



HIGH PRECISION SOURCE MEASURE UNIT MODEL 52400 SERIES

The Chroma 52400 series is a hybrid compatible PXI based SMU (Source Measurement Unit) card which can be used in both PXI and PXIe chassis. It is designed for highly accurate source or load simulation with precision voltage and current measurements.

SMU combines four-quadrant-source with precision and high speed measurement. This unique capability makes a SMU the ideal instrument in many parametric test applications ranging from ICs, two-lead components such as sensors, LEDs, laser diodes, transistors, to solar cells, batteries and many other electronic devices.

To meet various test requirements, the 52400 series has 16 control bandwidths allowing user selection of a stable operation, multi-ranges combined with 18 bit DAC/ADC to provide the best programming and measurement resolution and accuracy available at a sampling rate of up to 100k s/S. Special programmable output resistance allows users to set as internal series resistance of a battery making Chroma 52400 series SMU an ideal tool acting as a battery simulator.

\pm force, \pm sense and \pm guards lines are standard to avoid leakage current and reduce settling time, especially for the mobile IC and Sensor test applications requiring very low current.

The 52400 series has a built-in patented hardware sequence engine that uses deterministic timing to control each SMU. This sequencer comes with built-in 32k readings storage memory, it allows for cross module/card synchronization and latency free output control and measurement. This measurement is possible as no PC communication needed during test process.

C/C# and various versions of LabView/ LabWindows APIs plus versatile soft front panel are offered as standard accessories. The back connectors are compatible with both PXI and PXIe chassis. All of these features enable easiest integration to PXI or PXIe systems designed for any application.



MODEL 52400 SERIES

KEY FEATURES

- Hybrid Compatible PXI
- Four quadrant operation
- High source/measurement resolution (multiple ranges)
- Low output noise
- High programming/measurement speed (100k s/S) & slew rate
- Optional measurement log
- DIO bits
- Output profiling by hardware sequencer
- Programmable output resistance
- Floating & Guarding output
- 16 Control Bandwidth Selection
- Master / Slave operation
- Driver with LabView/LabWindows & C/C# API
- Softpanel GUI

APPLICATIONS

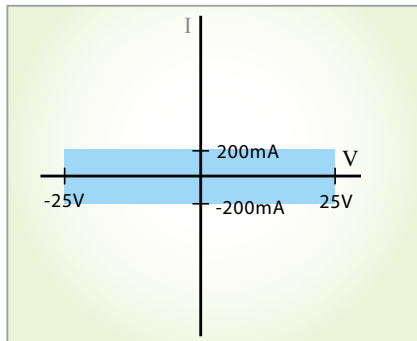
- Semiconductor Test
- LED / Laser Diode Test
- Battery Test
- Transistor Test
- Solar Cell Test
- Electric Vehicle Test
- Avionics Test
- Power Electronics Test
- Sensor Test



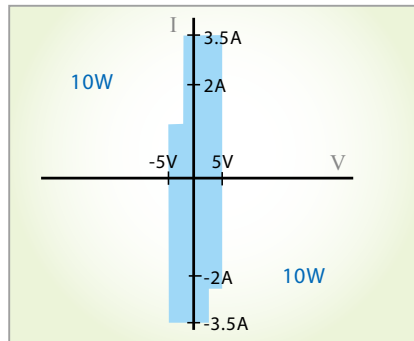
FOUR QUADRANT OPERATION

All Chroma 52400 series SMUs are designed for four quadrant operation for use by applications that require voltage/ current source or load simulation. During a load operation, the module is limited by the PXI chassis' standard of 20W heat dissipation per slot. This limit is noted as the imbalance in the quadrant diagrams for higher power models.

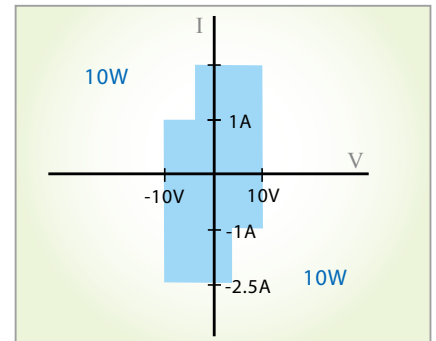
Below shows the quadrant diagrams of all Chroma 52400 SMU series.



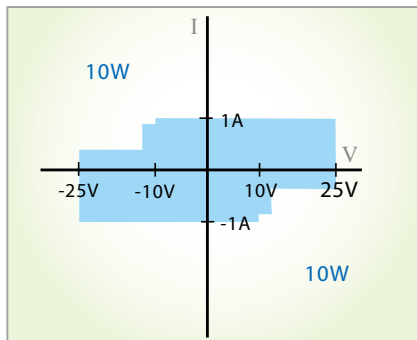
52401-25-200m



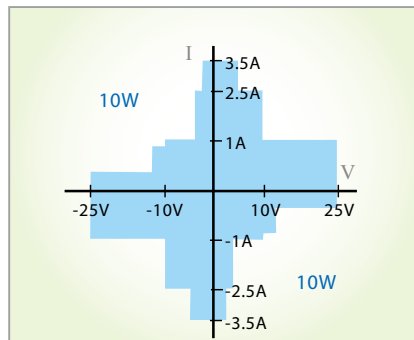
52405-5-3



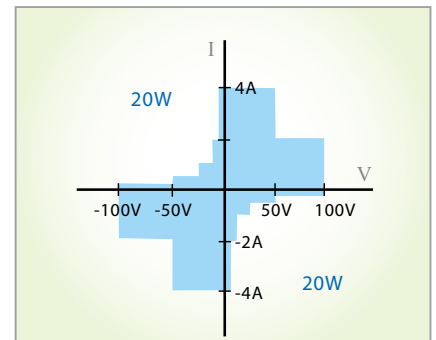
52405-10-2



52405-25-1



52405-25-3

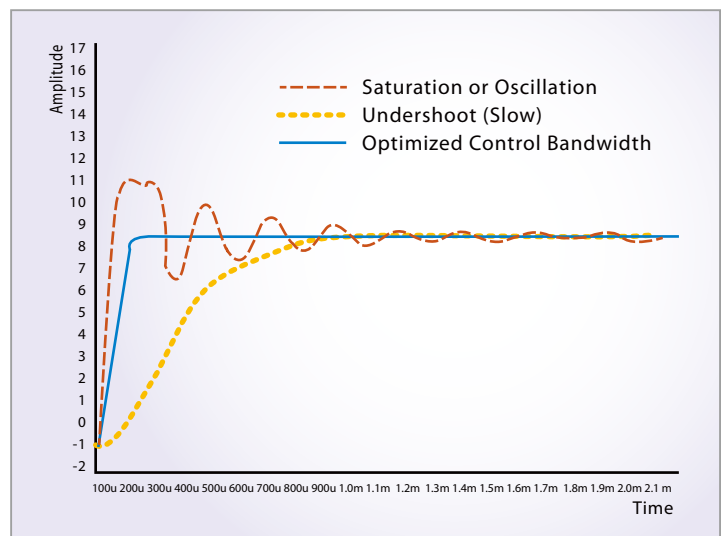


52420-100-4

CONTROL BANDWIDTH SELECTION

To reduce test times, Chroma's SMUs are designed for fast response providing a high speed output voltage and current. The impedance of the DUT, the fixture and/or cabling may potentially cause the entire control loop instability under voltage or current output mode. An unstable loop may cause saturation, oscillation, or even damage the DUT. As a result, user may be asked by SMU manufacturer to add a capacitor or an inductor in test fixture to regain stability of the system.

The 52400 series SMUs provide 16 user selectable control bandwidths eliminating the need for additional physical capacitors or inductors strategically placed at the DUT. The Chroma Bandwidth selection can be part of the test parameters in a test script where the value can be modified when DUT type is changed.



SMU Output Waveform under Different Control Scene

UNIQUE HARDWARE SEQUENCER

The Chroma Hardware Sequencer is a powerful tool that can predefine commands as instrument executable steps. This allows latency free control and measurement since no PC interaction is required during execution. The sequence optimizes the module's performance for applications like semiconductor test where speed and timing control are critical.

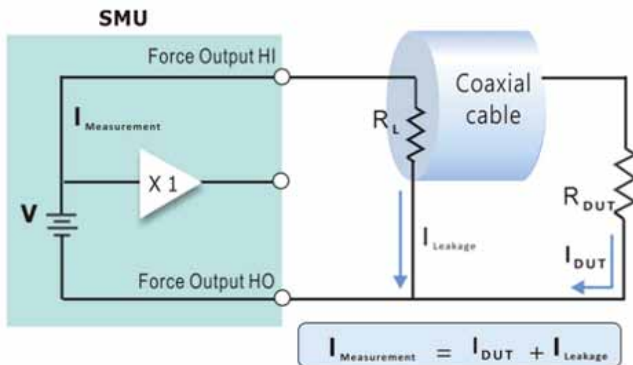
In this mode, once the instrument receives the start trigger, it will execute the commands in the sequencer table line by line or as defined upon trigger. Screen capture shown on the right is an example of sequence profile setting by using Soft Front Panel provided by Chroma.

Command	Channel	Delay Time	Delay Unit	Loop Times	Address	Value	Mode	Range	Ar
Command1	SCUR_MODE_SELECT	100	ms	...	...	...	...	...	...
Command2	READ_MODE_SELECT	100	ms	...	...	...	...	...	...
Command3	SET_V	100	ms	...	...	...	...	...	...
Command4	SET_ZONE_SELECT	100	ms	...	...	...	...	...	...
Command5	SET_ZONE_SELECT	100	ms	...	...	...	...	...	...
Command6	SET_ZONE_SELECT	100	ms	...	...	...	...	...	...
Command7	SET_ZONE_SELECT	100	ms	...	...	...	...	...	...
Command8	SET_ZONE_SELECT	100	ms	...	...	...	...	...	...
Command9	SET_ZONE_SELECT	100	ms	...	...	...	...	...	...
Command10	SET_ZONE_SELECT	100	ms	...	...	...	...	...	...
Command11	SET_ZONE_SELECT	100	ms	...	...	...	...	...	...
Command12	SET_ZONE_SELECT	100	ms	...	...	...	...	...	...
Command13	SET_ZONE_SELECT	100	ms	...	...	...	...	...	...
Command14	SET_ZONE_SELECT	100	ms	...	...	...	...	...	...
Command15	SET_ZONE_SELECT	100	ms	...	...	...	...	...	...
Command16	SET_ZONE_SELECT	100	ms	...	...	...	...	...	...
Command17	SET_ZONE_SELECT	100	ms	...	...	...	...	...	...
Command18	SET_ZONE_SELECT	100	ms	...	...	...	...	...	...

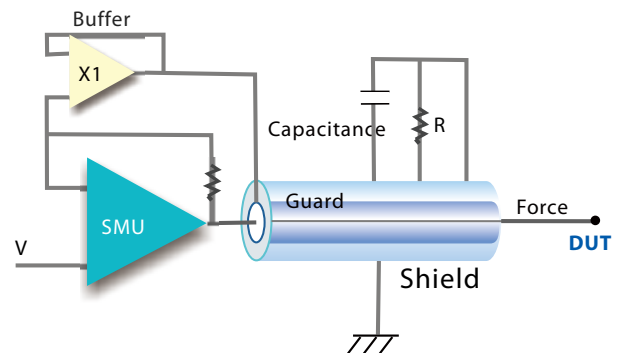
Hardware Sequencer to Predefine commands

GUARDING FOR LOW CURRENT APPLICATION

Guarding is an important technique for very-low current measurements. Guarding reduces Leakage Current error and decreases Settling Time. It keeps the potential of the guard connector at the same potential as the force conductor, so current does not flow between the force and guard conductors. It also eliminates the cable capacitance between source measure unit (SMU) and DUT for faster and more accurate measurements.



Leakage current flows through the cable's insulation resistance

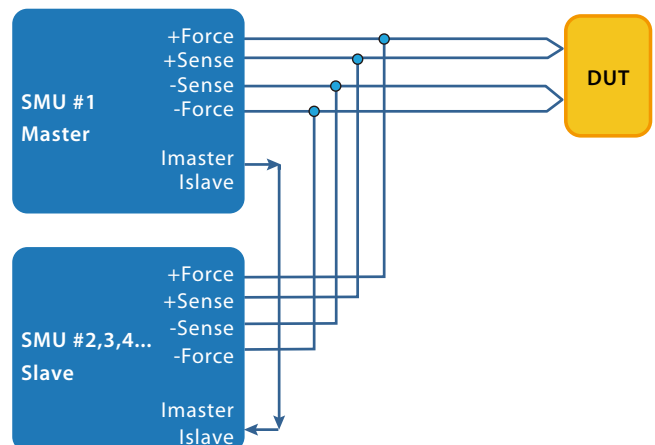


Guard Connection: Cable Capacitance is eliminated with Triaxial Cable

MASTER/SLAVE OPERATION

For maximum flexibility, Chroma 52400 series SMUs allow Master/Slave operation when higher current under FVMI mode is required! To ensure perfect current sharing between modules, for most reliable performance, Chroma SMUs allow only same model of channels being paralleled as higher current/ power module.

The ideal current sharing is achieved by one channel as Master and operated under FVMI mode while all the others will be set as FIMV mode. The Master channel will be programmed as application voltage desired and the analog signal of measured current will be used as the program current for rest of the FIMV channels. Figure on the right shows the configurations and connections for paralleled channels operated under Master/Slave mode.

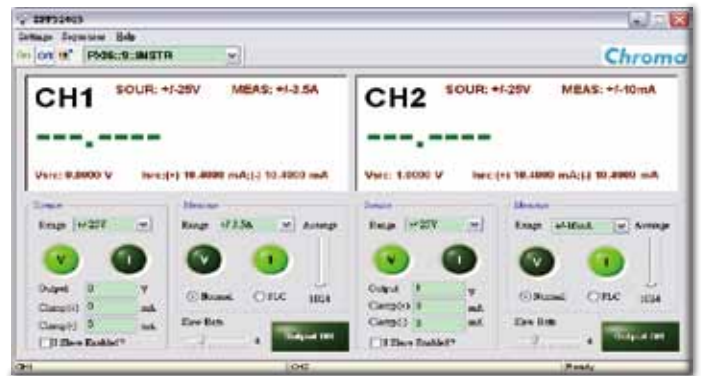


Wiring Structure for Master/Slave Control

VERSATILE SOFT FRONT PANEL

To integrate the 52400 series SMU systems, a versatile Soft Front Panel is provided as a standard accessory which allows users to conduct verification test or debugging. This Soft Front Panel provides GUI to set the SMU output mode, range and level. The measured voltage or current reading will be shown after output is on. For modules that have dual output channels, both channels can be controlled by same soft front panel

This Soft Front Panel also includes the control for hardware sequence setting described above. Users can save unlimited predefined profiles to PC and recall later for different applications.



Chroma 52400 Soft Front Panel

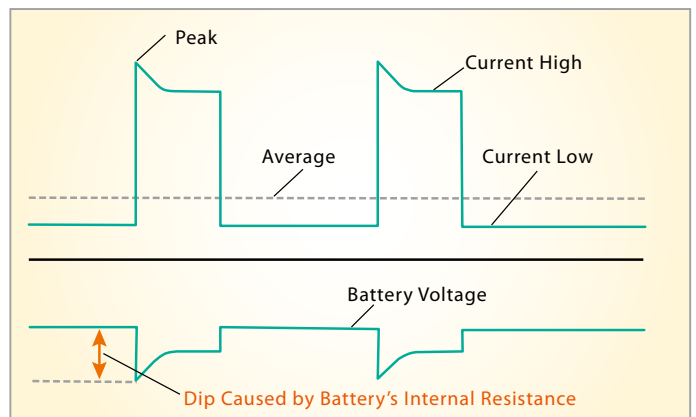
APPLICATIONS

DPS & Battery Simulation for Semiconductor Test

Device Power Supply (DPS) is a voltage source used to drive semiconductor ICs. With popularity of mobile applications, the DPS can be a voltage source from DC/DC converter or sometimes from a battery. The long operation time requirement makes the energy saving mode a common design for modern semiconductor devices. As a result, wide dynamic range of input current needs to be measured at high speed as well as high precision.

To meet this requirement, Chroma 52400 series SMU provides up to 10 current measurement ranges and 100k s/s sampling rate to ensure high speed and precision for both burst or quasi-state current measurement.

In case a battery is used as a DPS for the DUT, unique programmable resistance feature of the 52400 series SMU is capable of producing voltage dips that is observed in real battery setup. The voltage dip is caused by internal series resistance of battery when a burst of current drains through the DUT.

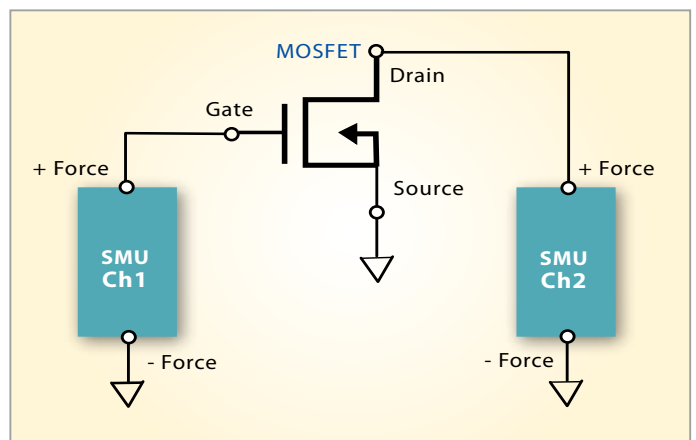


Influence of Battery Internal Resistance

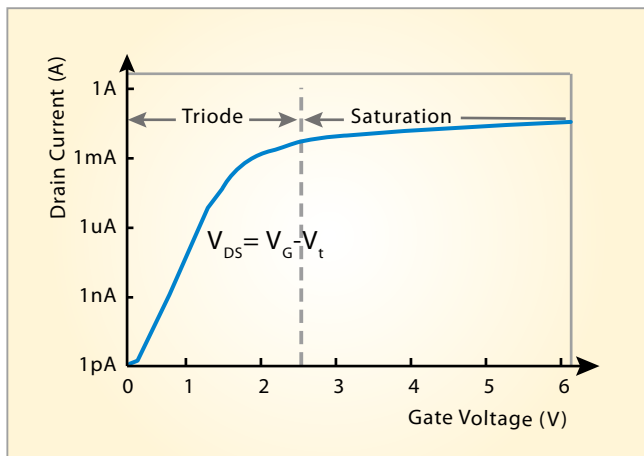
Transistor Test

The Current-Voltage (I-V) Characterization is crucial to ensure a FET meets specifications and works properly. These I-V tests may include gate leakage, breakdown voltage, drain current, etc. Programming and synchronizing multiple instruments is crucial to ensure correct test result. By using the 52400 series SMUs, users can quickly and accurately source and measure both current and voltage.

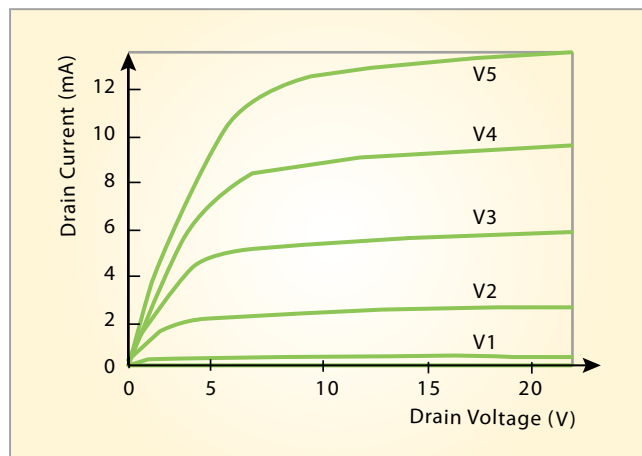
As indicated, The Force Hi (+Force) terminal of 52400 SMU CH1 is connected to the gate of the MOSFET and the Force Hi terminal of 52400 SMU CH2 is connected to the drain. The source terminal of the MOSFET is connected to the Force Lo (-Force) terminals of both SMU channels. By appropriately sweeping the voltage or current on different channels, user may get various MOSFET I-V characteristics.



Using two 52400 SMU Channels to Test MOSFET



Drain Current as a function of Gate Voltage



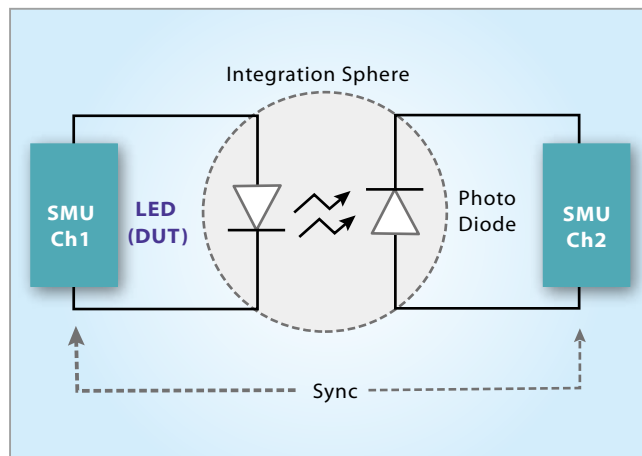
MOSFET drain family of curve measured by two SMU

LED/Laser Diode Test

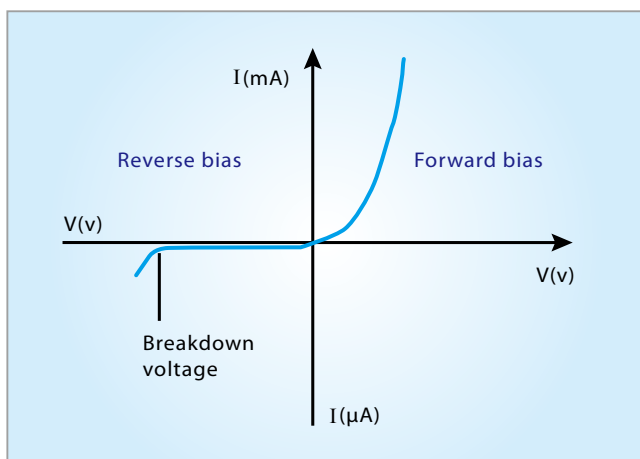
Light emitting devices such as LEDs or Laser Diodes require sourcing, loading and optical power measurement when conducting parametric test for LIV as well as reverse characteristics. The 52400 series SMU is capable of being in current source mode to drive the DUT to test the forward characteristics and being set as voltage sourcing mode for reverse performance.

Optical power measurement requires another measurement input. A photo diode is normally used to being an optical power sensor. The optical power is proportional to the short circuit of the photo diode, so failing to bias the photo diode to zero volt may cause less accurate measurements, due to the forward voltage of photo diode having higher temperature coefficient impact than the short circuit current. Another important feature of the 52400 series is the capability to compensate the voltage drop over the cable to ensure the photo diode is in true short circuit condition, while typical current shunt type of current measurement setup may cause voltage burden issues.

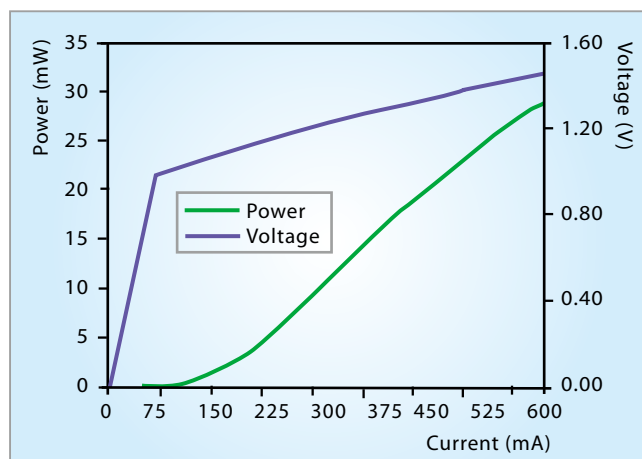
The dual input channels versions of Chroma 52400 series SMU, together with synchronous measurements are capable of covering all the test needs in one module to achieve smallest footprint and highest channel density when multiple DUTs need to be tested.



Typical LIV test setup for LED



Typical I-V Curve of LED/LD



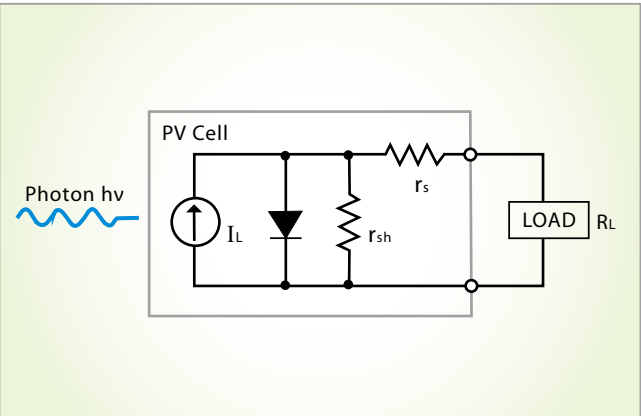
Typical LIV Curve of LED/LD

Solar Cell Test

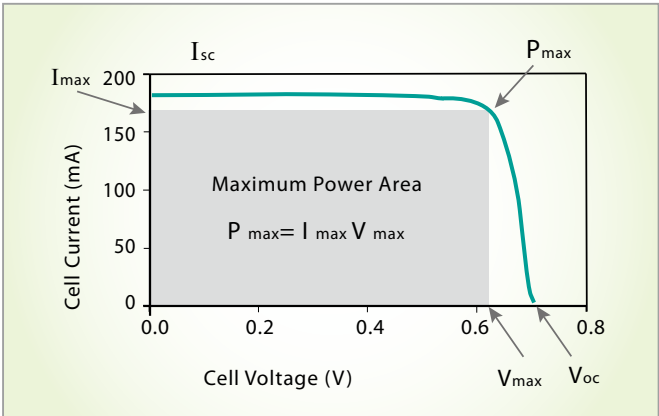
A solar cell has a diode structure type which can be characterized by I-V sweep. The nature of energy generation requires the unique load sweep for light forward I-V curve that is used to derive most of the important parameters of a solar cell. A voltage source will then be required for reverse performance testing. Unlike a conventional diode test, shunt and series resistors are both important performance indices of solar cells.

Chroma 52400 SMUs can be operated as load for light forward test and also as the voltage source for reverse bias characterization. This unique four-quadrant operation makes SMU an ideal test instrument for solar cell.

The 52400 series SMUs provide synchronous measurements for voltage and current, also between channels. This is important because the irradiance from solar simulator may cause temporary instability. So, irradiance monitoring is used to correct the photon current of a solar cell to 1 sun (100mW/m2), standard irradiance condition defined by IEC-60904-1.



Equivalent circuit of PV cell



Light forward I-V characteristic of PV cell

OTHER APPLICATIONS



Battery



Electrical Vehicle



Avionic



Power Electronics



Sensors

SPECIFICATIONS

Model Name	52401-25-200m	52405-5-3	52405-10-2	52405-25-1	52405-25-3	52420-100-4
Slot	1	1				2
Output Channels	2	2				1
Source	5W x 2	25W x 2				200W
Load	5W x 2	10W x 2				20W
Input Voltage	48VDC (Optional AC/DC Adapter required)					
Input Current	0.5A Max	1.5A Max				6A Max
Output Isolation	Isolated	None isolated between channels; Cards isolated by input				Cards isolated by input
Bits Resolution	18 bits	18 bits				20 bits DAC, 18 bits ADC
Programmable Loop Bandwidth	16 steps					
Number of Force Voltage Ranges	6	6	7	9	9	10
Number of Force Current Ranges	7	9	8	7	9	10
Number of Measure Voltage Ranges	12	6	7	9	9	10
Number of Measure Current Ranges	7	9	8	7	9	10
Force Voltage Ranges	± 25V, ± 10V, ± 5V, ± 2.5V, ± 1V, ± 500mV	± 5V, ± 2V, ± 1V, ± 500mV, ± 200mV, ± 100mV	± 10V, ± 5V, ± 2V, ± 1V, ± 500mV, ± 200mV, ± 100mV	± 25V, ± 12.5V, ± 10V, ± 5V, ± 2V, ± 1V, ± 500mV, ± 200mV, ± 100mV	± 25V, ± 12.5V, ± 10V, ± 5V, ± 2V, ± 1V, ± 500mV, ± 200mV, ± 100mV	± 100V, ± 50V, ± 20V, ± 10V, ± 5V, ± 2V, ± 1V, ± 500mV, ± 200mV, ± 100mV
Force Current Ranges	± 200mA, ± 20mA, ± 2mA, ± 200uA, ± 20uA, ± 2uA, ± 200nA	± 3.5A, ± 2.5A, ± 1A, ± 100mA, ± 10mA, ± 1mA, ± 100uA, ± 10uA, ± 1uA	± 2.5A, ± 1A, ± 100mA, ± 10mA, ± 1mA, ± 100uA, ± 10uA, ± 1uA	± 1A, ± 100mA, ± 10mA, ± 1mA, ± 100uA, ± 10uA, ± 1uA	± 3.5A(≤ 5V), ± 2.5A(≤ 10V), ± 1A, ± 100mA, ± 10mA, ± 1mA, ± 100uA, ± 10uA, ± 1uA	± 4A(≤ 50V), ± 2A, ± 1A, ± 100mA, ± 10mA, ± 1mA, ± 100uA, ± 10uA, ± 1uA, ± 100nA
Measure Voltage Ranges	± 25V, ± 10V, ± 5V, ± 2.5V, ± 1V, ± 500mV, ± 250mV, ± 100mV, ± 50mV, ± 25mV, ± 10mV, ± 4mV	± 5V, ± 2V, ± 1V, ± 500mV, ± 200mV, ± 100mV	± 10V, ± 5V, ± 2V, ± 1V, ± 500mV, ± 200mV, ± 100mV	± 25V, ± 12.5V, ± 10V, ± 5V, ± 2V, ± 1V, ± 500mV, ± 200mV, ± 100mV	± 25V, ± 12.5V, ± 10V, ± 5V, ± 2V, ± 1V, ± 500mV, ± 200mV, ± 100mV	± 100V, ± 50V, ± 20V, ± 10V, ± 5V, ± 2V, ± 1V, ± 500mV, ± 200mV, ± 100mV
Measure Current Ranges	± 200mA, ± 20mA, ± 2mA, ± 200uA, ± 20uA, ± 2uA, ± 200nA	± 3.5A, ± 2.5A, ± 1A, ± 100mA, ± 10mA, ± 1mA, ± 100uA, ± 10uA, ± 1uA	± 2.5A, ± 1A, ± 100mA, ± 10mA, ± 1mA, ± 100uA, ± 10uA, ± 1uA	± 1A, ± 100mA, ± 10mA, ± 1mA, ± 100uA, ± 10uA, ± 1uA	± 3.5A(≤ 5V), ± 2.5A(≤ 10V), ± 1A, ± 100mA, ± 10mA, ± 1mA, ± 100uA, ± 10uA, ± 1uA	± 4A(≤ 50V), ± 2A, ± 1A, ± 100mA, ± 10mA, ± 1mA, ± 100uA, ± 10uA, ± 1uA, ± 100nA
Force Voltage Accuracy	0.05% reading + 0.0076% F.S. (≥ 500mV Range) 0.02% reading + 25uV (< 500mV Range)	0.05% reading + 0.008% F.S. (≥ 500mV Range) 0.05% reading + 25uV (< 500mV Range)				0.02% reading + 0.002% F.S. (≥ 1V Range) 0.02% reading + 25uV (< 1V Range)
Force Current Accuracy	0.05% reading + 0.05% F.S. (≥ 2uA Range) 0.05% reading + 200pA (< 2uA Range)	0.1% reading + 0.1% F.S. (≥ 1A Range) 0.05% reading + 0.05% F.S. (< 1A Range)				0.1% reading + 0.025% F.S. (> 1A Range) 0.05% reading + 0.025% F.S. (≤ 1A Range) 0.05% reading + 200pA (< 1uA Range)
Force Current Accuracy	0.05% reading + 0.05% F.S. (≥ 2uA Range) 0.05% reading + 200pA (< 2uA Range)	0.1% reading + 0.1% F.S. (≥ 1A Range) 0.05% reading + 0.05% F.S. (< 1A Range)				0.1% reading + 0.025% F.S. (> 1A Range) 0.05% reading + 0.025% F.S. (≤ 1A Range) 0.05% reading + 200pA (< 1uA Range)

• Continued on next page →

SPECIFICATIONS

Model Name	52401-25-200m	52405-5-3	52405-10-2	52405-25-1	52405-25-3	52420-100-4
Measure Voltage Accuracy	0.02% reading + 0.0076% F.S. ($\geq 500\text{mV}$ Range) 0.05% reading + 25 μV ($< 500\text{mV}$ Range)	0.02% reading + 0.008% F.S. ($\geq 500\text{mV}$ Range) 0.05% reading + 25 μV ($< 500\text{mV}$ Range)				0.02% reading + 0.008% F.S. ($\geq 500\text{mV}$ Range) 0.02% reading + 25 μV ($< 500\text{mV}$ Range)
Measure Current Accuracy	0.05% reading + 0.05% F.S. ($\geq 2\mu\text{A}$ Range) 0.05% reading + 200pA ($< 2\mu\text{A}$ Range)	0.1% reading + 0.12% F.S. ($\geq 1\text{A}$ Range) 0.05% reading + 0.05% F.S. ($< 1\text{A}$ Range)				0.1% reading + 0.1% F.S. ($> 1\text{A}$ Range) 0.05% reading + 0.1% F.S. (1A Range) 0.05% reading + 0.05% F.S. ($< 1\text{A}$ Range) 0.05% reading + 200pA ($< 1\mu\text{A}$ Range)
Output Voltage Ripple & Noise	$< 50\text{mV}$ pp 20Mhz BW Full Load	$< 20\text{mV}$ pp 20Mhz BW Full Load	$< 20\text{mV}$ pp 20Mhz BW Full Load	$< 20\text{mV}$ pp 20Mhz BW Full Load	$< 20\text{mV}$ pp 20Mhz BW Full Load	$< 50\text{mV}$ pp 20Mhz BW Full Load
Measurement Sampling Rate	100K Sample/s	100K Sample/s	100K Sample/s	100K Sample/s	100K Sample/s	100K Sample/s
Output Connection	6 Wire (\pm Force/ \pm Sense/ \pm Guard)	6 Wire (\pm Force/ \pm Sense/ \pm Guard)	6 Wire (\pm Force/ \pm Sense/ \pm Guard)	6 Wire (\pm Force/ \pm Sense/ \pm Guard)	6 Wire (\pm Force/ \pm Sense/ \pm Guard)	6 Wire (\pm Force/ \pm Sense/ \pm Guard)
Measurement Log	32K Samples/channel	32K Samples/channel	32K Samples/channel	32K Samples/channel	32K Samples/channel	32K Samples/channel
Output Profiling	1024 Step	1024 Step	1024 Step	1024 Step	1024 Step	1024 Step
Trigger Input	1 CH	Programmable 8 CH	Programmable 8 CH	Programmable 8 CH	Programmable 8 CH	Programmable 8 CH
Trigger Output	1 CH	Programmable 8 CH	Programmable 8 CH	Programmable 8 CH	Programmable 8 CH	Programmable 8 CH
Floating Output	Channel Isolation	Channel Isolation	Channel Isolation	Channel Isolation	Channel Isolation	Channel Isolation
Master/Slave Mode	No	Yes	Yes	Yes	Yes	Yes
Programmable Resistance	No	Yes	Yes	Yes	Yes	Yes
Regulatory Compliance	CE/FCC	CE/FCC	CE/FCC	CE/FCC	CE/FCC	CE/FCC

All specifications are subject to change without notice.

ORDERING INFORMATION

52401-25-200m : High Precision Source Measure Unit, 25V/200mA

52405-5-3 : High Precision Source Measure Unit, 5V/3A

52405-10-2 : High Precision Source Measure Unit, 10V/2A

52405-25-1 : High Precision Source Measure Unit, 25V/1A

52405-25-3 : High Precision Source Measure Unit, 25V/3A

52420-100-4 : High Precision Source Measure Unit, 100V/4A

A524001 : 52401 External AC-DC Power Adaptor for Single Card

A524002 : External AC-DC Power Adaptor for Multi-Card

A524003 : 52401 Output Coaxial Cable

A524004 : 52401 Trigger Cable

A524005 : 52401 External DC Power Cable



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