Bench-Top Test and Debug of Power Transient Issues for Automotive and Aerospace/Defense Applications

Application Note

Introduction

Electronic control units (ECUs) used in automotive and aerospace/defense applications need to be immune to the harsh power systems in which they operate. Power system surges and drop-outs are common, so you need to thoroughly validate your ECU to assure proper operation.

To assist ECU designers, standard ISO test specifications have been developed that replicate the power transients seen in automotive applications. These test specifications are rigorous, and the test equipment required to generate these transients is specialized and expensive. As a result, this equipment typically remains in the quality control (QC) lab, and it may not be accessible to the design engineers who need it most.

The Agilent Technologies N6705A DC power analyzer can help by providing a simple way to create a variety of transient tests that you can run at your convenience on your own bench. Using the N6705A, you can gain valuable insight into the ECU's operation prior to tying up the expensive QC test equipment.

This application note tells how you can use the N6705A to improve your designs and reduce your overall ECU power transient test times.

Power transient generation

The Agilent N6705A DC power analyzer lets you quickly and easily generate power transients to apply to your ECU under development. The N6705A DC power analyzer is a mainframe that can hold from one to four advanced DC power modules. A large selection of 22 modules is available to meet your particular requirements. You can generate up to four channels of high-speed power supply transients. In particular, the following modules are ideally suited for ECU power supply transient testing:

Model Number	Max voltage	Max current	Max power	dv/dt[1]
N6751A	50 V	5 A	50 W	33 V/ms
N6752A	50 V	10 A	100 W	33 V/ms
N6754A	60 V	20 A	300 W	30 V/ms

[1]10% to 90% transitions, full resistive load and/or capacitance up to 680 µF

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Also, available with firmware revision C.00.09 and higher are full-featured arbitrary waveform generation capabilities, including waveform sequencing features and the ability to create deep, 64-k-point arbitrary waveform signals. **Figure 1** shows a power supply reset test pulse train that is commonly used for ECU test. In this case, the N6752A module is used to create a simple pulse-train using a sequence of pulses. The device under test (DUT) was a load of 100 Ω in parallel with 10 μF. A close up of the final pulse shows a rise time of 553 μs (see **Figure 2**). Fall time (not shown) was measured to be 206 μs. Rise and fall times of approximately 1 ms are commonly called for in these types of tests.

FIGURE 1.
Power supply reset test waveform profile created with N6705A
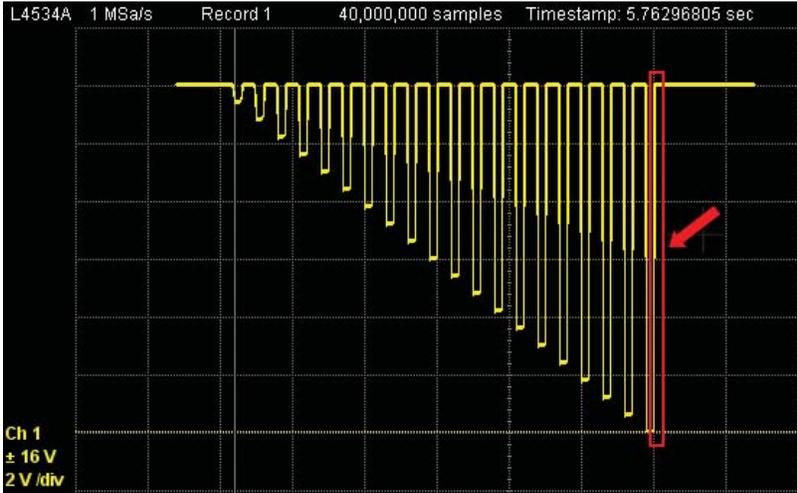
FIGURE 2.
Close up showing last drop-out pulse. Notice edge rise time is < 553 μs.

Using built-in waveform segments for easy waveform construction

Next let's explore how to generate transient waveforms for engine crank immunity testing using the N6705A. The built-in waveforms combined with the waveform sequence capability allows us to easily construct a common engine crank waveform used for ECU testing, as shown in **Figure 3**. This waveform is documented as the *Starting Profile* waveform in the ISO 16750-2 specification.

V_{batt}

12 V

V_{pp} = 2 V
V_{offset} = 7.5 V

t_{rise} = 100 ms

4.5 V

t_{fall} = 5 ms
t_{dwell} = 15 ms
t_{rise} = 50 ms

t

FIGURE 3.
"Starting Profile" transient waveform

You can create this waveform in five easy steps using the N6705A:

1. Define the waveform shape, including voltage levels, transition and dwell times and frequencies as shown in Figure 3. Count the number of individual sections — for example, in this case we have a ramp down, a ramp up, a sine wave (it doesn't matter how many cycles) and a final ramp up. Thus, this waveform has four sections (steps).

2. From the N6705A front panel, press the **Arb** button twice to view the Output 1 – Arb Selection window, navigate to the button titled Sequence and press **Enter** to select the sequence output type. Now press **Properties** and you will see the Sequence entry window, as shown in **Figure 4a.**

3. Press the **Add** waveform button three times to create a total of four steps. Modify steps 0, 1 and 3 to be type "Ramp" and step 2 to be of type "Sine." The Sequence Voltage Properties window should look as shown in **Figure 4b**.
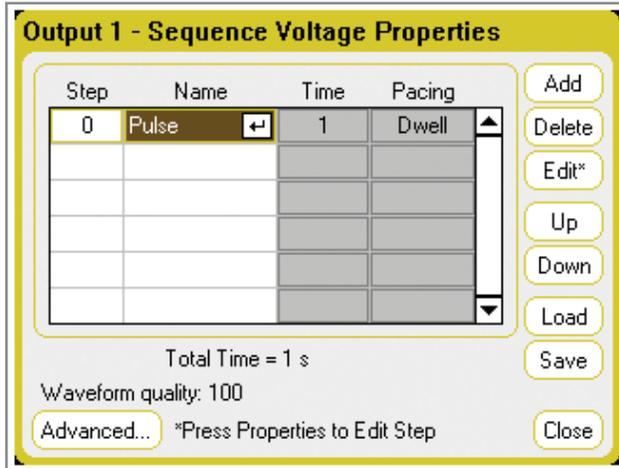
FIGURE 4A *Table showing sequence steps*
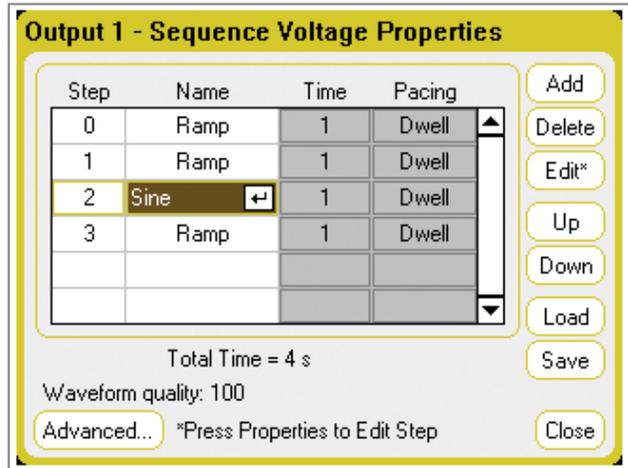
FIGURE 4B *"Add" multiple steps into sequence*

4. Now edit the steps for the waveform attributes you need. Use the navigation buttons to select the individual steps and press **Properties**. Edit step 0 through step 3 as shown in **Figure 5**.

5. When you are finished, save the sequence for future use by pressing **Save**.
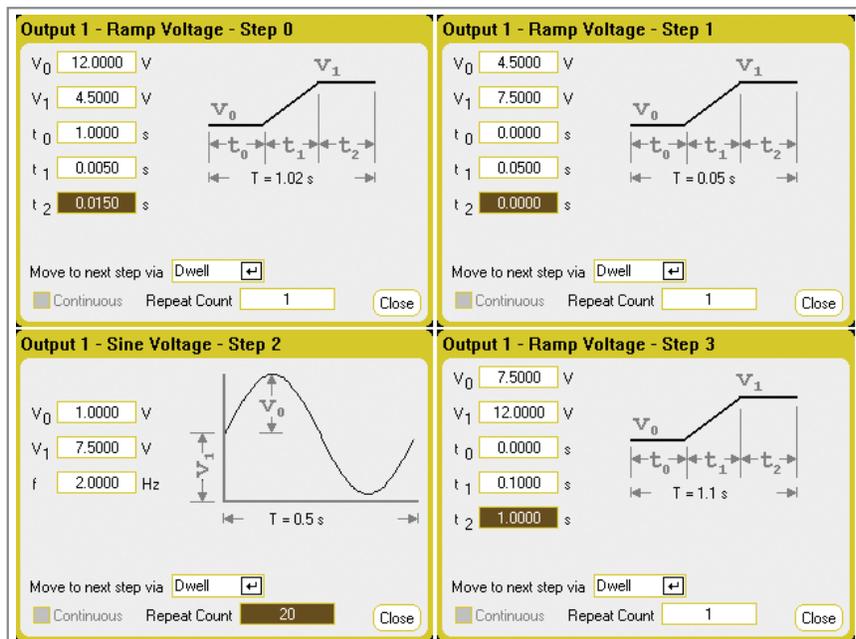
FIGURE 5. *Edit steps 0-3 with desired attributes*

If you followed these steps, you have just finished creating your waveform. To run the arb signal, set up channel 1 to 12 V, set the current limit as required and turn on the output. Next press **Arb Run/Stop**. The output waveform is generated, as shown in **Figure 6** (waveform capture using Agilent L4532A digitizer).
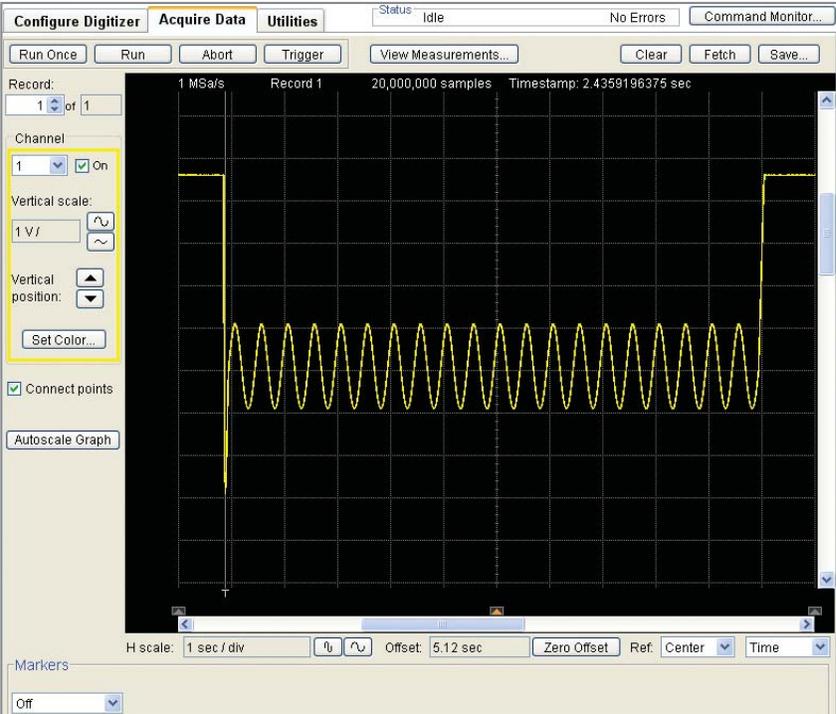
Using deep-memory arb for flexible waveform construction

How about the case where you need a more complicated waveform? Perhaps you need to generate a load-dump transient. Or perhaps you need to capture a transient, and then play it back. The N6705A with firmware revision C.00.09 and higher provides 64-k point deep-memory waveforms that you can use to create complicated waveforms.

In this example, we will create a simple load-dump type transient using the N6705A arb memory. The load-dump surge will be a maximum of 74 volts and will last approximately 150 ms. We will use the N6752A module to create the load-dump waveform. Note that the N6752A module's V_{max} is 60 V, but since the modules are all electrically isolated from chassis, they can be connected in series to achieve greater voltages (up to 240 V above chassis ground). For this example, we will simply use two N6752A modules in series. The configuration for this test is shown in **Figure 7**.

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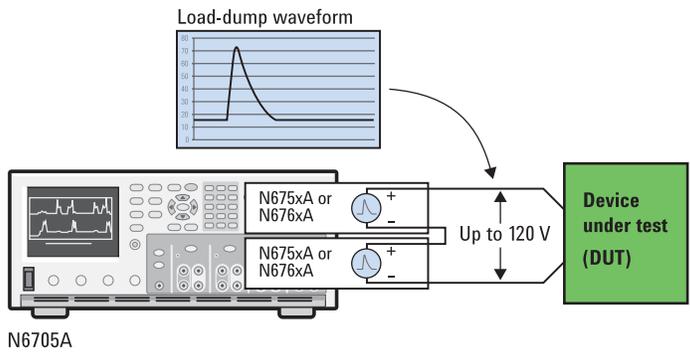
We can create the required waveform data using the simple comma-separated variable (CSV) format and import the waveform directly into N6705A memory. Use your favorite editor software to create the waveform. A convenient editor is the Agilent Technologies IntuiLink waveform editor software for function/arbitrary waveform generators. This editor allows you to easily draw waveforms and store them into a CSV file (see www.agilent.com/find/intuilink and see the editor for function/arbitrary waveform generators). In this case, we'll use IntuiLink to generate the waveform, save it in a CSV format and then use Microsoft® Excel to insert the proper header information. **Figure 8** (below) shows the resulting data that was created for this case as well as a small graphic of the resulting waveform.

Notice that since we are using two of the modules in series, the voltage in each of the modules is ½ the total. Also notice that the format of the first four lines in the CSV file is important. This waveform will be a "constant dwell" type, where the delay from point to point will be 50 µs. To declare this to the N6705A, specific keywords are required:

row 2 shows

%arbtype=arbcdvolt

and row 3 shows

%constantdwell=0.00005.
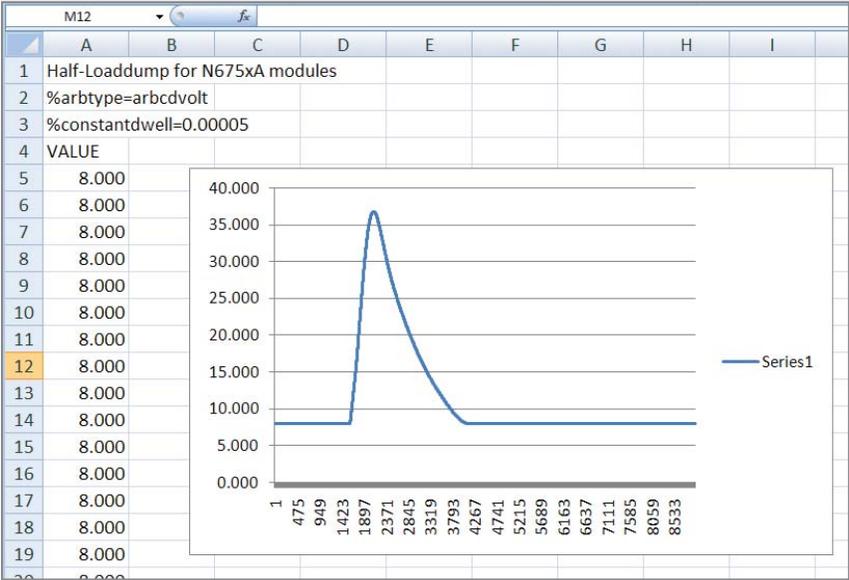
Take care to get the format for these first four rows correct, or the N6705A will not be able to import the data. Once the data is created and the formatting commands are in place, save the Microsoft Excel file as a CSV file.

Keep in mind that IntuiLink is just one option you can use. You also can simply use Microsoft Excel and its built-in functions to generate the voltage data at will. Or you may choose to use your oscilloscope or digitizer to capture live data, save it as a CSV file and play it back using the N6705A.

Importing the CSV waveform file into the N6752A as an arb function is simple with a flash memory stick. Just save the CSV file onto the stick, insert into the N6705A front panel USB adaptor plug, and using the Arb import feature import the waveform:

- Import load dump waveform to channel 1 and channel 2 see **Figure 9** (below):
  - Select **Channel 1**, navigate to the Output 1 – Arb Selection screen and select **Constant Dwell (CD)** output type.
  - Press **Properties** to open the Output 1 – CD Voltage Properties window, navigate to the **Import...** button and press.
  - Finally, using **Browse** to navigate, find the .CSV file to be used on the "External" (flash) USB drive and press **Import**.
  - Repeat the above steps for channel 2.
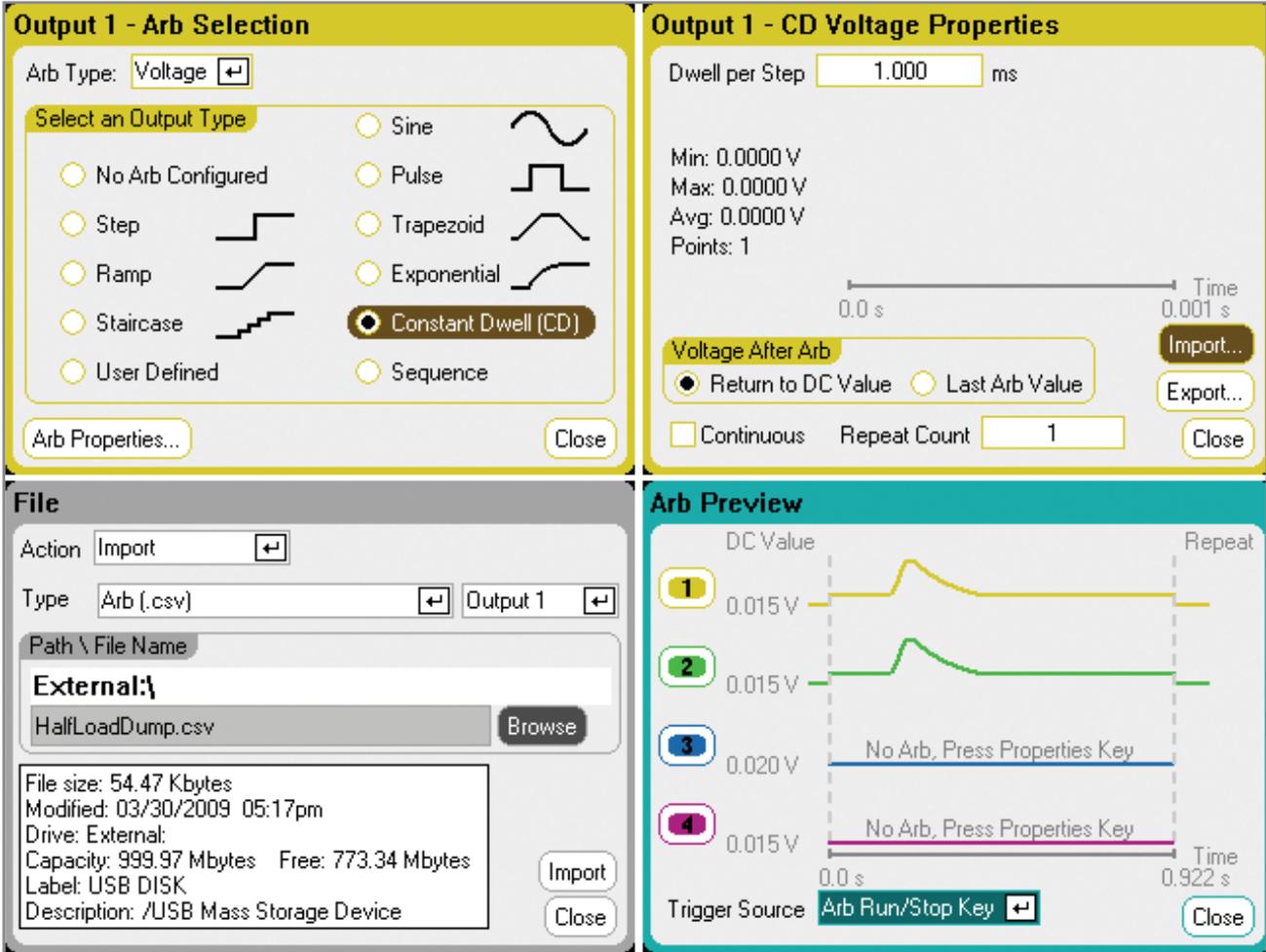
FIGURE 9. *Load-dump arb waveform configuration*

- When you return to the Arb Preview window it will show the imported waveform, and in this case, channel 1 and channel 2 will show ½ of the load-dump signal.

- Make sure the channels are both turned on. Set the output voltage to 16 V, which is the starting voltage of the arb waveform, so there is no discontinuity when the arb starts. However since we have two channels in series, the value per channel should be 8 V, not 16 V.

- Finally, press the **Arb Run/Stop** button. The output load dump pulse will be generated, as shown in **Figure 10** (below).

FIGURE 10.
Resulting load-dump waveform
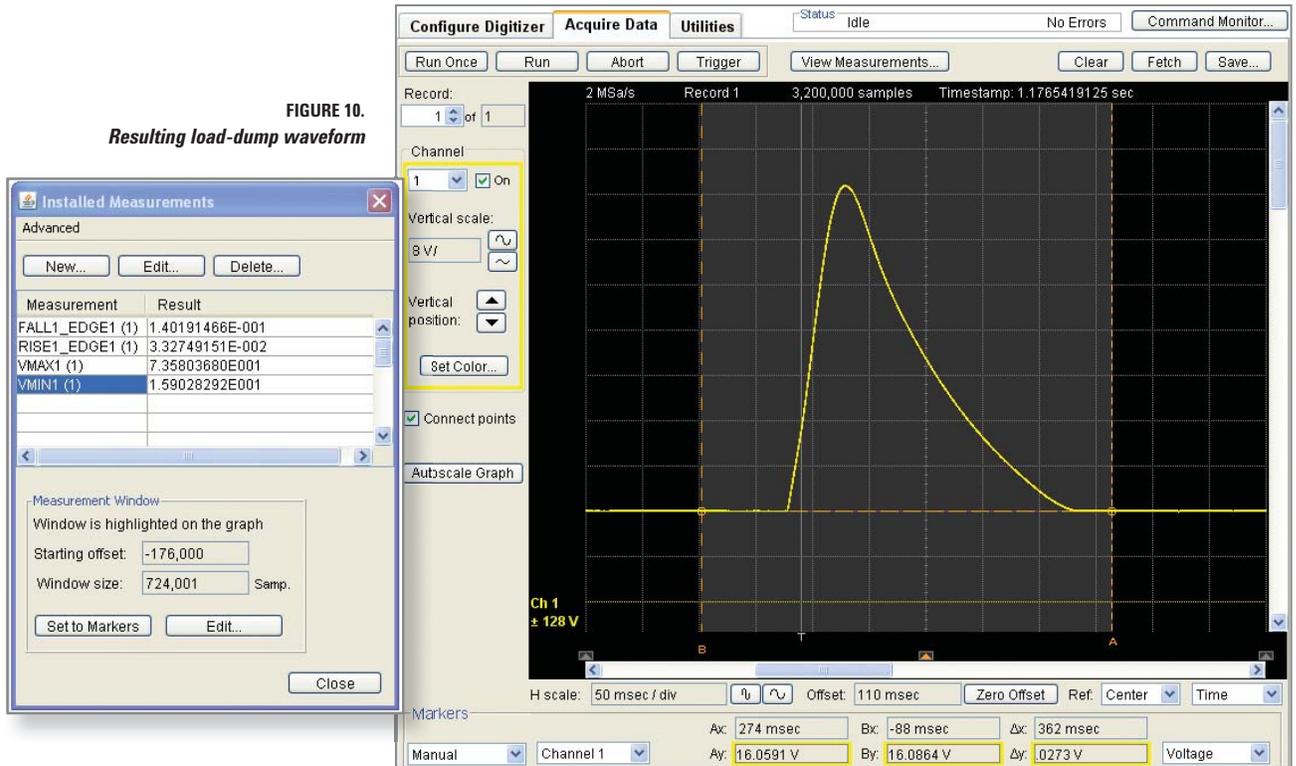
You can create and run waveforms you need for your testing using the approach outlined in this section. Start with a simple CSV file, import as a constant dwell arb, and run using the N6705A.

Conclusion

Automotive and aerospace defense ECU products operate in harsh power system environments. To successfully design for these environments, product development often takes an iterative approach: Start with a good design, complete thorough testing and modify your design as needed to meet your power immunity goals.

The Agilent N6705A DC power analyzer can help by allowing a variety of transient tests to be run at the convenience of your engineering bench. You can quickly gain valuable insight into the ECU's operation prior to tying up the expensive ISO compliant test equipment.

For more information see:

www.agilent.com/find/N6705A

www.agilent.com/find/n6705firmware

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