

Keysight Technologies

10 Hints to Improving Throughput with your Power Supply

Application Compendium



Introduction

Manufacturers continue to be asked to do more with less. Increasing throughput can reduce the amount of equipment used in test and the physical constraints of a manufacturing site. An improved work flow will also reduce inventory costs. Keysight Technologies, Inc. Advanced Power Supplies are designed to increase throughput while providing the highest level of protection to your device under test. Read all ten hints to learn more about improving test throughput.

Contents

1	Improve Throughput with Shorter Command Processing Time	03
2	Improve Throughput with Faster Up- and Down-programming Response Times	04
3	Use Power Supplies with Faster Measurement Systems to Increase Test Throughput	06
4	Take Advantage of a Power Supply's Digital Filtering for Faster Settling DC Measurement	07
5	Use the Built-in Capability for Making Faster Standby and Leakage Current Measurements	08
6	Take Advantage of Seamless Measurement Ranging for Instantaneous Range Changes During Test	09
7	Use List Mode for Faster Output Level Changes	10
8	Use List Mode and Triggers to Make Fast Swept Parametric Measurements	11
9	Combine the Power Supply's ARB and Digitizer Features for Ultra-fast Swept Parametric Measurements	13
10	Take Advantage of the Status Subsystem Features to Reduce Test Time	14

1. Improve Throughput with Shorter Command Processing Time

Application Brief

Improving test throughput starts with using faster power supplies. Command processing time is a key parameter governing a power supply's speed as it affects virtually all aspects of its use under automated control. Shorter command processing time can significantly increase throughput by taking seconds off of the test time. This is particularly true when the DUT needs to be tested at several output level settings and corresponding current or voltage measurements taken, which is frequently the case. The difference in command processing time can be many orders of magnitude between entry level and high performance system DC power supplies. When test throughput is important the test time savings from using high performance power supplies with fast command processing time will easily offset any extra premium in price.

An example of command processing time for a power supply is illustrated in the accompanying diagram. The command processing time is the time from when the command is first received to the point where the power supply starts acting on it. In this case it is when power supply's output starts to change. Command processing time can range from up to 100's of milliseconds for entry-level power supplies to under 1 millisecond for high performance power supplies.

The impact of the power supply's command processing time on test time and throughput is immediately evident. As one example, for a DUT tested at 10 different voltage settings, going from a power supply that has 100 millisecond long command processing time to a power supply that has just 1 millisecond long command processing time reduces the test time by nearly 2 seconds. This is a considerable amount of time in high-volume, high-throughput manufacturing test, and this is the savings for just output level changes. Comparable savings are likewise realized for other power supply operations as well, easily taking several more seconds off of the test time, significantly increasing test throughput.

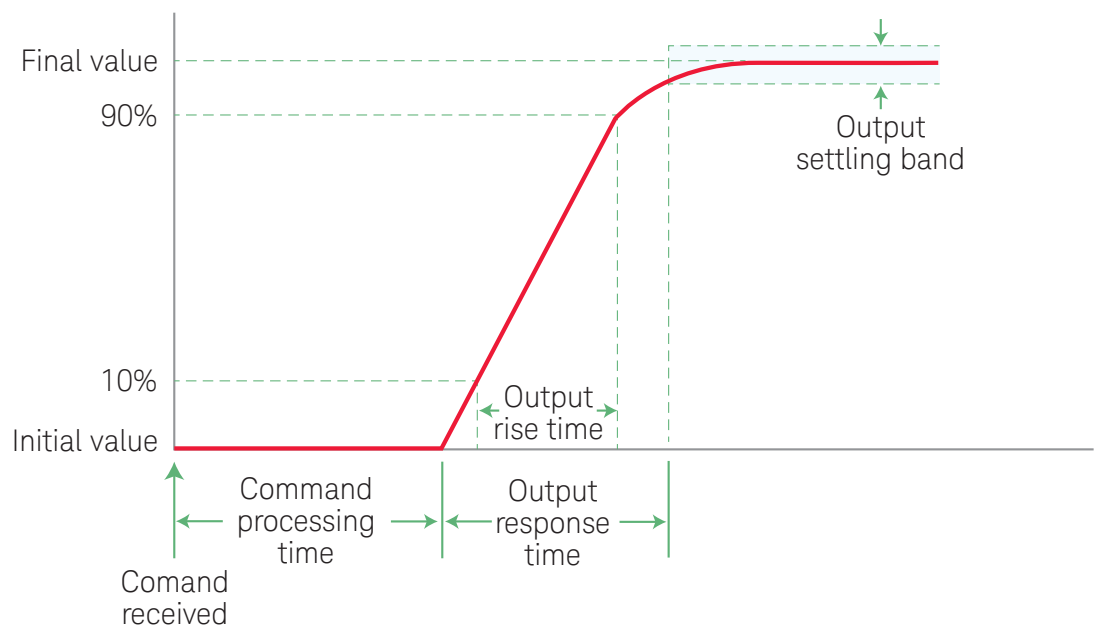


Figure 1-1. Power supply command processing time for an output level change

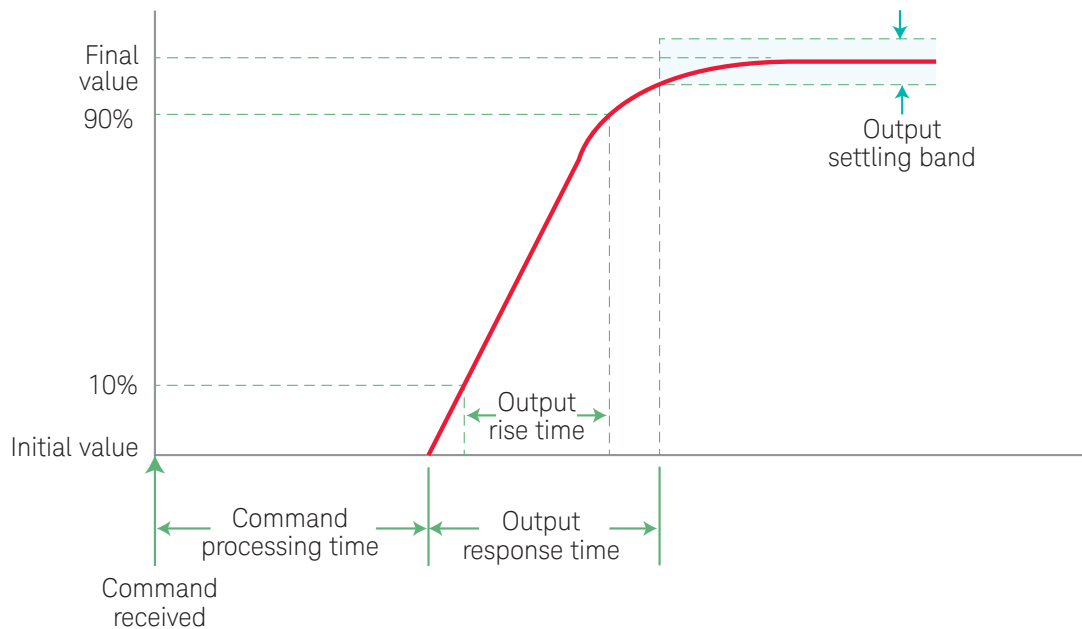
2. Improve Throughput with Faster Up- and Down-programming Response Times

Application Brief

Using power supplies having faster output up- and down-programming response times can significantly reduce test time, particularly when you need to set multiple output level settings throughout the DUT's test sequence. The difference in output programming response times can be many orders of magnitude between entry level and high performance system DC power supplies. Using a power supply having faster output programming response times can easily take seconds off your DUT's test time, greatly improving test throughput.

Up-programming response time is depicted in Figure 2-1. It is the time the power supply takes for the output to rise and settle within a small band around the final output level, after processing the command instructing it to change its output level.

The up-programming response time varies greatly with a power supply's level of performance. It can range from 100's of milliseconds for entry-level products to below 1 millisecond for high performance power supplies. The up-programming response time can even be down in the range of 10's of microseconds for some more-specialized high performance power supplies.



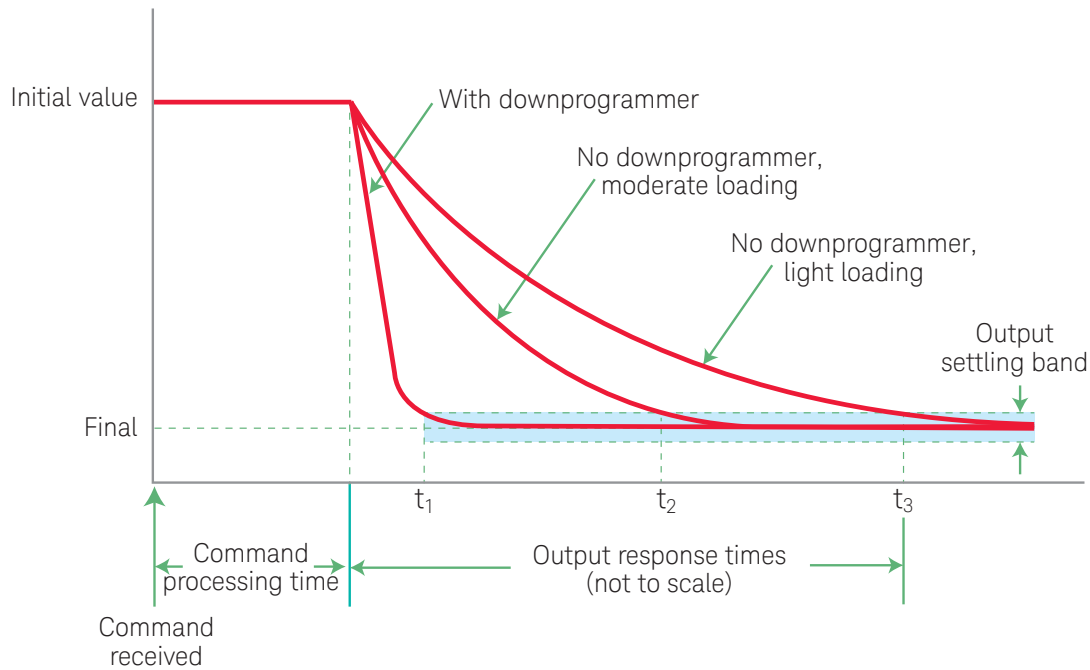


Figure 2-2. Power supply down-programming response times with and without a downprogrammer

The down-programming response time is like the up-programming response time except that the power supply is instead being programmed to a lower level. However, you need to look at down-programming independently as short up-programming time does not necessarily guarantee comparably short down-programming time. Not all power supplies have an active downprogrammer circuit to quickly pull the output back down. Without a downprogrammer the down-programming response time instead depends mainly on DUT loading to bring the output back down. Down-programming response times with and without a downprogrammer is depicted in Figure 2-2.

Down-programming response time likewise varies greatly with a power supply's level of performance. High performance power supplies invariably include a downprogrammer and have response times on the order of one millisecond or faster. In comparison, entry-level power supplies can have down-programming response times of 100's of milliseconds or longer. Many entry-level power supplies can even take as long as several seconds to down-program under no-load conditions.

When throughput is important, using higher performance power supplies having shorter output up- and down-programming response times can easily shave valuable seconds off your test time. This in turn increases test throughput and reduces cost, especially important for high volume, high throughput testing.

3. Use Power Supplies with Faster Measurement Systems to Increase Test Throughput

Application Brief

Using DC power supplies that incorporate faster, high performance measurement systems can literally trim seconds off your DUT test time, greatly improving throughput and reducing cost.

A good indicator of a DC power supply having a high performance measurement system is having a programmable measurement integration, or aperture, time, often programmed in power line cycles (PLCs). One reason for having a programmable integration time is for minimizing any 50 or 60 Hz AC line ripple getting into the DC measurement, by setting the time one or more multiples of a PLC. Setting the time to 1 PLC provides good ripple rejection with relatively good throughput. When AC line ripple is not an issue the integration time can be set even smaller than 1 PLC, further reducing measurement time. When the DC power supply has a programmable measurement integration time it will no doubt also have a fast-responding measurement system as well, typically just milliseconds, to complement the programmable integration time.

In comparison basic DC power supplies commonly use a 100 millisecond fixed integration time to support AC ripple rejection for both 50 and 60 Hz line frequencies. They also have low bandwidth, slow-responding measurement systems, which can long time to settle after any step change in loading, before a valid measurement can be taken.

The net result is it can take up to a few hundred milliseconds for a basic DC power supply to make a measurement while it may take but about one tenth of this time a DC power supply with a high performance measurement system to make the same measurement, and often with much better accuracy. If several measurements are taken during DUT testing, this can literally trim seconds off the test time, greatly improving throughput and reducing cost.

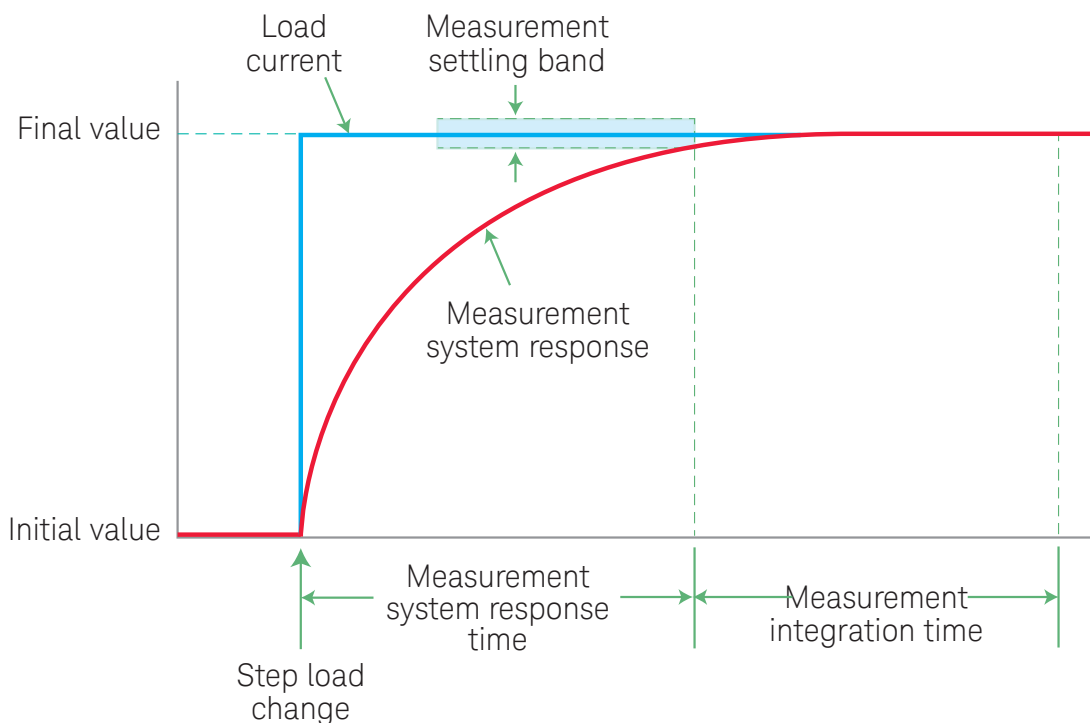


Figure 3-1. DC power supply measurement system response and integration times

4. Take Advantage of a Power Supply's Digital Filtering for Faster Settling DC Measurements

Application Brief

The DC average is virtually always the main value of interest when measuring a DUT's current drain. However, the current drain for many DUTs can be very dynamic, having a large portion of AC content relative to the DC average. An example of this is the pulsed current drain characteristic of many digital wireless devices. High AC content can be a problem when trying to make faster DC average measurements, requiring a longer measurement acquisition time to get acceptably consistent repeatability. For DC power supplies incorporating a digitizing measurement system, their DSP-based digital filtering window functions can provide faster DC average measurements of dynamic currents with more consistent repeatability. Less measurement time translates to higher test throughput, especially when many measurements are taken during test.

A rectangular, or unweighted digital filter windowing function treats all digitized samples taken over the measurement acquisition period with equal weighting. When you are able to exactly match the acquisition period to the fundamental period of the AC content, it is rejected from the DC average value to a great extent. However, when the fundamental period of the AC content is not accurately known, or there are multiple, non-harmonically related periods of AC content to be rejected, the rectangular windowing function rolls off at a 20 dB/decade slope and a very long acquisition period is then needed to get a consistently repeatable result.

In comparison a weighted digital windowing function emphasizes the digitized samples in the middle of the measurement acquisition period while deemphasizing the samples at the start and end of the acquisition period. This gives a much greater AC rejection roll off slope, providing greater DC measurement repeatability in much less acquisition time, in comparison to a rectangular windowing function. A Hann or Hanning window is one example of a weighted windowing function useful for this purpose.

For DUTs that draw dynamic currents, taking advantage of digital filtering features of DC power supplies incorporating digitizing measurement systems can substantially reduce the time needed for making accurate and consistently repeatable measurements, improving your test throughput as a result.

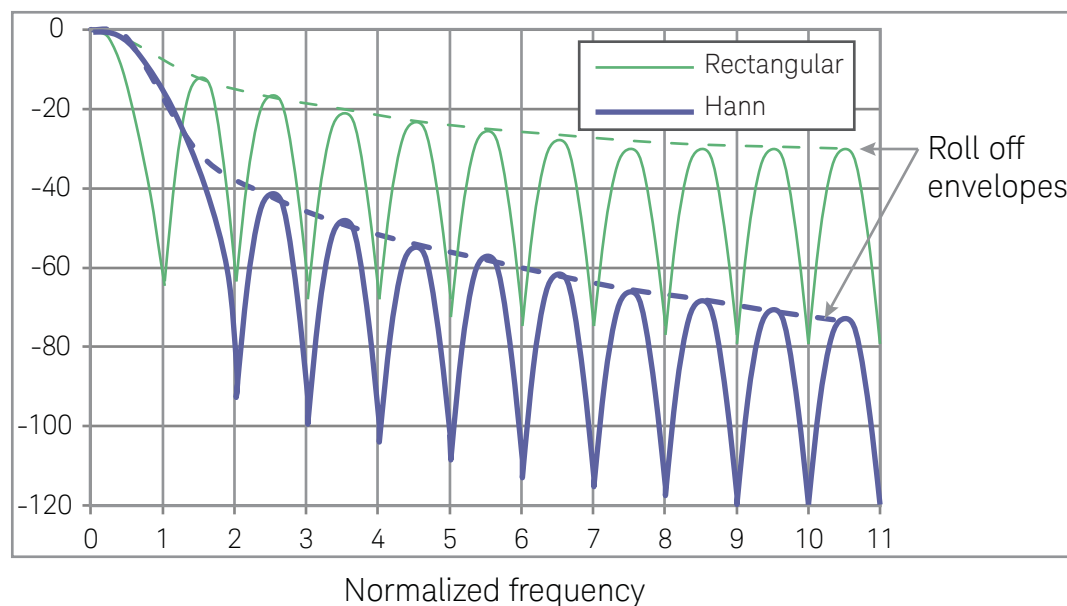


Figure 4-1. Rectangular and Hann window filter response characteristics

5. Use the Built-in Capability for Making Faster Standby and Leakage Current Measurements

Application Brief

Now more than ever a vast variety of products across many industries incorporate standby, sleep, or virtual off-modes where they go into a very low power state, but are not truly disconnected from their power source. They instead draw a small standby or leakage current in these powered-down states, ranging from microamps to milliamps. These low-level currents need to be tested in production to assure they do not exceed acceptable limits. The traditional approach of using separate equipment to measure these currents is extremely time-consuming. Instead, consider using the built-in measurement capability within the DC power supply.

Since these standby and leakage currents are but a small fraction of the DUT's active current drain, they cannot be accurately measured by the single measurement range available in standard, basic DC power supplies. This traditionally dictates adding a high value shunt resistor, a bypass relay, and a dedicated multiplexer channel with a DVM, in order to make an accurate low-level current measurement. Not only does this add complexity and introduce test system reliability issues, it also adds considerable test time in order to switch the shunt resistor into the measurement path, switch in the DVM, make the measurement, and then switch the shunt resistor and DVM back out again.

A better way to make low-level current measurements is to take advantage of DC power supplies that have additional ranges built-in for measuring these currents directly. Not only does this simplify and enhance reliability of the test system, it can save hundreds of milliseconds each time each time a low-level current measurement needs to be made by eliminating the need for switching a shunt resistor and DVM in and out of the current path.

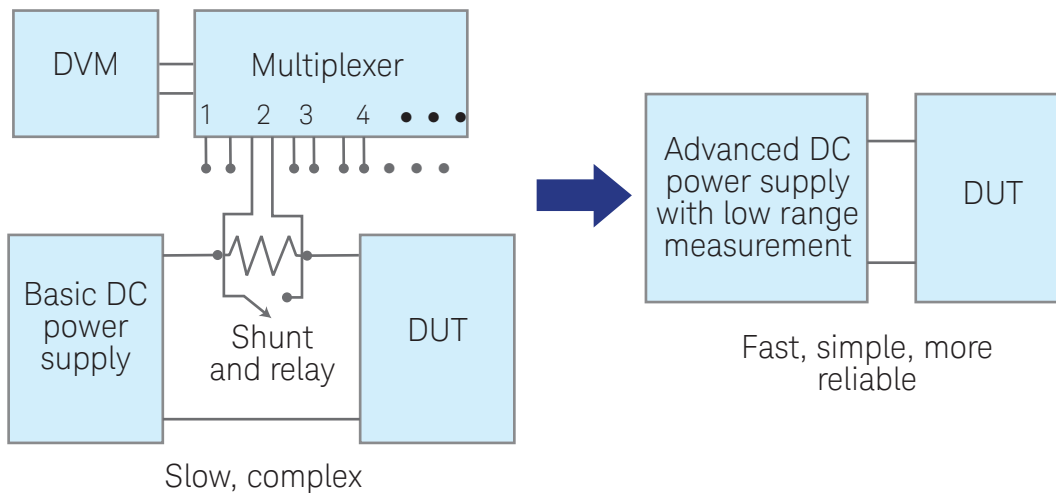


Figure 5-1. External solution versus capability built into the DC power supply for low-level current measurement

6. Take Advantage of Seamless Measurement Ranging for Instantaneous Range Changes During Test

Application Brief

Every millisecond matters when it comes to test time for high-throughput component and device testing. Using DC power supplies featuring seamless measurement ranging can save significant time during test, improving throughput and reducing test cost.

Many components and devices are tested at several bias voltage conditions, power levels, and various sleep, idle, and active states during test. The resultant current drains for the combination of all these factors spans a wide range, requiring multiple measurement ranges for getting accurate results.

A command needs to be sent to and processed by the DC power supply or other measurement equipment to manually change the measurement range each time, as required for the specific current level, for an accurate test result. Each manual measurement range change can take several milliseconds to process and complete. In comparison, with seamless measurement ranging, the measurement system is constantly tracking and utilizing the most appropriate range, or even combination of ranges, for best accuracy, based on the instantaneous current level, in real time. There is no longer the need to manually change ranges any more with seamless measurement ranging. This is distinctly different from autoranging measurement, which operates in a very non-real time fashion, even taking considerably more time than manual range changes and usually impractical under automated test.

When there ends up being a good number of measurement range changes required in order to test the component or device for all its combination of conditions, taking advantage of seamless measurement ranging can take many tens of milliseconds off the test time, a significant savings when overall test time may only be seconds long, and every millisecond matters!

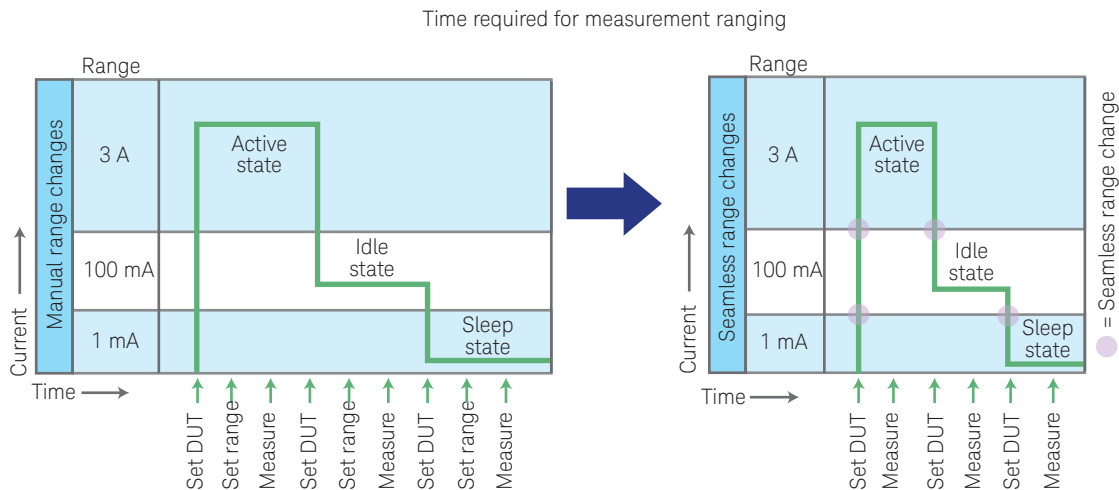


Figure 6-1. Comparing time required for manual versus seamless measurement ranging

7. Use List Mode for Faster Output Level Changes

Application Brief

Using power supplies that incorporate list mode capability can significantly reduce test time when you need to set several voltage (or current) level settings for a large number test conditions throughout a DUT's test sequence. The reduction in test time is even greater for DUTs that require multiple bias voltages. The test time decreases in proportion to the number of bias voltages set for each of the many test conditions for the DUT.

Using conventional power supplies, a separate output set level command is sent to each output every time the voltage or current needs to be changed for setting up the next test condition. Each output level command can take from several milliseconds to process for a high performance power supply, to up to as much as 100 milliseconds long for a basic power supply. When changing the levels for multiple power supplies for the next condition, each one gets set sequentially, multiplying the command processing time required by the number of power supply outputs required to be changed.

When using list mode, a sequence of voltage or current levels are pre-programmed into the power supply. The list only needs to be entered once. The list can then be executed repeatedly, as is the case in production test. Using a trigger to pace the list, the output level changes start to respond in just microseconds for a hardware trigger input, to a few milliseconds or less for a bus trigger input, minimizing the time required in comparison to sending commands to set levels each time. Even greater savings are achieved with multiple outputs as the list for each output are simultaneously sequenced with the same trigger, eliminating the extra command processing time required for each additional output.

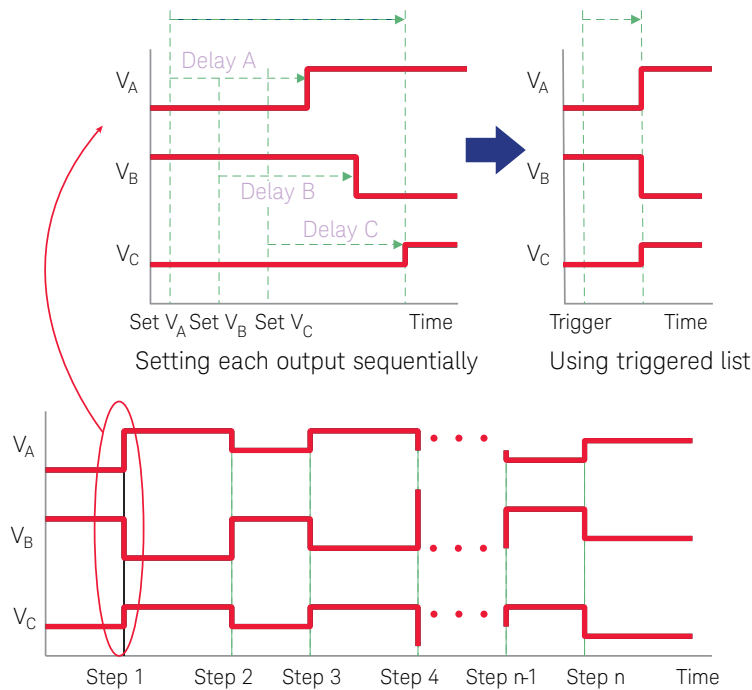


Figure 7-1. Power supply with list mode capability reduces test time

8. Use List Mode and Triggers to Make Fast Swept Parametric Measurements

Application Brief

Taking advantage of the list mode feature in a DC power supply can provide throughput benefits in additional ways over and above just quickly sequencing a series of voltage or current levels. Lists can also generate output trigger signals at strategic points in the list. These output trigger signals can be used to initiate other activities, including those involving external equipment. Triggering between instruments eliminates the need for a controller to continuously intervene, reducing test time.

One common practice is performing swept parametric measurements in conjunction with a DMM. An illustrative example of this is testing the linearity of a Hall Effect current sensing device. Here a series of current levels are furnished to the Hall Effect device's input and the DMM measures the device's corresponding output voltage levels.

Such swept parametric measurements often require hundreds of points. Keeping the sweep time as short as possible not only reduces test time, increasing test throughput, but can also minimize heating effects thus improving test accuracy as well. Eliminating having the test system controller execute the DC power supply's series of current level steps and trigger the DMM's corresponding voltage level measurements removes considerable time in performing a swept parametric measurement. Handshaking trigger signals between the DC power supply and the DMM accomplish just that. The DMM is set to take an array of measurement values corresponding to the number of current step levels in the trigger-paced list. The list generates a trigger output to the DMM to take a measurement at each step. The DMM in turn generates a measurement-complete trigger output for the DC power supply list to sequence to the next step.

Taking advantage of the list mode and trigger features available in more advance DC power supplies can greatly speed up swept parametric measurements, reducing time and increasing throughput of your testing.

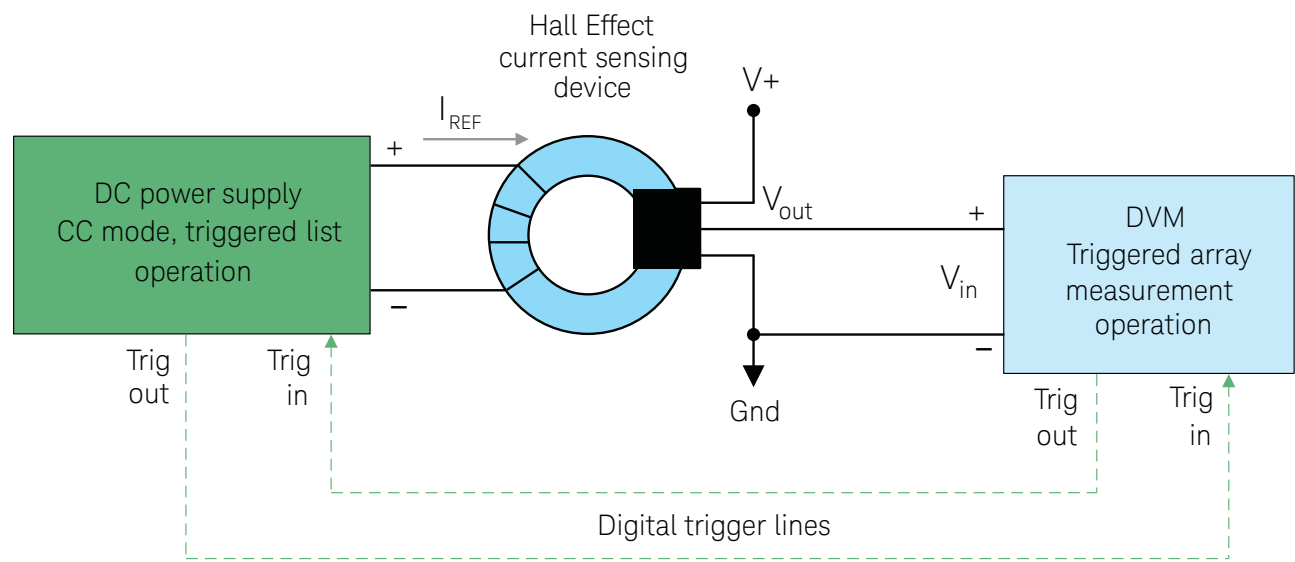


Figure 8-1. Hall Effect device swept parametric measurement set up for its transfer characteristics

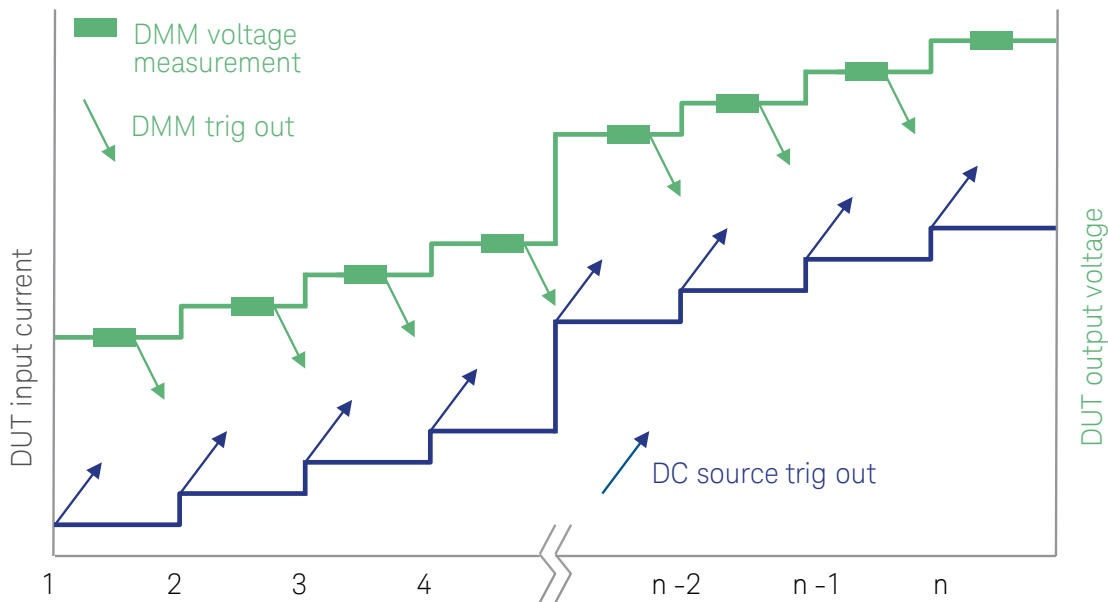


Figure 8-2. DC power supply list step with triggers handshaking with DMM measurement array with triggers

9. Combine the Power Supply’s ARB and Digitizer Features for Ultra-fast Swept Parametric Measurements

Application Brief

A traditional source measure unit (SMU) can perform a fairly fast swept parametric measurement. However there are times when even faster swept measurements are useful, such as when self heating of the DUT or test throughput are extremely critical, while still needing to measure hundreds of points or more to characterize the DUT. By taking advantage of the arbitrary waveform generation (ARB) and digitizer features incorporated in select DC system power supplies, swept parametric measurements can be performed at record speeds.

A traditional SMU uses a repeating source-delay-measure sequence of activities to perform a swept parametric measurement. This is basically comparable to the hint provided on using list mode and triggers for making fast parametric swept measurements. Higher performance SMUs have swept measurement rates running at up to about 20 KSa/sec.

A faster alternative is to initiate a suitable ARB output voltage or current waveform while simultaneously initiating a digitized measurement array of the corresponding dependent parameter to be measured at an appropriate sampling rate. Without having to individually synchronize each source-delay-measure event the measurement rate can run at up the maximum digitizer sampling rate. A variation of this theme is to use the DC power supply’s data logging feature instead of its digitizer feature, if available. This provides the advantage of integrating the measurement over a longer aperture time, but will take a correspondingly longer time.

In the illustration a 1.2 amp, 1.2 millisecond current ramp ARB was initiated while simultaneously sampling both the current and voltage at a 100 KSa/sec rate, for obtaining the forward voltage characteristics of a high brightness LED (HBLED). By drastically reducing the test time required the HBLED’s voltage drift due to temperature rise from self-heating was minimized.



Figure 9-1. HBLED fast ramped current forward voltage test

10. Take Advantage of the Status Subsystem Features to Reduce Test Time

Application Brief

Some power supply operations take notably longer than most to complete than others. Examples of this include:

- Enabling the output
- Initializing a triggered measurement
- Initializing a triggered output transient or output list event

When developing programs you can include long fixed wait statements to make certain these operations have completed before proceeding. However, this can easily add many tens of milliseconds or more of unnecessary waiting, increasing overall test time. A better way is to take advantage of the DC power supply's status subsystem features that eliminate unnecessary waiting for operations like the examples listed above.

Enabling the DC power supply output, or an output-on operation, may take many tens of milliseconds. It can take even longer if the output has a mechanical disconnect relay built-in. Instead of using a fixed wait statement, follow the "OUTPUT ON" command with a "*WAI" status subsystem command. This instructs the system DC power supply to not process any further commands until all pending operations are complete, in this case, the output-on operation. With this approach the test program continues executing as soon as the output-on operation is completed without any unnecessary additional waiting.

Triggered measurement and output sourcing events can substantially speed up testing by providing actions tightly synchronized with other test activities. But they do have some up-front set up overhead time needed for initializing them. Instead of using a fixed programming delay following an initialization operation it is better to take advantage of the Operation Status Group register in the status subsystem. The "WTG meas" bit (#3) or "WTG trans bit (#4) in the condition register can be monitored with a loop in the test program to see when they turn true. At the moment the measurement or output sourcing event is initiated and ready for a trigger the test program will then proceed with its execution without incurring any unnecessary additional waiting.

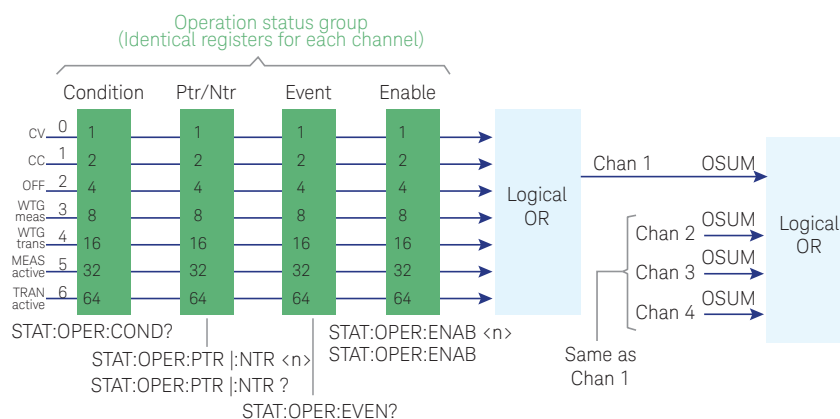


Figure 10-1. Agilent N6700 Series DC power system operation condition status group

myKeysight

myKeysight

www.keysight.com/find/mykeysight

A personalized view into the information most relevant to you.



www.axiestandard.org

AdvancedTCA® Extensions for Instrumentation and Test (AXIe) is an open standard that extends the AdvancedTCA for general purpose and semiconductor test. Keysight is a founding member of the AXIe consortium.



www.lxistandard.org

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



www.pxisa.org

PCI eXTensions for Instrumentation (PXI) modular instrumentation delivers a rugged, PC-based high-performance measurement and automation system.



Three-Year Warranty

www.keysight.com/find/ThreeYearWarranty

Keysight's commitment to superior product quality and lower total cost of ownership. The only test and measurement company with three-year warranty standard on all instruments, worldwide.



Keysight Assurance Plans

www.keysight.com/find/AssurancePlans

Up to five years of protection and no budgetary surprises to ensure your instruments are operating to specification so you can rely on accurate measurements.



www.keysight.com/quality

Keysight Technologies, Inc.
DEKRA Certified ISO 9001:2008
Quality Management System

Keysight Channel Partners

www.keysight.com/find/channelpartners

Get the best of both worlds: Keysight's measurement expertise and product breadth, combined with channel partner convenience.

ATCA®, AdvancedTCA®, and the ATCA logo are registered US trademarks of the PCI Industrial Computer Manufacturers Group.

www.keysight.com/find/power

www.keysight.com/find/APS

For more information on Keysight

Technologies' products, applications or services, please contact your local Keysight office. The complete list is available at:

www.keysight.com/find/contactus

Americas

Canada	(877) 894 4414
Brazil	55 11 3351 7010
Mexico	001 800 254 2440
United States	(800) 829 4444

Asia Pacific

Australia	1 800 629 485
China	800 810 0189
Hong Kong	800 938 693
India	1 800 112 929
Japan	0120 (421) 345
Korea	080 769 0800
Malaysia	1 800 888 848
Singapore	1 800 375 8100
Taiwan	0800 047 866
Other AP Countries	(65) 6375 8100

Europe & Middle East

Austria	0800 001122
Belgium	0800 58580
Finland	0800 523252
France	0805 980333
Germany	0800 6270999
Ireland	1800 832700
Israel	1 809 343051
Italy	800 599100
Luxembourg	+32 800 58580
Netherlands	0800 0233200
Russia	8800 5009286
Spain	0800 000154
Sweden	0200 882255
Switzerland	0800 805353
	Opt. 1 (DE)
	Opt. 2 (FR)
	Opt. 3 (IT)
United Kingdom	0800 0260637

For other unlisted countries:

www.keysight.com/find/contactus

(BP-07-10-14)