Keysight Technologies
How to Characterize a DC-DC Converter Using a DAQ and BenchVue Software

Application Note

KEYSIGHT TECHNOLOGIES

Unlocking Measurement Insights

This application note provides an easy, step-by-step approach for measuring and plotting several characteristics of a DC-DC converter using Keysight's 34970A/72A DAQs with BenchVue software. The DAQ includes a DMM and relays, and can make measurements at speeds of up to 250 readings/second at selected measurement points.

While one example is provided, the concepts described are applicable to a wide range of devices under test (DUTs) for which multiple measurements need to be made.

Test Setup

The DUT

The DC-DC converter, used for illustrative purposes, is a buck-type regulator. It takes 48 VDC in and outputs a regulated 15 VDC at up to 5 Amps (Figure 1).

Figure 1. DC-DC converter using ST Technologies L4975A IC.

Measurement parameters

When testing a DC-DC converter, typical parameters of interest include input and output DC voltage and current, AC ripple voltage, temperature rise and power efficiency. Instruments used for this purpose include a DC power supply, DAQ with DMM and switch mux, K-type thermocouple, and an electronic load. Figure 2 shows the configuration used to make the following measurements.

- For power measurements, current must be measured using a current shunt. A 0.005 Ohm resistor is used so that the voltage drop at high current levels does not appreciably affect the input or output voltage.
- The DC voltage is measured across the device and Ohm's Law is then applied to calculate current (I = E / 0.005). Thus, a scaling factor (1/.005 = 200) is applied to produce a current value. This is then multiplied by the measured input or output voltage to calculate power. Several channels are used in the DAQ instrument to measure the various voltages as shown in Figure 2.

In these tests, the converter was not attached to a heatsink or fan, so the temperature was allowed to rise unimpeded. A fan or metal heatsinks of different types can be easily applied for further characterization. Repeatable measurements are made possible by BenchVue and the 3497xA DAQ instrument, removing a lot of the drudgery from testing.

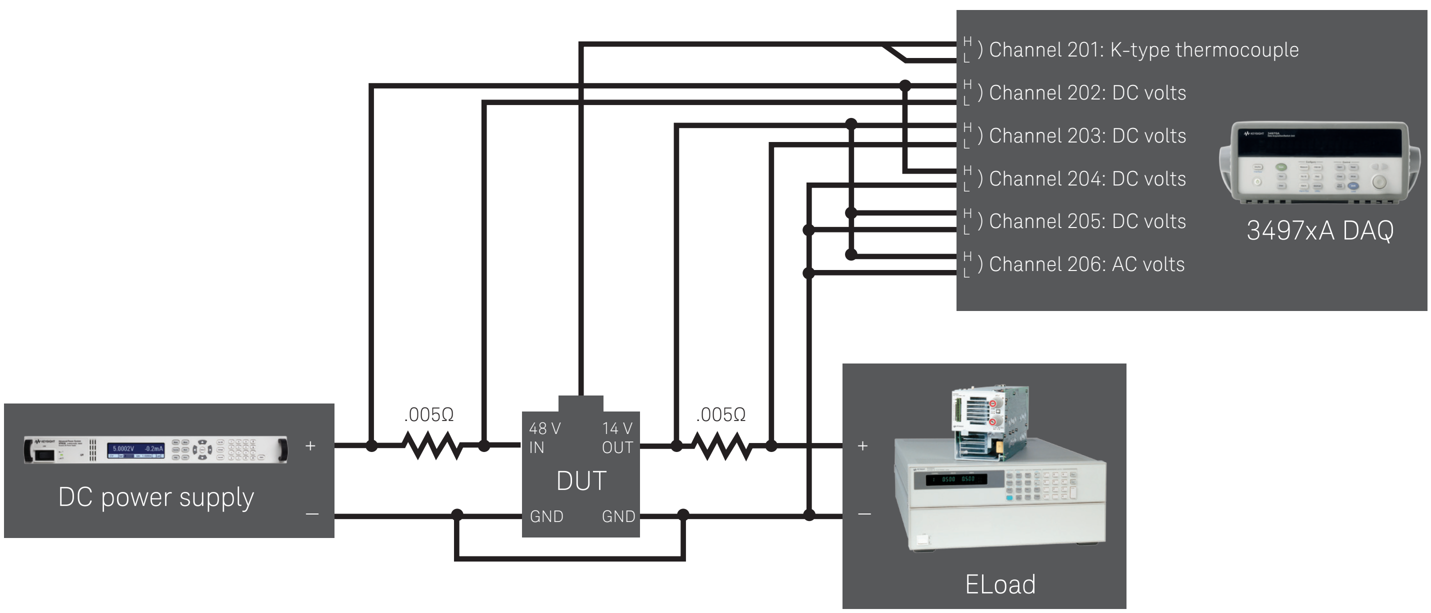


Figure 2. Test setup.

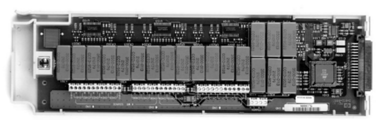
Choosing the right test equipment

Power supply

The DC-DC converter in our example was designed to provide up to 70 Watts (14 V at 5 A). Assuming that the converter has an efficiency of about 75% as expected, the power supply must be able to produce at least 94 Watts. We chose Keysight's N7953A power supply (60 Volts at 16.5 Amps) to test this device, but several other power supplies can be used which are supported by Keysight's BenchVue Power Supply Application (BV0002B).

Electronic load

BenchVue also supports several electronic load (ELoad) instruments with the Electronic Load App (BV0012B). Keysight's N3304A DC ELoad, can be used for these tests, as it can handle up to 60 Amps and up to 60 V, with 300 Watts of available load power capability.



Data acquisition (DAQ)

BenchVue's DAQ App (BV0006B) supports Keysight's 34970A and 34972A Data Acquisition and Data Logger Switch Units. Both units can use a range of modules that you can plug into one of the 3 slots on the unit.

Figure 3 provides information about the various plug-in modules. The experiments shown in this application note require three 2-wire measurements (high and low isolated from ground) and three single-ended measurements, with voltages under 300 V. Keysight's 34902A Reed Relay Multiplexer can be used because current sense resistors are used to measure current, currents higher than 50 mA will not be required. The 34702A also has high speed scanning capability, so readings can be sampled quickly, potentially catching any transients that may occur.

Product Comparison - 34970A/34972A Data Acquisition Control Unit Modules

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Product	**Description**	**Speed (Ch/Sec)**	**Max Voltage**	**Max Current**	**Comments**
34901A	20-ch. multiplexer (2/4-wire)	60	300V	1A	2 current channels (22 ch. total); built-in cold junction reference; connects to internal DMM
34902A	16-ch. multiplexer (2/4-wire)	250	300V	50 mA	Built-in cold junction reference; reed relays multiplex inputs to internal DMM
34903A	20-ch. actuator/GP switch	120	300V	1 A	Form C (SPDT) switches; no connection to internal DMM
34904A	4x8 matrix	120	300V	1 A	2-wire, full crosspoint; no connection to internal DMM
34905A	2-GHz dual 1:4 RF mux, 50 ohm	60	42V	0.7 A	1-GHz through provided BNC-to-SMB adapter cables; no connection to internal DMM
34906A	2-GHz dual 1:4 RF mux, 75 ohm	60	42V	0.7 A	1-GHz through provided BNC-to-SMB adapter cables; no connection to internal DMM
34907A	Two 8-bit digital I/O ports 26-bit, 100-kHz event counter Two 16-bit analog outputs	N/A N/A N/A	42 V 42 V +/-12V	400 mA 10 mA	Open Drain Gated, selectable input theshold Earth referenced, calibrated No connection to internal DMM
34908A	40-ch. single-ended multiplexer	60	300V	1 A	Common low, no 4-wire meas. Built-in cold junction reference; connects to internal DMM

Figure 3. Plug-in modules available for the Keysight 34970A and 34972A.

How to Use BenchVue DAQ for DC-DC Converter Characterization in 6 Easy Steps

Developed with the non-programmer in mind, Keysight's BenchVue software for the PC enables you to quickly set up, control and make measurements with multiple instruments. In our example, BenchVue can be used to control the power supply, ELoad and DAQ, but for the purposes of this application note, we will focus only on the DAQ App. With the DAQ app, you can quickly set up and measure many signals at the same time, gated by the scanning and measurement speed for each channel in the scan list. For more information about the BenchVue DAQ app features see the end of this app note.

Step 1. Module type selection

Select the switch module type (Figure 4). In this case, there is only one plug-in module in slot 2 – a 34902A 16-channel reed relay module configured as a multiplexer (scan module):

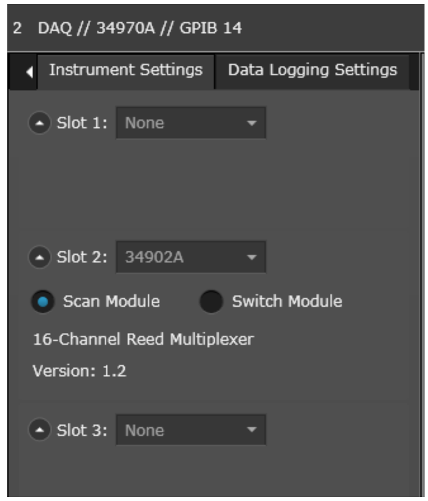

Figure 4. Mux module set up for scanning.

Step 2. Data logging

Set up data logging using the tab shown in Figure 5. In this case, scans of all the enabled channels can be manually controlled by clicking on the start and stop buttons. The time between scans is set to the fastest possible speed.

Once instrument and data logging settings have been set, these tabs can be hidden by clicking the arrow at the top, which provides more space for the channel and graphics tabs.

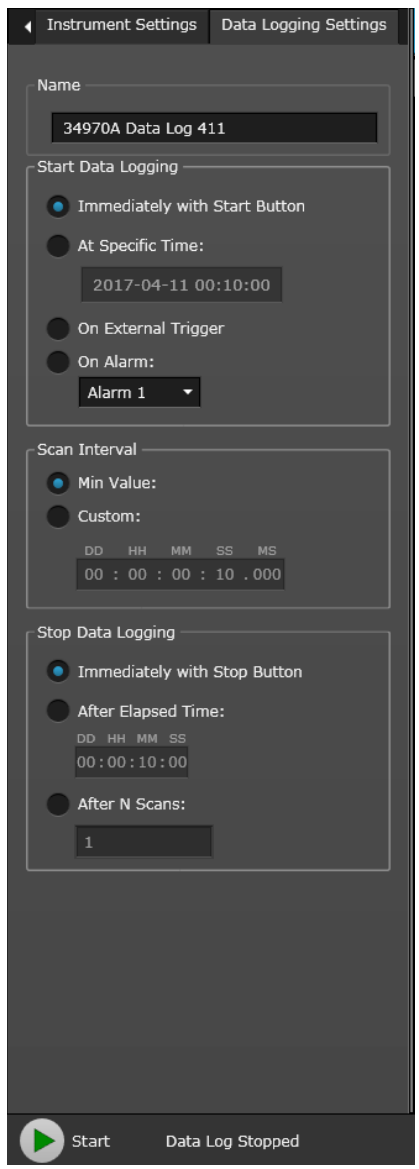

Figure 5. Data Logging setup.

Step 3. Channel configuration

Set up channels as shown in Figure 6. Channel names, measurement types, units, scaling factors and alarms can be set in this window (see red box), based on the wiring described earlier. Channels can be added to a scan list by checking the scan check box. The range and resolution can be specified in the measurement fields and scaling factors and alarms can be applied, if desired. In the example shown, the use of a 0.005 ohm sense resistor resulted in a scaling factor of 200, which changed the default units from Vdc to Adc (Amps DC). The thermocouple in channel 201 is set up to generate an alarm if the temperature goes higher than the value shown. Clicking on the more field opens pop-up windows, allowing additional parameters to be set.

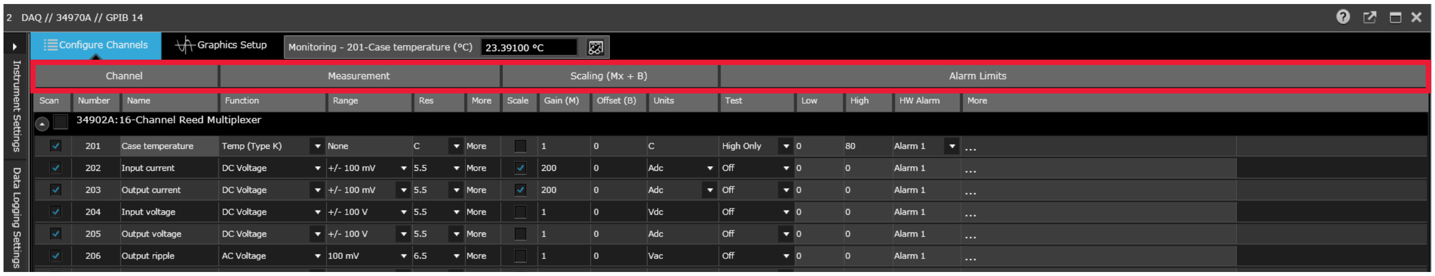

Figure 6. Channel configuration.

Step 4. Power calculations

Input and output power must be calculated. In order to do this, we recommend that you set up additional channels using the computed channel window (Figure 7). The input power is derived from the multiplication of the measured DC voltage and DC current, with the resulting units set to Watts.

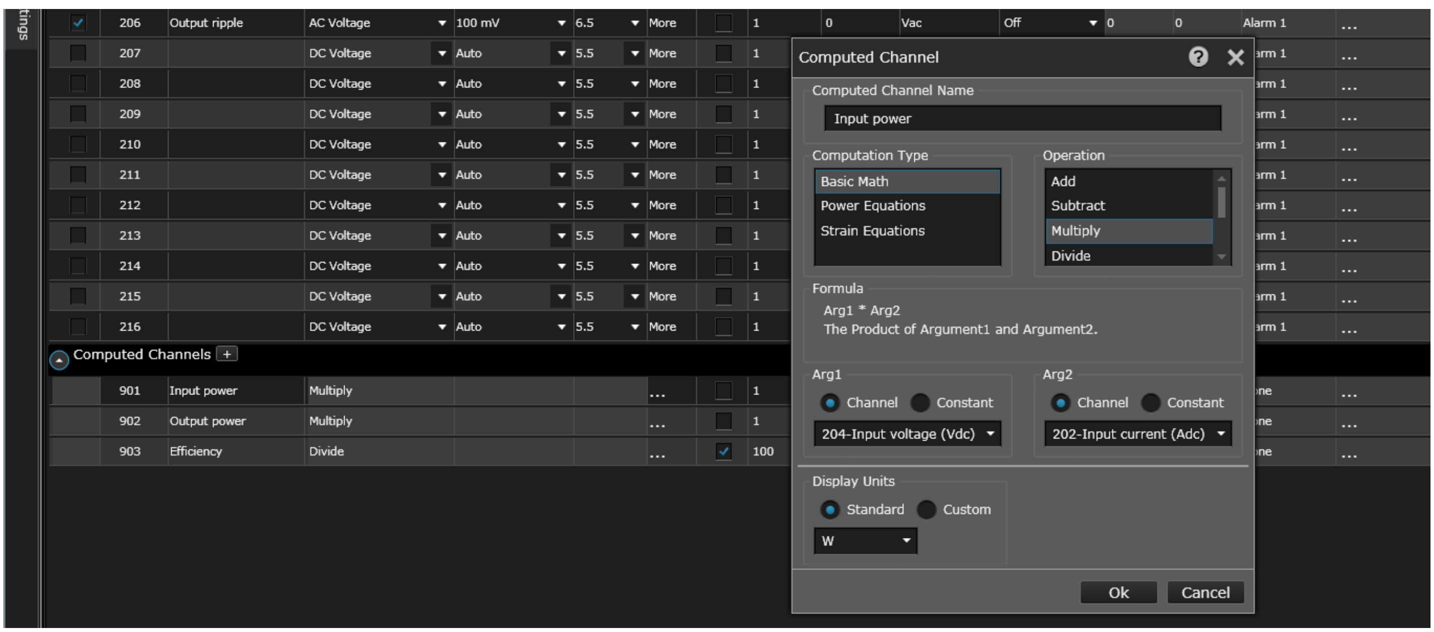

Figure 7. Input and Output Power Computed Channel setup.

We will be creating an XY chart to plot input and output current against each other (see Step 6). But first, you may want to create a strip chart, in this case one that plots efficiency vs. time : (Output Power/Input Power) x 100. So, another computed channel can be created that performs this division, applies a scaling factor (100), and sets the units to % as shown in Figure 8.

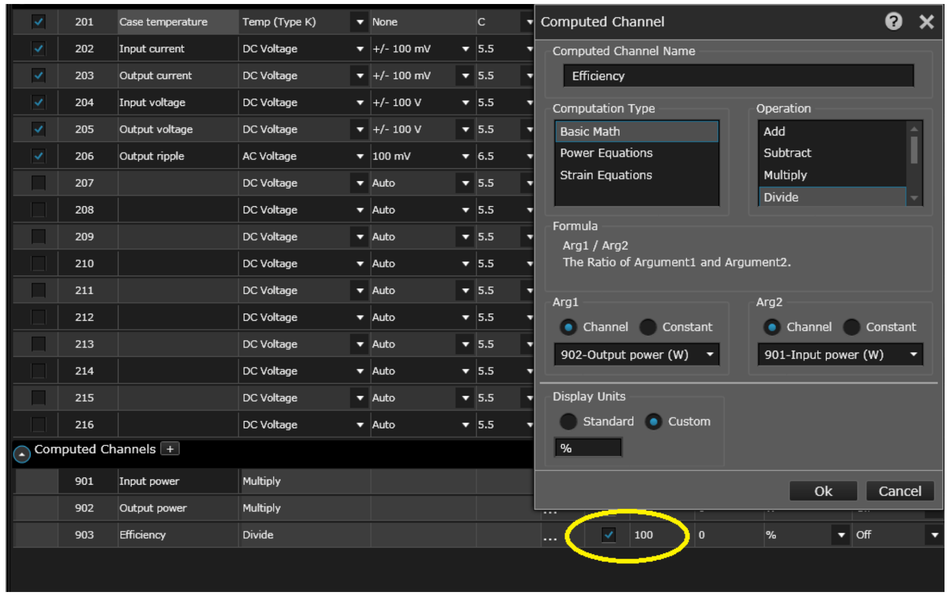

Figure 8. Efficiency in percent is computed by dividing computed powers and multiplying by 100.

Step 5. Graphing setup

Once the configuration is established, data logging can be started. Graphing is not required when logging data, but it is often used to see real-time information. The first step is to select the desired charts from the Gadgets bar on the left side of the Graphics Setup tab as shown in Figure 9. Once all desired gadgets have been selected and placed in the workspace, the gadgets bar can be hidden to provide a larger workspace.

XY Chart

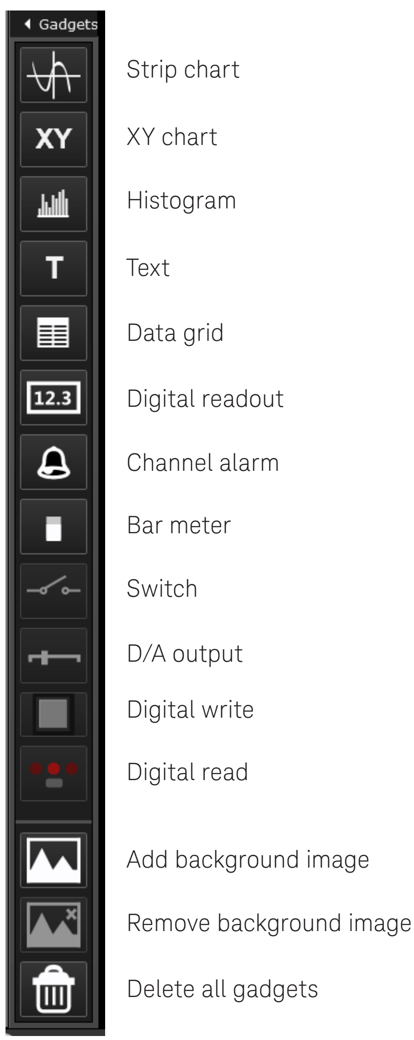

Figure 9. The gadgets bar.

When defining channels to be graphed on a strip chart, enable the Select Channels/ Markers bar as shown in Figure 10 (see red box). This tends to compress the scales above unless the chart is enlarged. After the channels have been defined, the setup bar can be hidden by clicking the arrow, proving more room to view chart data. Note that optional markers can also be defined, allowing time between markers to be measured. The left Y axis is defined as temperature, with units and degrees/ division chosen to show the expected range. The ground symbol can be used to change the offset, or the up/down arrows can be used in the channel definition area.

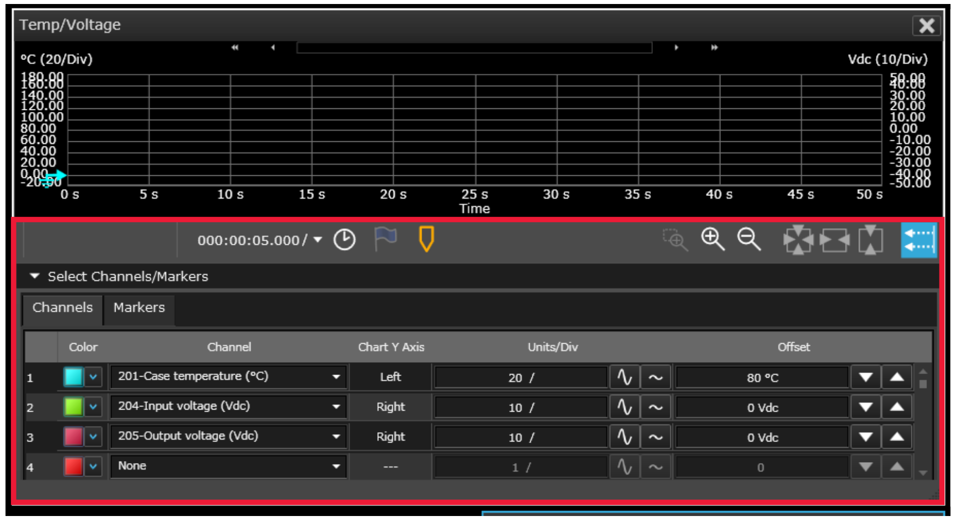

Figure 10. Strip chart channel selection.

Axes are defined by expanding the Gadget Properties bar on the right side of the workspace as shown in Figure 11. Every gadget has a different set of properties. By simply clicking the desired gadget, you can view or edit the appropriate data in the properties bar. The properties bar can then be hidden to provide more workspace area for the charts.

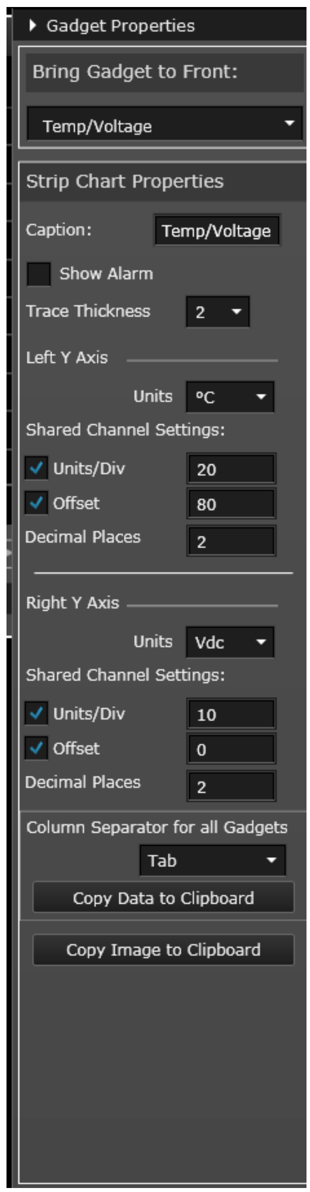

Figure 11. Gadget Properties for the strip chart.

Step 6. Gather data

When all properties are set, the app is ready to run. First, set the ELoad to 0 Amps,the Power Supply to 48 V and turn on its output. This is done by selecting the ELoad and PS BenchVue apps and setting their values, then returning to the DAQ App. Up to four instruments can be made visible in BenchVue's main window at one time, but there is so much content in the DAQ App that it is common to switch back and forth among the various apps.

Usually, switching-type DC-DC converters require a minimum load to regulate the voltage properly. Figure 12 shows a typical run, in which load current was initially zero, so the output voltage was not well regulated (note the red trace in the strip chart). When the load current was set to 0.5 Amps, good regulation occurred. An annotation was added to the chart once the datalog completed to make note of this. As an increasing load current was applied, the chip temperature increased. When it exceeded the alarm threshold (in this case, 50 °C), a red dot appeared on that measurement. Note that the measurement points are connected by a straight line. Faster measurements would make this less noticeable, but the AC voltage measurement is slow, resulting in a large delay between readings.

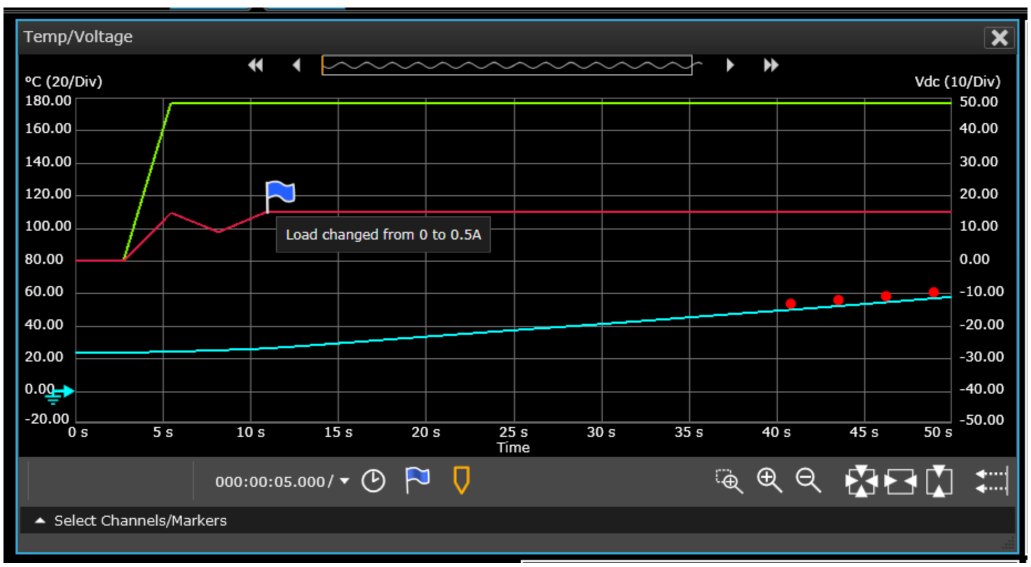

Figure 12. Strip chart showing case temperature (left Y-axis, blue trace), input voltage (yellow, right Y-axis) and output voltage (red, right Y-axis).

The input and output currents from the calculated channels are displayed on a second strip chart as shown in Figure 13. Annotations were placed on the chart after the logging was stopped, at the 0.5 A, 1 A, 1.5 A and 2 A load current points. The 2 A annotation was highlighted by hovering the mouse over the flag icon. The red section of the ripple trace indicates that the measurement was in overload. This was due to the output being unregulated while the load current was too low causing an AC voltage larger than 100 mV to be read. Hovering the mouse over the traces shows actual readings and times.

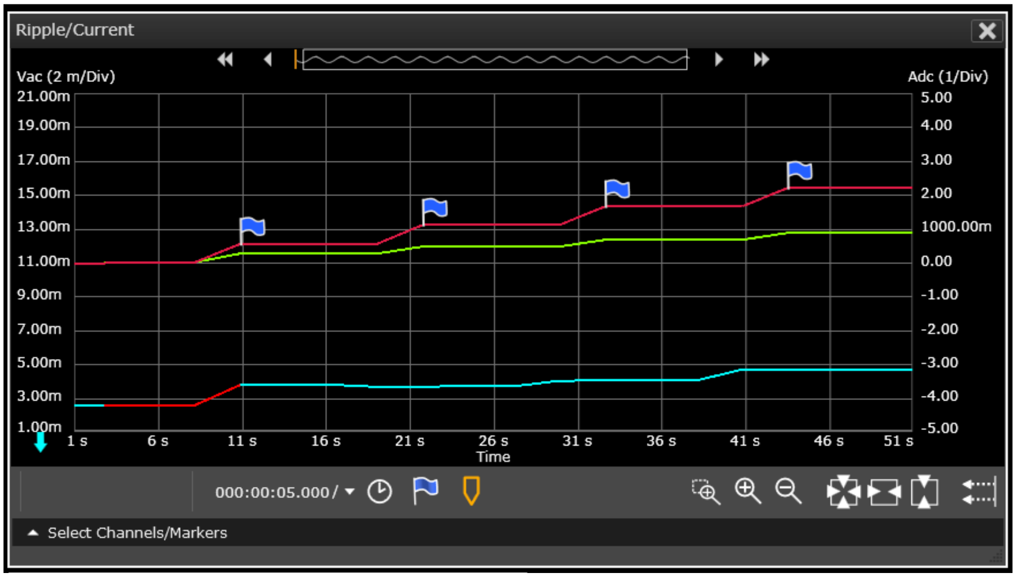

Figure 13. Strip chart showing input current (yellow, right Y-axis), output current (red, right Y-axis), and ripple voltage (blue, left Y-axis).

As mentioned earlier, another figure of merit is the input power vs. output power, and resulting efficiency. Those two charts are shown in the same workspace as shown in Figure 14. This particular DUT has higher efficiency at higher output currents. Another XY chart could be generated showing efficiency vs. load current.

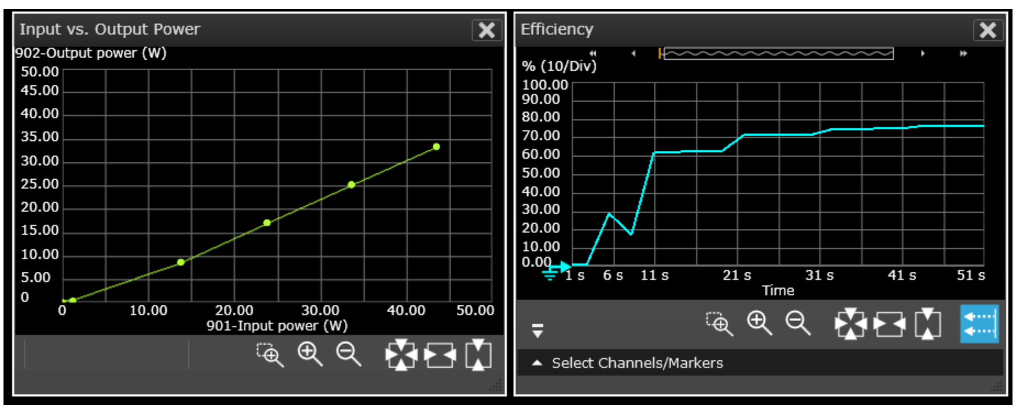

Figure 14. Power and efficiency charts.

The entire workspace is shown in Figure 15. Note that these windows have been arranged in tiles, but can be moved anywhere. They can be resized dynamically.

Figure 15. A complete view of the graphics workspace after a run.

When all measurements are completed, and even while in progress, the data can be exported in several common formats using the Export icon in the lower right corner of the DAQ App. Figure 16 shows a portion of the results of one set of measurements for the tests described.

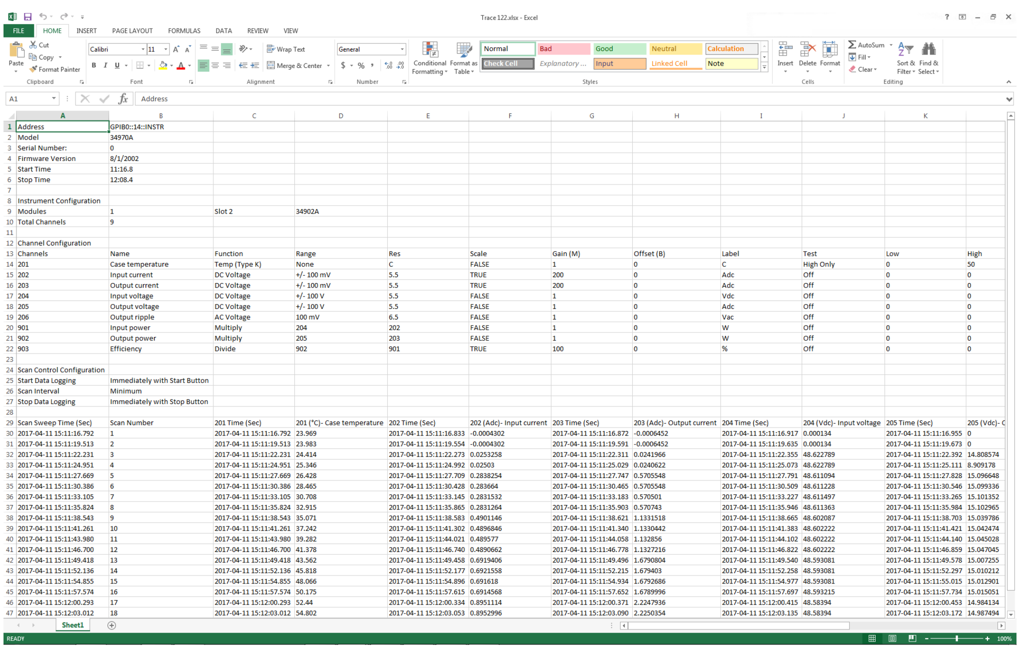

Figure 16. Data log records exported to Excel.

If for some reason data were not exported at the time of the data log, the logs can be viewed later using BenchVue's Data Manager.

BenchVue DAQ Application Features

- Define scan lists for all supported switch modules
- Select mux modules as either muxes or individual switches
- Define channels by name
- Select measurement functions (DCV, ACV, Period, Frequency, 2- and 4-wire Ohms, Temperature) per channel
- Select measurement range and number of digits of resolution per channel
- Apply any needed delays in measurements per channel
- Define measurement limits beyond which an alarm is generated (with up to four alarms), and the actions to be taken when alarms occur (stop, beep, email, execute batch file)
- Customize measured units using mx+b scale factors and apply new units to the result
- Create computed channels by doing simple math (+, –, x, /) on two channels at a time, applying new units to the result
- Monitor one channel continuously even while scanning through others
- Create strip charts with:
  - Up to 40 channels on each of up to 10 charts
  - Alarms highlighted
  - Annotations
  - Autoscale or manual scaling of axes
  - Two Y-axes, each with different units and units/div
  - Zoom capability
  - Different colors for all displayed channels
- Create XY, Histogram, Bar and Data Grid Charts
- Add Text gadgets to the workspace to describe anything
- See alarm lights at a glance
- Control individual switches on channels so enabled
- See digital I/O and DAC values on the multifunction module
- Place background images in the workspace
- Define datalogging parameters – start and stop conditions and measurement interval
- Compress unused sections of the screen, such as setup screens, to provide more space to see charts
- Export data to Excel, MATLAB and CSV; Screen images to clipboard or Word
- Save and recall instrument setups in both hardware and software
- Pause instrument communication to allow front panel use
- Designed to replace Keysight BenchLink DataLogger (BLDL 3/Pro– 34825A/34830A). Some restrictions apply – BLDL setups must be re-created for BenchVue DAQ

Conclusion

BenchVue, along with Keysight data acquisition instruments, power supplies and electronic loads, can be used easily and efficiently to generate performance data on a wide range of products, saving you time and money. The 3497xA DAQ, with its built-in high-performance DMM and selection of plug-in modules, allows scanning of multiple signals which can be plotted and observed real-time, and exported in common formats and with screen shots captured automatically. This single instrument provides multiple channels, unrestricted logging time, fewer cables, no programming, and easy setup. It allows you to focus on measurements, rather than the tools used to get the measurements.

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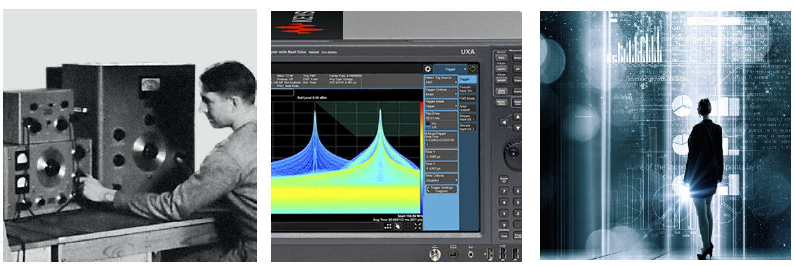

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