Agilent 4155C Semiconductor Parameter Analyzer

Agilent 4156C Precision Semiconductor Parameter Analyzer

Data Sheet

Introduction

Agilent 4155C and 4156C
Basic functions

- Set measurement and/or stress conditions
- Control measurement and/or stress execution
- Perform arithmetic calculations
- Display measured and calculated results on the LCD display
- Perform graphical analysis
- Store and recall measurement setups, and measurement and graphical display data
- Dump to printers or plotters for hardcopy output
- Perform measurement and analysis with built-in instrument BASIC
- Self test, Auto calibration

Configuration

The 4155C and 4156C both come standard with Desktop EasyEXPERT software. A PC-based instrument controller with Desktop EasyEXPERT preinstalled is also included with the standard configuration. You have the option of deleting the controller and cable from your order, but Desktop EasyEXPERT Standard edition is always included with both instruments.

If you want the Desktop EasyEXPERT Plus edition, you can request the B1541A-002 when you order a 4155C or 4156C. For more information about the Desktop EasyEXPERT Plus, please refer to page 11 of this data sheet.

<table>
<thead>
<tr>
<th>4155C</th>
<th>4156C</th>
</tr>
</thead>
<tbody>
<tr>
<td>4xMPSMU</td>
<td>4xHRSMU</td>
</tr>
<tr>
<td>2xVMU</td>
<td>2xVMU</td>
</tr>
<tr>
<td>2xVSU</td>
<td>2xVSU</td>
</tr>
<tr>
<td>Desktop EasyEXPERT</td>
<td>Desktop EasyEXPERT</td>
</tr>
</tbody>
</table>

Standard PC-based controller and USB/GPIB interface

41501B (Optional)

- 2xPGU (Option)¹
- HPSMU (Option) or 2xMPSMU (Option)¹

GNDU

SMU: Source monitor unit
Display resolution: 6 digits at each current range (0.01 fA display resolution at 10 pA range)²
HRSMU: High Resolution SMU
(1 fA/2 µV to 100 mA/100 V)
MPSMU: Medium Power SMU
(10 fA/2 µV to 100 mA/100 V)
HPSMU: High Power SMU
(10 fA/2 µV to 1 A/200 V)
VMU: Voltage Monitor Unit
(0.2 µV resolution in differential mode)
VSU: Voltage Source Unit
PGU: Pulse Generator Unit
(1 channel)
GNDU: Ground Unit

1. Minimum number of installable MPSMU or PGU is two.
2. Accuracy not guaranteed. Minimum guaranteed resolution is 1 fA at 10 pA range.
Hardware

Specification Condition

The “supplemental” information and “typical” entries in the following specifications are not warranted, but provide useful information about the functions and performance of the instruments.

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

1. 23 °C ±5 °C (double between 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. Integration time: medium or long
5. Filter: ON (for SMUs)
6. Kelvin connection (for HRSMU, HPSMU, and GNDU)
7. Calibration period: 1 year

Agilent 4156C Precision Semiconductor Parameter Analyzer

HRSMU (High Resolution SMU) Specifications

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>±2 V</td>
<td>100 μV</td>
<td>±(0.02%+400 μV)</td>
<td>2 μV</td>
<td>±(0.01%+200 μV)</td>
<td>100 mA</td>
</tr>
<tr>
<td>±20 V</td>
<td>1 mV</td>
<td>±(0.02%+3 mV)</td>
<td>20 μV</td>
<td>±(0.01%+1 mV)</td>
<td>100 mA</td>
</tr>
<tr>
<td>±40 V</td>
<td>2 mV</td>
<td>±(0.025%+6 mV)</td>
<td>40 μV</td>
<td>±(0.015%+2 mV)</td>
<td>1</td>
</tr>
<tr>
<td>±100 V</td>
<td>5 mV</td>
<td>±(0.03%+15 mV)</td>
<td>100 μV</td>
<td>±(0.02%+5 mV)</td>
<td>2</td>
</tr>
</tbody>
</table>

1 100 mA (Vout≤20 V), 50 mA (20 V<Vout≤50 V)
2 100 mA (Vout≤20 V), 50 mA (20 V<Vout≤50 V), 20 mA (40 V<Vout≤100 V)

Current Range, Resolution, and Accuracy (HRSMU)

<table>
<thead>
<tr>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>±10 pA</td>
<td>10 fA</td>
<td>±(4%+400 fA) 2</td>
<td>1 fA</td>
<td>±(4%+20 fA+1 fA×Vout/100) 2</td>
<td>100 V</td>
</tr>
<tr>
<td>±100 pA</td>
<td>10 fA</td>
<td>±(4%+400 fA) 2</td>
<td>10 fA</td>
<td>±(0.5%+40 pA+1 fA×Vout) 2</td>
<td>100 V</td>
</tr>
<tr>
<td>±1 nA</td>
<td>100 fA</td>
<td>±(0.5%+400 pA+1 fA×Vout) 2</td>
<td>100 fA</td>
<td>±(0.5%+400 pA+1 fA×Vout) 2</td>
<td>100 V</td>
</tr>
<tr>
<td>±10 nA</td>
<td>100 fA</td>
<td>±(0.1%+400 pA+10 fA×Vout)</td>
<td>100 fA</td>
<td>±(0.1%+20 pA+100 fA×Vout)</td>
<td>100 V</td>
</tr>
<tr>
<td>±100 nA</td>
<td>10 pA</td>
<td>±(0.1%+400 pA+100 fA×Vout)</td>
<td>10 pA</td>
<td>±(0.1%+200 pA+100 fA×Vout)</td>
<td>100 V</td>
</tr>
<tr>
<td>±1 μA</td>
<td>100 pA</td>
<td>±(0.1%+400 pA+1000 fA×Vout)</td>
<td>100 pA</td>
<td>±(0.1%+2000 pA+1000 fA×Vout)</td>
<td>100 V</td>
</tr>
<tr>
<td>±10 μA</td>
<td>10 pA</td>
<td>±(0.1%+400 pA+10000 fA×Vout)</td>
<td>10 pA</td>
<td>±(0.1%+20000 pA+10000 fA×Vout)</td>
<td>100 V</td>
</tr>
<tr>
<td>±100 μA</td>
<td>100 nA</td>
<td>±(0.06%+400 pA+1000 fA×Vout)</td>
<td>100 pA</td>
<td>±(0.06%+2000 pA+1000 fA×Vout)</td>
<td>100 V</td>
</tr>
<tr>
<td>±1 mA</td>
<td>1 μA</td>
<td>±(0.06%+400 pA+10000 fA×Vout)</td>
<td>1 μA</td>
<td>±(0.06%+20000 pA+10000 fA×Vout)</td>
<td>100 V</td>
</tr>
<tr>
<td>±100 mA</td>
<td>10 μA</td>
<td>±(0.1%+400 pA+100000 fA×Vout)</td>
<td>100 μA</td>
<td>±(0.1%+200000 pA+100000 fA×Vout)</td>
<td>100 V</td>
</tr>
</tbody>
</table>

1 The accuracy is applicable when offset cancellation has been performed.
2 The offset current specification is multiplied by one of the following factors depending upon the ambient temperature and humidity (RH = Relative Humidity):

<table>
<thead>
<tr>
<th>Temperature</th>
<th>5 °C to 18 °C</th>
<th>18 °C to 28 °C</th>
<th>28 °C to 40 °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>RH</td>
<td>x2</td>
<td>x1</td>
<td>x2</td>
</tr>
</tbody>
</table>

1 100 V (Vout≤20 mA), 40 V (20 mA≤Vout≤50 mA), 20 V (50 mA≤Vout≤100 mA)

Output Terminal/Connection:
Dual triaxial connectors, 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 (voltage) settling accuracy.

HRSMU Supplemental Information:
Maximum allowable cable resistance when using Kelvin connection (Force, Sense): 10 Ω
Typical voltage source output resistance (Force line/non-Kelvin connection): 0.2 Ω
Voltage measurement input resistance/current source output resistance:
±10¹⁵ Ω (10 pA range)
Current compliance setting accuracy for opposite polarity:
10 pA to 10 nA range: V/I setting accuracy ±12% of range
100 nA to 100 mA range: V/I setting accuracy ±2.5% of range

Vout is the output voltage in volts. Iout is the output current in amps.
For example, accuracy specifications are given as ±% of set/measured value (0.04%) plus offset value (200 nA+1 nA×Vout) for the 1 mA range.
The offset value consists of a fixed part determined by the set/measurement range and a proportional part that is multiplied by Vout or Vout/100.
Agilent 4156C Semiconductor Parameter Analyzer

MPSMU (Medium Power SMU) Specifications

**Voltage Range, Resolution, and Accuracy (MPSMU)**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>±2 V</td>
<td>100 μV</td>
<td>±(0.03%+960 μV+0.3×</td>
<td>lout</td>
<td>)</td>
</tr>
<tr>
<td>±20 V</td>
<td>1 mV</td>
<td>±(0.03%+4 mV+0.3×lout)</td>
<td>20 μV</td>
<td>±(0.02%+2 mV+0.3×lout)</td>
</tr>
<tr>
<td>±40 V</td>
<td>2 mV</td>
<td>±(0.03%+7 mV+0.3×</td>
<td>lout</td>
<td>)</td>
</tr>
<tr>
<td>±100 V</td>
<td>5 mV</td>
<td>±(0.04%+15 mV+0.3×lout)</td>
<td>100 μV</td>
<td>±(0.03%+5 mV+0.3×lout)</td>
</tr>
</tbody>
</table>

1. 100 mA (Vout ≤20 V), 50 mA (20 V < Vout ≤40 V)
2. 100 mA (Vout ≤20 V), 50 mA (20 V < Vout ≤40 V), 20 mA (40 V < Vout ≤100 V)

**Current Range, Resolution, and Accuracy (MPSMU)**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>±1 nA</td>
<td>100 fA</td>
<td>±(0.5%+3 pA+2 fA×Vout)</td>
<td>10 fA</td>
<td>±(0.5%+3 pA+2 fA×Vout)</td>
</tr>
<tr>
<td>±10 nA</td>
<td>1 pA</td>
<td>±(0.5%+7 pA+20 fA×Vout)</td>
<td>10 fA</td>
<td>±(0.5%+5 pA+20 fA×Vout)</td>
</tr>
<tr>
<td>±100 nA</td>
<td>10 pA</td>
<td>±(0.1%+50 pA+200 fA×Vout)</td>
<td>100 fA</td>
<td>±(0.1%+30 pA+200 fA×Vout)</td>
</tr>
<tr>
<td>±1 μA</td>
<td>100 pA</td>
<td>±(0.1%+400 pA+2 pA×Vout)</td>
<td>1 pA</td>
<td>±(0.1%+200 pA+2 pA×Vout)</td>
</tr>
<tr>
<td>±10 μA</td>
<td>10 μA</td>
<td>±(0.12%+500 pA+200 fA×Vout)</td>
<td>100 fA</td>
<td>±(0.12%+300 pA+200 fA×Vout)</td>
</tr>
<tr>
<td>±100 μA</td>
<td>100 μA</td>
<td>±(0.12%+40 μA+20 μA×Vout)</td>
<td>100 fA</td>
<td>±(0.12%+20 μA+20 μA×Vout)</td>
</tr>
<tr>
<td>±1 mA</td>
<td>100 μA</td>
<td>±(0.12%+50 μA+200 μA×Vout)</td>
<td>100 fA</td>
<td>±(0.1%+30 μA+200 μA×Vout)</td>
</tr>
</tbody>
</table>

1. 100 V (Iout ≤20 V), 40 V (20 mA < Iout ≤50 mA), 20 V (50 mA < Iout ≤100 mA)
2. Vout is the output voltage in volts. Iout is the output current in amps.

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 (voltage) settling accuracy.

MPSMU Supplemental Information:
Typical voltage source output resistance: 0.3 Ω
Voltage measurement input resistance/current source output resistance: ±10⁻¹⁵ Ω (1 nA range)
Current compliance setting accuracy for opposite polarity: 1 nA to 10 nA range: V/I setting accuracy ±12% of range
100 nA to 100 mA range: V/I setting accuracy ±2.5% of range

VSU and VMU specifications are common to both the 4155C and 4156C

**VSU (Voltage Source Unit) Specifications**

**VSU Output Range:**

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>±20 V</td>
<td>1 mV</td>
<td>±(0.05% of setting +10 mV)</td>
</tr>
</tbody>
</table>

1. Specification is applicable under no load current.
Max. Output Current: 100mA

**VSU Supplemental Information:**
Output resistance: 0.2 Ω (typical)
Maximum load capacitance: 10 μF
Maximum slew rate: 0.2 V/μs
Current limit: 120 mA (typical)
Output Noise: 1 mV rms (typical)

**VMU (Voltage Monitor Unit) Specifications**

**VMU Differential Mode Range, Resolution, and Accuracy:**

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>±0.2 V</td>
<td>2 μV</td>
<td>±(0.03%+10 μV+0.3 μV×Vi)</td>
<td></td>
</tr>
<tr>
<td>±2 V</td>
<td>2 μV</td>
<td>±(0.02%+100 μV+3 μV×Vi)</td>
<td></td>
</tr>
</tbody>
</table>

Max. Common Mode Voltage: ±20 V
Note: Vi is the input voltage of VMU2 in volts.
For example, accuracy specifications are given as ±% of set/measured value (0.02%) plus offset value (100 μV+3 μV×Vi) for the 2 V range. The differential mode offset value consists of a fixed part determined by the measurement range and a proportional part that is multiplied by Vi.

**VMU Measurement Range, Resolution, and Accuracy:**

<table>
<thead>
<tr>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>±2 V</td>
<td>2 μV</td>
<td>±(0.02%+200 μV)</td>
</tr>
<tr>
<td>±20 V</td>
<td>20 μV</td>
<td>±(0.02%+1 mV)</td>
</tr>
</tbody>
</table>

**VMU Supplemental Information:**
Input Impedance: ≥1 GΩ
Input leakage current (at 8 V): ≤500 pA
Measurement noise: 0.01% of range (p-p) (typical) when integration time is 10 PLC
Differential mode measurement noise: 0.005% of range (p-p) (typical) when integration time is short.
### Agilent 41501B SMU and Pulse Generator Expander

#### HPSMU (High Power SMU) Specifications

##### Voltage Range, Resolution, and Accuracy (HPSMU)

<table>
<thead>
<tr>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>±2 V</td>
<td>100 μV</td>
<td>±(0.03%+900 μV)</td>
<td>2 μV</td>
<td>±(0.02%+700 μV)</td>
<td>1 A</td>
</tr>
<tr>
<td>±20 V</td>
<td>1 mV</td>
<td>±(0.03%+4 mV)</td>
<td>20 μV</td>
<td>±(0.02%+2 mV)</td>
<td>1 A</td>
</tr>
<tr>
<td>±40 V</td>
<td>2 mV</td>
<td>±(0.03%+7 mV)</td>
<td>40 μV</td>
<td>±(0.02%+3 mV)</td>
<td>500 mA</td>
</tr>
<tr>
<td>±100 V</td>
<td>5 mV</td>
<td>±(0.04%+15 mV)</td>
<td>100 μV</td>
<td>±(0.03%+5 mV)</td>
<td>125 mA</td>
</tr>
<tr>
<td>±200 V</td>
<td>10 mV</td>
<td>±(0.045%+30 mV)</td>
<td>200 μV</td>
<td>±(0.035%+10 mV)</td>
<td>50 mA</td>
</tr>
</tbody>
</table>

##### Current Range, Resolution, and Accuracy (HPSMU)

<table>
<thead>
<tr>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>±1 nA</td>
<td>100 fA</td>
<td>±(0.5%+3 pA+2 fA×Vout)</td>
<td>10 fA</td>
<td>±(0.5%+3 pA+2 fA×Vout)</td>
<td>200 V</td>
</tr>
<tr>
<td>±10 nA</td>
<td>1 pA</td>
<td>±(0.5%+7 pA+20 fA×Vout)</td>
<td>10 fA</td>
<td>±(0.5%+7 pA+20 fA×Vout)</td>
<td>200 V</td>
</tr>
<tr>
<td>±1 μA</td>
<td>100 pA</td>
<td>±(0.12%+400 pA+200 fA×Vout)</td>
<td>100 fA</td>
<td>±(0.12%+400 pA+200 fA×Vout)</td>
<td>200 V</td>
</tr>
<tr>
<td>±10 μA</td>
<td>10 nA</td>
<td>±(0.12%+50 nA+20 pA×Vout)</td>
<td>100 fA</td>
<td>±(0.12%+50 nA+20 pA×Vout)</td>
<td>200 V</td>
</tr>
<tr>
<td>±100 μA</td>
<td>1 μA</td>
<td>±(0.12%+4 pA+200 pA×Vout)</td>
<td>100 fA</td>
<td>±(0.12%+4 pA+200 pA×Vout)</td>
<td>200 V</td>
</tr>
<tr>
<td>±1 mA</td>
<td>100 nA</td>
<td>±(0.12%+500 nA+200 pA×Vout)</td>
<td>100 fA</td>
<td>±(0.12%+500 nA+200 pA×Vout)</td>
<td>200 V</td>
</tr>
<tr>
<td>±10 mA</td>
<td>1 μA</td>
<td>±(0.12%+4 μA+200 nA×Vout)</td>
<td>100 fA</td>
<td>±(0.12%+4 μA+200 nA×Vout)</td>
<td>200 V</td>
</tr>
<tr>
<td>±100 mA</td>
<td>10 μA</td>
<td>±(0.12%+50 μA+2000 nA×Vout)</td>
<td>100 fA</td>
<td>±(0.12%+50 μA+2000 nA×Vout)</td>
<td>200 V</td>
</tr>
<tr>
<td>±1 A</td>
<td>100 μA</td>
<td>±(0.5%+500 μA+2 μA×Vout)</td>
<td>1 μA</td>
<td>±(0.5%+500 μA+2 μA×Vout)</td>
<td>200 V</td>
</tr>
</tbody>
</table>

1. 200 V (Iout ≤50 mA), 100 V (50 mA<Iout<100 mA)  
2. 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 mA)  

Vout is the output voltage in volts. Iout is the output current in amps. For example, accuracy specifications are given as ±% of set/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 set/measurement range and a proportional part that is multiplied by Vout.

### Output Terminal/Connection:
Dual triaxial connectors, Kelvin (remote sensing)

### Voltage/Current Compliance (Limiting):
- Voltage: 0 V to ±200 V  
- Current: ±1 pA to ±1 A  
- Compliance Accuracy: Same as the current (voltage) settling accuracy.

### HPSMU Supplemental Information:
- Maximum allowable cable resistance when using Kelvin connection:  
  - Force: 0.7 Ω (100 mA to 1 A)  
  - Force: 10 Ω (≤100 mA)  
  - Sense: 10 Ω  
- Typical voltage source output resistance (Force line/non-Kelvin connection): 0.2 Ω  
- Voltage measurement input resistance/current source output resistance: ≥10^13 Ω (1 nA range)  
- Current compliance setting accuracy for opposite polarity:  
  - 1 nA to 10 nA range: V/I setting accuracy ±12% of range  
  - 100 nA to 1 A range: V/I setting accuracy ±2.5% of range

![HPSMU measurement and output range](image_url)
PGU (Pulse Generator Unit) Specifications

Modes: Pulse or constant
Amplitude: 0 Vp-p to 40 Vp-p
Window: -40.0 V to +40.0 V
Maximum current:
  ±100 mA
  ±200 mA (pulse width ≤ 1 ms, average current 100 mA)
Pulse width: 1.0 µs to 9.99 s
Minimum resolution: 100 ns
Pulse period: 2.0 µs to 10.0 s
Minimum resolution: 100 ns
Delay: 0 s to 10 s
Minimum resolution: 100 ns
Transition time: 100 ns to 10 ms
Minimum resolution: 1 ns
Output impedance: 50 Ω or low impedance (≤ 1 Ω)

Burst count range: 1 – 65535

PGU Supplemental Information
Overshoot: ≤ ±5% of amplitude ±10 mV (50 Ω output impedance to 50 Ω load)
Pulse width jitter: 0.2% + 100 ps
Pulse period jitter: 0.2% + 100 ps
Maximum slew rate: 100 V/µs (50 Ω output impedance to 50 Ω load)
Noise: 0.2% of range (@ DC output)

PGU/DC Output Voltage and Accuracy (PGU)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Voltage Range</th>
<th>Resolution</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base</td>
<td>±20 V</td>
<td>4 mV</td>
<td>±(1% of Base +50 mV +1% of Pulse)</td>
</tr>
<tr>
<td></td>
<td>±40 V</td>
<td>8 mV</td>
<td>±(1% of Base +50 mV +1% of Pulse)</td>
</tr>
<tr>
<td>Pulse</td>
<td>±20 V</td>
<td>4 mV</td>
<td>±(3% of Base +50 mV)</td>
</tr>
<tr>
<td></td>
<td>±40 V</td>
<td>8 mV</td>
<td>±(3% of Base +50 mV)</td>
</tr>
</tbody>
</table>

Note: DC output is performed by the Base Parameter.

Pulse Range and Pulse Parameter (PGU)

<table>
<thead>
<tr>
<th>Range</th>
<th>Period</th>
<th>Width</th>
<th>Delay</th>
<th>Set Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2 µs - 100 µs</td>
<td>1 µs - 99.9 µs</td>
<td>0 - 100 µs</td>
<td>0.1 µs</td>
</tr>
<tr>
<td>2</td>
<td>100 µs - 1000 µs</td>
<td>1 µs - 999 µs</td>
<td>0 - 1000 µs</td>
<td>1 µs</td>
</tr>
<tr>
<td>3</td>
<td>1 ms - 10 ms</td>
<td>0.1 ms - 9.99 ms</td>
<td>0 - 10 ms</td>
<td>10 µs</td>
</tr>
<tr>
<td>4</td>
<td>10 ms - 100 ms</td>
<td>0.1 ms - 99.9 ms</td>
<td>0 - 100 ms</td>
<td>100 µs</td>
</tr>
<tr>
<td>5</td>
<td>100 ms - 1000 ms</td>
<td>1 ms - 999 ms</td>
<td>0 - 1000 ms</td>
<td>1 ms</td>
</tr>
<tr>
<td>6</td>
<td>1 s - 10 s</td>
<td>0.01 s - 9.99 s</td>
<td>0 - 10 s</td>
<td>10 ms</td>
</tr>
</tbody>
</table>

Note: Pulse width is defined when leading time is equal to trailing time.

PGU2 must be set in the same range as PGU1

Leading/Trailing Edge Times (PGU)

<table>
<thead>
<tr>
<th>Range</th>
<th>Set Resolution</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 ns - 1000 ns</td>
<td>1 ns</td>
<td>±(5% + 10 ns)</td>
</tr>
<tr>
<td>0.5 µs - 10 µs</td>
<td>10 ns</td>
<td>±(5% + 10 ns)</td>
</tr>
<tr>
<td>5.0 µs - 100 µs</td>
<td>100 ns</td>
<td>±(5% + 10 ns)</td>
</tr>
<tr>
<td>50 µs - 1000 µs</td>
<td>1 µs</td>
<td>±(5% + 10 ns)</td>
</tr>
<tr>
<td>0.5 ms - 10 ms</td>
<td>10 µs</td>
<td>±(5% + 10 ns)</td>
</tr>
</tbody>
</table>

Restrictions:
Pulse width < Pulse Period, Delay time < Pulse period, Leading time < Pulse width × 0.8
Trailing time < (Pulse period - Pulse width) × 0.8
Period, width, and delay of PGU1 and PGU2 must be in the same range. Leading time and trailing time for a PGU must be in the same range.

MPSMU Specifications
Same as 4155C MPSMU.

GNDU (Ground Unit) Specifications
Output Voltage: 0 V ±100 µV
Maximum sink current: 1.6 A
Output terminal/connection:
  Single triaxial connector, Kelvin (remote sensing)

GNDU Supplemental Information
Load Capacitance: ≤ ±1 µF
Cable resistance:
  Force ≤ ±1 Ω
  Sense ≤ ±10 Ω

HRSMU, MPSMU, HPSMU Supplemental Information
Maximum capacitive load: 1000 pF
Maximum guard capacitance: 900 pF
Maximum shield capacitance: 5000 pF
Maximum guard offset voltage: ±1 mV
Noise characteristics (typical, Filter: ON):
  Voltage source noise: 0.01% of V range (rms)
  Current source noise: 0.1% of I range (rms)
Voltage monitor noise: 0.02% of V range (p–p)
Current monitor noise: 0.2% of I
Output 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
Maximum slew rate: 0.2 V/µs
Capacitance Calculation Accuracy (Supplemental Data)

Accuracy is derived from the current range, voltage range, capacitance measurement and leakage current measurement integration times, and the guard capacitance of cabling and step voltage. The information in the chart below is based on the following conditions: Voltage Range ±20 V; Voltage Step: 100 mV; Guard Capacitance: 100 pF; Equivalent parallel resistance of DUT: \(1 \times 10^{15} \Omega\). The ratio of integration times for capacitance measurement and leakage current measurement is 1:1.

<table>
<thead>
<tr>
<th>HRSMU</th>
<th>Current Range</th>
<th>Integration Time</th>
<th>Max. Meas. Value</th>
<th>Resolution</th>
<th>Accuracy Reading %</th>
<th>Offset</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10 pA/100 pA</td>
<td>0.5 sec</td>
<td>100 pF/1 pF</td>
<td>5 fF</td>
<td>4.2</td>
<td>70 fF</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 sec</td>
<td>2 pF/20 pF</td>
<td>10 fF</td>
<td>4.3</td>
<td>90 fF</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 sec</td>
<td>76 pF/760 pF</td>
<td>20 fF</td>
<td>4.3</td>
<td>130 fF</td>
</tr>
<tr>
<td></td>
<td>1 nA</td>
<td>0.1 sec</td>
<td>700 pF</td>
<td>10 fF</td>
<td>0.84</td>
<td>160 fF</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.5 sec</td>
<td>4.5 nF</td>
<td>40 fF</td>
<td>0.85</td>
<td>280 fF</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 sec</td>
<td>18 nF</td>
<td>200 fF</td>
<td>0.93</td>
<td>740 fF</td>
</tr>
<tr>
<td></td>
<td>10 nA</td>
<td>0.1 sec</td>
<td>7 nF</td>
<td>10 fF</td>
<td>0.84</td>
<td>200 fF</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.5 sec</td>
<td>45 nF</td>
<td>40 fF</td>
<td>0.85</td>
<td>440 fF</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 sec</td>
<td>180 nF</td>
<td>200 fF</td>
<td>0.93</td>
<td>1.4 pF</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10 sec</td>
<td>940 nF</td>
<td>1 pF</td>
<td>1.3</td>
<td>6.2 pF</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MPSMU</th>
<th>Current Range</th>
<th>Integration Time</th>
<th>Max. Meas. Value</th>
<th>Resolution</th>
<th>Accuracy Reading %</th>
<th>Offset</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 nA</td>
<td>0.1 sec</td>
<td>700 pF</td>
<td>10 fF</td>
<td>0.91</td>
<td>170 fF</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.5 sec</td>
<td>4.5 nF</td>
<td>40 fF</td>
<td>0.94</td>
<td>340 fF</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 sec</td>
<td>18 nF</td>
<td>200 fF</td>
<td>1.0</td>
<td>1 pF</td>
</tr>
<tr>
<td></td>
<td>10 nA</td>
<td>0.1 sec</td>
<td>7 nF</td>
<td>10 fF</td>
<td>0.91</td>
<td>180 fF</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.5 sec</td>
<td>45 nF</td>
<td>40 fF</td>
<td>0.94</td>
<td>480 fF</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 sec</td>
<td>180 nF</td>
<td>200 fF</td>
<td>1.0</td>
<td>1.6 pF</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10 sec</td>
<td>940 nF</td>
<td>1 pF</td>
<td>1.6</td>
<td>7.6 pF</td>
</tr>
</tbody>
</table>

Current compliance must be smaller than the current range. The capacitance of the DUT and measurement path must be smaller than the maximum measurement value.

Functions

Measurement Setup

Setting
- Fill-in-the-blanks using front-panel or full-size external keyboard
- Load settings from floppy disk or via the LAN port
- Program using internal Instrument BASIC or via GPIB
- HELP Function
- Library: Default measure setup, Vce-Ic, Vds-Id, Vgs-Id, and Vf-If are predefined softkeys
- User-defined measurement setup library
- Auto file load function on power-up

Measurement
The 4155C and 4156C can perform dc or pulsed force/measure, and stress force. For dc, voltage/current sweep and sampling (time domain) measurements are available.

Voltage/Current Sweep

Measurement Characteristics
Each SMU and VSU can sweep using VAR1 (primary sweep), VAR2 (subordinate sweep), or VAR1 (synchronous sweep).
**Sampling (Time Domain) Measurement Characteristics**

Displays the time sampled voltage/current data versus time.
- Max. sampling points: 10,001 (linear)
- Sampling mode: linear, log, and thinned-out

Note: The thinned-out mode is similar to reverse-log sampling. Sampling measurement continues by thinning out older data until the sampling completion condition is satisfied.

**Sampling interval range and resolution:**
- Linear scale (auto mode): 60 µs to 480 µs range:
  - 20 µs resolution
  - 480 µs to 1 s range:
  - 80 µs resolution
  - 1 s to 65.535 s range:
  - 2 ms resolution

Linear scale (no limit mode), log scale, and thinned-out modes:
- 560 µs (720 µs at thinned-out mode) to 1 s range: 80 µs resolution
- 1 s to 65.535 s range: 2 ms resolution

Note: The following conditions must be set when initial interval is less than 2 ms.
- Number of measurement channels: 1
- Measurement ranging: fixed range
- Stop condition: disable

**Hold time:**
- Initial wait time: 0.03 s to 655.35 s
- 100 µs resolution

**Sampling measurement stop condition:**
- A condition to stop the sampling can be defined.
- Sampling interval setting accuracy (supplemental data):
  - 0.5% + 10 µs (sampling interval ≤480 µs)
  - 0.5% + 10 µs (480 µs ≤sampling interval <2 ms)
  - 0.5% + 100 µs (2 ms ≤sampling interval)

**C-V Measurement Characteristics**

Capacitance is a calculated value derived from the following equation:

\[ C = \frac{\Delta Q}{\Delta V} \]

\( \Delta Q \) is the change in charge when \( \Delta V \), the step voltage, is applied by the SMU; \( \Delta Q \) is derived from the measurement current (amps) and the integration time (seconds).

**Maximum Measurable Value**

Maximum measurable value depends on the current range, integration time, and step voltage (refer to the chart in supplemental data).

**Capacitance Calculation Accuracy**

Accuracy is dependent on accuracy of the current measurement and voltage measurement and the stray capacitance and leakage current of measurement path, etc. (Refer to the chart in supplemental data).

**Zero Offset**

Cancels stray capacitance of the fixtures and test leads.

**Leakage Current Compensation**

Cancels the influence of the leakage current to the capacitance measurement.

**Stress Force Characteristics**

SMU, VSU, and PGU output can be forced for the user specified period.

- Stress time set range: 500 µs to 31,536,000 s (365 days)
- Resolution:
  - 100 µs (500 µs ≤stress time ≤10 s)
  - 10 ms (10 s <stress time ≤31,536,000 s)
- Burst pulse count: 1–65,535 (PGU only)

Trigger: The 4155C and 4156C output a gate trigger while stress channels are forcing stress.

**Knob Sweep**

In knob sweep mode, sweep range is controlled instantaneously with the front-panel rotary knob. Only the Channel Definition page need be defined.

**Standby Mode**

SMUs in “Standby” remain programmed to their specified output value even as other units are reset for the next measurement.

**Other Characteristics**

**Arithmetic and Analysis Functions**

**Arithmetic Functions User Functions**

Up to six USER FUNCTIONS can be defined using arithmetic expressions. Measured data and analyzed variables from graphics analysis (marker, cursor, and line data) can be used in the computation. The results can be displayed on the LCD.

**Arithmetic Operators**

+, -,,^, /, ^, LGT (logarithm, base 10), LOG (logarithm, base e), EXP (exponent), DELTA, DIFF (differentiation), INTEG (integration), MAVG (moving average), SQRT, ABS (absolute value), MAX, MIN, AVG (averaging), COND (conditional evaluation).

**Physical Constants**

Keyboard constants are stored in memory as follows:
- \( q \): Electron Charge, 1.602177 E-19 C
- \( k \): Boltzmann’s Constant, 1.380658 E-23
- \( \epsilon (\varepsilon) \): Dielectric Constant of Vacuum, 8.854188 E-12

**Engineering Units**

The following unit symbols are also available on the keyboard:
- \( \times 10^{15} \), \( \times 10^{12} \), \( \times 10^{9} \), \( \times 10^{6} \), \( \times 10^{3} \), \( \times 10^{2} \), \( \times 10^{1} \), \( \times 10^{-1} \), \( \times 10^{-2} \), \( \times 10^{-3} \), \( \times 10^{-6} \), \( \times 10^{-9} \), \( \times 10^{-12} \)

**Analysis Capabilities**

**Overlay Graph Comparison**

A graphics plot can be stored and later recalled as an overlay plane. Four overlay planes can be stored. One plane can be overlaid onto the current data.

**Marker**

Marker to min/max, interpolation, direct marker, and marker slip

**Cursor**

Long and short, direct cursor.

**Line**

Two lines, normal mode, grad mode, tangent mode, and regression mode.

**Scaling**

Auto scale and zoom.

**Data Variable Display**

Up to two user defined parameters can be displayed on the graphics screen.

**Read Out Function**

The read out functions are built-in functions for reading various values related to the marker, cursor, or line.
Automatic Analysis Function
On a graphics plot, the markers and lines can be automatically located using the auto analysis setup. Parameters can be automatically determined using automatic analysis, user function, and read out functions.

User Variable
Display the data on the LCD via GPIB or instrument BASIC.

Output

Display
Display Modes
Graphics and list.

Graphics Display
X-Y or X-Y1/Y2 plot of source current/voltage, measured current/voltage, time, or calculated USER FUNCTION data.

List Display
Measurement data and calculated USER FUNCTION data are listed in conjunction with VAR1 step number or time domain sampling step number. Up to eight data sets can be displayed.

Display
8.4-inch diagonal color active matrix LCD, 640 dot (H × 480 dot) (V). More than 99.99% of the pixels on an LCD are active.

Hard Copy Functions

Graphics Hard Copy
Measured data and all data appearing on the LCD can be output via GPIB, parallel printer port, or network interface to supported HP plotters or printers. PCL, HR PCL (high-resolution PCL), and HP-GL formats are supported (selectable).

Text Hard Copy
Print out setup information or measured data list as ASCII text via GPIB, parallel printer port, or network interface to supported HP plotters or printers. PCL, HR PCL, and HP GL formats are supported (selectable).

Hard Copy File
Hard copy output can be stored to an internal or external mass storage device instead of sending it to a printer or plotter. The data can be stored in PCL, HR PCL, TIFF, HR TIFF (high-resolution TIFF), or HP GL formats.

Hard Copy via Network Interface
The network interface has lpr client capability.

High-Resolution (HR) Mode
This file mode is available for cases where an extremely clean print-out plot is desired.

Note: High-resolution mode takes significantly greater CPU time to generate, so its use is recommended for final reports only.

Data Storage
Mass storage device:
- Built-in 3.5-inch floppy disk drive
- Media: 3.5-inch 2HD or 2DD diskette
- Format type: HP LIF and DOS
- User area: 1.44 Mbyte (2HD) or 720 Kbyte (2DD)
- File types:
  - Auto start program file, initial setup file, measurement setup file, measurement setup/result file, stress setup file, customize file, hard copy data file, and Instrument BASIC program and data file.
- Form of data made by the HP BASIC program:
  - Data made by the HP BASIC program and data made by the Instrument BASIC program are compatible.
- Network mass storage device:
  - An NFS mountable mass storage device
- File types:
  - Auto start program file, initial setup file, measurement setup file, measurement setup/result file, stress setup file, customize file, and hard copy data file.
- Maximum number of files allowed per directory on network mass storage device:
  - 199
- Data storage (supplemental data):
  - 2HD DOS format:
    - Available bytes: 1457 K (byte)
- File size:
  - Measurement setup: 3843 (byte)
  - Stress setup: 601 (byte)
  - Measurement setup/result (Typical data): 15387 (byte)
  - (VAR1: 101, VAR2: 5)
  - Customized system setup:
    - 1661 (byte)
  - Hardcopy data:
    - 30317 (byte)
    - (Monochrome PCL 75DPI file)
    - Hardcopy data:
      - 38702 (byte)
      - (monochrome TIFF file)

Note: For LIF format, the total number of files is limited to 199.

Repeating and Automating Test

Instrument Control
Agilent 4155C and 4156C function control:
- Internal or external computer controls the 4155C and 4156C functions via the GPIB interface

Command sets:
- SCPI command set
- Agilent FLEX command set
- Agilent 4145B command set

Program Memory:
- Using the Agilent FLEX command set, the user can store program code in the 4155C or the 4156C. The maximum number of subprograms is 255 (8 bit).
- External instrument remote control:
  - Control external equipment via the GPIB interface.

Instrument BASIC
Instrument BASIC is a subset of HP BASIC.

Functions:
- Arithmetic operation, binary operation, string manipulation, logical operation, array operation, program flow control, event-initiated branching, program editing and debugging support, mass storage operation, instrument control, real-time clock, softkey operation, and graphics.
- Agilent 4145B automatic sequence program (ASP) typing aid:
  - 4145B ASP-like syntax softkeys are available in instrument BASIC. A 4145B ASP file cannot be read by the 4155C or 4156C.
- Remote control:
  - Instrument BASIC is remote controllable from an external computer via the GPIB interface.

Instrument BASIC memory area (supplemental data):
- Program (text) area: 16 K (byte)
- Variable/stack area: 500 K (byte)
- Common variable area: 600 K (byte)

Note: The memory size for common variable is decreased when hard copy or disk operation is performed.
Trigger Input:
External trigger input starts a sweep or sampling measurement or can be used as a trigger input for continuing an Instrument BASIC program.

Input Level:
TTL level, negative or positive edge trigger

Output:
External edge trigger outputs can be generated by the start of a sweep measurement, the start of each step in a staircase sweep, the start of each pulse leading edge for an SMU in pulse mode, and the issuance of an IBASIC trigger output command execution. In addition, you can set the trigger signal to be active during the Stress Force State. If you have a 41501A/B with PGU option, you can output a synchronized trigger output through the 41501A/B trigger output.

Output Level:
TTL level, negative or positive logic

4145B Data Compatibility and Syntax Commands

Setup and data file
Measurement setup and data from the 4145B can be loaded.

GPIB program
GPIB programs for the 4145B can be used when the 4145B command set is selected.

Note: There is a possibility that GPIB programs for the 4145B will need to be modified.

Interfaces

GPIB interface:
SH1, AH1, T6, L4, SR1, RL1, PP0, DC1, DT1, C1, C2, C3, C4, C11, E2

Parallel interface: Centronics RJ45:
Ethernet IEEE 802.3 10BASE-T
for a 10 Mbps CSMA/CD local area network

External keyboard:
Compatible PC-style 101-key keyboard (mini DIN connector)
Interlock and LED connector R-BOX control connector
Trigger in/out
SMU/PGU selector control connector (41501B)

Sample Application Programs

Flash EEPROM test
TDDB
Constant I (Electromigration test)
V-Ramp test
J-Ramp test
SWEAT
GO/NO-GO test
HCI degradation test
Charging pump test

Sample VEE Program

Vth measurement using the 4155C or 4156C, the E5250A, and a wafer prober.

VXI plug&play Drivers

VXI plug&play drivers for the 4155C and 4156C

Supported VXI plug&play operating systems:
Microsoft Windows 95, 98, NT, 2000 Professional, and XP Professional

Format
Tree-structured function panel. Panel mode for hardware configuration and manual parameter setting. Parameter mode for variable definition and I/O configuration.

General Specifications

Temperature range
Operating:
+10 °C to +40 °C (if using floppy disk drive)
+5 °C to +40 °C (if not using floppy disk drive)

Storage: -22 °C to +60 °C

Humidity range
Operating:
20% to 80% RH, non-condensing and wet bulb temperature ≤ 29 °C
(If using floppy disk drive)
15% to 80% RH, non-condensing and wet bulb temperature ≤ 29 °C
(If not using floppy disk drive)

Storage: 5% to 90% RH, non-condensing and wet bulb temperature ≤ 39 °C

Altitude
Operating: 0 to 2,000 m (6,561 ft)
Storage: 0 to 4,600 m (15,091 ft)

Power requirement
90 V to 264 V, 47 to 63 Hz

Maximum VA
4155C and 4156C: 450 VA
41501B: 350 VA

Regulatory Compliance

EMC: EN 61326-1:+A1, AS/NZS 2064.1
Safety:
CSA C22.2 No.1010.1 (1992), IEC 61010-1:+A2/EN 61010-1:+A2
UL3111-1:1994

Certification:
CE, CSA, NRTL/C, C-Tick

Dimensions
4155C and 4156C: 235 mm H × 426 mm W × 600 mm D
41501B: 190 mm H × 426 mm W × 600 mm D

Weight (approx.)
4155C and 4156C: 21 kg
41501B: 16 kg (option 412, HPSMU + 2 × PGU)

4155C and 4156C Furnished Accessories

Triaxial cable, 4 ea. (4155C)
Kelvin triaxial cable, 4 ea. (4156C)
Coaxial cable, 4 ea.
Interlock cable, 1 ea.
Keyboard, 1 ea.
User manual, 1 set
Sample application program disk, 1 ea.
Sample VEE program disk, 1 ea.
VXI plug&play drivers disk for the 4155C and 4156C, 1 ea.
VXI plug&play drivers disk for the E5250A, 1 ea.
LAN Interface Test Adapter, 1 ea.
16440A SMU/Pulse Generator Selector

The 16440A switches either an SMU or PGU to the associated output port. You can expand to 4 channels by adding an additional 16440A. The channel 1 PGU port provides a “PGU OPEN” function, which can disconnect the PGU by opening a semiconductor relay. The 16440A cannot work without two pulse generator units of the 41501A/B (SMU and Pulse Generator Expander).

Channel configurations:
- Two channels (CH1, CH2)
  - CH1: INPUT ports: 2 (SMU and PGU, PGU port has additional series semiconductor relay)
  - OUTPUT port: 1
  - CH2: INPUT ports: 2 (SMU and PGU)
  - OUTPUT port: 1

Voltage and Current Range

<table>
<thead>
<tr>
<th>Input port</th>
<th>Max. V</th>
<th>Max. I</th>
</tr>
</thead>
<tbody>
<tr>
<td>SMU</td>
<td>200 V</td>
<td>1.0 A</td>
</tr>
<tr>
<td>PGU</td>
<td>40 V</td>
<td>0.2 A (AC Peak)</td>
</tr>
</tbody>
</table>

Supplemental Information (at 23 °C ± 5 °C, 50%RH)

SMU port leakage current:
- < 100 fA @100 V

SMU port residual resistance (typical):
- 0.2 Ω

SMU port stray capacitance (typical @1 MHz):
- Force ↔ Common: 0.3 pF
  - Force ↔ Guard: 15 pF
  - Guard ↔ Common: 130 pF

PGU port residual resistance: 3.4 Ω

PGU port OFF capacitance (typical):
- 5 pF

PGU port OPEN capacitance (typical):
- 700 pF (@ 1 MHz, Vin - Vout = 0V)

PGU port signal transfer characteristics

- Overshoot: <5% of pulse amplitude (@20 ns leading and trailing time, 50 Ω pulse generator source impedance, 50 pF and 1 MΩ in parallel load).

General Specifications

- Dimensions: 50 mm H × 250 mm W × 275 mm D
- Approximate weight: 1.1 kg

16441A R-BOX

The 16441A R-BOX adds a selectable series resistor to the SMU output. You can select the resistor from the setup page, and the voltage drop due to the series resistor is automatically compensated for in the measurement result.

Measurement limitations with the 4155C and 4156C and R-BOX:

- If you measure device characteristics including negative resistance over 1 MΩ with the 4155C/4156C and R-BOX, there is a possibility that they cannot be measured.
- There is a possibility that the 4155C and 4156C cannot perform measurements because of DUT oscillations even with the R-BOX.

Whether oscillation occurs or not depends upon the DUT and measurement conditions.

- Number of SMU channels that can add a resistor: 2
- Resistor values:
  - 1 MΩ, 100 kΩ, 10 kΩ, 0 Ω (each channel)
- Resistance accuracy:
  - 0.3% (at 23 °C ±5 °C, between input/output terminal)
- Maximum voltage: 200 V
- Maximum current: 1 A (0 Ω selected)
- Kelvin connection: Kelvin connection is effective only when 0 Ω is selected.

Supplemental Information (at 23 °C ± 5 °C, 50%RH)

- Leakage current: <100 fA @100 V

16442A Test Fixture

Channel Information

- SMU:
  - 6 channels (1 triaxial connector per channel)
  - 3 channels (1 Kelvin triaxial connector per channel)
- VSU:
  - 2 channels (1 BNC connector per channel)
- VMU:
  - 2 channels (1 BNC connector per channel)
- PGU:
  - 2 channels (1 BNC connector per channel)
- GNDU:
  - 1 channel (1 triaxial connector)

INTLK:
- 6-pin connector

Supplemental Information (at 23 °C ± 5 °C, 50% RH)

- SMU channel:
  - Leakage current: 10 pA max @200 V
  - Stray capacitance: 15 pF max
  - Stray capacitance: 3 pF typical
  - Residual resistance: 60 mΩ typical
  - Guard capacitance: 70 pF max
- VSU channel residual resistance: 60 mΩ typical
- VMU channel residual resistance: 60 mΩ typical
- PGU channel characteristic impedance: 50 mΩ typical
- GNDU channel residual resistance: 40 mΩ typical

General Specifications

Temperature range:
- Operating: +5 °C to +40 °C
- Storage: -40 °C to +70 °C

Humidity range:
- Operating: 5% to 80% RH (no condensation)
- Storage: 5% to 90% RH at 65 °C (no condensation)

Dimensions:
- 140 mm H × 260 mm W × 260 mm D
- Weight (approx.): 2.5 kg

Accessory Specifications

Specification Condition

The “supplemental information” and “typical” entries in the following specifications are not warranted, but provide useful information about the functions and performance of the instruments (23 °C ±5 °C, 50% RH).
Agilent Desktop EasyEXPERT Software

Introduction
Agilent Desktop EasyEXPERT software makes every user a parametric test expert. The Microsoft® Windows®-based interface is familiar, even to new engineers who have limited experience using parametric measurement instruments. Its unique task-based approach enables the user to focus on the real task-at-hand (device characterization) without having to be a specialist at using the instrument hardware. Desktop EasyEXPERT supports all aspects of parametric test, from basic manual measurements to test automation across a wafer in conjunction with a semiautomatic wafer prober.

Features and benefits
Large application test library
Desktop EasyEXPERT comes with more than 230 application tests conveniently organized by device type, application, and technology. Many of these application tests will run on the 4155 and 4156 without modification. You also can easily edit and customize the furnished application tests to fit your specific needs.

Offline capability
Desktop EasyEXPERT can run in either online or offline mode. In offline mode you can perform tasks such as analyzing data and creating new application tests. This frees up your existing analyzer from being needed for development work and enables you to use it for its primary purpose: making measurements.

GUI-based classic test mode
Desktop EasyEXPERT offers a classic test mode that maintains the look, feel, and terminology of the 4155/4156 user interface. In addition, it improves the 4155/4156 user interface by taking full advantage of the Windows GUI features.

Easy test sequencing
A GUI-based Quick Test mode lets you to perform test sequencing without programming. You can select, copy, rearrange and cut-and-paste any application tests with a few simple mouse clicks. Once you have selected and arranged your tests, simply click on the measurement button to begin running an automated test sequence.

Prober control
All popular semiautomatic wafer provers are supported by Desktop EasyEXPERT. You can define wafer, die and module information for probing across an entire wafer. You can also combine wafer prober control with either Quick Test mode or an application test-based test sequence to perform multiple testing on various devices across the wafer.

Automatic data export
Desktop EasyEXPERT has the ability to automatically export measurement data in real time, in a variety of formats. You can save data to any drive connected to the PC. If you wish, you can export data to a network drive and view test results you wish, you can export data to a network drive and view test results on your desktop PC at the same time your instruments are performing testing in the lab.

Software Functions
Operation mode
Application test mode, Classic test mode, Quick test mode

Key Functions
- Categorized and predefined application library
- Device definition
- Measurement parameter settings
- Save/Recall My Favorite Setups
- Define/customize application library
- Execute measurement (Single/Repeat/Append)
- Quick test execution
- Save/Recall measurement data and settings
- Test result data management
- Import/Export device definition, measurement settings, my favorite setup, measurement data, and application library
- Graph plot display/analysis/printing
- Switching matrix control
- Workspace management

Application Library
Category:
Sample test definitions for the following applications. They are subject to change without notice.
Structure, CMOS, Bipolar (BJT), TFF, Discrete, Nanotechnology, Utility

Supported 4155/4156 Functionality
Desktop EasyEXPERT Standard edition
- Staircase Sweep

Desktop EasyEXPERT Plus edition
The following additional functions are supported.
- I/V-t Sampling except Thinned-out and Logarithmic modes
- VSU/VMU except differential voltage measurement using VMU
- PGU (41501B)
Each SMU can sweep using VAR1 (primary sweep), VAR2 (secondary sweep), or VAR1’ (synchronous sweep).

Staircase Sweep Measurement Mode
Forces 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. Number of Steps for VAR1 and VAR1': 1 to 1001
Number of Steps for VAR2: 1 to 128
Sweep type: Linear or logarithmic
Sweep direction: Single or double sweep
Hold Time: 0 to 655.35 s, 10 ms resolution
Delay Time: 0 to 65.5350 s, 100 μs resolution

Pulsed Sweep Measurement Mode
This mode forces 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**
This mode forces 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.

**Sampling (Time Domain) Measurement Mode**
This mode displays the time sampled voltage/current data (by SMU) versus time.
Sampling channels: up to 6
For sampling intervals < 2 ms, the number of sampling channels is 1
Sampling points: 1 to 10,001/(number of channels)
Sampling mode: linear
Sampling interval range:
60 µs to 2 ms, 10 µs resolution
2 ms to 65.535 s, 1 ms resolution
Hold time: -30 ms to -100 µs, 100 µs resolution
Bias hold time: 0 s

**Bias Hold Function**
This function is used to keep source output after measurement. Source modules apply the specified bias between measurements in a quick test or application test that defines some classic test setups, or a repeat measurement. Also, the source modules change the output value and the unused modules are disconnected when the next measurement is started.

**Current Offset Cancel**
This function subtracts the offset current from the current measurement raw data, and returns the result as the measurement data. It is used to compensate the error factor (offset current) caused by the measurement path such as the measurement cables, manipulators, or probe card.

**Other Measurement Characteristics**
**Measurement Control:**
- Single, Repeat, Append, and Stop
**SMU Setting Capabilities:**
  - Limited auto ranging, voltage/current compliance, power compliance, automatic sweep abort functions

**Arithmetic and Analysis Functions**
**User Functions**
Up to 20 user-defined functions can be defined using arithmetic expressions. Measured data and pre-defined variables can be used in the computation, and the results can be displayed on the LCD.

**Analysis Capabilities**
**Overlay Graph Comparison**
A graphics plot can be stored and overlaid.

**Scale**
Auto scale and zoom

**Marker**
Marker to min/max, interpolation, direct marker, and marker skip

**Cursor**
Direct cursor

**Line**
Two lines, normal mode, grad mode, tangent mode, and regression mode

**Automatic Analysis Function**
On a graphics plot, the markers and lines can be automatically located using the auto analysis setup. Parameters can be automatically determined using automatic analysis, user function, and read out functions.

**Data Variable Display**
Up to 20 user-defined parameters can be displayed on the graphics screen.

**Analysis Functions**
Up to 20 user-defined analysis functions can be defined using arithmetic expressions. Measured data, pre-defined variables and read out functions can be used in the computation, and the results can be displayed on the LCD.

**Read Out Functions**
These built-in functions are for reading various values related to the marker, cursor, or line.

**Graph Plot Display Mode**
The data display window can be printed. Only the X-Y graph can be printed.

**Graph Plot File**
The graph plot can be stored as image data to clipboard or mass storage device.
File type: bmp, gif, png, emf

**Output Display Modes**
X-Y graph, list display, and parameter display

**X-Y Graph Display**
X-axis and up to eight Y-axes
Linear and log scale
Real time graph plotting

**List Display**
Measurement data and calculated user function data are listed in conjunction with VAR1 step number or time domain sampling step number. Up to 20 data sets can be displayed.

**Other Functions**
Import/Export files
File type:
  - Agilent EasyEXPERT format, XML-SS format, CSV format

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The data display window can be printed. Only the X-Y graph can be printed.

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Import/Export files
File type:
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System Requirements

The following are the minimum requirements for executing Desktop EasyEXPERT.

<table>
<thead>
<tr>
<th>Operating System and Service Pack</th>
<th>Microsoft Windows XP Professional SP2</th>
<th>Microsoft Windows VISTA Business SP1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Processor</td>
<td>Intel Celeron 2 GHz</td>
<td>Vista Certified PC with</td>
</tr>
<tr>
<td>Memory</td>
<td>512 Megabytes DDR266</td>
<td>1 GB memory</td>
</tr>
<tr>
<td>Display</td>
<td>XGA 1024 x 768</td>
<td>(SXGA 1280 x 1024 recommended)</td>
</tr>
<tr>
<td>HDD</td>
<td>1 GB free space on the C drive, 10 GB (30 GB recommended) free space on a drive for test setup/result storage.</td>
<td></td>
</tr>
<tr>
<td>.NET Framework</td>
<td>Microsoft .NET Framework Ver. 2.0 Redistributable Package Microsoft .NET Framework Ver. 3.0 Microsoft .NET Framework 2.0 SP1</td>
<td></td>
</tr>
<tr>
<td>IO Libraries (for online mode)</td>
<td>Agilent IO Libraries Suite 15.0</td>
<td></td>
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<tr>
<td>Supported GPIB I/F (for online mode)</td>
<td>Agilent 82350B</td>
<td></td>
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<tr>
<td></td>
<td>Agilent 82357A</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Agilent 82357B</td>
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</tbody>
</table>

**Supported 4155/4156**

**Parameter Analyzers**
- 4155B, 4156B, 4155C, and 4156C
- Supported 4155/4156 firmware:
  - HOSTC: 03.08 or later
  - SMUC: 04.08 or later

**Supported External Instruments**

**Desktop EasyEXPERT Standard edition**
- Supported by switching matrix GUI: B2200A/B2201A
- Supported by application tests:
  - E5250A (E5252A), 4284A/E4980A, 81110A, 3458A

**Desktop EasyEXPERT Plus edition**
- All auxiliary instruments supported by Desktop EasyEXPERT Standard edition
- Also supported by switching matrix GUI: E5250A (E5252A)

**Setup Converter Tool**
- In addition to Desktop EasyEXPERT, Agilent supplies a Setup File Converter tool that runs on any Windows-based PC. This tool can convert 4155 and 4156 measurement setup files (files of type MES and DAT) into equivalent Desktop EasyEXPERT classic test mode setup files.

**Attached Software**
- Prober Control execution files
- Supported Probers:
  - Cascade Microtech Summit
  - 12 K or S300
  - SUSS MicroTec PA200 or PA300
  - Vector Semiconductor VX-2000 or VX-3000
  - 4155/56 setup file converter tool
- Supported operating systems:
  - Microsoft Windows 2000 Professional and XP Home or Professional

**Ordering Information**

B1541A
- Agilent Desktop EasyEXPERT software and measurement libraries
B1541A-001
- Agilent Desktop EasyEXPERT with license-to-use for standard edition
B1541A-002
- License-to-use for Agilent Desktop EasyEXPERT Plus
Remove all doubt

Our repair and calibration services will get your equipment back to you, performing like new, when promised. You will get full value out of your Agilent equipment throughout its lifetime. Your equipment will be serviced by Agilent-trained technicians using the latest factory calibration procedures, automated repair diagnostics and genuine parts. You will always have the utmost confidence in your measurements.

Agilent offers a wide range of additional expert test and measurement services for your equipment, including initial start-up assistance onsite education and training, as well as design, system integration, and project management.

For more information on repair and calibration services, go to

www.agilent.com/find/removealldoubt