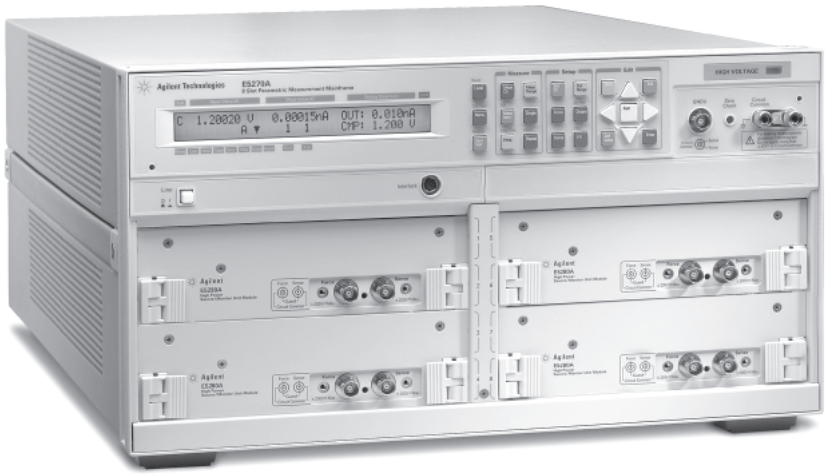
Agilent E5270A

8-Slot Parametric Measurement Mainframe

Technical Overview



Introduction

The Agilent E5270A 8-Slot Parametric Measurement Mainframe is completely user-configurable. You can install up to eight single-slot modules (such as the MPSMU), up to four dual-slot modules (such as the HPSMU), or any physically allowable combination thereof.

Basic Features

- Performs high-speed, dc parametric measurements
- Eight slots for plug-in modules
- User interface allows spot measurements to be made from the front panel
- High-resolution, analog-to-digital converter (ADC) available to all installed modules
- High-speed ADC present on each installed SMU
- 4-Amp ground unit
- BNC trigger-in and trigger-out connectors
- 16 general-purpose digital I/Os
- Program memory
- GPIB port for instrument control
- Self-test, self-calibration, diagnostics

Measurement Modes

The Agilent E5270A supports the following measurement modes:

- Spot
- Pulsed Spot
- Quasi-pulsed Spot
- Staircase Sweep
- Multi-Channel Sweep
- Pulsed Sweep
- Staircase Sweep with Pulsed Bias
- Linear Search
- Binary Search

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Hardware

Specification Conditions

Note: This document lists specifications and supplemental information for the E5270A and its associated modules. The specifications are the standards against which the E5270A and its associated modules are tested. When the E5270A or any of its associated modules are shipped from the factory, they meet the specifications. The "supplemental" information and "typical" entries in the following specifications are not warranted, but provide useful information about the functions and performance of the instrument.

The measurement and output accuracy are specified at the module connector terminals when referenced to the Zero Check terminal under the following conditions:

1. 23° C ±5° C (double for 5° C to 18° C, and 28° C to 40° C if not noted otherwise)
2. After 40 minutes warm-up
3. Ambient temperature change less than ±1° C after auto calibration execution
4. Measurement made within one hour after auto calibration execution
5. Averaging (high-speed per-SMU ADC): 128 samples in 1 PLC; Integration time (high-resolution central ADC): 1 PLC
6. Filter: ON (for SMUs)
7. Kelvin connection
8. Calibration period: 1 year

E5270A Mainframe Specifications

Supported Plug-In Modules

The E5270A supports eight slots for plug-in modules.

Part Number	E5270A Option	Description	Slots Occupied	Range of Operation
E5280A	E5270A-400	HPSMU	2	2 μV to 200 V, 10 fA to 1 A
E5281A	E5270A-410	MPSMU	1	2 μV to 100 V, 10 fA to 200 mA

Maximum Output Power

The total module power consumption cannot exceed 80 W. *Note: Using the HPSMU and MPSMU units, it is impossible to create a combination that exceeds the 80-watt limit.*

Maximum Voltage between Common and Ground

Maximum Common to Ground voltage must be ≤42 V.

Pulse Measurement

Pulse width: 500 μs to 2 s
Pulse period: 5 ms to 5 s
Period ≥Width + 2 ms (when Width ≤100 ms)
Period ≥Width + 10 ms (when Width >100 ms)
Pulse resolution: 100 μs

Ground Unit (GNDU) Specifications

The GNDU is furnished with the E5270A mainframe.

Output Voltage: 0 V ±100 μV

Maximum sink current: 4 A

Output terminal/connection: Triaxial connector, Kelvin (remote sensing)

GNDU Supplemental Information

Load capacitance: 1 μF

Cable resistance:

For I_s ≤1.6 A:
Force Line R <1 Ω
For 1.6 A <I_s ≤2.0 A:
Force Line R <0.7 Ω
For 2.0 A <I_s ≤4.0 A:
Force Line R <0.35 Ω
For all cases:
Sense Line R ≤10 Ω

Where I_s is the current being sunk by the GNDU.

MPSMU (Medium Power SMU) Module Specifications

Voltage Range, Resolution, and Accuracy (MPSMU)

Voltage Range	Force Resolution	Measure Resolution[1]	Measure Resolution[2]	Force Accuracy	Measure Accuracy[3]	Measure Accuracy[4]	Maximum Current
±2 V	100 μV	100 μV	2 μV	±(0.03% + 900 μV)	±(0.03% + 700 μV)	±(0.02% + 700 μV)	200 mA
±20 V	1 mV	1 mV	20 μV	±(0.03% + 4 mV)	±(0.03% + 4 mV)	±(0.02% + 2 mV)	200 mA
±40 V	2 mV	2 mV	40 μV	±(0.03% + 7 mV)	±(0.03% + 8 mV)	±(0.02% + 3 mV)	[5]
±100 V	5 mV	5 mV	100 μV	±(0.04% + 15 mV)	±(0.03% + 20 mV)	±(0.03% + 5 mV)	[6]

[1] Measurement resolution when using the high-speed ADC
[2] Measurement resolution when using the high-resolution ADC
[3] Measurement accuracy when using the high-speed ADC
[4] Measurement accuracy when using the high-resolution ADC
[5] 200 mA (Vout ≤20 V), 50 mA (20 V <Vout ≤40 V)
[6] 200 mA (Vout ≤20 V), 50 mA (20 V <Vout ≤40 V), 20 mA (40 V <Vout ≤100 V)

Current Range, Resolution, and Accuracy (MPSMU)

Current Range	Force Reso.	Meas. Reso.[1]	Meas. Reso.[2]	Force Accuracy	Measure Accuracy[3]	Max. Voltage
±1 nA	50 fA	50 fA	10 fA	±(0.5 % + 3 pA + 2 fA × Vout)	±(0.5 % + 3 pA + 2 fA × Vout)	100 V
±10 nA	500 fA	500 fA	10 fA	±(0.5 % + 7 pA + 20 fA × Vout)	±(0.5 % + 5 pA + 20 fA × Vout)	100 V
±100 nA	5 pA	5 pA	100 fA	±(0.12 % + 50 pA + 200 fA × Vout)	±(0.1 % + 30 pA + 200 fA × Vout)	100 V
±1 μA	50 pA	50 pA	1 pA	±(0.12 % + 400 pA + 2 pA × Vout)	±(0.1 % + 200 pA + 2 pA × Vout)	100 V
±10 μA	500 pA	500 pA	10 pA	±(0.12 % + 5 nA + 20 pA × Vout)	±(0.1 % + 3 nA + 20 pA × Vout)	100 V
±100 μA	5 nA	5 nA	100 pA	±(0.12 % + 40 nA + 200 pA × Vout)	±(0.1 % + 20 nA + 200 pA × Vout)	100 V
±1 mA	50 nA	50 nA	1 nA	±(0.12 % + 500 nA + 2 nA × Vout)	±(0.1 % + 300 nA + 2 nA × Vout)	100 V
±10 mA	500 nA	500 nA	10 nA	±(0.12 % + 4 μA + 20 nA × Vout)	±(0.1 % + 2 μA + 20 nA × Vout)	100 V
±100 mA	5 μA	5 μA	100 nA	±(0.12 % + 50 μA + 200 nA × Vout)	±(0.1 % + 30 μA + 200 nA × Vout)	[4]
±200 mA	10 μA	10 μA	200 nA	±(0.12 % + 100 μA + 400 nA×Vout)	±(0.1 % + 60 μA + 400 nA×Vout)	[5]

[1] Measurement resolution when using the high-speed ADC
[2] Measurement resolution when using the high-resolution ADC
[3] Measurement accuracy when using either the high-speed ADC or the high-resolution ADC
[4] 100 V (Iout ≤20 mA), 40 V (20 mA <Iout ≤50 mA), 20 V (50 mA <Iout ≤100 mA)
[5] 100 V (Iout ≤20 mA), 40 V (20 mA <Iout ≤50 mA), 20 V (50 mA <Iout ≤200 mA)
Vout is the output voltage in Volts. Iout is the output current in Amps. For example, accuracy specifications are given as ±% of output/measured value (0.1%) plus offset value (30 pA + 200 fA × Vout) for the 100 nA range. The offset value consists of a fixed part determined by the output/measurement range and a proportional part that is multiplied by Vout.

Power Consumption (MPSMU)

Voltage source mode:

Voltage Range	Power
2 V	20 × Ic (W)
20 V	20 × Ic (W)
40 V	40 × Ic (W)
100 V	100 × Ic (W)

Where Ic is the current compliance setting.

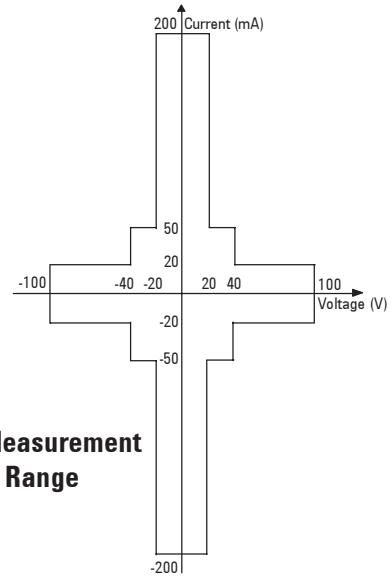
Current source mode:

Voltage Compliance	Power
Vc ≤20	20 × Io (W)
20 <Vc ≤40	40 × Io (W)
40 <Vc ≤100	100 × Io (W)

Where Vc is the voltage compliance setting and Io is output current.

Output terminal/connection:
Dual triaxial connector, Kelvin (remote sensing)

Voltage/Current Compliance (Limiting)
The SMU can limit output voltage or current to prevent damaging the device under test.
Voltage: 0 V to ±100 V
Current: ±1 pA to ±200 mA
Compliance Accuracy: Same as the current (or voltage) set accuracy.



MPSMU Measurement and Output Range

MPSMU Supplemental Information

Maximum allowable cable resistance (Kelvin connection):
- Force Line: 10 Ω (I ≤100 mA)
- Force Line: 1.5 Ω (100 mA <I ≤200 mA)
- Sense Line: 10 Ω (All cases)

Voltage source output resistance:
- 0.3 Ω Typical (Force line, Non-Kelvin connection)

Voltage measurement input resistance:
- $\geq 10^{13}$ Ω

Current source output resistance:
- $\geq 10^{13}$ Ω (1 nA range)

Current compliance setting accuracy (for opposite polarity):
- For 1 nA to 10 nA ranges: I setting accuracy ±12% of range
- For 100 nA to 200 mA ranges: I setting accuracy ±2.5% of range

Maximum capacitive load:
- For 1 nA to 10 nA ranges: 1000 pF
- For 100 nA to 10 mA ranges: 10 nF
- For 100 mA to 200 mA ranges: 100 μF

Maximum guard capacitance: 900 pF

Maximum shield capacitance: 5000 pF

Maximum guard offset voltage: ±1 mV

Noise characteristics (typical, filter ON):
- Voltage source: 0.01% of V range (rms.)
- Current source: 0.1% of I range (rms.)

Overshoot (typical, filter ON):
- Voltage source: 0.03% of V range
- Current source: 1% of I range

Range switching transient noise (typical, filter ON):
- Voltage ranging: 250 mV
- Current ranging: 10 mV

Slew rate: 0.2 V/μs

SMU pulse setting accuracy (fixed measurement range):
- Width: 0.5 % + 50 μs
- Period: 0.5 % + 100 μs

Trigger out delay (pulsed measurements):
- 0 to 32.7 ms with 100 μs resolution (<pulse width)

HPSMU (High Power SMU) Module Specifications

Voltage Range, Resolution, and Accuracy (HPSMU)

Voltage Range	Force Reso.	Meas. Reso.[1]	Meas. Reso.[2]	Force Accuracy	Measure Accuracy[3]	Measure Accuracy[4]	Maximum. Current
±2 V	100 μV	100 μV	2 μV	±(0.03% + 900 μV)	±(0.03% + 700 μV)	±(0.02% + 700 μV)	1 A
±20 V	1 mV	1 mV	20 μV	±(0.03% + 4 mV)	±(0.03% + 4 mV)	±(0.02% + 2 mV)	1 A
±40 V	2 mV	2 mV	40 μV	±(0.03% + 7 mV)	±(0.03% + 8 mV)	±(0.02% + 3 mV)	500 mA
±100 V	5 mV	5 mV	100 μV	±(0.04% + 15 mV)	± (0.03% + 20 mV)	± (0.03% + 5 mV)	125 mA
±200 V	10 mV	10 mV	200 μV	±(0.045% + 30 mV)	±(0.035% + 40 mV)	±(0.035% + 10 mV)	50 mA

[1] Measurement resolution when using the high-speed ADC
[2] Measurement resolution when using the high-resolution ADC
[3] Measurement accuracy when using the high-speed ADC
[4] Measurement accuracy when using the high-resolution ADC

Current Range, Resolution, and Accuracy (HPSMU)

Current Range	Force Reso.	Meas. Reso.[1]	Meas. Reso.[2]	Force Accuracy	Measure Accuracy[3]	Maximum Voltage
±1 nA	50 fA	50 fA	10 fA	±(0.5% + 3 pA + 2 fA × Vout)	±(0.5% + 3 pA + 2 fA × Vout)	200 V
±10 nA	500 fA	500 fA	10 fA	±(0.5% + 7 pA + 20 fA × Vout)	±(0.5% + 5 pA + 20 fA × Vout)	200 V
±100 nA	5 pA	5 pA	100 fA	±(0.12% + 50 pA + 200 fA × Vout)	±(0.1% + 30 pA + 200 fA × Vout)	200 V
±1 μA	50 pA	50 pA	1 pA	±(0.12% + 400 pA + 2 pA × Vout)	±(0.1% + 200 pA + 2 pA × Vout)	200 V
±10 μA	500 pA	500 pA	10 pA	±(0.12% + 5 nA + 20 pA × Vout)	±(0.1% + 3 nA + 20 pA × Vout)	200 V
±100 μA	5 nA	5 nA	100 pA	±(0.12% + 40 nA + 200 pA × Vout)	±(0.1% + 20 nA + 200 pA × Vout)	200 V
±1 mA	50 nA	50 nA	1 nA	±(0.12% + 500 nA + 2 nA × Vout)	±(0.1% + 300 nA + 2 nA × Vout)	200 V
±10 mA	500 nA	500 nA	10 nA	±(0.12% + 4 μA + 20 nA × Vout)	±(0.1% + 2 μA + 20 nA × Vout)	200 V
±100 mA	5 μA	5 μA	100 nA	±(0.12% + 50 μA + 200 nA × Vout)	±(0.1% + 30 μA + 200 nA × Vout)	[4]
±1 A	50 μA	50 μA	1 μA	±(0.5% + 500 μA + 2 μA × Vout)	±(0.5% + 300 μA + 2 μA × Vout)	[5]

[1] Measurement resolution when using the high-speed ADC
[2] Measurement resolution when using the high-resolution ADC
[3] Measurement accuracy when using either the high-speed ADC or the high-resolution ADC
[4] 200 V (Iout ≤50 mA), 100 V (50 mA <Iout ≤100 mA)
[5] 200 V (Iout ≤50 mA), 100 V (50 mA <Iout ≤125 mA), 40 V (125 mA <Iout ≤500 mA), 20 V (500 mA <Iout ≤1 A)

Vout is the output voltage in Volts. Iout is the output current in Amps. For example, accuracy specifications are given as ±% of output/measured value (0.1%) plus offset value (30 pA + 200 fA × Vout) for the 100 nA range. The offset value consists of a fixed part determined by the output/measurement range and a proportional part that is multiplied by Vout.

Power Consumption (HPSMU)

Voltage source mode:

Voltage Range	Power
2 V	20 × Ic (W)
20 V	20 × Ic (W)
40 V	40 × Ic (W)
100 V	100 × Ic (W)
200 V	200 × Ic (W)

Where Ic is the current compliance setting.

Current source mode:

Voltage Compliance	Power
Vc ≤20	20 × Io (W)
20 <Vc ≤40	40 × Io (W)
40 <Vc ≤100	100 × Io (W)
100 <Vc ≤200	200 × Io (W)

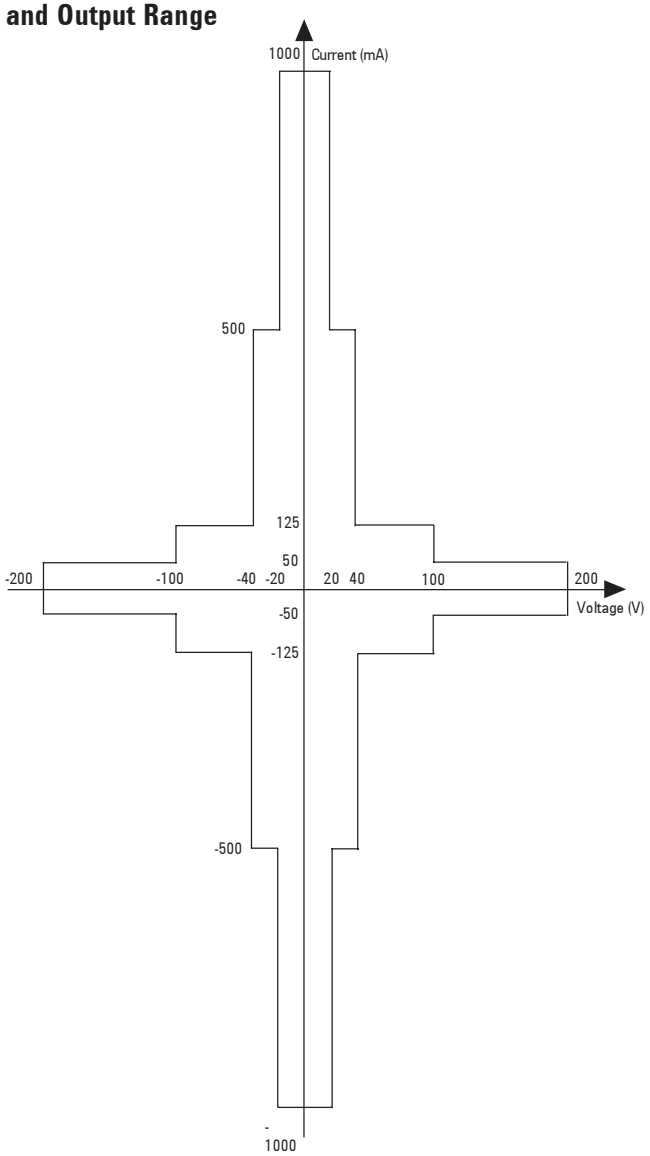
Where Vc is the voltage compliance setting and Io is output current.

Output terminal/connection: Dual triaxial connector, Kelvin (remote sensing)

Voltage/Current Compliance (Limiting):

The SMU can limit output voltage or current to prevent damaging the device under test.
Voltage: 0 V to ±200 V
Current: ±1 pA to ±1 A
Compliance Accuracy: Same as the current (or voltage) set accuracy.

HPSMU Measurement and Output Range



HPSMU Supplemental Information:

Maximum allowable cable resistance (Kelvin connection):
- Force Line: 10 Ω (I ≤100 mA)
- Force Line: 1.5 Ω (100 mA <I ≤1 A)
- Sense Line: 10 Ω (All cases)

Voltage source output resistance:
- 0.2 Ω Typical (Force line, Non-Kelvin connection)

Voltage measurement input resistance: $\geq 10^{13}\ \Omega$
Current source output resistance: $\geq 10^{13}\ \Omega$ (1 nA range)
Current compliance setting accuracy (for opposite polarity):
- For 1 nA to 10 nA ranges: I setting accuracy ±12% of range
- For 100 nA to 1 A ranges: I setting accuracy ±2.5% of range

Maximum capacitive load:
- For 1 nA to 10 nA ranges: 1000 pF
- For 100 nA to 10 mA ranges: 10 nF
- For 100 mA to 1 A ranges: 100 μF

Maximum guard capacitance: 900 pF
Maximum shield capacitance: 5000 pF
Maximum guard offset voltage: ±1 mV
Noise characteristics (typical, filter ON):
- Voltage source: 0.01% of V range (rms.)
- Current source: 0.1% of I range (rms.)

Overshoot (typical, filter ON):
- Voltage source: 0.03% of V range
- Current source: 1% of I range

Range switching transient noise (typical, filter ON):
- Voltage ranging: 250 mV
- Current ranging: 10 mV

Slew rate: 0.2 V/μs
SMU pulse setting accuracy (fixed measurement range):
- Width: 0.5 % + 50 μs
- Period: 0.5 % + 100 μs

Trigger out delay (pulsed measurements):
- 0 to 32.7 ms with 100 μs resolution (<pulse width)

Functions

Front Panel Operations

Display

- Display error messages
- Display spot measurement set value
- Display spot measurement result

Keypad Operations

- Set GPIB address
- Set local/remote mode
- Select measurement channel
- Set spot measurement set value
- Start calibration/diagnostics

MPSMU and HPSMU Measurement Mode Details

Spot measurement mode:
Outputs and measures voltage and current.

Staircase Sweep measurement mode:
Outputs swept voltage or current, and measures dc voltage or current. One channel can sweep current or voltage while up to eight channels can measure current or voltage. A second channel can be synchronized with the primary sweep channel as an additional voltage or current sweep source. Linear or log sweeps can be performed.

Number of Steps: 1-1,001
Hold Time: 0 - 655.35s, 1ms resolution
Delay Time: 0 - 65.5350s, 100μs resolution

Multi-Channel Sweep measurement mode:
Outputs swept voltage or current, and measures dc voltage or current.
Up to eight channels can sweep current or voltage and up to eight channels can measure current or voltage. Linear or log sweeps can be performed.

Number of Steps: 1-1,001
Hold Time: 0 - 655.35s, 1 ms resolution
Delay Time: 0 - 65.5350s, 100 μs resolution

Pulsed Spot measurement mode:
Outputs a voltage or current pulse and measures dc voltage or current.

Pulse Width: 500 μs to 100 ms, 100 μs resolution
Pulse Period: 5ms to 1 s (≥pulse width + 4 ms), 100 μs resolution
Maximum Pulse Duty: 50%

Pulsed Sweep measurement mode:
Outputs pulsed swept voltage or current, and measures dc voltage or current. A second channel can be programmed to output a staircase sweep voltage or current synchronized with the pulsed sweep output.

Staircase Sweep with Pulsed Bias measurement mode:
Outputs swept voltage or current, and measures dc voltage or current. A second channel can be programmed to output a pulsed bias voltage or current. A third channel can be synchronized with the primary sweep channel as an additional voltage or current sweep source.

Quasi-Pulsed Spot measurement mode:
Outputs quasi-pulsed voltage and measures dc voltage or current.

Linear Search measurement mode:
Outputs and measure voltage or current by using linear search method.

Binary Search measurement mode:
Outputs and measure voltage or current by using binary search method.

Time Stamp

The E5270A supports a time stamp function utilizing an internal quartz clock.
Resolution: 100 μs

Program Memory

The E5270A mainframe contains (volatile) memory that can be used to increase test measurement throughput. Program memory allows the storage of program code in the E5270A, eliminating the need to communicate over the GPIB interface. In addition, input data can be passed to code sequences stored in program memory.

Maximum lines of Storable Code: 40,000

Maximum number of program sequences: 2,000

Output Data Buffer

The number of data points that can be stored in the data buffer varies with the choice of the output data format.

Minimum number of Storable Data Points: 34,034

Trigger I/O

Trigger in/out synchronization pulses before and after setting and measuring dc voltage and current. Arbitrary trigger events can be masked or activated independently.

Input

An external trigger input signal can be used to do any of the following:

1. Start a measurement
2. Start a measurement at each sweep step for a staircase sweep or multi-channel sweep measurement
3. Start the source output at each sweep step for a staircase sweep, pulsed sweep, staircase sweep with pulsed bias, or multi-channel sweep measurement.
4. Start the pulsed output for a pulsed spot measurement.
5. Recover from a wait state.

Input Level: TTL level, negative or positive edge trigger, or TTL level, negative or positive gate trigger.

Output

An output trigger signal can be sent when one of the following events occurs:

1. The end of a measurement is reached.
2. The end of a measurement at each sweep step for a staircase sweep or multi channel sweep measurement is reached.
3. Completion of the source output setup at each sweep step for a staircase sweep, pulsed sweep, staircase sweep with pulsed bias, or multi-channel sweep measurement.
4. Completion of the pulsed output setup for a pulsed spot measurement.
5. A trigger command is issued.

Output Level: TTL level, negative or positive edge trigger, or TTL level, negative or positive gate trigger.

General Purpose Digital I/O

16 general-purpose digital I/O signals are available via a 25-pin DIN connector. These pins can be used as an alternative to the BNC trigger-in and trigger-out lines to synchronize the E5270A with other instruments. They can also be used as output and input ports for digital signals. The user can selectively assign pins to trigger mode or digital I/O mode.

Attached Software

A VXI*plug&play* driver for the E5270A and E5270 TIS Library software are supplied.

Supported operating systems:

Microsoft® Windows® 95, NT, 2000 Professional and XP Professional

General Specifications

Temperature range

Operating: +5° C to +40° C
Storage: -20° C to +60° C

Humidity range

Operating: 15% to 80% RH, non-condensing
Storage: 5% to 90% RH, non-condensing

Altitude

Operating: 0 m to 2,000 m (6,561 ft)
Storage: 0 m to 4,600 m (15,092 ft)

Power requirement

ac Voltage: 90 V to 264 V
Line Frequency: 47 Hz to 63 Hz

Maximum Volt-Amps (VA)

E5270A: 600 VA

Regulatory Compliance

EMC: IEC 61326-1:+A1/EN61326-1:+A1
AS/NZS 2064.1
Safety: CSA C22.2 No.1010.1-1992
IEC61010-1:+A2/EN61010-1:+A2
UL3111-1:1994

Certification

CE, CSA, NRTL/C, C-Tick

Dimensions

E5270A: 426 mm W x 235 mm H x 575 mm D

Weight

E5270A (empty): 17 kg
E5280A: 2.5 kg
E5281A: 1.6 kg

Furnished Accessories

Software CD-ROM (including VXIplug&play driver and E5270 TIS Library)

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