Semight INSTRUMENTS

High Precision SMU

S2016C

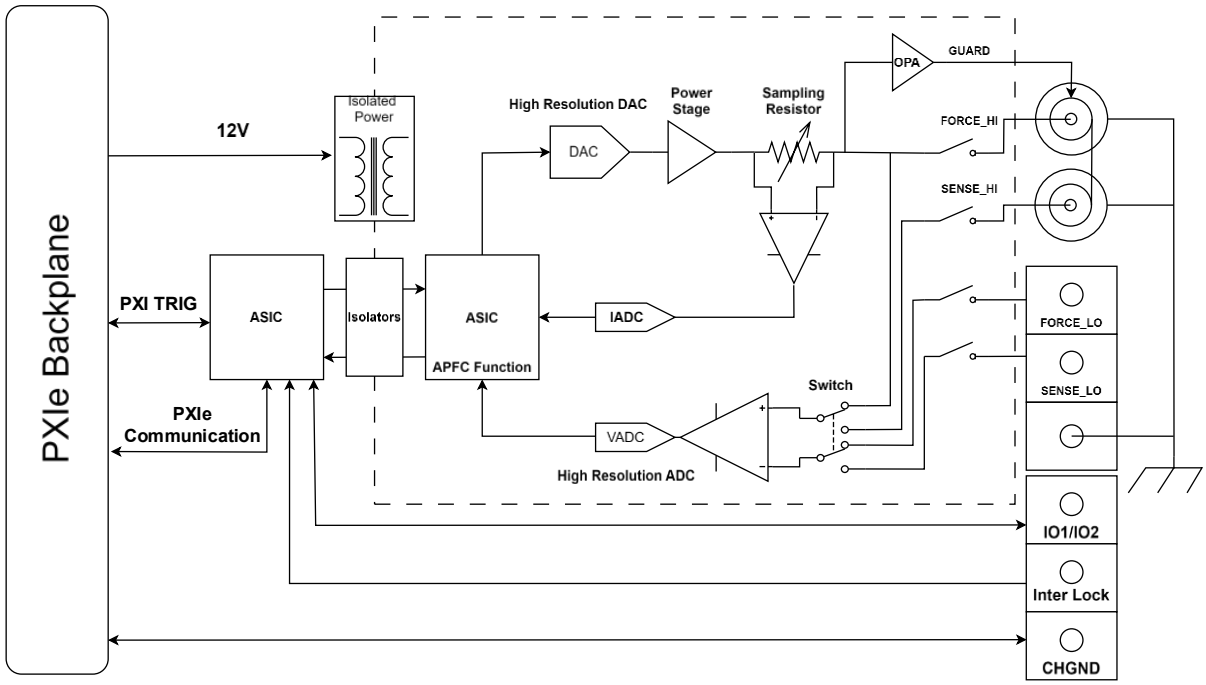
Datasheet V1.5

Based on bidirectional switching power supply and digital control loop technologies, the S2016C achieves precise and rapid output characteristics while significantly reducing module size. It complies with the PXIe standard, is compatible with existing mainstream PXIe chassis, features high integration, and enables multi-module synchronization testing. It provides ±200 V, ±1 A (DC), ±3 A (pulsed) output with 20 W constant power, a maximum sampling rate of 1 Msps, and a minimum measurement resolution of 1 fA/100 nV.

Contents

1 Product Description

The Semight S2016C is a compact and cost-effective, single-slot, single-channel PXIe Source/Measure Unit (SMU) with the capability to source and measure both voltage and current. It delivers output up to ±200 V, ±1 A (DC), and ±3 A (pulsed) with 20 W constant power and supports conventional SMU SCPI commands for easy test code migration. Compatible with existing mainstream PXIe chassis, it offers high integration, enabling easy channel expansion and multi-module synchronization. These features improve efficiency and lower the cost when integrating the SMUs into systems for production test.



S2016C Block Diagram

2 Features and Benefits

APFC System

Supports user modification of APFC (Adaptive Precision-Fast Control) parameters. Users can adjust the parameters based on load characteristics to achieve precise and rapid output characteristics.

Waveforms Comparison Before and After APFC Adjustment

Maximum Range

Output range: ±200 V, ±1 A (DC), ±3 A (pulsed). Dual modules enable easy LIV sweep testing.

Minimum Measurement Resolution

Current and voltage measurement resolution down to 1 fA/100 nV. Can make low-level measurements using a low-cost PXIe SMU that were previously only possible using a more expensive semiconductor device analyzer.

High-Speed Measurement

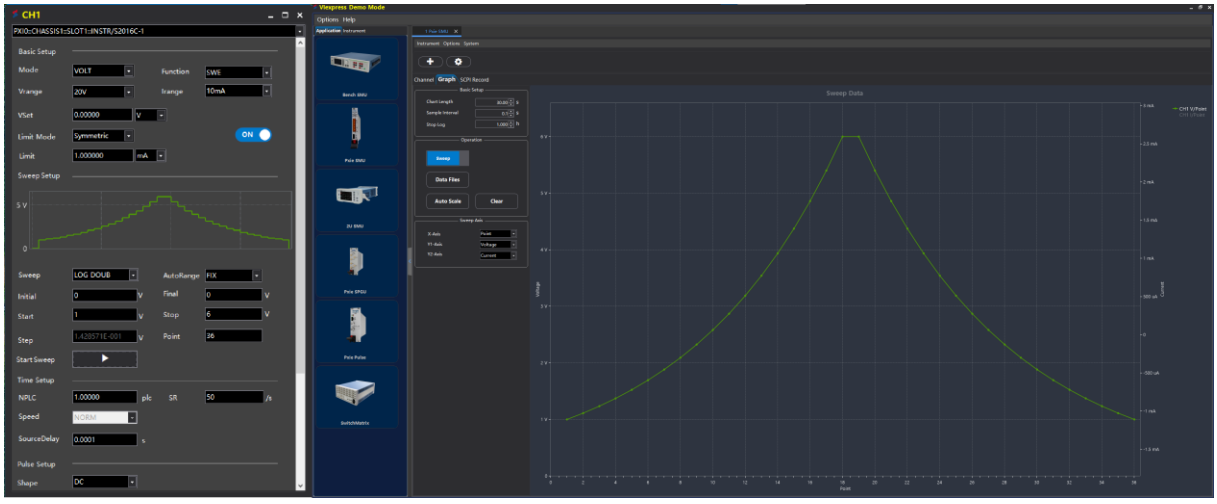
ADC sampling rates up to 1 Msps, with selectable NPLC (Number of Power Line Cycles) and sampling rate.

Sensing Mode

Supports 2-wire or 4-wire (remote-sensing) connections. Maximum sense lead resistance is 1 KΩ (for rated accuracy). Maximum voltage between output and sense terminals is 2 V.

Sweep Mode

Supports linear, logarithmic, and list sweeps in both single and double directions. The step interval is configurable from 1 µs to 16 s, with a maximum of 10^6 points per sweep.



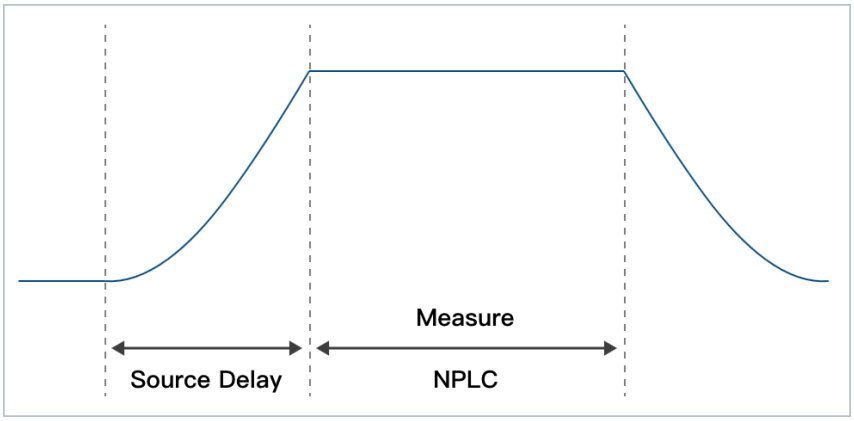
Double Logarithmic Sweep

Auto Ranging

Supports auto-ranging for both spot and sweep measurement. For overshoot-sensitive devices, it is recommended to turn off the output before switching ranges.

Source Delay

Supports Source Delay measurement. Users are recommended to set an appropriate Source Delay for more accurate measurements. Source Delay must exceed the source settling time, especially for low current ranges. When the sampling values are inaccurate, it is necessary to consider whether the Source Delay is appropriately set.



Source Delay and NPLC Setting Diagram

Protection

- Over-temperature protection: The system power shuts down at over temperature sensed internally.
- Over-current and over-voltage protection: If triggered, the module LED turns red, then operation resumes after a hardware reset command or power cycling.
- If the module LED fails to light, a problem may exist with a hardware module.

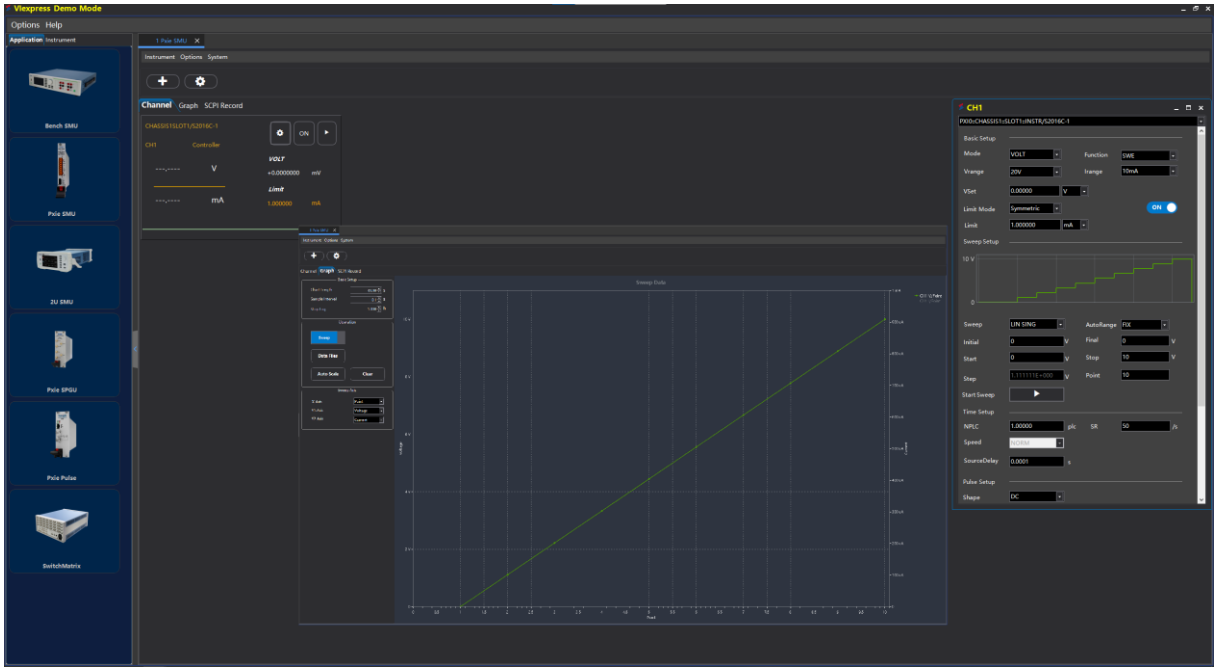
Synchronous Triggering

- Supports multi-module synchronous triggering using both internal (8 Trig Bus lines, 0 to 7) and external (2 Digital I/O lines, 1 to 2) trigger sources. Configure the internal Trig I/O to ensure all modules are on the same routing segment within the chassis. If not, the internal Trig I/O can be routed to the corresponding I/O via the chassis host software.
- The following principles must be adhered to for both internal and external triggering: A channel can be configured with multiple I/O ports for trigger output, but only a single I/O port can be configured for trigger input at any given time; An I/O port can be configured as a trigger input for multiple channels, but it can only be configured as a trigger output for one channel at any given time.
- Pulse width: 100 ns to 1 ms (configurable); Active high.
- External DIO trigger level:

DIO Parameters	Max Rating Value
Absolute Maximum Input Voltage	5.25 V
Absolute Minimum Input Voltage	-0.25 V
Minimum Logic High Level	2.1 V
Maximum Logic Low Level	0.7 V
Maximum Logic Output Current	2 mA
Maximum Sink Current	-50 mA

Free PC-Based GUI Control Software

Can make measurements and control remotely from a PC without the need to program.



Software GUI

PC System Configuration

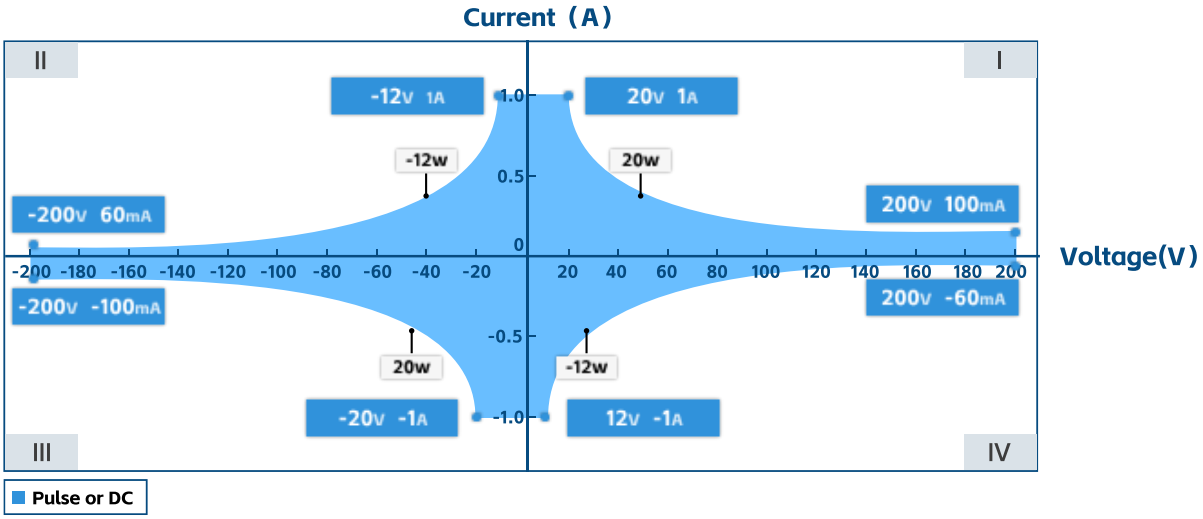
- Intel Core i7 or higher.
- Minimal 8 GB memory (additional memory required based on actual application).
- Windows 11 / Windows 10 (64-bit) / Windows 7 (64-bit, with required patches for driver installation).
- Installation of the Semight driver is required to configure and operate the module.

3 Specifications

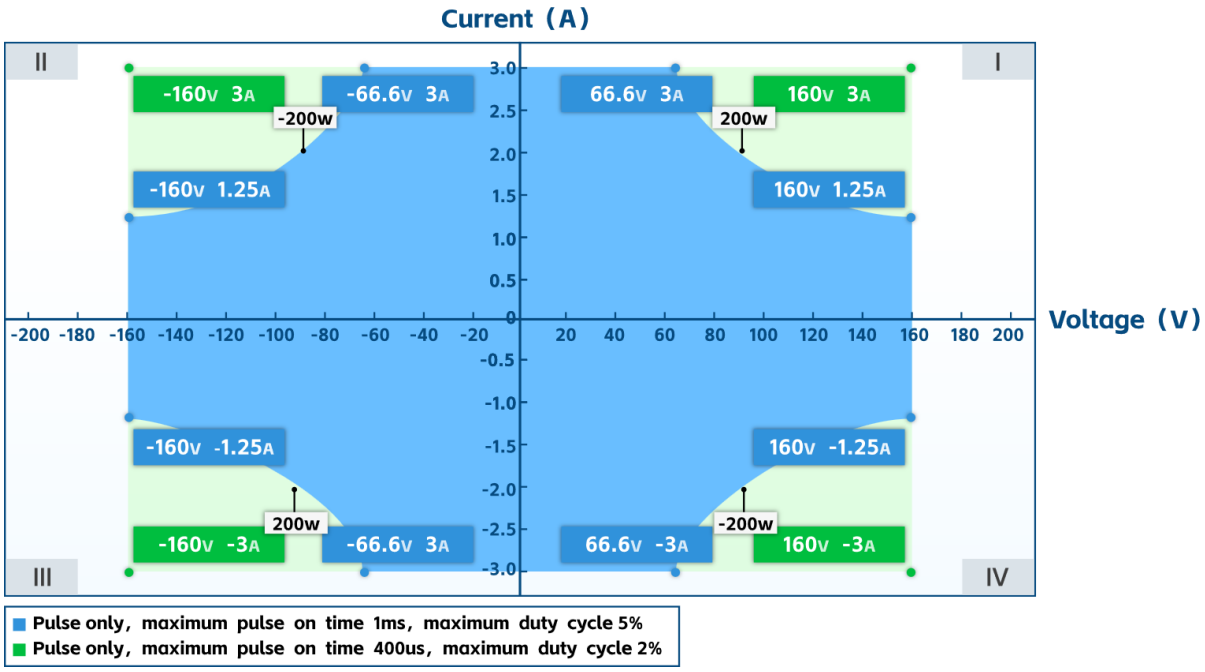
Operating Conditions:

- Temperature: 23 ℃ ± 5 ℃.
- Humidity: 30% to 60% (RH).
- Measure after a 60-minute warm-up; Ambient temperature change less than ±3 °C during measurement.
- Calibration period: 1 year.
- Measurement speed: 1 PLC (power line cycle).
- Fans set to the highest setting if the PXIe chassis has multiple fan speed settings.

SMU Output Capability



DC I-V Output Capability



Pulse I-V Output Capability

Voltage Programming and Measurement Resolution/Accuracy

	Range	Resolution	Accuracy (1 Year) ± (% reading + offset)[1]	*Typical Noise (RMS)* *0.1 Hz to 10 Hz*
Voltage Accuracy	±200 V[2]	100 µV	0.03% + 10 mV	*400 µV*
	±40 V	10 µV	0.03% + 2 mV	*100 µV*
	±20 V	10 µV	0.03% + 1 mV	*50 µV*
	±2 V	1 µV	0.03% + 100 µV	*10 µV*
	±0.6 V	100 nV	0.03% + 50 µV	*5 µV*
Temperature Coefficient	± (0.15 × Accuracy)/°C (0 °C to 18 °C, 28 °C to 50 °C)			
Overshoot	< ±0.1% (Typical, Normal; Step is 10% to 90% range, full-scale, resistive load)			
Noise 10 Hz to 20 MHz	< 5 mVrms, 20 V voltage source, 1 A resistive load			

[1] Example of calculating accuracy: To test the accuracy of a 120 mV output in the 600 mV range, the tolerance is:

$$\pm\ (\underbrace{120}_{reading} \times 0.03\% + \underbrace{0.05}_{offset})\ mV = \pm 0.086\ mV$$

[2] This instrument has a potentially dangerous high voltage (±210 V) output to the HI / Sense HI / Guard terminals. To prevent electric shock, relevant safety precautions must be taken before powering on. Do not connect the Guard terminal to any output, including shorting it to the chassis ground or output LO, as this will damage the instrument.

Current Programming and Measurement Resolution/Accuracy

	Range	Resolution	Accuracy (1 Year) ± (% reading + offset)	*Typical Noise (RMS) 0.1 Hz to 10 Hz*
Current Accuracy	±3 A[3]	1 µA	0.03% + 2 mA	*20 µA*
	±1 A	100 nA	0.03% + 90 µA	*4 µA*
	±100 mA	10 nA	0.03% + 9 µA	*600 nA*
	±10 mA	1 nA	0.03% + 900 nA	*60 nA*
	±1 mA	100 pA	0.03% + 90 nA	*6 nA*
	±100 µA	10 pA	0.03% + 9 nA	*700 pA*
	±1 µA[4]	100 fA	0.03% + 200 pA	*20 pA*
	±10 nA[4][5]	10 fA	0.06% + 9 pA	*600 fA*
	±1 nA[4][5]	1 fA	0.1% + 3 pA	*60 fA*
	±100 pA[4][5]	1 fA	0.3% + 1 pA	*30 fA*
Temperature Coefficient	± (0.15 × accuracy)/°C (0 °C to 18 °C, 28 °C to 50 °C)			
Overshoot	< ±0.1% (Typical, Normal; Step is 10% to 90% range, full-scale, resistive load)			

[3] 3 A range is available only for pulse mode, with typical accuracy.

[4] For accurate low current measurements, triaxial cable connection is recommended. Converting the triaxial output to standard wiring will affect current measurement accuracy.

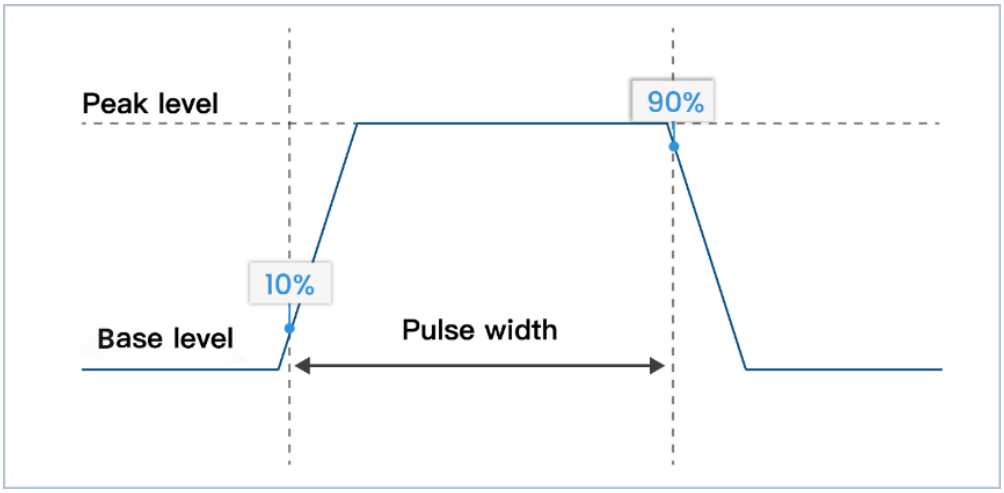
[5] Condition: NPLC = 10 PLC.

Resistance Measurement Resolution/Accuracy (4-Wire)

	Range	Resolution	Default Test Current	Typical Accuracy (1 Year) ± (% reading + offset)
Resistance Measurement Accuracy	600 mΩ	100 nΩ	1 A	0.07% + 50 μΩ
	6 Ω	1 μΩ	100 mA	0.07% + 500 μΩ
	60 Ω	10 μΩ	10 mA	0.07% + 5 mΩ
	600 Ω	100 μΩ	1 mA	0.07% + 50 mΩ
	6 KΩ	1 mΩ	100 μA	0.07% + 500 mΩ
	60 KΩ	10 mΩ	10 μA	0.15% + 5 Ω
	600 KΩ	100 mΩ	1 μA	0.08% + 50 Ω
	6 MΩ	1 Ω	100 nA	0.26% + 500 KΩ
	60 MΩ	10 Ω	10 nA	0.18% + 5 KΩ
	600 MΩ	100 Ω	1 nA	0.43% + 50 KΩ
	6 GΩ	1 KΩ	100 pA	1.35% + 500 KΩ
Temperature Coefficient	± (0.15 × accuracy)/°C (0 °C to 18 °C, 28 °C to 50 °C)			
Manual Current Source Resistance Measurement (4-Wire)	Total Error = Measured Voltage / Current Source Set Current = Resistance Reading x (Voltage Source Range Gain Error Percentage + Ammeter Range Gain Error Percentage + Current Source Range Offset Error / Set Current) + (Voltage Source Range Offset Error / Set Current Value) Example: Current Source Set Current = 1 A, Voltage Measurement Range = 600 mV Total Error = (0.03% + 0.03% + 90 μA / 1 A) + (50 μV / 1 A) ≈ 0.07% + 50 μΩ			

Pulse Source Specifications

Item	Specification
Minimum Programmable Pulse Width	100 μs
Pulse Width Programming Resolution	1 μs
Pulse Width Programming Accuracy	±10 μs
Pulse Width Jitter	2 μs
Pulse Width Definition	The time from 10% leading to 90% trailing edge as follows



Pulse Width Definition

Maximum Current Limit	Maximum Pulse Width	Maximum Duty Cycle
0.1 A/200 V	DC, no limit	100%
1 A/20 V	DC, no limit	100%
3 A/66.6 V	1 ms	5%
3 A/160 V	400 μs	2%

Pulse Source Rise Time

Output	Maximum Output	*Typical Rise Time*[6]	*Typical Settling Time*[7]	Test Load
Voltage Source	160 V	*800 µs*	*1.2 ms*	No load
	5 V	*50 µs*	*100 µs*	No load
Current Source	3 A to 1 mA	*100 µs*	*250 µs*	Full load[8]
	100 µA	*150 µs*	*400 µs*	Full load[8]
	1 µA	*800 µs*	*1.2 ms*	Full load[8]
	10 nA	*5 ms*	*20 ms*	Full load[8]
	1 nA	*10 ms*	*50 ms*	Full load[8]
	100 pA	*100 ms*	*500 ms*	Full load[8]

[6] Time required for the pulse leading edge to rise from 10% to 90%.

[7] Time required for the pulse to reach within 1% of final value.

[8] Test conditions: Normal mode, resistive full load, voltage rises to 6 V.

Output Settling Time

Output	Range	Output Settling Time[9]			Condition
		Fast[10]	Normal	Slow	
Voltage Source	200 V	< 600 µs	< 1.2 ms	< 2 ms	Time required to reach within 0.1% of final value at open load condition. Step is 10% to 90% range.
	40 V	< 200 µs	< 400 µs	< 900 µs	
	20 V	< 100 µs	< 200 µs	< 600 µs	
	2 V	< 300 µs	< 300 µs	< 300 µs	
	0.6 V	< 300 µs	< 300 µs	< 300 µs	
Current Source	3 A to 1 mA	< 150 µs	< 200 µs	< 0.8 ms	Time required to reach within 0.1% (0.3% for 3 A range) of final value under Normal mode at full load with the voltage output rising to 6 V. Step is 10% to 90% range.
	100 µA	< 150 µs	< 250 µs	< 0.8 ms	
	1 µA	< 1 ms	< 1 ms	< 1 ms	
	10 nA	< 10 ms	< 10 ms	< 10 ms	
	1 nA	< 50 ms	< 50 ms	< 50 ms	
	100 pA	< 500 ms	< 500 ms	< 500 ms	

[9] Output slew rate: Fast, Normal, Slow modes. Users can adjust APFC parameters according to load characteristics to achieve appropriate settling time or stability.

[10] Fast mode may exhibit significant output overshoot under different ranges or load conditions. For devices sensitive to overshoot, Normal or Slow mode is recommended.

Sampling Rate and NPLC Settings

Setting	Range
NPLC	0.00005 PLC to 10 PLC
Sampling Rate	5 sps to 1 Msps

Measurement Accuracy Derating

Add % of range using the following table for measurement with PLC < 1.

PLC	Range							
	0.6 V	2 V	20 V	40 V	200 V	100 pA to 1 µA	100 µA to 100 mA	1 A to 3 A
0.1	0.02%	0.02%	0.01%	0.01%	0.01%	0.02%	0.01%	0.01%
0.01	0.30%	0.30%	0.30%	0.03%	0.02%	0.20%	0.02%	0.02%
0.001	3.20%	3.20%	3.20%	0.40%	0.10%	2.50%	0.03%	0.03%

Environmental Specifications

Item	Specification
Environment	For use in indoor facilities
Operating	0 ℃ to +50 ℃, 30% to 60% RH, non-condensing
Storage	-30 ℃ to 70 ℃, 10% to 90% RH, non-condensing
Dimensions	210 x 130 x 20 mm
Weight	Net weight: 0.46 kg
Power Supply	Full Load: 12 V/3.5 A; 3.3 V/0.5 A; 5 V/0.01 A
Altitude	Operating: 0 m to 2000 m, Storage: 0 m to 4600 m
Pollution Degree	2
Warm-Up	1 hour

4 Ordering Information

Standard Factory Accessories: Output connector (cable not included), Digital I/O connector (cable not included), Installation Software USB Drive (PC software and product driver, PDF product datasheet, PDF user manual).

Model Number	
S2016C	High Precision SMU
Options	
TA-01003	Output Extension Adapter, Triaxial to Screw Terminals, 250 V, 1 A
Consumables/Accessories	
TA-03001	Triaxial Output Cable, Male-to-Male, 0.6 m, 250 V, 1 A
TA-03002	Triaxial Output Cable, Male-to-Male, 1.5 m, 250 V, 1 A
TA-03003	Triaxial Output Cable, Male-to-Male, 4 m, 250 V, 1 A
Service (Choose One)	
R3C	Factory Extended Warranty Service Plan – 36 Months
R5C	Factory Extended Warranty Service Plan – 60 Months

5 Warranty

No.	Item	Content	Warranty Period
1	Main Unit	Free repair within warranty	12 months
2	Options	Consumables and accessories are not covered under warranty	3 months
3	Calibration Interval	Factory calibrated or calibrated at the nearest Semight service center	12 months

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