INSIGHT^{10}

10 hints for using your power supply to decrease test time.

STOP WAITING FOR THE DUT

Most test programs spend most of the time waiting. Unless you're moving massive amounts of data, however, the computer, the I/O, and the instruments are usually not the culprit. Before upgrading your computing hardware or reaching for faster instruments, look carefully at execution sequence.

First-pass improvements

Start by looking for tests that leave the DUT in the desired state for the next test. If the DUT needs to be turned off for the start of a test, for instance, try to sequence a preceding test that leaves it off. If a particular test requires that the DUT is warmed up, place it later in the sequence and use a system timer to guarantee the DUT has been on long enough. These techniques can yield some big improvements, although they are not always feasible (and a thoughtful test plan usually has this level of optimization taken into account already).

Second-pass improvements

The next level of optimization is done on an individual test basis. Here's a typical sequence:

- Apply a load to the DUT or set up its programmed state and wait for DUT output to settle
- Connect relays to engage measurement equipment and wait for relays to close
- Set up measurement instrument and wait for setup to complete
- Initiate measurement and wait for measurement to complete
- Disconnect relays
- Turn off power source
- Wait for DUT output to settle

Each step usually involves a wait while the action completes. In addition, most DUTs need time to stabilize after power is applied or a load condition has changed. By separating the programming and wait stages, you can rearrange the test to program one instrument while waiting for another:

- Apply load to the DUT
- Connect relays to engage measurement equipment
- Set up measurement instrument
- Wait for all previous actions to complete:
  – Relays to close
  – Measurement instrument to settle
  – DUT output to settle
- Initiate measurement
- Wait for measurement to complete
- Disconnect relays
- Turn off power source
- Wait for DUT output to settle

Overlapping the wait periods minimizes overall delays. While the DUT is settling, the test program is busy programming the relays and setting up the measurement instrument.

To implement an overlapped wait, use a common or global timer. Each programming routine that sets up an instrument or DUT can tell a global timer how long each action will take; this identifies which action requires the longest wait. Then, when a measurement or other test requires that the previous commands be completed, a call to a single wait function will wait until the global timer expires before continuing:

- Apply load to the DUT
- Connect relays to engage measurement equipment
- Set up measurement instrument
- Wait For Global Timer
- Initiate measurement
- Wait For Global Timer
- Disconnect relays
- Turn off power source

With this approach, the test does not have to wait any more than is absolutely necessary for instrument setup, and the programming is simpler, too.

REDUCE TEST TIME WITH MULTIPLE SUPPLIES AND OVERLAPPED GPIB OPERATIONS

If measurement speed is at a premium, consider using multiple single-output power supplies instead of one multiple-output supply. With multiple supplies, you can overlap GPIB operations and avoid delays caused by sequential command processing in a multiple-output supply. In a multiple-output supply, commands sent to the various outputs are processed sequentially, one output at a time. With a multiple supply setup, however, one supply can be processing a command while the next is receiving a command, and so on.

This technique is most beneficial when making queries from the supplies. With a multiple-output supply, you must send the measure command and retrieve the response from that output before querying the next output. Because the measurements must be made one after the other, a query such as this sequence takes two measurement cycles to complete:

```
OUTPUT Dev1;"VOUT1?"
ENTER Dev1;"Volt1
OUTPUT Dev1;"VOUT2?"
ENTER Dev1;"Volt2
```

With multiple instruments, however, you can first send a command to all the supplies to start the measurement, then go back and retrieve the responses. Since the measurements are overlapped, this query sequence requires just one measurement cycle.

```
OUTPUT Dev1;"MEAS:VOLT?"
OUTPUT Dev2;"MEAS:VOLT?"
ENTER Dev1;"Volt1
ENTER Dev2;"Volt2
```

When you're using the VISA software driver, viQueryf() is a convenient function for making queries. However, this function does not allow for overlapped operations. To perform overlapping queries, break the query into individual steps using viPrintf() and viScanf(). Here's an example:

```
viPrintf(viDev1, "MEAS:VOLT?\n");
viPrintf(viDev2, "MEAS:VOLT?\n");
viScanf(viDev1, "%lf",&Volt1);
viScanf(viDev2, "%lf",&Volt2);
```

Although the time saving for an individual setup or query operation may be rather modest, for complex repetitive tests, the cumulative time savings can have a dramatic impact on overall system throughput.

USE THE BUILT-IN MEASUREMENT CAPABILITY OF POWER SOURCES AND LOADS

By taking advantage of the measurement features built into many power supplies and electronic loads, you can reduce both time and complexity in automated tests. With power supplies, these capabilities let you measure the supply's output voltage and current. With loads, you can measure load input voltage and current.

A good example is testing a dc-to-dc converter with four outputs, where you need to measure the input voltage to the converter and each of the four outputs in order to fully test the device. If you have a single DMM to measure the voltages,

you'll need a multiplexer to sequence through the measurements **(Figure 1)**. In addition to the complexity of this setup, your test program needs to wait for the multiplexer's switches to move and settle for each measurement.

The dc source and loads you need to test the converter can take care of the measurements for you **(Figure 2)**. They're already connected to the DUT, and there are no switching delays, so both the setup and test phases are much faster. Note the use of remote sensing here. Although this approach isn't required, it is generally a

good idea because it provides regulation and measurement at the DUT rather than at the loads or the dc source.

With no need for switching, you'll benefit from faster tests, greater reliability and simpler configurations, not to mention the time and rack space you'll save by eliminating the DMM and multiplexer. And if you want to measure current, this same approach will work quite well, while also eliminating the current shunts you'd otherwise need.
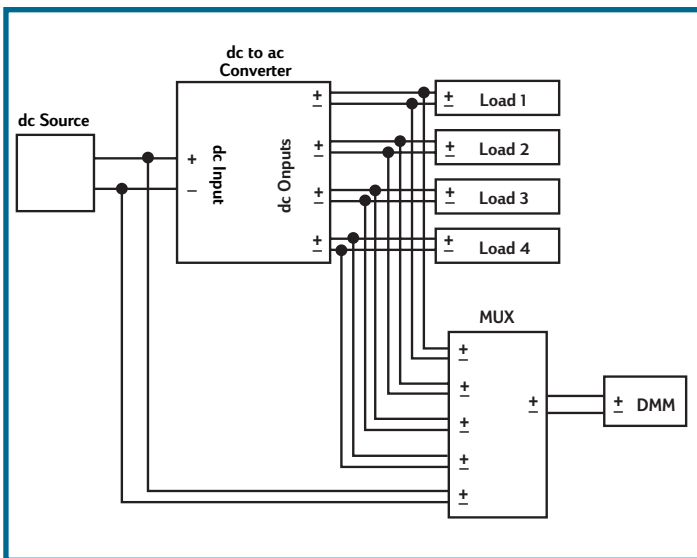

Figure 1. Testing a four-output dc-to-dc converter with a single DMM requires a complex multiplexing scheme and can involve significant delays.
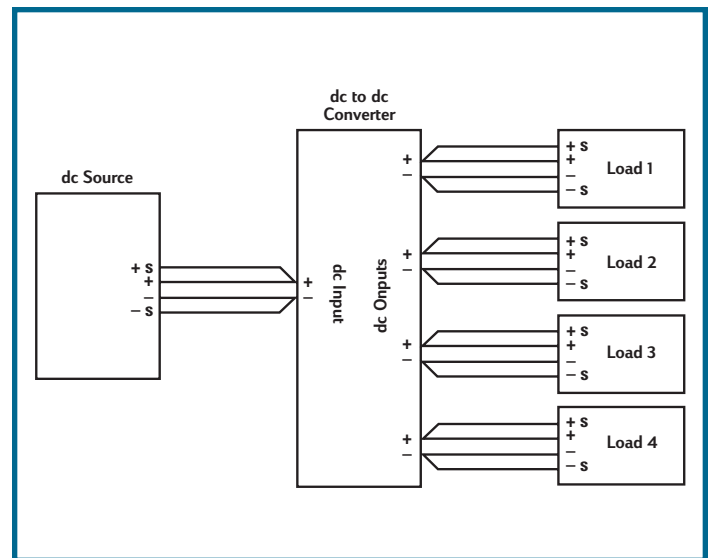

Figure 2. By using the built-in measurements in your dc power source and electronic loads, you can eliminate the DMM and MUX and significantly increase your test speed.

USE ONE-BOX POWER PRODUCTS TO REDUCE INTEGRATION, PROGRAMMING AND MAINTENANCE TIME IN **ATE** SYSTEMS

Many of today's system power supplies, ac sources, and electronic loads feature built-in voltage and current programmers, status readback, and service request interrupts in a single package **(Figure 1)**. You don't have to assemble the power subsystems for ATE systems from individual pieces and worry about performance. Specifications for one-box power instruments tell you exactly what you can expect.

Advantages

One-box solutions offer a number of features that reduce complexity and increase confidence:

- **Fully specified performance.** One set of specifications covers the complete instrument, from GPIB input to the output.

- **Reduced system cost.** With everything in one box, there is no long list of extras to buy and then stuff into a crowded equipment rack. This also eliminates external cabling and interconnections between units, greatly increasing reliability and simplifying integration.

- **Ease of use.** Front panel controls speed up system development. Outputs are programmed in volts, amps, and similar self-documenting programming commands. Extensive system features such as status readback and electronic calibration also speed development and reduce maintenance.

- **Application protection.** Overcurrent and overvoltage protection can shut down the output and send interrupt requests when dangerous conditions occur. In addition, external control ports on many newer instruments make it easy to incorporate emergency system shutdowns in response to external events.

Advanced Features

A number of advanced power products also include built-in measurement functions:

- **Auxiliary DVM functions.** Some of today's power supplies incorporate measurement capabilities that further reduce or eliminate the need for additional equipment.

- **Power analyzer measurement functions.** Built-in power analyzers let you monitor the effects that line disturbances generated by ac sources can have on equipment under test. Some ac sources even have a second power analyzer input that you can connect to the output of power protection equipment.
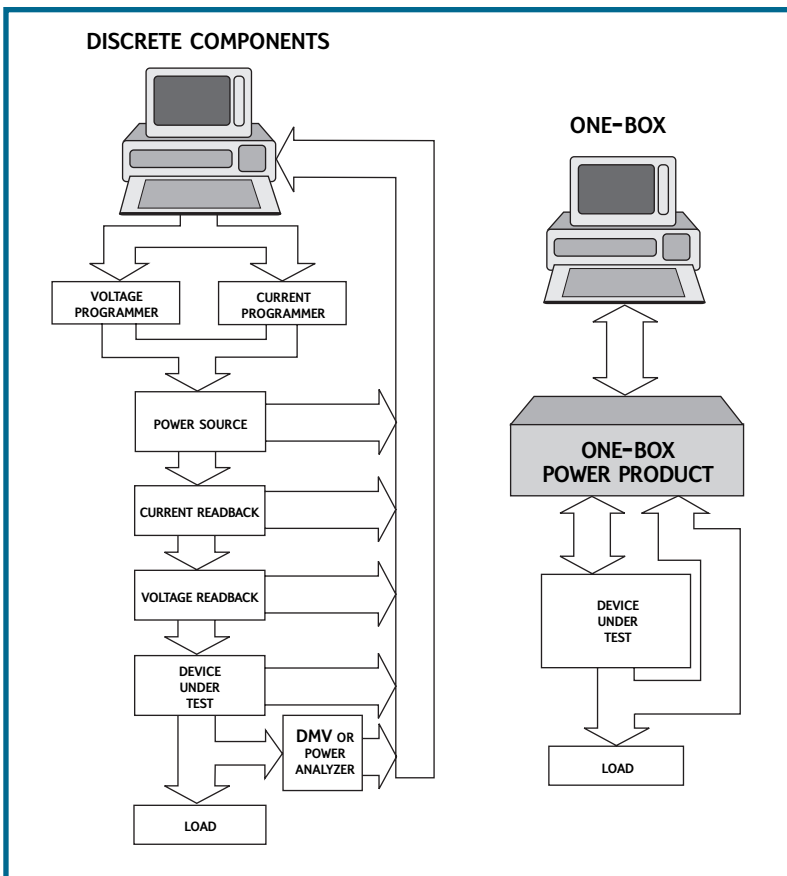

Figure 1. The one-box approach to power products pulls many of the elements you need for automated testing into a single instrument.

DIGITAL SIGNAL PROCESSING BOOSTS INSTRUMENT PERFORMANCE AND VALUE

The wide availability of low-cost, floating-point digital signal processing (DSP) has significantly enhanced the performance, functionality, and value of many ac and dc power supplies. These enhanced capabilities in turn often lead to significant improvements in test throughput and development time.

Overcoming analog limitations

DSP made big strides in overcoming the limitations of traditional analog designs, in which overall performance is ultimately limited by the components used in the instrument. Even the best designs are susceptible to the effects of semiconductor process limitations, noise, temperature drift, contamination of desired signals by undesired signals, and other factors. Correcting these undesired effects is very difficult, and in many cases, impossible.

Modern instrument designs try to overcome these obstacles by digitizing signals at the earliest possible point in the processing chain, after which all processing is done in the digital domain where error sources are more easily controlled.

Creating new test and measurement possibilities

With improved measurement accuracy of basic parameters assured in the digital domain, further processing opens up virtually unlimited possibilities for doing more with the data. For instance, DSP-based power supplies typically not only digitize output voltages and currents, but do so by acquiring time domain waveforms in much the same manner as digitizing oscilloscopes. Measurements ranging from instantaneous power to FFTs to custom filters can be implemented via algorithms, rather than by physical circuits as analog designs require.

Intelligent instruments can also speed up automated tests by taking over processing chores from the host computer.

Better information for better designs

Information about the test device's power consumption can help with fuse selection, loading predictions and other important design decisions. Spectral information can provide insight into ac powerline harmonic emissions' behavior as well as the tests needed to show compliance to the standards governing such emissions. Power consumption profiles in low-repetition, pulse-load devices such as cell phones provide valuable insight into battery life. By going beyond raw data to offer processed information, DSP can reduce both design and production test cycles.

INSIGHT⁶

USE MORE-ACCURATE POWER SUPPLIES

The benefits of improved power supply accuracy (both output level programming and readback accuracy) are obvious when you're thinking about precision and resolution. However, improved accuracy in a power source can deliver significant speed improvements, too.

If your power sources are not accurate enough or stable enough, you may need to continually verify their output levels with a DMM and possibly use a program loop to keep the voltages at or near expected values. Temperature drift, sudden load changes and insufficient resolution are just some of the factors that can cause

trouble. With a more-accurate supply, you avoid the complexity, expense and delays involved in this approach.

The situation is even more challenging if you have to use less-accurate supplies and a number of shunts, multiplexers, DMMs and other elements to make up a complete system. The one-box power system design described in Tip #4 helps in this respect because you have the advantage of integration and comprehensive performance specifications. There are fewer discrete elements in the system, improving reliability and reducing the chance of errors and instability.

INSIGHT 7

USE BINARY MODE TO TRANSFER LARGE AMOUNTS OF DATA

When transferring large data arrays such as measurement waveforms to or from an instrument, see if the instrument supports binary transfer. If it has waveform capture capabilities, chances are it offers binary mode in addition to ASCII. If you're moving only data, you don't need the alphanumeric capabilities of ASCII. Binary transmission requires fewer bytes reducing transfer time by a factor of two or more.

The disadvantage of binary mode is some additional data management work to ensure successful transfers (such as byte order). (Also, make sure the instrument isn't inadvertently set to binary mode when you're expecting it to be in ASCII.)

The good news for binary transfers is that the VISA I/O library can manage much of the housekeeping for you. This example illustrates the use of binary mode with an ac or dc source. The program is written in C, but the concepts apply to any language. (Call the VISA library from Visual Basic,® HP VEE, LabVIEW,® and other programming environments).

```c
/***********************************************************************************************************
 * This program demonstrates binary-mode data transfer using any of the following HP AC sources:
   6811B, 6812B, 6813B, 6841A, 6842A, 6843A

 * Or one the following HP DC power supplies: 66309B, 66309D, 66311A, 66311B, 66311D, 66312A, 66332A

 * Communication with the instrument is via the VISA GPIB library.  Link the program with visa32.lib
   when building an executable file.

 * The results are written to standard output, and usually should be redirected to a file.
 ***********************************************************************************************************/
#include <stdio.h>
#include "visa.h"

#define MAX_POINTS   4096          /* Largest array is 4096 points */
#define PWR_SRC_ADDR "GPIB0::5::INSTR" /* Interface GPIB0, address 5 */
#define TIMEOUT     10000          /* 10 seconds */

void main()
{
        ViSession defaultRM, PwrSrc;
        float aVolts[MAX_POINTS];
        long lPoints, i;

        /* Open a session for the default resource manager (required in every
         * VISA program) and for the power source (i.e. AC source or DC power
         * supply).
         */
        viOpenDefaultRM(&defaultRM);
        viOpen(defaultRM, PWR_SRC_ADDR, VI_NULL, VI_NULL, &PwrSrc);

        /* Set the timeout to allow enough time to transfer a large array.
         */
        viSetAttribute(PwrSrc, VI_ATTR_TMO_VALUE, TIMEOUT);

        /* Arm the data acquisition subsystem of the power source, and trigger it.
         */
        viPrintf(PwrSrc, "initiate:name acquire\n");
        viPrintf(PwrSrc, "trigger:acquire:immediate\n");

        /* Select binary format for array transfers.
         */
        viPrintf(PwrSrc, "format real\n");

        /* Query the power source for the array of voltage data.
         */
        viPrintf(PwrSrc, "fetch:array:voltage?\n");

        /* Fetch the data.  The %#zb format does the following:
         * - Puts the binary data into array aVolts, with the bytes arranged
         *    properly for the processor in use (e.g. Intel or Motorola).
         * - Uses the initial value of lPoints as the maximum number of points
         *    to be read.
         * - Puts the actual number of points read into lPoints.
         * The %*t format ensures that there are no bytes left over in the VISA
         * library's input buffer that could interfere with the next query.
         */
        lPoints = MAX_POINTS;
        viScanf(PwrSrc, "%#zb%*t", &lPoints, aVolts);

        /* Send the array of data to standard output.
         */
        printf("%ld points\n\n", lPoints);
        for (i=0; i<lPoints; ++i)
                printf("%7.2f\n", aVolts[i]);

        /* Close the VISA sessions. */
        viClose(PwrSrc);
        viClose(defaultRM);
}
```

TAKE ADVANTAGE OF SOPHISTICATED STATUS REPORTING FEATURES

Given the capabilities of today's system power supplies and loads, there's more need than ever to know what's going on inside the instrument and what actions it has taken in response to changing input signals and other factors.

For example, a common monitoring task is watching to see when a supply has entered constant current (CC) mode, in which the supply will adjust its voltage to maintain a specified current level as load conditions change. This can happen when a logic device fails, for instance, resulting in sharply higher current draws from the device under test. Failing to respond to the situation could cause extensive damage to the load or even unsafe conditions.

You could keep reading the supply's status via GPIB, looking to see if the CC bit has changed. However, this is both slow and time-consuming for the computer.

A faster way is to set up the supply so that a bit gets set in its serial poll register whenever CC mode is entered. Performing a serial poll is a much faster GPIB operation, so the process wastes less time with each check. Plus, if your programming environment supports interrupts via GPIB service requests (SRQs), you can eliminate the polling process altogether and set up the source to generate an SRQ when it enters CC mode.

Status register setups vary from instrument to instrument, and have evolved over time to offer very powerful monitoring and response capabilities. For example, many Agilent Technologies' supplies offer registers that show operating modes and conditions as standard events (normal operating conditions such as CV and CC) and questionable events. In this context, questionable events include overvoltage, overcurrent and overtemperature conditions, as well as transitions into unregulated states (when the supply is in neither constant current nor constant voltage mode). All of these conditions set bits in the status register and can be used to generate SRQs.

USE LIST MODE AND BACKPLANE TRIGGERING

Power supplies with a feature known as list mode let you store complete instrument setup states and recall them with a single command, rather than sending a long series of individual configuration steps. The more complicated your test sequence, the more time list mode can save. List mode is also handy with microprocessors and other applications that require a variety of voltage levels simultaneously.

In a modular power system, using triggering via the backplane in conjunction with list mode adds even more capability and flexibility. For instance, you can preconfigure various modules to output particular voltage levels, then with a single trigger command, turn them on at different times as well. **Figure 1** shows a block diagram of such a setup, and **Figure 2** shows the resulting output curves.

List mode and triggering can help in yet another way, by reducing the control chores for the computer in your test system. With a single trigger command to launch a programming sequence, you can then use module-to-module triggering via the backplane to initiate list mode setups on subsequent modules.
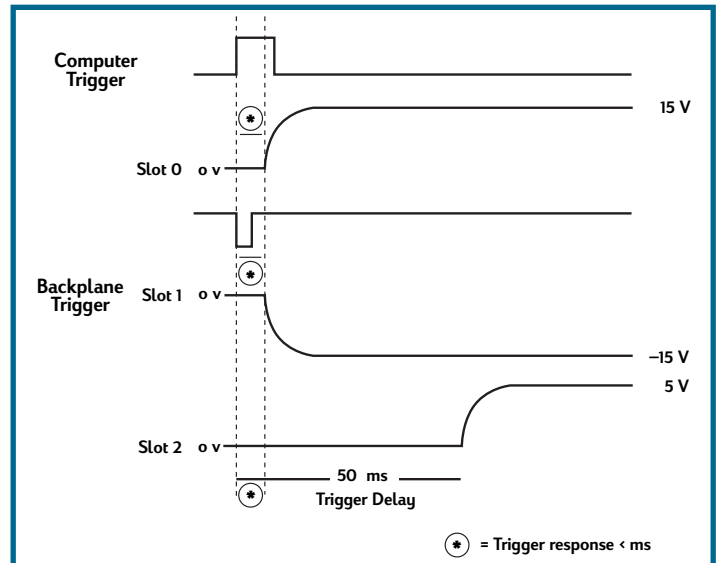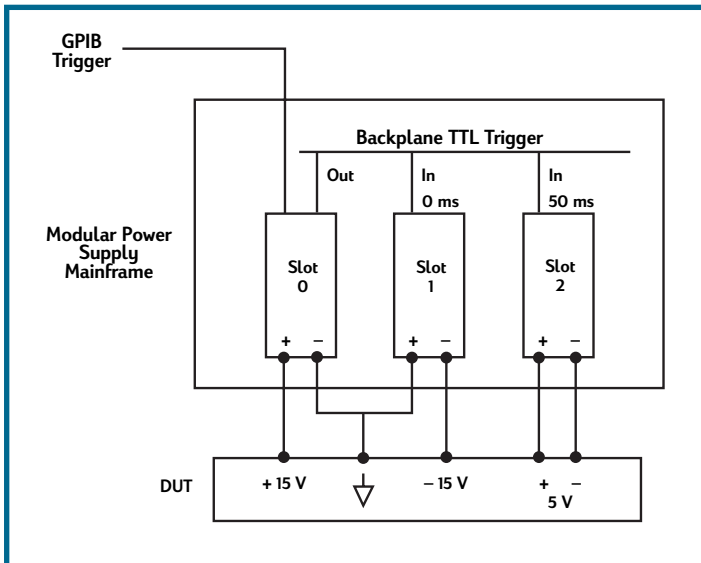

Figure 1. This three-module setup uses backplane triggering to launch outputs at different times. Slots 0 and 1 provide power simultaneously, while Slot 2 is set to start 50 ms later.

Figure 2. Here's the set of power curves generated by the setup shown in Figure 1.

INSIGHT¹⁰

USE SUPPLIES WITH DOWNPROGRAMMING FOR FASTER LEVEL CHANGES

Using power supplies that incorporate a feature known as downprogramming can significantly reduce test time, particularly when you need to set multiple voltage level settings. Without downprogramming, the capacitor in the supply's output filter (or any load capacitance) can take seconds or even minutes to discharge when you reduce the output voltage level (the lighter the load, the longer it takes).

Downprogramming uses an active circuit to force the output down to the new level within a matter of milliseconds in most cases. This circuit kicks in automatically whenever the voltage level you set (either manually or programmatically) is below the present output level. The downprogramming level is fixed in most supplies, but some offer programmable downprogramming.

In time-critical tests, it's a good idea to watch out for downprogramming delays. Because programming up is typically faster than programming down, try to sequence multiple tests in such a way that each consecutive test is at the same or higher voltage level as the previous test.

Note that downprogramming can be a handy way to discharge batteries, too. If you've charged the battery then reduced the output voltage (or in some supplies, turned off the output with the "OUTPUT OFF" command), downprogramming will activate and force the supply to act as an electronic load and thereby drain the battery. This is a great feature if you want it, but bear in mind that it can inadvertently drain batteries you don't want to discharge. To maintain the charge, be sure to disconnect the battery before reducing the output level on the supply.

CAUTION: When charging or discharging batteries, do not turn off the supply's ac power. The supply's overvoltage protection circuit may trip and short the battery, which can damage the supply and cause the battery to overheat.

Agilent Technologies
Innovating the HP Way

When you're trying to boost throughput in time-critical production test systems, don't forget your power supplies. A small change in the way you operate or program a supply can have a surprising impact on test speeds. This brochure offers 10 simple tips for getting more done in less time.

For complete information on Agilent Technologies' power products, systems and applications, please call the engineers at Agilent Technologies or visit our Web site at **www.agilent-tech.com/find/insight10** The Web site offers detailed product information, download links for drivers and other software items, application notes, technical articles and answers to frequently asked questions.