2651A

50A, 고전력 시스템 소스미터® SMU 계측기

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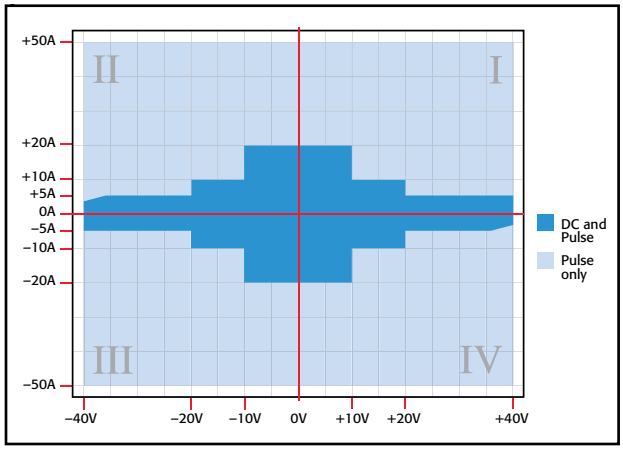
- **소스 또는 싱크 :**
  - 2,000W의 펄스 전력 (±40V, ±50a)
  - 200W의 DC 전원 (± 10V @ ±20a, ±20V @±10a, ±40V @ ±5a)
- 2 개의 장치 (직렬 또는 병렬)를 쉽게 연결하여 최대 ±100a 또는 ±80V의 솔루션 생성
- 1pa 분해능 으로 매우 낮은 누설 전류를 정밀하게 측정
- 포인트 당 1 µs (1 MHz), 18 비트 샘플링으로 과도 동작을 정확하게 특성화
- PWM (Pulse Width Modulated) 구동 방식 및 장치 별 구동 자극을 위한 1% ~ 100% 펄스 듀티 사이클
- 정밀 전원 공급 장치, 전류소스, DMM, 임의 파형 발생기, V 또는 I 펄스 발생기와 측정, 전자 부하 및 트리거 컨트롤러를 모두 하나의 계측기에 결합
- TsP® Express I-V 특성화 소프트웨어, LabVIEW® 드라이버 및 Keithley의 테스트 스크립트 빌더 소프트웨어 개발 환경 포함

응용 분야

- 전력 반도체, HblED 및 광학 장치 특성화 및 테스트
- 태양 전지 특성화 및 테스트
- GaN, siC 및 기타 복합 재료 및 장치의 특성 분석
- 반도체 접합 온도 특성
- 고속, 고정밀 디지털화
- 일렉트로마이그레이션 연구
- 고전류, 고전력 장치 테스트

고전력 모델 2651A 소스미터 SMU 계측기는 고전력 전자 제품의 특성을 분석하고 테스트하도록 특별히 설계되었습니다. 이 SMU 계측기는 고휘도 LED, 전력 반도체, DC-DC 컨버터, 배터리, 태양 전지 및 기타 고전력 재료, 구성 요소, 모듈 및 하위 어셈블리를 포함하여 R & D, 신뢰성 및 생산 스펙트럼 전반에 걸친 응용 제품의 생산성을 향상시킬 수 있습니다. 모델 2651A는 매우 유연한 4 사분면 전압 및 전류 소스/부하를 정밀 전압 및 전류 미터와 결합하여 제공합니다. 다음과 같이 사용할 수 있습니다.

- 반도체 특성 분석 장비
- V 또는 I 파형 발생기
- V 또는 I 펄스 발생기
- 정밀 전원
- 실제 전류 소스
- 디지털 멀티 미터 (DCV, DCI, 옴 및 6½ 자리 해상도의 전력)
- 정밀 전자 부하



모델 2651a는 최대 ±40V 및 ±50a를 소싱 또는 싱킹 할 수 있습니다.

두 가지 측정 모드 : 디지털화 또는 통합

모델 2651A의 두 가지 측정 모드를 사용하여 빠르게 변화하는 열 효과를 포함하여 과도 및 정상 상태 동작을 정확하게 특성화합니다. 각 모드는 독립적 인 아날로그-디지털 (A / D) 변환기에 의해 정의됩니다. 디지타이징 측정 모드는 포인트 당 1µs 측정이 가능합니다. 18 비트 A / D 변환기를 사용하면 과도 특성을 정확하게 측정 할 수 있습니다. 보다 정확한 측정을 위해서는 22 비트 A / D 변환기를 기반으로 하는 통합 측정 모드를 사용하십시오.

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주문 정보

2651A 고전력 시스템 소스미터® SMU 계측기

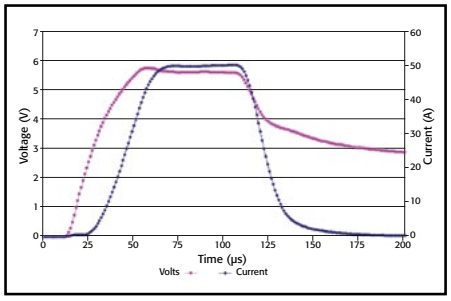
제공되는 액세서리

- 2651A-KIT-1A : 낮은 임피던스 케이블 어셈블리 (1m)
- CS-1592-2 : 고전류 피닉스 커넥터 (수)
- CS-1626-2 : 고전류 피닉스 커넥터 (암)
- CA-557-1 : 감지 선 케이블 어셈블리 (1m)
- 7709-308A : 디지털 I/O 커넥터
- CA-180-3A : TSP 링크/이더넷 케이블
- 설명서 CD
- 소프트웨어 도구 및 드라이버 CD

악세서리

2600-KIT	Screw Terminal Connector Kit
ACS-BASIC	Component Charaterization Software
4299-6	Rack Mount Kit
8011	Test Socket Kit

테스트 처리량을 희생하지 않는 정확한 소스 리드 백을 위해 동시에 실행되는 2 개의 A/D 컨버터가 각 측정 모드 (전류 용 및 전압 용)에 사용됩니다.



듀얼 디지타이징 A/D 컨버터는 최대 1µs/point로 샘플링 하여 전류 및 전압 파형의 완전한 동시 특성 분석이 가능합니다.

고속 펄스

모델 2651A는 100µs의 짧은 펄스를 정확하게 소싱 및 측정하여 테스트 중에 원하지 않는 자체 가열 효과를 최소화합니다. 추가적인 제어 유연성으로 펄스 폭을 100µs에서 DC로 프로그래밍하고 듀티 사이클을 1%에서 100%로 프로그래밍 할 수 있습니다.
단일 장치는 최대 50A를 펄스 할 수 있습니다.

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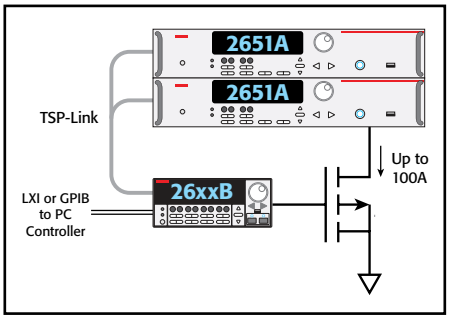
두 개의 장치를 결합하여 최대 100A의 펄스를 발생시킵니다.

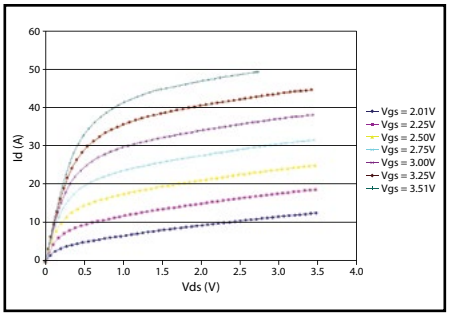
확장 기능

TSP-Link Technology 기술을 통해 여러 모델 2651A와 선택한 Series 2600B SMU 계측기를 결합하여 최대 64개의 채널을 갖춘 더 큰 통합 시스템을 구성 할 수 있습니다. 내장된 500ns 트리거 컨트롤러를 통해 정밀한 타이밍과 긴밀한 채널 동기화가 보장됩니다. 진정한 SMU 핀당 계측기 테스트는 완전히 분리 된 독립적인 소스미터 SMU 계측기 채널을 통해 보장됩니다.

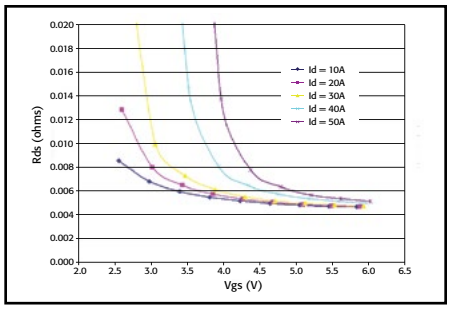


Keithley의 TsP 및 TSP-Link Technologies는 메인 프레임 기반 시스템의 전력 및 / 또는 채널 제한 없이 진정한 핀당 SMU 핀 테스트를 지원합니다.

또한 2 개의 모델 2651A를 TSP-Link Technology와 병렬로 연결하면 전류 범위가 50A에서 100A로 확장됩니다. 두 장치를 직렬로 연결하면 전압 범위가 40V에서 80V로 확장됩니다. 내장 된 인텔리전스는 장치를 단일 계측기로 처리 할 수 있게하여 테스트를 단순화하여 업계 최고의 다이나믹 레인지 (100A ~ 1pA)를 만듭니다. 이 기능을 사용하면 훨씬 광범위한 전력 반도체 및 기타 장치를 테스트 할 수 있습니다.



50a (2개의 유닛으로 100a)까지 정밀 측정하면 보다 완전하고 정확한 특성화가 가능합니다.



1µV 측정 분해능 및 최대 50a (2 개의 장치로 100a)의 전류 소싱을 통해 저수준 RDS 측정을통해 차세대 장치를 지원할 수 있습니다.

2600b 시리즈 SMu 계측기의 표준 기능

각 모델 2651A에는 다음과 같은 대부분의 2600B 시리즈 SMU 계측기에서 제공되는 모든 기능이 포함되어 있습니다.

- 벤치 탑 I-V 특성화 도구 또는 다중 채널 I-V 테스트 시스템의 구성 요소로 사용 가능
- 반도체 구성 요소 특성 분석을위한 소프트웨어 ACS Basic Edition 소프트웨어를 프로그래밍하거나 설치하지 않고도 일반적인 I-V 테스트를 빠르고 쉽게 수행 할 수 있는 TSP Express 소프트웨어 (옵션).
- ACS Basic에는 특성 곡선 모음을 생성하기 위한 추적 모드가 있습니다.
- Keithley의 테스트 스크립트 프로세서 (TSP®) 기술은 사용자 정의 사용자 테스트 스크립트를 생성하여 테스트를 자동화하고 계측기가 PC를 직접 제어하지 않고도 비동기식 으로 작동 할 수 있도록 하는 프로그래밍 시퀀스 생성을 지원합니다.
- 여러 SMU 계측기가 시스템에 함께 연결될 때 병렬 테스트 실행 및 정밀 타이밍
- LXI 준수
- 프로브스테이션, 구성 요소 처리기 또는 기타 자동화 도구와 직접 상호 작용할 수 있는 14 개의 디지털 I / O 라인
- USB 메모리 장치를 통한 추가 데이터 및 테스트 프로그램 저장을 위한 USB 포트

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Specification Conditions

이 문서에는 모델 2651A 고전력 시스템 소스미터 SMU 계측기의 사양 및 보충 정보가 포함되어 있습니다. 사양은 모델 2651A가 테스트되는 표준입니다. 출고시 모델 2651A는 이러한 사양을 충족합니다. 보충 및 일반적인 값은 보증되지 않으며 23°C에서 적용되며 유용한 정보로만 제공됩니다. 정확도 사양은 일반 및 고용량 모드 모두에 적용 할 수 있습니다.

소스 및 측정 정확도는 다음 조건 하에서 모델 2651A 터미널에서 지정됩니다.

- 23° ±5°C, <70 percent relative humidity
- After two-hour warm-up
- Speed normal (1 NPLC)
- A/D autozero enabled
- Remote sense operation or properly zeroed local operation
- Calibration period: One year

VOLTAGE ACCURACY SPECIFICATIONS [1, 2]

	SOURCE			MEASURE		
Range	Programming Resolution	Accuracy ±(% reading + volts)	Noise (Vpp) (typical) 0.1 Hz to 10 Hz	Default Display Resolution	Integrating ADC Accuracy [3] ±(% reading + volts)	High-Speed ADC Accuracy [4] ±(% reading + volts)
100.000 mV	5 µV	0.02% + 500 µV	100 µV	1 µV	0.02% + 300 µV	0.05% + 600 µV
1.00000 V	50 µV	0.02% + 500 µV	500 µV	10 µV	0.02% + 300 µV	0.05% + 600 µV
10.0000 V	500 µV	0.02% + 5 mV	1 mV	100 µV	0.02% + 3 mV	0.05% + 8 mV
20.0000 V	500 µV	0.02% + 5 mV	1 mV	100 µV	0.02% + 5 mV	0.05% + 8 mV
40.0000 V	500 µV	0.02% + 12 mV	2 mV	100 µV	0.02% + 12 mV	0.05% + 15 mV

CURRENT ACCURACY SPECIFICATIONS [5]

	SOURCE			MEASURE		
Range	Programming Resolution	Accuracy ±(% reading + amps)	Noise (Ipp) (typical) 0.1Hz to 10Hz	Default Display Resolution	Integrating ADC Accuracy [3] ±(% reading + amps)	High-Speed ADC Accuracy [4] ±(% reading + amps)
100.000 nA	2 pA	0.1 % + 500 pA	50 pA	1 pA	0.08% + 500 pA	0.08% + 800 pA
1.00000 µA	20 pA	0.1 % + 2 nA	250 pA	10 pA	0.08% + 2 nA	0.08% + 4 nA
10.0000 µA	200 pA	0.1 % + 10 nA	500 pA	100 pA	0.08% + 8 nA	0.08% + 10 nA
100.000 µA	2 nA	0.03% + 60 nA	5 nA	1 nA	0.02% + 25 nA	0.05% + 60 nA
1.00000 mA	20 nA	0.03% + 300 nA	10 nA	10 nA	0.02% + 200 nA	0.05% + 500 nA
10.0000 mA	200 nA	0.03% + 8 µA	500 nA	100 nA	0.02% + 2.5 µA	0.05% + 10 µA
100.000 mA	2 µA	0.03% + 30 µA	1 µA	1 µA	0.02% + 20 µA	0.05% + 50 µA
1.00000 A	200 µA	0.08% + 3.5 mA	300 µA	10 µA	0.05% + 3 mA	0.05% + 5 mA
5.00000 A	200 µA	0.08% + 3.5 mA	300 µA	10 µA	0.05% + 3 mA	0.05% + 5 mA
10.0000 A	500 µA	0.15% + 6 mA	500 µA	100 µA	0.12% + 6 mA	0.12% + 12 mA
20.0000 A	500 µA	0.15% + 8 mA	500 µA	100 µA	0.08% + 8 mA	0.08% + 15 mA
50.0000 A [6]	2 mA	0.15% + 80 mA	N/A	100 µA	0.05% + 50 mA [7]	0.05% + 90 mA [8]

NOTES

1. Add 50µV to source accuracy specifications per volt of HI lead drop.
2. For temperatures 0° to 18°C and 28° to 50°C, accuracy is degraded by ±(0.15 × accuracy specification)/°C.
   High-capacitance mode accuracy is applicable at 23° ±5°C only.
3. Derate accuracy specification for NPLC setting <1 by increasing error term.
   Add appropriate typical percent of range term for resistive loads using the table below.

NPLC Setting	100mV Range	1V to 40V Ranges	100nA Range	1µA to 100mA Ranges	1A to 20A Ranges
0.1	0.01%	0.01%	0.01%	0.01%	0.01%
0.01	0.08%	0.07%	0.1 %	0.05%	0.1 %
0.001	0.8 %	0.6 %	1 %	0.5 %	1.8 %

4. 18-bit ADC. Average of 1000 samples taken at 1µs intervals.
5. At temperatures 0° to 18°C and 28° to 50°C; 100nA to 10µA accuracy is degraded by ±(0.35 × accuracy specification)/°C.
   100µA to 50A accuracy is degraded by ±(0.15 × accuracy specification)/°C.
   High-capacitance mode accuracy is applicable at 23° ±5°C only.
6. 50A range accessible only in pulse mode.
7. 50A range accuracy measurements are taken at 0.008 NPLC.
8. Average of 100 samples taken at 1µs intervals.

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DC POWER SPECIFICATIONS

MAXIMUM OUTPUT POWER: 202W maximum.

SOURCE/SINK LIMITS [1]:

Voltage: ±10.1V at ±20.0A, ±20.2V at ±10.0A, ±40.4V at ±5.0A [2].
Four-quadrant source or sink operation.

Current: ±5.05A at ±40V [2], ±10.1A at ±20V, ±20.2A at ±10V
Four-quadrant source or sink operation.

CAUTION: Carefully consider and configure the appropriate output-off state and source and compliance levels before connecting the Model 2651A to a device that can deliver energy. Failure to consider the output-off state and source and compliance levels may result in damage to the instrument or to the device under test.

PULSE SPECIFICATIONS

MINIMUM PROGRAMMABLE PULSE WIDTH [3]: 100µs. Note: Minimum pulse width for settled source at a given I/V output and load can be longer than 100µs.

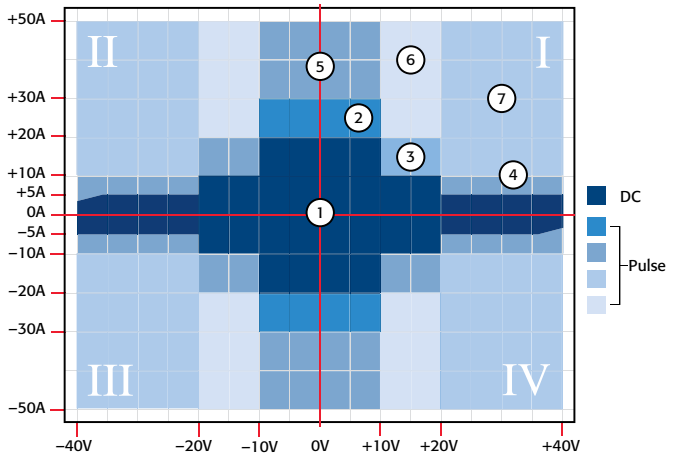
PULSE WIDTH PROGRAMMING RESOLUTION: 1µs.

PULSE WIDTH PROGRAMMING ACCURACY [3]: ±5µs.

PULSE WIDTH JITTER: 2µs (typical).

PULSE RISE TIME (TYPICAL):

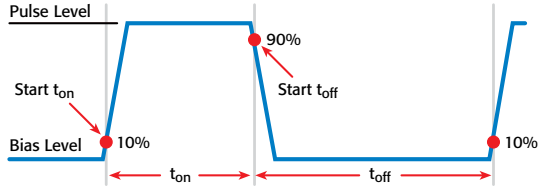
Current Range	R_{load}	Rise Time (typical)
50 A	0.05 Ω	26 µs
50 A	0.2 Ω	57 µs
50 A	0.4 Ω	85 µs
20 A	0.5 Ω	95 µs
50 A	0.8 Ω	130 µs
20 A	1 Ω	180 µs
10 A	2 Ω	330 µs
5 A	8.2 Ω	400 µs



Region	Region Maximums	Maximum Pulse Width [3]	Maximum Duty Cycle [4]
1	5 A at 40 V	DC, no limit	100%
1	10 A at 20 V	DC, no limit	100%
1	20 A at 10 V	DC, no limit	100%
2	30 A at 10 V	1 ms	50%
3	20 A at 20 V	1.5 ms	40%
4	10 A at 40 V	1.5 ms	40%
5	50 A at 10 V	1 ms	35%
6	50 A at 20 V	330 µs	10%
7	50 A at 40 V	300 µs	1%

NOTES

1. Full power source operation regardless of load to 30°C ambient. Above 30°C or power sink operation, refer to "Operating Boundaries" in the Model 2651A Reference manual for additional power derating information.
2. Quadrants 2 and 4 power envelope is trimmed at 36V and 4.5A.
3. Times measured from the start of pulse to the start off-time; see figure below.



4. Thermally limited in sink mode (quadrants 2 and 4) and ambient temperatures above 30°C. See power equations in the Model 2651A Reference Manual for more information.

모델 2651Aa는 다중 채널 동기화를 위해 GPIb, lXI, Digital I/O 및 Keithley의 TSP 링크 기술을 지원합니다.

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ADDITIONAL SOURCE SPECIFICATIONS

NOISE (10Hz to 20MHz): <100mV peak-peak (typical), <30mV RMS (typical), 10V range with a 20A limit.

OVERSHOOT:

Voltage: <±(0.1% + 10mV) (typical). Step size = 10% to 90% of range, resistive load, maximum current limit/compliance.

Current: <±(0.1% + 10mV) (typical). Step Size = 10% to 90% of range, resistive load. See Current Source Output Settling Time specifications for additional test conditions.

RANGE CHANGE OVERSHOOT:

Voltage: <300mV + 0.1% of larger range (for <20V ranges) (typical).
<400mV + 0.1% of larger range (for ≥20V ranges) (typical).
Overshoot into a 100kΩ load, 20MHz bandwidth.

Current: <5% of larger range + 360mV/R_{load} (for >10μA ranges) (typical). $I_{out} \times R_{load} = 1V$.

VOLTAGE SOURCE OUTPUT SETTLING TIME: Time required to reach within 0.1% of final value after source level command is processed on a fixed range. [1]

Range	Settling Time (typical)
1 V	< 70 μs
10 V	<160 μs
20 V	<190 μs
40 V	<175 μs

CURRENT SOURCE OUTPUT SETTLING TIME: Time required to reach within 0.1% of final value after source level command is processed on a fixed range. Values below for $I_{out} \times R_{load}$.

Current Range	R_{load}	Settling time (typical)
20 A	0.5 Ω	<195 μs
10 A	1.5 Ω	<540 μs
5 A	5 Ω	<560 μs
1 A	1 Ω	< 80 μs
100 mA	10 Ω	< 80 μs
10 mA	100 Ω	<210 μs
1 mA	1 kΩ	<300 μs
100 μA	10 kΩ	<500 μs
10 μA	100 kΩ	< 15 ms
1 μA	1 MΩ	< 35 ms
100 nA	10 MΩ	<110 ms

TRANSIENT RESPONSE TIME:

10V and 20V Ranges: <70μs for the output to recover to within 0.1% for a 10% to 90% step change in load.

40V Range: <110μs for the output to recover to within 0.1% for a 10% to 90% step change in load.

GUARD OFFSET VOLTAGE: <4mV, current <10mA.

REMOTE SENSE OPERATING RANGE [2]:

Maximum Voltage between HI and SENSE HI: 3V.
Maximum Voltage between LO and SENSE LO: 3V.

MAXIMUM IMPEDANCE PER SOURCE LEAD:

Maximum impedance limited by 3V drop by remote sense operating range.

Maximum resistance = 3V/source current value (amperes) (maximum of 1Ω per source lead).

3V = L di/dt.

VOLTAGE OUTPUT HEADROOM:

5A Range: Maximum output voltage = 48.5V – (Total voltage drop across source leads).

10A Range: Maximum output voltage = 24.5V – (Total voltage drop across source leads).

20A Range: Maximum output voltage = 15.9V – (Total voltage drop across source leads).

OVERTEMPERATURE PROTECTION: Internally sensed temperature overload puts unit in standby mode.

LIMIT/COMPLIANCE: Bipolar limit (compliance) set with single value.

Voltage [3]: Minimum value is 10mV; accuracy is the same as voltage source.

Current [4]: Minimum value is 10nA; accuracy is the same as current source.

NOTES

1. With measure and compliance set to the maximum current for the specified voltage range.
2. Add 50μV to source accuracy specifications per volt of HI lead drop.
3. For sink mode operation (quadrants II and IV), add 0.6% of limit range to the corresponding voltage source accuracy specifications. For 100mV range add an additional 60mV of uncertainty. Specifications apply with sink mode enabled.
4. For sink mode operation (quadrants II and IV), add 0.6% of limit range to the corresponding current limit accuracy specifications. Specifications apply with sink mode enabled.

ADDITIONAL MEASUREMENT SPECIFICATIONS

CONTACT CHECK [1]

Speed	Maximum Measurement Time to Memory for 60Hz (50Hz)	Accuracy (1 Year) 23° ±5°C ±(% reading + ohms)
Fast	1.1 ms (1.2 ms)	5% + 15 Ω
Medium	4.1 ms (5 ms)	5% + 5 Ω
Slow	36 ms (42 ms)	5% + 3 Ω

NOTES

1. Includes measurement of SENSE HI to HI and SENSE LO to LO contact resistances.

ADDITIONAL METER SPECIFICATIONS

MAXIMUM LOAD IMPEDANCE:

Normal Mode: 10nF (typical), 3μH (typical).
High-Capacitance Mode: 50μF (typical), 3μH (typical).

COMMON MODE VOLTAGE: 250V DC.

COMMON MODE ISOLATION: >1GΩ, <4500pF.

MEASURE INPUT IMPEDANCE: >10GΩ.

SENSE HIGH INPUT IMPEDANCE: >10GΩ.

MAXIMUM SENSE LEAD RESISTANCE: 1kΩ for rated accuracy.

OVERRANGE: 101% of source range, 102% of measure range.

HIGH-CAPACITANCE MODE [1,2]

ACCURACY SPECIFICATIONS [3]: Accuracy specifications are applicable in both normal and high-capacitance modes.

VOLTAGE SOURCE OUTPUT SETTLING TIME: Time required to reach within 0.1 % of final value after source level command is processed on a fixed range. [4]

Voltage Source Range	Settling Time with C_{load} = 4.7μF (typical)
1 V	75 μs
10 V	170 μs
20 V	200 μs
40 V	180 μs

MODE CHANGE DELAY:

100μA Current Range and Above:
Delay into High-Capacitance Mode: 11ms.
Delay out of High-Capacitance Mode: 11ms.

1μA and 10μA Current Ranges:
Delay into High-Capacitance Mode: 250ms.
Delay out of High-Capacitance Mode: 11ms.

MEASURE INPUT IMPEDANCE: >10GΩ in parallel with 25nF.

VOLTAGE SOURCE RANGE CHANGE OVERSHOOT: <400mV + 0.1% of larger range (typical). Overshoot into a 100kΩ load, 20MHz bandwidth.

NOTES

1. High-capacitance mode specifications are for DC measurements only and use locked ranges. Autorange is disabled.
2. 100nA range is not available in high-capacitance mode.
3. Add an additional 2nA to the source current accuracy and measure current accuracy offset for the 1μA range.
4. With measure and compliance set to the maximum current for the specified voltage range.

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MEASUREMENT SPEED SPECIFICATIONS [1, 2]

MAXIMUM SWEEP OPERATION RATES (operations per second) FOR 60Hz (50Hz):

A/D Converter Speed	Trigger Origin	Measure To Memory Using User Scripts	Measure To GPIB Using User Scripts	Source Measure To Memory Using User Scripts	Source Measure To GPIB Using User Scripts	Source Measure To Memory Using Sweep API	Source Measure To GPIB Using Sweep API
0.001 NPLC	Internal	20000 (20000)	9800 (9800)	7000 (7000)	6200 (6200)	12000 (12000)	5900 (5900)
0.001 NPLC	Digital I/O	8100 (8100)	7100 (7100)	5500 (5500)	5100 (5100)	11200 (11200)	5700 (5700)
0.01 NPLC	Internal	4900 (4000)	3900 (3400)	3400 (3000)	3200 (2900)	4200 (3700)	4000 (3500)
0.01 NPLC	Digital I/O	3500 (3100)	3400 (3000)	3000 (2700)	2900 (2600)	4150 (3650)	3800 (3400)
0.1 NPLC	Internal	580 (480)	560 (470)	550 (465)	550 (460)	560 (470)	545 (460)
0.1 NPLC	Digital I/O	550 (460)	550 (460)	540 (450)	540 (450)	560 (470)	545 (460)
1.0 NPLC	Internal	59 (49)	59 (49)	59 (49)	59 (49)	59 (49)	59 (49)
1.0 NPLC	Digital I/O	58 (48)	58 (49)	59 (49)	59 (49)	59 (49)	59 (49)
HS ADC	Internal	38500 (38500)	18000 (18000)	10000 (10000)	9500 (9500)	14300 (14300)	6300 (6300)
HS ADC	Digital I/O	12500 (12500)	11500 (11500)	7500 (7500)	7000 (7000)	13200 (13200)	6000 (6000)

HIGH SPEED ADC BURST MEASUREMENT RATES [3]

Burst Length (readings)	Readings per Second	Bursts per Second
100	1,000,000	400
500	1,000,000	80
1000	1,000,000	40
2500	1,000,000	16
5000	1,000,000	8

MAXIMUM SINGLE MEASUREMENT RATES (operations per second) FOR 60Hz (50Hz)

A/D Converter Speed	Trigger Origin	Measure To GPIB	Source Measure To GPIB	Source Measure Pass/Fail To GPIB
0.001 NPLC	Internal	1900 (1800)	1400 (1400)	1400 (1400)
0.01 NPLC	Internal	1450 (1400)	1200 (1100)	1100 (1100)
0.1 NPLC	Internal	450 (390)	425 (370)	425 (375)
1.0 NPLC	Internal	58 (48)	57 (48)	57 (48)

MAXIMUM MEASUREMENT RANGE CHANGE RATE: >4000 per second for >10μA (typical).

MAXIMUM SOURCE RANGE CHANGE RATE: >325 per second for >10μA, typical. When changing to or from a range ≥1A, maximum rate is >250 per second, typical.

COMMAND PROCESSING TIME: Maximum time required for the output to begin to change following the receipt of the smua.source.levelv or smua.source.leveli command. <1ms typical.

NOTES

1. Tests performed with a Model 2651A on channel A using the following equipment: Computer hardware (Intel® Pentium® 4 2.4GHz, 2GB RAM, National Instruments™ PCI-GPIB). Driver (NI-488.2 Version 2.2 PCI-GPIB). Software (Microsoft® Windows® XP, Microsoft Visual Studio® 2010, VISA™ version 4.1).
2. Exclude current measurement ranges less than 1mA.
3. smua.measure.adc has to be enabled and the smua.measure.count set to the burst length.

TRIGGERING AND SYNCHRONIZATION SPECIFICATIONS

TRIGGERING:

Trigger In to Trigger Out: 0.5μs (typical).
Trigger In to Source Change [1]: 10μs (typical).
Trigger Timer Accuracy: ±2μs (typical).
Source Change [1] After LXI Trigger: 280μs (typical).

SYNCHRONIZATION:

Single-Node Synchronized Source Change [1]: <0.5μs (typical).
Multi-Node Synchronized Source Change [1]: <0.5μs (typical).

NOTES

1. Fixed source range with no polarity change.

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SUPPLEMENTAL INFORMATION

FRONT PANEL INTERFACE: Two-line vacuum fluorescent display (VFD) with keypad and navigation wheel.

DISPLAY:

Show error messages and user defined messages.
Show current and voltage measurements (6½-digit to 4½-digit).
Display source and limit settings.
View measurements stored in dedicated reading buffers.

KEYPAD OPERATIONS:

Change host interface settings.
Save and restore instrument setups.
Load and run factory and user defined test scripts that prompt for input and send results to the display.
Store measurements into dedicated reading buffers.

PROGRAMMING: Embedded Test Script Processor (TSP®) scripting engine is accessible from any host interface.
Responds to individual instrument control commands.
Responds to high speed test scripts comprised of instrument control commands and Test Script Language (TSL) statements (for example, branching, looping, and math).
Able to execute high speed test scripts stored in memory without host intervention.

MINIMUM USER MEMORY AVAILABLE: 16MB (approximately 250,000 lines of TSP code).

TEST SCRIPT BUILDER: Integrated development environment for building, running, and managing TSP scripts. Includes an instrument console for communicating with any TSP enabled instrument in an interactive manner. Requires:
VISA (NI-VISA included on CD),
Microsoft® .NET Framework (included on CD),
Keithley I/O Layer (included on CD),
Intel® Pentium III 800MHz or faster personal computer,
Microsoft Windows® 2000, XP, Vista®, or 7.

TSP EXPRESS (embedded): Tool that allows users to quickly and easily perform common I-V tests without programming or installing software. To run TSP Express, you need:
Java™ Platform, Standard Edition 6,
Microsoft Internet Explorer®, Mozilla® Firefox®, or another Java-compatible web browser.

SOFTWARE INTERFACE: TSP Express (embedded), direct GPIB/VISA, read/write with Microsoft Visual Basic®, Visual C/C++®, Visual C#®, LabVIEW™, CEC TestPoint™ Data Acquisition Software Package, NI LabWindows™/CVI, etc.

READING BUFFERS: Nonvolatile memory uses dedicated storage areas reserved for measurement data. Reading buffers are arrays of measurement elements. Each element can hold the following items:

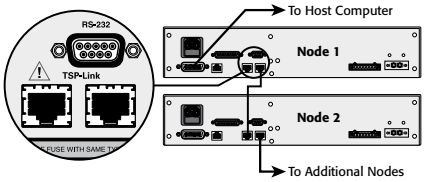
Measurement
Measurement status
Timestamp
Source setting (at the time the measurement was taken)
Range information

Two reading buffers are reserved for each Model 2651A channel. Reading buffers can be filled using the front panel STORE key and retrieved using the RECALL key or host interface.

Buffer Size, with timestamp and source setting: >60,000 samples.

Buffer Size, without timestamp and source setting: >140,000 samples.

SYSTEM EXPANSION: The TSP-Link expansion interface allows TSP-enabled instruments to trigger and communicate with each other. See figure below.

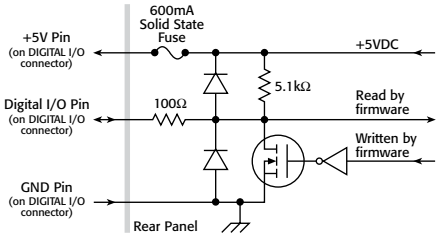


Each Model 2651A has two TSP-Link connectors to make it easier to connect instruments together in sequence.
Once source-measure instruments are interconnected through the TSP-Link expansion interface, a computer can access all the resources of each source-measure instrument through the host interface of any Model 2651A.
A maximum of 32 TSP-Link nodes can be interconnected. Each source-measure instrument consumes one TSP-Link node.

TIMER: Free-running 47-bit counter with 1MHz clock input. Resets each time instrument power is turned on. If the instrument is not turned off, the timer is reset to zero every 4 years.
Timestamp: TIMER value is automatically saved when each measurement is triggered.
Resolution: 1µs.
Timestamp Accuracy: ±100ppm.

GENERAL

DIGITAL I/O INTERFACE:



Connector: 25-pin female D.
Input/Output Pins: 14 open drain I/O bits.
Absolute Maximum Input Voltage: 5.25V.
Absolute Minimum Input Voltage: –0.25V.
Maximum Logic Low Input Voltage: 0.7V, +850µA max.
Minimum Logic High Input Voltage: 2.1V, +570µA.
Maximum Source Current (flowing out of digital I/O bit): +960µA.
Maximum Sink Current At Maximum Logic Low Voltage (0.7): –5.0mA.
Absolute Maximum Sink Current (flowing into digital I/O pin): –11mA.
5V Power Supply Pin: Limited to 250mA, solid-state fuse protected.
Output Enable Pin: Active high input pulled down internally to ground with a 10kΩ resistor; when the output enable input function has been activated, the Model 2651A channel will not turn on unless the output enable pin is driven to >2.1V (nominal current = 2.1V/10kΩ = 210µA).

IEEE-488: IEEE-488.1 compliant. Supports IEEE-488.2 common commands and status model topology.

RS-232: Baud rates from 300bps to 115200bps. Programmable number of data bits, parity type, and flow control (RTS/CTS hardware or none). When not programmed as the active host interface, the Model 2651A can use the RS-232 interface to control other instrumentation.

ETHERNET: RJ-45 connector, LXI, 10/100BT, Auto MDIX.

LXI COMPLIANCE: LXI Class C 1.2.
Total Output Trigger Response Time: 245µs minimum, 280µs (typical), (not specified) maximum.
Receive Lan[0-7] Event Delay: Unknown.
Generate Lan[0-7] Event Delay: Unknown.

EXPANSION INTERFACE: The TSP-Link Technology expansion interface allows TSP-enabled instruments to trigger and communicate with each other.
Cable Type: Category 5e or higher LAN crossover cable. 3 meters maximum between each TSP-enabled instrument.

USB: USB 2.0 host controller.

POWER SUPPLY: 100V to 250V AC, 50Hz to 60Hz (autosensing), 550VA maximum.

COOLING: Forced air; side and top intake and rear exhaust.

WARRANTY: 1 year.

EMC: Conforms to European Union EMC Directive.

SAFETY: UL listed to UL61010-1:2004. Conforms to European Union Low Voltage Directive.

DIMENSIONS: 89mm high × 435mm wide × 549mm deep (3.5 in. × 17.1 in. × 21.6 in.).

BENCH CONFIGURATION (with handle and feet): 104mm high × 483mm wide × 620mm deep (4.1 in. × 19 in. × 24.4 in.).

WEIGHT: 9.98kg (22 lbs).

ENVIRONMENT: For indoor use only.

ALTITUDE: Maximum 2000 meters above sea level.

OPERATING: 0° to 50°C, 70% relative humidity up to 35°C. Derate 3% relative humidity/°C, 35° to 50°C.

STORAGE: –25° to 65°C.