Keysight Technologies

Addressing Your Power Test Challenges with Versa*Power* Architecture

Application Note

KEYSIGHT TECHNOLOGIES

Introduction

In this paper we will discuss the structure of Versa*Power* power supply architecture and explore how it can help you overcome your toughest power test challenges. Versa*Power* architecture was developed by Keysight Technologies, Inc. and is currently found only in Keysight's Advanced Power System (APS) N6900 and N7900 system power supply families.

Versa*Power* architecture delivers the fastest, most accurate, integrated power system, allowing you to:

– Accelerate test-system throughput with industry-leading speed

– Capture your DUT's current profile with accurate measurements

– Reduce your ATE development time and cost with highly integrated capabilities

VersaPower architecture encompasses the core internal design of the power supplies in the APS family. What makes VersaPower architecture special compared to a common switching power supply architecture? It uses cutting-edge technology to deliver industry-leading performance and adds innovative capabilities never before seen in a switching power supply design. Figure 1 shows a simplified diagram of the VersaPower architecture found in the APS N6900 and N7900 system power supplies.

In the following sections, we will take a look at each module in the VersaPower architecture, explore key technologies and features in that module, and discuss how they can help you overcome your power test challenges.

AC-to-DC conversion module

The AC-to-DC conversion module takes the AC input and converts it to a 48-V DC bus. This conversion provides a common starting point for the rest of the VersaPower design. The AC input can be a wide range of voltage values — from 100 VAC to 240 VAC — and frequency values, including 50 Hz, 60 Hz, and 400 Hz. This module simply senses the AC line power being used and automatically adjusts it.

DC-to-DC conversion module

The main function of the DC-to-DC conversion module is to take the standard 48-V DC bus and scale it to meet the voltage and current range of the power supply. The module houses some of the standard stages and technologies you would expect in a DC-to-DC conversion module, including the FET bridge, rectification, and filtering. However, it differs from a standard DC-to-DC conversion module in that it allows bidirectional power flow and incorporates other key technologies. Let's take a look at these technologies and how they benefit you during test:

- Bidirectional power flow: This capability allows VersaPower supplies to both source and sink power. Bidirectional power flow helps deliver an integrated solution for testing power-storage devices such as batteries and battery-management systems.
- Synchronous rectification: Traditional rectification uses diodes that allow power to flow in one direction, but synchronous rectification uses FETs instead. Using FETs allows power to flow in either direction, which enables the bidirectional power flow capability and provides improved output stability under dynamic load conditions.
- Ripple-canceling technology: This proprietary technology enables very low output noise. The low output noise makes power supplies with VersaPower architecture a great solution for precision semiconductor, communication, and radar applications.
- Multistage filtering: VersaPower uses multiple stages of filtering implemented using precision components. This enhanced filtering ensures a low-noise DC output and reduces the amount of capacitance at the power supply's output. Lower output capacitance makes it possible for a supply to make fast output changes, which allows you to create a test system with faster throughput.

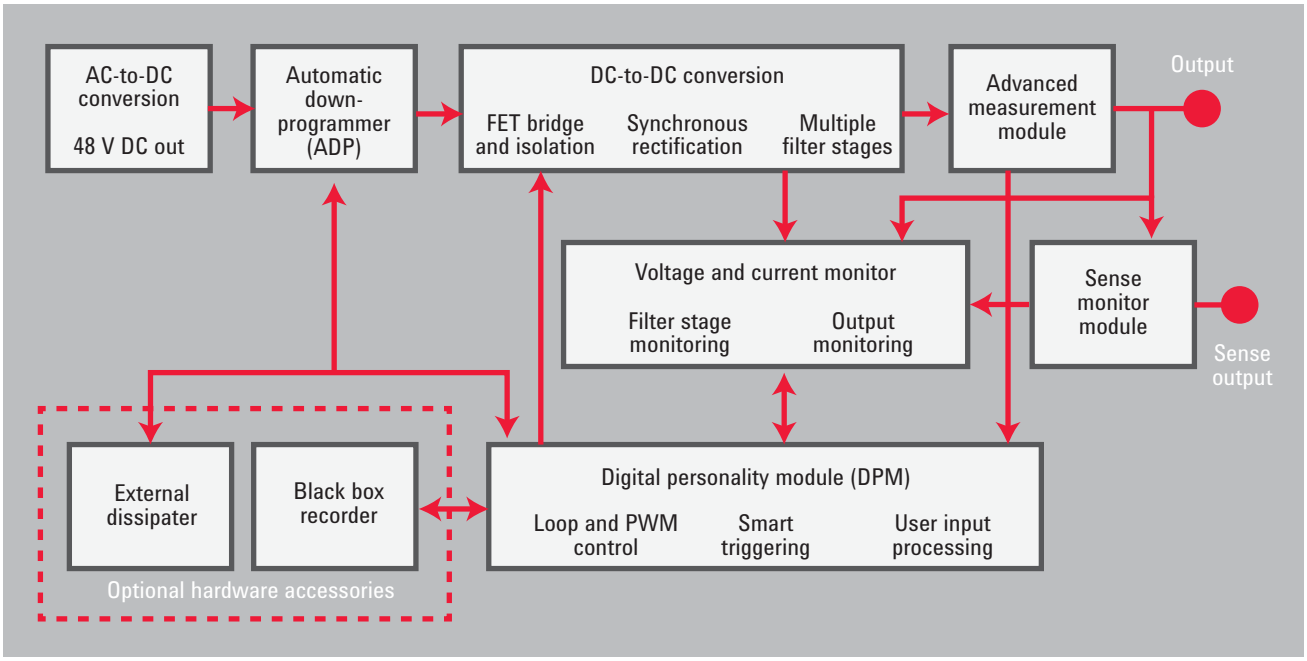

Figure 1. VersaPower architecture block diagram

Advanced measurement module

The advanced measurement module (AMM) provides high accuracy and high resolution voltage and current measurement capability. The AMM has two 18-bit analog-to-digital converters (ADCs) that are continuously sampling time-synchronized voltage and current data, which is passed to the digital personality module (covered later). The digital personality module works with the AMM module to allow you to scale the sampling rate of the measurement data up or down. Using the scaling capability, you can tune the measurement data to meet your needs. For example, you can scale it for averaged voltage and current measurements geared to accuracy or scale it for a digitized approach to capture voltage or current dynamic behavior, such as measuring a device's inrush current.

A growing trend in electronic design is to make devices more power efficient. To optimize power, engineers working with devices such as automotive infotainment systems and portable base stations have adopted a dynamic current usage model. This model means current usage ranges from low current levels when the device is inactive to high current levels when it is active.

To address this trend, Versa*Power* designers focused on the current measurement capability in the AMM. First, they implemented two current measurement ranges in the AMM. One range is for measuring low-level current and the other is targeted at high-level current. These two ranges are controlled by a technology known as seamless ranging. Seamless ranging automatically switches between the ranges based on the output current level. The switching is done seamlessly without any disruption in the output level and no gap in measurement data. Seamless ranging essentially turns 18 bits of resolution to 21 bits when measuring dynamic current. For example, in Figure 2 we can clearly see the 25-A pulses of the device under test (DUT), but when we zoom into the low-level current between the pulses, we can also see 50-mA pulses — all with a single measurement pass.

Seamless ranging also can be used to speed up throughput in tests that require two current measurement ranges. Seamless ranging automatically changes ranges based on the DUT's current, so there is no time wasted on range changes or the need to run a test over at each different measurement range.

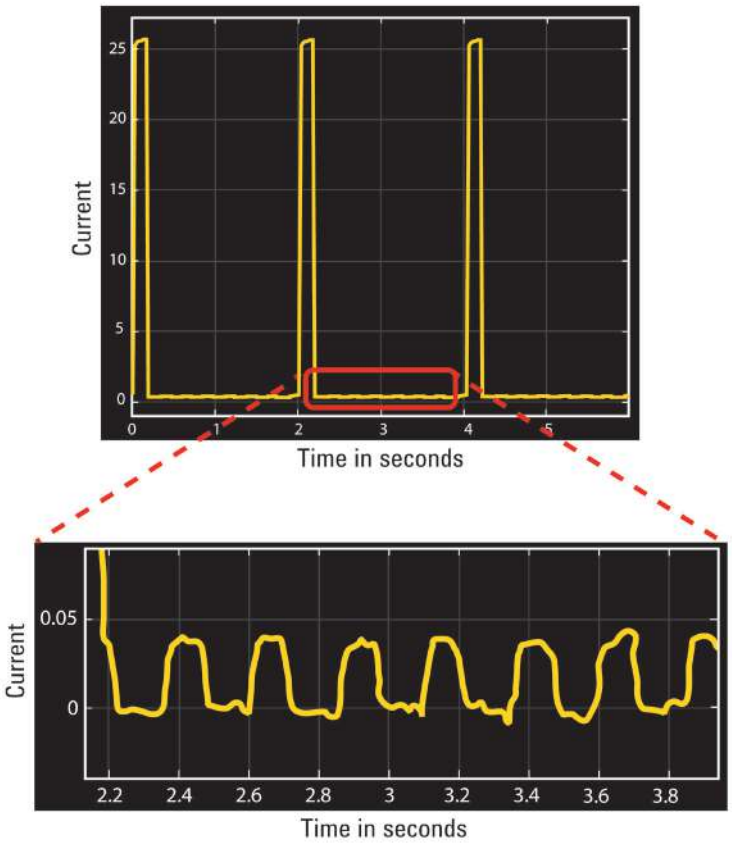

Figure 2. Dynamic current measurement example

Voltage and current monitor module

The voltage and current monitor module provides voltage and current feedback to the digital personality module. This module provides loop feedback of the output voltage and current, and it also includes nested loops for monitoring voltage and current in the filter section. These nested loops provide consistent output behavior and specifications over the entire voltage and current operating range of the power supply, so you won't run into any unexpected behavior during test. For output current monitoring, Versa*Power* architecture uses digital current control loops rather than analog loops to enable nonlinear regulation techniques. This arrangement allows the power supply to react faster to sudden load changes and deliver better protection and output stability to your DUT.

Sense monitor module

The Versa*Power* sense monitor module allows you to extend the output regulation of the power supply from the power supply's output connectors to the input of the DUT or anywhere in between. This is an extension of the technology used in the voltage and current monitor module. This module is able to provide the same specifications up to a 1-V drop across the output cabling and slightly reduced specifications for cabling lengths that drop up to 25% of the rated output voltage. A broken sense line can lead to unintended damaging high-voltage levels at the DUT. To prevent damage, before turning the output on, power supplies use a continuity check to ensure the sense lines are not open, but they do not check if the sense lines open during testing. The Versa*Power* sense monitor module employs a proprietary technology called *continuous broken sense lead detection* that allows it to continuously monitor the sense lines even when the output is on. This technology has no effect on the power supply's output and can detect an open sense line at any time during test to ensure your DUT is protected. The sense module can also detect reversed and shorted sense lines for maximum protection.

Automatic downprogrammer and external dissipater modules

In this section we will look at two modules in the Versa*Power* architecture: the automatic downprogrammer (ADP) and the external dissipater. As we discussed earlier, the DC-to-DC conversion module is designed for bidirectional power flow, but the AC-to-DC conversion module allows power to flow only in one direction. If current is flowing in reverse through the DC-to-DC conversion module, it will cause the bus voltage between the two conversion modules to rise. This is where the ADP comes in: If the bus voltage begins to rise, the ADP will sink current to maintain the bus voltage at 48 V. The ADP has the ability to sink up to 10% of the power supply's rated current. This capability is useful when you are working with DUTs with energy storage components at their input, such as capacitors. When you try to lower the voltage on a DUT with energy storage at the input, it will resist and slow the speed of the voltage decrease. The ADP overcomes this by allowing the power supply to sink power when the voltage is higher than the programmed value. This feature is useful when test throughput or DUT protection is an important part of your test plan.

The external dissipater module is an optional external accessory for power supplies that use Versa*Power* architecture. When connected to a Versa*Power* supply, the dissipater module extends the current sink capability from 10% (made possible by the ADP) to 100% to give the power supply full two-quadrant operation. Because supplies that offer two-quadrant operation can source and sink power, they provide an integrated solution for testing power storage or bidirectional power devices. Two-quadrant operation is not easy to find in a power supply with power levels of 1 kW and above, so test engineers often turn to combining a power supply with an electronic load. The downside to this approach is added complexity and nonideal or discontinuous operation when the DUT's current transitions between sourcing and sinking. The two-quadrant operation enabled by the external dissipater provides continuous glitch-free operation between sourcing and sinking current transitions. Figure 3 shows a Versa*Power* supply with the external dissipater connected to a DUT that has current switching back and forth from sourcing 10 A to sinking 10 A. Notice the voltage level remains constant during the current transitions, which is hard to achieve without an integrated two-quadrant solution.

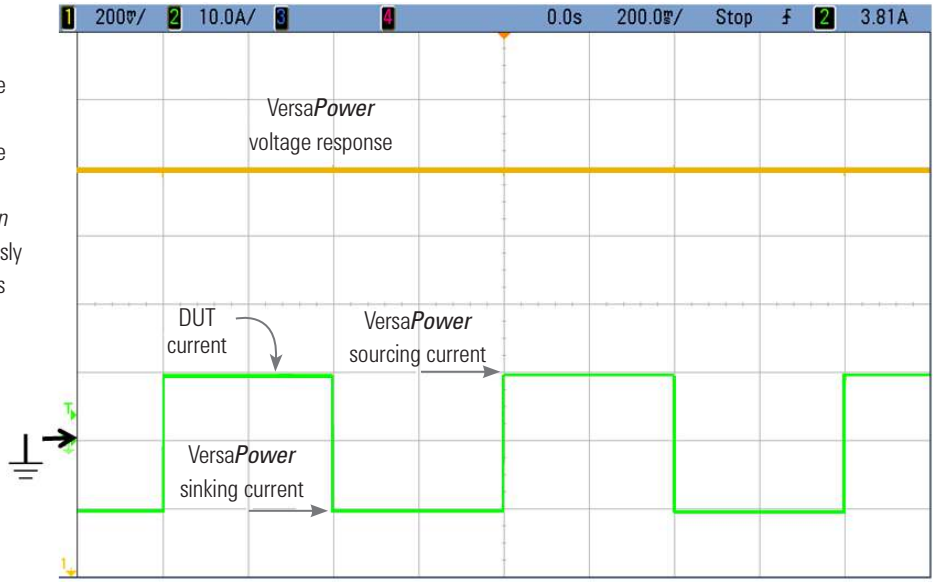

Figure 3. Screen capture showing continuous current sourcing and sinking capability of Versa*Power power supplies*

The engineers who designed Versa*Power* power supplies made the external dissipater module separate and optional so if you need the two-quadrant capability you can easily add it, and if you don't need two-quadrant operation, you don't have to pay for it. The resulting power supply footprint also is smaller without the optional hardware.

Digital personality module

The digital personality module (DPM) is the command and control center of the Versa*Power* architecture. Its main functions include:

- Receives user inputs from either the remote interface or front panel, processes them, and turns them into the corresponding control or monitoring actions
- Reads in the voltage and current monitor data and provides the pulse width modulation signal for controlling the switching in the DC-to-DC conversion module
- Controls and monitors the ADP module, the external dissipater module, advanced measurement module and the black-box recorder module (covered in the next section)
- Implements Versa*Power* smart triggering system (more on this next)

Versa*Power* architecture's smart trigger system is implemented in the FPGA design of the DPM. It provides trigger capabilities never before seen in a system power supply. These capabilities enable better test throughput and DUT protection.

Examples of how the smart trigger system can be set up to generate a trigger: a measurement reaches a specific value, the output of the power supply finishes a transition, a status bit changes, or an external trigger is received.

Example actions that can be initiated from a trigger event: turn the output on/off, start a measurement, change the voltage or current level, or perform a user-defined action.

An innovative capability in the smart trigger system is logical trigger expressions. Logical trigger expressions allow you to "and," "or," and "not" multiple trigger conditions together to create an expression based on trigger events and logic gates. If the output of the logical expression becomes true, the instrument will initiate a user-defined response, such as shut off the output. This capability allows your test system to react in hardware time instead of software time, which can mean the difference between your DUT experiencing no damage and your DUT experiencing catastrophic damage.

Black-box recorder module

The black-box recorder (BBR) module is an innovation first brought to market by Versa*Power* architecture. It was designed for customers who are working with high-value DUTs who want a power record they can access in case something unexpected happens during test. The concept of the BBR is similar to a flight data recorder in an airplane. The BBR module works in the background of the Versa*Power* supply, totally independent of any other power supply function. When the power supply is turned on, it is constantly recording data to nonvolatile memory in the BBR module. Examples of data it captures include voltage, current, power, trigger events, status bits, and user-defined tags. The data can be recorded in two modes:

- 24-hour mode records data at a rate of 100 times per second to memory
- 10-day mode records data at a rate of 10 times per second

When something unexpected happens during test, you can access the BBR data and use it as a forensic tool to figure out what happened and ensure it doesn't happen again. Like the external dissipater, the BBR module is an optional hardware accessory.

Other benefits delivered by Versa*Power* architecture

Versa*Power* architecture also delivers:

- Arbitrary waveform capability for generating voltage or current transients to simulate nonideal power environments
- Built-in paralleling capabilities for addressing higher power needs; paralleled supplies equally share the load current to ensure maximum performance
- Built-in power, amp-hour, and watt-hour measurement capability for testing power storage devices
- Built-in watchdog timer capability to ensure DUT protection against test system software crashes

Conclusion

In this paper we looked at the Versa*Power* architecture found in the Advanced Power System N6900 and N7900 families of system power supplies. Versa*Power* architecture delivers a whole new level of power supply performance and innovative capabilities. It was designed to reduce test system complexity and help you overcome your toughest power test challenges. In this paper we took a detailed look at how Versa*Power* delivers on this design vision with technologies such as automatic down programming, seamless ranging, ripple-canceling technology, smart triggering, black-box recorder, and more.

For more information on the Advanced Power System (APS) N6900 and N7900 system power supply families with VersaPower go to: www.keysight.com/find/APS

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