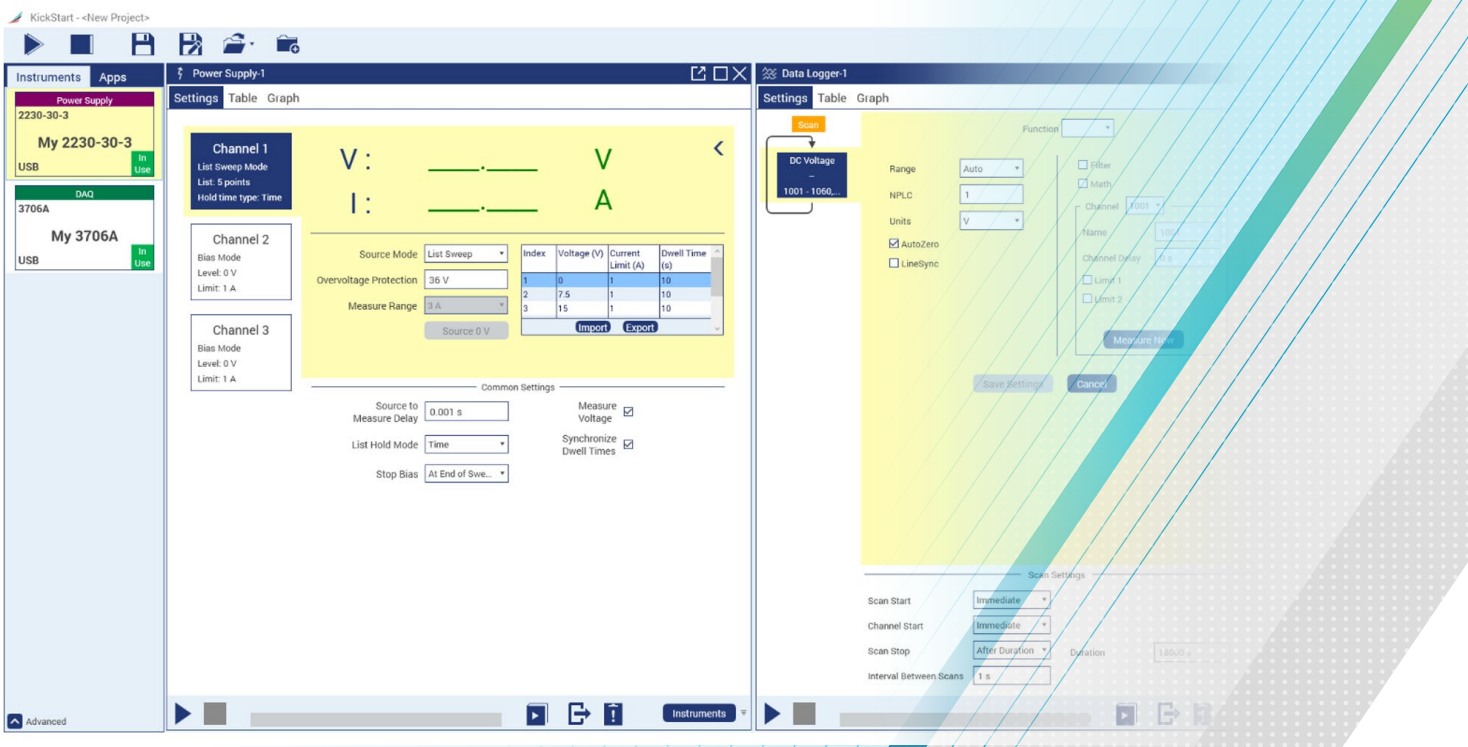
Wide Bandgap Device Reliability Testing with Keithley's KickStart Software

APPLICATION NOTE



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Introduction

Wide bandgap (WBG) semiconductors such as silicon carbide (SiC) and gallium nitride (GaN) are overtaking standard silicon devices thanks to their high-power efficiency, operation at higher switching frequencies, and promise of far lower leakage. Their increased performance makes them ideal for high energy applications where efficiency is crucial, such as drive systems for electric vehicles (EVs) or charging stations used to rejuvenate EV batteries. As wide bandgap semiconductors penetrate more applications, ensuring their long-term reliability is an important step in the device design process. Testing early in the device design is critical to identifying problem spots before the devices are packaged or make their way into a production environment. Along with high quality test equipment such as DC power supplies, data acquisition units, source measure units (SMUs), and digital multimeters (DMMs), engineers can expedite their device analysis using powerful software tools that save time in test automation and data collection. One such software package is Keithley's KickStart Software that controls a wide assortment of the aforementioned equipment and helps ensure that you can get the best results faster.

Wide Bandgap Reliability Testing

One of the main goals for these new devices is to have a longer lifespan than their predecessors while being subjected to as much as ten times the operating voltage as their predecessors, likely in high temperature environments. Reliability testing is a must to ensure that the devices are robust and dependable in their end applications.

Typical reliability tests involve stressing a batch of sample devices for hundreds or thousands of hours with bias voltages that are greater than or equal to their normal operating voltages while subjecting them to temperatures that are well beyond normal operating conditions. During this stress, a variety of key operating parameters are measured at specific time intervals. Changes in device performance may indicate a defect in the part, allowing it to be pulled for failure analysis before it gets to the end user. For more information on reliability testing see our application note Optimizing Reliability Testing of Power Semiconductor Devices and Modules with Keithley SMU Instruments and Switch Systems.

Testing Solutions

When considering a test and measurement solution for reliability testing, a few factors are important. There are two parts to a reliability testing solution: the instrument powering the device and the instrument measuring the device. A multi-channel, programmable power supply can be used to power and stress the device. The channels of the power supply can be routed together in series or parallel to increase the voltage or current output of the supply. Programmable power supplies that have sweeping functionality allow you to customize the stressing routine to fit your testing needs. Batches of devices can be connected in parallel to a single supply to increase test density as shown in **Figure 1**.

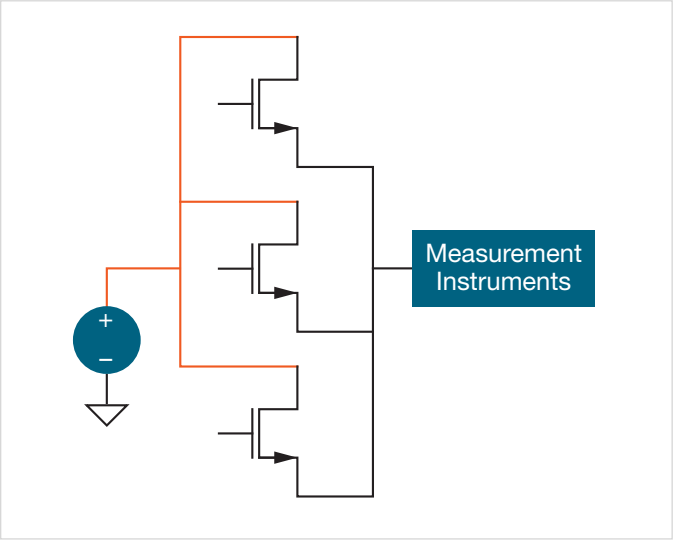

Figure 1: Parallel devices connected to a power supply.

On the measurement side, a DMM provides options to choose the level of accuracy and resolution that you need with either a 6½-digit or 7½-digit meter. DMMs can also have switching capabilities, increasing the number of devices that can be tested at a given time and decreasing overall test time. Some switch cards may be limited to voltage measurements, but current can still be measured by connecting a known value resistor in series with the device and measuring the voltage across the resistor. This configuration is shown in **Figure 2**. Multi-channel DMMs are great tools to monitor temperature, as well, during temperature-controlled tests.

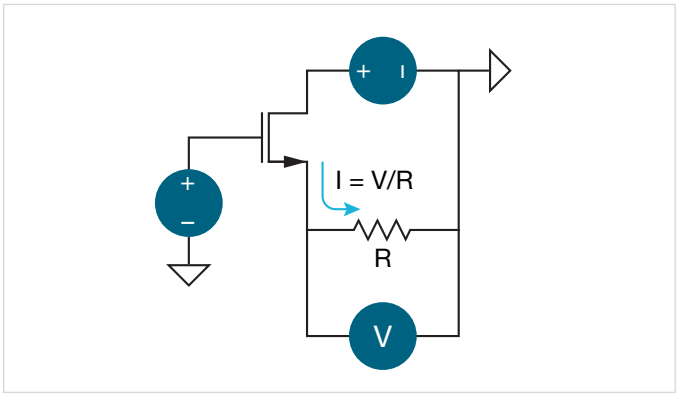

Figure 2: Current measurement using series resistance.

For applications where the device needs to be fully characterized within the stressing routine, an SMU may be the best option, as it provides the ability to accurately source voltage or current and measure voltage and current simultaneously. Like power supplies, SMUs may offer multiple channels, helping to provide a full device characterization solution for two- and three-terminal devices.

Software that controls the whole solution can ease integration and setup by automating the process. The software should be able to collect data for extended periods of time, ensuring you can view trends in the devices.

The Keithley Solution

Keithley Instruments provides high quality testing solutions that are optimal for wide bandgap reliability testing. **Figure 3** shows a selection of models to power, monitor, and characterize your device. The 2230 Series DC Power Supply has several models including the 2230-60-3 for higher voltage and the 2230-30-6 for higher current. Keithley also offers the DAQ6510, a 2-slot system with a 6½-digit DMM for monitoring and the 2657A SMU for characterization testing requiring more than 1100 V.

Power The Device

Model 2230 DC Power Supply

- 2230-30-6: 2 channels of 30 V, 6 A and 1 channel of 5 V, 3 A
- 2230-60-3: 2 channels of 60 V, 3 A and 1 channel of 5 V, 3 A
- Programmable
- Combine channels in parallel or series
- mV resolution

Monitor The Device

3706A System Switch/Multimeter

- 7.5 digit digital multimeter
- 6 slots for switch cards
- 14 switch card options
- Up to 576 2 wire channels per mainframe

Characterize The Device

2470 Graphical High Voltage SMU

- 1100 V / 1 A DC 20 W max
- Source and sink operation
- 10 fA measure resolution
- 5 inch touch screen GUI

Figure 3: Keithley solutions for wide bandgap semiconductor testing.

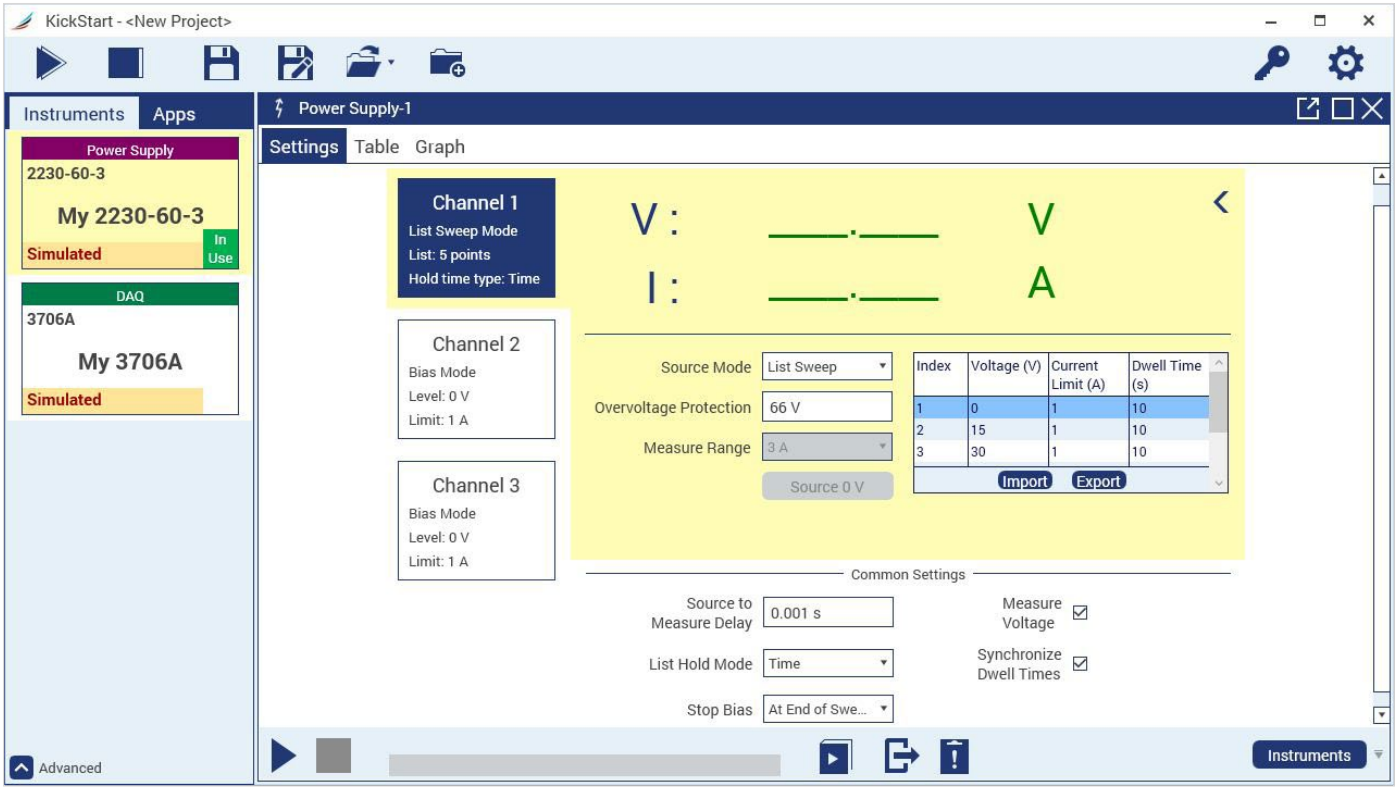

Figure 4: Configuring the 2230-60-3 DC Power Supply using the Power Supply App in KickStart Software.

Keithley's KickStart Software ties the whole solution together, with intuitive controls and long-term data collection. KickStart Software can control up to eight instruments at a time, allowing you to do more with one PC. The Power Supply App, shown in **Figure 4**, can configure each of the power supply channels individually. You can output a constant bias voltage for stressing or customize the output sequence using the list sweep function. The sweep points can be defined directly in KickStart Software or by importing a ready-made CSV file. The time for each point in the sweep is controlled by the list hold time setting. Setting this to Points sets up a number of measurements to take per step in the sweep. Changing this setting to Time allows you to set a custom dwell time in seconds for each step, truly customizing the stress sequence applied to the device.

At the same time, the 3706A System Switch/Multimeter can be configured to monitor the device behavior during stressing. KickStart Software's Data Logger App allows you to configure a scan to make voltage measurements on the desired channels as shown in **Figure 5**.

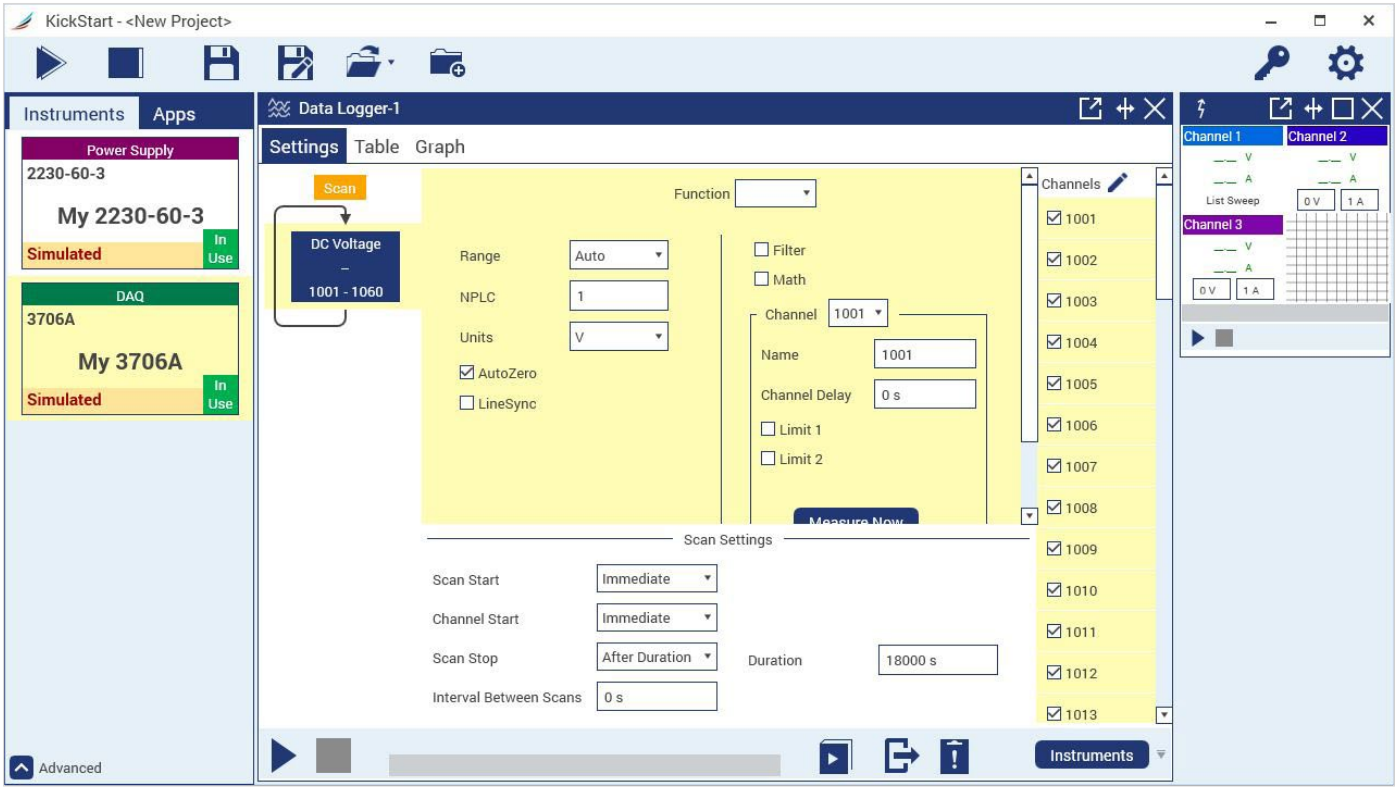

Figure 5: Configuring the 3706A System Switch / Multimeter using the Data Logger App in KickStart Software.

Reliability testing is conducted over a long period of time, and KickStart Software makes it easy to select whether to end the test after a certain number of scans have been completed or after a time duration, by using the Scan Stop setting. The interval between scans can be set to ensure the right amount of data is captured.

The I-V Characterizer App is perfect for configuring the SMU for characterization. For more information on using KickStart Software to characterize these devices, see our application note, Breakdown and Leakage Current Measurements on High Voltage Semiconductor Devices Using the Keithley 2470 SourceMeter® Source Measure Unit (SMU) Instrument and KickStart Software.

Once the stressing configuration is set up, all apps can be started at the same time by using the Run All button at the top of the KickStart Software screen. Alternatively, each app can be run individually by using the run button at the bottom of the app screen. While the tests are running, the data is returned to the built-in graph and table in real time, so you can observe trends in the data as they occur.

Conclusion

Reliability testing is an important part of the design process for wide bandgap semiconductors. Using Keithley's Kickstart Software to control your power supply, multi-channel DMM, or SMU means you can spend less time writing code and configuring your setup, and more time getting results.

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