Ten Fundamentals

You Need to Know About Your DC Power Supply

Agilent Technologies

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Introduction

Understanding how measurement tools operate can provide insight into how to improve testing methods. With modern performance and safety features in power supplies, the flexibility exists to create test setups that are simpler and more effective. Use these 10 fundamentals about your power supply to take advantage of these features.

1 Program your Power Supply Correctly to Operate in Constant Voltage or Constant Current Mode

The output of a power supply can operate in either constant voltage (CV) mode or constant current (CC) mode depending on the voltage setting, current limit setting, and load resistance. In most circumstances, a power supply output operates in either CV or CC mode. However, there are some unusual circumstances that will cause the power supply to enter a third mode called unregulated (UNR) mode. Understanding these three modes will make it easier to correctly program your power supply.

Constant Voltage

A power supply will operate in constant voltage (CV) mode provided the load does not require more current than the current limit setting. Based on Ohm's law, $V = I \times R$, maintaining a constant voltage while changing the load resistance requires the current to increase or decrease. As long as the current draw $I_{out} = V_S/R_L$ is less than the current limit setting, the power supply regulates the output at the voltage setting. In Figure 1, the power supply will operate on the horizontal line V_S with $I_{out} = V_S/R_L$.

Constant Current

If the load resistance decreases, such as when a DUT component fails, and the load resistance, R_L, is less than R_C, where R_C is the ratio of the power supply voltage setting to the current limit setting, the power supply will regulate the current instead. Again, Ohm's law dictates a change in voltage if the current stays constant at the current limit setting. This operating mode is known as constant current (CC). In Figure 1, the power supply will operate on the vertical line I_S with $V_{out} = I_S \times R_L$.

Unregulated State

If a power supply is unable to regulate its output voltage or output current, the output will become unregulated and indicate unregulated (UNR) mode. Neither the voltage nor the current will be at the corresponding set point and the values at which they settle are unpredictable. While UNR mode can occur for a variety of reasons, it is not very common.

Possible causes of UNR include:

- The power supply has an internal fault.
- The AC input line voltage is below the specified range.
- The load resistance is R_C, the value at which the output will crossover from CV to CC, or CC to CV (see Figure 1).
- There is another source of power connected across your power supply output, such as when outputs are used in parallel.
- The output is transitioning from CV to CC, or CC to CV. This transition can cause a momentary UNR.

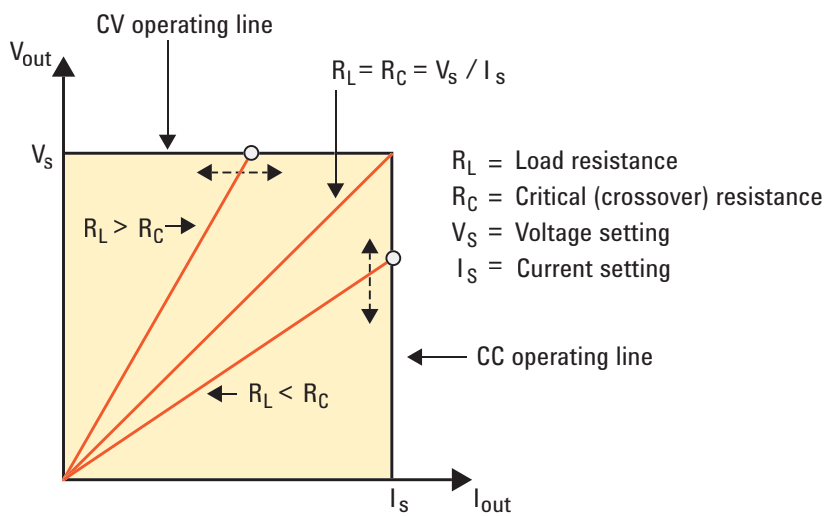


Figure 1: Power supply output characteristic

2 Use Remote Sense to Regulate Voltage at Your Load

Ideally, lead connections from your power supply to your load have no resistance. In reality, lead resistance increases with lead length and wire gauge. The resulting effect when a supply delivers current through the wire may decrease the voltage at the load. To compensate, use remote sensing to correct for these voltage drops.

Typically, a power supply is shipped from the factory with the sense leads connected locally at the output terminals. However, for setups with long load leads or for complex setups with relays and connectors, the voltage at the output terminals will not accurately represent the voltage at the load. (Figure 2)

Depending on the gauge and length of wire, the resistivity of your load connections could cause a much lower voltage at your load than you want. High current situations, for example, will invariably lead to significant voltage drops even with short load leads. Consider the resistances of different gauges of copper wire in the following table:

Wire gauge (AWG)	Resistance (mΩ / ft)
22	16.1
20	10.2
18	6.39
16	4.02
14	2.53
12	1.59
10	0.999

Table 1: Resistance in mΩ per foot for different wire gauges

As a general rule, for every 3-gauge increase in your copper wire, the resistance doubles. Since you must select the proper gauge wire to satisfy the current requirements of the load, remote sense at the load will improve voltage regulation without shortening lead length or decreasing wire gauge.

When you connect the remote sense terminals to the load, the internal feedback amplifier sees the voltage directly at the load, rather than at the output terminals. Since the control loop senses the voltage directly at the load, the supply will keep the load voltage constant, regardless of voltage drops caused by load lead gauge, load lead length, output relays, or connectors.

Remember the following when you use remote sense:

- Use two-wire twisted shielded cable for your sense leads.
- Connect the sense lead cable's shield to ground on only one end of the cable.
- Do not twist or bundle sense leads together with load leads.
- Prevent an open circuit at the sense terminals, as they are part of the output's feedback path.
  - Agilent uses internal sense protect resistors. These resistors prevent the output voltage from rising more than a few percent if the sense leads inadvertently open.
- Most supplies can compensate only for a maximum load lead drop of a few volts.

To implement remote sense (Figure 3):

1. Disconnect the sense terminal connections from the main outputs.
2. Connect each sense terminal to the proper polarity load contact.
3. If necessary, set the power supply to remote sense mode or 4-wire mode.

Figure 2: The effects of 6 feet of 14 AWG leads with sense connected to the output terminals. A 0.3 V drop develops over the leads (0.15 V per lead).

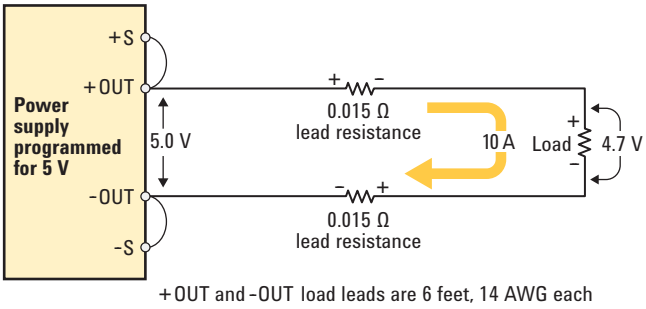
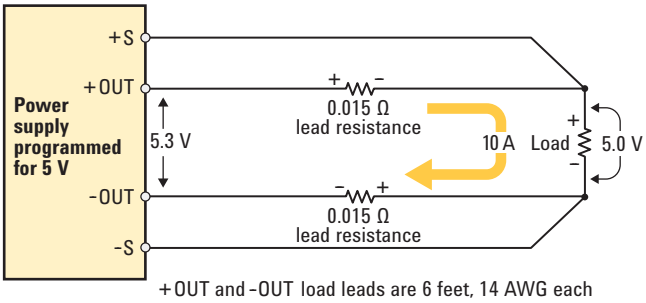


Figure 3: Using remote sense to compensate for load lead voltage drop



3 Use Your Power Supply to Measure DUT Current

You can obtain an accurate DUT current measurement with an ammeter, a current shunt, or the built-in readback on your power supply. Ultimately, you should select one method over another after considering the advantages and disadvantages of each. More often than not, the current readback on your power supply can provide you with the accuracy you need for a measurement.

Ammeter

A common way to measure DUT current is to use a bench DMM set in ammeter mode. While an ammeter has the benefit of a specified accuracy, you must break the circuit to insert the ammeter. A DMM also has a limit on the maximum current you can measure, typically several amps.

External current shunt/DMM

You can also make current measurements with shunts. With a current shunt, you can conveniently select the most appropriate shunt resistor to match your current range. Your accuracy is based on the DMM's voltage measurement accuracy and the precision of the shunt. While this method can produce highly accurate results, certain errors can adversely affect your measurements. You must pay attention to these commonly overlooked complications:

- **Thermal EMF** – dissimilar metals cause thermocouple voltages to develop
- **Shunt miscalibration** – accurate readings require calibration of the shunt resistance
- **Self-heating effects** – higher temperature from current flow can cause shunt resistance to change

In addition to these concerns, installing a current shunt requires you to break your circuit in order to connect the shunt in series. A current shunt installed in a rack-mount system may even require complex connections involving relays and switches.

Built-in current readback

You can avoid the difficulties involved with connecting current shunts by using a power supply's built-in readback. Current readback on a power supply uses an internal shunt, selected to complement the output rating of the supply. You do not need to disconnect the DUT or connect a DMM.

Consider the level of measurement accuracy you can expect with a high-quality power supply (Table 2).

Power supply current readback accuracy	
Output current level	*Typical accuracy*
100% of rated output	0.1% to 0.5%
10% of rated output	0.5% to 1%
1% of rated output	Near 10%

Table 2: Relative accuracy of power supply current readback

Power supply measurement specifications account for the errors that affect an external shunt. Therefore, your power supply readback may already be accurate enough for most current measurement applications, particularly for currents between 10% and 100% of the rated output current of the supply.

Choose built-in current readback when you will benefit from these attributes:

- Reduction in connection equipment – no need for relays, switching, and wiring
- Simplicity of use
- Power supply provides readings directly in amps
- Circuit disconnect not required
- Specified accuracy – accuracy values already account for shunt errors
- Synchronized measurements – readback measurements can be triggered to start with other power-related events

4 Connect Power Supply Outputs in Series or Parallel for More Power

You can connect two or more power supply outputs in series to get more voltage, or connect outputs in parallel to get more current.

When you connect outputs in series for higher voltage, observe the following precautions:

- Never exceed the floating voltage rating (output terminal isolation) of any of the outputs
- Never subject any of the power supply outputs to a reverse voltage
- Only connect outputs that have identical voltage and current ratings in series

Set each power supply output independently so that the voltages sum to the total desired value. To do this, first set each output to the maximum desired current limit the load can safely handle. Next, set the voltage of each output to sum to the total desired voltage. For example, if you are using two outputs, set each to one half the total desired voltage. If you are using three outputs, set each to one third the total desired voltage.

When you connect outputs in parallel for higher current, observe the following precautions:

- One output must operate in constant voltage (CV) mode and the other(s) in constant current (CC) mode
- The output load must draw enough current to keep the CC output(s) in CC mode
- Only connect outputs that have identical voltage and current ratings in parallel

Set the current limit of all outputs equally such that they sum to the total desired current limit value. Set the voltage of the CV output to a value slightly lower than the voltage value of the CC outputs. The CC outputs supply the output current to which they have been set and drop their output voltage until they match the voltage of the CV unit, which supplies only enough current to fulfill the total load demand.

To sense the voltage directly at the load, use remote sense with your series or parallel setup. For some power supplies, you must deliberately set each output for "remote sense," sometimes called "4-wire mode."

Using remote sense with series connections:

When you use remote sense in a series configuration, wire the remote sense terminals on each output in series and connect them to the load as shown in Figure 4.

Using remote sense with parallel connections:

When you use remote sense in a parallel configuration, wire the remote sense terminals on each output in parallel and connect them to the load as shown in Figure 5.

To simplify the settings for paralleled outputs, some power supplies support an advanced feature called "output grouping." Up to four identical outputs can be "grouped," enabling you to control all grouped outputs as if they were a single, higher-current output.

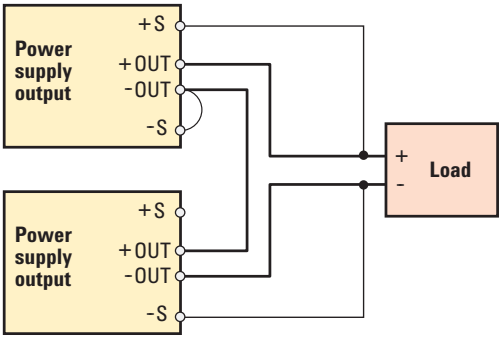


Figure 4:
Series connection with remote sense

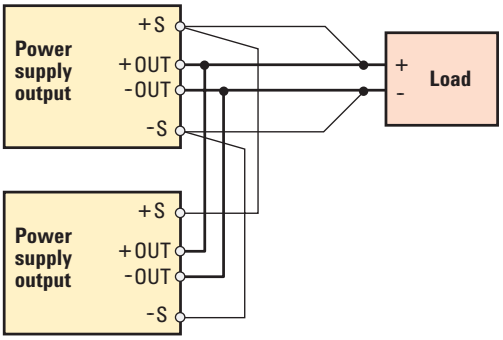


Figure 5:
Parallel connection with remote sense

5 Minimize Noise From Your Power Supply to Your DUT

If your DUT is sensitive to noise on its DC power input, you will want to do everything you can to minimize noise on the input. Here are three simple steps you can take.

Choose a power supply that has low noise

To minimize noise, start at your source.

Since filtering noise from your power supply can be difficult, you want to select a power supply that has very low noise to begin with. Choosing a linearly regulated power supply can accomplish this; however, linear power supplies can be large and can generate large amounts of heat. Instead, consider choosing a switching-regulated power supply. Modern switch-mode power supply technology has improved to the point where the noise on the output can be comparable to that of a linear supply. A comparison of noise on a typical linear supply versus a performance switching supply is shown in Table 3.

	RMS noise	Peak-to-peak noise
Linearly regulated power supply	~ 500 µV	~ 4 mV
Switching-regulated power supply	~ 750 µV	~ 5 mV

Table 3: A comparison of power supply noise for linearly regulated versus switching-regulated supplies

Selecting a supply with low RMS and peak-to-peak output voltage noise specifications is an excellent start, but you can also minimize the noise with proper attention to the lead connections to your DUT.

Shield supply-to-DUT connections

The connections between your supply and DUT can be susceptible to noise pick-up. Different types of interference include inductive coupling, capacitive coupling, and radio frequency interference. There are a number of ways to reduce noise, but the most effective is to ensure your load and sense connections use shielded two-wire cables.

When you use shielded cable, make sure to connect the shield to earth ground at only one end. For example, connect the shield on the power supply end to earth ground, as shown in Figure 6. Neglecting to connect the shield on either end can increase capacitive pick-up.

Do not connect the shield to ground at both ends because ground loop currents can occur. Figure 7 shows a ground loop current that developed because of the difference in potential between the supply ground and the DUT ground. The ground loop current can produce voltage on the cabling that appears as noise to your DUT.

In addition to proper shielding, balancing your cable impedance can preserve the low noise profile of your power supply.

Balance output-to-ground impedance

Common-mode noise is noise that is generated when common-mode current flows from inside a power supply to earth ground and produces voltage on impedances to ground, including cable impedance. To minimize the effect of common-mode current, equalize the impedance to ground from the plus and minus output terminals on the power supply. You should also equalize the impedance from the DUT plus and minus input terminals to ground. Use a common-mode choke in series with the output leads and a shunt capacitor from each lead to ground to accomplish this task.

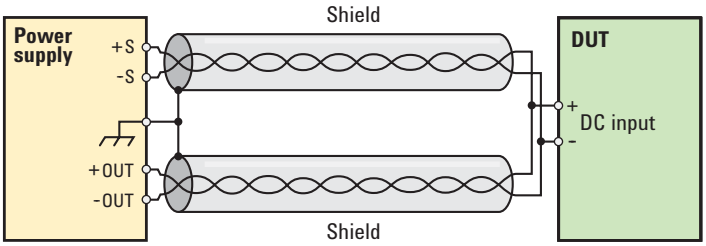


Figure 6:
Shield is connected to earth ground only on one end of cable

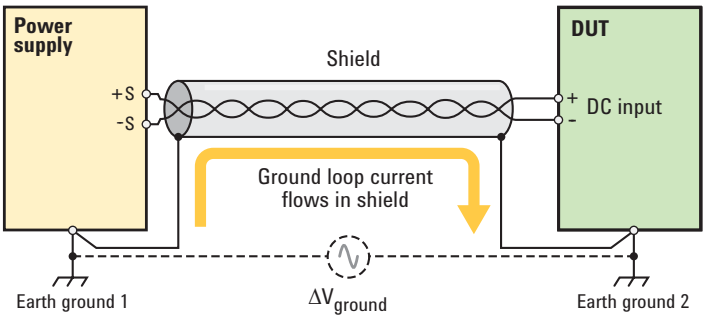


Figure 7:
Shield connected improperly (at both ends) results in ground loop current

6 Safeguard Your DUT Using Built-in Power Supply Protection Features

Most DC power supplies have features that protect sensitive DUTs and circuitry from exposure to potentially damaging voltage or current. When the DUT trips a protection circuit in the power supply, the protection circuit turns off the output and displays a notification. Two common protection features are over-voltage and over-current protection.

When you design your test, it is important to understand these protection features to protect your DUT.

Over-voltage protection (OVP)

OVP is a value set in volts designed to protect your DUT from excessive voltage. When the power supply output voltage exceeds your OVP setting, the protection will trip and turn off the output.

OVP is always enabled. When power supplies are shipped from the factory, OVP is typically set well above the maximum rated output of the power supply. Set your OVP trip voltage low enough to protect your DUT from excessive voltage, but high enough to prevent nuisance tripping from normal fluctuations in the output voltage. Fluctuations can occur during output transient conditions, such as load current changes.

CAUTION: On most power supplies, OVP responds to the voltage at the output terminals, not the sense terminals. When using remote sense, program your OVP trip voltage high enough to account for load lead voltage drops.

OVP circuits can respond to an over-voltage condition in microseconds, however, the output voltage itself will take longer to go down. The time for the output to go down depends on the down-programming capabilities of the power supply and the load that is connected to the output. Some power supplies have a silicon-controlled rectifier (SCR) across the output that fires when the OVP trips, which brings the voltage down much faster.

Over-current protection (OCP)

Most power supplies have an output voltage setting and a current limit setting. The current limit setting determines the value in amps at which the power supply will prevent excessive current from flowing. This constant current (CC) mode regulates the output current at the current limit but will not turn off the output. Instead, the voltage decreases below the voltage setting and the power supply continues to produce current at the current limit setting in CC mode.

OCP shuts off the output to prevent excessive current flow to the DUT. When you enable OCP, if the supply enters CC mode, a protection will trip and turn off the output. In effect, OCP turns the current limit setting into a trip value in amps. Set your current limit low enough to protect your DUT from excessive current, but high enough to prevent nuisance tripping due to normal fluctuations in the output current that can occur during output transient conditions, such as during an output voltage change. When a power supply is shipped from the factory, OCP is turned off.

Figure 8:
Power supply front panel showing over-voltage protection, over-current protection, constant voltage, and constant current mode

7 Use Output Relays to Physically Disconnect your DUT

Although you may expect your power supply output to be completely open when you set an "output off" state, this may not be the case. When set to "off," the output impedance will vary from model to model and may depend upon the options installed in the power supply. The "output off" state will typically set the output voltage and output current to zero and disable the internal power-generating circuitry. However, these settings do not guarantee that no current will flow into or out of your DUT, as would be the case if the output terminals were physically disconnected from your DUT.

When the power supply output is "off" but not completely open, your DUT test could be adversely affected for a number of reasons:

- Your DUT contains a source of DC power that is connected directly across the power supply output.
- Your DUT contains a source of DC power that is connected across the output in a reverse-polarity configuration.
- Your DUT is sensitive to extra capacitive loading.
- Your DUT produces a changing voltage across the power supply output.

Some power supply models have an internal output relay option that can completely disconnect the power supply output from your DUT. The relay in Figure 9 opens when you use an "output off" setting and stops all current flow to the DUT. But even with a relay option installed, certain models may still have output capacitors or capacitively coupled networks connected from the output terminals to chassis ground because of the location of the relays, so your DUT will still be connected to these components (see Figure 10).

In critical applications where you require a complete disconnect between the power supply output and your DUT, check with your power supply vendor to see if an output relay option exists that will provide a complete disconnect. If this configuration is not available, you may have to provide your own external output disconnect relays.

The downsides of an external relay configuration are the added cost and complexity to your test setup and the extra space required. You will need to provide the relays, connect wires from the power supply output to the relays, and install a means to control the relays. You may also find it more difficult to synchronize the opening and closing of the external relays with other power-related events.

When available, built-in output disconnect relays provide these advantages over external relays:

- Less complexity
  - Less wiring
  - No external relay control circuitry
- Consumes less space
- Better built-in synchronization of relay open/close with other power-related events
- Relays open upon fault conditions such as over-voltage and over-current

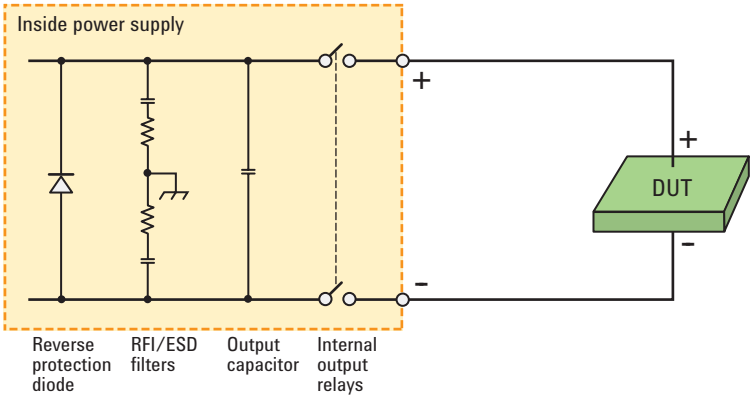


Figure 9: An example of a power supply with internal relays located right at the output terminals. With the relays open, your DUT is completely disconnected.

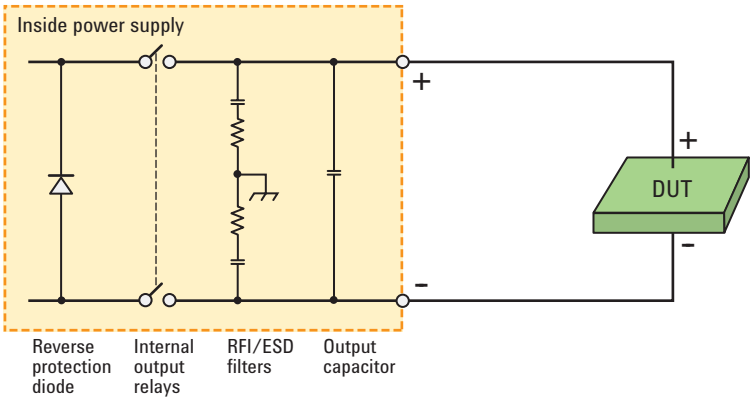


Figure 10: An example of a power supply with internal relays located inboard of some output components. With the relays open, these components remain connected to your DUT.

8 Capture Dynamic Waveforms Using a Power Supply's Built-in Digitizer

While most power supplies can measure DUT steady-state voltage and current, some power supplies can also measure dynamic voltage and current. These supplies feature a built-in digitizer.

Traditionally, digitizers are used for data acquisition to capture and store analog signals. Like an oscilloscope, which uses a digitizer to display the analog signal present on one of its inputs, a power supply's built-in digitizer captures the dynamic voltage and current waveforms produced on its output.

Basic digitizer operation

Figure 11 shows a digitizer converting an analog waveform into a set of data points. Upon a trigger, the digitizer takes measurement samples and stores them in a buffer.

When you make a digitizing measurement, you can set two of the following three parameters:

- **Time interval** – time between samples
- **Number of samples** – total number of samples you want to take
- **Acquisition time** – total time during which you want to take samples

When two parameters are set, the remaining parameter will be determined by the following equation:

Acquisition time = Time interval x (Number of samples -1)

In a similar manner, a power supply's built-in digitizer can be configured to trigger and capture power supply output voltage or current waveforms. The supply's digitizer will store a buffer of readings with the waveform data points. You can retrieve the data and use any standard software for analysis. You also can use your own customized program or available device characterization software to easily visualize the results in the time domain (oscilloscope-like view or data-logger view) or perform a statistical analysis.

An example digitizer application

If you use your power supply in place of a battery, you can capture dynamic information about the current flowing into your DUT, allowing you to better understand the current drain on your DUT batteries. Consequently, you can make appropriate design adjustments to optimize your DUT power management during the DUT's various modes of operation.

Figure 12 shows a sample waveform obtained on a cell phone's current draw using a power supply output digitizer and device characterization software (this is not an oscilloscope display).

When you use device characterization software, the captured data is displayed graphically in the time domain much like an oscilloscope displays a signal. The idle, receive, and transmit current states are discernible from the waveform. Of course, you can analyze digitized data in ways other than using device characterization software.

You can use a bus interface such as USB, LAN, or GPIB to capture and retrieve digitized waveform information. Retrieved data can be returned either as a scalar value, with the power supply calculating a single number averaged from the data (as it does for the front panel display), or as an array of values. You can even acquire pre- and post-trigger data by changing the trigger offset to capture waveforms such as peak current draw during a DC inrush current test.

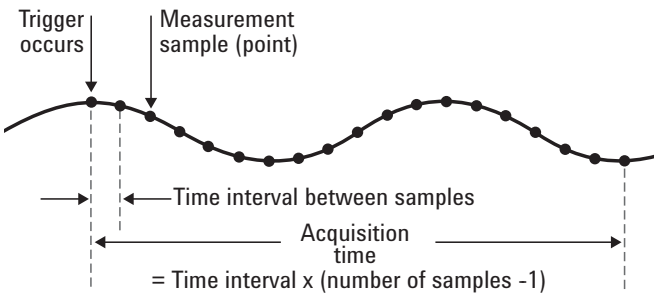


Figure 11: A digitizer converts an analog waveform into data points by sampling.

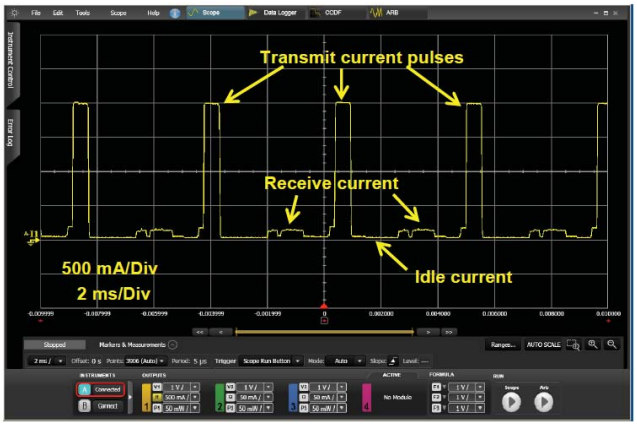


Figure 12: Device characterization software uses a power supply's built-in digitizer to capture data showing a cell phone's current draw from the power supply.

9 Create Time-Varying Voltages Using Power Supply List Mode

Typically, power supplies are used to bias circuits that require a constant voltage. However, more advanced applications may require a time-varying voltage (or current). Modern power supplies can easily manage both using list mode to address the time-varying applications.

What is list mode?

Normally, you can program a PC to change the voltages on a power supply output for discrete periods of time. In this way, your program controls the transitions between voltages to allow you to test your DUT at different voltages.

List mode lets you generate these voltage sequences and synchronize them to internal or external signals without tying up the computer. You set individually programmed steps of voltage (or current), and an associated step duration. After setting the duration for each step, you trigger the list to execute directly on the power supply. You may set the power supply to move on to the next step based on dwell times or triggers. A list can be programmed to repeat once or multiple times (see Figure 13).

To create a list, set the following:

- **One or more voltage or current steps** – defined voltage or current values
- **Dwell times** – duration associated with each voltage or current step
- **Repeat count** – the number of times you want the list to repeat

Two uses of list mode for testing

The list mode on a power supply can be an effective tool for running two types of tests:

- **Voltage sequence test** – a test where measurements are taken while the DUT is exposed to discrete stimulus voltage values.
- **Voltage waveform test** – a test where measurements are taken while the DUT is exposed to a stimulus voltage waveform.

In both cases, the stimulus involves creating a sequence of voltage steps. The first has multiple levels of steady-state voltages and the second has a continuously varying voltage profile. The two tests are commonly used for DUT design verification. Be aware that DC power supplies are limited in bandwidth and typically can generate voltage waveforms only at frequencies up to tens of kilohertz. Also, most power supplies are unipolar devices that create only positive voltages.

Using list mode

You can use list mode for performing a voltage waveform test on automotive electronic systems. During the startup of an internal combustion engine, also known as a cold-crank, battery voltage levels drop considerably as enormous amounts of current are drawn by the electric starter motor (see Figure 14). The battery voltage then plateaus once the engine is turning and hits a final level as the electric starter turns off.

You can enter the simplified sequence in Table 4 into a list to perform ECU design validation testing on an automotive electronic system. (Simulate transitions between voltage levels with additional steps.) This test ensures that the automotive electronics have adequate power transient immunity. Use list mode in this manner when you need to apply a time-varying voltage to your DUT.

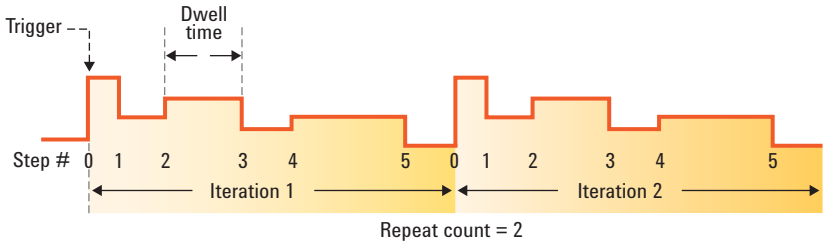


Figure 13: A list is a sequence of individually programmed voltage (or current) steps initiated with a trigger.

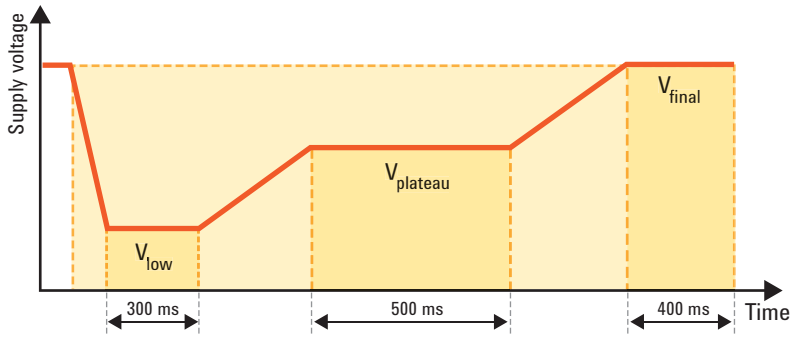


Figure 14: An automotive cold-crank profile represented with list steps

Step	Voltage level	Voltage value	Dwell time
0	V_{low}	8 V	300 ms
1	$V_{plateau}$	12 V	500 ms
2	V_{final}	14 V	400 ms

Table 4: A simple list used to simulate the automotive crank voltage profile in Figure 14

10 Tips for Rack-Mounting Your Power Supply

When you are planning out a test rack, selecting an instrumentation layout can be a challenging task. Safety, reliability, and performance are among the many requirements that affect your choices.

Specifically, pay attention to these considerations when you put your DC power supply in a rack:

- **Weight distribution**
  Distribute weight properly to avoid rack instability
- **AC input power**
  Provide adequate AC input power to avoid excessive current draw
- **Heat management**
  Provide proper heat management to avoid excessive temperatures
- **Magnetic interference**
  Place instruments properly to minimize magnetic interference
- **Routing wires**
  Route wires to minimize conducted and radiated noise

Weight distribution

Typically, a power supply is one of the heaviest instruments in your test rack. Mount the power supply near the bottom of the rack to lower the rack's center of gravity and consequently lower the risk of tipping the rack. (Figure 15)

AC input power

When you plan the size of your AC input line, use the maximum current rating of each instrument in your rack to ensure the AC line providing power to your rack is adequate. Most instruments draw a relatively constant amount of current. However, a power supply's AC input current varies with the power supply's output loading. If you do not know the maximum load you expect on the output of the power supply, plan for the worst case scenario by using the maximum rated input current of the supply.

Heat management

Typically, power supplies have internal cooling fans. When you mount your power supply in a rack, be sure to provide adequate spacing for the power supply's air intake and for exhaust air. Keep thermally sensitive instruments such as DMMs away from power supplies because high temperatures can have an adverse effect on DMM readings.

Magnetic interference

LCD displays have replaced most CRT displays; however, if older computers or oscilloscopes with CRT displays are used, be aware that they are susceptible to magnetic fields. Magnetic fields can also affect the performance and accuracy of some instruments. For example, a voltmeter's circuitry could be susceptible to a large magnetic field produced by a transformer, such as that inside a power supply. Be sure to install your DC supplies away from your magnetically sensitive instruments, especially your DMM.

Routing wires

Since power wires can radiate electrical noise and both stimulus and measurement signal-carrying wires are susceptible to this noise, separate power wires from signal-carrying cables.

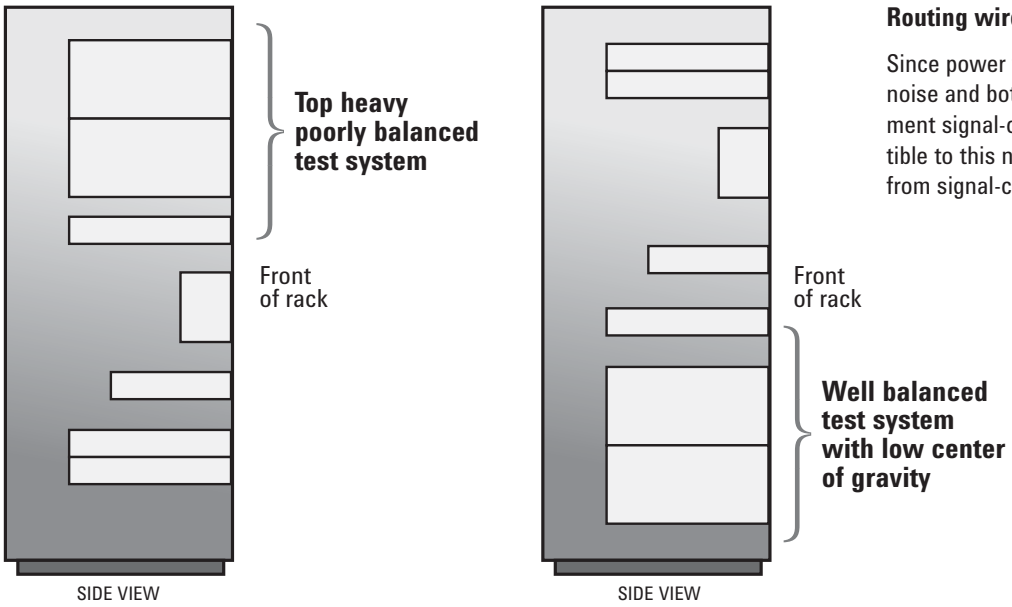


Figure 15: To properly balance your test system, place larger, heavier instruments near the bottom.

Glossary

Down programming
When a power supply with current sink capability is programmed to a voltage level less than that of the voltage at the output terminals, the supply will automatically begin to sink current. The downprogrammer can be thought of as an internal load across the power supply's output terminals that helps bring the output voltage down quickly.

DUT
Device under test

Linear-regulated power supply
A power supply design technique consisting of placing a control element in series with the full-wave bridge rectifier and the outputs. Simplified, the control element can be thought of as a variable resistor controlled by a feedback circuit that monitors the output and adjusts the resistance accordingly to keep the output voltage constant.

RFI/ESD filters
RFI (radio-frequency interference) filters prevent undesired behavior from power supply by providing a path to ground for noise current to flow. Similarly, ESD (electrostatic discharge) filters prevent damage to your power supply by providing a path to ground for static electricity to discharge.

Self-heating effects (shunt)
Current flowing through a shunt resistor dissipates power (I^2 x R) and heats up the shunt causing a change in the resistance value.

SCR (silicon controlled rectifier)
An SCR placed across the output terminals of a DC power supply creates a direct short-circuit on the output of the supply when an over-voltage condition is detected. Also known as a "crowbar," this over-voltage protection prevents excessive voltage from the reaching the load.

Switching-regulated power supply
A power supply design technique that uses a regulating element that acts like a rapidly opened and closed switch. The duty cycle, or the ratio of time that the switches are open or closed, is controlled by a feedback circuit. This circuit monitors the output and adjusts the duty cycle to keep the output voltage constant.

Thermal EMF (thermal electromotive force)
Thermoelectric voltages are generated when you make circuit connections with dissimilar metals at different temperatures. This occurs because any metal-to-metal junction forms a thermocouple, which generates voltage proportional to the junction temperature. These junctions occur anywhere you connect metal leads, such as at the DUT, at the relay, and to the multimeter.

Voltage/current rating
The specified maximum voltage or current output that a power supply can produce.

Resources

Related Agilent Literature

"10 Hints For Using Your Power Supply to Decrease Test Time"
5968-6359E
http://cp.literature.agilent.com/litweb/pdf/5968-6359E.pdf

"10 Practical Tips You Need to Know About Your Power Products"
5965-8239E
http://cp.literature.agilent.com/litweb/pdf/5965-8239E.pdf

"Understanding Linear Power Supply Operation"
5989-2291EN
http://cp.literature.agilent.com/litweb/pdf/5989-2291EN.pdf

"Test-System Development Guide"
5989-5367EN
http://cp.literature.agilent.com/litweb/pdf/5989-5367EN.pdf

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LAN eXtensions for Instruments puts the power of Ethernet and the Web inside your test systems. Agilent is a founding member of the LXI consortium.

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