DATA SHEET

# 4082F Flash Memory Cell Parametric Test System

## Keysight 4080 Series

Easy to use and simple to operate NAND flash cell testing system is essential to evaluate and produce NAND cell in volume manufacturing. Keysight offers the fast and precise measurements with 4082F flash memory cell parametric test system including built-in semiconductor pulse generator unit (SPGU), cost-effective pulse generator and optional high-frequency switching matrix.


KEYSIGHT TECHNOLOGIES

# Table of Contents

## Solution Overview

Keysight 4082F flash memory cell parametric test system is designed to perform fast and precise DC measurements, capacitance measurements, flash cell test and other high frequency applications such as ring oscillator measurement. The system supports up to eight source monitor units (SMUs). Each SMU is self-calibrating and can be individually configured to force either current or voltage, as well as simultaneously measure either current or voltage. The system also supports a fully guarded switching matrix customizable from 12 to 48 pins. One special pin is dedicated to chuck connection.

The Keysight 4082F can select pulse generation from a semiconductor pulse generator unit (SPGU) mainframe that supports up to five high-voltage SPGUs (HV-SPGUs) with ±40V output or cost-effective pulse generator with 2 output channels of ±19V output. An optional Keysight 4082F flash memory cell parametric test system high frequency (HF) switching matrix with integrated SPGU is also available. The HF matrix is organized as 3 x 4 matrices (six inputs in total), and 1 TO 2 furnished cables may be used on each matrix pair to create 3 x 48 matrix (three inputs in total). The system also has one 1.6 A ground unit.

The 4082F can be provided in either a low-current or an ultra-low current configuration, depending upon the type of matrix card specified. Only 4082F models containing the ultra-low current matrix cards can be the high-resolution SMU (HRSMU). An optional high-speed capacitance measurement unit (HS-CMU) is available for the 4082F, which enables the measurement of capacitance and impedance with unprecedent speed. External instruments can be integrated into the system via six auxiliary input ports or forty-eight extended path inputs. The extended path inputs allow the user to connect external signals directly to the DUT pins.

## Primary Test Target

NAND flash cell testing in R&D and volume manufacturing.

## Measurement Functions

DC current, DC voltage, capacitance and conductance, impedance, and differential voltage.

## Key Measurement Capabilities

- DC measurements (spot, sweep, pulse bias, pulse sweep)
- Capacitance, conductance and impedance measurements
- Two terminal differential voltage measurements
- Pulse force (semiconductor pulse generator unit, pulse generator)
- Switching matrix

## Other Available Integrations

- Spectrum/signal analyzer
- WGFMU (Waveform Generator Fast Measurement Unit)

| | | |
|---|---|---|
| **DC measurement** | | |
| Measurement unit | | HRSMU (High Resolution SMU)[1] |
| | | MPSMU (Medium Power SMU) |
| | | HPSMU (High Power SMU) |
| Measurement functions | | Spot, sweep, pulse bias, and pulse sweep |
| Measurement range | Using two low current SMU ports | 1 fA[2] to 100 mA, 2 µV to 100 V |
| | Using six standard SMU ports | 10 fA to 1 A[3], 2 µV to 200 V[3] |
| **Capacitance, conductance, and impedance measurement** | | |
| Measurement unit | | HS-CMU (High Speed Capacitance Measurement Unit) |
| | | Keysight E4980A LCR meter |
| HS-CMU | Measurement functions | C/G, C/G-V, C/G-V/f, Z/θ and Z/θ-f |
| | Measurement frequencies | 1 kHz to 2 MHz, 34 points |
| | Measurement ranges | 1 fF to 100 nF, 0.1 nS to 7.5 mS |
| | DC bias voltage | ±10 V |
| Keysight E4980A | Measurement functions | C/G and C/G-V |
| | Measurement frequencies | 1 kHz, 10 kHz, 100 kHz, and 1 MHz |
| | Measurement ranges | 1 fF to 100 nF, 0.1 nS to 7.5 mS |
| | DC bias voltage | ±40 V |

1. Can be used only with ultra-low current matrix cards
2. Using HRSMU. Using MPSMU, 10 fA to 100 mA, 2 µV to 100 V
3. Using optional HPSMU. Using MPSMU, 10 fA to 100 mA, 2 µV to 100V

| | |
|---|---|
| **Two terminal differential voltage measurements** | |
| Measurement unit | Keysight 3458A/34470A |
| Measurement range | 0.1 µV to 100 V (only when using ultra-low current matrix cards), or 1 µV to 100V |
| **Semiconductor pulse generator unit (SPGU)[1]** | |
| The 4082F cabinet supports an optional high-voltage semiconductor pulse generation unit (HV-SPGU) mainframe that contains the SPGU modules. | |
| Maximum number of installable HV-SPGU modules | 5 |
| Number of channels per HV-SPGU modules | 2 |
| Pulse level support | Each HV-SPGU channel supports 2-level and 3-level pulses |
| Pulse level (at open load) | ±40 V (at 2-level and 3-level) |
| Pulse period (at 50 Ω load) | 350 ns to 10 s with 10 ns resolution |
| Pulse width (at 50 Ω load) | 50 ns to [Period – 50 ns] with 2.5 ns[2] or 10 ns[3] resolution |
| Pulse delay (at 50 Ω load) | 0 s to [Period – 75 ns] with 2.5 ns[2] or 10 ns[3] resolution |
| Transition time[4] setting range (at 50 Ω load) | 20 ns to 400 ms with 2 ns[2] or 8 ns[3] resolution |
| Transition time minimum (at 50 Ω load) | 20 ns[5], 30 ns[6] |
| **Pulse generator[7]** | |
| The 4082F cabinet supports an optional pulse generator Keysight 81150A with 2 output channels. Specifications are defined through HF matrix (required option 501). | |
| Maximum number of installable channels | 2 |
| Pulse force mode | 2-level and 3-level outputs<br>(needs 2 ch for 3-level output) |
| Pulse level (at open load) | ±19 V (at 2-level and 3-level) |
| Pulse period (at 50 Ω load) | 350 ns to 999 s with 10 ns resolution |

1. When SPGU is configured, pulse generator 81150A is not available to add.
2. Transition time setting ≤ 8 µs
3. Transition time setting > 8 µs
4. Transition time is interval time between the 10% and 90% amplitude points on the leading/trailing edge.
5. |Vamp| ≤ 10 V (to 50 Ω)
6. 10 V < |Vamp| ≤ 20 V (to 50 Ω)
7. When pulse generator 81150A is configured, SPGU is not available to add.

| Switching matrix | |
|---|---|
| Number of measurement pins | Between 12 and 48 pins<br>Note: One additional pin is dedicated for the prober chuck connection. |
| Instrument ports | Up to eight SMUs |
| | One ground unit (GNDU) |
| | Eight auxiliary (AUX) ports (two ports are used for HS-CMU) |
| | 48 extended paths |
| | Six optional high-frequency (HF) ports and pulse switch input/output ports |

## Specifications

Accuracy is specified under the conditions below.

| Specification conditions | |
|---|---|
| Temperature | 23 °C ± 5 °C[1] |
| Humidity | 15% to 70% RH[2] |
| Warm up time | At least 60 minutes |
| Self-calibration | Within one hour after calibration |
| Integration time | Medium or long[3] |
| Performance test | Should be performed annually |

1. Less than ±3 °C temperature changes and within one hour after self adjustment
2. 15% to 60% RH (no condensation) for current measurement accuracy of the HRSMU in 10 pA to 100 nA range and isolation resistance of the low-current port.
3. For SMU current ranges that are less than or equal to 1 nA, the integration time must be long (16 PLC or longer).
   Note: the temperature changes after calibration must be less than 3°C.

## Switching Matrix Subsystem

| Switching matrix subsystem | | |
|---|---|---|
| Maximum DUT pins | | 48 output pins plus one pin for the prober chuck connection (triaxial connector). Two types of DC switching matrix cards are available: standard low-current and ultra-low current. |
| Maximum number of instrument ports | SMU port in test head | Eight SMUs + one GNDU<br>- Two ports for low-current measurement (Non-Kelvin)<br>- Four ports (Kelvin)<br>- Two ports (Non-Kelvin)<br>- One port for GNDU (Kelvin) |
| | Auxiliary ports | Six for external instruments (digital voltmeter, etc.) and two for HS-CMU or E4980A<br>- Two triaxial input ports (Force/guard/common, AUX ports 1 and 2)<br>- Four BNC two-pair input ports (Force/common and sense/common, AUX ports 3 to 6)<br>- Two BNC input ports (Force/common, AUX ports 7 and 8, connected to HS-CMU in default) |
| | Extended path | 48 extended paths<br>The system provides one on/off relay for each path. |
| Maximum voltage at each port | SMU port in test head | ±200 V |
| | AUX port | ±200 V (AUX ports 1 and 2)<br>±100 V (AUX ports 3 to 8) |
| | Optional HF ports | ±100 V (between force and common of each HF port)<br>±100 V (between two of forces of all HF ports)<br>±100 V (between any force of HF ports and any force of extended paths) |
| | Extended path | ±100 V (between force and common of each extended path)<br>±100 V (between any force of the optional HF ports and any force of extended path) |
| | Zero reference | ±200 mV |

| | | |
|---|---|---|
| Maximum current, port to DUT pin | SMU port in test head | ±1.0 A |
| | AUX port | ±1.0 A |
| | GNDU | ±1.6 A |
| | Optional HF ports | ±0.5 A |
| | Extended path | ±0.5 A |
| Maximum residual resistance | Through AUX port | Low current port: Force 1.0 Ω<br>Kelvin port: Force 1.0 Ω, Sense 2.5 Ω<br>Non-Kelvin port: Force 1.0 Ω |
| Maximum stray capacitance between DUT pins | | 3 pF[1] |
| Isolation resistance | | Low current (with guard): 1 x $10^{15}$ Ω [1] |
| **Optional high frequency (HF) ports** | | |
| Maximum number of instrument ports | | Six ports for external instruments.<br>HF ports 1 through 3 can access measurement pins 1 through 24, and HF port 4 through 6 can access measurement pins 25 through 48. The user has the option of connecting any of the following HF port pairs together via a 1 TO 2 cable in order to access all (1 through 48) measurement pins: HF ports 1 and 4, HF ports 2 and 5, and HF ports 3 and 6. |
| Maximum residual resistance | | 2.0 Ω[1] |
| Optional HF port bandwidth (@ -3 dB) | | 60 MHz[1] (50 Ω load impedance from port to DUT pin, 3 x 24 configuration) |
| Optional HF port cross talk between pins | | ±2%[1] (5 kΩ load impedance: from port to DUT pin, 20 ns pulse transition time) |

1. Supplemental characteristics

**Test Head Circuit Diagram**

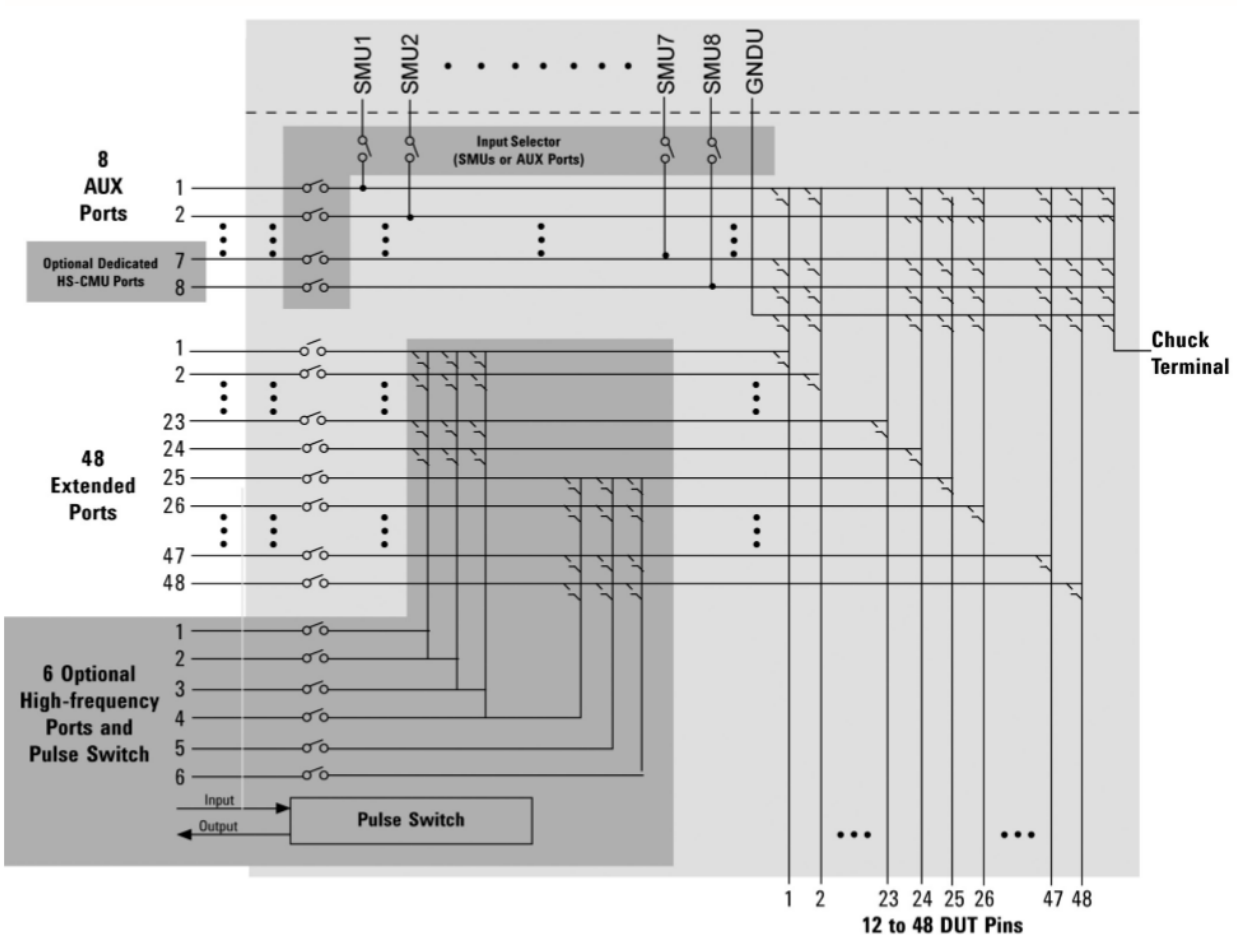


Figure 1: Test Head Circuit Diagram

| Optional pulse switch | |
|---|---|
| The optional pulse switch includes seven semiconductor switching relays, for reliable and direct control of pulse shaping by the pulse generator or CPU. The pulse switch is integrated into the 4082F test head. | |
| Maximum number of instrument ports | Refer to page 5 |
| Number of blocks | 2 |
| Number of switches of each block | Block 1:<br>Three relays (make or break, selectable type) and 1 relay (transfer type to create multilevel pulse)<br>Block 2:<br>One relay (make or break, selectable type) and two relays (transfer type to create multilevel pulse) |
| Control input port | One input per each block (PSC1 and PSC2) |
| Control method | Both the PG and CPU can control all switches. PG or CPU control is independent for every block. In the case of PGH control, block 1 can be controlled by the PSC1 input and block 2 can be controlled by either PSC1 or PSC2 (selectable). |
| Mode of relay control | Make or break, selectable type relay:<br>Normally open or normally closed modes are selectable.<br>Transfer type relay:<br>Normally open and normally closed modes are selectable. |
| Maximum voltage | ±40 V<br>Between force and common of each switch<br>Between PSI 21 and PSO 2<br>Between PSI 31 and PSO 3<br>Between PSI 41 and PSO 4<br>Between PSI 51 and PSO 5<br>Between PSI 11 (or PSI 12) and PSO 1<br>Between PSI 11 and PSI 12<br>Between PSI 61 (or PSI 62) and PSO 6<br>Between PSI 61 and PSI 62<br>Between PSI 71 (or PSI 72) and PSO 7<br>Between PSI 71 and PSI 72 |
| Maximum current | ±0.4 A (from input to output) |
| Maximum residual resistance | Nominal 1.5 Ω[1] (from IN to OUT) |
| OFF capacitance | 50 pF (between IN and OUT: Vin-Vout = 0 V)[1]<br>100 pF (between force and common @ output of make or break, selectable type relay: Vin-Vout = 0 V)[1] |
| Operating time of switching | Max. 500 µs[1] |

1. Supplemental characteristics

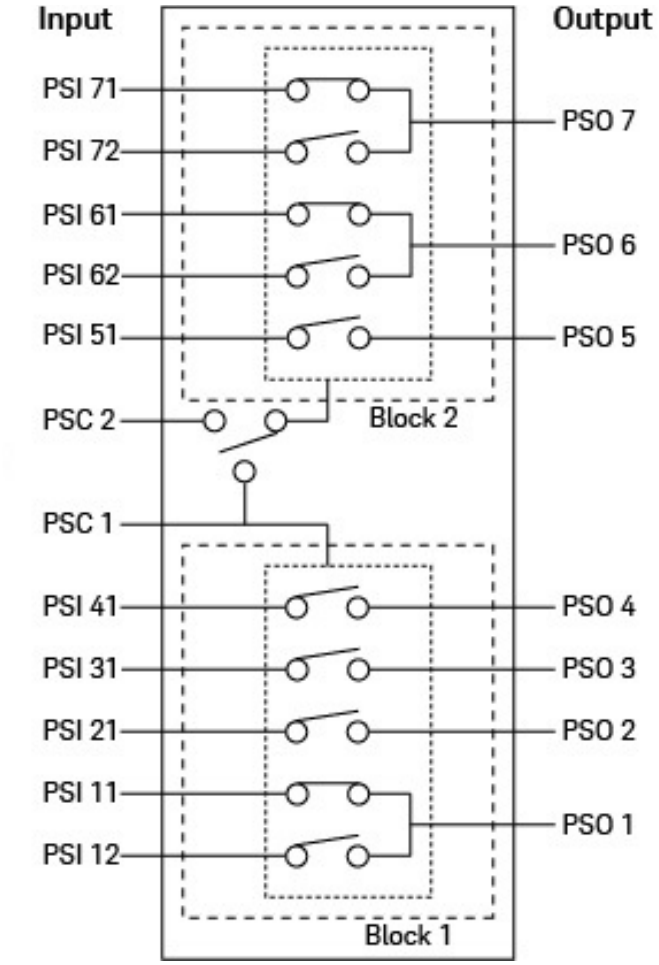


Figure 2: Pulse switch diagram

# DC Measurement Subsystem

## SMU (Source and Monitor Unit)

**Voltage source/monitor range, resolution, and accuracy using HRSMU**

| Full scale voltage range | Force resolution | Measure resolution: high speed | Measure resolution: precision | Force accuracy | Measure accuracy |
|---|---|---|---|---|---|
| ±2V | 100 µV | 100 µV | 2 µV | a: 0.02%<br>b: 0.025%<br>c: Rmat x Io | a: 0.03%<br>b: 0.035%<br>Rmat x Io |
| ±20 V | 1 mV | 1 mV | 20 µV | a: 0.02%<br>b: 0.015%<br>c: Rmat x Io | a: 0.03%<br>b: 0.02%<br>c: Rmat x Io |
| ±40 V | 2 mV | 2 mV | 40 µV | | |
| ±100 V | 5 mV | 5 mV | 100 µV | | |

**Voltage source/monitor range, resolution, and accuracy using MPSMU and HPSMU**

| Full scale voltage range | Force resolution | Measure resolution: high speed | Measure resolution: precision | Force accuracy | Measure accuracy |
|---|---|---|---|---|---|
| ±2 V | 100 µV | 100 µV | 2 µV | a: 0.05%<br>b: 0.05%<br>c: Rmat x Io | a: 0.04%<br>b: 0.04%<br>c: Rmat x Io |
| ±20 V | 1 mV | 1 mV | 20 µV | | |
| ±40 V | 2 mV | 2 mV | 40 µV | | |
| ±100 V | 5 mV | 5 mV | 100 µV | | |
| ±200 V[1] | 10 mV | 10 mV | 200 µV | | a: 0.045%<br>b: 0.04%<br>c: Rmat x Io |

1. Using HPSMU

Note: Force accuracy is given by ±(a% of output setting value + b% of output range + c) V
Measure accuracy is given by ±(a% if measured value + b% of measurement range + c) V
Io = Output current, Rmat = Residual resistance of switching matrix force port
Note: Rmat is different at each port. When using prober chuck connection pin, add 0.1 Ω to Rmat.
Low current port (SMU1 and SMU2): 1.0 Ω
Kelvin port (SMU3 to SMU6): 3 mΩ
Non-Kelvin port (SMU7 and SMU8): 1.0 Ω

| Current source/monitor range, resolution, and accuracy using MPSMU connected to ports SMU1 and SMU2 | | | | | |
|---|---|---|---|---|---|
| **Full scale current range** | **Force resolution** | **Measure resolution: high speed** | **Measure resolution: precision** | **Force accuracy** | **Measure accuracy** |
| ±100 mA | 5 µA | 5 µA | 100 nA | a: 0.12%<br>b: 0.1 + 0.0005 x Vo %<br>c: 0 | a: 0.1%<br>b: 0.05 + 0.0005 x Vo %<br>c: 0 |
| ±10 mA | 500 nA | 500 nA | 10 nA | | |
| ±1 mA | 50 nA | 50 nA | 1 nA | | |
| ±100 µA | 5 nA | 5 nA | 100 pA | | |
| ±10 µA | 500 pA | 500 pA | 10 pA | | |
| ±1 µA | 50 pA | 50 pA | 1 pA | a: 0.2%<br>b: 0.1 + 0.0005 x Vo %<br>c: 0.02 pA/V x Vo | a: 0.2%<br>b: 0.05 + 0.0005 x Vo %<br>c: 0.02 pA/V x Vo |
| ±100 nA | 5 pA | 5 pA | 100 fA | | |
| ±10 nA | 500 fA | 500 fA | 10 fA | a: 1%<br>b: 0.1 + 0.0005 x Vo %<br>c: 3 pA + 0.02pA/V x Vo | a: 1%<br>b: 0.1 + 0.0005 x Vo %<br>c: 3 pA + 0.02pA/V x Vo |
| ±1 nA | 50 fA | 50 fA | 10 fA | | |

Note: The HPSMU cannot be connected to SMU1 and SMU2 ports.

Current measurement accuracy of the SMU may be affected by electromagnetic field strength over 3 V/m at a frequency of 80 MHz to 1 GHz.

| Current source/monitor range, resolution, and accuracy using HRSMU connected to ports SMU1 and SMU2 | | | | | |
|---|---|---|---|---|---|
| **Full scale current range** | **Force resolution** | **Measure resolution: high speed** | **Measure resolution: precision** | **Force accuracy** | **Measure accuracy** |
| ±100 mA | 5 µA | 5 µA | 100 nA | a: 0.12%<br>b: 0.05 + 0.0001 x Vo %<br>c: 0 | a: 0.1%<br>b: 0.04 + 0.0001 x Vo %<br>c: 0 |
| ±10 mA | 500 nA | 500 nA | 10 nA | a: 0.06%<br>b: 0.04 + 0.0001 x Vo %<br>c: 0 | a: 0.06%<br>b: 0.03 + 0.0001 x Vo %<br>c: 0 |
| ±1 mA | 50 nA | 50 nA | 1 nA | a: 0.06%<br>b: 0.05 + 0.0001 x Vo %<br>c: 0 | a: 0.06%<br>b: 0.04 + 0.0001 x Vo %<br>c: 0 |
| ±100 µA | 5 nA | 5 nA | 100 pA | a: 0.07%<br>b: 0.04 + 0.0001 x Vo %<br>c: 0 | a: 0.06%<br>b: 0.035 + 0.0001 x Vo %<br>c: 0 |
| ±10 µA | 500 pA | 500 pA | 10 pA | a: 0.07%<br>b: 0.05 + 0.0001 x Vo %<br>c: 0 | a: 0.06%<br>b: 0.04 + 0.0001 x Vo %<br>c: 0 |
| ±1 µA | 50 pA | 50 pA | 1 pA | a: 0.12%<br>b: 0.05+ 0.0001 x Vo %<br>c: 0 | a: 0.12%<br>b: 0.035 + 0.0001 x Vo %<br>c: 0 |
| ±100 nA | 5 pA | 5 pA | 100 fA | a: 0.12%<br>b: 0.05+ 0.0001 x Vo %<br>c: 1 fA/V x Vo | a: 0.12%<br>b: 0.04+ 0.0001 x Vo %<br>c: 1 fA/V x Vo |

**Current source/monitor range, resolution, and accuracy using HRSMU connected to ports SMU1 and SMU2 (continues)**

| Full scale current range | Force resolution | Measure resolution: high speed | Measure resolution: precision | Force accuracy | Measure accuracy |
|---|---|---|---|---|---|
| ±10 nA | 500 fA | 500 fA | 10 fA | a: 1%<br>b: 0.05 + 0.0001 x Vo %<br>c: 3 pA + 1 fA/V x Vo | a: 1%<br>b: 0.04 + 0.0001 x Vo %<br>c: 3 pA + 1 fA/V x Vo |
| ±1 nA | 50 fA | 50 fA | 10 fA | a: 1%<br>b: 0.07 + 0.0001 x Vo %<br>c: 3 pA + 1 fA/V x Vo | a: 1%<br>b: 0.04 + 0.0001 x Vo %<br>c: 3 pA + 1 fA/V x Vo |
| ±100 pA | 5 fA | 5 fA | 2 fA | a: 4%<br>b: 0.04 + 0.0001 x Vo %<br>c: 500 fA + 1 fA/V x Vo | a: 4%<br>b: 0.12 + 0.0001 x Vo %<br>c: 500 fA + 1 fA/V x Vo |
| ±10 pA | 1 fA | 2 fA | 1 fA | a: 4%<br>b: 0.04 + 0.0001 x Vo %<br>c: 500 fA + 1 fA/V x Vo | a: 4%<br>b: 1.0 + 0.0001 x Vo %<br>c: 500 fA + 1 fA/V x Vo |

| Current source/monitor range, resolution, and accuracy using MPSMU or HPSMU connected to ports SMU3 to SMU8 | | | | | |
|---|---|---|---|---|---|
| **Full scale current range** | **Force resolution** | **Measure resolution: high speed** | **Measure resolution: precision** | **Force accuracy** | **Measure accuracy** |
| ±1 A[1] | 50 µA | 50 µA | 1 µA | a: 0.5%<br>b: 0.1 + 0.0005 x Vo %<br>c: 0 | a: 0.5%<br>b: 0.05 + 0.0005 x Vo %<br>c: 0 |
| ±100 mA | 5 µA | 5 µA | 100 nA | a: 0.12%<br>b: 0.1 + 0.0005 x Vo %<br>c: 0 | a: 0.1%<br>b: 0.05 + 0.0005 x Vo %<br>c: 0 |
| ±10 mA | 500 nA | 500 nA | 10 nA | | |
| ±1 mA | 50 nA | 50 nA | 1 nA | | |
| ±100 µA | 5 nA | 5 nA | 100 pA | | |
| ±10 µA | 500 pA | 500 pA | 10 pA | | |
| ±1 µA | 50 pA | 50 pA | 1 pA | a: 0.2%<br>b: 0.1+ 0.0005 x Vo %<br>c: 300 pA + 10 pA/V x Vo | a: 0.2%<br>b: 0.05 + 0.0005 x Vo %<br>c: 300 pA + 10 pA/V x Vo |
| ±100 nA | 5 pA | 5 pA | 100 fA | | |
| ±10 nA[2] | 500 fA | 500 fA | 10 fA | a: 1%<br>b: 0.1 + 0.0005 x Vo %<br>c: 303 pA + 10 pA/V x Vo | a: 1%<br>b: 0.1 + 0.0005 x Vo %<br>c: 303 pA + 10 pA/V x Vo |
| ±1 nA[2] | 50 fA | 50 fA | 10 fA | | |

1. Using HPSMU
2. Supplemental characteristics when using the SMU3 to SMU8 ports

Note: Force accuracy is given by ±(a% of output setting value + b% of output range + c) A

Measure accuracy is given by ±(a% if measured value + b% of measurement range + c) A

Note: The HPSMU can only be connected to the SMU3 and SMU4 ports.

Note: Current measurement accuracy of the SMU may be affected by electromagnetic field strength over 3 V/m at a frequency of 80 MHz to 1 GHz.

Vo = Output voltage

| SMU other specifications | |
|---|---|
| Over current range | 15% of range (0% of 100 mA range of MPSMU/HRSMU, 0% for 1 A range of HPSMU, 5% for 10 pA/100 pA range of HRSMU) |
| Over voltage range | V force: 0% of range<br>V measure: 10% of range (0% for 100 V range of MPSMU, 0% for 200 V range of HPSMU) |
| Current compliance setting range | 1 pA to maximum current |
| Accuracy of converse polar current limit | ±2% of range (100 nA to 1 A ranges)<br>±10% of range (10 pA to 10 nA ranges) |
| Maximum capacitive load | ≤ 1000 pF |
| Maximum allowable guard capacitance | 250 pF (between single line and guard lone outside of matrix) |
| Maximum slew rate | 0.2 V/µs |

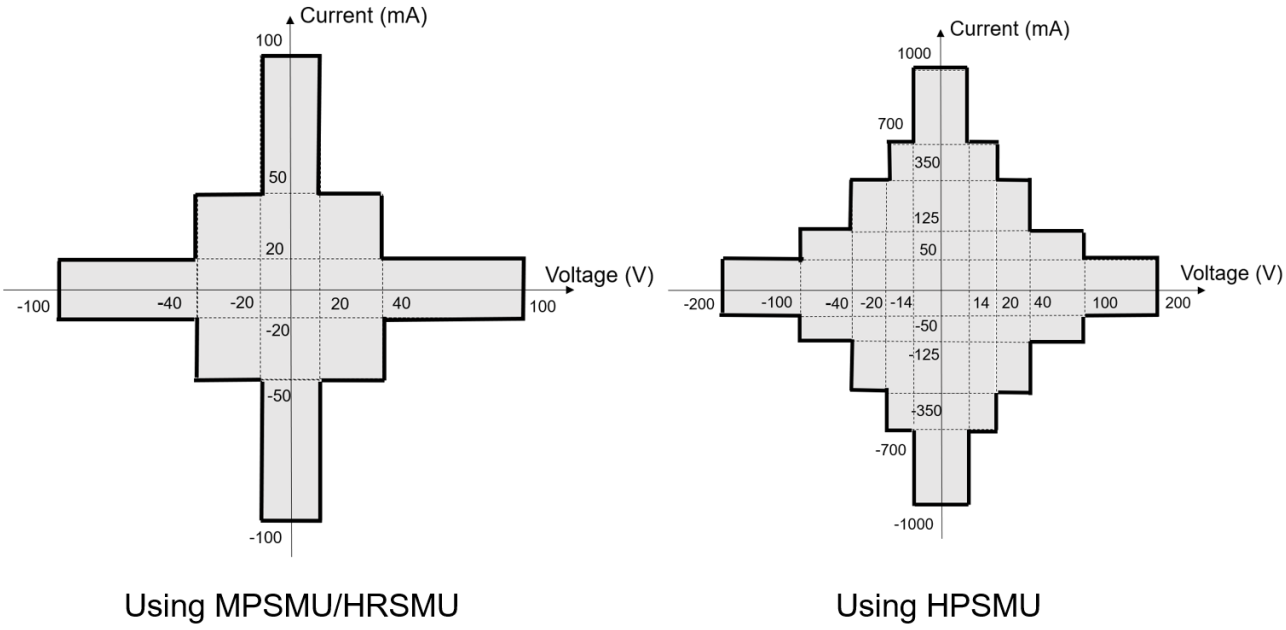


Figure 3: Measurement and output range (using MPSMU/HRSMU and HPSMU)

## Ground Unit (GNDU)

This unit is used for ground when making measurements.

| Specifications | |
|---|---|
| Output voltage | 0 V |
| Maximum current | ±1.6 A |
| Offset voltage | ± 200 µV |
| Maximum capacitance load | 1 µF[1] |

1. Supplemental characteristics

## Digital Volt Meter (Keysight 3458A/34470A)

Voltage measurement range, resolution, and accuracy (at number of power line cycle ≥ 1).

| Specifications | | |
|---|---|---|
| **Full scale voltage range** | **Resolution** | **Accuracy ±(% of reading + volt)** |
| 0.1 V | 0.1 µV | 0.01% + 100 µV |
| 1 V | 1 µV | 0.01% + 100 µV |
| 10 V | 10 µV | 0.01% + 200 µV |
| 100 V | 100 µV | 0.02 % + 1 mV |

## SMU Configuration

The default SMU configuration depends upon the matrix card that is chosen (standard low current or ultra-low current.) Refer the tables below which show the SMU installation configuration associated with different combinations of SMU resource options.

**SMU installation when using ultra-low current matrix cards**

| No HPSMU | | | One HPSMU | | | Two HPSMUs | | |
|---|---|---|---|---|---|---|---|---|
| **Port number** | **Installed SMU** | **Installation order** | **Port number** | **Installed SMU** | **Installation order** | **Port number** | **Installed SMU** | **Installation order** |
| 1 | MPSMU | 2 | 1 | MPSMU | 1 | 1 | MPSMU | Fixed |
| 2 | MPSMU | Fixed | 2 | MPSMU | Fixed | 2 | MPSMU | Fixed |
| 3 | MPSMU | Fixed | 3 | **HPSMU** | **Fixed** | 3 | **HPSMU** | **Fixed** |
| 4 | MPSMU | Fixed | 4 | MPSMU | Fixed | 4 | **HPSMU** | **Fixed** |
| 5 | MPSMU | 1 | 5 | MPSMU | Fixed | 5 | MPSMU | Fixed |
| 6 | MPSMU | 3 | 6 | MPSMU | 2 | 6 | MPSMU | 1 |
| 7 | MPSMU | 4 | 7 | MPSMU | 3 | 7 | MPSMU | 2 |
| 8 | MPSMU | 5 | 8 | MPSMU | 4 | 8 | MPSMU | 3 |

**SMU installation when using ultra-low current matrix cards**

| One HRSMU, no HPSMUs | | | One HRSMU, one HPSMU | | | One HRSMU, two HPSMUs | | |
|---|---|---|---|---|---|---|---|---|
| **Port number** | **Installed SMU** | **Installation order** | **Port number** | **Installed SMU** | **Installation order** | **Port number** | **Installed SMU** | **Installation order** |
| 1 | MPSMU | 2 | 1 | MPSMU | 1 | 1 | MPSMU | Fixed |
| 2 | **HRSMU** | **Fixed** | 2 | **HRSMU** | **Fixed** | 2 | **HRSMU** | **Fixed** |
| 3 | MPSMU | Fixed | 3 | **HPSMU** | **Fixed** | 3 | **HPSMU** | **Fixed** |
| 4 | MPSMU | Fixed | 4 | MPSMU | Fixed | 4 | **HPSMU** | **Fixed** |
| 5 | MPSMU | 1 | 5 | MPSMU | Fixed | 5 | MPSMU | Fixed |
| 6 | MPSMU | 3 | 6 | MPSMU | 2 | 6 | MPSMU | 1 |
| 7 | MPSMU | 4 | 7 | MPSMU | 3 | 7 | MPSMU | 2 |
| 8 | MPSMU | 5 | 8 | MPSMU | 4 | 8 | MPSMU | 3 |
| **Two HRSMUs, no HPSMUs** | | | **Two HRSMUs, one HPSMU** | | | **Two HRSMUs, two HPSMUs** | | |
| **Port number** | **Installed SMU** | **Installation order** | **Port number** | **Installed SMU** | **Installation order** | **Port number** | **Installed SMU** | **Installation order** |
| 1 | **HRSMU** | **Fixed** | 1 | **HRSMU** | **Fixed** | 1 | **HRSMU** | **Fixed** |
| 2 | **HRSMU** | **Fixed** | 2 | **HRSMU** | **Fixed** | 2 | **HRSMU** | **Fixed** |
| 3 | MPSMU | Fixed | 3 | **HPSMU** | **Fixed** | 3 | **HPSMU** | **Fixed** |
| 4 | MPSMU | Fixed | 4 | MPSMU | Fixed | 4 | **HPSMU** | **Fixed** |
| 5 | MPSMU | 1 | 5 | MPSMU | Fixed | 5 | MPSMU | Fixed |
| 6 | MPSMU | 2 | 6 | MPSMU | 1 | 6 | MPSMU | Fixed |
| 7 | MPSMU | 3 | 7 | MPSMU | 2 | 7 | MPSMU | 1 |
| 8 | MPSMU | 4 | 8 | MPSMU | 3 | 8 | MPSMU | 2 |

Note: installation order indicates the order in which additional MPSMUs must be installed.

# Capacitance Measurement Subsystem

## High-Speed CMU (Capacitance Measurement Unit)

Measurement accuracy is specified between any two measurement pins except the chuck connection pin.

| Specifications | | |
|---|---|---|
| Measurement range | | 1 fF to 1.2 nF and 10 nS to 7.5 mS (1 MHz)<br>1 fF to 10 nF and 1 nS to 6.3 mS (100 kHz)<br>1 fF to 100 nF and 0.1 nS to 6.3 mS (10 kHz)<br>10 fF to 100 nF and 0.1 nS to 0.63 mS (1 kHz) |
| Measurement frequency | | Setting range 1 kHz to 2 MHz (34 points) |
| Test signal level | | Setting range 10 mV, 30 mV, 50 mV, and 100 mV |
| DC bias | Full-scale voltage range | ±10 V (setting resolution: 1 mV) |
| | Force accuracy | ±(0.1% of setting + 10 mV) |

**C/G measurement range, resolution, and accuracy**

| Frequency | C range | C accuracy ±(% of reading + % of range) | G range | G accuracy ±(% of reading + % of range) |
|---|---|---|---|---|
| 2 MHz[1] | 7 pF | 3.2% + [6.3 + (2.3 x $Gm^2$ / 88 µS)]% | 88 µS | 3.2% + [6.5 + (2.5 x $Cm^3$/ 7 pF)]% |
| | 70 pF | 2.8% + [2.3 + (1.9 x Gm / 880 µS)]% | 880 µS | 2.8% + [2.4 + (2.1 x Cm/ 70 pF)]% |
| 1 MHz | 10 pF[1] | 0.8% + [1.1 + (0.6 x Gm / 63 µS)]% | 63 µS[1] | 0.8% + [1.1 + (0.6 x Cm/ 10 pF)]% |
| | 100 pF | 0.7% + [0.4 + (0.5 x Gm / 630 µS)]% | 630 µS | 0.7% + [0.4 + (0.5 x Cm/ 100 pF)]% |
| | 1 nF | 1.5% + [0.3 + (2.1 x Gm / 6.3 mS)]% | 6.3 mS | 1.5% + [0.3 + (2.2 x Cm/ 1 nF)]% |
| 100 kHz | 10 pF[1] | 0.4% + [1.1 + (0.3 x Gm / 6.3 µS)]% | 6.3 µS[1] | 0.4% + [1.1 + (0.4 x Cm/ 10 pF)]% |
| | 100 pF | 0.2% + [0.4 + (0.2 x Gm / 63 µS)]% | 63 µS | 0.2% + [0.4 + (0.2 x Cm/ 100 pF)]% |
| | 1 nF | 0.2% + [0.3 + (0.4 x Gm / 630 µS)]% | 630 µS | 0.2% + [0.3 + (0.4 x Cm/ 1 nF)]% |
| | 10 nF | 0.5% + [0.3 + (1.0 x Gm / 6.3 mS)]% | 6.3 mS | 0.5% + [0.3 + (1.0 x Cm/ 10 nF)]% |

**C/G measurement range, resolution, and accuracy (continues)**

| Frequency | C range | C accuracy ±(% of reading + % of range) | G range | G accuracy ±(% of reading + % of range) |
|---|---|---|---|---|
| 10 kHz | 100 pF | 0.3% + [0.2 + (0.3 x Gm / 6.3 µS)]% | 6.3 µS | 0.3% + [0.2 + (0.3 x Cm/ 100 pF)]% |
| | 1 nF | 0.2% + [0.2 + (0.2 x Gm / 63 µS)]% | 63 µS | 0.2% + [0.2 + (0.2 x Cm/ 1 nF)]% |
| | 10 nF | 0.2% + [0.2 + (0.2 x Gm / 630 µS)]% | 630 µS | 0.2% + [0.2 + (0.2 x Cm/ 10 nF)]% |
| | 100 nF | 0.3% + [0.2 + (1.0 x Gm / 6.3 mS)]% | 6.3 mS | 0.7% + [0.2 + (0.7 x Cm/ 100 nF)]% |
| 1 kHz | 100 pF[1] | 0.3% + [0.4 + (0.3 x Gm / 0.63 µS)]% | 0.63 µS[1] | 0.3% + [0.4 + (0.3 x Cm/ 100 pF)]% |
| | 1 nF | 0.3% + [0.1 + (0.3 x Gm / 6.3 µS)]% | 6.3 µS | 0.3% + [0.1 + (0.3 x Cm/ 1 nF)]% |
| | 10 nF | 0.3% + [0.1 + (0.3 x Gm / 63 µS)]% | 63 µS | 0.3% + [0.1 + (0.3 x Cm/ 10 nF)]% |
| | 100 nF | 0.3% + [0.1 + (0.3 x Gm / 630 µS)]% | 630 µS | 0.3% + [0.1 + (0.3 x Cm/ 100 nF)]% |

1. Accuracy of this range is supplemental characteristics.
2. Gm: Measured conductance
3. Cm: Measured capacitance

Conductance and capacitance measurements are specified under the following conditions:
- Measurement frequency: 1 kHz, 10 kHz, 100 kHz or 1 MHz
- Integration time: MEDIUM or LONG
- Test signal level: 30 mVrms
- Stray capacitance: Must be under 5 pF between force and guard
- Calibration and offset cancel: Specifications are valid for the data after calibration data measurement and offset cancel
- Capacitance measurement accuracy of HS-CMU may be affected by conducted RF field strength over 3 Vrms at frequency range of 1 MHz to 20 MHz.

**Z/θ measurement accuracy (supplemental characteristics)**

| Frequency | C range | C accuracy ±(% of reading + % of range) | θ accuracy |
|---|---|---|---|
| 1 MHz | 10 kΩ | 0.8 % + 1.8% | ±0.26 rad |
| | 1 kΩ | 0.7 % + 0.6 % | ±0.02rad |
| | 100 Ω | 1.5 % + 0.5 % | ±0.02 rad |
| 100 kHz | 100 kΩ | 0.4 % + 1.8 % | ±0.03 rad |
| | 10 kΩ | 0.2 % + 0.6 % | ±0.01 rad |
| | 1 kΩ | 0.2 % + 0.5 % | ±0.01 rad |
| | 100 Ω | 0.5 % + 0.5 % | ±0.01 rad |
| 10 kHz | 100 kΩ | 0.3 % + 0.3 % | ±0.01 rad |
| | 10 kΩ | 0.2 % + 0.3 % | ±0.01 rad |
| | 1 kΩ | 0.2 % + 0.3 % | ±0.01 rad |
| | 100 Ω | 0.3 % + 0.3 % | ±0.01 rad |
| 1 kHz | 100 kΩ | 0.3 % + 0.2 % | ±0.01 rad |
| | 10 kΩ | 0.3 % + 0.2 % | ±0.01 rad |
| | 1 kΩ | 0.3 % + 0.2 % | ±0.01 rad |

## Keysight E4980A LCR Meter

Measurement accuracy is specified between any two measurement pins except the chuck connection pin and valid after calibration data measurement and offset cancel.

| Specifications | | |
|---|---|---|
| Measurement range | | 1 fF to 1.2 nF and 10 nS to 7.5 mS (1 MHz)<br>1 fF to 10 nF and 1 nS to 6.3 mS (100 kHz)<br>1 fF to 100 nF and 0.1 nS to 6.3 mS (10 kHz)<br>10 fF to 100 nF and 0.1 nS to 0.63 mS (1 kHz) |
| Measurement frequency | | 1 kHz,10 kHz, 100 kHz, and 1 MHz |
| Test signal level | | 30 mV (rms) |
| DC bias | Full-scale voltage range | ±40 V |
| | Force accuracy | ±(0.1% of setting + 10 mV) |
| | Bias current isolation function | OFF |

**C/G measurement range, resolution, and accuracy**

| Frequency | C range | C accuracy ±(% of reading + % of range) | G range | G accuracy ±(% of reading + % of range) |
|---|---|---|---|---|
| 1 MHz | 10 pF[1] | 0.8% + [1.0 + (0.6 x $Gm^2$ / 63 µS)]% | 63 µS[1] | 0.8% + [1.0 + (0.6 x $Cm^3$/ 10 pF)]% |
| | 100 pF | 0.8% + [0.3 + (0.6 x Gm / 630 µS)]% | 630 µS | 0.8% + [0.3 + (0.6 x Cm/ 100 pF)]% |
| | 1 nF | 1.5% + [0.2 + (1.7 x Gm / 6.3 mS)]% | 6.3 mS | 1.3% + [0.2 + (2.2 x Cm/ 1 nF)]% |
| 100 kHz | 10 pF[1] | 0.4% + [1.0 + (0.3 x Gm / 6.3 µS)]% | 6.3 µS[1] | 0.4% + [1.0 + (0.4 x Cm/ 10 pF)]% |
| | 100 pF | 0.3% + [0.3 + (0.3 x Gm / 63 µS)]% | 63 µS | 0.3% + [0.3 + (0.3 x Cm/ 100 pF)]% |
| | 1 nF | 0.3% + [0.2 + (0.4 x Gm / 630 µS)]% | 630 µS | 0.3% + [0.2 + (0.4 x Cm/ 1 nF)]% |
| | 10 nF | 0.5% + [0.2+ (1.0 x Gm / 6.3 mS)]% | 6.3 mS | 0.7% + [0.2 + (0.8 x Cm/ 10 nF)]% |
| 10 kHz | 100 pF | 0.3% + [0.2 + (0.3 x Gm / 6.3 µS)]% | 6.3 µS | 0.3% + [0.2 + (0.3 x Cm/ 100 pF)]% |
| | 1 nF | 0.3% + [0.1 + (0.3 x Gm / 63 µS)]% | 63 µS | 0.3% + [0.1 + (0.3 x Cm/ 1 nF)]% |
| | 10 nF | 0.3% + [0.1 + (0.3 x Gm / 630 µS)]% | 630 µS | 0.3% + [0.1 + (0.3 x Cm/ 10 nF)]% |
| | 100 nF | 0.3% + [0.1 + (1.0 x Gm / 6.3 mS)]% | 6.3 mS | 0.7% + [0.1 + (0.7 x Cm/ 100 nF)]% |
| 1 kHz | 100 pF[1] | 0.4% + [0.5 + (0.4 x Gm / 0.63 µS)]% | 0.63 µS[1] | 0.4% + [0.5 + (0.4 x Cm/ 100 pF)]% |
| | 1 nF | 0.3% + [0.1 + (0.3 x Gm / 6.3 µS)]% | 6.3 µS | 0.3% + [0.1 + (0.3 x Cm/ 1 nF)]% |
| | 10 nF | 0.3% + [0.1 + (0.3 x Gm / 63 µS)]% | 63 µS | 0.3% + [0.1 + (0.3 x Cm/ 10 nF)]% |
| | 100 nF | 0.3% + [0.1 + (0.3 x Gm / 630 µS)]% | 630 µS | 0.3% + [0.1 + (0.3 x Cm/ 100 nF)]% |

1. Accuracy of this range is supplemental characteristics.
2. Gm = Measured conductance
3. Cm = Measured capacitance

Note: Accuracy is specified between any DUT pins. Stray capacitance between force and guard must be under 5 pF.
Frequency accuracy: ±0.1%; Test signal level 30 mVrms ± 5 mVrms
When measurement speed is set to SHORT, add 0.25% to the $ of reading and 0.1% to the % of range.
When open/short calibrations at DUT pins are carried out, accuracy is the same as in the above table. (Note that the length of cable from the output pins must be less than 1 meter, and capacitance to guard must be under 100 pF.)

# Pulse Generator Subsystem

## Semiconductor Pulse Generator Unit

| Specifications | |
|---|---|
| Supported pulse generators | High-voltage semiconductor pulse generator unit (HV-SPGU) modules |
| Maximum number of installable HV-SPGU modules | 5 |
| Number of channels per HV-SPGU modules | 2 |
| Pulse force mode | Each HV-SPGU channel supports 2-level and 3-level pulses |
| Output mode | All pulse generator channels (up to 10) can force synchronously |
| HV-SPGU output impedance | 50 Ω |
| HV-SPGU load impedance | 0.1 Ω to 1 MΩ |
| Pulse level (at open load) | ±40 V (at 2-level and 3-level) |
| Pulse period (at 50 Ω load) | 350 ns to 10 s with 10 ns resolution |
| Pulse width (at 50 Ω load) | 50 ns to [Period – 50 ns] with 2.5 ns[1] or 10 ns[2] resolution |
| Pulse delay (at 50 Ω load) | 0 s to [Period – 75 ns] with 2.5 ns[1] or 10 ns[2] resolution |
| Transition time (at 50 Ω load) | 20 ns to 400 ms with 2 ns[1] or 8 ns[2] resolution |
| Transition time minimum (at 50 Ω load) | 20 ns[3], 30 ns[4] |
| Pulse amplitude (at open load) | 0 to 80 V peak-to-peak |
| Pulse level resolution (at open load) | 0.4 mV (Vout ≤ 10 V)<br>1.6 mV (Vout > 10 V) |
| Pulse level accuracy (at open load) | ±(2% + 150 mV) |
| Pulse shape accuracy (at 50 Ω load) | Delay: ±(3% of setting + 1 ns)<br>Transition time: -5% of setting to (+5% of setting + 35 ns)<br>Overshoot/ringing: ±(5% of amplitude + 20 mV)<br>Skew between pins: ±10 ns |
| Pulse shape accuracy (at 5 kΩ load, supplemental characteristics) | Transition time: -5% of setting to (+5% of setting + 35 ns)<br>Overshoot/ringing: ±(5% of amplitude + 20 mV)<br>Skew between pins: ±10 ns |

1. Transition time setting ≤ 8 µs
2. Transition time setting > 8 µs
3. |Vamp| ≤ 10 V (to 50 Ω)
4. 10 V < |Vamp| ≤ 20 V (to 50 Ω)

## Pulse Generator

| Specifications[1] | |
|---|---|
| Supported pulse generators | Keysight 81150A pulse generator |
| Maximum number of installable channels | 2 |
| Pulse force mode | 2-level and 3-level outputs<br>(needs 2 ch for 3-level) |
| Output impedance | 50 Ω |
| Load impedance | 2.5 Ω to 1 MΩ |
| Pulse period (at 50 Ω load) | 350 ns to 999 s with 10 ns resolution |
| Pulse width (at 50 Ω load) | 50 ns to 999 ms with 50 ps min. resolution |
| Pulse delay (at 50 Ω load) | 0 s to 998 ms with 10 ps min. resolution |
| Transition time (at 50 Ω load) | 20 ns to 200 ms with 100 ps min. resolution |
| Pulse level (at open load) | ±19 V (at 2-level and 3-level) |
| Pulse level resolution (at open load) | 1 mV |
| Pulse level accuracy (at open load) | ±(2% of amplitude + 150 mV) |
| Pulse shape accuracy (at 50 Ω load) | Width: ±(3% of setting + 2 ns), ±(0.5% of setting + 2 ns)[2]<br>Delay: ±(3% of setting + 1 ns), ±(0.5% of setting + 1 ns)[2]<br>Transition time: (-10% of setting) to (+10% of setting + 20 ns)<br>Overshoot/ringing: ±(5% of amplitude + 20 mV) |
| Pulse shape accuracy (at 5 kΩ load, supplemental characteristics) | Transition time: ±(10% of setting + 5 ns)<br>Overshoot/ringing: ±(5% of amplitude + 20 mV) |
| Burst count | $10^9$ (max.) |

1. Specifications are defined through HF matrix (required option 501).
2. Supplemental characteristics after timing calibration

# System Controller and System Software

## System Controller

| Item | Description |
|---|---|
| Supported controller | Dedicated System Controller (Keysight N9171B) |
| Operating system | RedHat Enterprise Linux 7.1 (for Keysight N9171B) |

## System Software

**Standard 4080 software provides following capabilities**

| Item | Description |
|---|---|
| System management | |
| Control of subsystems | Test Instrument Set (TIS) library for C language |
| Parameter measurement utility | PARA library |
| Off-line debugging | |
| Interactive debugging panel (IDP) | Includes test algorithm code generation function |
| System maintenance | Automatic diagnostics |

## Keysight SPECS (Semiconductor Process Evaluation Core Software)

Keysight SPECS is a test shell environment for the 4080 Series. Users have full access to the Linux environment within the test shell. The 4080 Series requires SPECS version 3.10-20 or later.

**Test development**
User interaction occurs via a graphical interface with spreadsheet-like operation. Test plans require simple specifications: wafer, die, test and probe.

**Customization**
Keysight supplies basic development, engineering, and operator test shell frameworks, which users can tailor or modify to create entirely new frameworks.

**Analysis & output**
All data is output into a flat ASCII file which users can manipulate to allow for input into database software. In addition, the data management structure supports x-y graphs, histograms, and wafer maps.

## Keysight SPECS-FA (Factory Automation)

Keysight SPECS-FA, the factory automation version of Keysight SPECS test shell, runs on the 4080 Series testers. The SPECS-FA fully supports SEMI automation standards E5 (SECS II), E30 (GEM), E87 (CMS), E39 (OSS), E40 (PMS), E90 (STS), and E94 (CJM).

## Parallel Test Capability

4080 Series testers support both synchronous and asynchronous parallel test. Keysight SPECS and SPECS-FA support a powerful virtual multiple test head technology that enables separate measurement threads to run completely independently of one another. This eliminates measurement “dead time” (time spent waiting for other measurement threads to complete) and maximize throughput.

# General Specifications

| **Operating and storage requirements** | | |
|---|---|---|
| Temperature range | Operating | 5 °C to 30 °C (no condensation) |
| | Storage | -20 °C to 50 °C<br>-20 °C to 60 °C (for un unpacked system) |
| Humidity range | Operating | 15% to 70% (no condensation) |
| | Storage | < 80% RH (no condensation)<br>< 90% RH, < 12 hrs (for unpacked system) |
| Altitude | Operating | 0 m to 2000 m |

| **Power requirement** | | |
|---|---|---|
| **Nominal line voltage[1]** | **Allowable voltage range** | **Required maximum current** |
| 200 Vac | 180 – 200 Vac | 30 A |
| 208 Vac | 188 – 228 Vac | 24 A |
| 220 Vac | 198 – 242 Vac | 30 A |
| 240 Vac | 216 – 252 Vac | 30 A |

1. Line frequency must be 48 Hz to 63 Hz.

## General Specifications (continues)

| | |
|---|---|
| **Regulatory and standard compliance** | |
| EMC | IEC 61326-1<br>ICES/NMB-001<br>AS/NZS CISPR 11<br>KC |
| Safety | IEC 61010-1<br>Canada: CAN/CSA-C22.2 No. 61010-1, C/US<br>SEMI S2-1016 and S8-1116 |
| Certifications | CE, CSA C/US, RCM, ICES/NMB-001 |
| **Dimensions** | |
| System cabinet | 600 mm (W) by 905 mm (D) by 1800 mm (H) |
| Test head | 780 mm (W) by 680 mm (D) by 440 mm (H) |
| **Weight** | |
| System cabinet (max.) | 294 kg (including 3458A, SPGU with 5 x HV-SPGU, system controller) |
| Test head | 137 kg (including 7 MPSMUs, 1 HPSMU, 1 HS-CMU, 48 pins, HF matrix, and manipulator extension shelf with enclosure, fan, and duct) |
| **Supported probers and probe cards[2]** | |
| Prober | TEL (Tokyo Electron)<br>ACCRETECH |
| Probe card | JEM (Japan Electronic Material)<br>MJC (Micronics Japan Co.)<br>FormFactor |

2. Please contact your local sales representative regarding the latest information on supported prober and probe cards.

## Recommended Conditions for Ultra-Low Current and Low Voltage Measurements

In addition to the conditions listed in general specifications, Keysight recommends that the following additional conditions be satisfied for measuring precise low current and low voltage with the 4082F.

| Recommended conditions for ultra-low current and low voltage measurements[1] | |
|---|---|
| Probe cards[2] | JEM and MJC |
| Temperature | Within ±1°C after calibration |
| Temperature change period | ≥ 10 minutes |
| Humidity | ≤ 50% |
| Warm up time | ≥ 60 minutes |
| Floor vibration | ≤ 1 mG |
| Floor vibration frequency | ≥ 10 Hz |
| Air cleanliness | ≤ class 10,000 |
| Line voltage | Burst noise ≤ 1 kV<br>Surge noise ≤ 1 kV<br>This line voltage environment applies IEC 61326-1 |

1. The information in this section applies only to system configured with ultra-low current matrix cards and a high-resolution SMU.
2. Please contact your local sales representative regarding the latest information on supported prober and probe cards.

## Learn more at: www.keysight.com

For more information on Keysight Technologies' products, applications or services, please contact your local Keysight office. The complete list is available at: www.keysight.com/find/contactus

KEYSIGHT TECHNOLOGIES