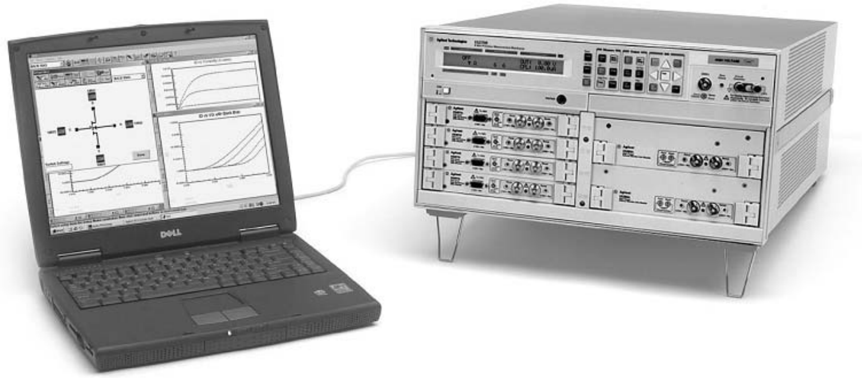
Agilent 4157B

Modular Semiconductor Parameter Analyzer

Technical Overview

November 2004



Introduction

The Agilent 4157B Modular Semiconductor Parameter Analyzer combines the hardware flexibility of the Agilent E5270B 8-Slot Precision Measurement Mainframe with the software versatility of I/CV 3.0 Lite Automation Software.

Basic Features

The 4157B is an integrated, turnkey solution. The standard configuration includes the E5270B mainframe, a PC-based instrument controller with I/CV 3.0 Lite pre-installed, and an Agilent 82357A USB/GPIB interface. The E5270B mainframe is completely user-configurable. You have the option of deleting the controller and cable from your order, but I/CV 3.0 Lite is always included with the 4157B. If you want the full version of I/CV 3.0, you can request the E5240CU upgrade kit when you order the 4157B. For more information about the differences between I/CV 3.0 Lite and I/CV 3.0, please refer to the Agilent I/CV 3.0 Technical Overview, publication number 5989-1408EN.

Software Functions

- PC-based instrument control via a GUI
- Set measurement conditions
- Control measurement execution
- Perform arithmetic calculations
- Display measured and calculated results
- Perform graphical analysis
- Store and recall measurement setups and measurement and graphical display data
- Test sequencing and data disposition
- Wafer prober control
- Post-test data analysis (wafer maps, histograms, statistical information)
- Print to networked printers
- Transfer measurement data and setups over a LAN
- Self-test, self-calibration, diagnostics

Hardware Functions

- Performs high-speed, dc parametric measurements
- Eight slots for plug-in modules
- High-resolution analog-to-digital converter (HR-ADC) available to all installed modules
- High-speed analog-to-digital converter (HS-ADC) present on each installed SMU
- 4 Amp ground unit
- GPIB port for instrument control
- User interface allows spot measurements to be made from the E5270B front panel
- Self-test, self-calibration, diagnostics

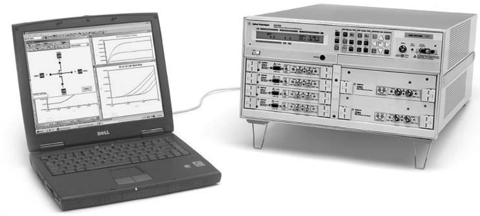
Measurement Modes

- Spot
- Staircase Sweep
- Multi-Channel Sweep
- Custom Sweep
- Pulsed Spot
- Pulsed Sweep
- Staircase Sweep with Pulsed Bias
- Sampling

Hardware

Specification Conditions

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



1. Temperature: 23°C ± 5°C (double for 5°C to 18°C, and 28°C to 40°C if not noted otherwise)
2. Humidity: 15% to 60% (double for 60% to 70%)
3. After 40 minutes warm-up
4. Ambient temperature change less than ±1°C after auto calibration execution
5. Measurement made within one hour after auto calibration execution
6. Averaging (high-speed per-SMU ADC): 128 samples in 1 PLC;
   Integration time (high-resolution central ADC):
   1 PLC (1 nA to 1A range)
   20 PLC (100 pA range)
   50 PLC (1 pA to 10 pA range)
7. Filter: ON (for SMUs)
8. Kelvin connection
9. Calibration period: 1 year

Note: This document lists specifications and supplemental information for the E5270B and its associated modules. The specifications are the standards against which the E5270B and its associated modules are tested. When the E5270B 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.

E5270B Mainframe Specification

Supported Plug-In Modules

The E5270B supports eight slots for plug-in modules.

Part Number	Description	Slots Occupied	Range of Operation	Measure Resolution
E5280B	HPSMU	2	-200 V to 200 V, -1 A to 1 A	2 μV, 10 fA
E5281B	MPSMU	1	-100 V to 100 V, -100 mA to 100 mA	0.5 μV, 10 fA
E5287A	Atto Level HRSMU	1	-100 V to 100 V, -100 mA to 100 mA	0.5 μV, 1 fA
E5288A[1]	Atto Sense and Switch Unit (ASU)	-	-100 V to 100 V, -100 mA to 100 mA	0.5 μV, 0.1 fA

1. This is connected with the E5287A Atto Level HRSMU

Maximum Output Power

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

Maximum Voltage between Common and Ground

≤ ± 42 V.

Pulse Measurement

Pulse width: 500 μsec 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) Specification

The GNDU is furnished with the E5270B 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: innocent

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		Force Accuracy[1]	Measure Accuracy[1]		Maximum Current
		High Speed ADC	High Resolution ADC		High Speed ADC	High Resolution ADC	
±0.5 V	25 µV	25 µV	0.5 µV	±(0.03 % + 350 µV)	±(0.03 % + 250 µV)	±(0.02 % + 250 µV)	100 mA
±2 V	100 µV	100 µV	2 µV	±(0.03 % + 900 µV)	±(0.03 % + 700 µV)	±(0.02 % + 700 µV)	100 mA
±5 V	250 µV	250 µV	5 µV	±(0.03 % + 2 mV)	±(0.03 % + 2 mV)	±(0.02 % + 1 mV)	100 mA
±20 V	1 mV	1 mV	20 µV	±(0.03 % + 4 mV)	±(0.03 % + 4 mV)	±(0.02 % + 2 mV)	100 mA
±40 V	2 mV	2 mV	40 µV	±(0.03 % + 7 mV)	±(0.03 % + 8 mV)	±(0.02 % + 3 mV)	[2]
±100 V	5 mV	5 mV	100 µV	±(0.04 % + 15 mV)	±(0.03 % + 20 mV)	±(0.03 % + 5 mV)	[3]

1. ±(% of output/measured value + offset voltage V)
2. 100 mA (Vo ~ 20 V), 50 mA (20 V < Vo ~ 40 V), Vo is the output voltage in Volts.
3. 100 mA (Vo ~ 20 V), 50 mA (20 V < Vo ~ 40 V), 20 mA (40 V < Vo ~ 100 V), Vo is the output voltage in Volts.

Current Range, Resolution, and Accuracy (MPSMU)

Current Range	Force Resolution	Measure Resolution[4]		Force Accuracy[1]	Measure Accuracy[1 2]	Maximum Voltage
		High Speed ADC	High Resolution ADC			
±1 nA	50 fA	50 fA	10 fA	±(0.5 %+3 pA+2 fA x Vo)	±(0.5 %+3 pA+2 fA x Vo)	100 V
±10 nA	500 fA	500 fA	10 fA	±(0.5 %+7 pA+20 fA x Vo)	±(0.5 %+5 pA+20 fA x Vo)	100 V
±100 nA	5 pA	5 pA	100 fA	±(0.12 %+50 pA+200 fA x Vo)	±(0.1 %+30 pA+200 fA x Vo)	100 V
±1 µA	50 pA	50 pA	1 pA	±(0.12 %+400 pA+2 pA x Vo)	±(0.1 %+200 pA+2 pA x Vo)	100 V
±10 µA	500 pA	500 pA	10 pA	±(0.12 %+5 nA+20 pA x Vo)	±(0.1 %+3 nA+20 pA x Vo)	100 V
±100 µA	5 nA	5 nA	100 pA	±(0.12 %+40 nA+200 pA x Vo)	±(0.1 %+20 nA+200 pA x Vo)	100 V
±1 mA	50 nA	50 nA	1 nA	±(0.12 %+500 nA+2 nA x Vo)	±(0.1 %+300 nA+2 nA x Vo)	100 V
±10 mA	500 nA	500 nA	10 nA	±(0.12 %+4 µA+20 nA x Vo)	±(0.1 %+2 µA+20 nA x Vo)	100 V
±100 mA	5 µA	5 µA	100 nA	±(0.12 %+50 µA+200 nA x Vo)	±(0.1 %+30 µA+200 nA x Vo)	[3]

1. ±(% of output/measured value + offset current A (fixed part determined by the output/measurement range + proportional part that is multiplied by Vo)
2. Measurement accuracy when using either the high-speed ADC or the high-resolution ADC
3. 100 V (Io ≤ 20 mA), 40 V (20 mA < Io ≤ 50 mA), 20 V (50 mA < Io ≤ 100 mA), Io is the output current in Amps.
4. Specified measurement resolution is limited by fundamental noise limits.

Power Consumption (MPSMU)

Voltage source mode:

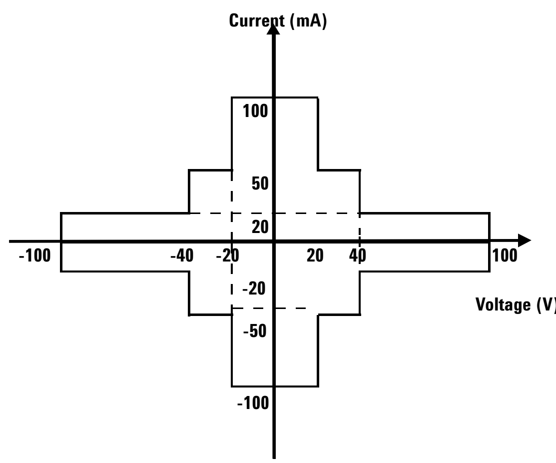
Voltage Range	Power
0.5 V	20 x Ic (W)
2 V	20 x Ic (W)
5 V	20 x Ic (W)
20 V	20 x Ic (W)
40 V	40 x Ic (W)
100 V	100 x Ic (W)

Where Ic is the current compliance setting.

Current source mode:

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

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



MPSMU Measurement and Output Range

Output terminal/connection:
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 ±100 mA
Compliance Accuracy: Same as the current (or voltage) set accuracy.

MPSMU Supplemental Information
Maximum allowable cable resistance (Kelvin connection):
Force Line: 10 Ω
Sense Line: 10 Ω
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 100 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 100 mA ranges: 100 µF
Maximum guard capacitance: 900 pF
Maximum shield capacitance: 5000 pF
Maximum guard offset voltage: ±3 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
Maximum capacitive load:
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 Resolution	Measure Resolution		Force Accuracy[1]	Measure Accuracy[1]		Maximum Current
		High Speed ADC	High Resolution ADC		High Speed ADC	High Resolution ADC	
±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)	[2]
±100 V	5 mV	5 mV	100 µV	±(0.04 % + 15 mV)	±(0.03 % + 20 mV)	±(0.03 % + 5 mV)	[3]
±200 V	10 mV	10 mV	200 µV	±(0.045 % + 30 mV)	±(0.035 % + 40 mV)	±(0.035 % + 10 mV)	[4]

1. ±(% of output/measured value + offset voltage V)
2. 1 A (Vo ≤20 V), 500 mA (20 V <Vo ≤40 V), Vo is the output voltage in Volts.
3. 1 A (Vo ≤20 V), 500 mA (20 V <Vo ≤40 V), 125 mA (40 V <Vo ≤100 V), Vo is the output voltage in Volts.
4. 1 A (Vo ≤20 V), 500 mA (20 V <Vo ≤40 V), 125 mA (40 V <Vo ≤100 V), 50 mA (100 V <Vo ≤200 V), Vo is the output voltage in Volts.

Current Range, Resolution, and Accuracy (HPSMU)

Current Range	Force Resolution	Measure Resolution[4 5]		Force Accuracy[1]	Measure Accuracy[1 2]	Maximum Voltage
		High Speed ADC	High Resolution ADC			
±1 nA	50 fA	50 fA	10 fA	±(0.5 %+3 pA+2 fA x Vo)	±(0.5 %+3 pA+2 fA x Vo)	200 V
±10 nA	500 fA	500 fA	10 fA	±(0.5 %+7 pA+20 fA x Vo)	±(0.25 %+5 pA+20 fA x Vo)	200 V
±100 nA	5 pA	5 pA	100 fA	±(0.12 %+50 pA+200 fA x Vo)	±(0.1 %+30 pA+200 fA x Vo)	200 V
±1 µA	50 pA	50 pA	1 pA	±(0.12 %+400 pA+2 pA x Vo)	±(0.1 %+200 pA+2 pA x Vo)	200 V
±10 µA	500 pA	500 pA	10 pA	±(0.12 %+5 nA+20 pA x Vo)	±(0.1 %+3 nA+20 pA x Vo)	200 V
±100 µA	5 nA	5 nA	100 pA	±(0.12 %+40 nA+200 pA x Vo)	±(0.1 %+20 nA+200 pA x Vo)	200 V
±1 mA	50 nA	50 nA	1 nA	±(0.12 %+500 nA+2 nA x Vo)	±(0.1 %+300 nA+2 nA x Vo)	200 V
±10 mA	500 nA	500 nA	10 nA	±(0.12 %+4 µA+20 nA x Vo)	±(0.1 %+2 µA+20 nA x Vo)	200 V
±100 mA	5 µA	5 µA	100 nA	±(0.12 %+50 µA+200 nA x Vo)	±(0.1 %+30 µA+200 nA x Vo)	[3]
±1 A	50 µA	50 µA	1 µA	±(0.5 %+500 µA+2 µA x Vo)	±(0.1 %+300 µA+2 µA x Vo)	[4]

1. ±(% of output/measured value + offset current A (fixed part determined by the output/measurement range + proportional part that is multiplied by Vo)
2. Measurement accuracy when using either the high-speed ADC or the high-resolution ADC
3. 200 V (Io ≤ 50 mA), 100 V (50 mA < Io ≤ 100 mA)
4. 200 V (Io ≤ 50 mA), 100 V (50 mA < Io ≤ 125 mA), 40 V (125 mA < Io ≤ 500 mA), 20 V (500 mA < Io ≤ 1 A), Io is the output current in Amps.
5. Specified measurement resolution is limited by fundamental noise limits.

Power Consumption (HPSMU)

Voltage source mode:

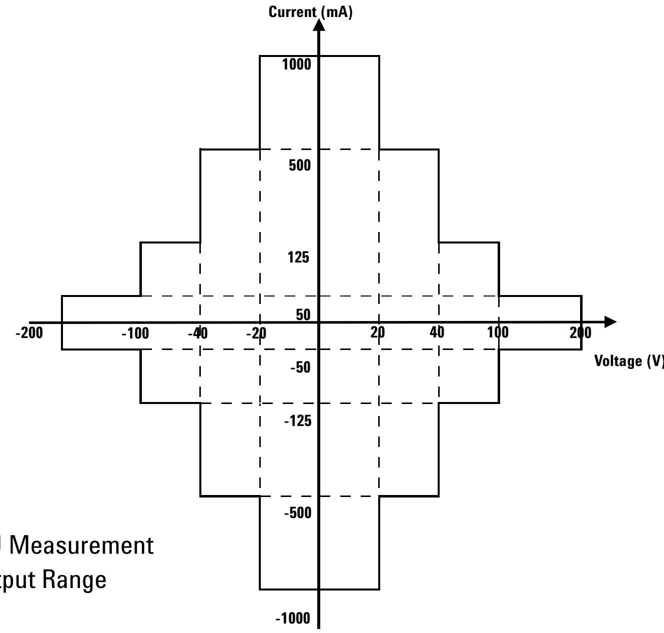
Voltage Range	Power
2 V	20 x Ic (W)
20 V	20 x Ic (W)
40 V	40 x Ic (W)
100 V	100 x Ic (W)
200 V	200 x Ic (W)

Where Ic is the current compliance setting.

Current source mode:

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

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



HPSMU Measurement and Output Range

Output terminal/connection:

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 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:

- ≥ 10^{13} Ω

Current source output resistance:

- ≥ 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 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

Maximum capacitive load:

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)

Atto Level HRSMU Module Specifications (without ASU)

Voltage Range, Resolution, and Accuracy (Atto Level HRSMU without ASU)

Voltage Range	Force Resolution	Measure Resolution		Force Accuracy[1]	Measure Accuracy[1]		Maximum Current
		High Speed ADC	High Resolution ADC		High Speed ADC	High Resolution ADC	
±0.5 V	25 µV	25 µV	0.5 µV	±(0.02 % + 150 µV)	±(0.01 % + 250 µV)	±(0.01 % + 150 µV)	100 mA
±2 V	100 µV	100 µV	2 µV	±(0.02 % + 400 µV)	±(0.01 % + 700 µV)	±(0.01 % + 200 µV)	100 mA
±5 V	250 µV	250 µV	5 µV	±(0.02 % + 750 µV)	±(0.01 % + 2 mV)	±(0.01 % + 250 µV)	100 mA
±20 V	1 mV	1 mV	20 µV	±(0.02 % + 3 mV)	±(0.01 % + 4 mV)	±(0.01 % + 1 mV)	100 mA
±40 V	2 mV	2 mV	40 µV	±(0.025 % + 6 mV)	±(0.015 % + 8 mV)	±(0.015 % + 2 mV)	[2]
±100 V	5 mV	5 mV	100 µV	±(0.03 % + 15 mV)	±(0.02% + 20 mV)	±(0.02 % + 5 mV)	[3]

1. ±(% of output/measured value + offset voltage)
2. 100 mA (Vout ≤20 V), 50 mA (20 V <Vout ≤40 V), Vo is the output voltage in Volts.
3. 100 mA (Vout ≤20 V), 50 mA (20 V <Vout ≤40 V), 20 mA (40 V <Vout ≤100 V), Vo is the output voltage in Volts.

Current Range, Resolution, and Accuracy (Atto Level HRSMU without ASU)

Current Range	Force Resolution	Measure Resolution[4,5]		Force Accuracy[1]	Measure Accuracy[1,2]	Maximum Voltage
		High Speed ADC	High Resolution ADC			
±10 pA	5 fA	1 fA	1 fA	±(0.5 %+40 fA+10 aA x Vo)	±(0.5 %+15 fA+10 aA x Vo)	100 V
±100 pA	5 fA	5 fA	2 fA	±(0.5 %+120 fA+100 aA x Vo)	±(0.5 %+40 fA+100 aA x Vo)	100 V
±1 nA	50 fA	50 fA	10 fA	±(0.25 %+400 fA+1 fA x Vo)	±(0.25 %+300 fA+1 fA x Vo)	100 V
±10 nA	500 fA	500 fA	10 fA	±(0.25 %+4 pA+10 fA x Vo)	±(0.25 %+2 pA+10 fA x Vo)	100 V
±100 nA	5 pA	5 pA	100 fA	±(0.12 %+40 pA+100 fA x Vo)	±(0.1 %+20 pA+100 fA x Vo)	100 V
±1 µA	50 pA	50 pA	1 pA	±(0.12 %+400 pA+1 pA x Vo)	±(0.1 %+200 pA+1 pA x Vo)	100 V
±10 µA	500 pA	500 pA	10 pA	±(0.07 %+4 nA+10 pA x Vo)	±(0.05 %+2 nA+10 pA x Vo)	100 V
±100 µA	5 nA	5 nA	100 pA	±(0.07 %+40 nA+100 pA x Vo)	±(0.05 %+20 nA+100 pA x Vo)	100 V
±1 mA	50 nA	50 nA	1 nA	±(0.06 %+400 nA+1 nA x Vo)	±(0.04 %+200 nA+1 nA x Vo)	100 V
±10 mA	500 nA	500 nA	10 nA	±(0.05 %+4 µA+10 nA x Vo)	±(0.04 %+2 µA+10 nA x Vo)	100 V
±100 mA	5 µA	5 µA	100 nA	±(0.12 %+40 µA+100 nA x Vo)	±(0.1 %+20 µA+100 nA x Vo)	[3]

1. ±(% of output/measured value + offset current A (fixed part determined by the output/measurement range + proportional part that is multiplied by Vo)
2. Measurement accuracy when using either the high-speed ADC or the high-resolution ADC.
3. 100 V (Io ≤ 20 mA), 40 V (20 mA < Io≤ 50 mA), 20 V (50 mA < Io≤ 100 mA), Io is the output current in Amps.
4. Minimum 10 aA display resolution at 10 pA range by 6 digits.
5. Specified measurement resolution is limited by fundamental noise limits.

Power Consumption (Atto Level HRSMU without ASU)

Voltage source mode:

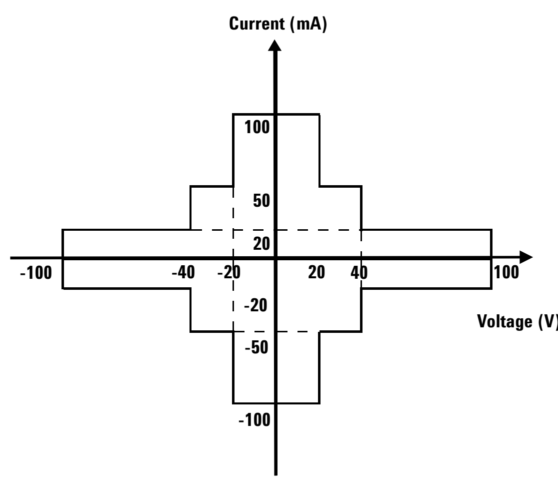
Voltage Range	Power
0.5 V	20 x Ic (W)
2 V	20 x Ic (W)
5 V	20 x Ic (W)
20 V	20 x Ic (W)
40 V	40 x Ic (W)
100 V	100 x Ic (W)

Where Ic is the current compliance setting.

Current source mode:

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

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



Atto Level HRSMU without ASU Measurement and Output Range

Output terminal/connection:
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: ±100 fA to ±100 mA
Compliance Accuracy: Same as the current (or voltage) set accuracy.

Atto Level HRSMU without ASU Supplemental Information
Maximum allowable cable resistance (Kelvin connection):
Force Line: 10 Ω
Sense Line: 10 Ω
Voltage source output resistance:
0.3 Ω Typical (Force line, Non-Kelvin connection)
Voltage measurement input resistance:
≥ 10^{13} Ω
Current source output resistance:
≥ 10^{13} Ω (1 nA range)
Current compliance setting accuracy (for opposite polarity):
For 10 pA to 10 nA ranges:
I setting accuracy ±12% of range
For 100 nA to 100 mA ranges:
I setting accuracy ±2.5% of range
Maximum capacitive load:
For 10 pA to 10 nA ranges: 1000 pF
For 100 nA to 10 mA ranges: 10 nF
For 100 mA to 100 mA ranges: 100 µF
Maximum guard capacitance: 900 pF
Maximum shield capacitance: 5000 pF
Maximum guard offset voltage: ±3 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
Maximum capacitive load:
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)

Atto Level HRSMU Module Specifications (with ASU)

Voltage Range, Resolution, and Accuracy (Atto Level HRSMU with ASU)

Voltage Range	Force Resolution	Measure Resolution		Force Accuracy[1]	Measure Accuracy[1]		Maximum Current
		High Speed ADC	High Resolution ADC		High Speed ADC	High Resolution ADC	
±0.5 V	25 µV	25 µV	0.5 µV	±(0.02 % + 150 µV)	±(0.01 % + 250 µV)	±(0.01 % + 150 µV)	100 mA
±2 V	100 µV	100 µV	2 µV	±(0.02 % + 400 µV)	±(0.01 % + 700 µV)	±(0.01 % + 200 µV)	100 mA
±5 V	250 µV	250 µV	5 µV	±(0.02 % + 750 µV)	±(0.01 % + 2 mV)	±(0.01 % + 250 µV)	100 mA
±20 V	1 mV	1 mV	20 µV	±(0.02 % + 3 mV)	±(0.01 % + 4 mV)	±(0.01 % + 1 mV)	100 mA
±40 V	2 mV	2 mV	40 µV	±(0.025 % + 6 mV)	±0.015 % + 8 mV)	±(0.015 % + 2 mV)	[2]
±100 V	5 mV	5 mV	100 µV	±(0.03 % + 15 mV)	±(0.02% + 20 mV)	±(0.02 % + 5 mV)	[3]

1. ±(% of output/measured value + offset voltage)
2. 100 mA (Vout ≤20 V), 50 mA (20 V <Vout ≤40 V), Vo is the output voltage in Volts.
3. 100 mA (Vout ≤20 V), 50 mA (20 V <Vout ≤40 V), 20 mA (40 V <Vout ≤100 V), Vo is the output voltage in Volts.

Current Range, Resolution, and Accuracy (Atto Level HRSMU with ASU)

Current Range	Force Resolution	Measure Resolution[4 5]		Force Accuracy[1]	Measure Accuracy[1 2]	Maximum Voltage
		High Speed ADC	High Resolution ADC			
±1 pA	1 fA	100 aA	100 aA	±(1.8 %+15 fA)	±(1.8 %+12 fA)	100 V
±10 pA	5 fA	1 fA	400 aA	±(0.5 %+40 fA+10 aA x Vo)	±(0.5 %+15 fA+10 aA x Vo)	100 V
±100 pA	5 fA	5 fA	500 aA	±(0.5 %+120 fA+100 aA x Vo)	±(0.5 %+40 fA+100 aA x Vo)	100 V
±1 nA	50 fA	50 fA	10 fA	±(0.25 %+400 fA+1 fA x Vo)	±(0.25 %+300 fA+1 fA x Vo)	100 V
±10 nA	500 fA	500 fA	10 fA	±(0.25 %+4 pA+10 fA x Vo)	±(0.25 %+2 pA+10 fA x Vo)	100 V
±100 nA	5 pA	5 pA	100 fA	±(0.12 %+40 pA+100 fA x Vo)	±(0.1 %+20 pA+100 fA x Vo)	100 V
±1 µA	50 pA	50 pA	1 pA	±(0.12 %+400 pA+1 pA x Vo)	±(0.1 %+200 pA+1 pA x Vo)	100 V
±10 µA	500 pA	500 pA	10 pA	±(0.07 %+4 nA+10 pA x Vo)	±(0.05 %+2 nA+10 pA x Vo)	100 V
±100 µA	5 nA	5 nA	100 pA	±(0.07 %+40 nA+100 pA x Vo)	±(0.05 %+20 nA+100 pA x Vo)	100 V
±1 mA	50 nA	50 nA	1 nA	±(0.06 %+400 nA+1 nA x Vo)	±(0.04 %+200 nA+1 nA x Vo)	100 V
±10 mA	500 nA	500 nA	10 nA	±(0.06 %+4 µA+10 nA x Vo)	±(0.04 %+2 µA+10 nA x Vo)	100 V
±100 mA	5 µA	5 µA	100 nA	±(0.12 %+40 µA+100 nA x Vo)	±(0.1 %+20 µA+100 nA x Vo)	[3]

1. ±(% of output/measured value + offset current A (fixed part determined by the output/measurement range + proportional part that is multiplied by Vo)
2. Measurement accuracy when using either the high-speed ADC or the high-resolution ADC.
3. 100 V (Io ≤ 20 mA), 40 V (20 mA < Io ≤ 50 mA), 20 V (50 mA < Io ≤ 100 mA), Io is the output current in Amps
4. Minimum 1 aA display resolution at 1 pA range by 6 digits.
5. Specified measurement resolution is limited by fundamental noise limits.
6. Measurements at lower range are affected strongly by vibrations and shocks. Do not place the environment of vibrations and shocks during measurements.

Power Consumption (Atto Level HRSMU with ASU)

Voltage source mode:

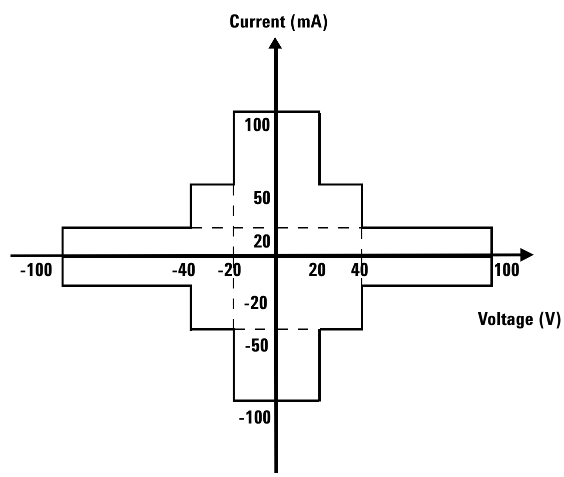
Voltage Range	Power
0.5 V	20 x Ic (W)
2 V	20 x Ic (W)
5 V	20 x Ic (W)
20 V	20 x Ic (W)
40 V	40 x Ic (W)
100 V	100 x Ic (W)

Where Ic is the current compliance setting.

Current source mode:

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

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



Atto Level HRSMU with ASU
Measurement and Output Range

Output terminal/connection:
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: ±10 fA to ±100 mA
Compliance Accuracy: Same as the current (or voltage) set accuracy.

Atto Level HRSMU with ASU Supplemental Information
Maximum allowable cable resistance (Kelvin connection):
Force Line: 10 Ω
Sense Line: 10 Ω
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 pA to 10 nA ranges:
I setting accuracy ±12% of range
For 100 nA to 100 mA ranges:
I setting accuracy ±2.5% of range
Maximum capacitive load:
For 1 pA to 10 nA ranges: 1000 pF
For 100 nA to 10 mA ranges: 10 nF
For 100 mA to 100 mA ranges: 100 μF
Maximum guard capacitance: 660 pF
Maximum shield capacitance: 3500 pF
Maximum guard offset voltage:
±4.2 mV (Iout ≤ 100 μA)
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
Maximum capacitive load:
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)

Atto Sense and Switch Unit (ASU)

AUX Path Specification

Maximum Voltage
100 V: between AUX Input and AUX Common
100 V: between AUX Input and Circuit Common
42 V: between AUX Common and Circuit Common

Maximum Current
0.5 A: between AUX Input and Force output

ASU Supplemental Information

Band width (at -3 dB): < 30 MHz (AUX port)

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, HPSMU, and Atto Level HRSMU 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, 1003s 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: 5 ms 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 E5270B supports a time stamp function utilizing an internal quartz clock.

Resolution: 100 μs

Program Memory

The E5270B mainframe contains (volatile) memory that can be used to increase test measurement throughput. Program memory allows the storage of program code in the E5270B, 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 E5270B 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 E5270B 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 70% RH, non-condensing
Storage: 5% to 80% RH, at 50°C, 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)

E5270B: 600 VA

Regulatory Compliance

EMC:	IEC61326-1:+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

E5270B: 426 mm W x 235 mm H x 575 mm D

Weight

E5270B (empty): 17 kg
E5280B: 2.5 kg
E5281B: 1.4 kg
E5287A: 1.5 kg
E5288A: 0.5 kg

4157B Furnished Accessories

Manual CD-ROM
Software CD-ROM (including VXI*plug&play* driver and E5270 TIS Library)
PC-based controller
Agilent 82357A USB/GPIB interface (including Agilent IO library)
E5241C Agilent I/CV 3.0 Lite (including manual CD-ROM and software CD-ROM)

Automation Software

I/CV 3.0 Lite

Overview

Agilent I/CV 3.0 Lite provides automated test solutions for semiconductor characterization. It supports the Agilent E5270 Series, the Agilent E5260 Series, the Agilent 4155C and 4156C, the Agilent E5250A Low Leakage Switch, the Agilent B2200A and B2201A Ultra Low Leakage Switch, the Keithley 707 Switching Matrix, the Agilent 4284A and 4294A LCR meters, and many popular semi-automatic wafer probers. I/CV Lite also provides wizard-based test development, test execution, and sequencing along with data logging and post- analysis tools on Microsoft ® Windows.®

Configuration Information

I/CV 3.0 Lite comes standard with the 4157B. A PC-based instrument controller with I/CV 3.0 Lite pre-installed and an Agilent 82357A USB/GPIB interface are also included in the standard 4157B configuration. If you prefer to use your own PC and GPIB interface, the controller and cable can be deleted from your order. I/CV 3.0 Lite, however, is always included with the 4157B. If you want the full version of I/CV 3.0, you can request the E5240CU upgrade kit when you order the 4157B. For more information on the differences between I/CV 3.0 Lite and I/CV 3.0, please refer to the Agilent I/CV 3.0 Technical Overview, publication number 5989-1408EN.

Software Functions

Interactive Measurements
I/CV Lite includes Agilent ICS as the default measurement tool. ICS provides point-and-click measurements and graphical analysis capabilities for semiconductor parametric measurements. Created setups can be used as measurement algorithms in the script editor.

Script Editor
The script editor provides a wizard-based interface for building test scripts used in the execution of automated tests. It allows access to libraries of built-in software components that support functions for creating test plans. Components include:

- Automated sub-die prober movement
- Switch connection execution
- Test algorithm execution
- Pass/Fail determination and processing
- Conditional branching: IF, ELSE
- User variable creation
- User prompts
- Message displays
- Test script commenting

Wafer Prober Navigation
I/CV Lite provides support for popular semiautomatic probers as well as several automatic probers. Probe plans can be defined that include sub-die movement for performing automated test of multiple modules or individual devices across a wafer. Interactive prober control can also be implemented for analytical applications.

Test Execution
Test scripts can be executed for either manual or automated tests. Manual tests are used for single devices or single modules (which can include several devices) on a manual prober. Automated tests are used for wafer tests combing semiautomatic prober control with die or module test scripts. Test wizards provide step-by-step instructions for entering runtime information, selection of wafer navigation plans, selection of test plans, and starting a test.

Auto-Analysis and Test Reporting
Parametric quantities from test data can be extracted and standard reports and graphs can be generated. Supported graphs and reports include:
- Color wafer maps
- Histograms
- Parameter statistics
- Parametric values vs. die location
- Tables of I-V or C-V curve data

Software Measurement Tool Support
Test algorithms can be created using the following tools:
- Agilent ICS
- Microsoft VBScript (resident in the script editor)

Computer System Requirements

Operating System
Microsoft Windows 2000 Professional or XP Professional with Service Pack 1

CPU
300 MHz Pentium II-class
(500 MHz Pentium III-class or faster recommended)

Hard Disk
5 GB available space
(20 GB recommended)

Memory
128 MB for Windows 2000 Professional
(256 MB recommended)
256 MB for Windows XP Professional

Disk Drive
CD-ROM

Software Security
Parallel or USB port required to connect security key

Control I/F
Supported GPIB card (see requirements below)

GPIB Card Support

Agilent

Card	Windows 2000 Professional	Windows XP Pro. (Service Pack 1)
82341C (ISA)	X	-
82357A* (USB/GPIB)	X	X

Agilent I/O Library L.02.01 required
*The 4142B cannot be controlled with the 82357A.

National Instruments

Card	Windows 2000 Professional	Windows XP Pro. (Service Pack 1)
PCI-GPIB	X	X
GPIB-USB-A	X	X

Prober Support

All prober support is via GPIB.

Cascade Microtech
S 300 with Nucleus version 3.0
Summit 12k with Nucleus version 3.0

SUSS MicroTec
All SUSS MicroTec probe stations using Prober Bench v5.0

Vector Semiconductor
AX-2000 /VX-3000,Version 3.2 or later

Supported Measurement Instruments
- E5270 Series of Parametric Measurement Solutions
- E5270B Precision Measurement Mainframe
- E5260 Series of High Speed Measurement Solutions
- 4155A/B/C Semiconductor Parameter Analyzer
- 4156A/B/C Precision Semiconductor Parameter Analyzer
- 4284A Precision LCR Meter
- 4294A Impedance Analyzer*
- E5250A Low Leakage Switch Mainframe
- B2200A fA Leakage Switch Mainframe
- B2201A 14ch Low Leakage Switch Mainframe
- Keithley 707 Switch

*VBScript libraries are supplied.

For more information about Agilent and its products, go to **www.agilent.com**.
For more information about Agilent Technologies semiconductor test products, applications, and services, visit our website: **www.agilent.com/go/semiconductor** or you can call one of the centers listed and ask to speak with a semiconductor test sales representative.

Americas
Brazil (11) 4197-3600
Canada (French) 1 877 894-4414
Canada (English) 1 800 447-8378
Mexico 33 134-5841
United States 1 800 447-8378

Asia/Asia Pacific
Australia 1 800 629-485
China 1 800 276-3059
Hong Kong 852 2599 7889
India 91/11 690-6156
Japan 0120 421-345
Malaysia 1 800 880-780
New Zealand 0 800 738 378
Philippines 1 800 1651-0135
Singapore 1 800 276-3059
South Korea 080 778-0011
Taiwan 0 800 047-662
Thailand 1 800 2758-5822

Europe
Austria (01) 25 125-7183
Belgium (0) 2 404-9380
Denmark 080301040
Finland 20 547-9999
France (0) 825 010710
Germany (0) 18 05 24-63 34
Greece 20 547-9999
Ireland 016158393
Italy 02 92 60 8333
Luxembourg (0) 2 404-9340
Netherlands (0) 20 547-9999
Poland 20 547-9999
Russia 20 547-9999
Spain 91 631 3383
Sweden 020 120-9975
Switzerland (Italian) (0) 2 92 60 8484
Switzerland (German) (0) 1 735-9300
Switzerland (French) (0) 825 010 700
United Kingdom (0) 7004 222-222

Middle East
Israel 20 547-9999

5989-1358EN

Agilent Technologies