

# Source Meter(SMU)自動校 驗測試系統整合方案



# 自動校驗測試系統標準件選用



Source: Keithley Data Sheet.

選擇高於待校正儀器規格的電錶為標準件。

例如：廠內所使用之型號為2611B，標準件建議選擇1台7.5-digit 7510以保證能覆蓋廠內設備輸出與量測的規格。

並每年送TAF認證實驗室進行校正，以確保標準件之準確度。

# Keithley SourceMeter: 四象限輸出(5.5-digit)與量測(6.5-digit)

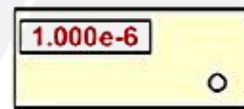
Precision Power Supply



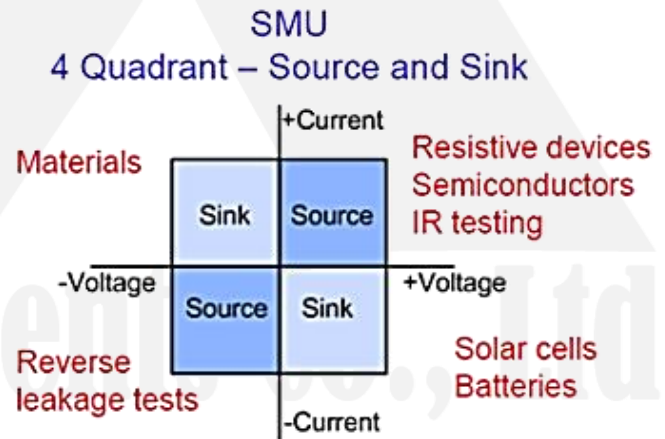
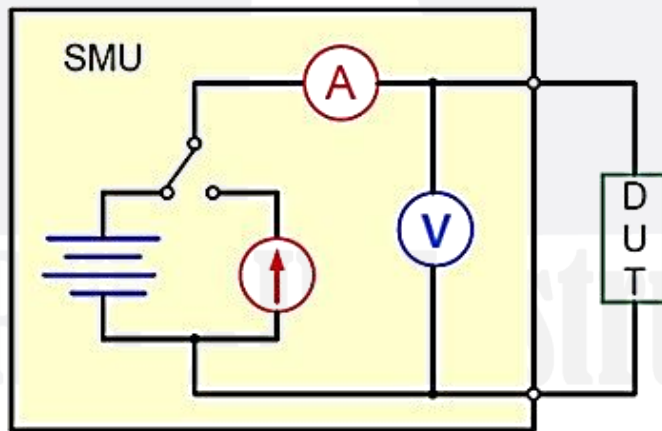
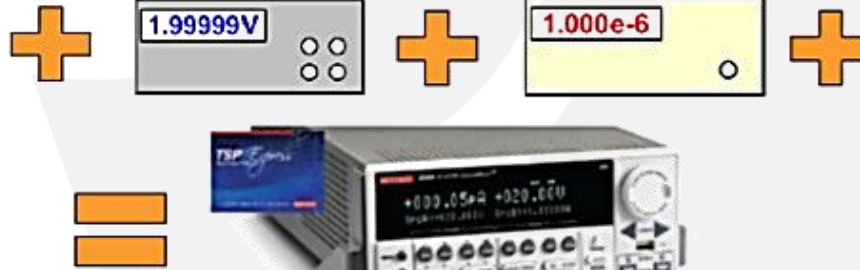
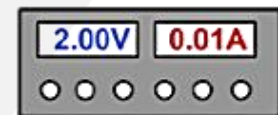
DMM  
(measure I, V, and R)



Current Source



Electronic Load



Source: Keithley Training Material

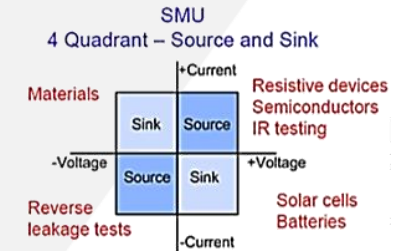
# Keithley SourceMeter Spec Glance (e.g., 2611B/2612B)

## VOLTAGE ACCURACY SPECIFICATIONS<sup>2,3</sup>

Range	Source			Measure	
	Programming resolution	Accuracy ± (% reading + volts)	Typical Noise (Peak to Peak)	Display resolution	Accuracy <sup>4</sup> ± (% reading + volts)
200 mV	5 µV	0.02 % + 375 µV	20 µV	100 nV	0.015 % + 225 µV
2 V	50 µV	0.02 % + 600 µV	50 µV	1 µV	0.02 % + 350 µV
20 V	500 µV	0.02 % + 5 mV	300 µV	10 µV	0.015 % + 5 mV
200 V	5 mV	0.02 % + 50 mV	2 mV	100 µV	0.015 % + 50 mV

## CURRENT ACCURACY SPECIFICATIONS<sup>2,5</sup>

Range	Source			Measure	
	Programming resolution	Accuracy ± (% reading + amperes)	Typical Noise (Peak to Peak)	Display resolution	Accuracy <sup>4</sup> ± (% reading + amperes)
100 nA	2 pA	0.06 % + 100 pA	5 pA	100 fA	0.06 % + 100 pA
1 µA	20 pA	0.03 % + 800 pA	25 pA	1 pA	0.025 % + 500 pA
10 µA	200 pA	0.03 % + 5 nA	60 pA	10 pA	0.025 % + 1.5 nA
100 µA	2 nA	0.03 % + 60 nA	3 nA	100 pA	0.02 % + 25 nA
1 mA	20 nA	0.03 % + 300 nA	6 nA	1 nA	0.02 % + 200 nA
10 mA	200 nA	0.03 % + 6 µA	200 nA	10 nA	0.02 % + 2.5 µA
100 mA	2 µA	0.03 % + 30 µA	600 nA	100 nA	0.02 % + 20 µA
1 A	20 µA	0.05 % + 1.8 mA	70 µA	1 µA	0.03 % + 1.5 mA
1.5 A	50 µA	0.06 % + 4 mA	150 µA	1 µA	0.05 % + 3.5 mA
10 A <sup>6</sup>	200 µA	0.5 % + 40 mA	N/A	10 µA	0.4 % + 25 mA



**Voltage Calibration**  
**Step:** 4-Range \* 2 \* (P, N) \* 2 (Src, Meas.) = 16 steps

**Current Calibration**  
**Step:** 10-Range \* 2 \* (P, N) \* 2 (Src, Meas.) = 40 steps

Thus, the total calibration step >= 112 steps (Assumption: 1 Range takes 2 measure points @ 50%, 95%)

**Source: Keithley Specification**

# 自動校驗測試系統配置

利用程式同時控制標準件與待校正件。



# 自動校驗測試系統電壓校正

連接SMU至電錶電壓輸入端



利用程式設定SMU預校正的電壓值並輸出，透過程式讀回SMU電壓錶讀值與電錶電壓讀值進行比對。

計算出電錶電壓讀值與SMU電壓錶讀值及電錶電壓讀值與SMU輸出電壓設定值間的誤差。



# 自動校驗測試系統電流校正

連接SMU至電錶電流輸入端



利用程式設定SMU預校正的電流值並輸出，透過程式讀回SMU電流錶讀值與電錶電流讀值進行比對。

計算出電錶電流讀值與SMU電流錶讀值及電錶電流讀值與SMU輸出電流設定值間的誤差。

# 自動校驗測試系統配置



待校正件與標準件的比對結果。利用程式依據序號產生讀值報表以使用人員記錄。

RUI XIN Instruments Co., Ltd



# 自動校驗測試系統: 自動產生校驗報告 (參考格式)

瑞新儀器有限公司 RUI XIN Instruments Co., Ltd  
43548 台中市梧棲區建國北街217巷67號  
No.67, Ln. 217, Jianguo N. St., Wuqi Dist.,  
Taichung City 435, Taiwan (ROC)



## Calibration Certificate

Report No:1890230-2

Manufacturer: KEITHLEY  
Model Number: 2636B  
Serial Number: 4014361

Calibration Date: 21 September 2018  
Temperature: 22.4 °C  
Relative Humidity: 37.5 %

Procedure:

Condition as Received / Returned: **IN TOLERANCE**

### Calibration Facility

No.67, Ln. 217, Jianguo N. St.,  
Wuqi Dist., Taichung City 435,  
Taiwan (ROC)

Engineer: \_\_\_\_\_

Approved By: \_\_\_\_\_

# 自動校驗測試系統: 自動產生校驗報告 (參考格式)

## Measurement Report -

As-Received / As-Returned

Report Number:  
1890230-2

Test Description	Expected Value	Measured Value	Measurement Uncertainty	Lower Limit	Upper Limit	Test Status
<b>CHA VOLTAGE SOURCE ACCURACY TESTS</b>						
<b>CONFIG: RESET DEFAULTS   REMOTE SENSE</b>						
<b>200mV Range</b>						
100.000 mV	100.000 mV	99.9770 mV	3.4e-006 V	99.6050 mV	100.3950 mV	Pass
190.000 mV	190.000 mV	189.9580 mV	4.0e-006 V	189.5870 mV	190.4130 mV	Pass
-100.000 mV	-100.000 mV	-100.1733 mV	4.8e-006 V	-100.3950 mV	-99.6050 mV	Pass
-190.000 mV	-190.000 mV	-190.1553 mV	3.0e-006 V	-190.4130 mV	-189.5870 mV	Pass
<b>2V Range</b>						
1.00000 V	1.00000 V	1.000010 V	1.1e-005 V	0.999200 V	1.000800 V	Pass
1.90000 V	1.90000 V	1.899813 V	1.6e-005 V	1.899020 V	1.900980 V	Pass
-1.00000 V	-1.00000 V	-1.000390 V	1.1e-005 V	-1.000800 V	-0.999200 V	Pass
-1.90000 V	-1.90000 V	-1.900200 V	1.4e-005 V	-1.900980 V	-1.899020 V	Pass

TEST REPORT GENERATED BY: TEST SYSTEM, TEST

# 自動校驗測試系統: 自動產生校驗報告 (參考格式)

## CHA CURRENT MEASURE ACCURACY TESTS

### CONFIG: RESET DEFAULTS

#### 1uA Range

0.50000 $\mu\text{A}$	0.499980 $\mu\text{A}$	0.50014 $\mu\text{A}$	1.4e-010 A	0.49946 $\mu\text{A}$	0.50050 $\mu\text{A}$	Pass
0.90000 $\mu\text{A}$	0.899879 $\mu\text{A}$	0.90008 $\mu\text{A}$	1.5e-010 A	0.89925 $\mu\text{A}$	0.90050 $\mu\text{A}$	Pass
-0.50000 $\mu\text{A}$	-0.499998 $\mu\text{A}$	-0.49991 $\mu\text{A}$	1.4e-010 A	-0.50052 $\mu\text{A}$	-0.49947 $\mu\text{A}$	Pass
-0.90000 $\mu\text{A}$	-0.899921 $\mu\text{A}$	-0.89985 $\mu\text{A}$	1.5e-010 A	-0.90055 $\mu\text{A}$	-0.89930 $\mu\text{A}$	Pass

#### 10uA Range

5.0000 $\mu\text{A}$	5.00036 $\mu\text{A}$	5.0007 $\mu\text{A}$	3.3e-010 A	4.9976 $\mu\text{A}$	5.0031 $\mu\text{A}$	Pass
9.0000 $\mu\text{A}$	8.99971 $\mu\text{A}$	9.0002 $\mu\text{A}$	3.8e-010 A	8.9960 $\mu\text{A}$	9.0035 $\mu\text{A}$	Pass
-5.0000 $\mu\text{A}$	-4.99977 $\mu\text{A}$	-5.0000 $\mu\text{A}$	3.1e-010 A	-5.0025 $\mu\text{A}$	-4.9970 $\mu\text{A}$	Pass
-9.0000 $\mu\text{A}$	-8.99922 $\mu\text{A}$	-8.9996 $\mu\text{A}$	3.9e-010 A	-9.0030 $\mu\text{A}$	-8.9955 $\mu\text{A}$	Pass

#### 100uA Range

50.000 $\mu\text{A}$	50.0036 $\mu\text{A}$	50.014 $\mu\text{A}$	2.8e-009 A	49.969 $\mu\text{A}$	50.039 $\mu\text{A}$	Pass
90.000 $\mu\text{A}$	89.9927 $\mu\text{A}$	90.007 $\mu\text{A}$	3.6e-009 A	89.950 $\mu\text{A}$	90.036 $\mu\text{A}$	Pass
-50.000 $\mu\text{A}$	-49.9841 $\mu\text{A}$	-49.988 $\mu\text{A}$	3.0e-009 A	-50.019 $\mu\text{A}$	-49.949 $\mu\text{A}$	Pass
-90.000 $\mu\text{A}$	-89.9751 $\mu\text{A}$	-89.982 $\mu\text{A}$	3.8e-009 A	-90.018 $\mu\text{A}$	-89.932 $\mu\text{A}$	Pass

Comments:

\*\*\*\*\* End of Measurement Report \*\*\*\*\*

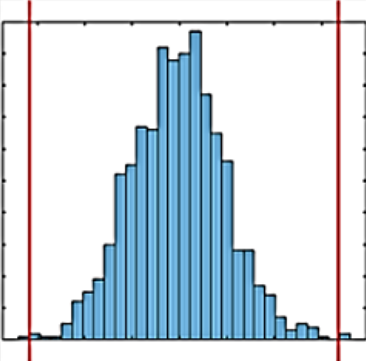
# 自動校驗測試系統:軟體介面

軟體主要功能包含：控制, 軟體, 計算( $U_c$  與TUR), 校驗報告

## Calibration Automation System for Keithley SourceMeter

CALIBRATION | REPORT | UNCERTAINTY | INSTR | Misc | Date Time: 2019/08/26, 23:00:00 AM

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<b>Source Func</b> Current	<b>UUT Reading</b> 0	0.148	Mean 0.1505	
<b>Source Range</b> 1A	0.152	0.151	Standard Deviation 0.0181708	
<b>Cal Points, %</b> 5%, 50%, 95%	0.149	0.15	Degrees of Freedom 7	
<b>Number of Meas</b> 8	0.151	0.149		

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**EXPANDED UNCERTAINTY ( $U_c$ ) Calc.** START

Uncertainty of Type A 0.0763763	Expanded Uncertainty ( $U_c$ ) 0.5069	UpperLimit 0.2	TUR ( $\geq 4$ , Suggested) 0.98
Uncertainty of Type B 0.173205		Lower Limit 0.1	
k Value 2	$U_c = \sqrt{U_A^2 + U_B^2}$	TUR = (US-LS)/(2* $U_c$ )	

# 結語:此自動校驗測試系統可支援全系列的Keithley SourceMeter



Feature	2651A / 2657A High Current / High Voltage	2634B / 2635B / 2636B Low Current	2602B / 2612B Dual Channel	2601B / 2611B Single Channel	2604B / 2614B Dual Channel Benchtop
# of Channels	1 (optional expansion to 32 via TSP-Link®)	1 – 2 (optional expansion to 64 via TSP Link for 2635B/2636B)	2 (optional expansion to 64 via TSP-Link)	1 (optional expansion to 32 via TSP-Link)	2
Current Max / Min	2651A: 50A pulse/100fA 2657A: 120mA/1fA	2634B: 10A pulse/1fA 2636B, 2635B: 10A pulse/0.1fA	10A pulse/100fA	10A pulse/100fA	10A pulse/100 fA
Voltage Max / Min	2651A: 40V/100nV 2657A: 3,000V/100nV	200V/100nV	40V/100nV for 2602B 200V/100nV for 2612B	40V/100nV for 2601B 200V/100nV for 2611B	40V/100nV for 2604B 200V/100nV for 2614B
System-Level Automation	Digital I/O, TSP-Link, Contact Check	Digital I/O, TSP-Link, Contact Check (not available on 2634B)	Digital I/O, TSP-Link, Contact Check	Digital I/O, TSP-Link, Contact Check	N/A
Max readings / sec	38,500 1µSec/pt., 18-bit digitizer	20,000	20,000	20,000	20,000
Computer interface	GPIB, LAN (LXI), RS-232	GPIB, LAN (LXI), RS-232, USB	GPIB, LAN (LXI), RS-232, USB	GPIB, LAN (LXI), RS-232, USB	GPIB, LAN (LXI), RS-232, USB
Connectors/Cabling	2651A: Screw terminal, adaptors for banana 2657A: HV triax, SHV	Triax	Screw terminal, adaptors for banana or triax	Screw terminal, adaptors for banana or triax	Screw terminal, adaptors for banana or triax

Feature	6430 Low I SourceMeter	2430 High Power SourceMeter Instrument	2410 High V SourceMeter Instrument	2420 / 2425 / 2440 High I SourceMeter Instruments	2400 / 2401 Low Power SourceMeter Instruments	2450 Advanced Touchscreen SourceMeter Instruments
Current Max / Min	105mA / 10pA	10.5A pulse / 100pA	1.05A / 10pA	5.25A / 100pA	1.05A / 10pA	1.05A/10fA
Voltage Max / Min	200V / 1µV	200V / 1µV	1100V / 1µV	100V / 1µV	200V / 1µV	200V/10nV
Power	2W	1100W	22W	110W	22W	20W
Max readings / sec	256	2,000	2,000	2,000	2,000	3,100
Interface	GPIB, RS-232, Digital I/O, Trigger Link Trigger Bus	GPIB, RS-232, Digital I/O, Trigger Link Trigger Bus	GPIB, RS-232, Digital I/O, Trigger Link Trigger Bus	GPIB, RS-232, Digital I/O, Trigger Link Trigger Bus	GPIB, RS-232, Digital I/O, Trigger Link Trigger Bus	GPIB, USB 2.0, LAN/LXI, Digital I/O, TSP-Link
Connectors	Triax	Banana (front / rear)	Banana (front / rear)	Banana (front / rear)	Banana (front / rear)	Banana (front) Triax (rear)

# 聯絡資訊

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