GSM-20H10
Source Meter

Cooper Liu

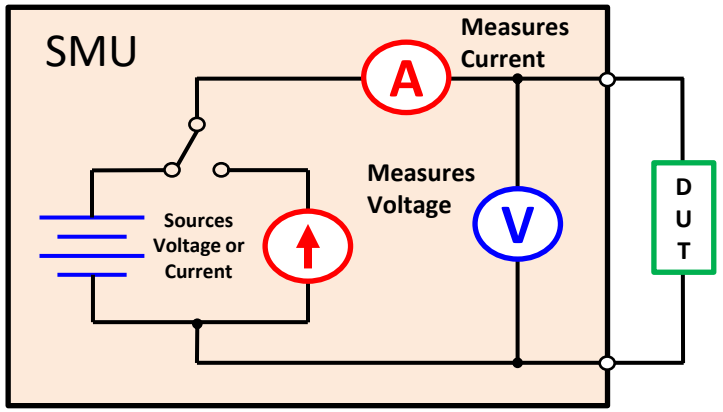
Outline

- Introduce Source Meters (SMU)
- Main Features
- Applications of SMU

Introduce Source Meters (SMU)

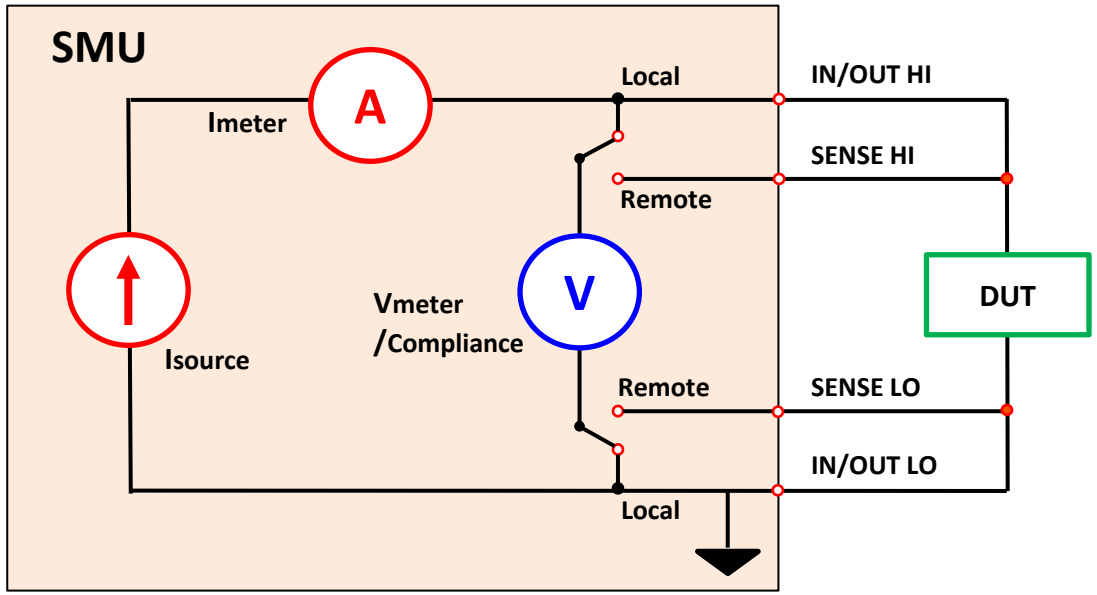
What is Source Meter?

- Main functions and features
  - Four-quadrant power supply and DMM function
  - Low power supply wattage, high voltage/current resolution
  - Measuring voltage/low current/resistance (high resolution)
  - High measuring speed requirement

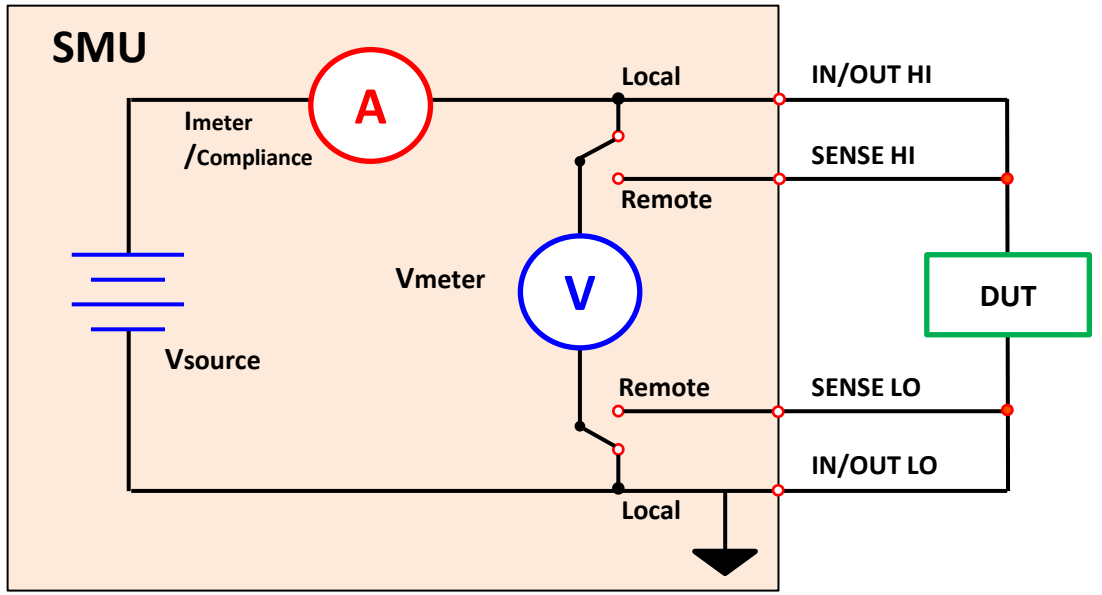


What is Source Meter?

- Main functions and features



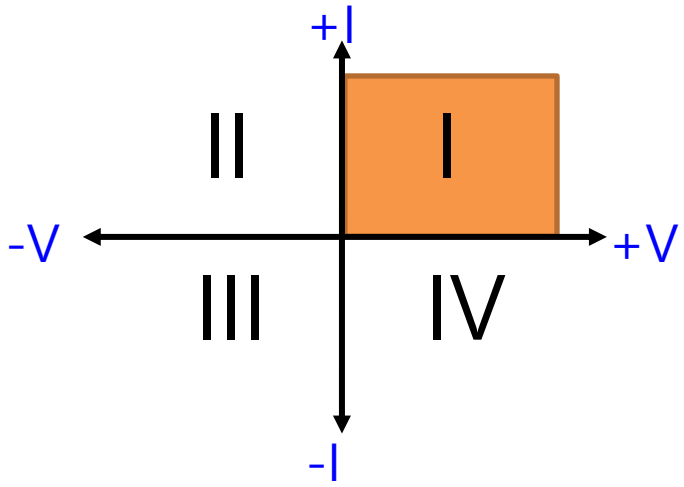
Source I, Measure V, I, Ω



Source V, Measure I, V, Ω

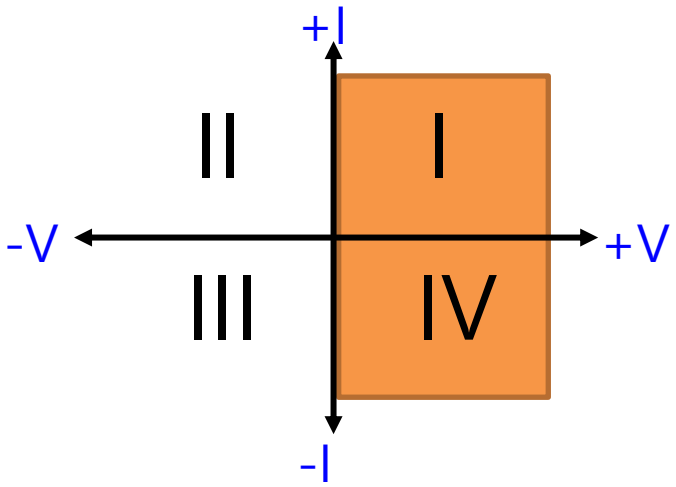
What is Source Meter?

- Type of power supply



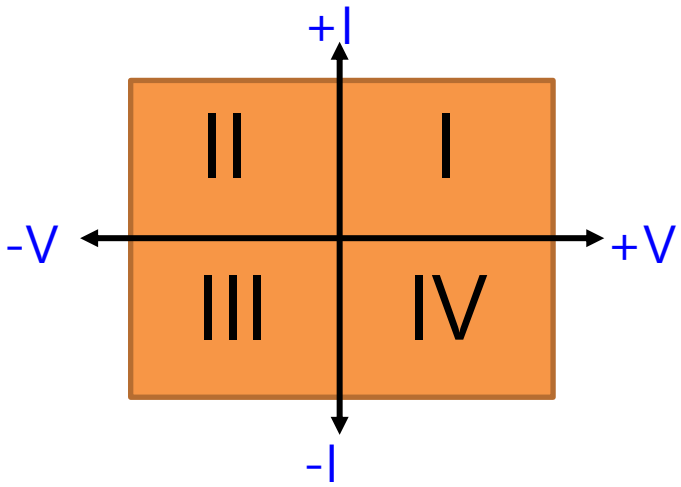
General power supply
GPP/GPE/PSW…

(Terminal outputs V/I, current is irreversible.)



Power supply with sink function
PPH...

(Current can be injected.)



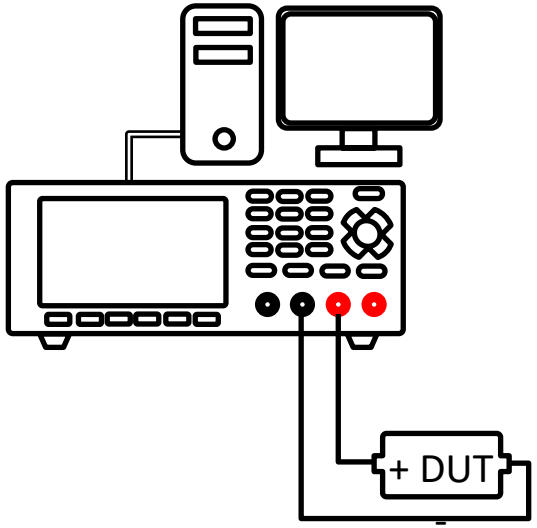
Source Meter
GMS-20H10

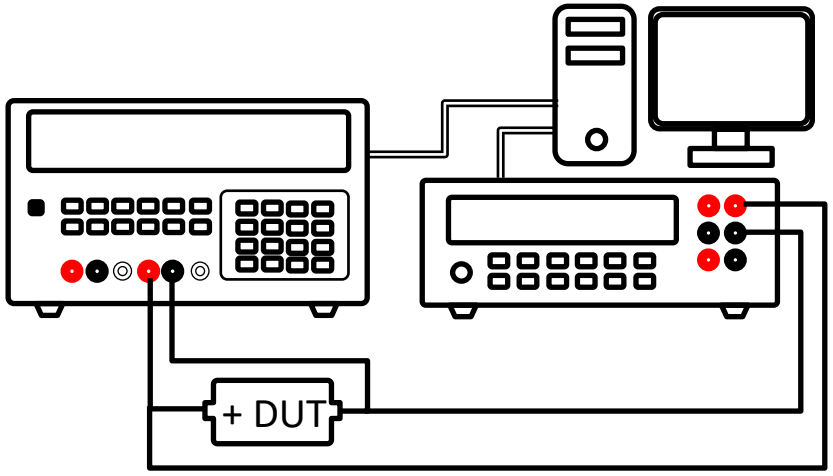
Bipolar DC Power Supply

(V/I input and output can be performed.)

What is Source Meter?

- **Advantages over Power Supply + DMM**
  - Saves space
  - Simplifies the wiring connection

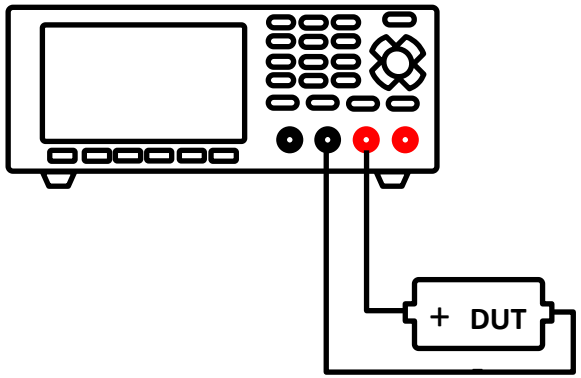


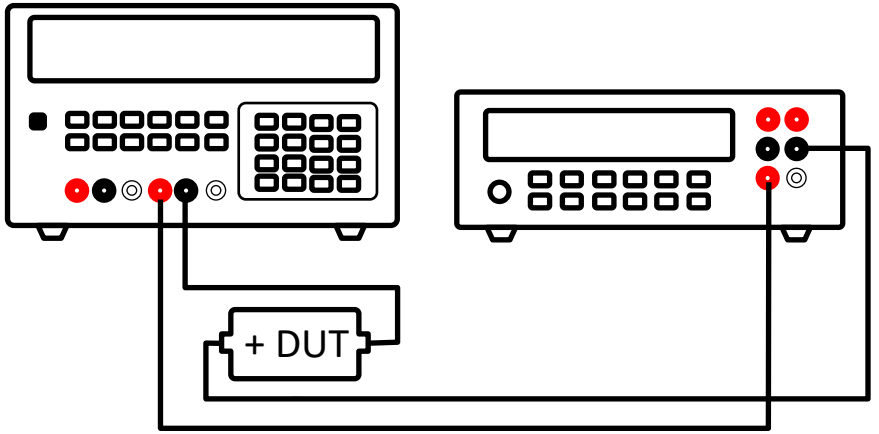


Measure voltage by power supply and DMM

What is Source Meter?

- **Advantages over Power Supply + DMM**
  - Saves space
  - Simplifies the wiring connection
  - No need to re-wire in between voltage meter and current meter





Measure voltage by power supply and DMM

What is Source Meter?

- Name:
  - **System SourceMeter® (Tek/Keithley Trademark Reg.)**
  - **Precision Source / Measure Units (Keysight used often)**
  - **Source Meter**
  - **DC Voltage/Current Source/Monitor**
  - **SMU**

Main Features

Main Features

Source:

- Maximum output ±210V, ±1.05A, 22W
- Built-in 4 sequence output modes, up to 2500 points
- OVP /OTP Protection Function

Meter:

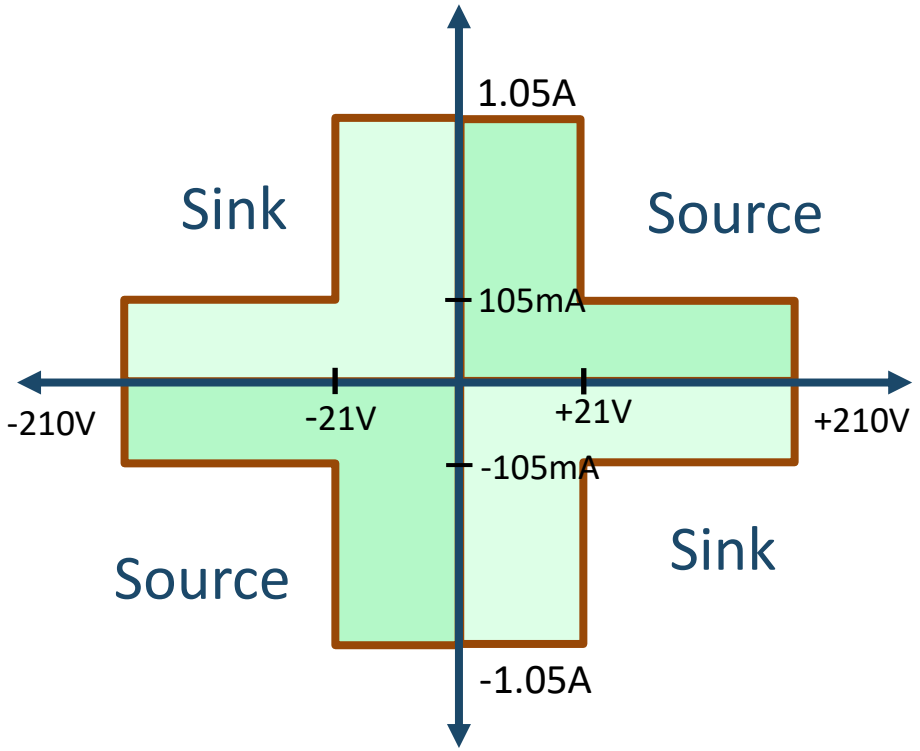
- 0.012% basic measure accuracy with 6½-digit resolution
- Variable Sampling Speed
- SDM (Source Delay Measure) cycle
- 2-, 4-, and 6-wire remote V-source and measure sensing
- Variable Display Digits
- Built-in Limit function
- Built-in 5 calculation functions

Others:

- Standard SCPI command, Provide Interface: RS-232, USBTMC, LAN, GPIB (Optional)
- 4.3" TFT LCD, Digital Number Keypad
- Built-in RTC Clock

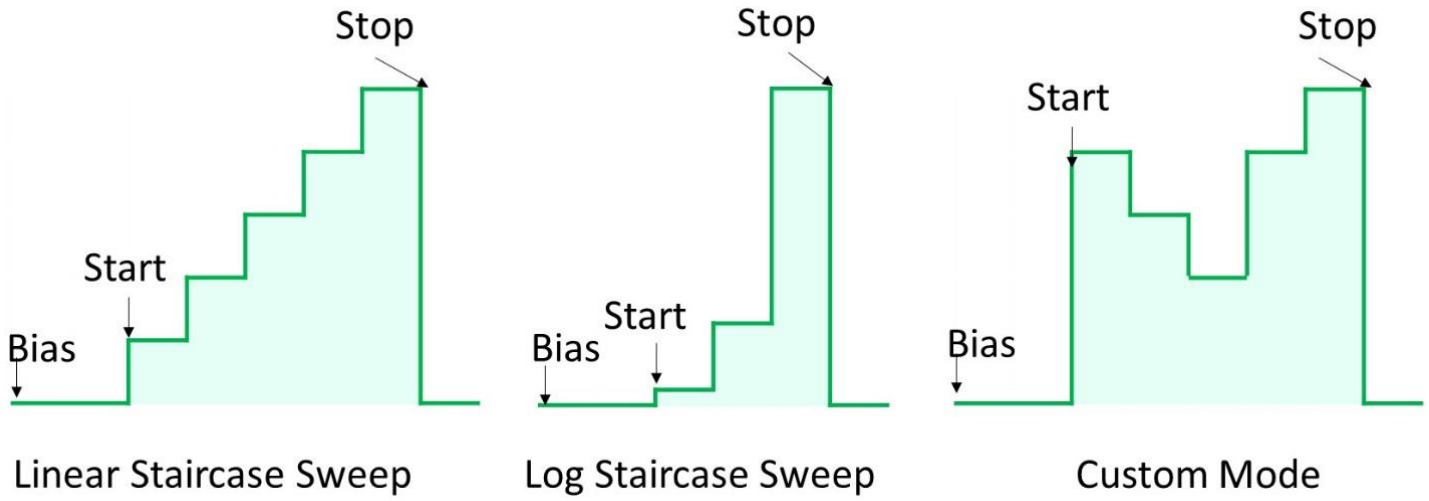
Main Features - Source

- Maximum output: ±210V/±1.05A/22W
  - ± 21V up to 1.05A
  - ± 210V up to 105mA
  - Max Power : 22W



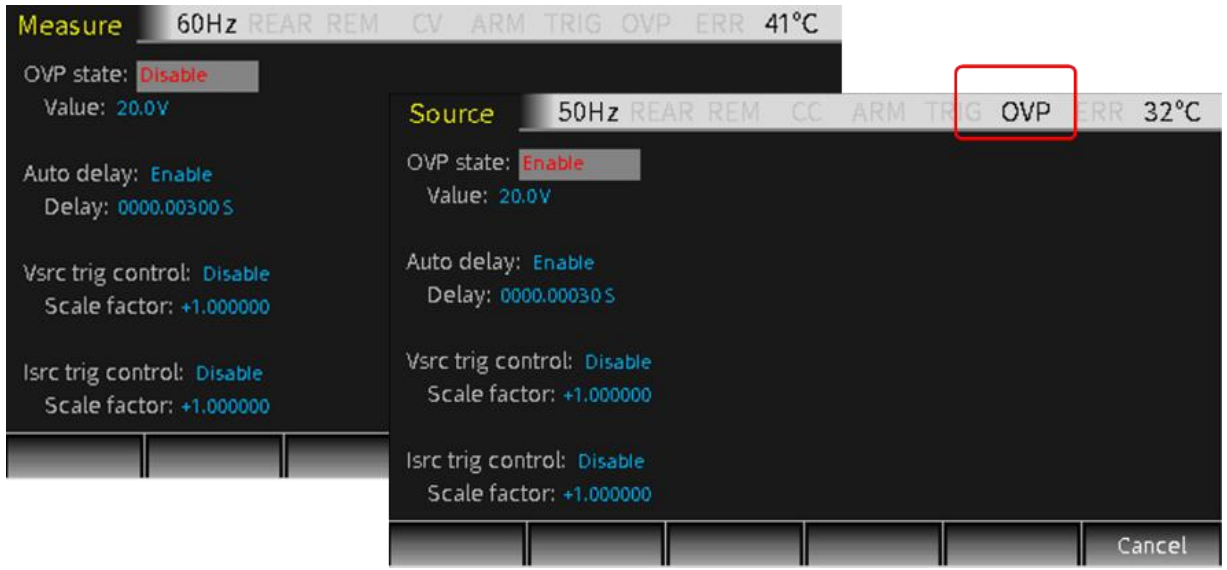
Main Features - Source

- Built-in 4 sequence output modes, up to 2500 points
  - Linear Stair
  - Log Stair
  - SRC-MEM
  - Custom



Main Features - Source

- OVP /OTP Protection Function

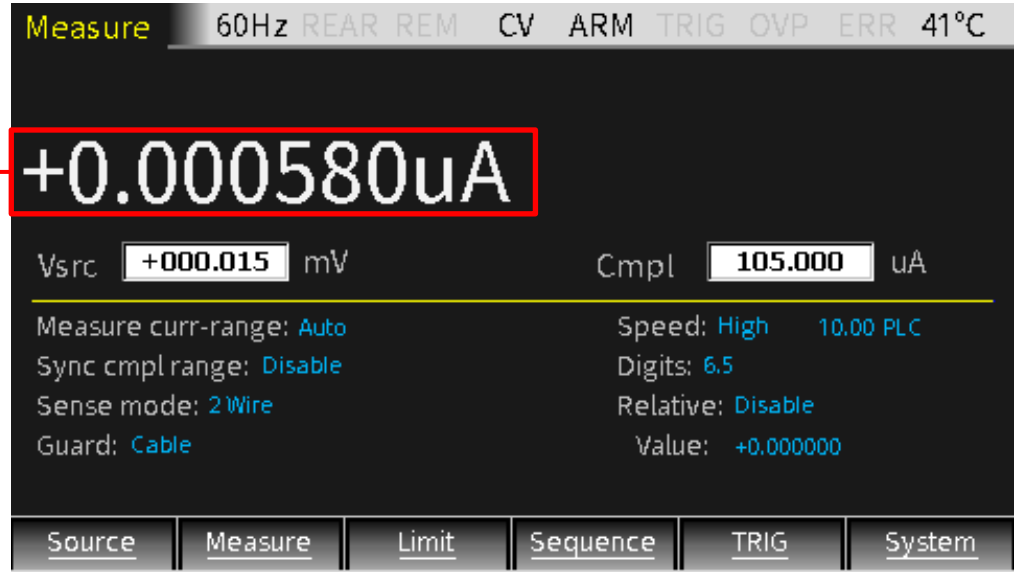


Main Features - Meter

- 0.012% basic measure accuracy with 6½-digit resolution

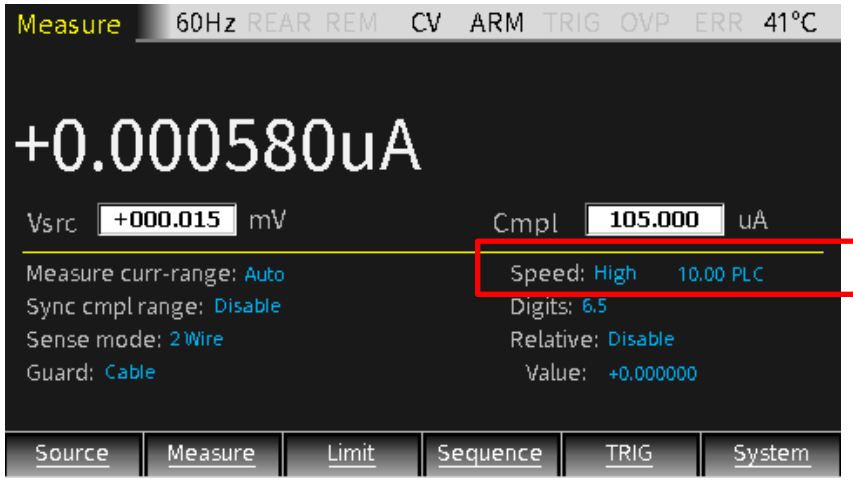
Voltage Range	±200.000mV	±2.00000V	±20.0000V	±200.000V
Measurement Resolution	1uV	10uV	100uV	1mV
Measurement Accuracy	±(0.012%+300uV)	±(0.012%+300uV)	±(0.015%+1.5mV)	±(0.015%+10mV)

6½-digit



Main Features - Meter

- Variable Sampling speed (High/Normal/Medium/Fast/Other)

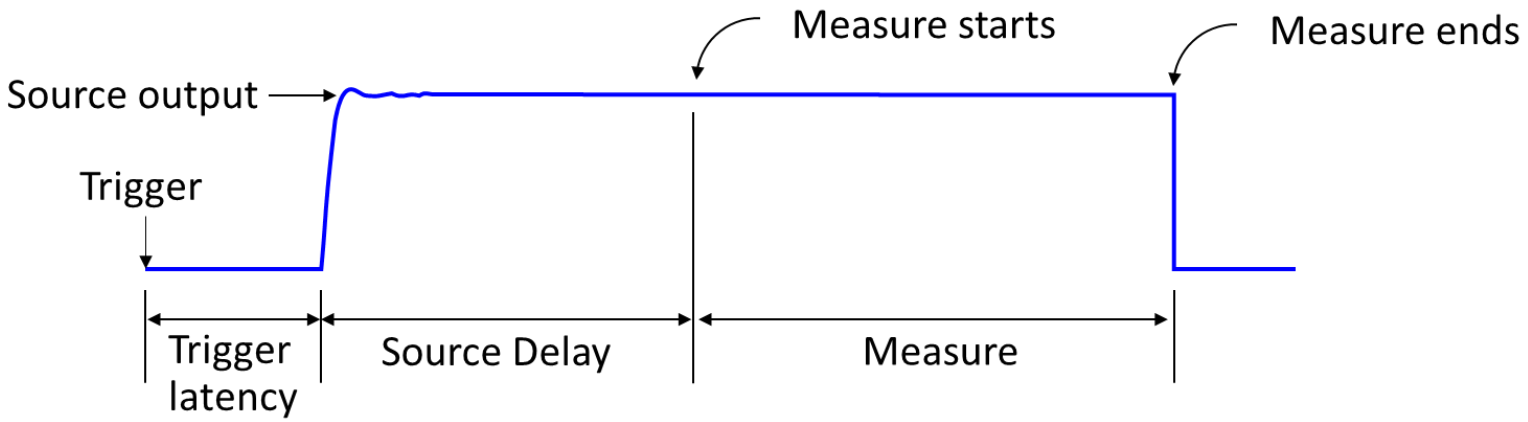


Variable Sampling speed

Sampling mode	Fast	Medium	Normal	High	Other
Speed, NPLC	0.01	0.1	1	10	User defined
Digit	3½	4½	5½	6½	Selectable

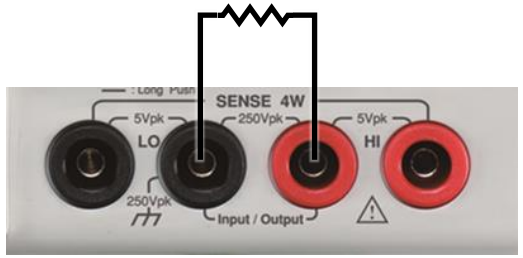
Main Features - Meter

- SDM (Source Delay Measure) cycle
  - When the signal changes, the sampling delay can be programmed or edited or adjusted, which is useful for the circuit under test to stabilize before the measurement.

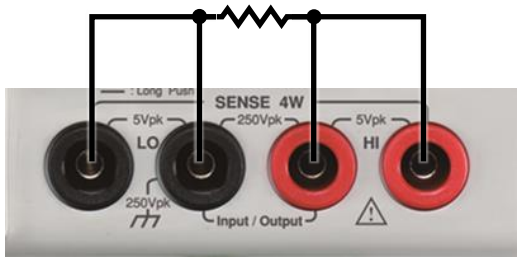


Main Features - Meter

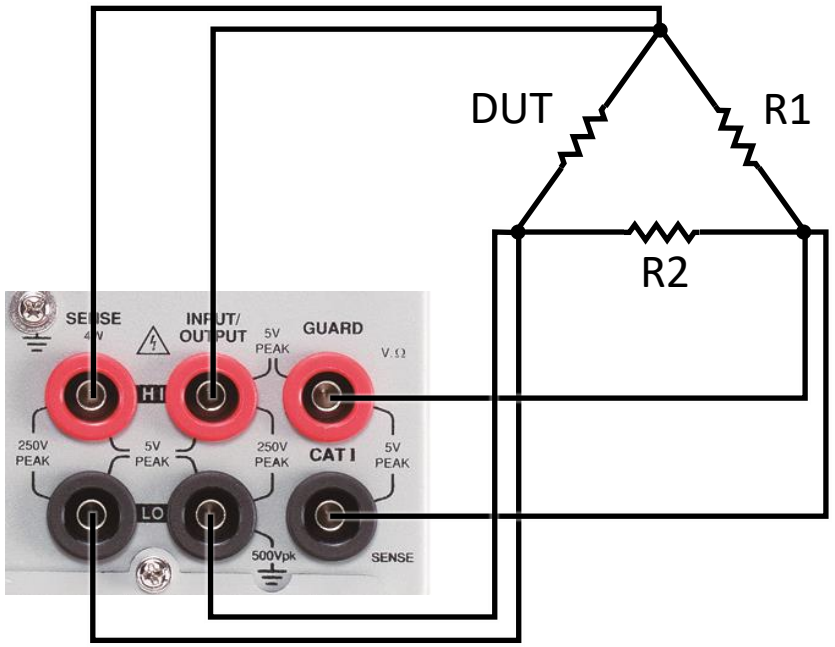
- 2, 4, and 6-wire remote V-source and measure sensing



2-wire



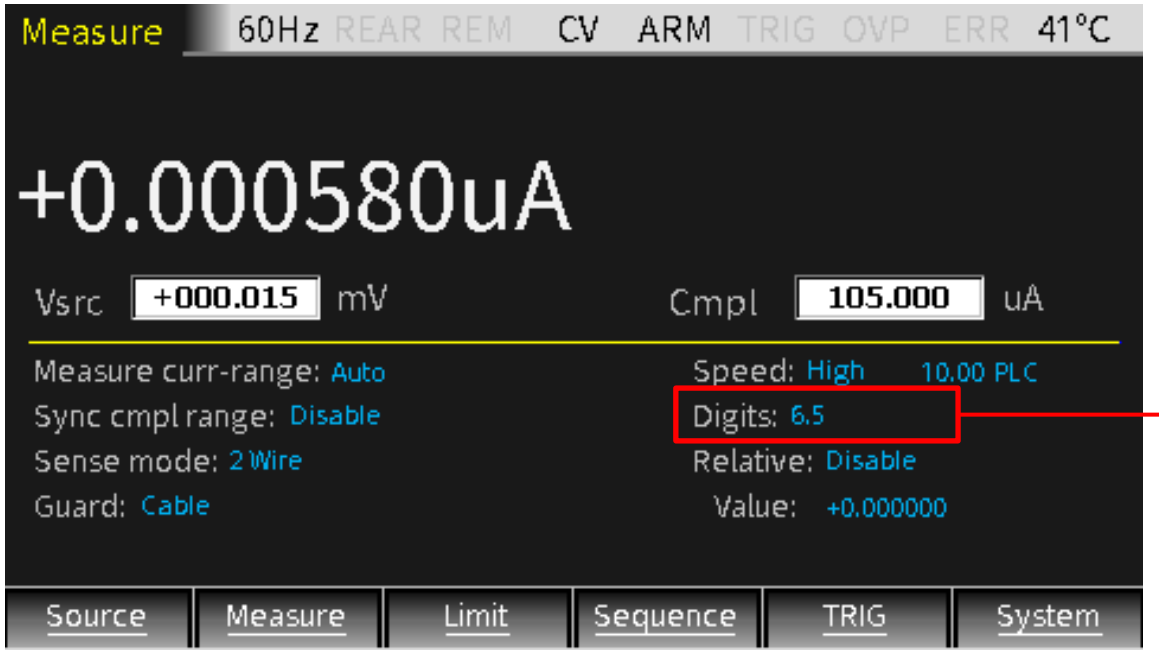
4-wire



6-wire

Main Features - Meter

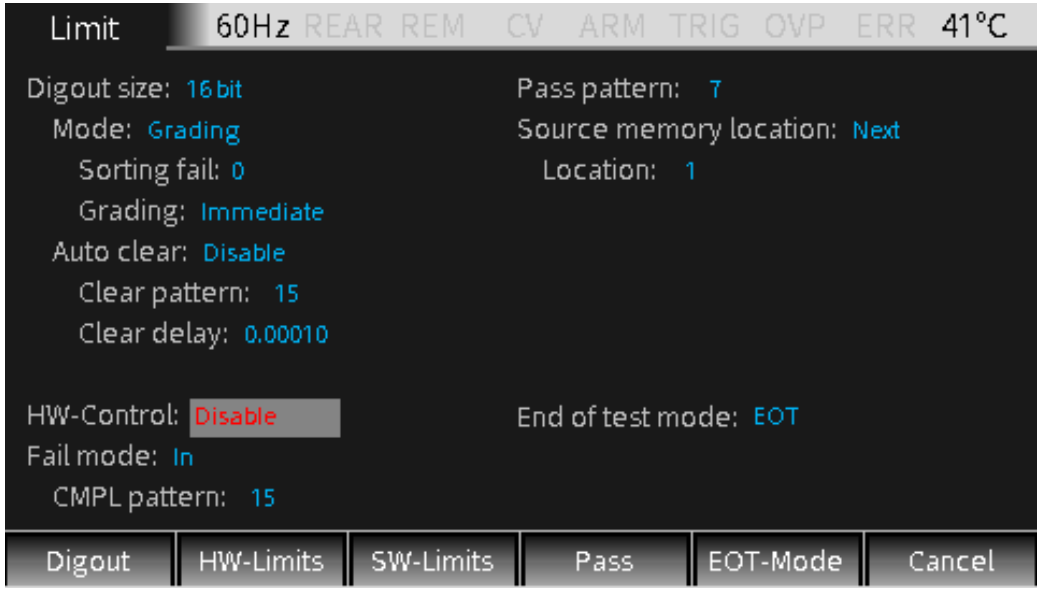
- Display digits (3.5/4.5/5.5/6.5) variable

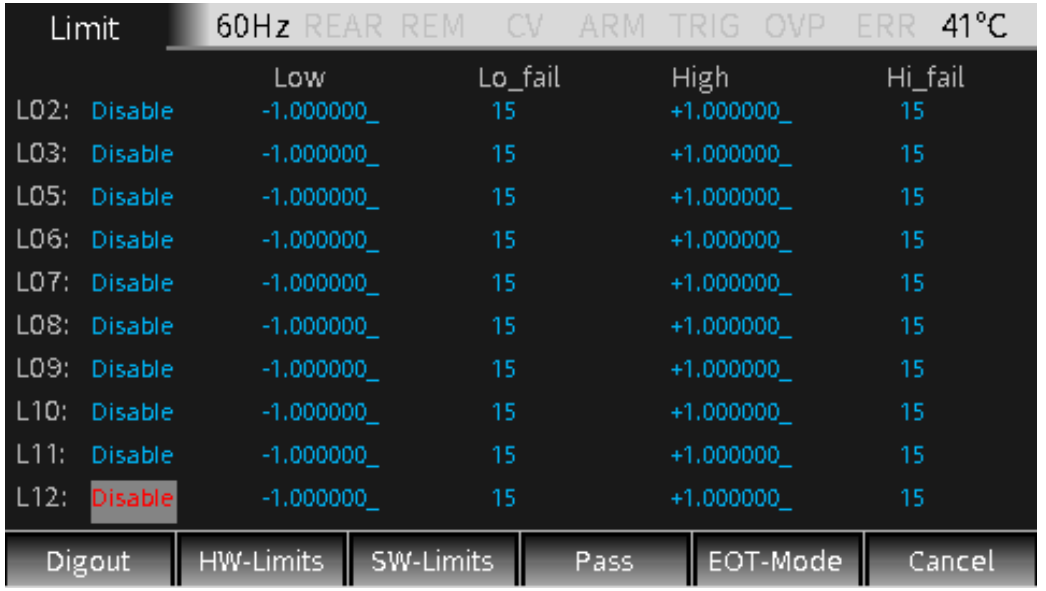


Adjustable display digits

Main Features - Meter

- Built-in Limit function, supports 11 groups of Limit tests (PASS/FAIL)



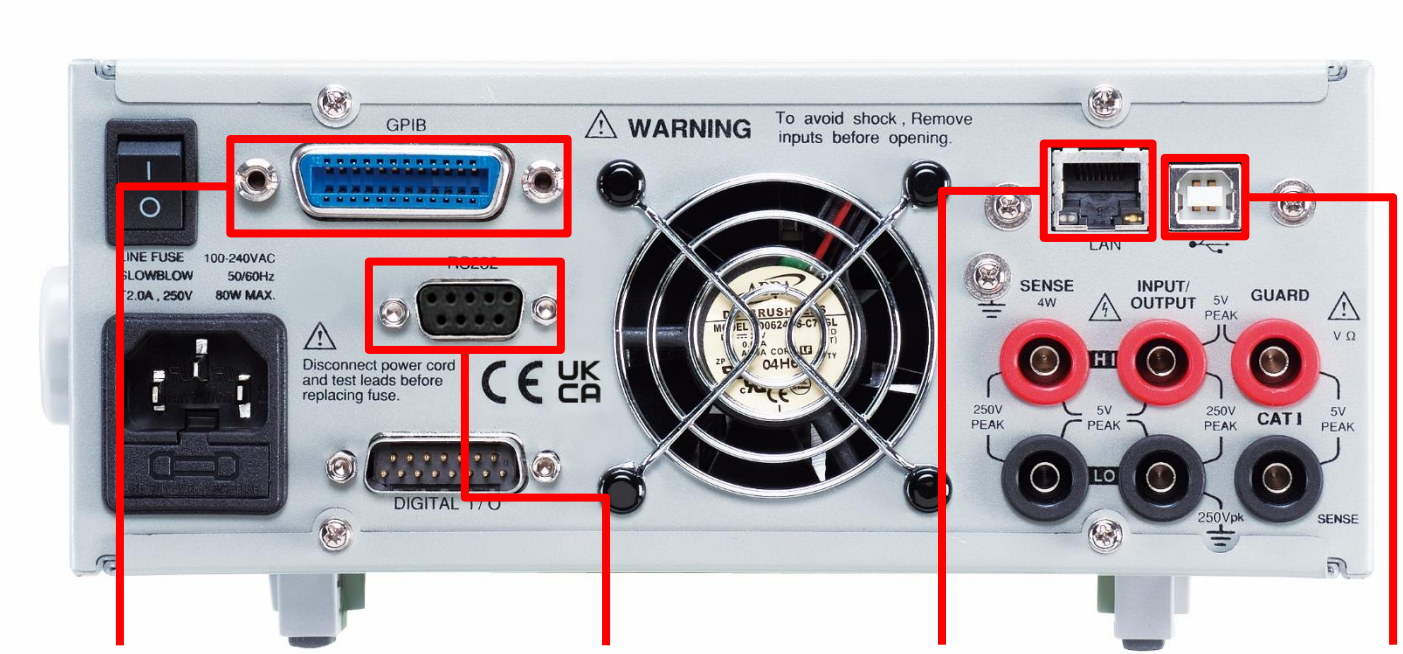


Main Features - Meter

- Built-in 5 calculation functions
  - Power, Power = V∗I
  - Compensated Ohms, CompOhms $= \frac{(V2-V1)}{(I2-I1)}$
  - Voltage Coefficient, Vceoff(%) = $\left[\frac{\Delta R}{\{R2*\Delta V\}}\right] * 100\%$
  - Varistor Alpha, VarAlpha $\alpha = \frac{log(I2 \div I1)}{log(v2 \div V1)}$
  - Percent Deviation, Dev = $\left[\frac{(X-Y)}{Y}\right] * 100\%$

Main Features - Other

- Standard SCPI RS-232 , USB-TMC, LAN, GPIB (Optional)



GPIB (Option) **RS-232** **LAN** **USB Device**

Main Features - Other

- 4.3" TFT LCD, Digital Number Keypad
  - With the large 4.3-inch screen, all measurement settings, parameters and results can be completely displayed on the screen: the digital number keypad provides users with a more friendly input method.

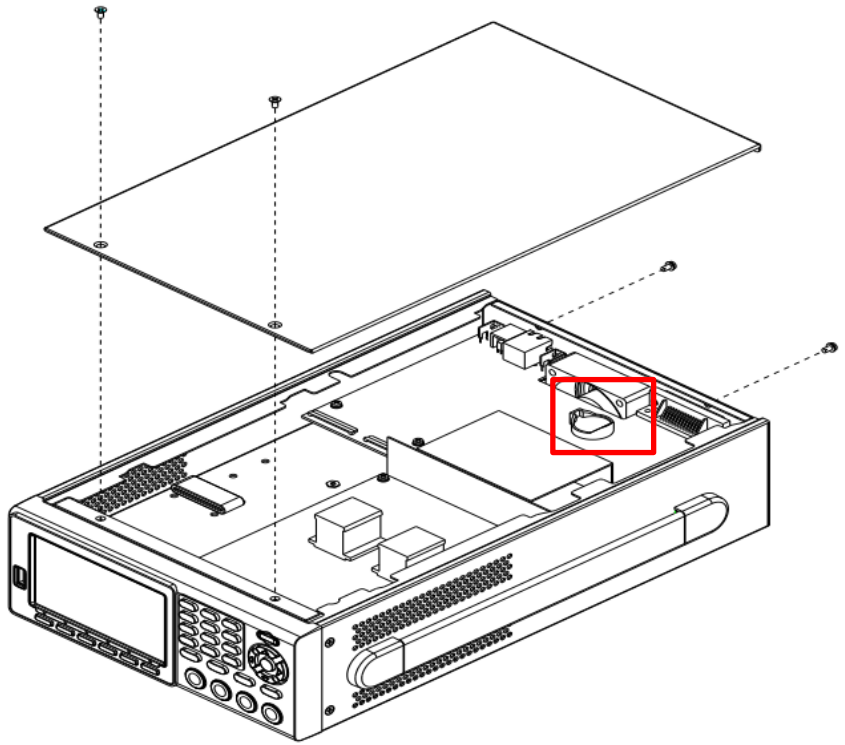
4.3” TFT LCD Panel

Digital input keypad

Keithley 2400 Dot-matrix display

Main Features - Other

- Built-in RTC clock
  - The built-in RTC Clock circuit allows users to record the time when storing the file, which is convenient fc data comparison or recording.



Applications of SMU

Applications of SMU

No.	Test classification	DUT
1	Semiconductor Device Characterization Test	Resistors, Diodes, BJT Transistors, MOSFET Transistors, SICs
2	Energy and Efficiency Characteristic Testing	LED, OLED Display, solar cell, battery, DC-DC converter
3	Sensor Characterization Test	Resistance characteristics, Hall effect
4	Organic Material Characterization Testing	E-ink, Printed electronics
5	Nanomaterial Characterization Testing	Graphene

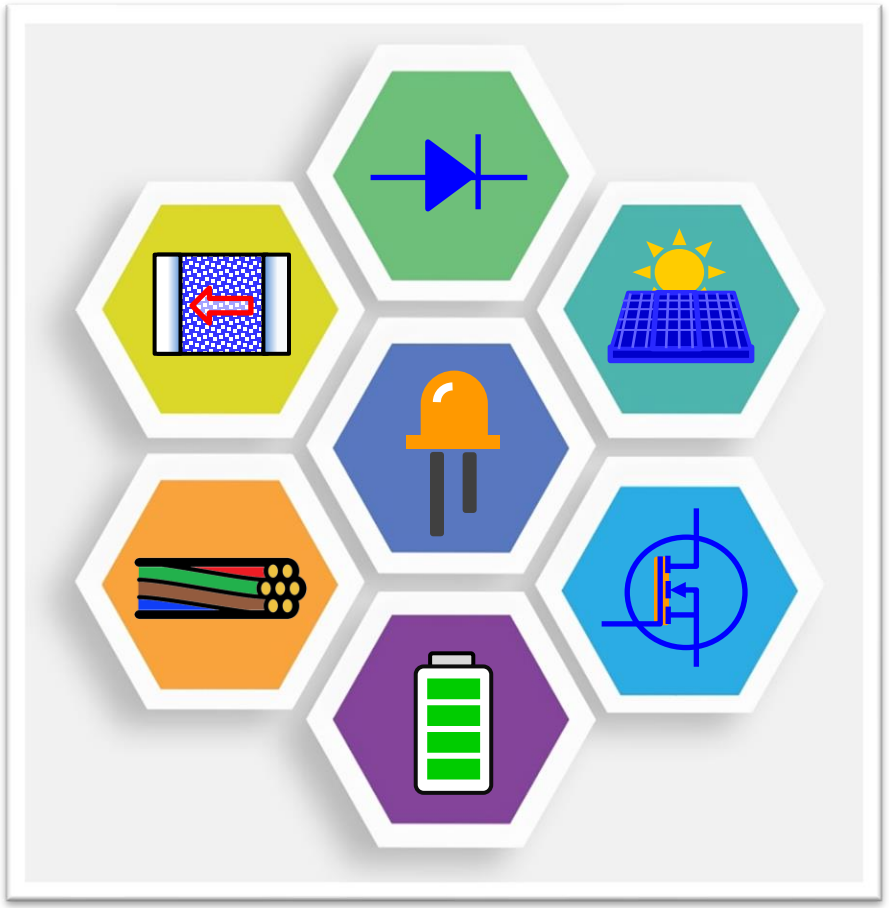
From: Tek/Keithley, Keysight, ADCMT..etc

Applications of SMU

Microcircuit		
1	IC	IV test, I/O curves
Component		
1	Diode	Forward conduction voltage, forward current, reverse breakdown voltage, reverse current
2	BJT	IV test, characteristic curve
3	MOSFET	IV test, characteristic curve
4	IGBT	IV test, characteristic curve
Battery		
1	Lithium battery	IV test, charge-discharge scan curve
2	Solar battery	IV test, discharge scan curve
Material		
1	Graphene	IV test, I/O curves
2	Carbon nanotube	IV test, I/O curves

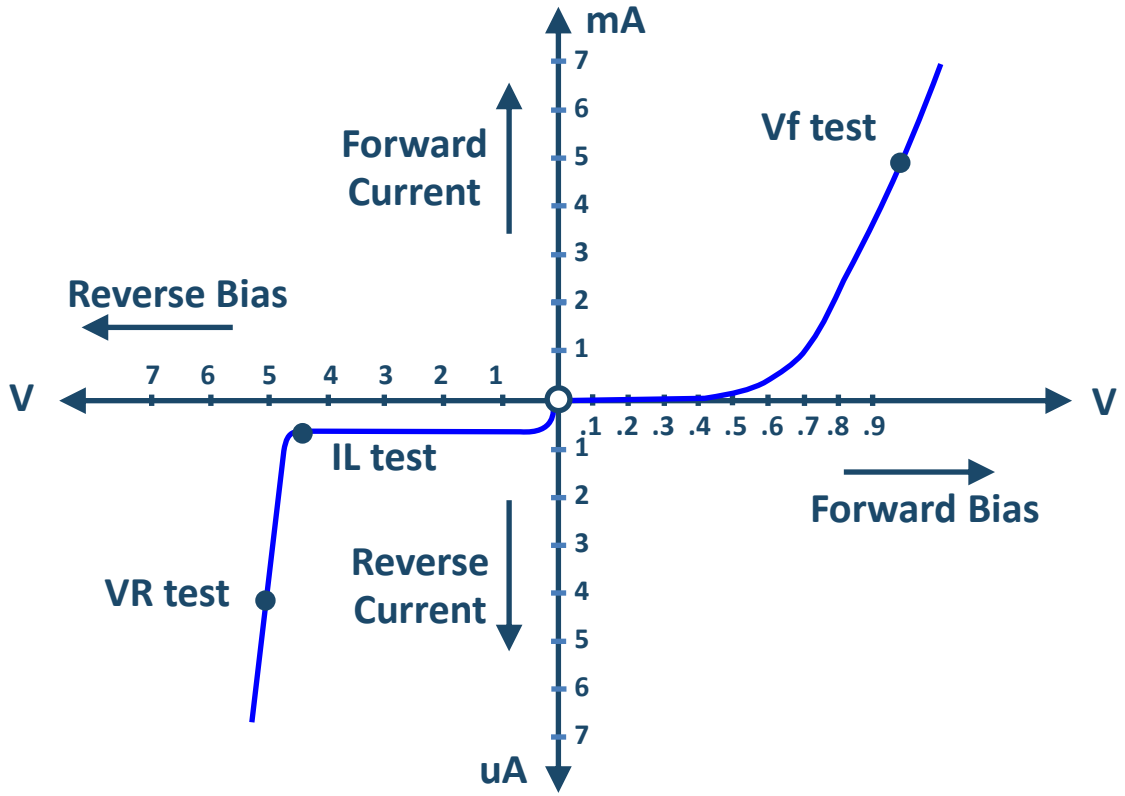
Applications of SMU

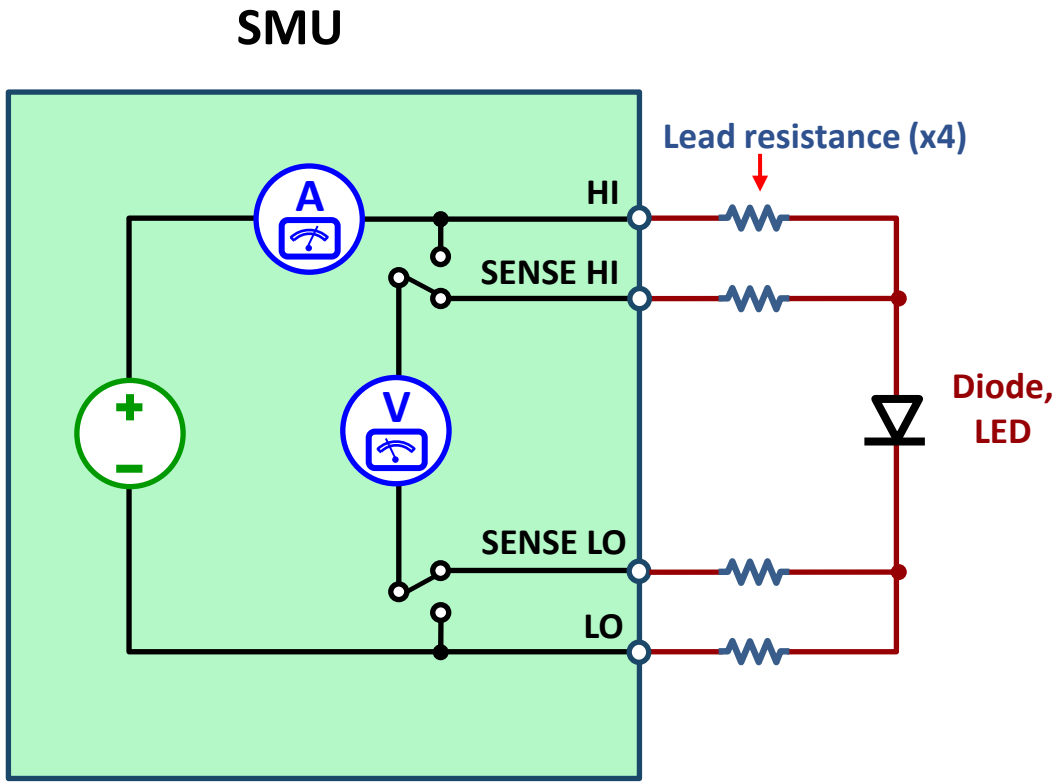
- Diode characteristics test
- Solar cell V-I characteristics test
- MOSFET characteristics test
- Battery charging and discharging test
- Precise low resistance measurement
- High resistance measurement
- LED thermal resistance measurement



Diode, LED V-I characteristics test

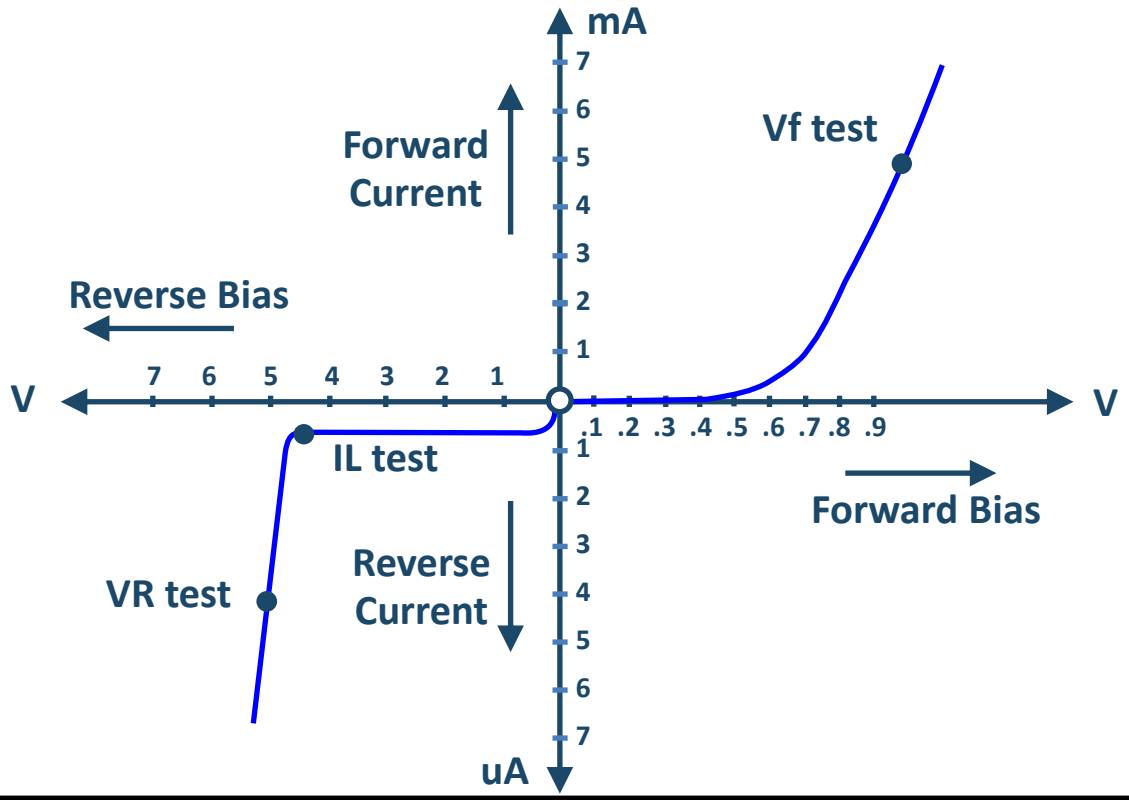
- Forward bias test

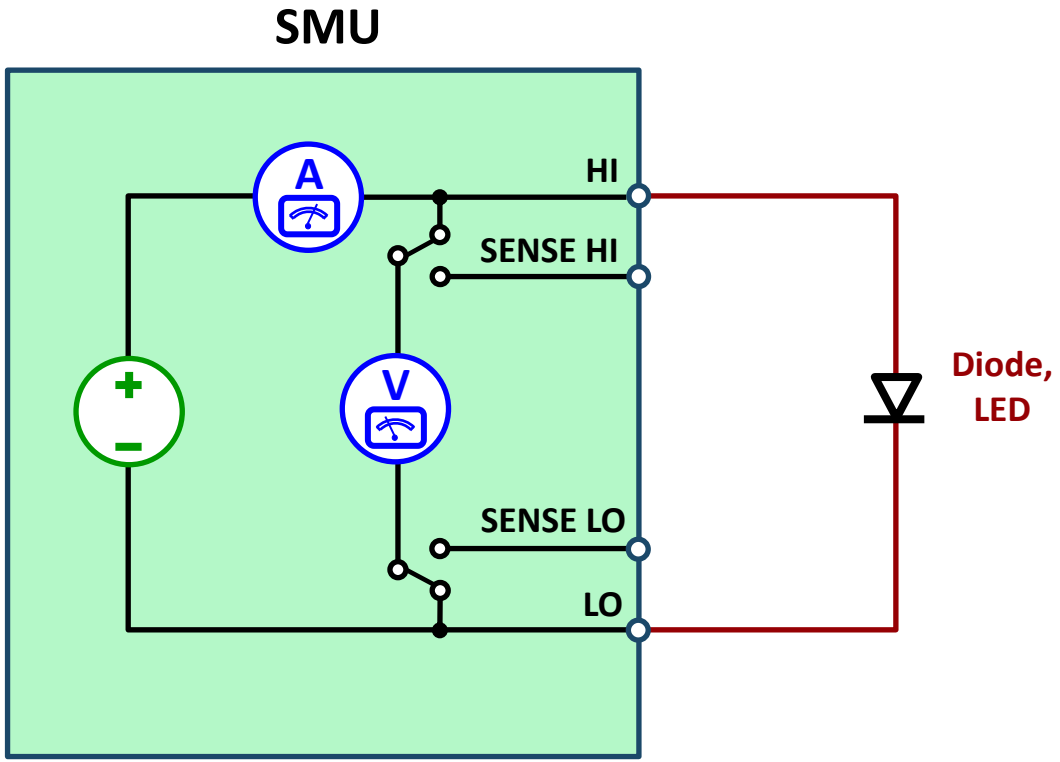




Diode, LED V-I characteristics test

- Forward bias test
- Reverse bias test: leakage current, breakdown voltage

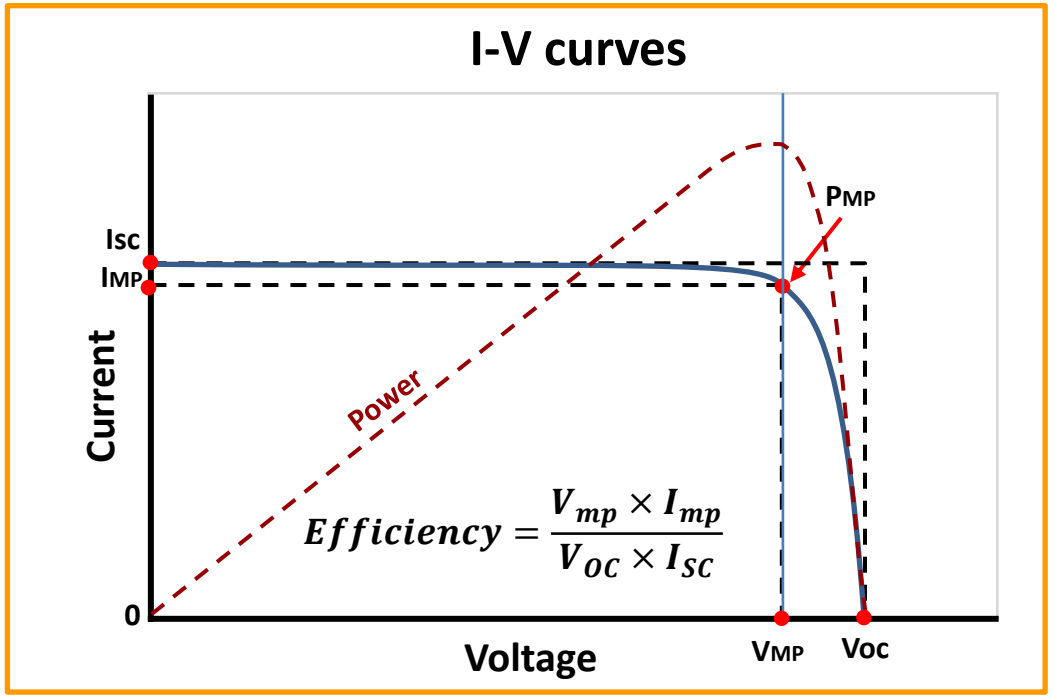


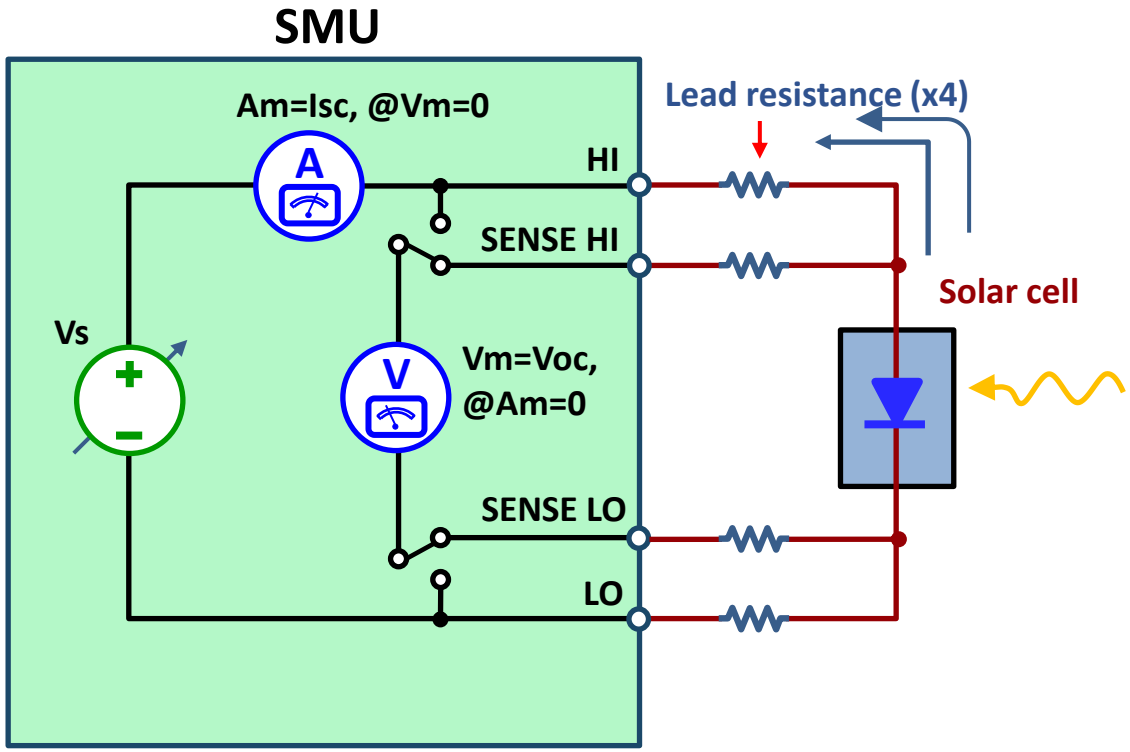


Solar cell V-I characteristics test

- Use SMU as load to obtain Isc, Voc, PMP (by VMP x IMP) and get efficiency by

$$\text{Efficiency} = \frac{\text{Vmp} \times \text{Imp}}{\text{Voc} \times \text{Isc}}$$





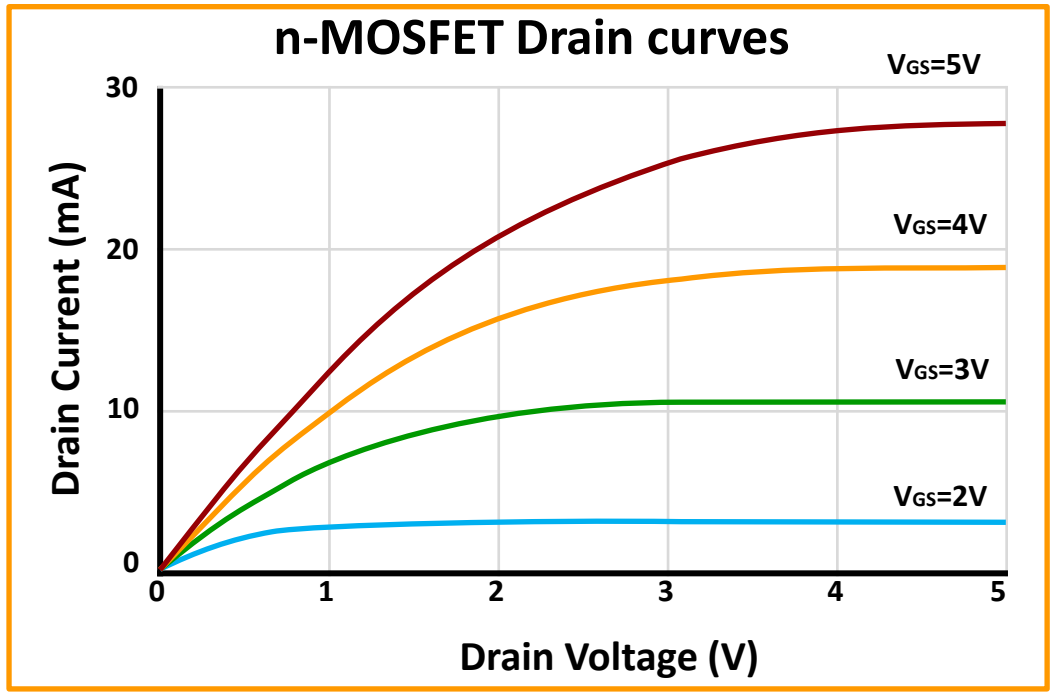
MOSFET characteristics test

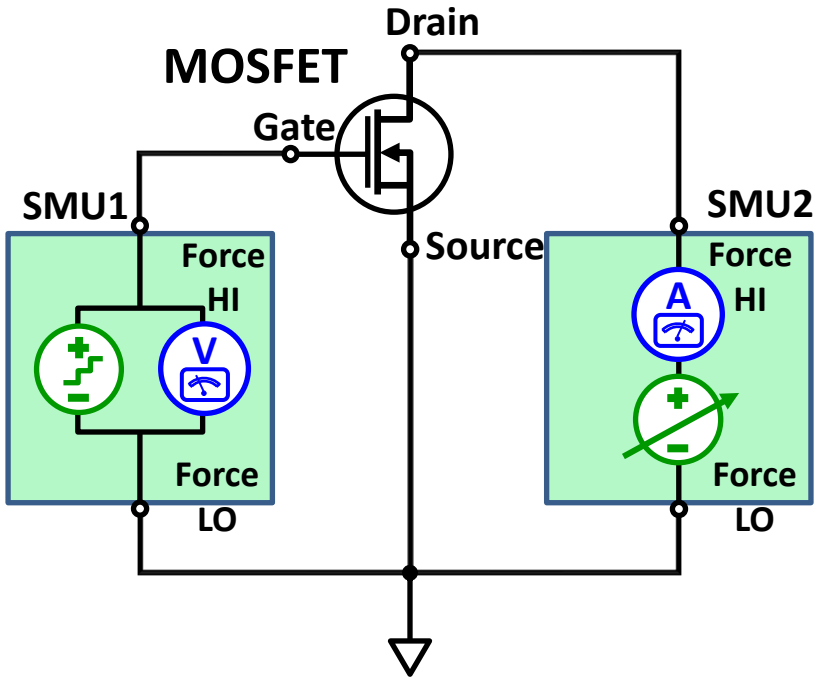
- Drain curves
- Threshold voltage
- Transconductance
- Gate leakage current
- Drain leakage Current
- Breakdown voltage

MOSFET – Drain Curve

The most popular characteristic while use a MOSFET

1. Use SMU1 to set Vgs, SMU2 to sweep Vds, measure Ids to get the curve
2. Set Vgsto other values, sweep Vds to obtain the different curves.

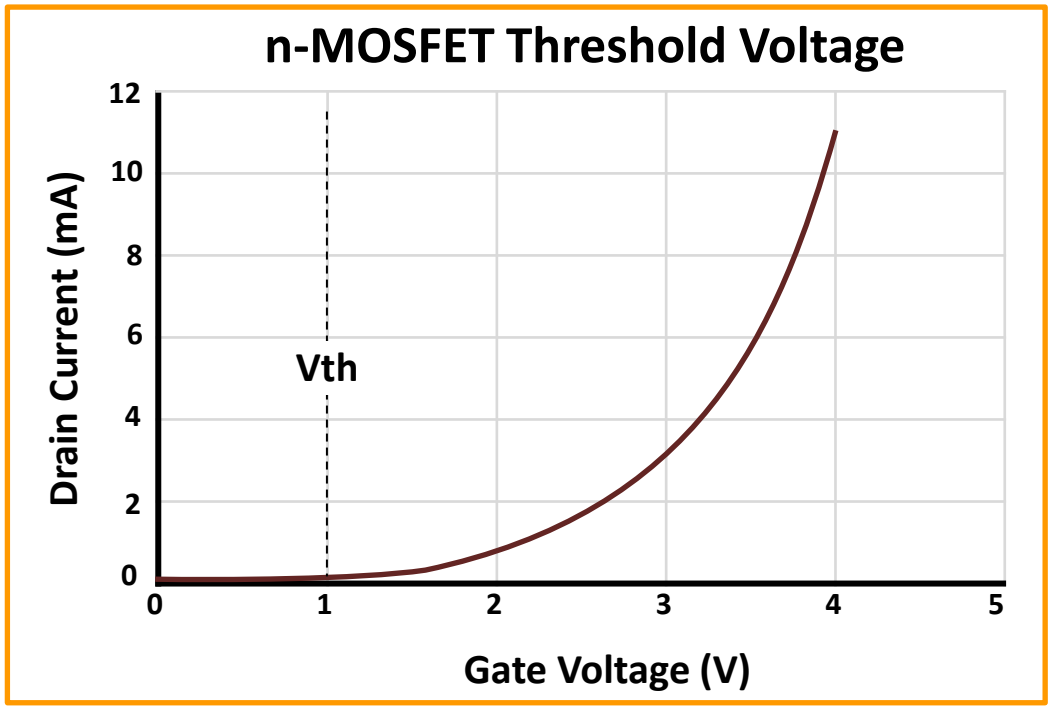


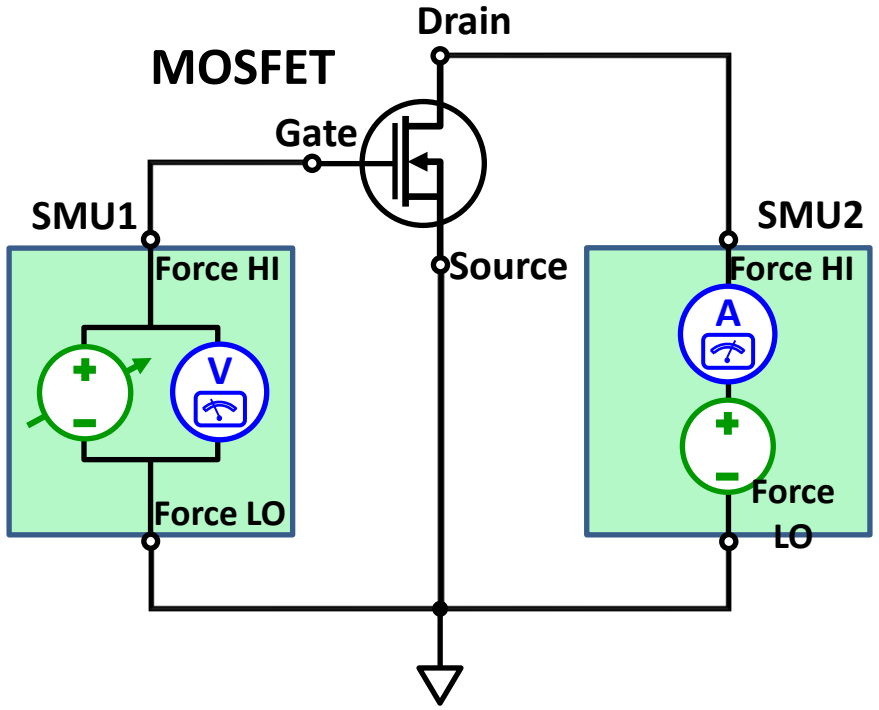


MOSFET – Gate Threshold Voltage, Vth

Vth is the gate to source voltage that appears when the minimum Ids flows from source to drain.

1. Set Vds to a particular value with SMU2, which the minimum IDS will occur.
2. Sweep Vgs with SMU1 until IDS reaches the specified value. The Vgs is Vth.

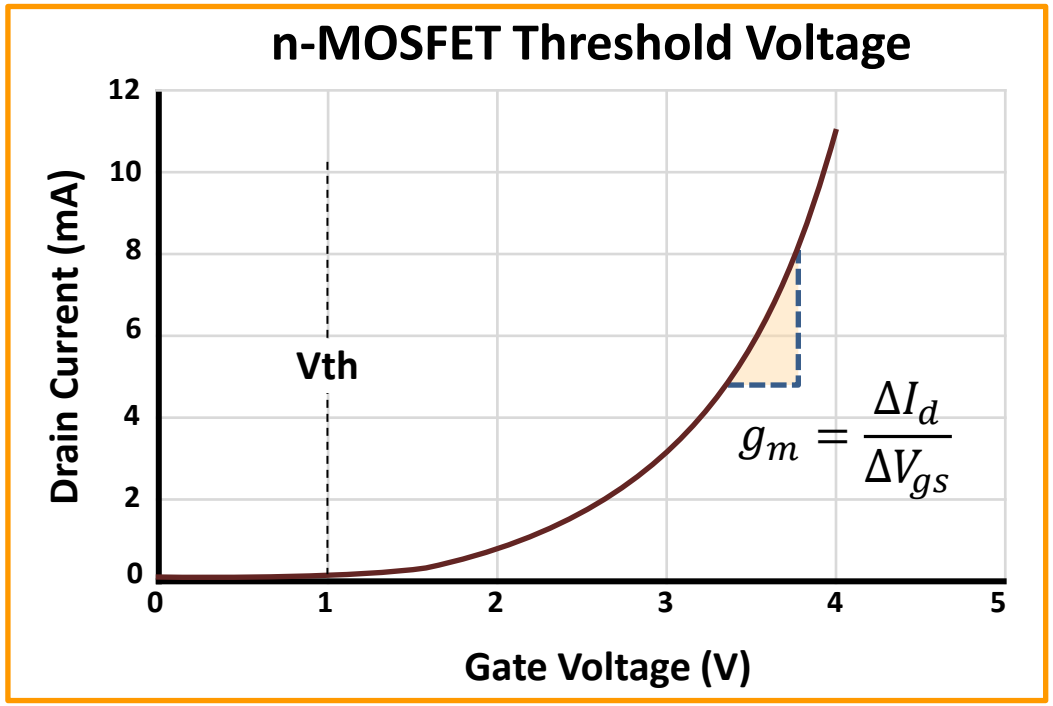


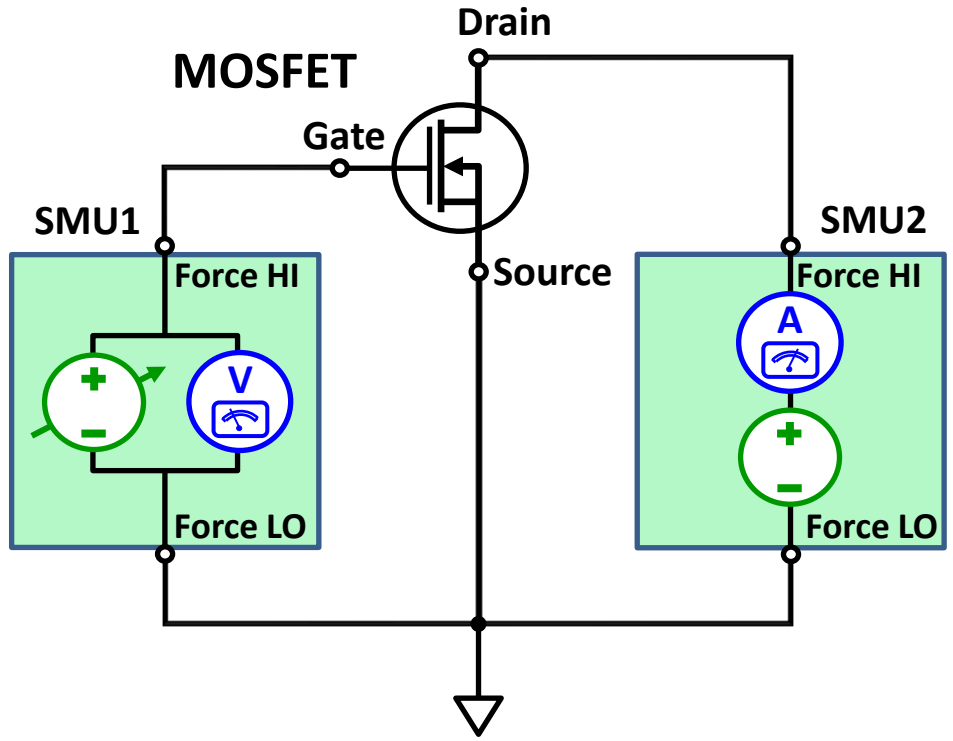


MOSFET – Transconductance, gm

gm represents the signal gain of a MOSFET.

1. Set the constant voltage Vds with SMU2.
2. Sweep Vgs with SMU1 and measure Ids SMU2 current meter.

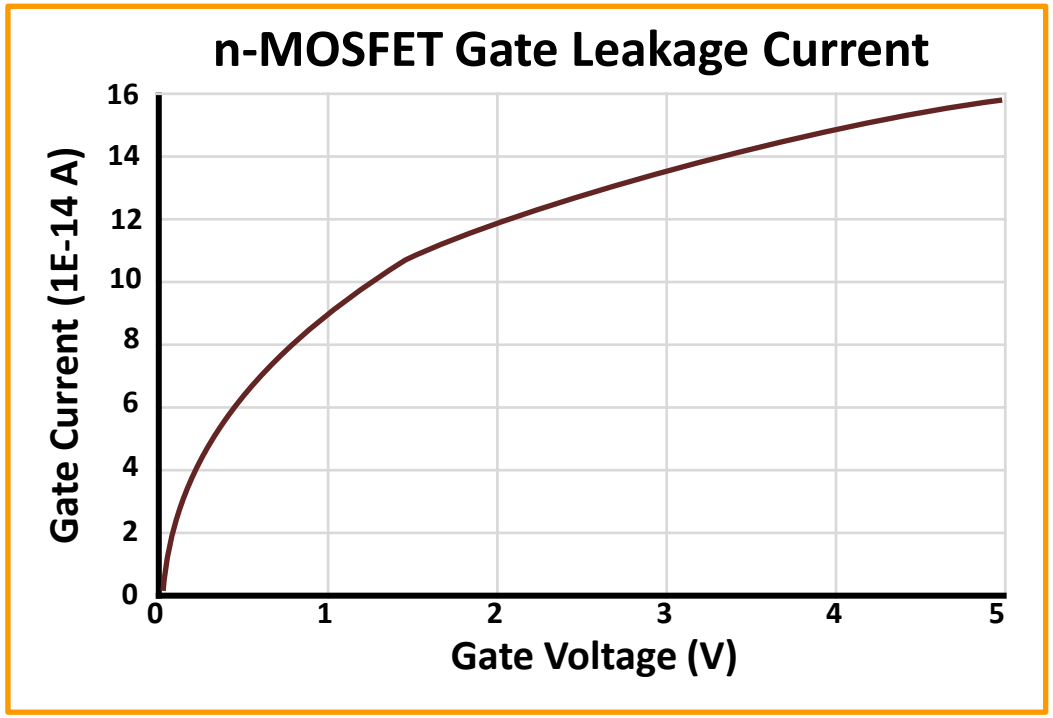


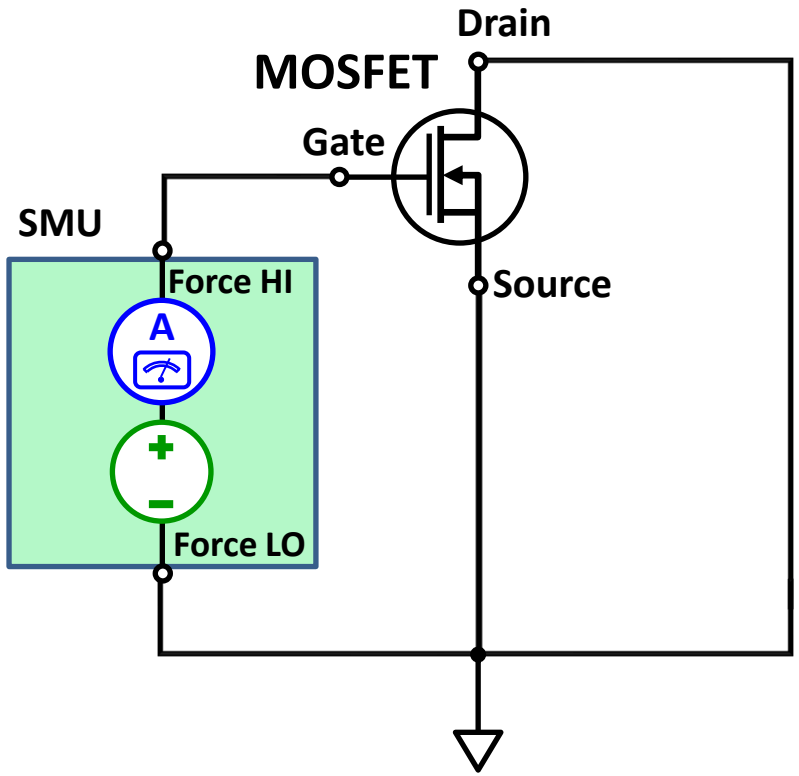


MOSFET – Gate leakage current, Igss

Igss is the current between the gate and source at V_{DS} = 0.

1. Short Drain and Source
2. Sweep Vgs over the desired range, measure the current.

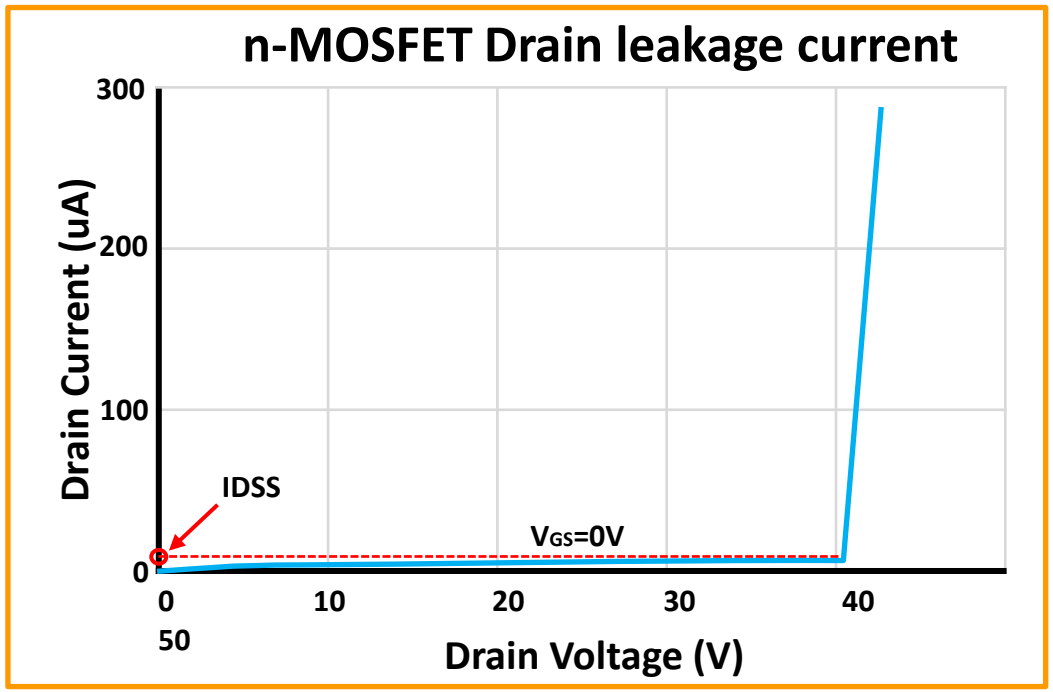


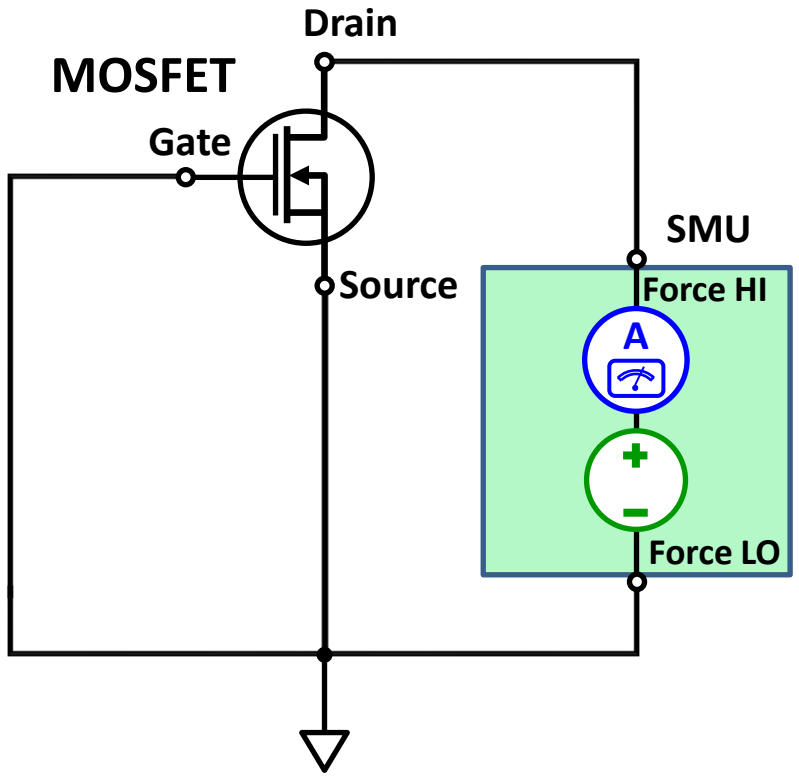


MOSFET – Drain leakage current

Idss is the current between the drain and source at V_{GS} = 0.

1. Short Gate and Source
2. Sweep Vds and monitor the leakage current of Drain-Source

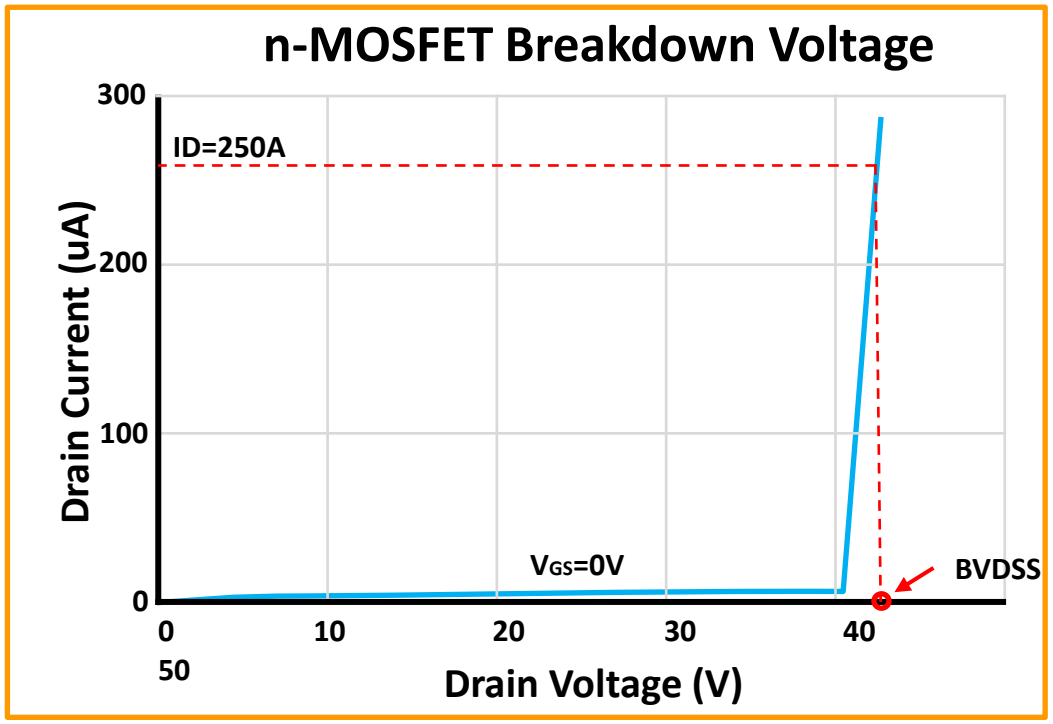


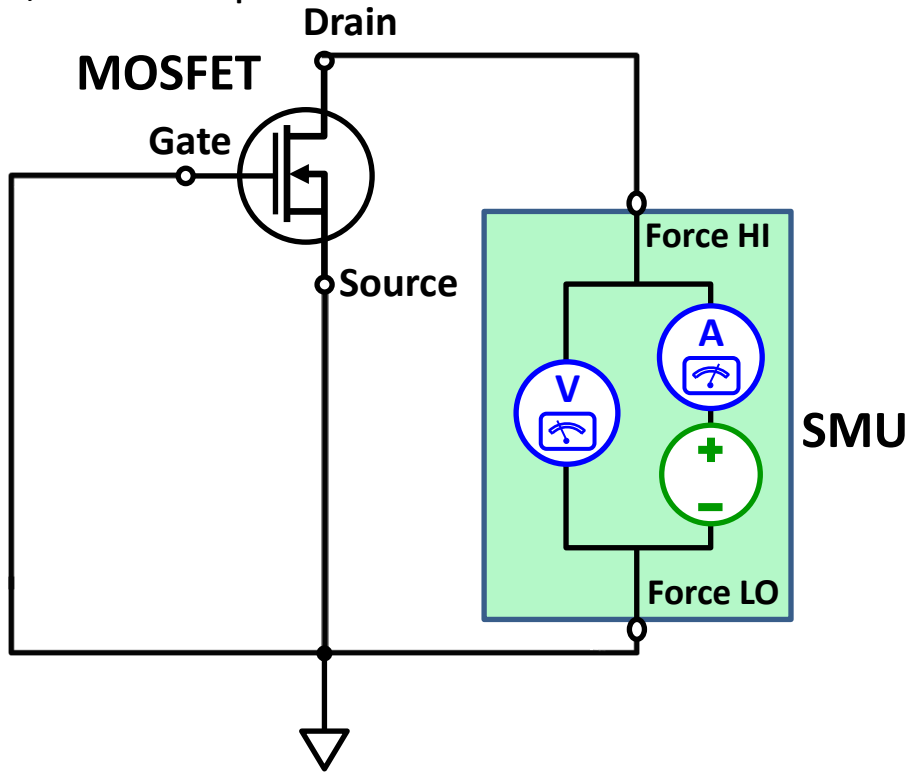


MOSFET – Drain Source Breakdown voltage, BVdss

When Vgs=0, BVdss causes a significant Ids to flow.

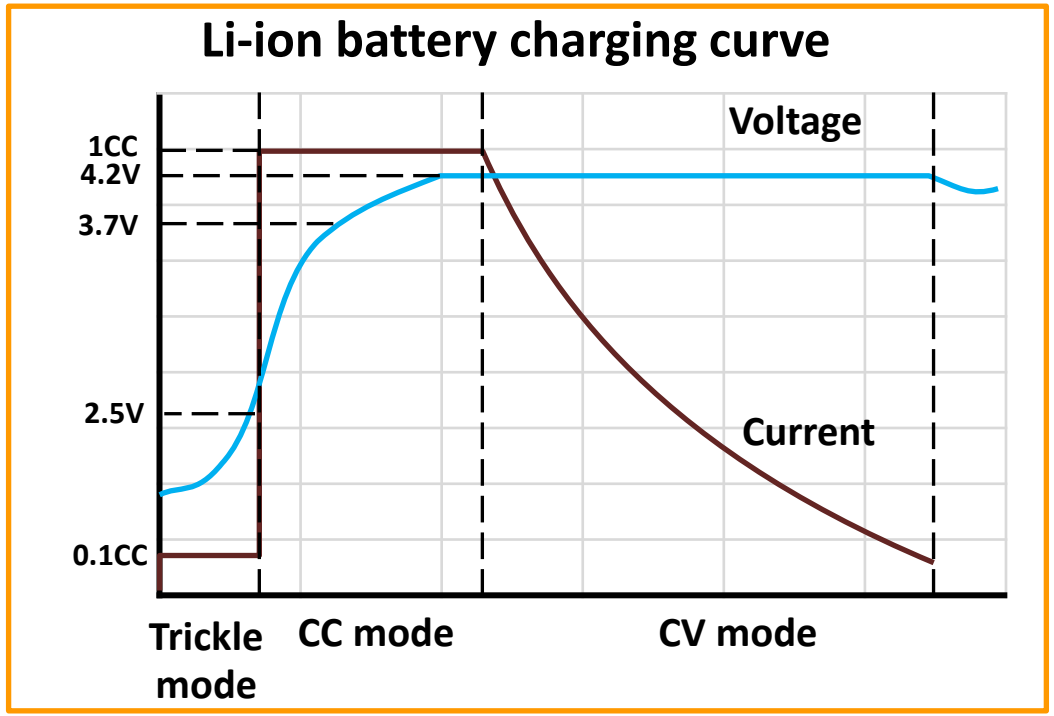
1. Short Gate and Source.
2. Increase Vds until Ids starts to flow and reaches the specified value, at which point Vds is measured.

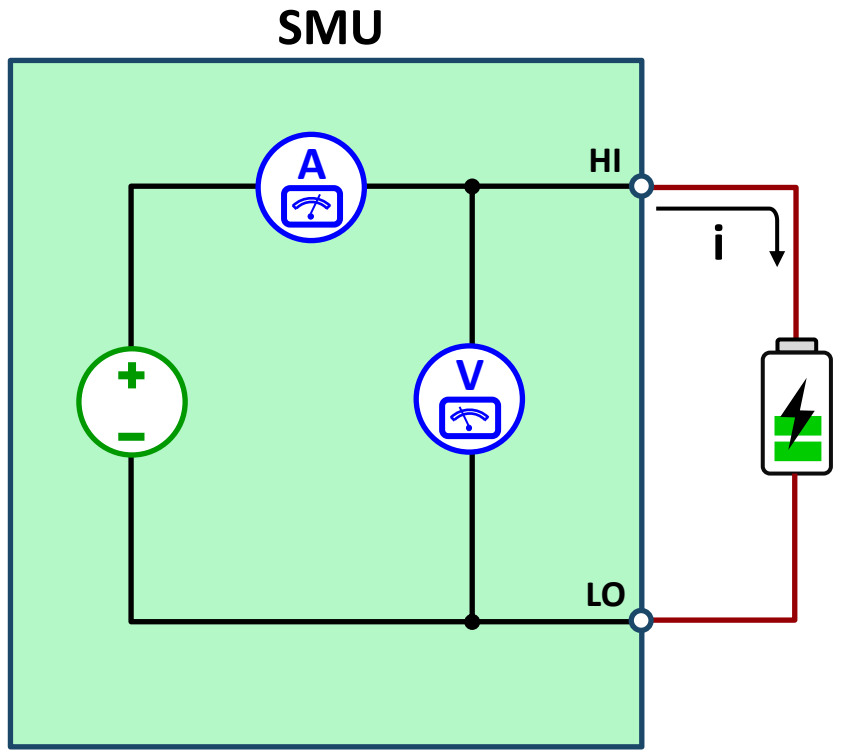




Battery charging test

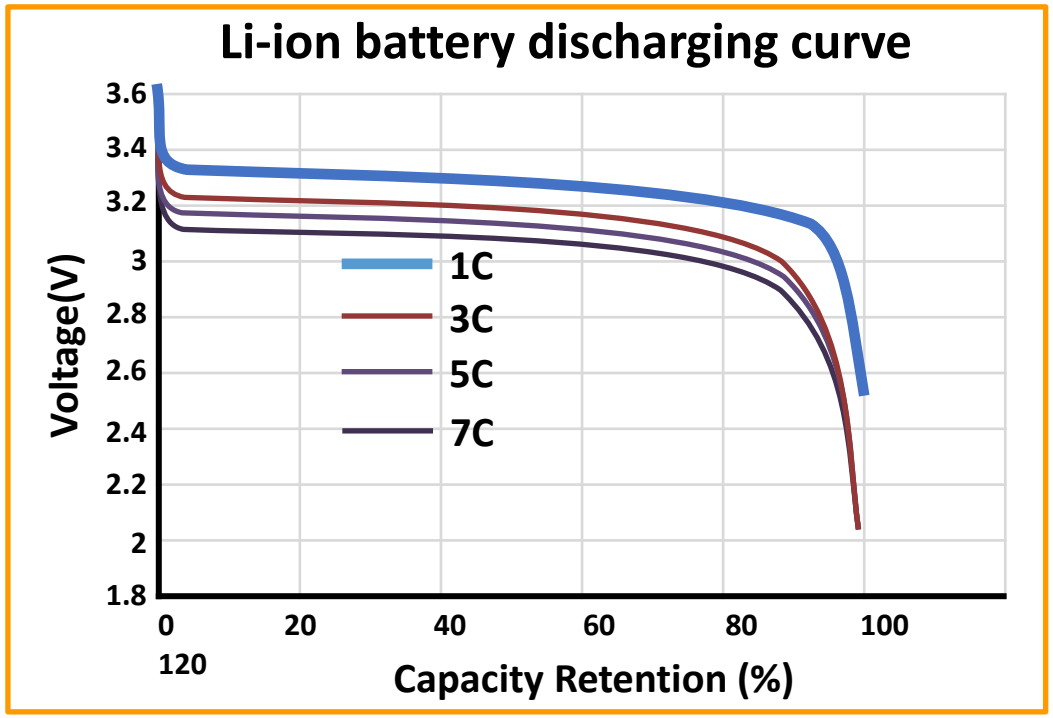
- SMU as voltage and current source
- SMU voltage > Battery voltage
- Current flows from SMU to battery

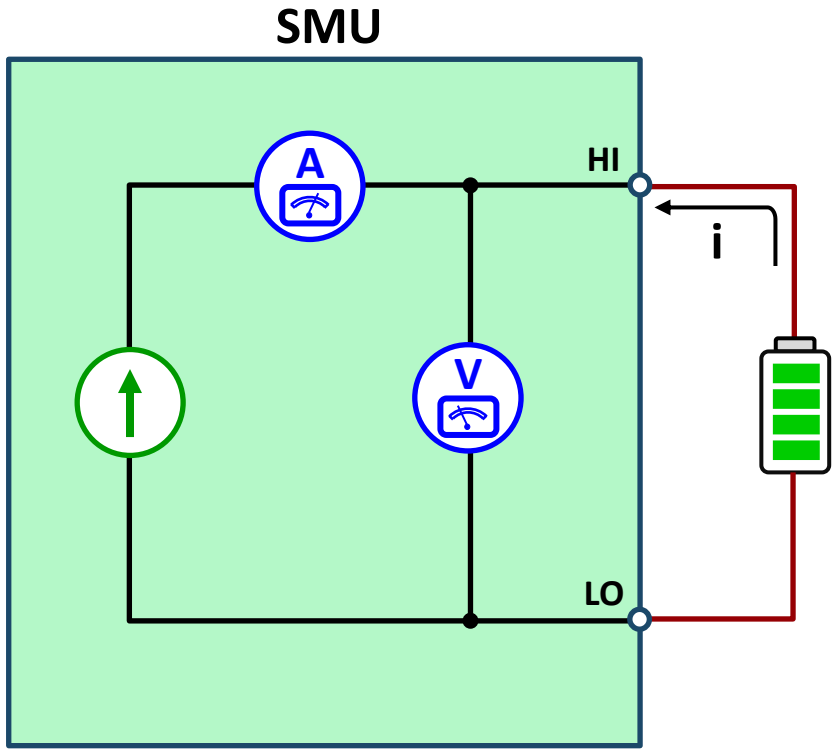




Battery discharging test

- SMU as a load
- SMU voltage < Battery voltage
- Current flows from battery to SMU

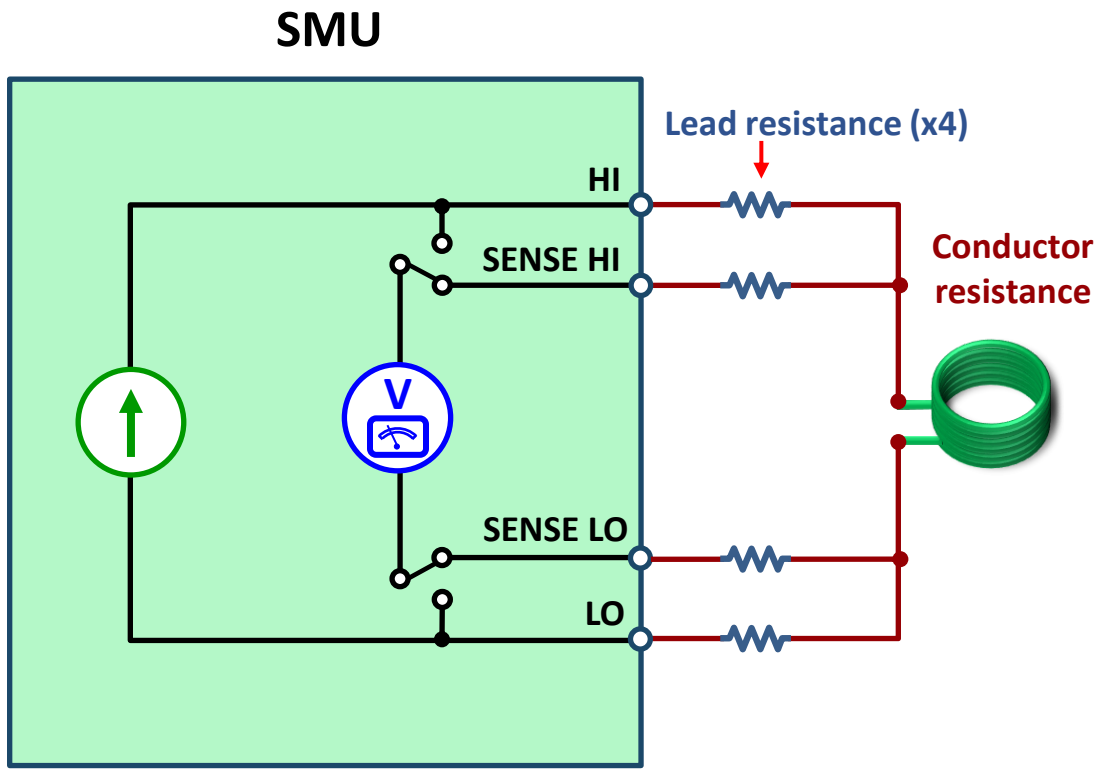




Low resistance measurement

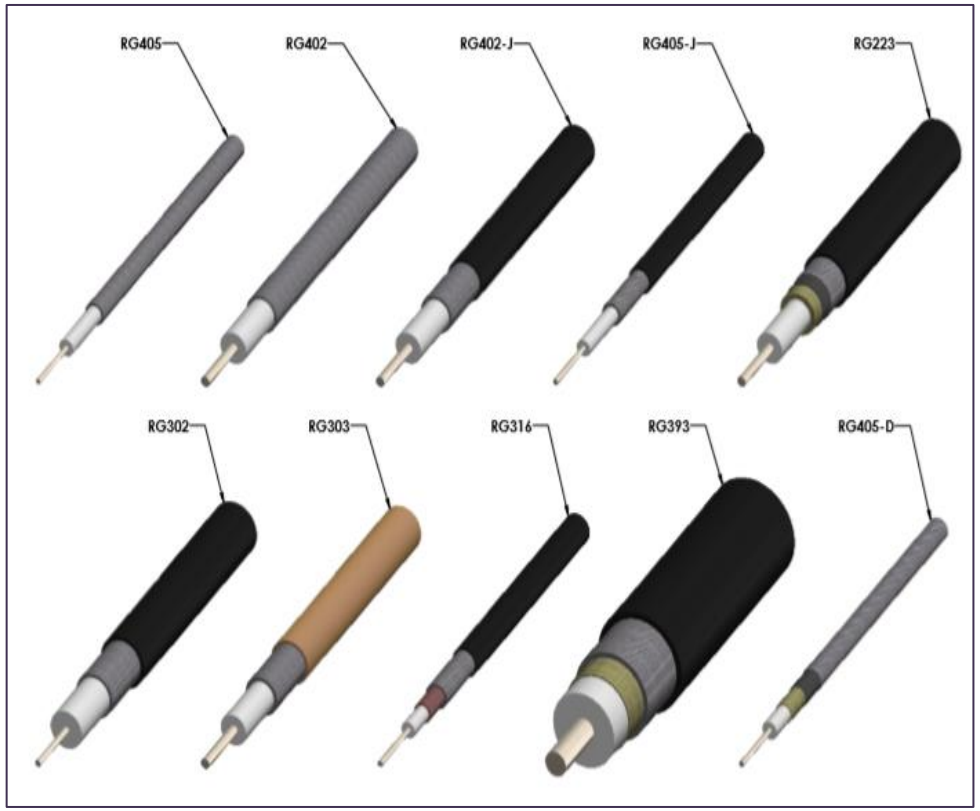
- Example: conductor resistance measurement.

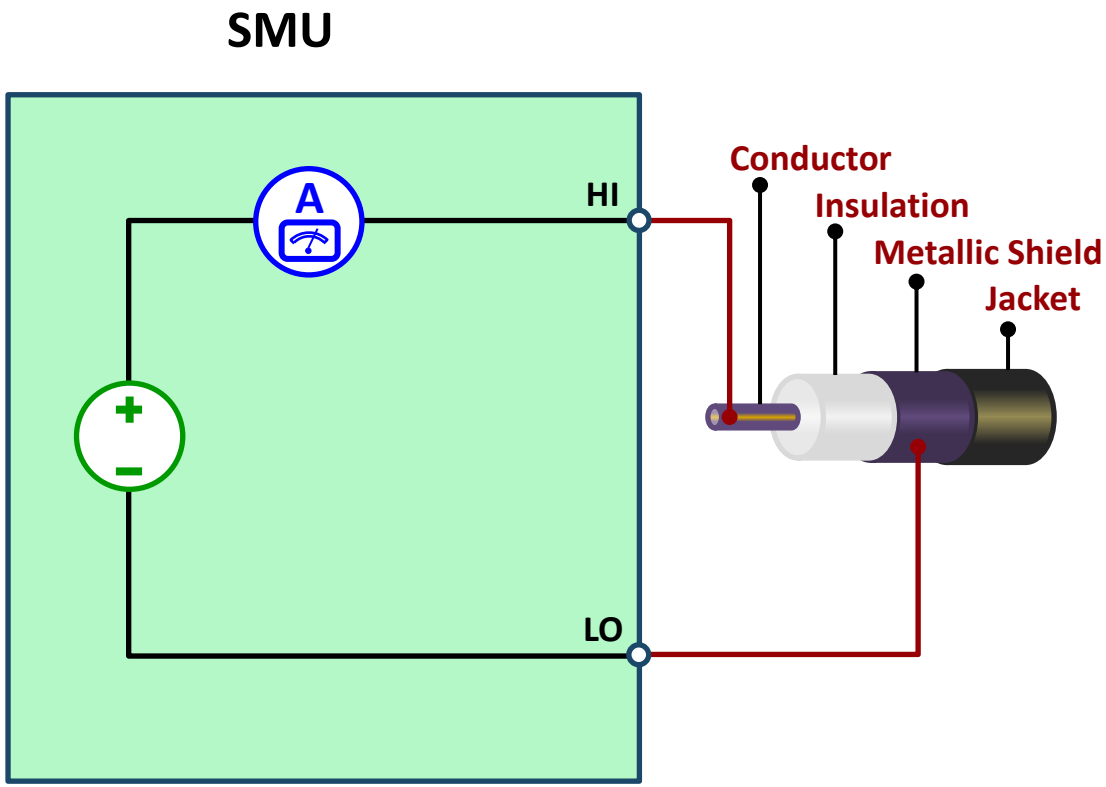
Wire Resistance Chart (20°C)				
Gauge (AWG)	Diameter (in)	Diameter (mm)	Resistance (Ω/ft)	Resistance (Ω/m)
28	0.0126	0.3211	5.29	17.35
29	0.0113	0.2859	6.92	22.69
30	0.0100	0.2546	8.83	29.30
31	0.0089	0.2268	10.01	32.85
32	0.0080	0.2019	13.29	43.60
33	0.0071	0.1798	19.21	63.01
34	0.0063	0.1601	24.69	81.00
35	0.0056	0.1426	27.76	91.07
36	0.0050	0.1270	35.00	114.84



Insulation resistance measurement

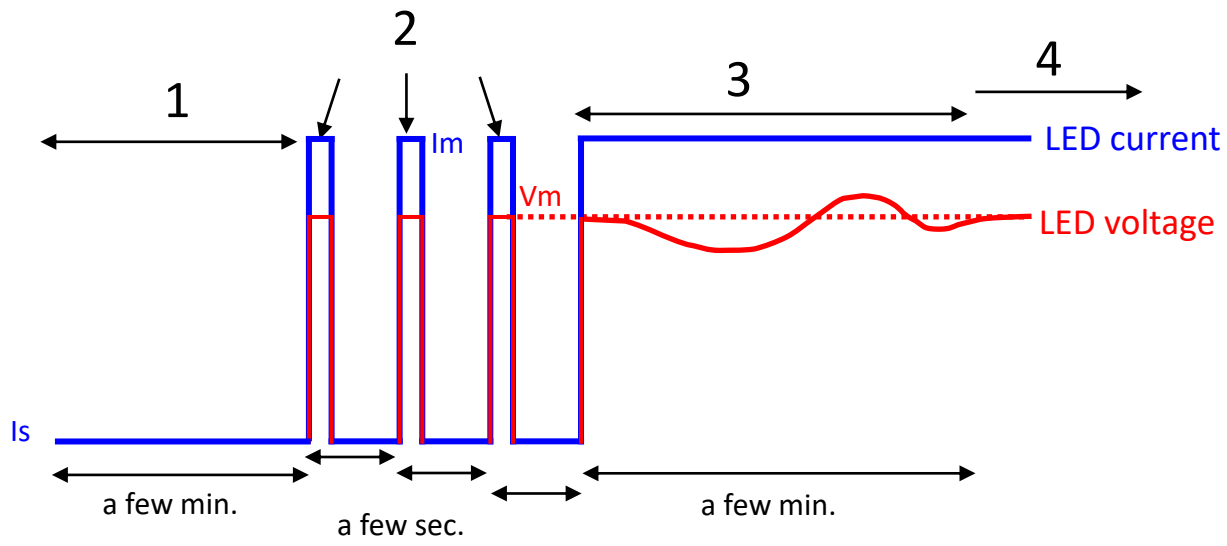
- Example: Cable insulation resistance measurement.

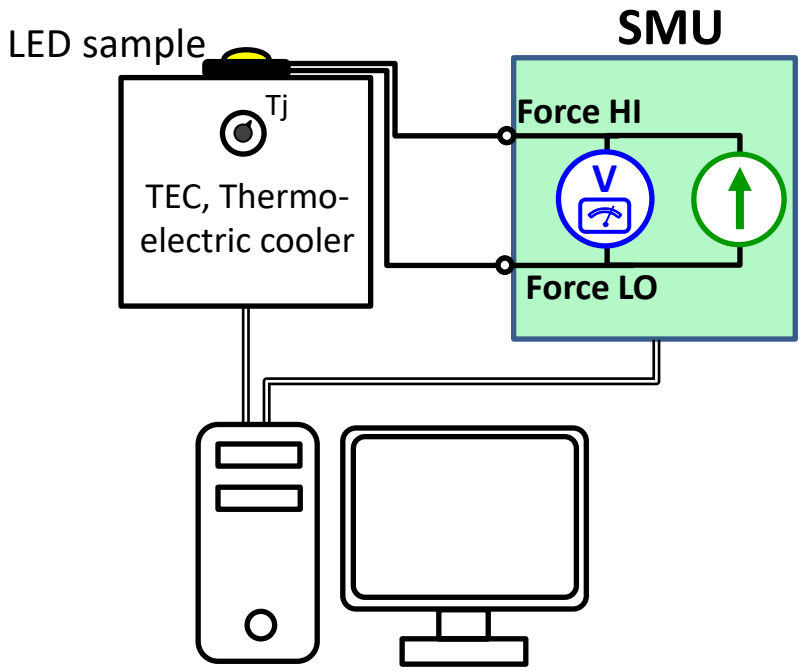




LED – Thermal resistance measurement

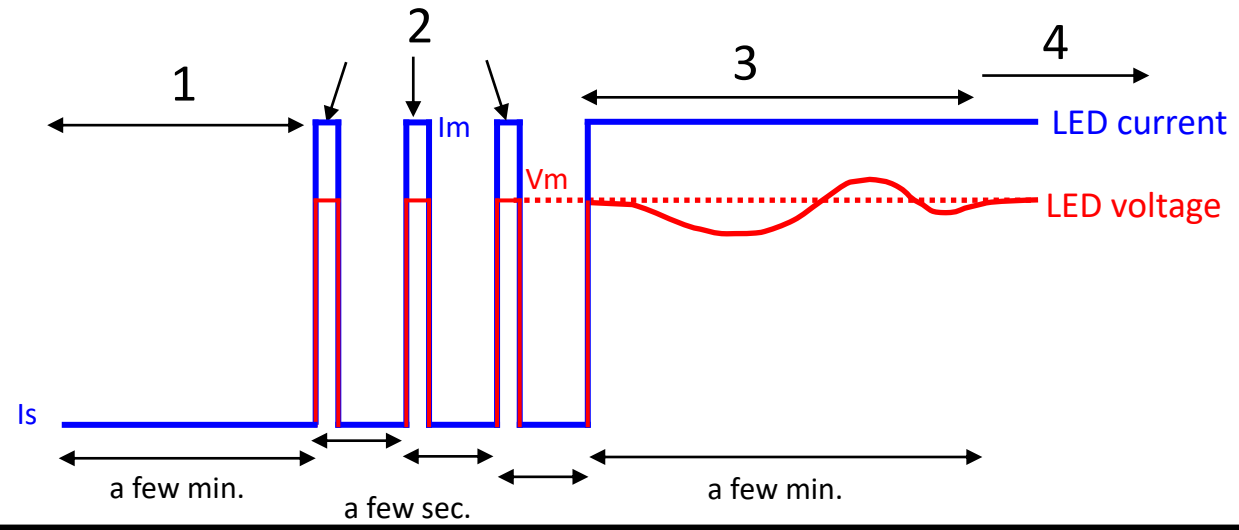
1. Set LED sample temperature at Tj. SMU outputs a small current Is.
2. SMU outputs pulse current Im. Measure voltage and record as Vm.
3. Alter output to DC current. Tune the LED temperature to stabilize voltage to Vm.

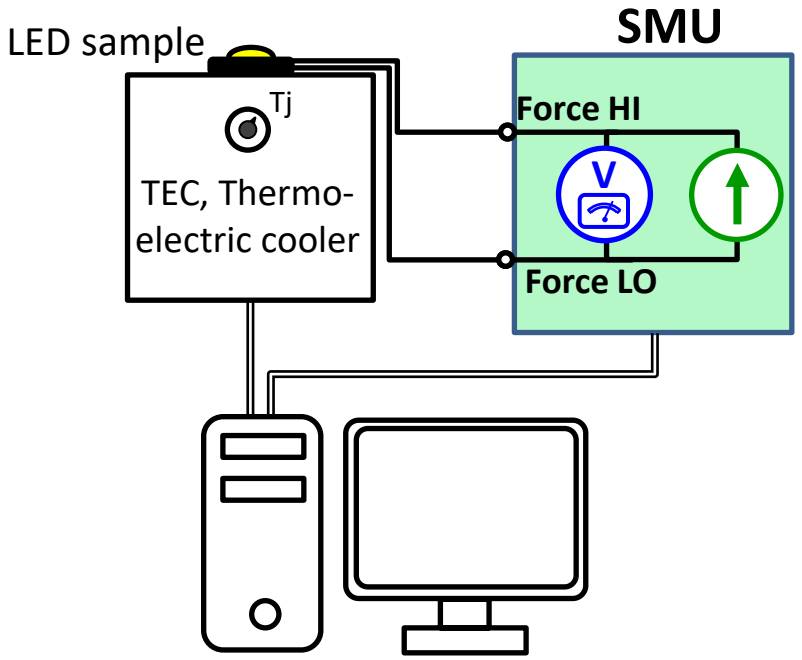




LED – Thermal resistance measurement

1. Set LED sample temperature at Tj. SMU outputs a small current Is.
2. SMU outputs pulse current Im. Measure voltage and record as Vm.
3. Alter output to DC current. Tune the LED temperature to stabilize voltage to Vm.
4. Record temperature as Tm. Calculate Rt. $$Rt = \frac{|Tj - Tm|}{Vm \times Im}$$

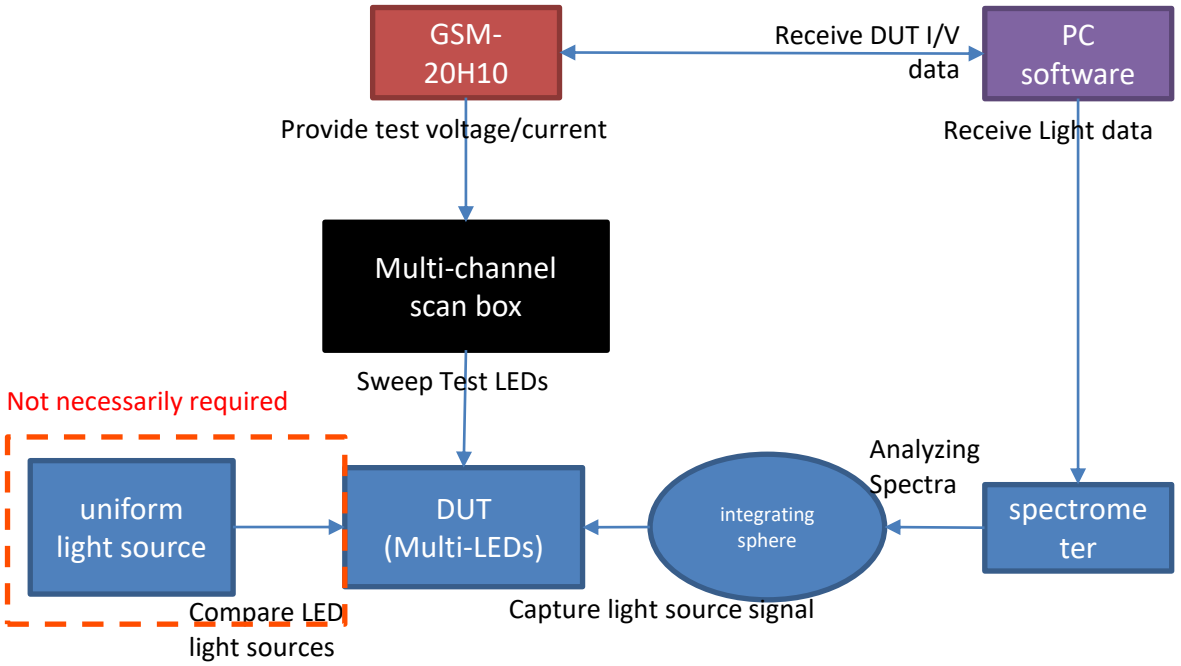




Successful Story in Taiwan

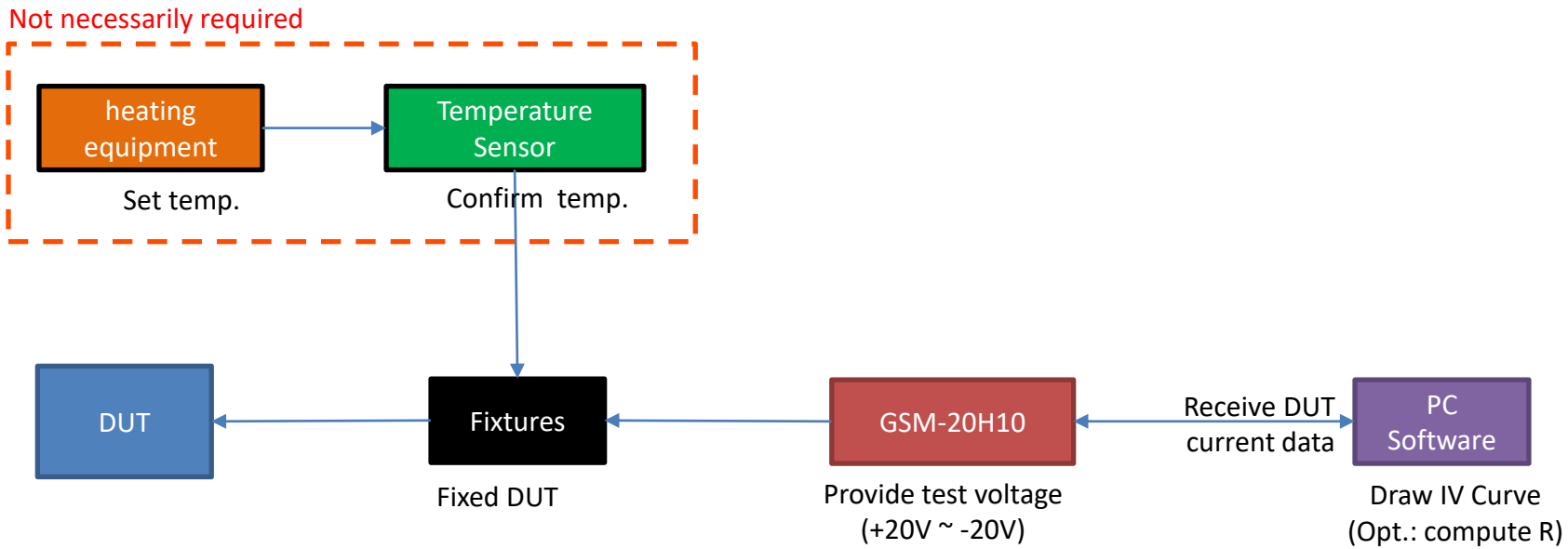
LIV Test System (with Tempoint Corp. in TW)

- **LIV (Light-Current-Voltage)**



Material Test (Plated Sheet)

- **IV (Current-Voltage)**

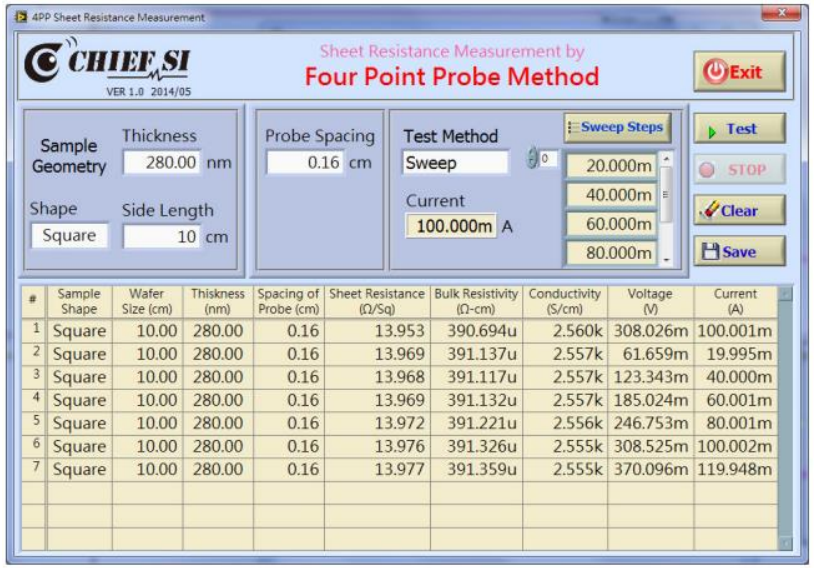


Note: This type of test will also be used to test other materials that require exposure.

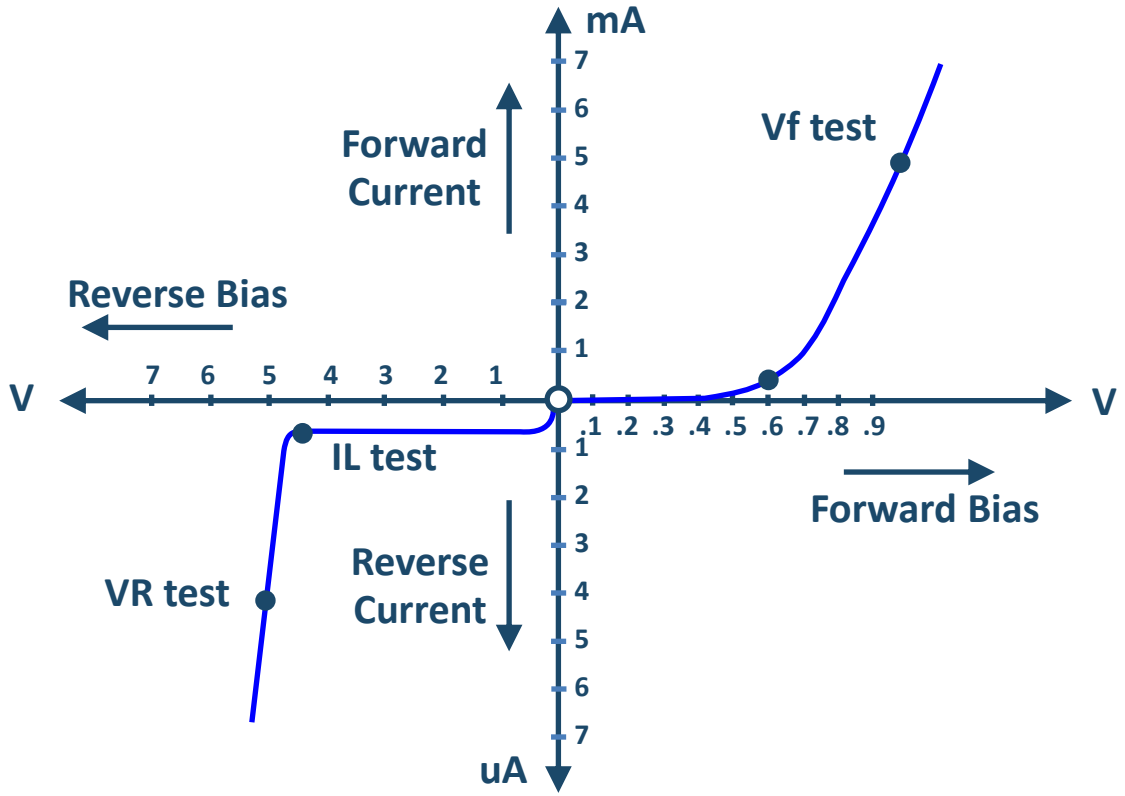
Four-Point Probe Sheet Resistance Measurement

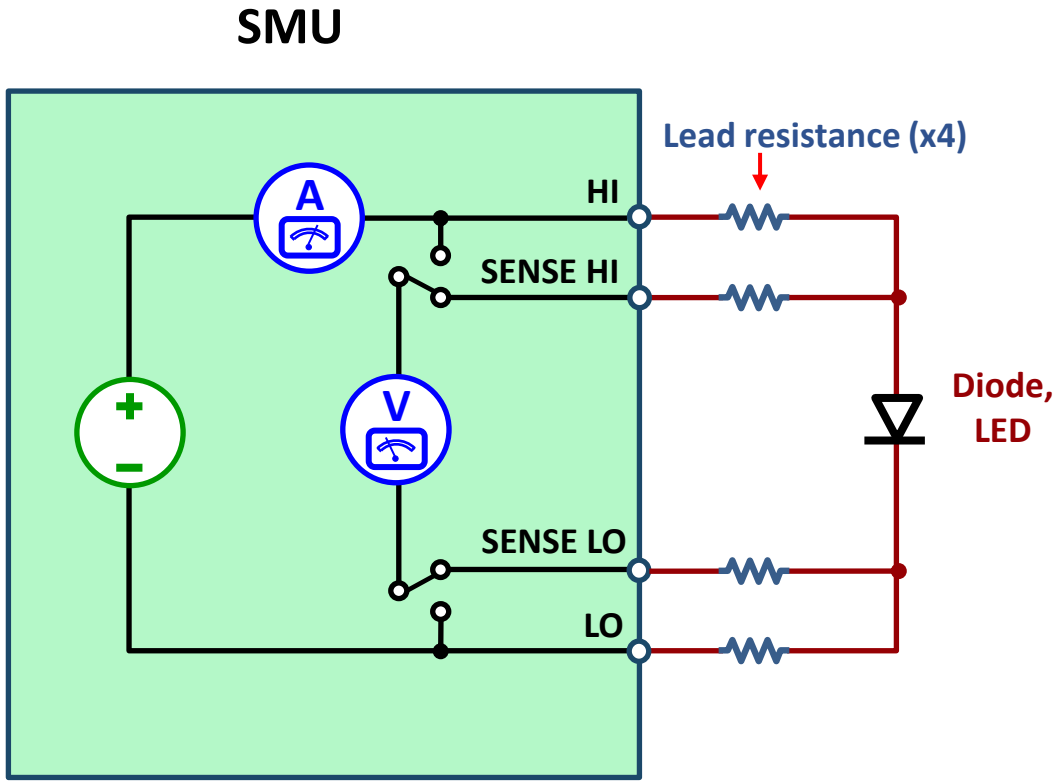
System Features:

- User-friendly and intuitive software interface
- Precisely measure the thin film resistance of the DUT
- Constant current measurement. Single-point measurement or multi-point scanning can be selected
- When the thickness of the film is known, the bulk resistivity and conductivity are calculated at the same time
- Adopt .CSV file storage format, which is convenient for users to process data
- Compatible with ~~Keithley 2400~~ SMU GSM-20H10. It can also be customized with various SMUs and micro- and high-resistance meters according to user needs.



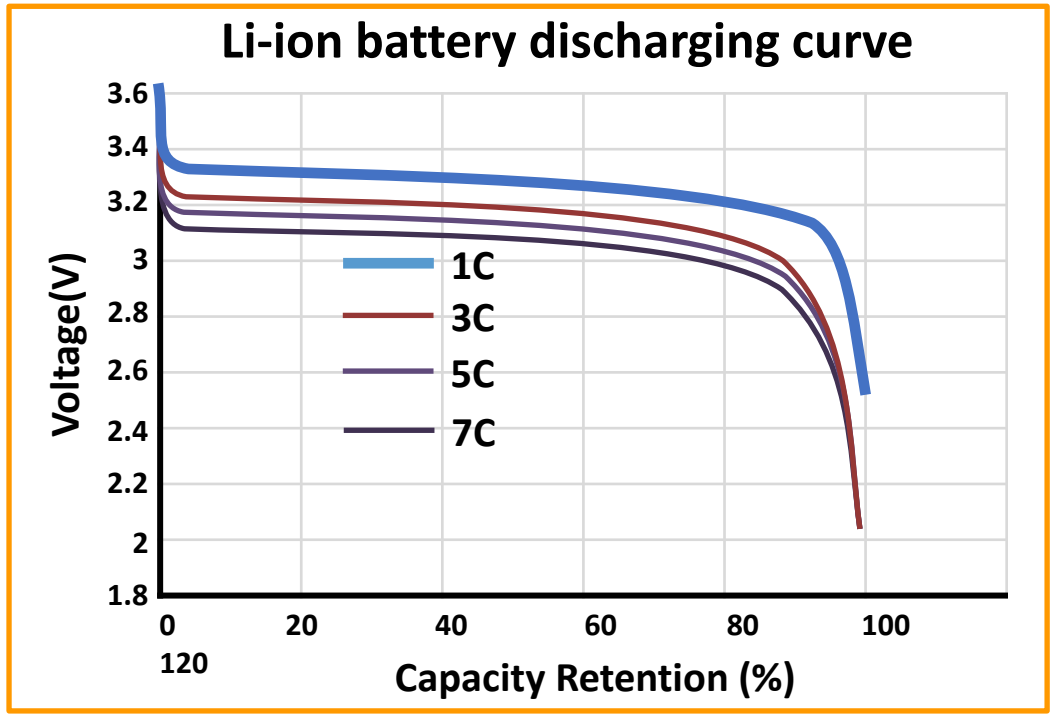
UVLED V-I characteristics test (by Tom)

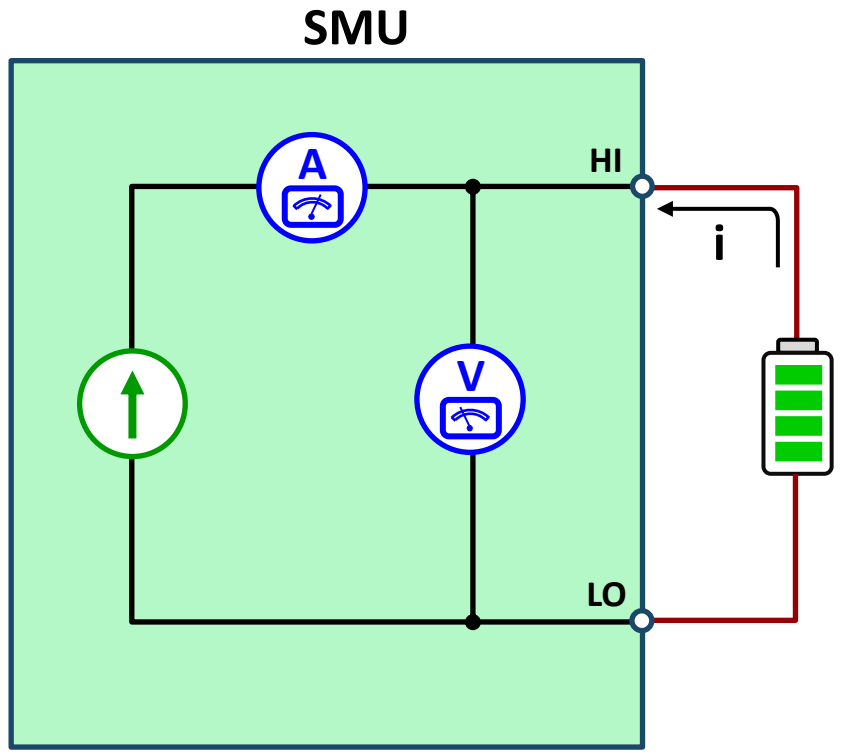




Battery discharging test

- Battery discharging test (Department of Earth Sciences of NCU)






THANK
YOU
GRACIAS
ARIGATO
SHUKURIA
DANKSCHEEN
BÏYAN
SHUKRIA
TINGKI
YAQHANYELAY
TASHAKKUR ATU
CHALTU
NUHUN
SNACHALHUYA
SPASSIBO
SUKSAMA
EKHMET
WABEEJA
MAITEKA
YUSPAGARÀTAN
HUI
GUI
HÀTUR
SPASIBO
DENKAUJA
NEHACHALHYA
UNALCHÉESH
EKÓJU
SIKOMO
MAKETU
MINMONCHAR
BOLZÏN
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GRAZIE
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