 101 through 104 and 201 through 204 for banks 1 and 2 respectively. The counter/totalizer channels are assigned channel numbers 301 and 302. The programmable clock is not assigned a channel number.
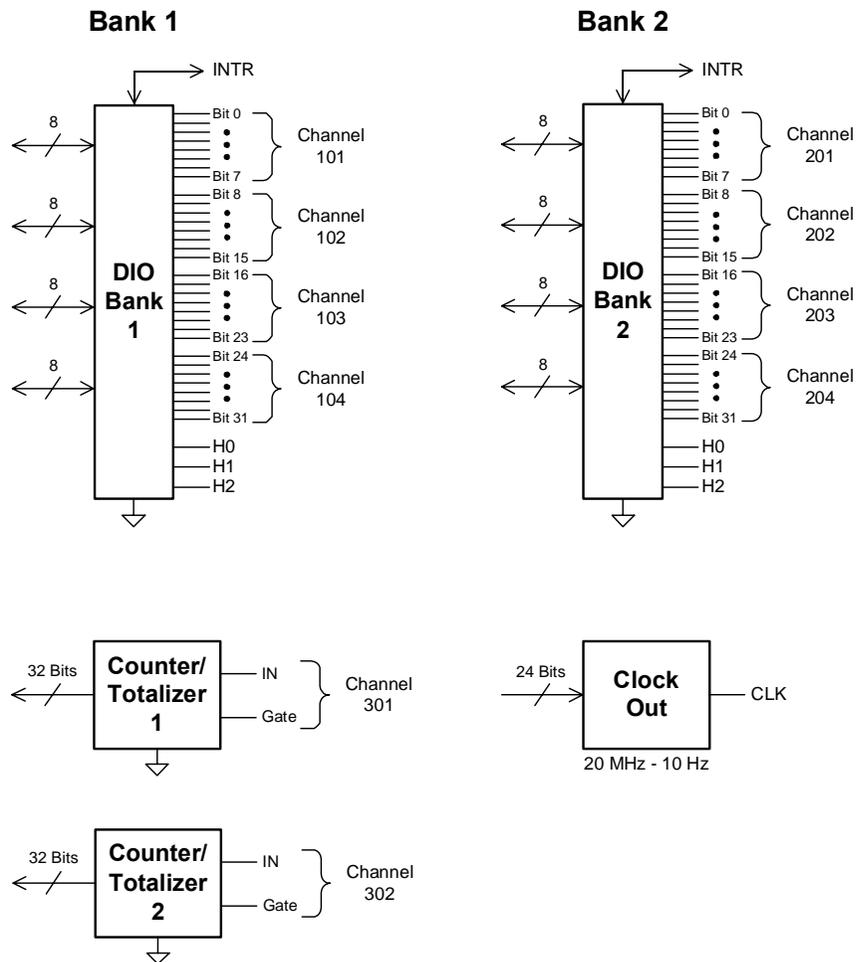
Basic Digital I/O Operations

Channel Numbering and Width

The digital channels are numbered by bank; 101 through 104 and 201 through 204 for banks 1 and 2 respectively.

Using SCPI commands you can group digital I/O channels together to allow 16- or 32-bit operations. The first and third channels on a bank can be control channels. Width and direction of the memory operations are controlled by the width and direction of the first channel on the bank (i.e., 101 or 201). In the SCPI language for the 34950A, BYTE refers to 8-bit operations, WORD refers to 16-bit operations, and LWORd refers to 32-bit operations.

This diagram illustrates how the channels are numbered for each configuration.

	Bank 1				Bank 2			
	Channel							
BYTE (default)	101	102	103	104	201	202	203	204
	8-bits	8-bits	8-bits	8-bits	8-bits	8-bits	8-bits	8-bits
WORD	101		103		201		203	
	16-bits		16-bits		16-bits		16-bits	
LWORd	101				201			
	32-bits				32-bits			

Reading Digital Data

The simplest way to read a digital channel is using the `MEASure:DIGital?` query. This query sets the channel to be an input channel and sets all other channel parameters to the default settings.

For example, sending the following SCPI command to a Digital I/O module installed in slot 1 of the mainframe will read the value of the 8-bit channel 102. An unsigned integer value is returned that represents the state of the 8 bits on channel 102.

```
MEAS:DIG? BYTE, (@1102)
```

By adding parameters to the command, you can set the channel width, polarity, and threshold for read. For example, sending the following SCPI command you can read the 32-bit channel 201.

```
MEAS:DIG? LWOR, (@1201)
```

To read digital data with more control over the channel parameters, use the SCPI CONFigure and SENSe commands. The CONFigure commands set up the digital I/O channel parameters. For example, sending the following SCPI command to a Digital I/O module installed in slot 1 of the mainframe, sets a 16-bit input channel (103) to use a 2.5 V input threshold, and normal polarity.

```
CONF:DIG WORD, 2.5, NORM, (@1103)
```

Once configured, the data is read using the following command.

```
SENS:DIG:DATA:WORD? (@1103)
```

You may also read an individual bit using the SENSe commands. This allows you to check the state of an individual bit in a channel without having to create an input mask. For example, the following command returns the state of bit 3 in the channel 101 byte.

```
SENS:DIG:DATA:BIT? 3, (@1101)
```

The acceptable range for the bit parameter is based on the channel width as shown below:

- BYTE (8-bit): <bit> can range from '0' to '7'
- WORD (16-bit): <bit> can range from '0' to '15'
- LWORd (32-bit): <bit> can range from '0' to '31'

The SENSe command differs from the MEASure command in that it will not change the direction (input or output) of the channel. If the channel is configured as an output, the SENSe command will return the value being driven.

Writing Digital Data

To write digital data, set the channel output parameters using the SOURce commands. For example, sending the following SCPI commands to a Digital I/O module in slot 1 sets a 32-bit channel to use normal polarity, with active drive and a 'set' output voltage of 4 volts.

```
CONF:DIG:WIDT LWOR,(@1201)
CONF:DIG:POL NORM,(@1201)
SOUR:DIG:DRIV ACT,(@1201)
SOUR:DIG:LEV 4,(@1201)
```

The width and polarity parameters apply to both input and output operations.

You can set a channel to output in either active drive or open collector configurations. When set to `ACTive`, the module drives the digital lines for both high and low. The voltage level that represents a logic '1' can be set using the `SOURce:DIGital:LEVel` command. Output voltages can range from 1.66 V (default) to 5 V.

When the channel is set to `OCOLlector`, lines are driven low, but set to high impedance (Hi-Z) when asserted. In the open collector mode, multiple lines can be connected together by providing external pull-ups.

> **NOTE**   When using external pull-ups in the open collector mode, the outputs will not exceed 5 V.

Once a channel has been configured, write digital data to the channel using the `SOURce:DIGital:DATA` command.

```
SOUR:DIG:DATA:LWOR 26503,(@1201)
```

You may also use a hexadecimal format to represent values in the commands. For example, to send the decimal value of 26503 in hex use the command form:

```
SOUR:DIG:DATA:LWOR #h6787,(@1201)
```

> **NOTE**   Writing to a channel automatically configures the channel as an output.

Note that the data should match the channel width configured using `CONFigure:DIGital:DATA:WIDTh` command. The data written is masked by the configured width so that any extra bytes will be discarded. For example: sending the value 65531 to a byte wide channel will result in the channel discarding the upper byte and outputting 251.

Channel Width and Polarity, Threshold, Level, and Drive

When the width of a channel is set to `WORD` or `LWORd`, the channel direction (input or output) of the channels spanned by the width is controlled by the channel in operation. That is, all grouped channels are automatically set to the same input or output operation.

Channel settings of polarity, threshold, level, and drive mode are unchanged when channels are combined. For example, consider the following command sequence.

```
CONF:DIG:POL NORM,(@1101)
CONF:DIG:POL INV,(@1102)
CONF:DIG:WIDT WORD,(@1101)
```

This command sequence set the first 8 bits (channel 101) to normal polarity for input and output operations, set the next 8 bits (channel 102) to inverted polarity, and then combines the bits into a 16-bit channel. When this WORD channel is used, the first eight bits will input or output using normal polarity but the next 8 bits will read or written using inverted polarity.

Threshold, level, and drive settings all behave in the same manner as the polarity setting described above.

Handshaking

Handshaking provides a means to synchronize the input or output of digital data. By default, no handshaking is used and data is input or output as the command is executed. The handshake is configured per bank.

The 34950A provides a synchronous handshake mode (strobe handshake). You can use this mode with basic input and output operations. You *must* use this handshake mode to use buffered I/O (see "Buffered I/O Operations" on page 277).

The handshake is performed using three lines on each bank. The lines are labeled H0, H1, and H2. The function of each line is set by the input or output mode in use. Since there are only three handshake lines per bank, the SCPI handshake commands are only valid for the first channel in a bank. Once handshaking is enabled, it applies to the width of the first channel in the bank.

The three handshaking lines on each bank also differ slightly if you are using buffered (memory) I/O (see page 277) or unbuffered I/O operations. You can also perform unbuffered operations without any handshake. The function of each line for each mode of operation is defined in the table below.

	H0	H1	H2
Unbuffered Synchronous Input	I/O Direction (output)	Strobe (output)	Not Used (Hi-Z)
Unbuffered Synchronous Output	I/O Direction (output)	Strobe (output)	Not Used (Hi-Z)
Buffered Synchronous Input	Start/Stop (output)	Not Used (Hi-Z)	Input Strobe (input)
Buffered Synchronous Output (internal clock)	Start/Stop (output)	Strobe (output)	Not Used (Hi-Z)
Buffered Synchronous Output (external clock)	Start/Stop (output)	Not Used (Hi-Z)	Output Strobe (input)

The following handshake command sets the synchronous handshaking mode for the channels in bank 1.

```
CONF:DIG:HAND SYNC, (@1101)
```

This form of the handshaking command also allows you to optionally set the input threshold, output drive level, and polarity of all the handshake lines. For example, the following command sets bank 2 to use synchronous handshaking, with an input threshold of 2.5 V, an output drive level of 2.5 V, and normal polarity. Other parameters such as the handshake timing are set to default values (refer to the *Programmer's Reference Help file* for details).

```
CONF:DIG:HAND SYNC, 2.5, 2.5, NORM, (@1201)
```

You can set parameters by using a sequence of commands instead of the CONFigure macro command. For example, the following command sequence sets the handshaking mode to synchronous, the output drive to open collector, and the handshake rate to 1 MHz.

```
CONF:DIG:HAND:MODE SYNC, (@1101)
CONF:DIG:HAND:DRIV OCOL, (@1101)
CONF:DIG:HAND:RATE 1000000, (@1101)
```

Setting the Handshake Line Parameters

You can set the handshake lines' input threshold, output drive mode, and output drive voltage. These settings affect all the handshake lines in the bank. Handshake line polarity can be set for each individual handshake line.

For example, you can invert the polarity of the handshake line H1 on bank 2 with the following command.

```
CONF:DIG:HAND:POL INV, H1, (@1201)
```

You can set the output drive mode, output voltage, and input threshold for all handshake lines in each bank. For example, the following commands set the drive mode to active, the drive voltage to 4.5 V, and the input threshold to 1.0 V on bank 2.

```
CONF:DIG:HAND:DRIV ACT, (@1201)
SOUR:DIG:HAND:LEV 4.5, (@1201)
SENS:DIG:HAND:THR 1, (@1202)
```

NOTE	The settings for drive mode, output drive level, and input threshold also apply to the bank's interrupt line.

NOTE	When using external pull-ups in the open collector mode, the outputs will not exceed 5 V.

Synchronous Handshake Mode

In the synchronous handshake mode, a strobe or clock signal is used to transfer data to or from an external device. The strobe line (H1) is an output and is pulsed once for each transfer.

Synchronous Unbuffered Inputs   For synchronous handshake unbuffered inputs the H0 line indicates the direction of the transfer. This line is set high to indicate an input operation. The H0 line will remain in the high state until the 34950A direction is changed. The H1 line is the strobe output line. The H2 line is not used and is set to high impedance.

The timing of the input operation is controlled by the T_{CYCLE} parameter set using the `CONFigure:DIGital:HANDshake:RATE` command. This setting affects strobe width, memory clock rate, as well as the setup and hold times. Alternatively, the reciprocal form of the command `CONFigure:DIGital:HANDshake:CTIMe` can be used to specify the speed in terms of time instead of a rate. T_{CYCLE} begins when the 34950A executes one of the input commands.

The timing should be set such that the device sending the data ensures the data lines are valid prior to T_{SETUP} time. The trailing edge of the strobe line indicates the 34950A will latch the data within the T_{HOLD} time. T_{SETUP} is 90 ns and T_{HOLD} is 0 ns. Since T_{HOLD} = 0 µs, the sending device can use the trailing edge of the strobe to initiate a change in the data lines.

A synchronous unbuffered input is shown in the diagram below (default handshake line polarity).
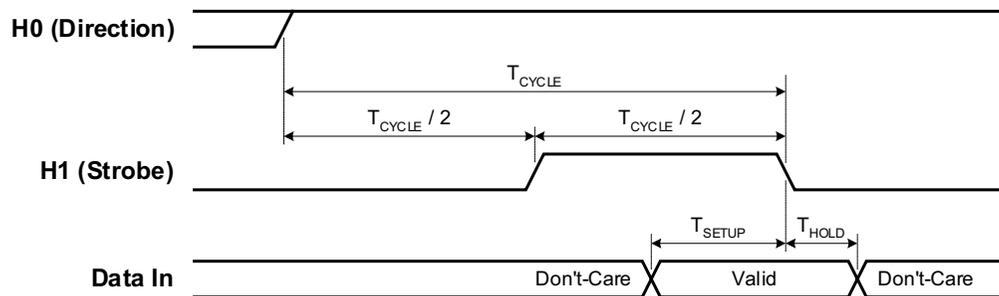
For example, the following SCPI commands set a 34950A in slot 5 to have a 16-bit input using synchronous handshake. Two data inputs are then performed and the strobe line is pulsed for each query. The I/O direction line is set high following the first `SENSe:DIGital:DATA:WORD?` query and remains high until the digital channel is reset or reconfigured.

```
CONF:DIG:WIDT WORD, (@5101)
CONF:DIG:DIR INP, (@5101)
CONF:DIG:HAND SYNC, (@5101)
SENS:DIG:DATA:WORD? (@5101)
SENS:DIG:DATA:WORD? (@5101)
```

Synchronous Unbuffered Outputs   For synchronous handshake unbuffered outputs, the H0 line indicates the direction of the transfer. This line is set low to indicate an output operation. The H0 line will remain in the low state until the 34950A direction is changed. The H1 line is the strobe output line.

When the 34950A executes an output command, it sets the data lines and waits for $T_{CYCLE}/2$ before asserting the strobe line. The leading edge of the strobe indicates the data is valid. The strobe line is asserted for $T_{CYCLE}/2$ and then de-asserted. The H2 line is not used and is set to high impedance.

The timing of the output operation is controlled by the T_{CYCLE} parameter set using the `CONFigure:DIGital:HANDshake:RATE` command. This setting affects strobe width, memory clock rate, as well as the setup and hold times. Alternatively, the reciprocal form of the command `CONFigure:DIGital:HANDshake:CTIMe` can be used to specify the speed in terms of time instead of a rate. The timing should be set such that the device receiving the data can read the data lines during the $T_{CYCLE}/2$ time.

A synchronous unbuffered output is shown in the diagram below (default handshake line polarity).
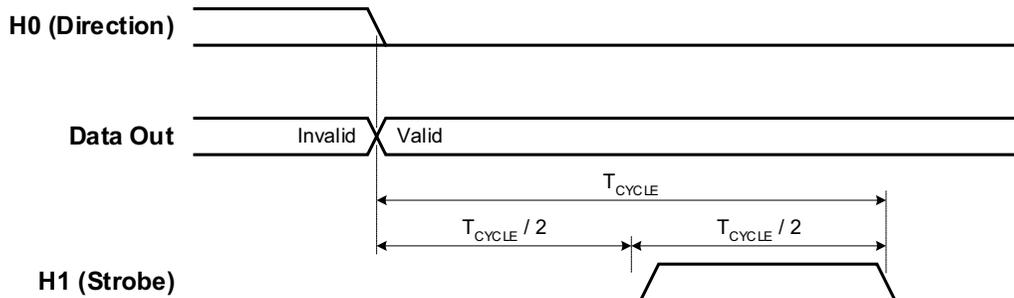
For example, the following SCPI commands set a 34950A in slot 5 to have a 16-bit output using synchronous handshake. Two data outputs are then performed and the strobe line is pulsed for each. The I/O direction line is set low following the first `SOURce:DIGital:DATA:WORD` command and remains low until the digital channel is reset of reconfigured.

```
CONF:DIG:WIDT WORD, (@5101)
CONF:DIG:DIR OUTP, (@5101)
CONF:DIG:HAND SYNC, (@5101)
SOUR:DIG:DATA:WORD #hFFFF, (@5101)
SOUR:DIG:DATA:WORD #h4DB5, (@5101)
```

Synchronous Buffered Inputs You can use synchronous mode handshake with buffered (memory) input operations. (Buffered operations are described in more detail beginning on page 277.) For buffered input operations, the H0 line acts as a start/stop line. This line will be set high when the memory input command is executed and will return low when the memory input operation has completed. The H1 line is not used and is set to high impedance.

An external strobe input on the H2 line controls the pace of memory transfers. The sending device must ensure the data is valid before the T_{SETUP} and stays valid until after T_{HOLD}. T_{SETUP} is 30 ns and T_{HOLD} is 55 ns.

A synchronous buffered input using an external clock is shown in the diagram below (default handshake line polarity).
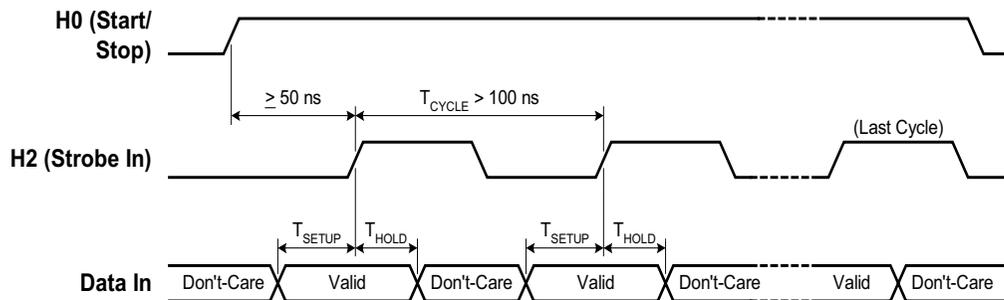
For example, the following SCPI commands set a 34950A in slot 5 to have an 8-bit input using synchronous handshake with an external strobe input. The number of bytes to read into memory is set to infinite (continuous reading into memory until the memory is stopped). The memory is enabled and then triggered. The start/stop line is set high following the first byte handshake and remains high until the last byte is captured.

```
CONF:DIG:WIDT BYTE, (@5101)
CONF:DIG:DIR INP, (@5101)
CONF:DIG:HAND SYNC, (@5101)
SENS:DIG:MEM:SAMP:COUN 0, (@5101)
SENS:DIG:MEM:ENAB ON, (@5101)
SENS:DIG:MEM:STAR (@5101)
```

Synchronous Buffered Outputs   You can use synchronous mode handshake with buffered (memory) output operations. (Buffered operations are described in more detail beginning on page 277.) For buffered output operations, the H0 line acts as a start/stop line. This line will be set high when the memory output command is executed by the 34950A and will return low when the memory output operation has completed.

Synchronous memory output operations can be paced using either the *internal* strobe or an *external* strobe.

When using the *internal* strobe, the H1 line is the strobe output line. The timing of the output operation when using the default `INTernal` clock is controlled by the `CONFigure:DIGital:HANDshake:RATE` command. This setting affects strobe width, memory clock rate, as well as the setup and hold times. Alternatively, the reciprocal form of the command `CONFigure:DIGital:HANDshake:CTIMe` can be used to specify the speed in terms of time instead of a rate. The timing should be set such that the device receiving the data can latch the data lines during the T_{CYCLE} time.

The receiving device should detect the leading edge of the strobe line, wait for the 34950A to set the data (T_{PD}) and then latch the data. Latching the data on the trailing edge of the strobe is recommended, however, you can the data following T_{PD}. T_{PD} ranges from -23 to 23 ns.

A synchronous buffered output using the internal clock is shown in the diagram below (default handshake line polarity).
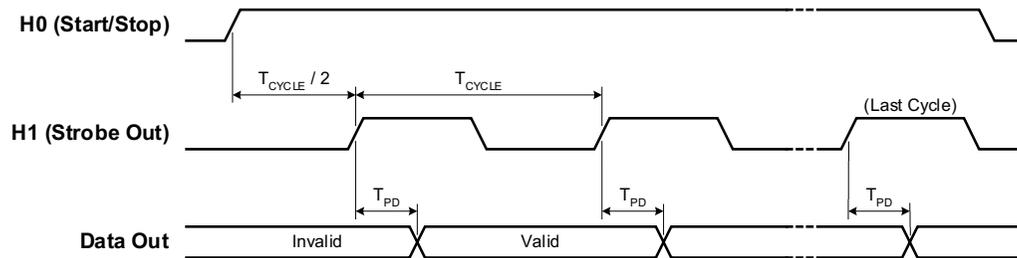
Optionally, you can provide an *external* strobe input on the H2 line to control the memory transfers. If you pace the memory inputs from an external clock, the 34950A will sense the leading edge of the strobe and set the data. The data will be valid after T_{PD} and the receiving device may latch the data. T_{PD} ranges from 140 ns to 60 ns. The maximum T_{PD} of 140 ns limits operation in this mode to 7 MHz.

A synchronous buffered output using an external clock is shown in the diagram below (default handshake line polarity).
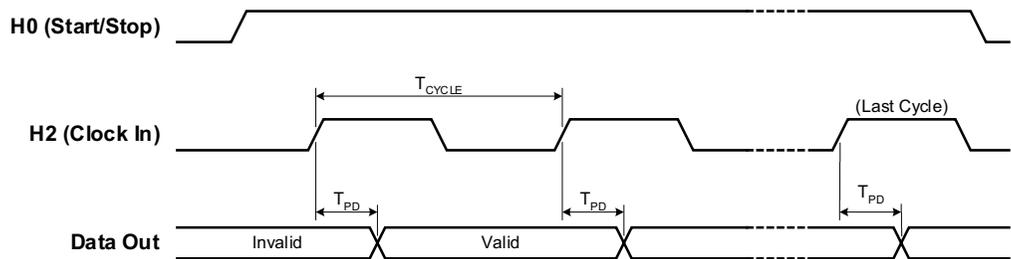
For example, using the *internal* strobe, the following SCPI commands set a 34950A in slot 5 to have a 32-bit output using synchronous handshake. The number of times to output the traces is set to 4. A trace is then loaded into memory and assigned to the channel. The memory is enabled and then triggered. The start/stop line is set high following the first byte handshake and remains high until the last byte is output.

```
CONF:DIG:WIDT LWOR, (@5101)
CONF:DIG:DIR OUTP, (@5101)
CONF:DIG:HAND SYNC, (@5101)
SOUR:DIG:MEM:NCYC 4, (@5101)
TRAC:DATA:DIG:LWOR (@5101), mytrace, #hFFEEFFEE, #hBCBC9999
SOUR:DIG:MEM:TRAC mytrace,(@5101)
SOUR:DIG:MEM:ENAB ON, (@5101)
SOUR:DIG:MEM:STAR (@5101)
```

Using an *external* strobe, the following SCPI commands set a 34950A in slot 5 to have an 8-bit output using synchronous handshake with an external strobe input. The number of times to output the traces is set to infinite (continuous output until the memory is stopped). The memory is enabled and then triggered. The start/stop line is set high following the first byte handshake and remains high until the last byte is output.

```
CONF:DIG:WIDT BYTE, (@5101)
CONF:DIG:DIR OUTP, (@5101)
CONF:DIG:HAND SYNC, (@5101)
CONF:DIG:HAND:SYNC:STR:SOUR EXT, (@5101)
SOUR:DIG:MEM:NCYC 0, (@5101)
TRAC:DATA:DIG:BYTE (@5101), mytrace, 260, 139
SOUR:DIG:MEM:TRAC mytrace,(@5101)
SOUR:DIG:MEM:ENAB ON, (@5101)
SOUR:DIG:MEM:STAR (@5101)
```

Buffered I/O Operations

Each of the two banks on the 34950A has its own memory that can be used to store patterns to output (traces) or to store input patterns. The width of the first channel in each bank controls the width of the memory operations. Memory may be used as:

- 64K x 8 bits
- 64K x 16 bits
- 32K x 32 bits

Buffered (Memory) Output

Each bank on the 34950A has its own memory for use in buffered transfers. Changing a bank from an input to an output will clear all memory for that bank. For buffered outputs, you download "traces" of digital data to the memory. Multiple traces (up to 32) can be downloaded into each bank. A specified trace is then output using the handshaking parameters set.

The general steps to output from memory are:

1 Set the channel width and direction.
2 Set the handshake mode.
3 Set the trigger source.
4 Set the number of times to output the trace.
5 Load the trace(s) into memory.
6 Set which trace to use.
7 Enable the memory.
8 Trigger the output.

Set the channel width and direction.   Use the `SOURce:DIGital:DATA` command to set the channel width and set the channel as an output. Additionally, the data specified in the command will be the initial state of the data lines before the memory operation begins.

Set the handshake mode.   You must use synchronous handshaking mode. You can use either an internal or external strobe (clock) to pace the outputs. Handshaking is described in more detail on page 270.

Set the trigger source.   By default, the trigger source is set to use a software trigger. You can also use one of the interrupt lines (see page page 281) as a trigger source.

Set the number of times to output the trace. Each trace can be output once, multiple times, or infinitely. The SOURce:DIGital:MEMory:NCYCles command sets the number of times to output the trace. If not set to infinite, you can output the trace from 1 to 255 times (the output is controlled by the handshake).

Load the trace(s) into memory. Named traces are downloaded using the TRACe:DATA:DIGital command. The channel width used should match the width of the channel set in step 1. If you change the width of a bank, all traces in memory are cleared. The trace names must start with a character and may be up to 12 characters in length. The trace name used must be unique to the bank. Up to 32 traces may be downloaded (up to the maximum memory).

Traces can be added or deleted only when memory is disabled. Memory output cannot be enabled unless the bank has a trace assigned to it.

For example, the following commands load two traces into memory for bank 1 of a module in slot 1. In this example, each byte of the LWORd to output is sent as a separate byte.

```
TRAC:DATA:DIG:LWOR (@1101), MyTrace1, 255, 200, 128, 0
TRAC:DATA:DIG:LWOR (@1101), MyTrace2, 254, 192, 64, 32
```

You can also send trace data in IEEE-488 block format using this command.

The 34950A also has two special built-in traces for your use. You can generate and download a count-up trace and a walking 1's pattern using the TRACe:DATA:DIGital:FUNCtion command. See the *Programmer's Reference Help file* for more details.

NOTE	You can generate a count-down or walking zero pattern by inverting the data line polarity.

Set which trace to use. The SOURce:DIGital:MEMory:TRACe command assigns the desired trace to the bank. This command allows you to switch between the traces pre-loaded into the bank's memory.

Enable the memory. Enable the memory on the bank using the SOURce:DIGital:MEMory:ENABle command. This command sets the selected trace to be the output and puts the bank in the wait-for-trigger state.

Trigger the output.   When the default trigger source is used, the `SOURce:DIGital:MEMory:STARt` command triggers the output. The selected trace will be output when the handshake occurs.

If the trigger source has been set to one of the interrupt lines (see page), the output will wait for the interrupt to occur and then the handshake to occur before the trace is output.

You can also output the trace one sample at a time on the data lines using the `SOURce:DIGital:MEMory:STEP` command. This command outputs one sample and then puts the memory in the stopped state. The STEP command also overrides the interrupt line so it can be used to trigger a transfer even if the interrupt line is set to be the trigger source.

Deleting Traces

You can delete traces in memory to recover the memory space. Use the `TRACe:DELete:NAME` command to delete a specific trace. Note that deleting a specific trace does not de-fragment the memory. You can delete all traces using the `TRACe:DELete:ALL` command.

Buffered (Memory) Input

Each bank on the 34950A has its own memory for use in buffered transfers. Changing a bank from an output to an input will clear all memory for that bank. The general steps to use input memory are:

1 Set the channel width and parameters.
2 Set the handshake mode.
3 Set the number of samples to collect.
4 Start the capture.
5 Check the status of the transfer.
6 Retrieve the captured data.

Set the channel width and direction.   Use the `CONFigure:DIGital` command to set the channel width, direction, thresholds, and polarity. See for basic input operations.

Set the handshake mode.   You must use synchronous handshaking mode. Handshaking is described in more detail on .

Set the number of samples to collect. The `SENSe:DIGital:MEMory:SAMPle:COUNt` command sets the number of samples to capture. If you set the number of counts to infinite (0 = default), the bank will capture data until a STOP is received. Older samples are overwritten if memory gets full. Allowed sample counts depend upon the channel width as follows:

- BYTE (8-bit) 1 to 65535
- WORD (16-bit) 1 to 65535
- LWORd (32-bit) 1 to 32767

Start the capture. The `SENSe:DIGital:MEMory:STARt` command sets the channel to begin the data capture. The capture begins when the handshake occurs.

Check the status of the transfer. You can use the `SENSe:DIGital:MEMory:DATA:POINts?` query to return the number of samples currently in memory.

Retrieve the captured data. Set the desired memory retrieval format using the `SENSe:DIGital:DATA:FORMat` command. You can set the memory to be read as either `LIST` or `BLOCk`. The `LIST` parameter (default) returns the data as comma separated ASCII values. `BLOCk` returns the data in IEEE-488 block format.

Before you can read the data in memory, you must stop the memory operations using the `SENSe:DIGital:MEMory:ENABle OFF` command.

Read all the captured data using the `SENSe:DIGital:MEMory:DATA:ALL?` query. This performs a non-destructive read of all data in the bank's memory.

To read specific captures, use the `SENSe:DIGital:MEMory:DATA?` form of the command. This command takes *index* and *count* parameters to specify which data to retrieve. The oldest data in memory has an *index* of '0'. The *count* specifies the number of samples to read. *count* + *index* must be less than the number of captured points.

Both these data reads are non-destructive to the bank memory. To clear the memory for new data, send the `SENSe:DIGital:MEMory:CLEar` command.

Interrupt Lines

Each bank has an interrupt line that can be used with memory input or output operations. When a bank is set to input data, the interrupt line is an output. When a bank is set to output data, the interrupt line is set to be an input. You can set the polarity of the interrupt line for input and output operations using the `CONFigure:DIGital:INTerrupt:POLarity` command.

You can configure the interrupt line drive mode, output drive level, and input threshold. These parameters are set for both the handshake lines and interrupt line on a bank. See for details about setting these parameters.

Memory Output Operations

For memory output operations, the interrupt line is sensed and can be used to start or stop memory output operations. This provides a hardware means to control the data output.

The `SOURce:DIGital:INTerrupt:MODE` command sets how the bank will behave when using memory output. The mode can be set to one of three values:

- `STARt`: The memory output will begin on the rising edge of the interrupt line.
- `STOP`: The memory output is halted on the rising edge of the interrupt line.
- `GATE`: The interrupt line acts a a gate for the memory output. The bank can output when the interrupt line is asserted, and will stop when the interrupt line is de-asserted.

When you have set the polarity and mode, enable the interrupt using the `SOURce:DIGital:INTerrupt:ENABle` command.

Memory Input Operations

For memory input operations, the interrupt line is an output and is set on a pattern match or when the memory has been filled. You can set the interrupt line to be driven or open collector using the `SENSe:DIGital:HANDshake:DRIVe` command.

> **NOTE** The settings for drive mode, output drive level, and input threshold also apply to the bank's handshake lines.

When set to `ACTive` the interrupt line will be driven by the module. The high output voltage is set for both the handshaking and interrupt line on a bank with the `SOURce:DIGital:HANDshake:LEVel` command.

When set to `OCOLlector` the interrupt line will be driven low, but will go to high impedance mode when in the 'High' state. The open collector mode requires external pull-ups.

The `SENSe:DIGital:INTerrupt:MODE` command sets the condition that will cause the interrupt to be asserted. When set to `MFULl` the interrupt is given when the memory is full. When set to `COMPare` the interrupt is asserted when the pattern is detected (see page). When either condition is removed, the interrupt is de-asserted.

The interrupt line is enabled by the `SENSe:DIGital:INTerrupt:ENABle` command and the status can be checked using the SCPI Status System (refer to the *Programmer's Reference Help file*).

Byte Ordering

When using buffered memory operations, the width of the data sets how the memory data is interpreted. Changing the width of the first channel in a bank invalidates any traces stored or captured.

Output Operations   For output operations (see), traces are put into memory using the `TRACe:DATA:DIGital` command.

For output operations, the data stored in memory is output as follows:

- `BYTE` output - first byte in memory on the first handshake, next byte in memory on the second handshake, and so on.
- `WORD` output - first and second byte in memory on the first handshake, next two bytes in memory on the second handshake, and so on.
- `LWORd` output - first four bytes in memory on the first handshake, next four bytes in memory on the second handshake, and so on.

Note that for `WORD` outputs the first byte in memory is considered the most significant byte and is output on the upper bits (8 through 15). For `LWORd` outputs the first byte is output on bits 24 through 31.

You can change the byte order reported using the `FORMat:BORDer` command. This command allows you to swap the most-significant and least-significant byte ordering for all data transfer operations. The command is applied globally and cannot be assigned to an individual slot or channel.

Input Operations   For input operations (see page [page 279](#)), bytes are read into memory as follows:

- `BYTE` input - the first byte in memory was read on the first handshake, the next byte in memory was read on the second handshake, and so on.

- `WORD` input - first and second byte in memory were read on the first handshake, next two bytes in memory were read on the second handshake, and so on.

- `LWORd` input - first four bytes in memory were read on the first handshake, next four bytes in memory were read on the second handshake, and so on.

Note that for `WORD` inputs the first byte in memory is considered the most significant byte and was read on the upper bits (8 through 15). For `LWORd` inputs the first byte was read on bits 24 through 31.

Pattern Matching

Pattern matching can be used on input channels only. Pattern matching can be done with or without handshaking. When a pattern match occurs, the 34950A can set an interrupt line or system alarm. A pattern match can also be used to start or stop a buffered (memory) transfer.

Pattern matching is done on a per bank basis and always starts at the first channel of a bank and works up to encompass the configured width of the channel.

Patterns are set up and enabled using the `CALCulate` subsystem of SCPI commands. For example, the following commands set up a pattern match (#HF00F) and assert the interrupt line when the input pattern is equal to the match pattern.

```
CONF:DIG:WIDT WORD, (@1101)
CALC:COMP:DATA #HF00F, (@1101)
CALC:COMP:TYPE EQUAL, (@1101)
SENS:DIG:INT:MODE COMP, (@1101)
SENS:DIG:INT:ENAB ON, (@1101)
CALC:COMP:STAT ON, (@1101)
```

Once the pattern matching state is turned on, the 34950A polls for the pattern #HF00F to appear on the data lines of channel 101. The interrupt line will be asserted when the pattern is matched. In the example above the last command, `CALCulate:COMPare:STATe`, also sets the mainframe alarm on a pattern match.

You can use pattern matching to start or stop a buffered (memory) input transfer. When the desired pattern is found, the 34950A can be set to start or stop a capture.

For example, the following commands establish a byte pattern match on channels 101 and 201. When the pattern is found, 200 samples are captured.

```
CONF:DIG:WIDTH BYTE,(@3101,3201)
CALC:COMP:DATA:BYTE 140,(@3101,3201)
CALC:COMP:STAT ON,(@3101,3201)
DIG:MEM:SAMP:COUN 200,(@3101,3201)
DIG:MEM:COMP:ACT STAR,(@3101,3201)
DIG:MEM:ENAB ON,(@3101,3201)
```

Counter

The 34950A has two 10 MHz frequency counter/totalizer measurement input channels. The counters can operate in two general modes: *Totalizer* mode, and *Initiated Measurement* mode. In the totalizer mode, the counter acts as a basic totalizer. In the initiated measurement mode, the counter can make frequency, period, duty cycle, and pulse width measurements.

Totalizer Mode

Totalizer mode is the default operating mode for the counters. When the counter is configured for TOTalizer mode, it automatically starts running. The totalized count can be read, reset, scanned, and monitored.

The simplest way to take a totalizer measurement is to use the MEASure form of the command. For example, the following command configures the totalizer on the first bank, initiates the measurement, and returns the result. The data is returned in a floating point format.

MEAS:COUN:TOT? READ, (@1301)

You can also reset the totalizer count by setting the parameter to RRESet. For example, the following command configures the totalizer on the first bank, initiates the measurement, and returns the result. The totalize count is reset when the data is read.

MEAS:COUN:TOT? RRES, (@1301)

Totalizer counts begin as soon as the channel is configured for the totalize measurement. You can stop a count by sending SENSe:COUNter:ABORt command and restart the count using the SENSe:COUNter:INITiate command.

The slope of the edges being counted can be configured using the SENSe:COUNter:SLOPe command. By default, when started, the totalizer counts rising edges.

Additionally, you can control when the edges are counted by setting the gate source to external and providing a gate signal on the gate input. In external gate mode the counter totalizes when the gate is asserted. The gate time setting controls how long the counter totalizes. Once the external gate has been de-asserted a new measurement must be armed via the SENSe:COUNter:INITiate command. The figure below shows an externally gated totalizer measurement. The number of totalized counts is '5' in this particular example.
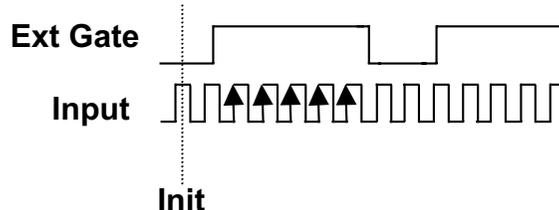
Initiated Measurement Mode

Measurements such as frequency, period, duty cycle, and pulse width require an initiate command and a gate. The `SENSe:COUNter:INITiate` command is used to initiate (arm) the measurement. The measurement is gated by either an internal (default) or the external gate source. For measurements the external gate acts like an external trigger which triggers the internal gate timer.

The gate source is set using the `SENSe:COUNter:SOURce` command. The default gate source is `INTernal`. The gate is the aperture over which the signal data is gathered. When the gate is internal, the measurement begins as soon as the `INITiate` command is received.

Since the measurements are all derived from the same basic measurement, you can retrieve the measured frequency, period, duty-cycle, and pulse width from the same initiated and gated measurement. For example, the following commands set the counter to measure the input signal for 1 ms using the internal gate. The frequency, period, duty cycle, and pulse width are returned as floating point numbers.

```
CONF:COUN:FREQ 1e-3, (@1301)
SENS:COUN:INIT (@1301)
SENS:COUN:FREQ? (@1301)
SENS:COUN:PER? (@1301)
SENS:COUN:PWID? (@1301)
SENS:COUN:DCYC? (@1301)
```

The `CONFigure:COUNter:FREQuency` command parameter sets the internal gate time (to 1e-3 or 1 ms in the above example). You can also set the gate time using the `SENSe:COUNter:GATE:TIME` command.

Clock

The general-purpose clock output is derived from the internal time base. The output clock is divided down from the time base clock such that:

Clock Output (Hz) = (time base frequency)/(divisor)

The time base frequency is 40 MHz. The divisor can be an integer from 2 to 4^6 providing a range of 20 MHz to 10 Hz for the clock output. The valid values for the clock output rate are: 20 MHz, 13.33 MHz, 10 MHz, 8 MHz, 6.667 MHz, ... 10Hz. The clock output frequency will round to the nearest achievable frequency.

The commands used to control the clock output are:

```
SOUR:MOD:CLOC:FREQ {<freq>|MIN|MAX|DEF},<slot>
SOUR:MOD:CLOC {OFF|ON|0|1},<slot>
```

You can obtain the rounded value of the currently set clock frequency using the following query.

```
SOUR:MOD:CLOC:FREQ?
```

You can also set the logic "1" voltage level for external clock output. For example, the following command sets the output clock level to 4.5 V for the module in slot 5.

```
SOUR:MOD:CLOC:LEV 4.5, 5
```

34950A D-Sub Connectors

The 34950A uses two D-sub 78-pin female connectors. Each connector provides contains one bank of the module. As viewed from the rear panel, the connectors and their banks are shown below.

P1 (Bank 1)   P2 (Bank 2)
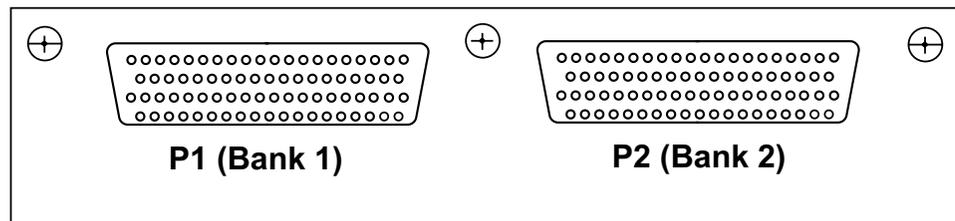
As viewed from the rear panel, the pins in each connector are numbered as shown below.
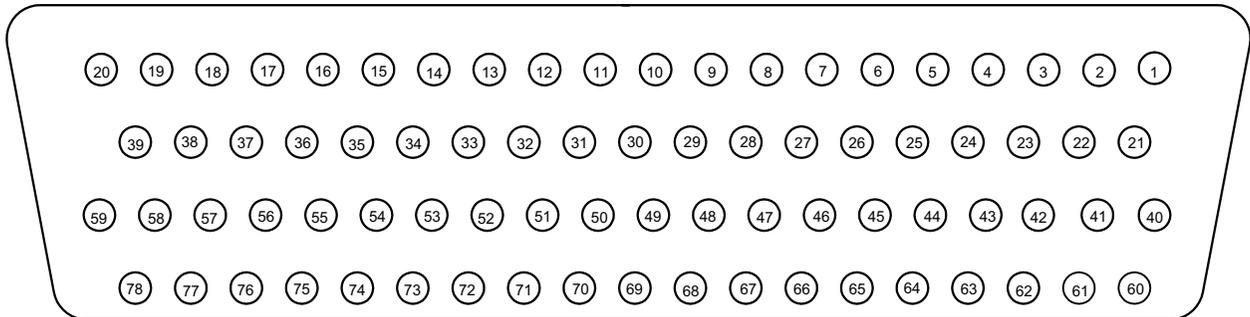
P1 (Bank 1) Connector Pin Assignments

Pin	Signal		Pin	Signal		Pin	Signal		Pin	Signal	
1	GND	CH301	21	GND	CH104	40	18	CH103	60	8	CH102
2	CNTR		22	27		41	GND		61	GND	
3	GND		23	GND		42	17		62	NC	
4	GATE		24	26		43	GND		63	GND	CH101
5	GND		25	GND		44	16		64	7	
6	INTR		26	25		45	GND		65	GND	
7	GND		27	GND		46	15		66	6	
8	H2		28	24		47	GND	CH102	67	GND	
9	GND		29	GND	CH103	48	14		68	5	
10	H1		30	23		49	GND		69	GND	
11	GND		31	GND		50	13		70	4	
12	H0		32	22		51	GND		71	GND	
13	GND	CH104	33	GND		52	12		72	3	
14	31		34	21		53	GND		73	GND	
15	GND		35	GND		54	11		74	2	
16	30		36	20		55	GND		75	GND	
17	GND		37	GND		56	10		76	1	
18	29		38	19		57	GND		77	GND	
19	GND		39	GND		58	9		78	0	
20	28					59	GND				

P2 (Bank 2) Connector Pin Assignments

Pin	Signal	CH	Pin	Signal	CH	Pin	Signal	CH	Pin	Signal	CH
1	GND	CH302	21	GND	CH204	40	18	CH203	60	8	CH202
2	CNTR		22	27		41	GND		61	GND	
3	GND		23	GND		42	17		62	CLK	
4	GATE		24	26		43	GND		63	GND	
5	GND		25	GND		44	16		64	7	CH201
6	INTR		26	25		45	GND		65	GND	
7	GND		27	GND		46	15		66	6	
8	H2		28	24		47	GND	CH202	67	GND	
9	GND		29	GND	CH203	48	14		68	5	
10	H1		30	23		49	GND		69	GND	
11	GND		31	GND		50	13		70	4	
12	H0		32	22		51	GND		71	GND	
13	GND	CH304	33	GND		52	12		72	3	
14	31		34	21		53	GND		73	GND	
15	GND		35	GND		54	11		74	2	
16	30		36	20		55	GND		75	GND	
17	GND		37	GND		56	10		76	1	
18	29		38	19		57	GND		77	GND	
19	GND		39	GND		58	9		78	0	
20	28					59	GND				

34950T Terminal Block

The optional 34950T terminal block has screw type connections and the terminal are labeled with the channel and bit information. The 34980A Product Reference CD (shipped with the instrument) contains a 34950T Wiring Log for you to document your wiring configuration for this module. You can open the wiring log file in Microsoft® Excel® or Adobe® Acrobat® format.
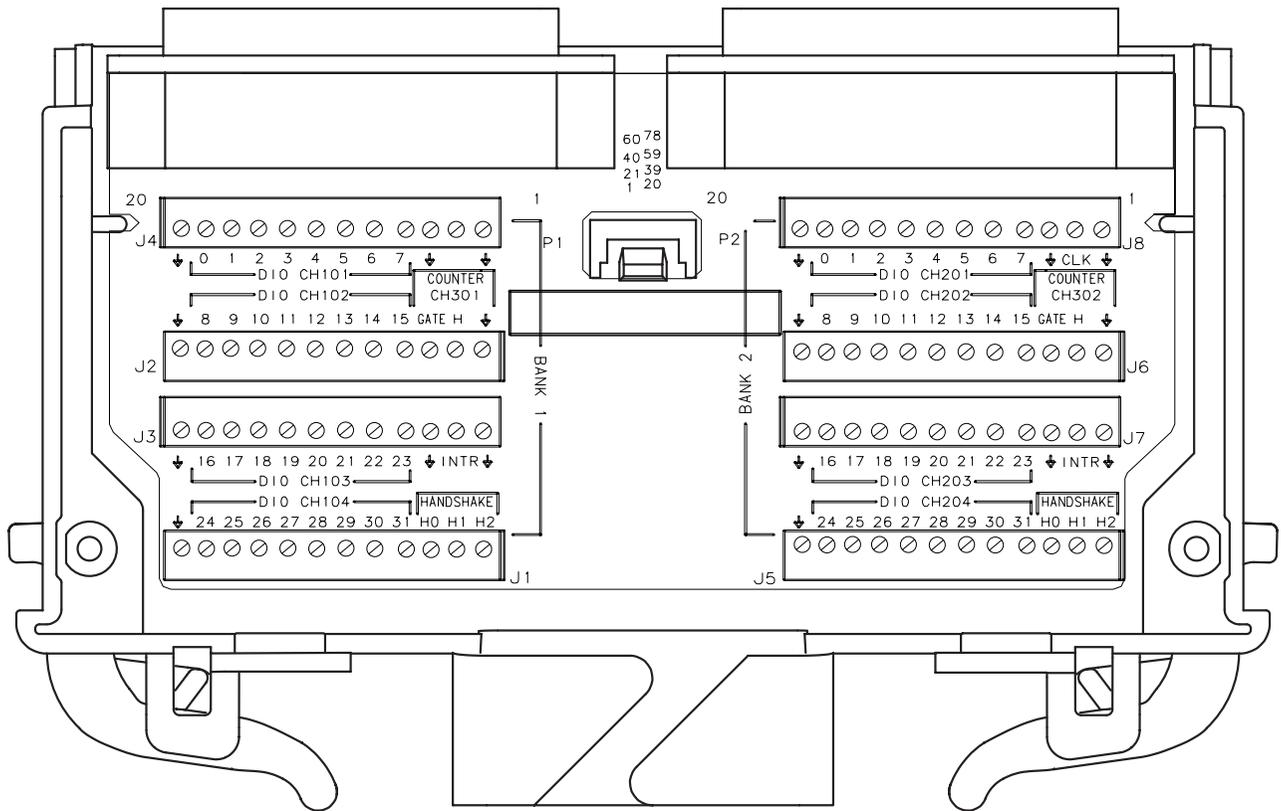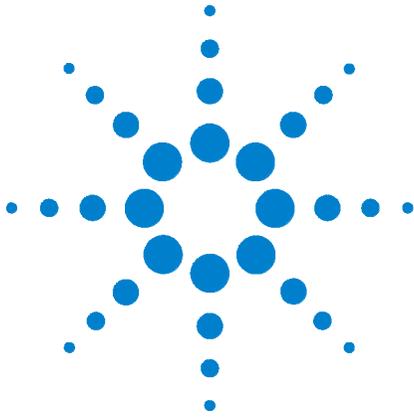
11

4-Channel Isolated D/A Converter with Waveform Memory Module

Agilent Technologies

34951A 4-Channel Isolated D/A Converter with Waveform Memory Module

The 34951A 4- Ch Isolated D/A module (DAC module) has four independent, isolated DAC channels that output DC voltage up to ±16V or DC current up to ±20 mA. Since the DACs are electrically isolated, you can stack or combine multiple DACs to have up to ±64 V on a module. You can control each channel manually, or use the onboard memory to store multiple sequenced points.

Level Output Mode

The module can generate voltages between - 16 V DC and +16 V DC at 500 μV resolution on any or all four channels. Each channel configured for voltage output has hardware remote- sensing capability to ensure that an accurate voltage is present at the load. With the remote sensing feature, the DAC channel outputs an additional voltage to compensate for the voltage drop in the test leads. Thus, using the sense connections, the load voltage equals the programmed voltage as long as the resistance in each sense lead is less than 2.5Ω and the maximum voltage drop in the output leads is 0.5 volts.

NOTE	To ensure that an accurate voltage is present at the loads, it is recommended that you use remote-sensing. However, if remote-sensing is not used, do not connect loads or cables to the remote-sensing terminals (H Sense and L Sense).

When using the remote- sensing feature, connect sense wires from the load to the High Sense and Low Sense terminals for the desired channels.

Each channel can also generate current between - 20 mA and +20 mA at 630 nA resolution. When outputting current the High Sense and Low Sense terminals are not used and are opened. For protection, each channel incorporates a fuse that will open at greater than 20 mA. If an overload condition exists, the fuse will open, but no error or SRQ will be generated. To reset the fuse, remove the overload and wait a few minutes for the fuse to cool.

Waveform (Trace) Mode

Using the internal waveform point storage, you can output provided sine, square, or ramp and triangle wave shapes, or define your own wave shape with up to 512,000 points. The module can output points with a settling time of 40 μs and a 200 kHz point- to- point update rate.

The on-board memory provides storage for you to create up to 32 voltage or current waveforms. You can apply a different waveform to each channel to output. Or you can apply the same waveform to more than one channel. For each channel you can designate the gain, frequency, and/or offset for its output.

The waveforms are stored in volatile memory. Therefore, whenever power to the 34980A is cycled, the volatile memory empties of data it has contained.

The waveform feature of the 34951A is not intended as a full-featured substitute for a function generator, but as a means of storing point-to-point updates.

Clock In

You can configure each DAC channel on the module to synchronize off either an internally-generated 20 MHz clock or the positive edge of an external user-supplied clock.

An external clock must be less than 10 MHz or indeterminate behavior will result. Additionally, as the maximum point-to-point update rate of the DACs is 200 kHz, if you configure a DAC to run off an external clock, you will need to ensure that the correct clock divisor is also configured for that DAC. For example, if you supply a 10 MHz external clock, the minimum clock divisor is 50 because the maximum update rate is 200 kHz. If a clock divisor less than the minimum is configured, indeterminate behavior will results. Thresholds for the Clock In are 5 V TTL tolerant.

Clock Out

There is one clock output on the DAC module, which you can configure to output at frequencies up to 10 MHz. Since it uses a 16-bit clock divisor, the available output frequencies range in steps of 20 MHz/2^{16} with a minimum output frequency of 305 Hz. The output impedance of the Clock Out is 50 Ω.

NOTE	The line between external Clock Out and external Clock In is shared. You can use the external Clock Out to provide the external Clock In signal. However, both a user-supplied external clock and the module's Clock Out cannot drive the line at the same time.

Trigger In

You can configure each DAC on the module to trigger off an externally provide Trigger In that has a pulse width greater than 100 ns. The Trigger In line is 5V TTL tolerant.

Trigger Out

The DAC module can source a TTL level Trigger Out. Trigger Out has a pulse width between 5 and 10 μs.

NOTE The line between external Trigger Out and external Trigger In is shared. You can use the external Trigger Out to provide the external Trigger In signal. However, both a user-supplied external trigger and the 34951A Trigger Out cannot drive the line at the same time.

Auto-Calibration

The 34951A features auto-calibration (auto-cal). Upon receipt of the `CALibration:MODule?` command, you can adjust all four channels of the DAC module. The adjustments, performed under complete control of the 34980A, require approximately one minute per module.

WARNING Because the auto-cal uses the internal DMM, do not route signals on ABus1 when performing an auto-cal of a DAC module. Do not apply a signal to ABus1 via the Analog Bus connector on the rear of the mainframe (pins 4, 5, and 9). The auto-cal will abort if a signal is detected on ABus1.

Before performing an auto calibration, be sure to allow a one-hour warm-up of the DMM and 34951A module. The adjustment is valid for 90 days for temperatures within $5\ ^{\circ}\text{C}$ of the auto-cal temperature. For the calibration constants to be saved, calibration security must be off. Otherwise, the new calibration constants can be used while power is on. But when power is lost, the DAC module will revert to using the previously stored calibration constants. For SCPI programming examples for the auto-cal, refer to .

34951A SCPI Programming Examples

The programming examples below provide you with SCPI command examples to use for actions specific to the DAC module.

The slot and channel addressing scheme used in these examples follow the form **sccc** where **s** is the mainframe slot number (1 through 8) and **ccc** is the three-digit channel number. Valid channels for this module are 1-4. For information on specific configurations, refer to the simplified schematic on .

For complete information on the SCPI commands used to program the 34980A, refer to the Agilent 34980A Programmer's Reference contained on the 34980A Product Reference CD. For example programs, also refer to the 34980A Product Reference CD.

Level Mode

Example: Outputting a DC voltage level   This command sets the output voltage level for the specified DAC channels. After setting the desired level, send the `OUTPut:STATe` command to close the corresponding output relay and enable outputs from the specified channels. The following command outputs +2.5 V DC on DAC channels 1 and 2 for a module in slot 4.

```
SOURce:VOLTage 2.5,(@4001,4002)
OUTPut:STATe ON,(@4001,4002)
```

Example: Outputting a current level   This command sets the output current level on the specified channels on the DAC module. After setting the desired level, send the `OUTPut:STATe` command to close the corresponding output relay and enable outputs from the specified channels. The following command outputs +5 mA on DAC channels 1 and 2 for a module in slot 4 and closes the output relay.

```
SOURce:CURRent 5E-3,(@4001,4002)
OUTPut:STATe ON,(@4001,4002)
```

Waveform Mode

Example: Downloading a waveform to memory and outputting waveform from DACs   The following command segment downloads a 1000-point sine waveform to memory on the module in slot 4 and outputs the waveform from DAC channels 1 and 2. The trace name is `"TEST_SINE"`.

```
TRACe:FUNCtion 4,SINusoid, TEST_SINE, 1000
SOURce:FUNCtion:TRACe TEST_SINE,(@4001,4002)
OUTPut:STATe ON,(@4001,4002)
SOURe:FUNCtion:ENABle ON,(@4001,4002)
```

Example: Downloading trace points to memory and outputting waveform from DACs

The following command segment downloads seven trace points to memory on the module in slot 4 and output the waveform from DAC channels 1 and 2. The trace name is "NEG_RAMP".

```
TRACe:DATA 4,NEG_RAMP, 1, .67, .33, 0, -.33, -.67, -1
SOURce:FUNCtion:TRACe NEG_RAMP,(@4001,4002)
OUTPut:STATe ON,(@4001,4002)
SOURe:FUNCtion:ENABle ON,(@4001,4002)
```

Example: Setting the amplitude of a waveform for offset and gain

The following commands set the offset to 5.25 and the gain to 1.5 on DAC channels 1 and 2 of a module in slot 4.

```
SOURce:FUNCtion:VOLTage:OFFSet 5.25,(@4001,4002)
SOURce:FUNCtion:VOLTage:GAIN 1.5,(@4001,4002)
```

Example: Setting cycle count for a waveform
The following command segments turn off the trace output mode on DAC channels 1 and 2 in slot 4, set the cycle count to 100, then turn the trace output mode back on.

```
SOURce:FUNCtion:ENABle OFF,(@4001,4002)
SOURce:FUNCtion:TRACe:NCYCles 100,(@4001,4002)
SOURce:FUNCtion:ENABle ON,(@4001,4002)
```

Example: Deleting a waveform
The following command deletes the trace named "TEST_WFORM" from the module in slot 4.

```
TRACe:DELete 4,TEST_WFORM
```

External Clock

Example: Selecting an external clock source and setting a clock divisor
The first command selects the external clock source on DAC channels 1 and 2 in slot 4. The external clock input is shared between these two channels. The second command sets the clock divisor to 100 on the same DAC channels (the external clock input signal is divided by 100).

```
SOURce:FUNCtion:CLOCk:SOURce EXTernal,(@4001,4002)
SOURce:FUNCtion:CLOCk:EXTernal:DIVisor 100,(@4001,4002)
```

Example: Outputting a clock
The following commands set the clock output frequency for slot 4 to 5 kHz and enable the output.

```
SOURce:MODule:CLOCK:FREQuency 5E+3,4
SOURce:MODule:CLOCK:STATE ON,4
```

External Trigger

Example: Selecting the external trigger source and issuing trigger source   The following command segment enables the trigger output mode on a DAC module installed in slot 4, then enables the external trigger source on DAC channels 1 and 2. The last command issues an external trigger pulse from the module.

```
SOURce:MODule:TRIGger:OUTPut ON,4
SOURce:FUNCtion:TRIGger:SOURce EXTernal,(@4001,4002)
SOURce:MODule:TRIGger:EXTernal:IMMediate 4
```

Auto Calibration

Example: Performing an auto calibration on all DAC channels   This command performs an auto-cal of all four channels on a DAC module. Because the auto-cal takes can take up to one minute per DAC channel, you may want to increase the time-out value of your programming application prior to sending this command.

The following command performs an auto-cal of a DAC module in slot 5 and returns a pass/fail indication.

```
CALibration:MODule? 5
```

The following command performs an auto-cal of all 34951A DAC modules in a mainframe.

```
CALibration:MODule? ALL
```

Example: Effects of using the secure state command on storing calibration constants   The following command removes instrument security, and the calibration constants are stored in non-volatile memory if sent before the `CALibration:MODule?` command.

```
CALibration:SECure:STATe OFF <security code>
```

If the instrument is secured at the time of auto-cal, the calibration constants are stored in volatile memory and are lost when power is turned off. The `*RST` command will not discard the calibration constants. The command to secure the instrument is:

```
CALibration:SECure:STATe ON <security code>
```

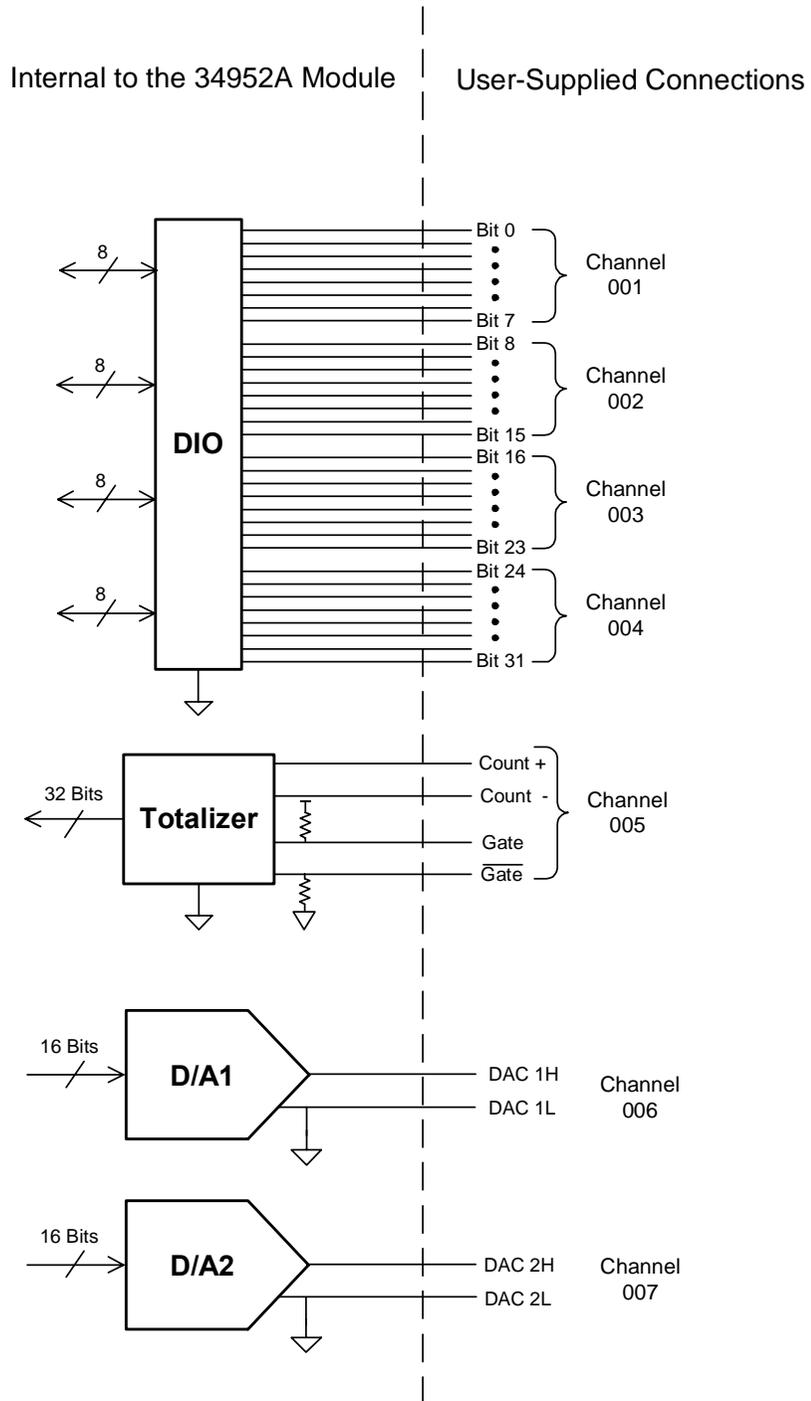| **NOTE**	The default security code is AT34980.

Configuring a DAC Module

Example: Querying the system for module identify (all modules) The following command returns the identify of the module installed in slot 7.

```
SYSTem:CTYPe? 7
```

Example: Resetting the module(s) to power-on state The following command resets a module in slot 4 to its power-on state.

```
SYST:CPON 4
```

| **NOTE** | Using this command will erase any downloaded waveforms. |

34951A Simplified Block Diagrams

The following diagram shows how the module is generally configured.
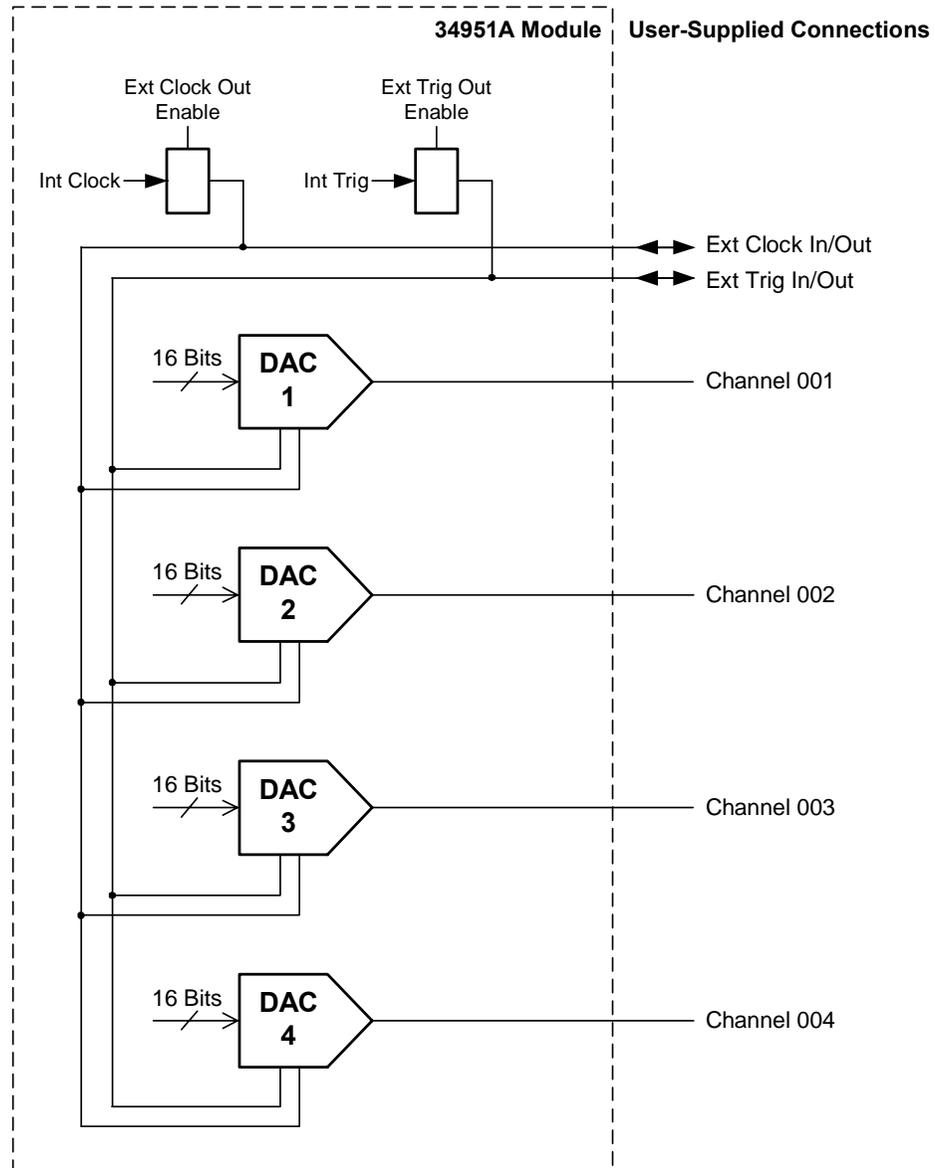
For more detail on the internal configuration of each DAC channel, see the next page.

The following diagram shows individual DAC channel configuration. All channels are configured the same.
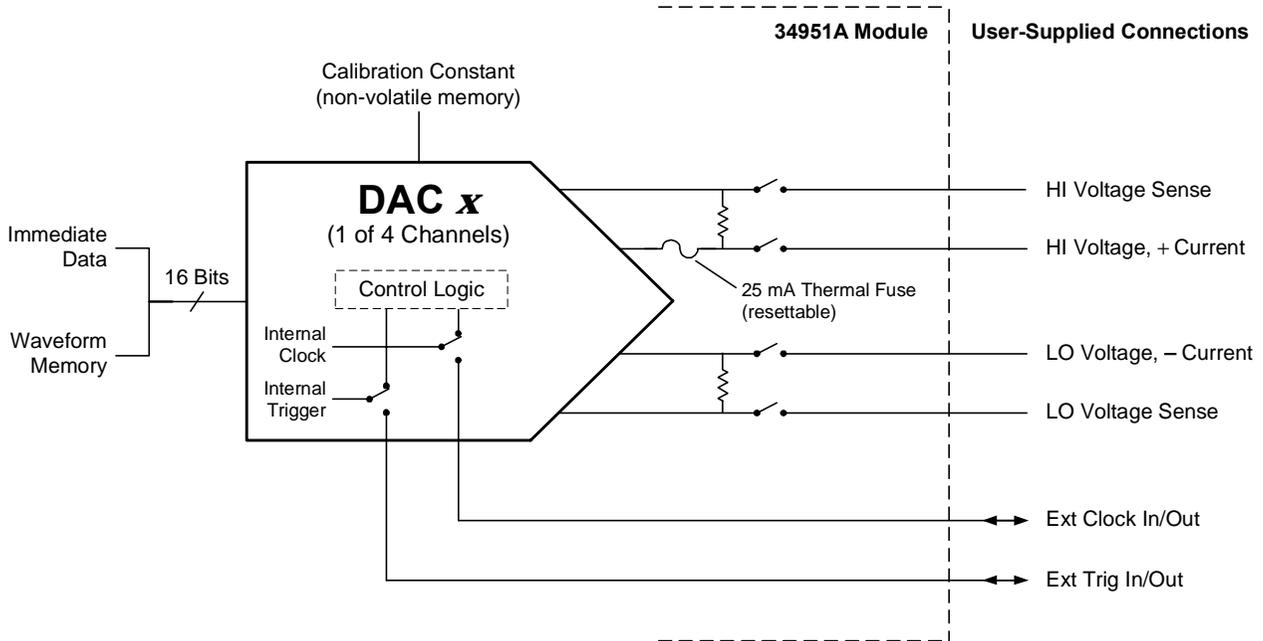
34951A D-Sub Connector Pinout
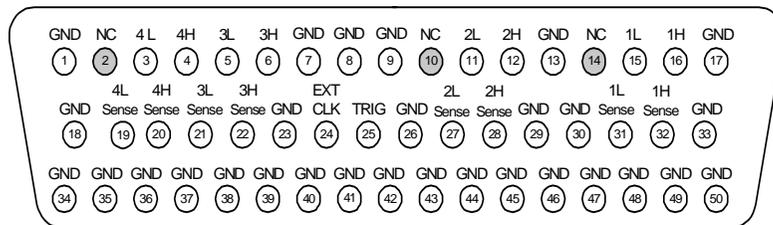
50-Pin D-Sub
Female Connector

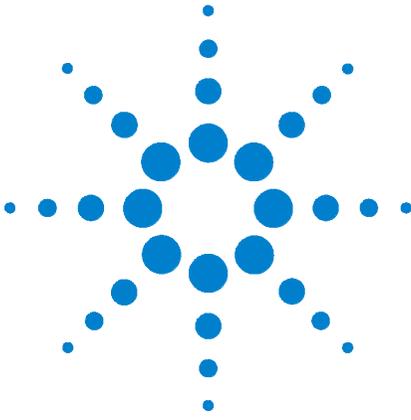| Description	Socket	Description	Socket	Description	Socket	Description	Socket	Description	Socket
1L	15	3L Sense	21	GND	8	GND	34	GND	44
1H	16	3H Sense	22	GND	9	GND	35	GND	45
1L Sense	31	4L	3	GND	13	GND	36	GND	46
1H Sense	32	4H	4	GND	17	GND	37	GND	47
2L	11	4L Sense	19	GND	18	GND	38	GND	48
2H	12	4H Sense	20	GND	23	GND	39	GND	49
2L Sense	27	External Clock	24	GND	26	GND	40	GND	50
2H Sense	28	Trigger	25	GND	29	GND	41	No Connect	2
3L	5	GND	1	GND	30	GND	42	No Connect	10
3H	6	GND	7	GND	33	GND	43	No Connect	14

34951T Terminal Block

Each terminal block is labeled with the model number and the abbreviated module name. In addition, space is available on the label for you to write the slot number.

The 34980A Product Reference CD (shipped with the instrument) contains a 34951T Wiring Log for you to document your wiring configuration for this module. You can open the wiring log file in Microsoft® Excel® or Adobe® Acrobat® format.

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Multifunction Module with DIO, D/A, and Totalizer

Agilent Technologies
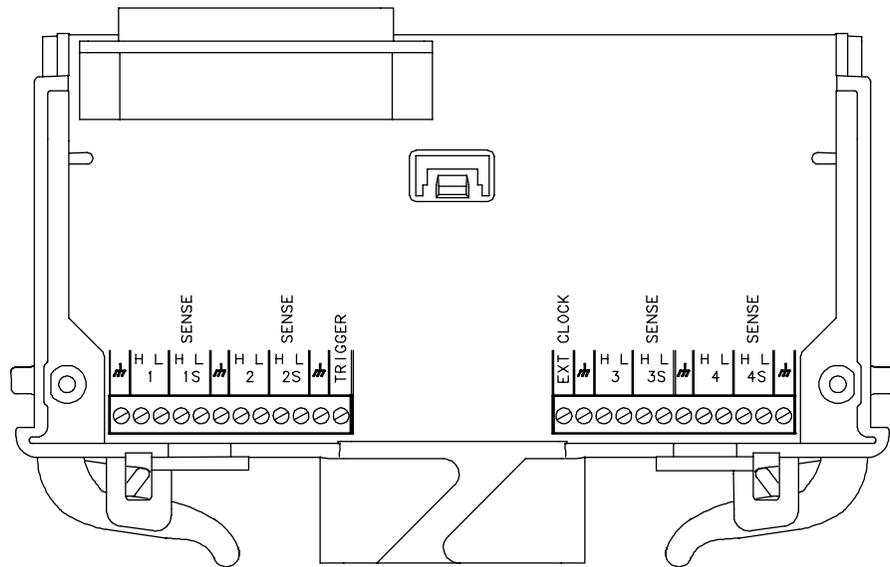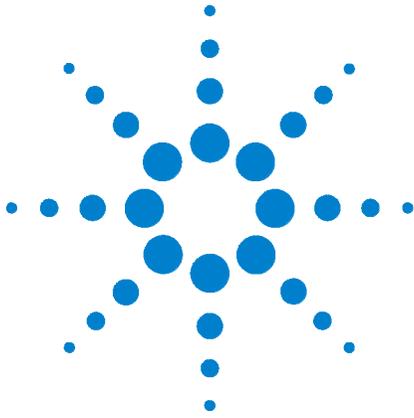
34952A Multifunction Module

The 34952A Multifunction Module with DIO, D/A, and Totalizer combines four 8-bit ports of digital input/output, a 100 kHz totalizer, and two ±12 volt earth-referenced analog outputs. You can include digital inputs and totalizer input in a scan list. You can make connections via standard 50-pin D-sub cables or the optional 34952T terminal block.

Digital Input/Output

The Digital Input/Output (DIO) consists of four 8-bit ports with TTL-compatible inputs and output. The open-drain outputs can sink up to 400 mA. From the front panel, you can read data from only one 8-bit input port at a time. You can configure the DIO ports for 8, 16, or 32-bit operations. The DIO channels are connected by internal 5 V pull-up resistors when configured as inputs.

Totalizer Input

The 32-bit totalizer can count pulses at a 100 kHz rate. You can configure the totalizer to count on the rising edge or falling edge of the input signal. A TTL high signal applied to the Gate terminal enables counting and a low signal disables counting. A TTL low signal applied to the Not-Gate terminal enables counting and a high signal disables counting. The totalizer counts only when both terminals are enabled.

NOTE	When a gate is not connected, the gate terminal is pulled to the enabled state, effectively creating a "gate always" condition.

Analog Output (DAC)

The two analog outputs are capable of outputting voltages between ±12 volts with 16 bits of resolution. Each DAC channel is capable of 10 mA maximum current. Use the two analog outputs to source bias voltages to your DUT, to control your analog programmable power supplies, or as set points for your control systems. The outputs are programmed directly in volts.

34952A SCPI Programming Examples

The programming examples below provide you with SCPI command examples to use for actions specific to the general purpose switch modules.

The slot and channel addressing scheme used in these examples follow the form **sccc** where **s** is the mainframe slot number (1 through 8) and **ccc** is the channel number. For information on specific configurations, refer to the simplified schematic on .

For complete information on the SCPI commands used to program the 34980A, refer to the Agilent 34980A Programmer's Reference contained on the 34980A Product Reference CD. For example programs, also refer to the 34980A Product Reference CD.

Digital Input/Output

Example: Configuring a DIO channel   The following program segment configures channel 1 on the DAC module in slot 3 as an output and then reads the output value (the channel is not reconfigured as an input). Then, the channel is reconfigured as an input and the value is read again.

The second command below returns 64 as it is physically reading the output data.

```
SOURce:DIGital:DATA:BYTE 64,(@3001)
SENSe:DIGital:DATA:BIT? 0,(@3001)
```

The second command below returns whatever is being input externally.

```
CONFigure:DIGital:STATe INPut,(@3001)
SENSe:DIGital:DATA:BIT? 0,(@3001)
```

Totalizer

Example: Reading totalizer channel count   The following command reads the count on totalizer channel 5 on the Multifunction module in slot 3.

```
SENSe:TOTalize:DATA? (@3005)
```

Example: Configuring the totalizer reset mode   To configure the totalizer reset mode, send either of the following commands.

The following command configures totalizer channel 5 on the Multifunction module in slot 3 to be read without resetting its count.

```
SENSe:TOTalize:TYPE READ,(@3005)
```

The following command configures totalizer channel 5 on the Multifunction module in slot 2 to be reset to "0" after it is read (RRESet means "read and reset").

```
CONFigure:TOTalize RRES,(@2005)
```

Example: Configuring the totalizer for count   This command configures the totalizer to count on the rising edge (positive) or falling edge (negative) of the input signal. The following command configures the totalizer (channel 5) on a Multifunction module in slot 3 to count on the negative edge (falling) of the input signal.

```
TOTalize:SLOPe NEGative,(@3005)
```

Example: Clearing count on the totalizer channel   This command immediately clears the count on the specified totalizer channels. The following command clears the count on the totalizer (channel 5) on a Multifunction module in slot 3.

```
TOTalize:CLEAR:IMMediate (@3005)
```

DAC Output

Example: Setting output voltage   This command sets the output voltage level for the specified DAC channels. The following command outputs +2.5 V DC on DAC channels (6 and 7) of a Multifunction module in slot 4.

```
SOURce:VOLTage 2.5,(@4006,4007)
```

Configuring a Multifunction Module

Example: Querying the system for module identify   The following command returns the identify of the module installed in slot 7.

```
SYSTem:CTYPe? 7
```

Example: Resetting module(s) to power-on state   The following command resets a module in slot 4 to its power-on state.

```
SYSTem:CPON 4
```

34952A Simplified Block Diagram
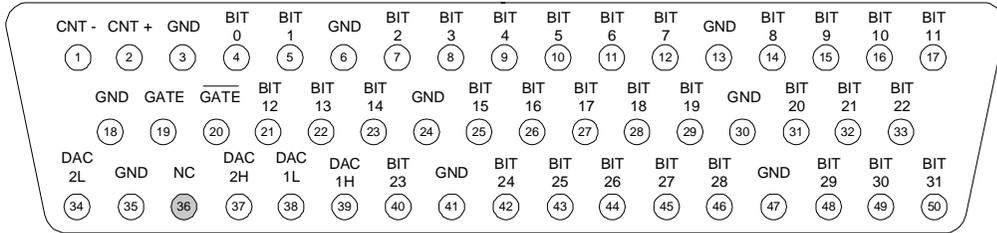
Internal to the 34952A Module | User-Supplied Connections

34952A D-Sub Connector

50-Pin D-Sub
Female Connector

Description		Socket	Description		Socket	Description		Socket	Description	Socket
Channel 1	Bit 0	4	Channel 3	Bit 16	26	Channel 5 Totalizer	Count -	1	GND	47
	Bit 1	5		Bit 17	27		Count +	2	No Connect	36
	Bit 2	7		Bit 18	28		Gate	19		
	Bit 3	8		Bit 19	29		Not-Gate	20		
	Bit 4	9		Bit 20	31	Channel 6	DAC 1L	38		
	Bit 5	10		Bit 21	32		DAC 1H	39		
	Bit 6	11		Bit 22	33	Channel 7	DAC 2L	34		
	Bit 7	12		Bit 23	40		DAC 2H	37		
Channel 2	Bit 8	14	Channel 4	Bit 24	42		GND	3		
	Bit 9	15		Bit 25	43		GND	6		
	Bit 10	16		Bit 26	44		GND	13		
	Bit 11	17		Bit 27	45		GND	18		
	Bit 12	21		Bit 28	46		GND	24		
	Bit 13	22		Bit 29	48		GND	30		
	Bit 14	23		Bit 30	49		GND	35		
	Bit 15	25		Bit 31	50		GND	41		

34952T Terminal Block

Each terminal block is labeled with the model number and the abbreviated module name. In addition, space is available on the label for you to write the slot number.

The 34980A Product Reference CD (shipped with the instrument) contains a 34952T Wiring Log for you to document your wiring configuration for this module. You can open the wiring log file in Microsoft® Excel® or Adobe® Acrobat® format.

The 34952T provides space for breadboard and for a connector to control an external Opto-22 standard board.

Breadboard

Breadboard

Space and wiring provided for
user-supplied Opto-22 connector

13
Breadboard Module

34959A Breadboard Module Description

The 34959A Breadboard Module provides a 137mm x 190mm x 23mm (5.4" x 7.5" x 0.9") space inside the 34980A Multifunction Switch/Measure Unit, for you to install custom circuitry to support applications not available on the standard plug-in modules.

This module minimizes the need for customer-supplied circuitry by providing +5V and +12V power supplies for logic and relay drive use, 16 general purpose digital I/O bit lines with control lines, and 32 relay drive lines. Your custom circuitry can access the 34980A mainframe's internal DMM and four Analog Buses. Desired measurement and I/O functions can be programmed using standard read/write commands.

Internally, most of the customer-provided circuitry connects to the module through two ribbon cables; the Analog Bus connections are made by hard-soldering to a grid of holes provided on the Agilent-supplied PC board. Two external ports are provided for Dsub connectors (DB50 or DB78) between the module and your field wiring.

The sheet metal base of the module provides fifteen countersunk holes for flexible mounting of circuit boards, terminal blocks or other components.

As with all other plug-in modules for the 34980A, cooling is provided within the mainframe chassis.

34959A Breadboard Simplified Block Diagram
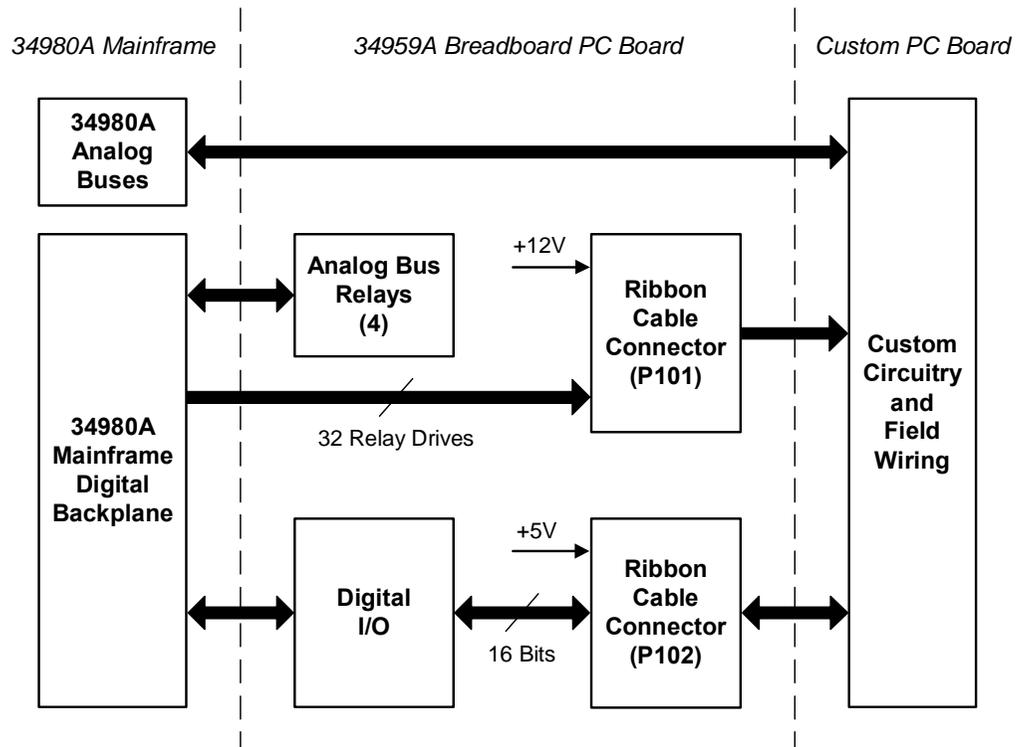
34959A Breadboard Module Disassembly

The module as shipped as shown below. The port covers must be removed if DB50/78 connectors will be installed for external connections; otherwise they can remain in place. The top cover provides mechanical integrity and shielding for the module, and should be attached except when the module is being configured. To unfasten the top cover, remove the screw with a Torx T10 driver, slide the cover back 5mm as shown, and lift the cover up. Reverse this procedure to replace the cover.

34959A Breadboard Module as Shipped

The Agilent-supplied PC board must be removed if you are making connections to the Analog Buses, in order to solder the necessary relays (not provided) and lead wires. To remove this PC board, remove the Torx T10 screw shown, slide the cover back 5mm to clear the two retaining tabs, and lift the board up. Reverse this procedure to reinstall the board.

Removal of the Agilent-Supplied PC Board
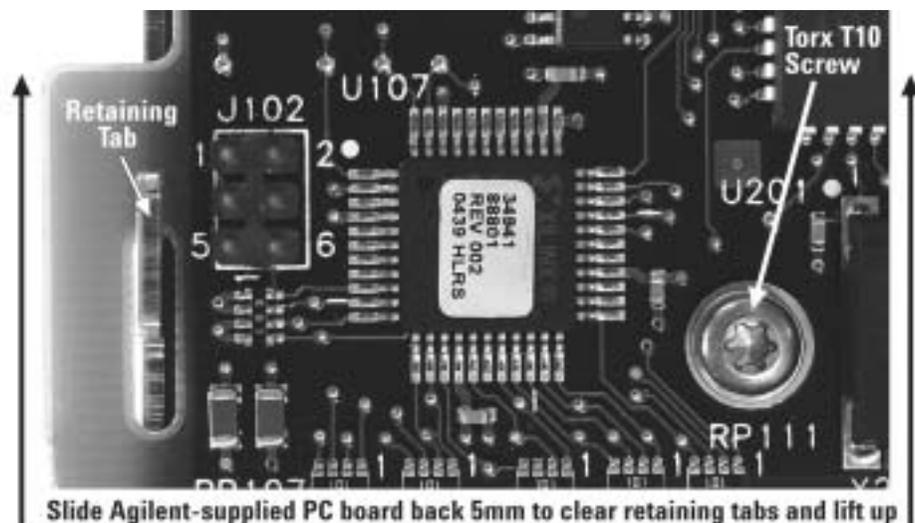
34959A Breadboard Module Layout (shown with cover removed)
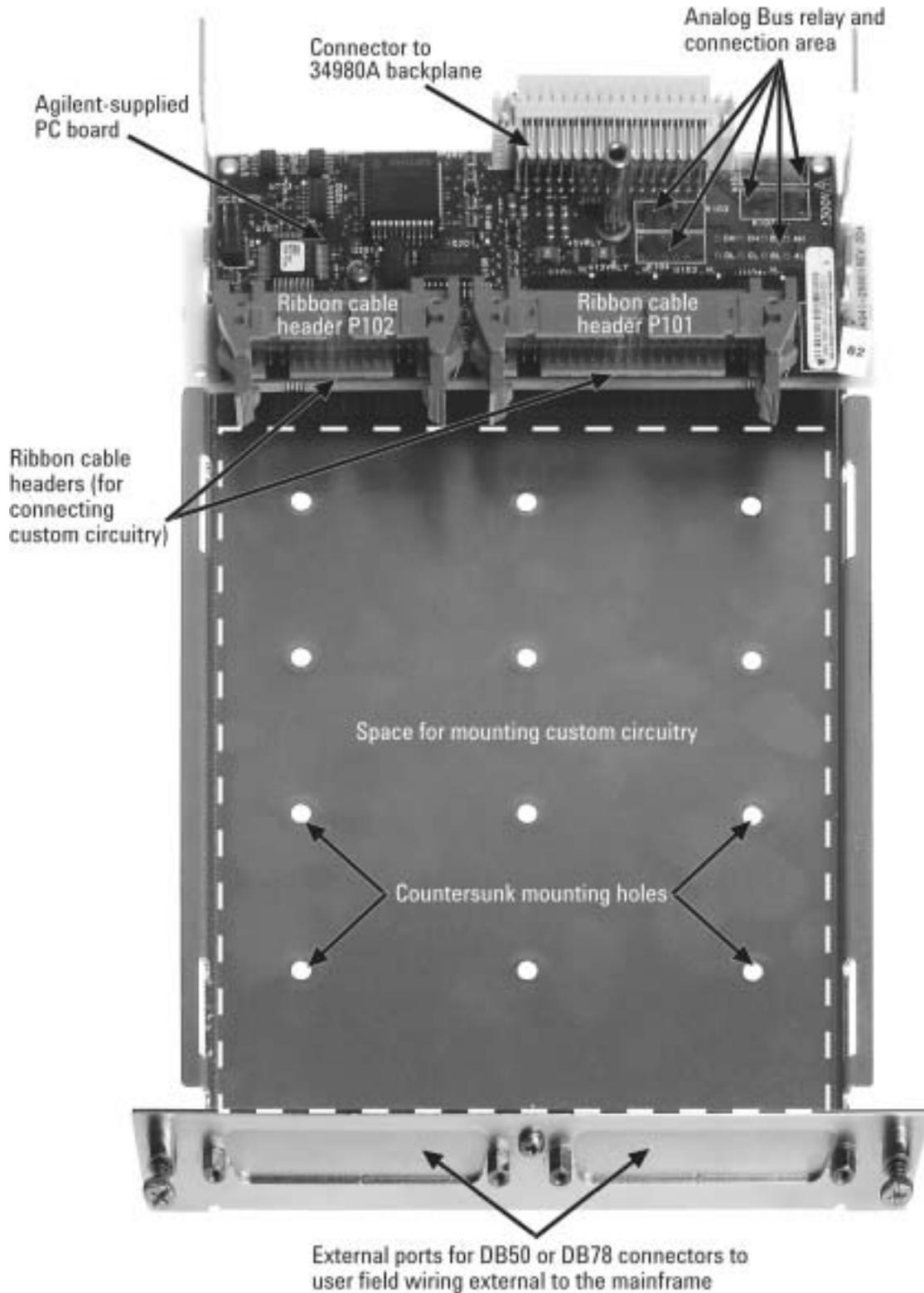
Ribbon Cable Header Pin Assignment Information

The 34959A breadboard is supplied with two ribbon cable headers, which may be used to access 5V and 12V power, open/close four Analog Bus channels, open/close up to 28 customer-supplied general-purpose relays, and utilize two 8-bit banks of digital I/O. The supplied cable headers (3M Pak 100 series), recommended connectors and their respective pin assignments are shown below. *Pay careful attention to the polarization notches (indexing keys) on the connectors and headers, to correctly identify Pin #1.*

Supplied 26-Pin Ribbon Cable Header P102 (3M part #3429-5602)

26-pin 0.1″ Ribbon Cable Connector (typical keyed connector)

-Pin numbers are shown from side facing header P102-
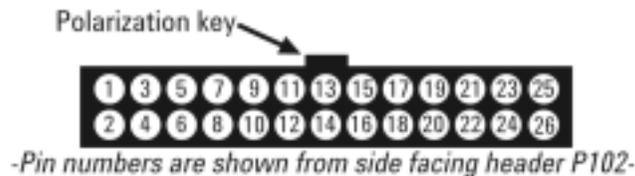
Pin Connection Information for 26-Pin Ribbon Cable Header P102

1	Relay Ground	14	Digital Channel 001; Bit 5
2	Digital Channel 002; Bit 7	15	Digital Channel 001; Bit 4
3	Digital Channel 002; Bit 6	16	+5V power supply
4	Digital Channel 002; Bit 5	17	Digital Channel 001; Bit 3
5	Digital Channel 002; Bit 4	18	Digital Channel 001; Bit 2
6	+5V power supply	19	Digital Channel 001; Bit 1
7	Digital Channel 002; Bit 3	20	Digital Channel 001; Bit 0
8	Digital Channel 002; Bit 2	21	Relay Ground
9	Digital Channel 002; Bit 1	22	Control Line 1: Channel 1 Strobe Line
10	Digital Channel 002; Bit 0	23	Control Line 2: Channel 2 Strobe Line
11	Relay Ground	24	Control Line 3: Read/Write Status Line
12	Digital Channel 001; Bit 7	25	+5V power supply
13	Digital Channel 001; Bit 6	26	Relay Ground

Supplied 40-Pin Ribbon Cable Header P101 (3M part #3432-5602)
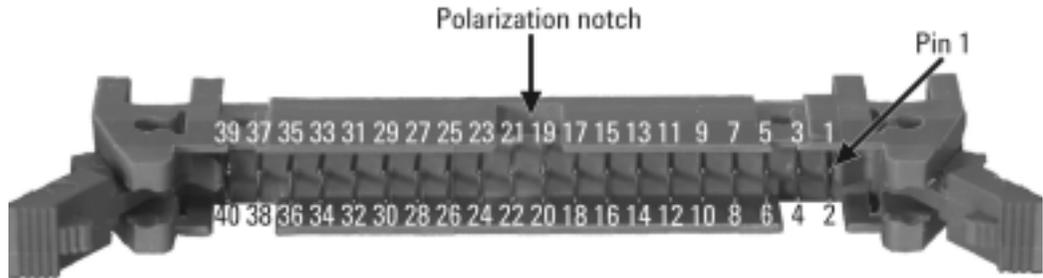
40-pin 0.1″ Ribbon Cable Connector (typical keyed connector)
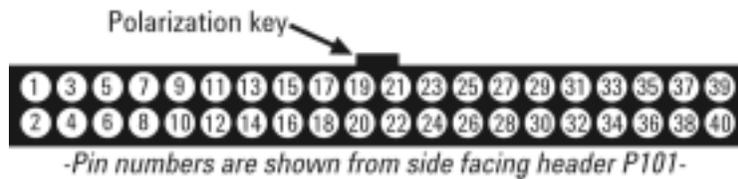
Pin Connection Information for 40-Pin Ribbon Cable Header P101

1	Channel 914 (dual-purpose relay drive*)	21	+12V power supply
2	Channel 913 (dual-purpose relay drive*)	22	reserved - do not connect to this pin
3	Channel 912 (dual-purpose relay drive*)	23	reserved - do not connect to this pin
4	Channel 911 (dual-purpose relay drive*)	24	reserved - do not connect to this pin
5	Channel 128 (gen. purpose relay drive)	25	Channel 116 (gen. purpose relay drive)
6	Channel 127 (gen. purpose relay drive)	26	Channel 115 (gen. purpose relay drive)
7	Channel 126 (gen. purpose relay drive)	27	Channel 114 (gen. purpose relay drive)
8	Channel 125 (gen. purpose relay drive)	28	Channel 113 (gen. purpose relay drive)
9	Channel 124 (gen. purpose relay drive)	29	Channel 112 (gen. purpose relay drive)
10	Channel 123 (gen. purpose relay drive)	30	Channel 111 (gen. purpose relay drive)
11	Channel 122 (gen. purpose relay drive)	31	Channel 110 (gen. purpose relay drive)
12	Channel 121 (gen. purpose relay drive)	32	Channel 109 (gen. purpose relay drive)
13	Channel 120 (gen. purpose relay drive)	33	Channel 108 (gen. purpose relay drive)
14	Channel 119 (gen. purpose relay drive)	34	Channel 107 (gen. purpose relay drive)
15	Channel 118 (gen. purpose relay drive)	35	Channel 105 (gen. purpose relay drive)
16	Channel 117 (gen. purpose relay drive)	36	Channel 106 (gen. purpose relay drive)
17	reserved - do not connect to this pin	37	Channel 104 (gen. purpose relay drive)
18	reserved - do not connect to this pin	38	Channel 103 (gen. purpose relay drive)
19	reserved - do not connect to this pin	39	Channel 102 (gen. purpose relay drive)
20	+12V power supply	40	Channel 101 (gen. purpose relay drive)

CAUTION   *If Analog Bus relays K101-K104 are installed, channels 911-914 are dedicated to Analog Buses 1-4 and equipment damage may result from making connections to pins 1 through 4 of P101. Otherwise, channels 911-914 and pins 1-4 may be used as four additional general purpose relay drive lines.

Configuring the 34959A Breadboard Module

<table>
<tr><td>**WARNING**</td><td>SHOCK HAZARD   Only qualified personnel who are aware of the hazards involved should install, remove or configure the 34959A breadboard for the 34980A mainframe. Before touching any installed accessory, turn off all power to the mainframe and terminal blocks, and to all external devices connected to the mainframe or terminal blocks.</td></tr>
</table>

Accessing the 34980A Mainframe's Analog Bus

If your custom circuitry will need access to the four Analog Buses on the mainframe's backplane, you must install relays (not provided) on and make connections directly to the Agilent-supplied PC board (see the explanation on page 313 for PC board removal, and the table on page 318 for connection information). The following enlargement of the Analog Bus control area of the board shows where to install the relays and make wire connections:

Analog Bus Relay Installation and Solder Hole Locations
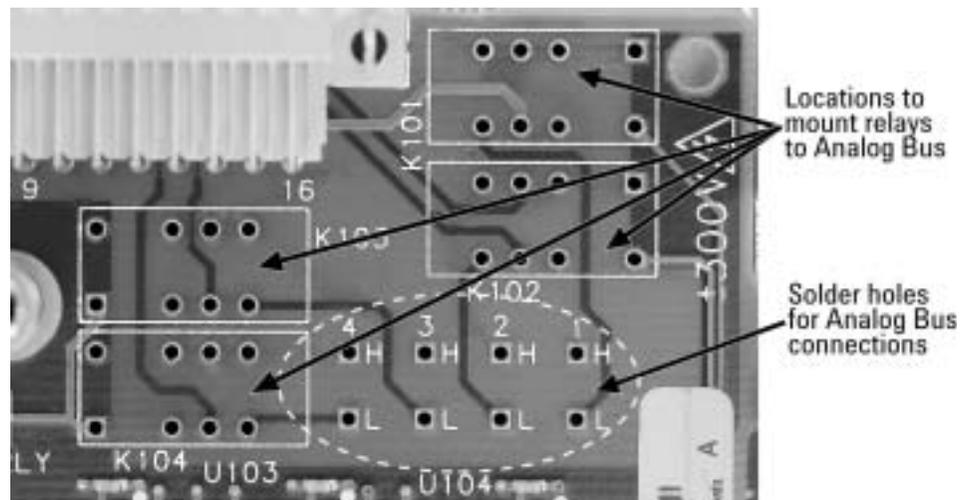
The locations for relays K101-104 are marked on the board. You may install any or all of these relays, as needed. The suggested supplier for these relays is:

Vendor: Omron Electronics LLC
Part Number: G6S-2-DC12 (qty 4)
Description: RELAY 2C 12VDC-COIL 2A 250VDC
Vendor Address: 55 East Commerce Drive, Schaumberg, Illinois 60173-5302 U.S.A.

<table>
<tr><td>**CAUTION**</td><td>When soldering relays to the Agilent-supplied PC board, take special care to avoid shorts between pins. Shorting these connections may result in damage to the breadboard module, the 34980A mainframe, other installed modules, or your test circuitry.</td></tr>
</table>

The connections from the Analog Bus outputs (8 holes marked on the Agilent-supplied PC board as 1 through 4, H and L) to your custom circuitry should be made with wire insulated for 300V service.

CAUTION	When soldering wire to the Analog Bus connection holes, take special care to avoid shorts between wires and/or holes. Shorting these connections may result in damage to the breadboard module, the 34980A mainframe, other installed modules, or your test circuitry.

The following table shows which relays must be installed to control the four Analog Bus channels, and which holes on the Agilent-supplied PC board (see the photo on for the locations to solder each two-wire output connection):

34959A Breadboard: Connections to the 34980A Analog Buses

Relay #	Analog Bus Channel	Bus #	Connect to Hole on PC Board
K101	911	1	1H and 1L
K102	912	2	2H and 2L
K103	913	3	3H and 3L
K104	914	4	4H and 4L

WARNING	SHOCK HAZARD If *any* of the relays K101-K104 are installed on the 34959A module's Agilent-supplied PC board *and* connections are made to the Analog Bus output area, hazardous voltages (up to 300V) may be present on the customer's installed circuit board or attached test circuitry.

CAUTION	The 34980A mainframe may provide significant current (up to 5A) to the breadboard before current limits within the mainframe or the Agilent-supplied PC board activate. Use adequate current limiting devices (power supply fuses rated at 0.5A are recommended) to protect the hardware installed on your custom circuit board.

Installing Custom Circuitry on the 34959A Breadboard Module

Connection to the Ribbon Cable Headers

The two supplied headers P101 and P102 have ejecting latches and polarization notches. Although individual crimp terminals can be used to connect to the header pins, the most secure connection will be achieved by using keyed ribbon cable connectors. The selection of ribbon connectors is left to the user. However, if you desire to hard-solder connections to your custom PC board, the following diagram and connector part numbers are offered as a suggestion:

Connection from Headers P101 and P102 to a Custom PC Board
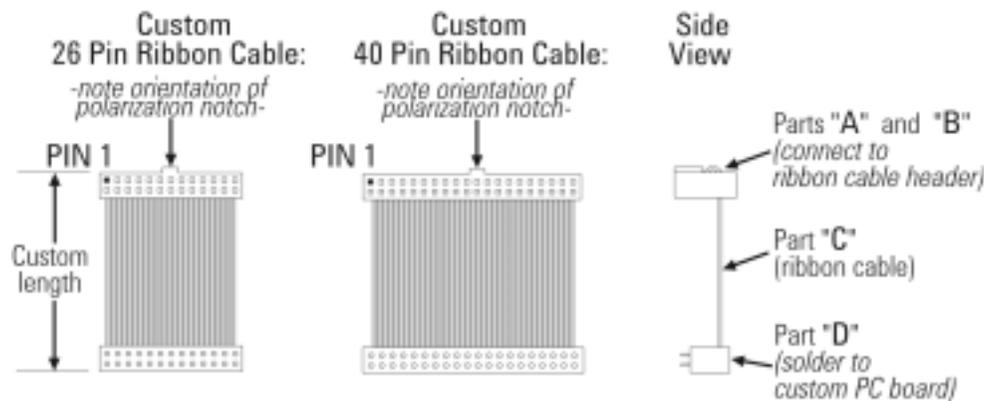
Suggested Part Numbers for Ribbon Cable Connections Shown above

Part	Description	AMP Part Number	3M Part Number
	for connection to 26-pin header		
A	26-pin wire-mount socket	746288-6	3399-xxxx
B	26-pin strain relief	499252-3	3448-3026
C	26-conductor ribbon cable	971111-3	
D	PC-board mount	2-216093-6	
	for connection to 40-pin header		
A	40-pin wire-mount socket	746288-9	3417-xxxx
B	40-pin strain relief	499252-1	3448-3040
C	40-conductor ribbon cable	971111-5	
D	PC-board mount	4-216093-0	

The suggested suppliers for these cables and connectors are:

Vendor: 3M Corporation
Vendor Address: 6801 River Place Boulevard, Austin, TX 78726 U.S.A.

Vendor: AMP
Vendor Address: Harrisburg, PA 17105 U.S.A.

Installing a Custom PC Board

The remaining space in the breadboard module is available for installing custom circuitry. Fifteen 3.18 mm (0.125") diameter holes, countersunk on the bottom of the sheet metal base, are provided for mounting the PC board to the base. The maximum allowable height of the board and attached components above the base, including spacers, is 23 mm. Assuming a PC board thickness of 1.6 mm, you should use 5.1 mm long spacers and M3x0.5mm thread flathead screws. The figure on page 323 provides the dimensions of the largest PC board which will fit the breadboard module, the locations of the countersunk mounting holes, and their location relative to the ribbon cable headers and Dsub ports.

If you utilize a PC board with the maximum allowable dimensions, it may be necessary to first remove the Agilent-supplied PC board (34980A backplane interface with ribbon cable headers), install the custom board by inserting the Dsub connectors into the ports provided, secure the custom board, and then reinstall the Agilent-supplied PC board. When the module assembly is complete, replace the sheet metal cover and install the module in an available slot within the 34980A mainframe.

Extending the Breadboard Connections During Development

During development of your custom circuitry, you may need to work with your PC board on a test bench, outside the confines of the breadboard module. This should be done by using ribbon cable extenders and extra length of Analog Bus connection wire. Once your final PC board configuration is achieved, these leads should be shortened to allow fixed installation of the PC board inside the module.

CAUTION	Use of the Y1132A Service Extender from the 34980A mainframe to the breadboard module is not recommended, because the Service Extender is not rated for the 300V potentials available on the breadboard's Analog Bus connectors.

Spacing and Insulation Requirements for High Voltage Applications

If your planned use of the 34959A breadboard module will involve the application of high voltages ($\}$ 30V$_{rms}$ AC or $\}$ 60V DC), refer to appropriate electrical standards for high-voltage circuit spacing and wire insulation requirements.

Operating Considerations

Electrical Specifications

The specifications below were derived from the individual components used to provide the relay drive and digital I/O functions:

Electrical Specifications for the 34959A Breadboard Module

Specification	Test Conditions	Minimum	Typical	Maximum
Total Power Consumption (by customer-installed circuits)	all connections total			6W
Connector P101 (Relay Drive)				
Current Limit (per relay drive pin)	all outputs driven simultaneously			150 mA
On Resistance (to chassis)	@ 100 mA output		4.2W	5.7W
	@ 400 mA output		6.5W	8.0W
Input Voltage				42V
Leakage Current	@ max. input voltage			8 3A
Connector P102 (Digital I/O)				
High level input voltage		2V		5.5V
Low level input voltage		0V		0.8V
High level output voltage	@ 4 mA output	2.4V		
	@ 500 3A output	3.0V		
Low level output voltage	@ 8 mA output			0.4V

Environmental Voltage Limits

See "Module Considerations" on page 116 for detailed environmental operating conditions for the 34980A mainframe and its installed modules. That guidance sets a maximum voltage rating for the Analog Buses of 300V in pollution degree 1 (dry) conditions, and derates the maximum voltage to 100V for pollution degree 2 (possible condensation) conditions. This guidance applies to any circuitry installed in the 34959A module.

Module Cooling

The maximum recommended power consumption/dissipation for the breadboard module and its installed circuitry is 6 watts, resulting in a 5°C rise in temperature.

NOTE	To allow adequate cooling of the breadboard module, ensure that your circuit layout does not impede air flow.

Dimension Information for the Custom PC Board Area

Utilization of the empty space within the 34959A breadboard module is left entirely up to the user. However, assuming you want to most fully utilize the space provided, output signals through the Dsub ports, and connect your board securely to the supplied ribbon cable headers, four detailed dimension drawings are provided in this section to assist with your PC board fabrication.

The figure on illustrates the external dimensions of the largest PC board that will fit into the space provided, and provides distances on the plane of that board from the datum to the following locations:

- The 15 PC board mounting holes in the sheet metal base.
- Pin 1 of the board mounting position for the 26-pin ribbon cable connector carrying digital I/O signals and control power to/from header P102.
- Pin 1 of the board mounting position for the 40-pin ribbon cable connector carrying relay drive signals and control power from header P101.
- The center of the two user-supplied Dsub output connectors.
- The mounting holes for the two Dsub connectors. Note that this dimension, labelled "Dimension A" on the drawing, varies with the selection of Dsub connector used (e.g., DB50, DB78M, DB78F).

The figure on shows the mounting footprints for the recommended DB50(M/F) connectors. The two figures on show the footprints for the recommended DB78M and DB78F connectors, respectively. The part numbers for the recommended connectors are listed in the following table:

Recommended Dsub Connectors as Shown in Dimension Drawings 2 through 4

Connector	Agilent Part Number	Conec Part Number
DB-50 (M)	1253-5853	161C18569X
DB-50 (F)	1253-5854	DSSEXSTCM39A
DB-78 (M)	1253-6006	DLH5XP8CK53X
DB-78 (F)	1253-6007	DLH5XS8CK53X

The suggested supplier for the Dsub connectors is:

Vendor: **Conec Corporation**
Vendor Address: **343 Technology Drive, Garner, NC 27529 U.S.A.**

Dimensions of Suggested (maximum size) Custom PC Board

5X71.79
45.80
5X21.79
2.74

140.834
5X121.79
118.505

Pin 1
Connection to
26-pin header

Pin 1
Connection to
40-pin header

189.330
3X179.33

34980A backplane

3X139.33

Location of sheet metal mounting base holes
Diameter 3.18mm

3X99.33

3X59.33

Footprint for mounting 50-pin Dsub connectors shown

Pin 1

Pin 1

Dimension A

DATUM

3X19.33   2X21.55

34.66

0.45   106.15

143.57

Clearance to
sheet metal

Dimension A	
DB-50 (M/F):	10.38 mm
DB-78 (M):	12.25 mm
DB-78 (F):	10.87 mm

All dimensions are
shown in millimeters.

PC Board Footprint of Suggested DB50 Connectors (M/F)

All dimensions are shown in millimeters.
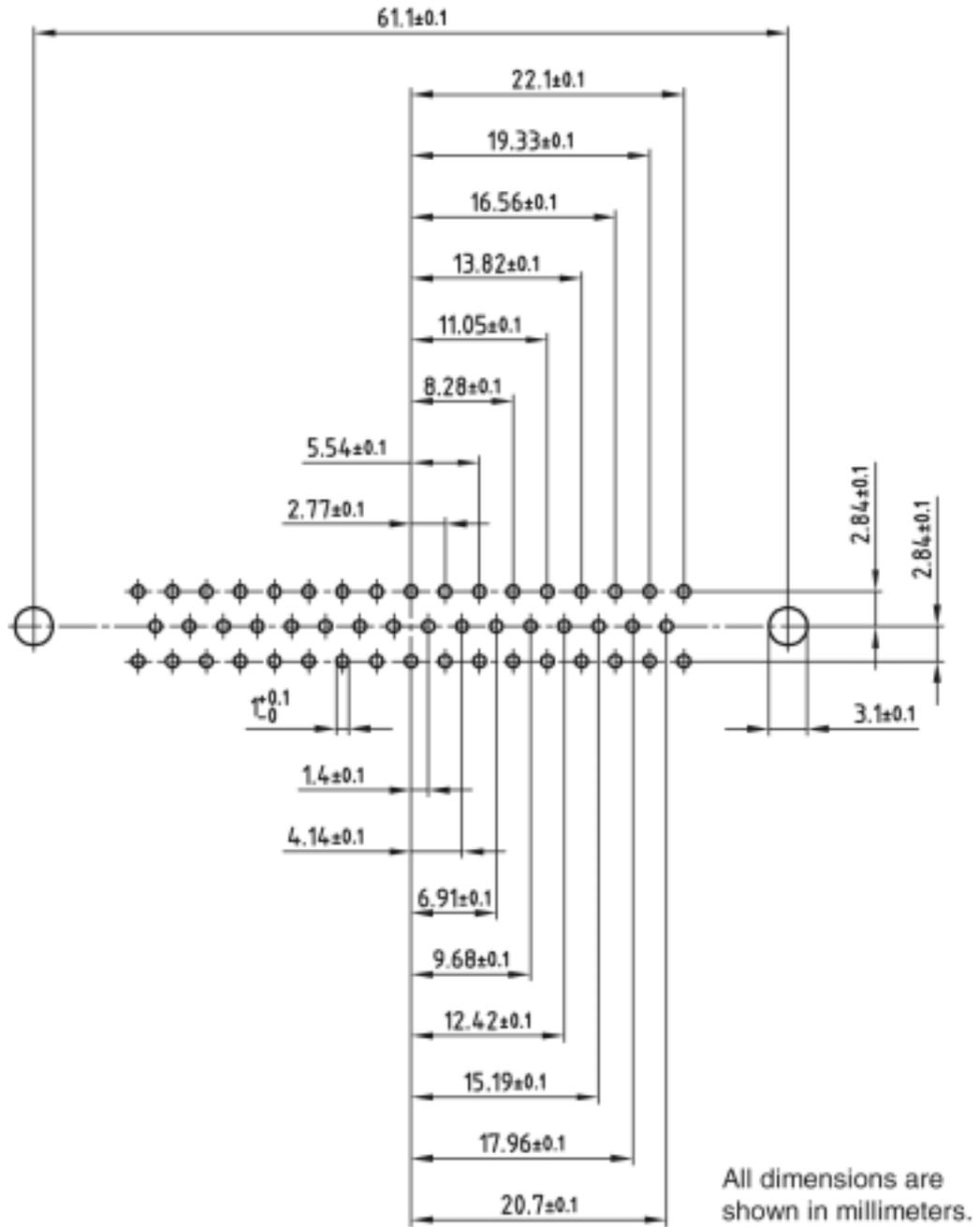
PC Board Footprint of Suggested DB78M Connector
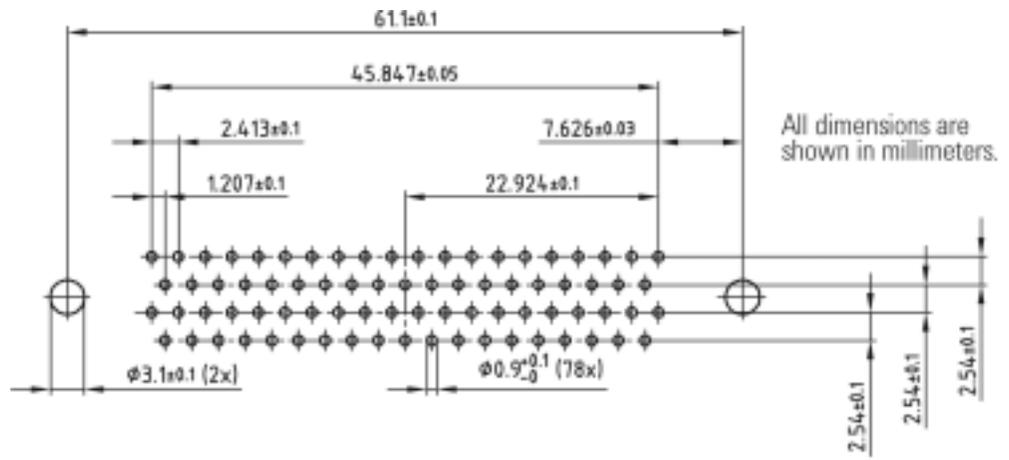
PC Board Footprint of Suggested DB78F Connector
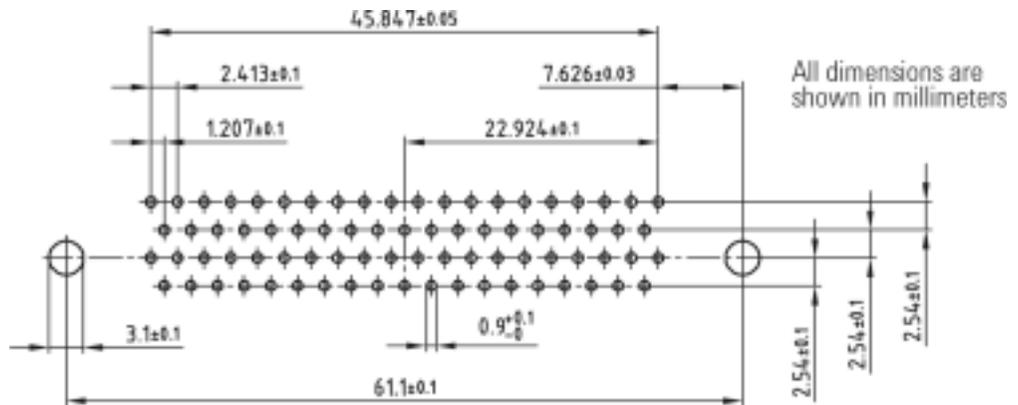
Programming the 34959A Breadboard Module

The 34959A Breadboard Module has three methods of signal input/output between the 34980A mainframe and the user-designed circuitry. The first is to access the four Analog Buses. The second provides control for up to 32 general purpose relays you may install on your PC board (only 28 general purpose relays if the four Analog Bus relay control lines will be used). The third provides two bytes of simple digital I/O with handshake signals.

Analog Bus Relay Functions

The 34980A mainframe provides four two-wire internal Analog Buses for signal routing. The channels for the four Analog Buses are numbered 911 through 914. If any of the optional Analog Bus relays K101 through K104 are installed on the 34959A, you can route external signals to the Analog Buses or access signals introduced to those buses through other installed modules. Refer to Chapter 2 for configuring the internal DMM for making voltage, current, resistance, temperature or frequency measurements.

The Agilent 34980A *Programmer's Reference* details the SCPI language and syntax for all commands available through the remote interface. Examples of some commands you will use to control relays to the analog bus, query relay status or assign custom labels to these channels are described below:

The `ROUTe:OPEN` command is used to open a relay. The syntax is:

`ROUTe:OPEN (@<ch_list>)`

Example: If the Breadboard Module is in slot 1, the following command opens relay K101 to Analog Bus 1 (channel 911):

`ROUTe:OPEN (@1911)`

The `ROUTe:OPEN?` command is used to query the status of a relay. The syntax is:

`ROUTe:OPEN? (@<ch_list>)`

Example: If the Breadboard Module is in slot 3, the following query returns the status of relay K104 to Analog Bus 4 (channel 914). A 1 is returned if the relay is open; a 0 is returned if the relay is closed:

`ROUTe:OPEN? (@3914)`

The `ROUTe:CLOSe` command is used to close a relay. The syntax is:

`ROUTe:CLOSe (@<ch_list>)`

Example: If the Breadboard Module is in slot 7, the following command closes relay K103 to Analog Bus 3 (channel 913):

```
ROUTe:CLOSe (@7913)
```

The `ROUTe:CLOSe?` command is used to query the status of a relay, with opposite results to the `ROUTe:OPEN?` command. The syntax is:

```
ROUTe:CLOSe? (@<ch_list>)
```

Example: If the Breadboard Module is in slot 6, the following query returns the status of relay K104 to Analog Bus 4 (channel 914). A 1 is returned if the relay is closed; a 0 is returned if the relay is open:

```
ROUTe:CLOSe? (@6914)
```

The `ROUTe:CHANnel:LABel` command is used to assign a user-defined label to any of the 32 channels accessible by the Breadboard Module, including the Analog Bus channels. These labels may be up to 18 ASCII characters in length, and are not required to be unique. The syntax is:

```
ROUTe:CHANnel:LABel <label>, (@<ch_list>)
```

Example: If the Breadboard Module is in slot 2, the following command assigns the label "Test Point A" to Analog Bus channel 913:

```
ROUTe:CHANnel:LABel "Test Point A",(@2913)
```

Most SCPI commands can address more than one channel at a time, including specifying a range of channels. Refer to the Agilent 34980A *Programmer's Reference* for more complete information.

General Purpose Relay Functions

In addition to the four dual-purpose relay channels 911-914, which may be used as general purpose relay drive channels if relays K101-K104 are not installed, the 34959A breadboard module provides 28 additional general purpose relay drive lines. The channels for these relay drives are numbered 101 through 128. All of the SCPI commands described in the previous section, "Analog Bus Relay Functions" on page 326, also apply to these relay drives. Since relay selection is left to the user's discretion, take particular note of the maximum current limits specified in the Electrical Specifications table on page 321 when choosing and driving your relays.

Digital I/O Functions

The Digital input/output (DIO) interface provides two 8-bit bytes of DIO, which may be accessed individually or combined together to form one 16-bit word. Three control lines are provided. See the Pin Connection Information table (for P102) on page 315 for connection information. The three control lines provide handshake of the read/write SCPI commands (SENSe and SOURce) sent to the mainframe, as follows:

Timing for Read Commands

When the 34980A receives a SCPI command to read from the breadboard, control line 3 is set high (its default setting, indicating a read request).

If the read target is byte 1, control line 1 is set strobe low, the byte 1 data is read, and then control line 1 is set strobe high. The strobe pulse width is 3.75 µs, and the time from strobe low to valid data is 1.25 µs.

Similarly, *if the read target is byte 2*, control line 2 is set strobe low, the byte 2 data is read, and then control line 2 is set strobe high. The strobe pulse width is 3.75 µs, and the time from strobe low to valid data is 1.25 µs.

*If both bytes are configured as a word, and targeted as a word in the read (*SENSe*) command*, both control lines 1 and 2 are set strobe low, all 16 bits are read, and then both control lines are set strobe high. The strobe pulse width is longer (5 µs) than for a single byte read, but the time from strobe low to valid data is still 1.25 µs.

In all three cases, once the data has been read by the mainframe, the data lines are left in tri-state (indeterminate).

The read timing diagram is shown on page 329.

Timing for Write Commands

When the 34980A receives a SCPI command to write to the breadboard, control line 3 is set low (indicating a write request).

If the write target is byte 1, control line 1 is set strobe low, the byte 1 data is written to the 8 output bits, and then control line 1 is set strobe high. Valid data is present 1.25 µs before the control line strobe is set high. Control line 3 is then set high.

Similarly, *if the write target is byte 2*, control line 2 is set strobe low, the byte 2 data is written to the 8 output bits, and then control line 2 is set strobe high. Valid data is present 1.25 µs before the control line strobe is set high. Control line 3 is then set high.

*If both bytes are targeted in the write (*SOURce*) command*, both control lines 1 and 2 are set strobe low, both bytes' data are written to the 16 output bits, and then both control lines are set strobe high. Valid data is present 1.25 3s before the control line strobe is set high. Control line 3 is then set high.

In all three cases, once the data has been written by the mainframe, the data is kept on the data lines until another (read or write) command changes them.

The write timing diagram is shown below.

Timing Diagrams for the Digital Read and Write Commands

The strobe timing, control line status and data timing for the read and write commands as explained above are illustrated in the diagrams that follow:

34959A Breadboard Module Digital I/O Timing Diagrams
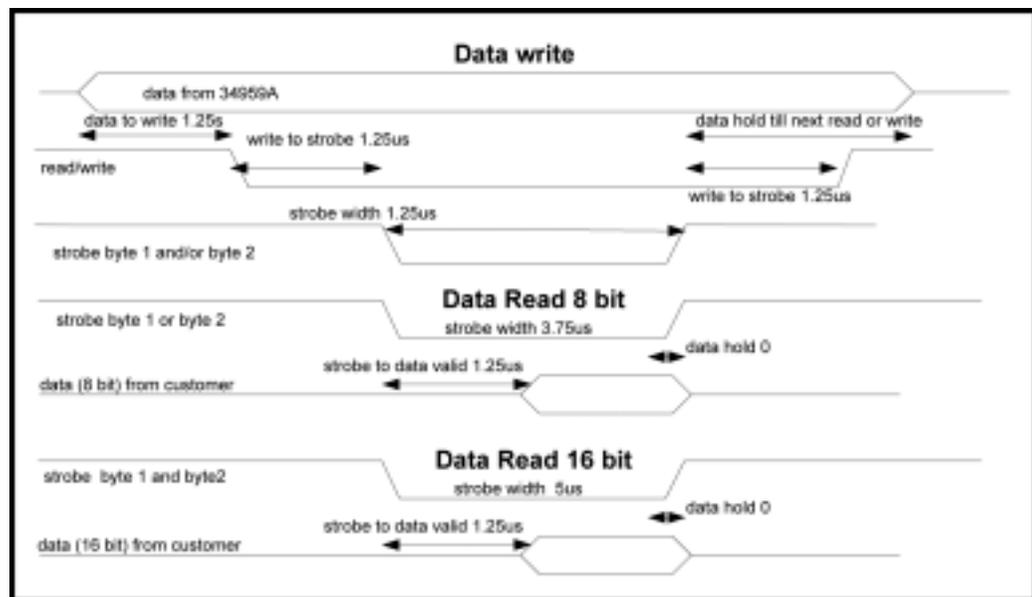
Digital Channel Numbering

The two 8-bit DIO channels, numbered 001 and 002, are intended to be used as two separate channels (bytes). However, they can be grouped together as a single 16-bit channel (word). When these channels are grouped, all bits in Channel 002 will be reconfigured to operate in the same direction (input or output) as Channel 001; Channel 001 will become the control channel, and should be used for all DIO channel configuration commands.

Read Command Syntax

Before reading digital data from the breadboard, you must first configure the digital channel width as byte or word, using the `CONFigure:DIGital:WIDTh` command. The syntax is:

`CONFigure:DIGital:WIDTh <width>,(@<ch_list>)`

Example: If the Breadboard Module is in slot 1, the following command configures channel 002 as a byte:

`CONFigure:DIGital:WIDTh BYTE, (@1002)`

Example: If the Breadboard Module is in slot 7, the following command configures channels 001 and 002 together as a word:

`CONFigure:DIGital:WIDTh WORD, (@7001)`

After either channel has been configured as a byte, or both have been configured as a word, you must then specify the target channel for *input* operations, using the `CONFigure:DIGital:DIRection` command. The syntax is:

`CONFigure:DIGital:DIRection <direction>, (@<ch_list>)`

Example: If the Breadboard Module is in slot 3, and channel 002 has been configured as a byte, the following command configures channel 002 as a byte-width input:

`CONFigure:DIGital:DIRection INPut, (@3002)`

Example: If the Breadboard Module is in slot 5, and both channels have been configured as a word, the following command configures the combined channel as a word-width input (note that it is only necessary to specify the first channel in SCPI, once the word width has been specified):

`CONFigure:DIGital:DIRection INPut, (@5001)`

Once the data width and direction have been configured, the data (either word, byte or bit) is read using the `SENSe` command. The syntax is:

`SENSe:DIGital:DATA:<width>? (@<ch_list>)`

Example: If the Breadboard Module is in slot 3, and channel 002 has been configured as a byte input, the following command returns the value of the channel 002 byte as an integer:

`SENSe:DIGital:DATA:BYTE? (@3002)`

Example: If the Breadboard Module is in slot 4, and channels 001 and 002 have been configured as a word input, the following command returns the value of the combined channel word as an integer:

`SENSe:DIGital:DATA:WORD? (@4001)`

Example: If the Breadboard Module is in slot 6, and channel 001 has been configured as a byte input, the following command returns the state of bit 4 on the channel 001 byte:

`SENSe:DIGital:DATA:BIT? 4,(@6001)`

Write Command Syntax

Before writing digital data to the breadboard outputs, you must first configure the digital channel width as byte or word, using the same commands listed under "Read Command Syntax" on page 330.

After either channel has been configured as a byte, or both have been configured as a word, you must then specify the target channel for *output* operations, using the `CONFigure:DIGital:DIRection` command. The syntax is the same as for input operations, except for the specified `<direction>`.

Example: If the Breadboard Module is in slot 3, and channel 002 has been configured as a byte, the following command configures channel 002 as a byte- width output:

`CONFigure:DIGital:DIRection OUTPut, (@3002)`

Example: If the Breadboard Module is in slot 5, and both channels have been configured as a word, the following command configures the combined channel as a word- width output (note that it is only necessary to specify the first channel in SCPI, once the two channels have been configured as a word):

`CONFigure:DIGital:DIRection OUTPut, (@5001)`

Once the data width and direction have been configured, the data (either word, byte or bit) is written to the output lines using the `SOURce` command. The syntax of that command is subtly different for writing a single bit versus writing an entire byte or word.

To output a digital bit, the specified bit number must be 0 (LSB) through 7 (MSB) of the targeted byte, and the syntax is:

`SOURce:DIGital:DATA:BIT {0|1}, <bit>, (@<ch_list>)`

Example: If the Breadboard Module is in slot 3, and channel 002 has been configured as a byte output, the following command writes a 1 to bit 6 of channel 002:

`SOURce:DIGital:DATA:BIT 6,1 (@3002)`

To output a digital byte, the specified value may be binary (valid values from #B00000000 through #B11111111), hexadecimal (valid values from #H0 through #HFF) or integer (valid values 0 through 255) and the syntax is:

`SOURce:DIGital:DATA:BYTE <data>, (@<ch_list>)`

Example: If the Breadboard Module is in slot 6, and channel 002 has been configured as a byte output, any of the following commands will write the value 10011101 to channel 002:

`SOURce:DIGital:DATA:BYTE #B10011101,(@6002)`

`SOURce:DIGital:DATA:BYTE #H9D,(@6002)`

`SOURce:DIGital:DATA:BYTE 157,(@6002)`

To output a digital word, the specified value may be binary (valid values from #B0000000000000000 through #B1111111111111111), hexadecimal (valid values from #H0 through #HFFFF) or integer (valid values 0 through 65535) and the syntax is:

`SOURce:DIGital:DATA:WORD <data>, (@<ch_list>)`

Example: If the Breadboard Module is in slot 8, and channels 001 and 002 have been configured as a word output, any of the following commands will write the value 1001100110011001 to the combined digital channel:

`SOURce:DIGital:DATA:WORD #B1001100110011001,(@8001)`

`SOURce:DIGital:DATA:WORD #H9999,(@8001)`

`SOURce:DIGital:DATA:WORD 39321,(@8001)`

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