# [Calibrate voltage drops and interrupts before testing]

**Mike HertzLoren Dunn**,**Mark Maciejka**,**Dan Steinken**, - March 16, 2017

Poor power supply quality—in the form of dips, dropouts, and other voltage variations—can result in electrical malfunctions that can have serious consequences. To verify that automotive systems will operate properly in the presence of a voltage-supply interruption, you need to test the electronics under conditions that mimic these real-world supply conditions.

You can simulate power interruptions with a signal generator, but you must ensure that the signal generator produces the intended conditions to simulate these effects. To attain the right voltage waveforms, you must first validate the signal generator's waveform characteristics with an oscilloscope. Then, you can connect the generator to the electronic units under test. We'll show you two methods for acquiring needed data with an oscilloscope.

Typical conditions you need to test for include:

- Voltage dips (defined as a sudden reduction in voltage to a lower voltage, followed by recovery to the original voltage).
- Short interruptions (defined as a complete disappearance of supply voltage for a short period followed by a recovery to the original voltage).
- Voltage variations (defined as gradual changes of the supply voltage to a higher or lower voltage value than the rated voltage).

**Figure 1** shows an example abbreviated waveform from the standard ISO 16750-2:2012. This waveform shape is used to verify the reset behavior of devices that have reset functionality (such as microcontrollers) at different voltage drops. Note that the waveform begins at 13.55 V. In the first dip, the voltage level drops approximately 10.6% to 12.12 V where it dwells for 105 ms, then the level returns to its original 13.55 V battery level. After 0.5 s, the second dip lowers the voltage level 21.2% to 10.68 V where it dwells for 105 ms before returning to the original level. This process of decrementing the voltage dip level, then returning to source voltage continues at fixed intervals until the level reaches 0 V.

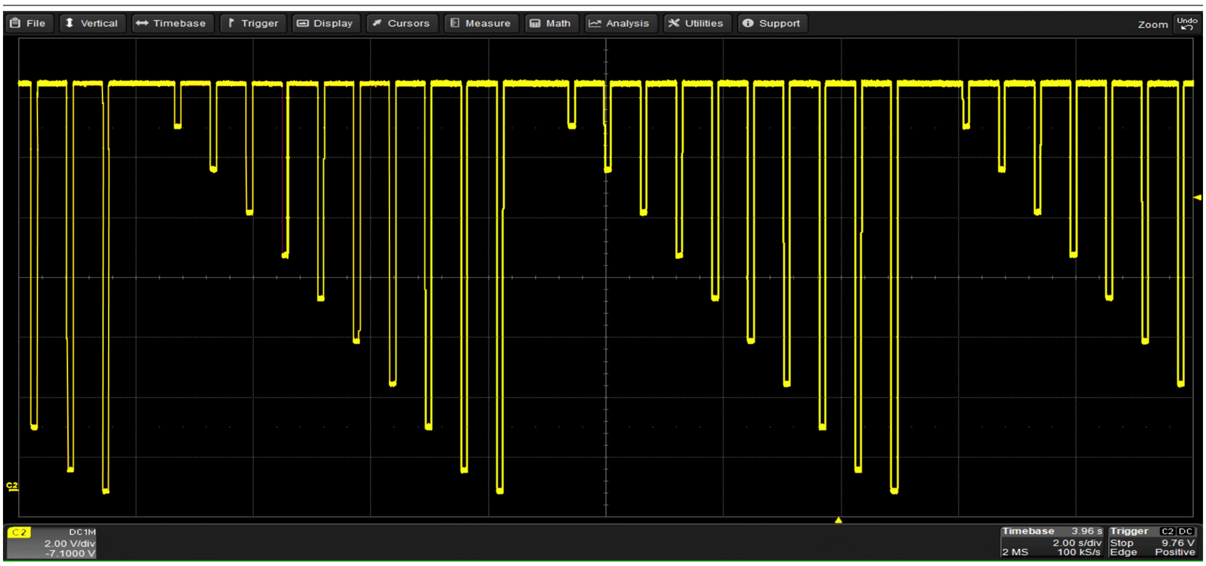


**Figure 1. Signal used for testing below-battery voltage levels drops incrementally, dwelling for 105 ms each time**.

### Runt-trigger thresholds to isolate dips

Testing the time duration and voltage-level reduction of each dip is a time-consuming and error-prone task when relying on a live operator to measure from a single waveform capture using cursors. Not only do cursors rely on the operator's hand-eye coordination, but they are also specified to yield a 2% measurement inaccuracy. In addition, significant time is lost waiting for an operator to manually place each cursor at the correct time and voltage level. Lastly, the results will only be for a single acquisition, which doesn't provide statistical significance.

**Figure 2** shows a measurement method that solves each of the problems listed above. With this method, you can use a negative-going runt trigger to isolate a specific dip level. A runt trigger is a hardware trigger selection in which the waveform must first pass through one threshold, but not cross through a second threshold, to meet the trigger criteria. By selecting a negative-going runt polarity, your trigger isolates a voltage dip that meets the criteria. Because the trigger can cause the oscilloscope to lock onto this specific dip level each time, the oscilloscope rapidly accumulates measurement statistics.

**Figure 2. Runt trigger, measurement parameters and histogram quantify the first dip both in terms of voltage and percent.**

In Fig. 2, the trigger has locked onto the first dip. With display persistence turned on, you can see that the first dip is the only dip that the oscilloscope acquires (right image). A histogram further displays quantified results with statistical significance. In this case, the histogram is plotting the distribution of pulse width along the X-axis, with the number of occurrences of each width displayed on the Y-axis (Fig. 2, right, blue). Statistics showing measurement results are tallied in the measurement parameter table (Fig. 2, right, bottom).

In addition to the measurement of negative pulse width in parameter P1 (corresponding to dip dwell time), gated measurements of voltage mean are performed with parameters P2 and P3 (corresponding to the average starting voltage and the average dip voltage). Note that by restricting the measurement region to a specific gated area, each of these parameters are correctly measuring the waveform in a very specific region of interest. Measurement parameter P4 computes the voltage drop between the starting voltage and the first dip, while parameter P5 computes the ratio between that voltage difference and the starting voltage. By multiplying by 100% (parameter P6), the voltage dip in percentage is calculated in P7 as 10.57%.

**In Figure 3**, the runt trigger thresholds are adjusted and the preceding analysis is automatically performed on the second dip in the series, including gated measurements and a histogram distribution of the dip dwell time, along with statistical quantification of the voltage level of the dip in both voltage and percentage.

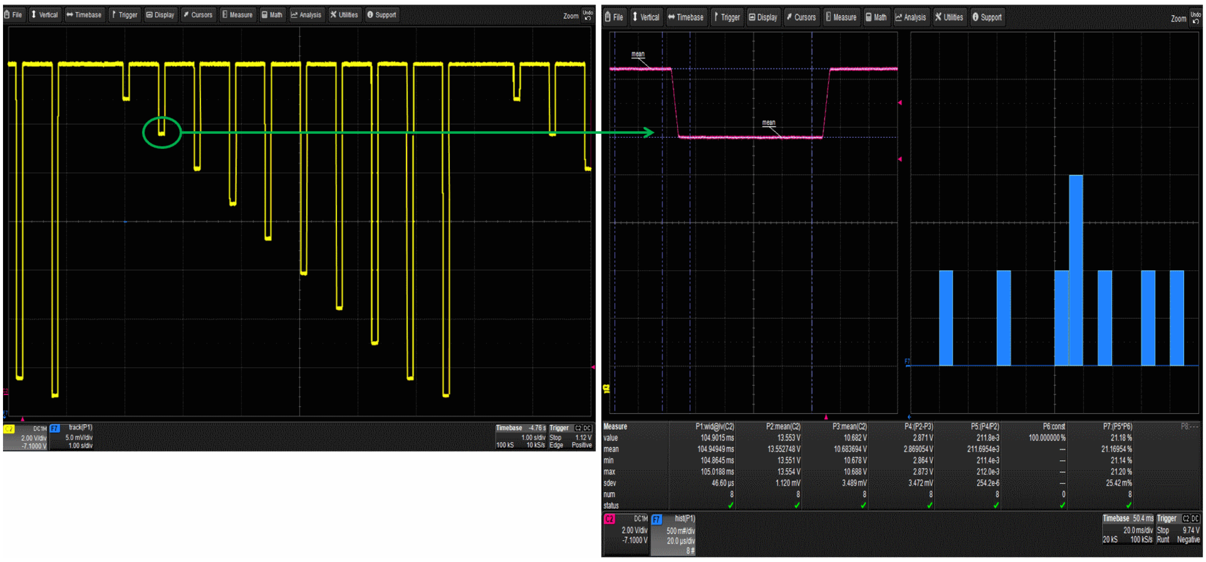


**Figure 3. The oscilloscope's runt trigger locks onto second dip and performs the statistical analysis.**

**Independent gating for mean values**
An alternative method for determining the mean values of each dip without the use of a runt trigger is to set the oscilloscope's trigger mode to edge trigger on the lowest dip. Doing so will stabilize the repeating waveform because the lowest dip in the repeating pattern is a unique trigger event. Then, multiple mean voltage measurement parameters can operate simultaneously, with measurement parameters gated independently to calculate the mean value of each subsequent dip. An example of this is shown in **Figure 4**.


**Figure 4. Edge triggering on the lowest dip lets you use multiple mean-voltage measurement parameters.**

The left side of Fig. 4 shows the gated area for the mean value in measurement parameter P1, which corresponds to the first dip with a mean value of 12.112 V. The gated measurement area shows the seventh dip in the series and the oscilloscope calculates the mean value of 3.538 V. Note that this method differs from the previous method, because it uses the edge trigger rather than the runt trigger. Thus, the oscilloscope can simultaneously measure multiple dips (**Figure 5**).


**Figure 5. The oscilloscope simultaneously measures multiple dips while the gated region of the 3.538 V dip is highlighted.**

Testing the operation of electrical devices in the presence of a voltage disturbance requires that a signal generator first be calibrated with an oscilloscope. Default methods for testing involve the use of manual cursors, which is time consuming and prone to errors. Two two techniques have been developed for validating the setup for voltage drop tests, which are both more rapid and more accurate than previous methods.

**Mike Hertz** *is a Field Applications Engineer with Teledyne LeCroy in Michigan.*
**Loren Dunn** *is Manager of the Hitachi Automotive Systems test laboratories.*
**Mark Maciejka** *is Lead EMC Test Engineer, Hitachi Automotive Systems.*

**Dan Steinken** *is a Sales Engineer with Teledyne LeCroy, based in Indianapolis.*

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