Applications Overview:
Simplified I/V Characterization of Nanotechnology Devices

What is a SMU?

Source measure units (SMUs) are an all-in-one solution for current voltage (I/V) characterization with the combined functionality of a precision power supply, high precision DMM, and electronic load. Keithley pioneered the development of individual, compact, bench-top SMU instruments and is the leading supplier of these instruments today.

Testing a Nanotech Device

Nanotechnology is a broad field involving different types of devices and materials. Many of these tiny structures require I/V tests for electrical characterization. A Carbon nanotube field effect transistor (CNTFET) is a FET that uses a CNT as the conducting channel between the source and drain. Since a CNT FET is a three-terminal device, either two or three SMU instruments are required for electrical characterization as shown in **Figure 1.** Keithley SMU instruments are perfect for nanotech applications and test because:

- They can limit current or voltage to a level low enough to avoid device damage.
- They have the ability to measure and source low current (<1µA).
- They can be easily be synchronized for testing multi-terminal devices.

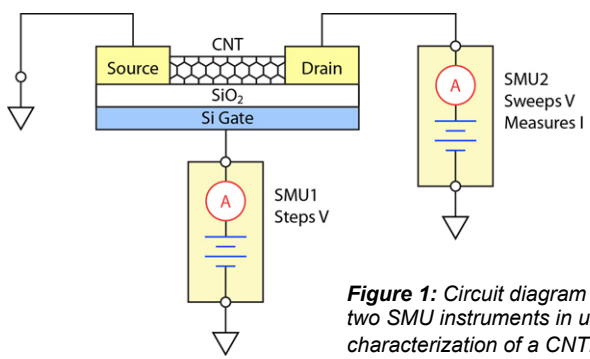

Figure 1: *Circuit diagram showing two SMU instruments in use for I/V characterization of a CNTFET.*

Common Measurements Made in I/V Characterization of CNTFETs:

- Drain Current (I_D): The current taken from the voltage source by the drain terminal is called the drain current. Drain current can yield a lot of insight on the device's operation and efficiency.
- Drain Voltage (V_D): The voltage measured at the drain terminal of a CNTFET is the drain voltage.
  Drain current and drain voltage can yield a lot of insight on the CNTFET's operation and efficiency.
- Other measurements include:
  - Gate Voltage (V_G) • Threshold Voltage (V_{TH}) • Gate Current (I_G)

Figure 2 shows a CNTFET family of I/V curves generated by using two Keithley SourceMeter SMU instruments.

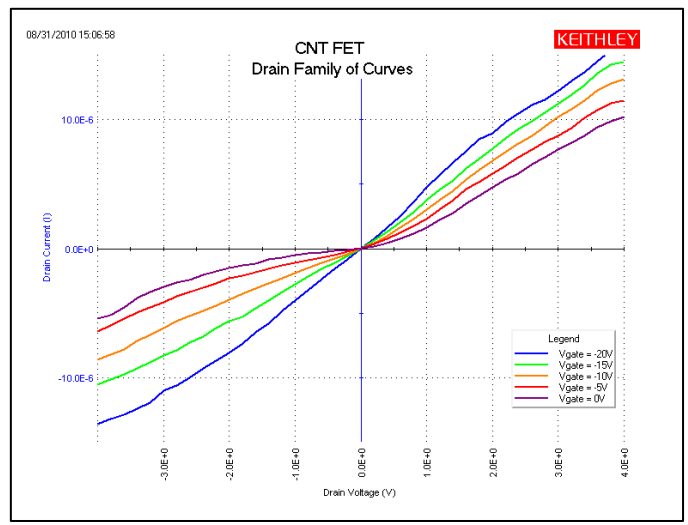

Figure 2: *I/V curve of a CNTFET.*

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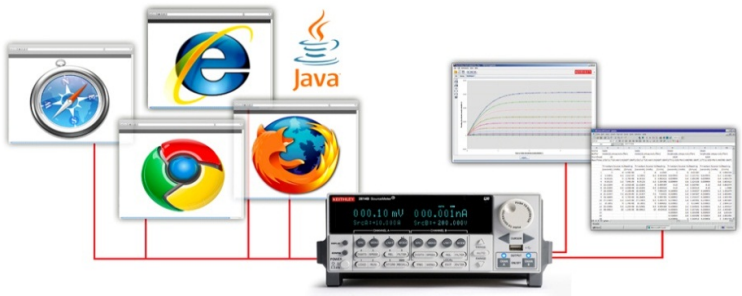
What are Series 2600B SourceMeter SMU Instruments?

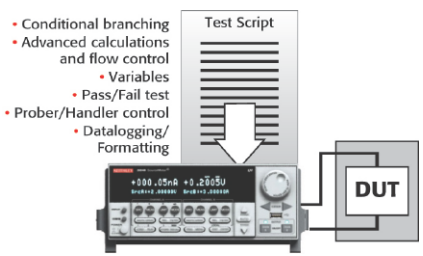
The Series 2600B are the industry's leading current/voltage source and measure solutions, and are built from Keithley's 3rd generation SMU technology. The Series 2600B offers single-and dual-channel models that significantly boost productivity in applications ranging from bench-top I/V characterization through highly-automated production test.

Browser-based Testing



The Series 2600B are the only SMU Instruments to feature built-in, Java-based test software that enables true plug & play I/V characterization through any browser, on any computer, from anywhere in the world. Simply connect the Series 2600B instrument to the Internet via the supplied LAN cable, open a browser, type in the Series 2600B instrument's I.P. address, and begin testing. Resulting data can then be exported to a spreadsheet, such as Excel, for further analysis and formatting, or for inclusion in other documents & presentations.

Automated Testing without Control of a PC



For test applications that demand the highest levels of automation and throughput, the Series 2600B's test script processor (TSP®) technology delivers industry-best performance by fully embedding and then executing complete test programs from within the SMU instrument itself. This virtually eliminates all the time-consuming bus communications to and from the PC controller, and thus dramatically improves overall test times.

Key Specifications of the Series 2600B SourceMeter SMU Instruments

Features	2601B / 2611B Single Channel	2602B / 2612B Dual Channel	2604B / 2614B Dual Channel Bench-Top	2634B /2635B / 2636B Low Current Single Channel (2635B) Dual Channel (2634B, 2636B)
# of Channels	1 (optional expansion to 32 via TSP-Link)	2 (optional expansion to 64 via TSP-Link)	2	1 – 2 (optional expansion to 32 or 64 via TSP-Link. Not available for 2634B)
Current Max / Min	10A pulse / 100fA	10A pulse / 100fA	10A pulse / 100 fA	10A pulse / 0.1fA for 2635B 10A pulse / 0.1fA for 2636B 10A pulse/ 1fA for 2634B
Voltage Max / Min	40V / 100nV for 2601B 200V / 100nV for 2611B	40V / 100nV for 2602B 200V / 100nV for 2612B	40V / 100nV for 2604B 200V / 100nV for 2614B	200V / 100nV
Power	30 – 40W	30 – 40W per channel	30 – 40W per channel	30W per channel
Max readings / sec	20,000	20,000	20,000	20,000
Computer Interface	GPIB, LAN (LXI), USB 2.0, RS-232	GPIB, LAN (LXI), USB 2.0, RS-232	GPIB, LAN (LXI), USB 2.0, RS-232	GPIB, LAN (LXI), USB 2.0, RS-232
Connectors/ Cabling	Screw terminal; adaptors available for banana or triax	Screw terminal; adaptors available for banana or triax	Screw terminal; adaptors available for banana or triax	Triax
System-level automation	Digital I/O, TSP-Link, Contact Check	Digital I/O, TSP-Link, Contact Check	Not available	Digital I/O, TSP-Link, Contact Check (not available on 2634B)

For additional information, please refer to Keithley's website at **www.keithley.com** for:

- Detailed Series 2600B specifications
- Application notes
- White papers

For other information, please contact your local applications engineer.

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