KEITHLEY
A Tektronix Company

TIPS AND TECHNIQUES FOR

Efficient DC Testing and Current–Voltage Characterization

По вопросам продаж и поддержки обращайтесь:

Архангельск (8182)63-90-72
Астана +7(7172)727-132
Белгород (4722)40-23-64
Брянск (4832)59-03-52
Владивосток (423)249-28-31
Волгоград (844)278-03-48
Вологда (8172)26-41-59
Воронеж (473)204-51-73
Екатеринбург (343)384-55-89
Иваново (4932)77-34-06
Ижевск (3412)26-03-58
Казань (843)206-01-48
Калининград (4012)72-03-81
Калуга (4842)92-23-67
Кемерово (3842)65-04-62
Киров (8332)68-02-04
Краснодар (861)203-40-90
Красноярск (391)204-63-61
Курск (4712)77-13-04
Липецк (4742)52-20-81
Магнитогорск (3519)55-03-13
Москва (495)268-04-70
Мурманск (8152)59-64-93
Набережные Челны (8552)20-53-41
Нижний Новгород (831)429-08-12
Новокузнецк (3843)20-46-81
Новосибирск (383)227-86-73
Орел (4862)44-53-42
Оренбург (3532)37-68-04
Пенза (8412)22-31-16
Пермь (342)205-81-47
Ростов-на-Дону (863)308-18-15
Рязань (4912)46-61-64
Самара (846)206-03-16
Санкт-Петербург (812)309-46-40
Саратов (845)249-38-78
Смоленск (4812)29-41-54
Сочи (862)225-72-31
Ставрополь (8652)20-65-13
Тверь (4822)63-31-35
Томск (3822)98-41-53 Тула (4872)74-02-29 Тюмень (3452)66-21-18 Ульяновск (8422)24-23-59 Уфа (347)229-48-12 Челябинск (351)202-03-61 Череповец (8202)49-02-64 Ярославль (4852)69-52-93

Единый адрес: kyh@nt-rt.ru | http://keithley.nt-rt.ru

TIPS AND TECHNIQUES FOR

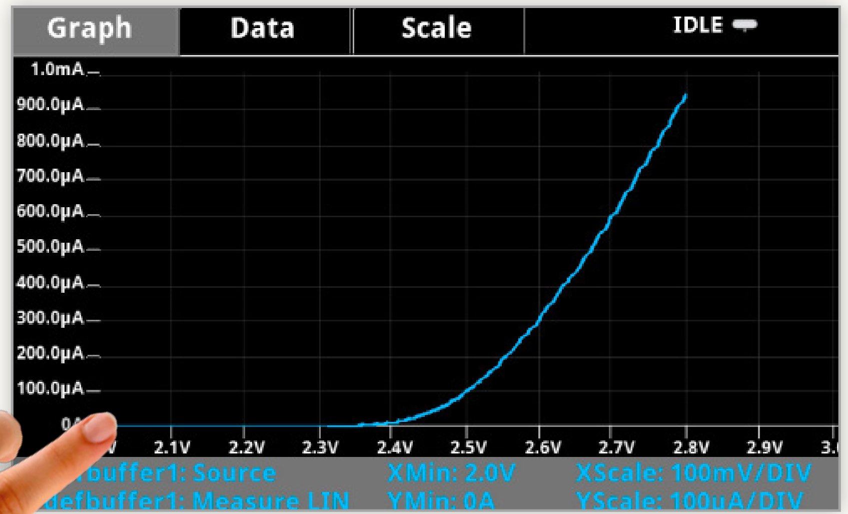
Efficient DC Testing and Current–Voltage Characterization

This e-guide explores some of the most common DC current vs. voltage (I-V) tests being performed today, the seemingly inherent complications posed by each, and how new techniques can help to not only overcome these challenges but enhance efficiency and productivity, as well.

Contents

KEITHLEY
A Tektronix Company

I-V Characterization of Two-Terminal Devices

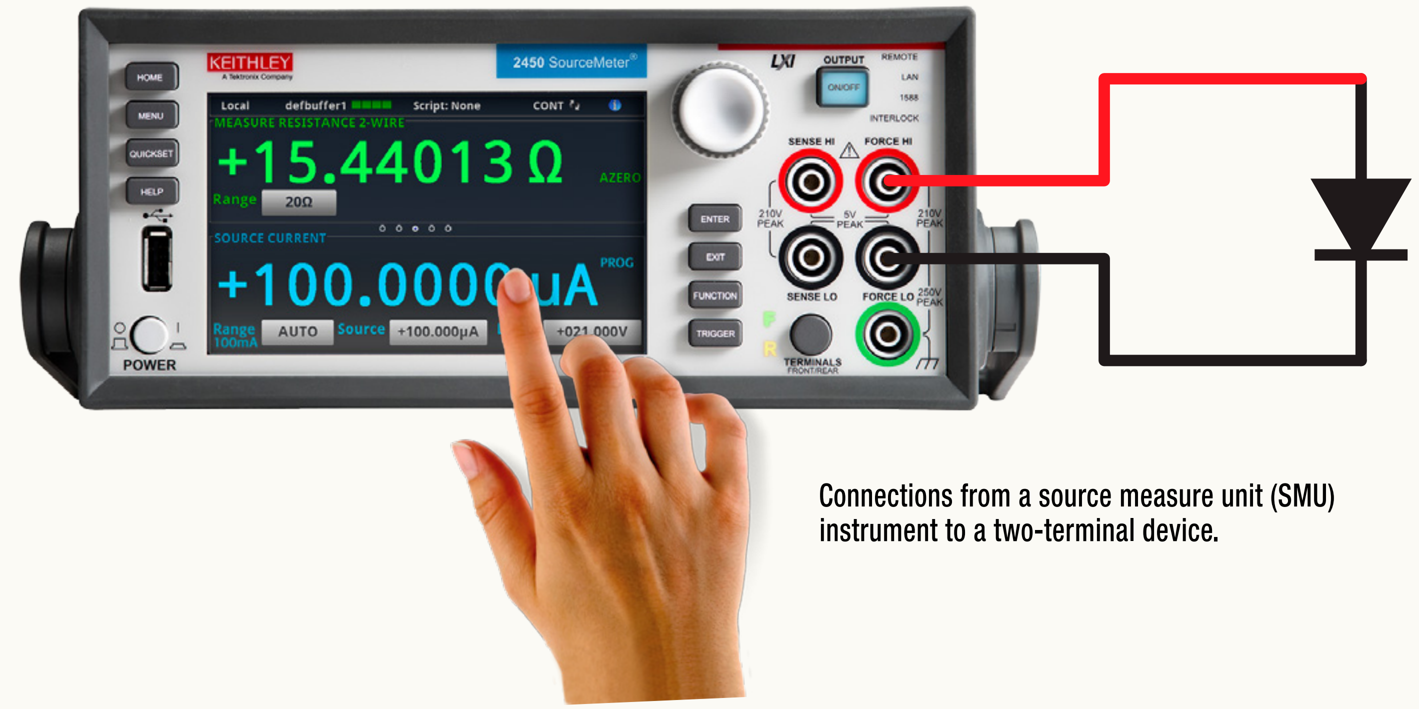


I-V Curve of an LED using a Model 2450 SourceMeter® SMU Instrument.

The current-voltage (I-V) characteristic of a two-terminal device is defined as the relationship of the current through the device and the voltage across its terminals. I-V characterization is routinely performed in research and development on a variety of electronic two-terminal devices, including resistors, diodes, LEDs, solar cells, and sensors. I-V characterization of two-terminal devices involves stepping the voltage level across a device or the current level through a device from one level to another and measuring the resulting currents or voltages in an operation that is known as a sweep. The data collected is plotted with voltage on the X-axis and the current on the Y-axis to produce the characteristic I-V curve.

Typically, test instrumentation such as power supplies and digital multimeters (DMMs) are used to perform these sweeps, however, this traditional method can be quite confusing for novice and even experiences users.

- Configuring the instrumentation to perform sweeps can be complicated and requires programming if there is no built-in sweep capability.
- Synchronizing multiple instruments to collect I-V curve data requires extensive instrument knowledge and programming.
- Visualizing the data takes time. It must be moved from the instrument to a spreadsheet application and a graph must be configured to properly display the I-V curve.



Connections from a source measure unit (SMU) instrument to a two-terminal device.

Two-terminal I-V characterization can be greatly simplified with a source measure unit (SMU) instrument, such as Keithley's 2450 or 2460 SourceMeter® SMU Instrument, which combines the capabilities of a high resolution power supply and a precision DMM into a single instrument.

- The source-measure-delay cycle ensures proper timing for the source to settle before measuring and performs sweeps without any external synchronization.
- Built-in sweep capabilities use either a source voltage/ measure current or source current/measure voltage test method that can be configured quickly for faster results.
- Collected data can be viewed immediately via the Touch, Test, Invent® user interface.

KEITHLEY
A Tektronix Company

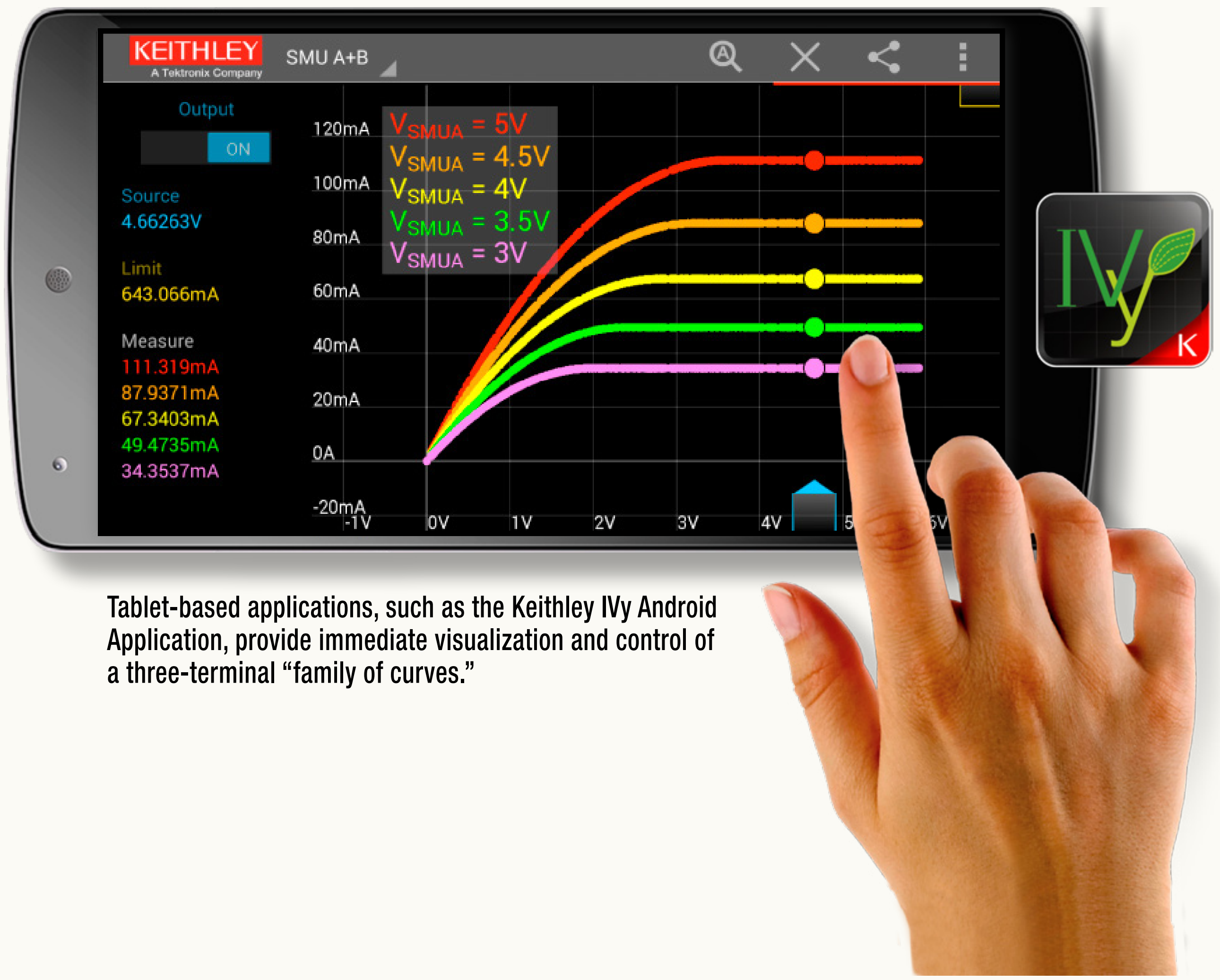
Characterizing the I-V Parameters of Three-Terminal Devices

Characterizing the I-V parameters of three-terminal devices, like MOSFETs is crucial to ensuring proper operation in the intended application and in meeting specifications. Some of these I-V tests include gate leakage, breakdown voltage, threshold voltage, transfer characteristics, drain current, and ON-resistance. Though this process shares many similarities with two-terminal-device I-V characterization, with three-terminal electronic components, the current-voltage relationship at one pair of terminals is dependent on the current or voltage on a third terminal. The data from each sweep is plotted on a complex current-voltage graph with multiple curves, each curve representing the current-voltage relationship of the terminal pair at a different value of current or voltage on the third terminal.

Characterizing three-terminal devices often requires several instruments, including a sensitive ammeter, multiple voltage sources, and a voltmeter.

- Integrating, programming, and synchronizing multiple instruments can be tedious and time consuming.
- Instrument and device timing behaviors, setting proper ranges, offset corrections, etc., must be considered to get proper results.
- Requires writing programs or configuring pre-written test software to source voltage or current in a certain range, then measure the current or voltage relationship.
- SMU instruments simplify three-terminal device testing by combining source and measure operations into a single instrument, but at least two SMU instruments are required.

Keithley has harnessed the power of mobile electronics to simplify the task of three-terminal device testing. The IVy Android Application for Keithley Series 2600B SourceMeter® SMU instruments enables incredibly easy, interactive three-terminal device characterizing in just three simple steps and with minimal setup. [Learn what makes Keithley IVy the fastest and easiest way to create a family of curves for a three-terminal device.]



Tablet-based applications, such as the Keithley IVy Android Application, provide immediate visualization and control of a three-terminal "family of curves."

Get advice on efficient DC I-V characterization to maximize productivity.
Send us your question or join the discussion in our application forum

KEITHLEY
A Tektronix Company

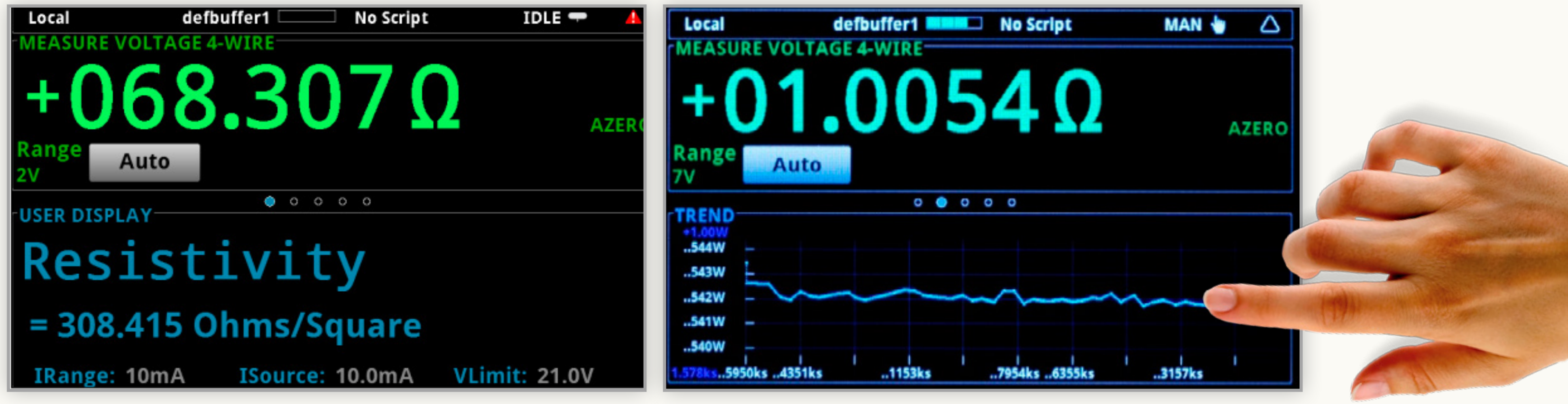
Measuring Resistance - Configuring an Instrument to Properly Display Results

Resistance is the measure of a material's opposition to the flow of electricity and its measurement is specified in the unit of Ohms. Resistance measurements are typically performed by sourcing a known current level through a device, measuring the resulting voltage across its terminals, then using Ohms Law to calculate the resistance. This is the method used most often by the resistance measurement functions of digital multimeters (DMMs) and source measure unit (SMU) instruments to measure resistance.

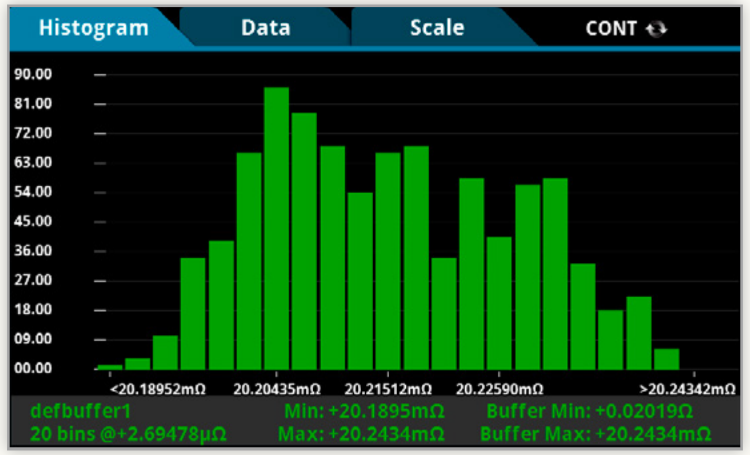
Making a resistance measurement using SMU instruments is relatively easy, but there are associated challenges when changes to how that resistance is measured need to be made.

- The current level being sourced into the device under test needs to be modified to determine how it responds at different levels.
  - More current is needed to get a good measurement through a very low resistance device.
  - The device has extremely high resistance and the source voltage/measure current test method is required.
- Data visualization is needed for a trend plot of resistance over time to determine how the device is affected by environmental factors, self-heating, or component drive.

The Keithley Model 2450 and 2460 SourceMeter® SMU instruments feature a Touch, Test, Invent® graphical user interface (GUI) that makes it very easy to configure the instrument to measure different current levels. They can be just as easily configured to use the source voltage/measure current method or source current/measure voltage. And, while trending data is difficult to do on traditional instruments, the colorful GUI on the models 2450 and 2460 displays the trend plot directly on the instrument as data is being collected.



Modern instruments, such as Keithley's Model 2450 or 2460 Touchscreen SourceMeter® SMU Instruments, can display resistivity on the user interface.



Modern instruments, such as Keithley's Touchscreen SourceMeter® SMU Instruments, can also display a measurement historgram on the front panel.

KEITHLEY
A Tektronix Company

Device Power and Efficiency Measurements

Greener, more efficient semiconductor devices, integrated circuits, and power systems require testing to evaluate parameters such as maximum power, battery discharge rates, power efficiency vs. current, or device off-state current. Power is a calculated measurement and requires measuring the voltage across the device, as well as the current through the device. The voltage measurement is then multiplied by the current measurement to calculate the power. Efficiency is the ratio of power drawn out of a device to the power sourced in to the device.

While measuring power is fairly straightforward with a source measure unit (SMU) instrument, measuring efficiency is a bit more involved.

- Multiple instruments are required to measure power at both the input and output of the device.
- Traditional instruments do not calculate or display efficiency.
- Automating the test using a PC requires knowledge of the instrument command set and PC programming skills.

Keithley Model 2450 or 2460 SourceMeter® SMU instruments with Touch, Test, Invent® graphical user interface greatly simplify the process of measuring power efficiency through the use of Keithley's Test Script Processor (TSP®) technology and TSP-Link® virtual backplane. Using TSP technology and TSP-Link communication bus, power efficiency measurements, which require two instruments, can be made quickly and easily from the front panel of a single instrument with the power efficiency calculated and displayed automatically.

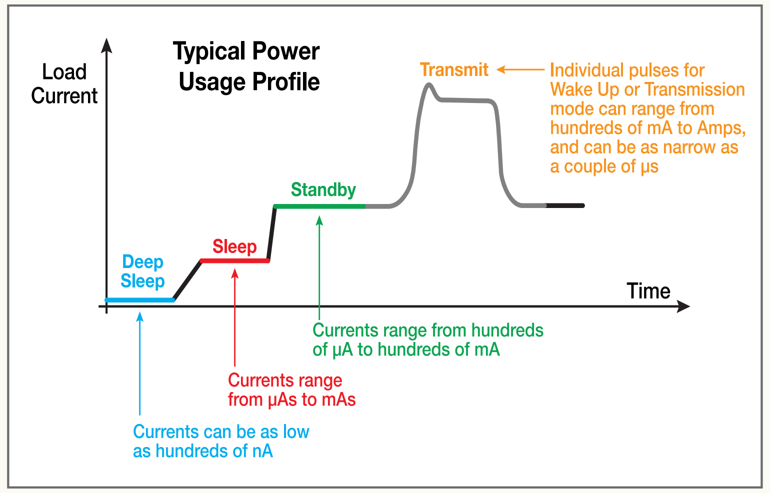
Instruments like the 2450 SourceMeter SMU Instrument can display power and solar cell max power, short circuit current, and open circuit voltage.

Get advice on efficient DC I-V characterization to maximize productivity.
Send us your question or join the discussion in our application forum

KEITHLEY
A Tektronix Company

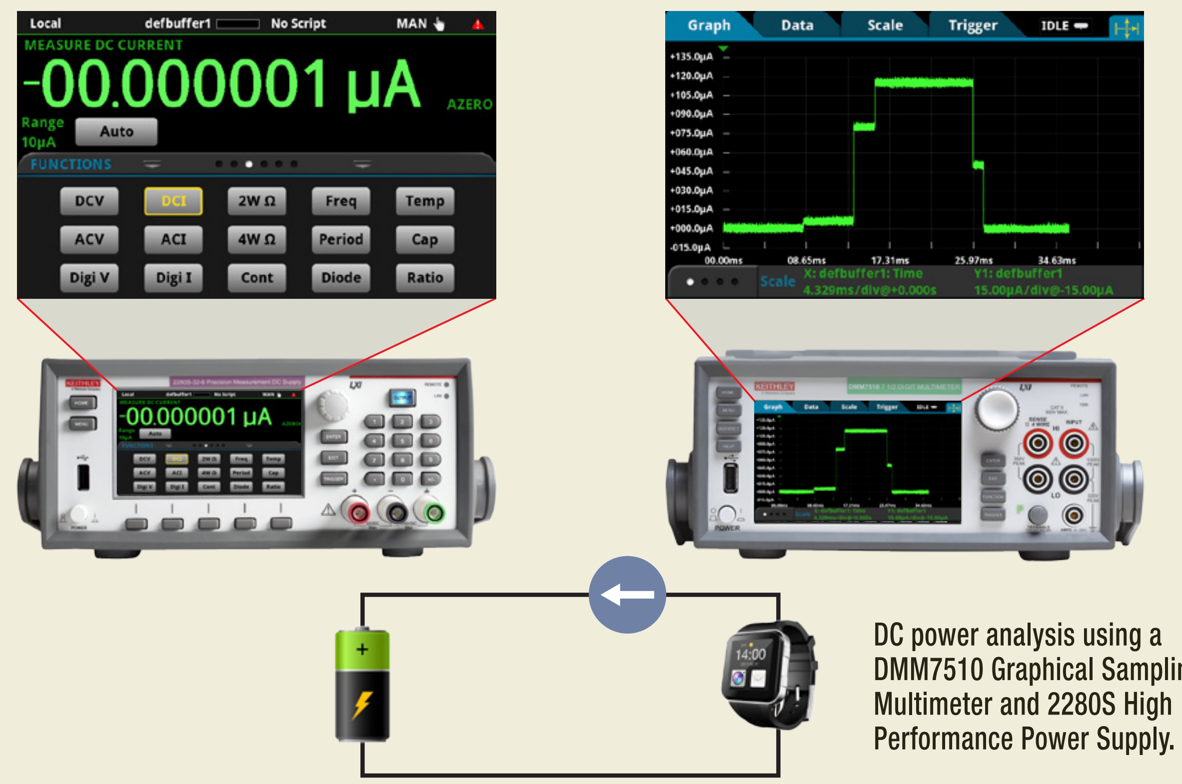
DC Power Consumption Analysis for Low Power Products

Characterizing a power usage profile is essential for low power devices, such as Internet of things (IoT,) portable wireless, wearable, portable and implantable medical, and low power industrial products. Power usage directly correlates with battery drain and impacts product usefulness. DC Power analysis is a non-trivial task, since these devices often draw current in wide ranges from nano-amps to amps depending on operating modes and often have short wake up times, as well, tthat can last for as little as a few microseconds and require extensive data logging periods to capture a complete power usage profile.



There are several challenges associated with analyzing DC power consumption low power devices, including:

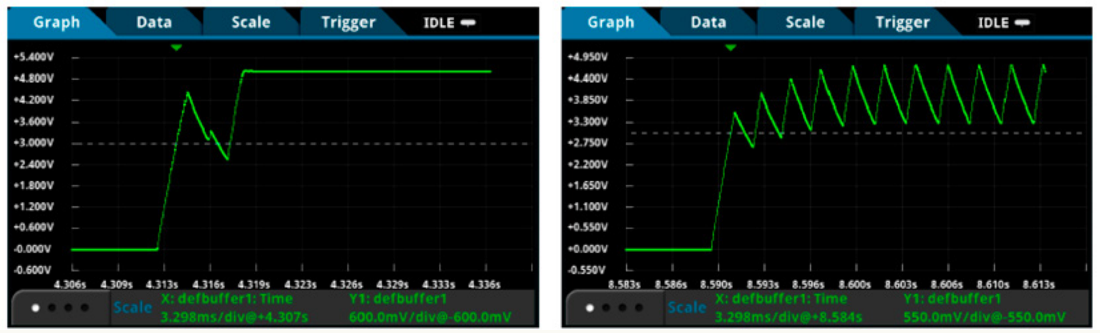
- **Achieving high accuracy load current measurements over wide ranges** - Typical DC power consumption profile for low power products has wide ranges of load current from nano-Amps to Amps. Most instruments do not have high accuracy/sensitivity across all ranges.
- **Capturing narrow load current bursts when the product transitions to its active modes** - Most individual pulses occur as bursts of activities with a duration as narrow as microseconds. Existing instruments do not have the high sample rate required to capture the load current burst.
- **Extensive data logging** – These tests typically run for long periods, requiring test instruments with memory sufficient to support long-term monitoring.
- **Error introduced by the test instruments** - Existing solutions introduce error into the system as burden voltage. Since the overall power consumption is low in this application, a high burden voltage introduced in the system results in large error.
- **Clean stable power** - Existing solutions may introduce errors with noisy outputs.



DC power analysis using a DMM7510 Graphical Sampling Multimeter and 2280S High Performance Power Supply.

The DMM7510 Graphical Sampling Multimeter and 2280S Precision Measurement DC Power Supply combination offers high accuracy, high signal sampling rate, a large memory for long data logging periods, low burden voltage, and clean, stable power. An unprecedented combination of performance and price makes this an ideal solution for low DC power consumption testing.

Characterizing Load Current Waveforms and Transient Behavior



Power-up anomalies on the buck converter. Temporary output voltage dip (left) and permanent failure to power-up (right.)

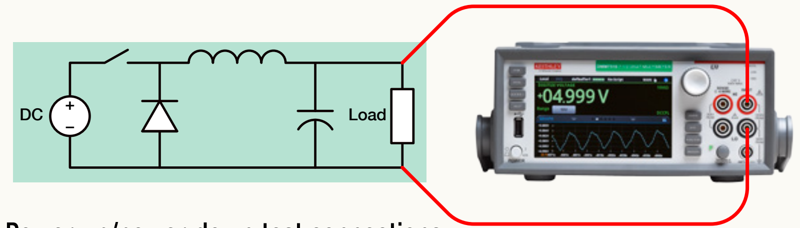
Most electronic systems contain analog circuits, microprocessors, DSPs, ASICs, and/or FPGAs that require multiple supply voltages. To ensure reliable and repeatable operation of these systems, transient behaviors, such as power-up and power-down timing, ramp rates, and the magnitude of different supply voltages must be appropriately controlled. Voltage and current sizing, monitoring, sequencing, and tracking are essential for characterizing the transient performance of power supplies.

Characterizing power supply transients poses challenges that include:

- The need to measure dynamic events, such as power-up and power-down transients, due to inadequate accuracy for capture, triggering function, or speed for a transient event.
- Optimal speed to answer — Need for deeper insight into the problem without having to be a measurement expert.

The DMM7510 Graphical Sampling Multimeter combines accuracy, speed, and triggering to accurately capture dynamic transient events with its ability to:

- Capture and visualize waveforms and transient signals without adding other tools and/or instruments.
- Offer more insight into measured data.
- Offer more measurement confidence for today's ultra-low power measurement needs.
- Significantly improve efficiency and minimize the learning curve.



Power-up/power-down test connections.

Panning and zooming into the soft-start behavior (top) and output voltage overshoot before reaching steady state (bottom.)

По вопросам продаж и поддержки обращайтесь:

Архангельск (8182)63-90-72
Астана +7(7172)727-132
Белгород (4722)40-23-64
Брянск (4832)59-03-52
Владивосток (423)249-28-31
Волгоград (844)278-03-48
Вологда (8172)26-41-59
Воронеж (473)204-51-73
Екатеринбург (343)384-55-89
Иваново (4932)77-34-06
Ижевск (3412)26-03-58
Казань (843)206-01-48
Калининград (4012)72-03-81
Калуга (4842)92-23-67
Кемерово (3842)65-04-62
Киров (8332)68-02-04
Краснодар (861)203-40-90
Красноярск (391)204-63-61
Курск (4712)77-13-04
Липецк (4742)52-20-81
Магнитогорск (3519)55-03-13
Москва (495)268-04-70
Мурманск (8152)59-64-93
Набережные Челны (8552)20-53-41
Нижний Новгород (831)429-08-12
Новокузнецк (3843)20-46-81
Новосибирск (383)227-86-73
Орел (4862)44-53-42
Оренбург (3532)37-68-04
Пенза (8412)22-31-16
Пермь (342)205-81-47
Ростов-на-Дону (863)308-18-15
Рязань (4912)46-61-64
Самара (846)206-03-16
Санкт-Петербург (812)309-46-40
Саратов (845)249-38-78
Смоленск (4812)29-41-54
Сочи (862)225-72-31
Ставрополь (8652)20-65-13
Тверь (4822)63-31-35
Томск (3822)98-41-53
Тула (4872)74-02-29
Тюмень (3452)66-21-18
Ульяновск (8422)24-23-59
Уфа (347)229-48-12
Челябинск (351)202-03-61
Череповец (8202)49-02-64
Ярославль (4852)69-52-93

Единый адрес: kyh@nt-rt.ru | http://keithley.nt-rt.ru