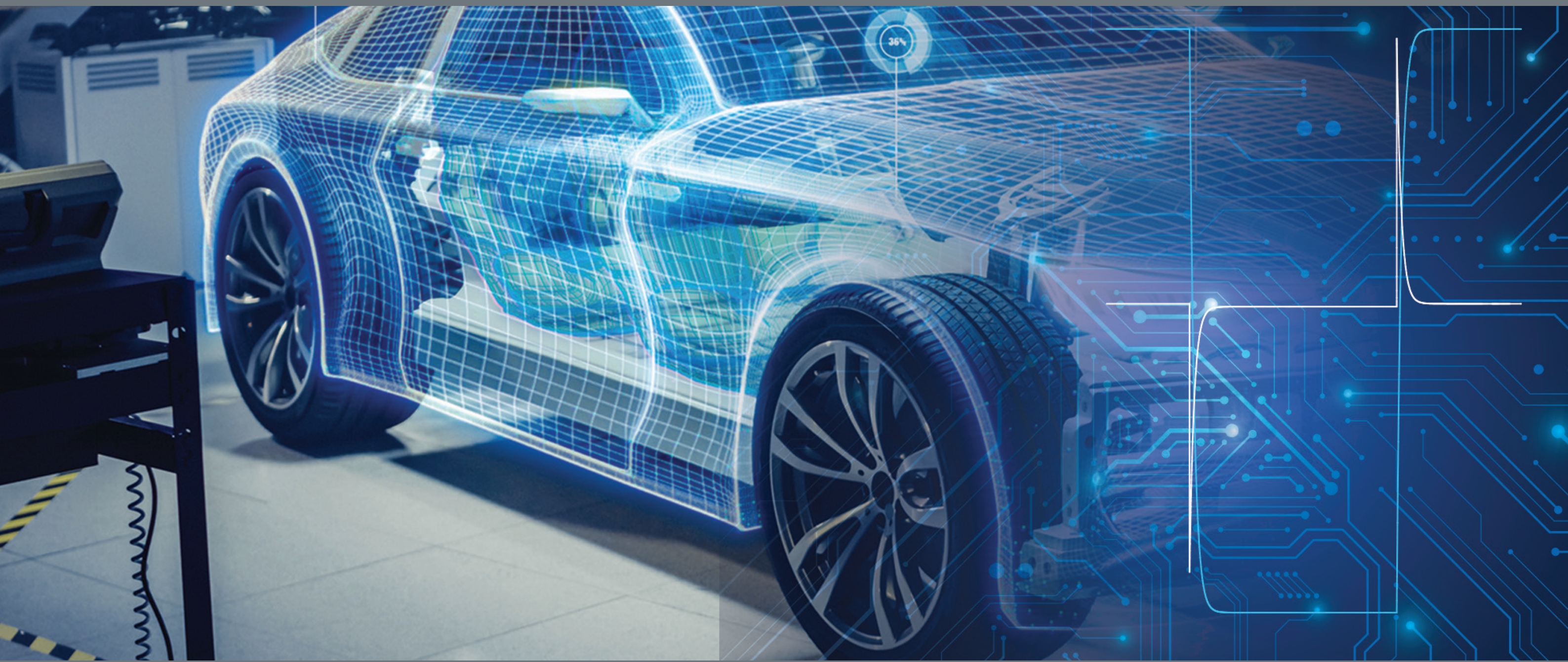
Insights and best practice

EMC COMPLIANCE KNOW-HOW



TECHNICAL NOTE 0105

DROPOUT TESTING

"ARE YOU DOING IT WRONG?"

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"We created this document to help test engineers understand the different accepted methods of performing the testing and eliminate errors that can occur while performing drop-out testing"

The challenge

Different test setups and confusion about the intent of the standard can result in different results and behavior of the device under test during the simulation.

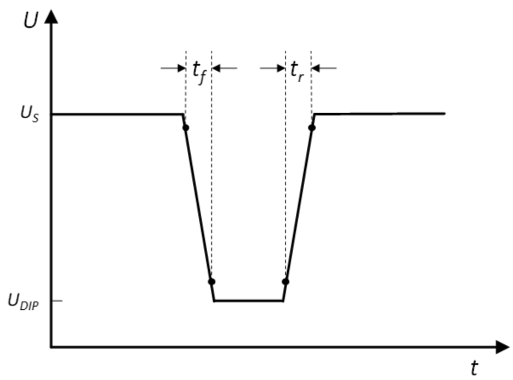
These types of testing are usually called 'dips and drops' testing. A dip is a short dip in the voltage to something higher than 0V, where a drop is when the supply voltage to the DUT (device under test) drops to zero for a defined period. There is some confusion for users about this type of testing, for which there are a large number of standards from OEM standards to international regulations like ISO 16750-2. This comes from two or three different ways of performing the testing, but also because the standards writer doesn't make their intent clear, or the user is confused about how best to perform the test according to the stated intent of the standard.

What Happens in the Vehicle

Let's start with what happens in the vehicle. Is this low-impedance (or short?) as seen by the DUT or is this an open-circuit event? Let's take for example, the commonly defined 'fuse blown in the vehicle' explanation found in some standards. This is an obvious low-impedance test as the DUT will see a sudden voltage drop caused by a short somewhere else in the vehicle (hence the fuse blowing) with a duration for as long as it takes for the fuse to blow. Conversely, an open-circuit event caused by a loose or corroded contact is, a high-impedance event if one discounts loads parallel to the DUT.

What the Standards Define Dictates Equipment Used

A dropout test is typically defined by four parameters: dip voltage, rise and fall time, and duration, but really, the rise and fall time determines what type of equipment needs to be used for that testing.



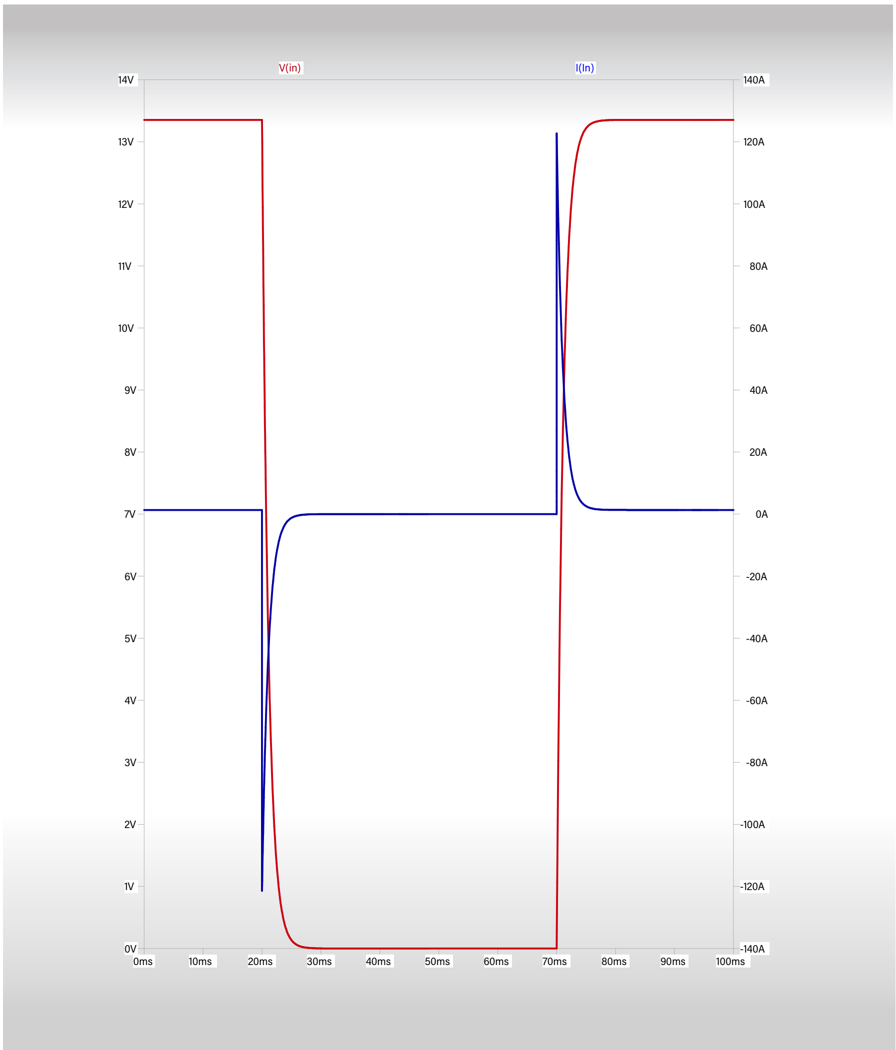
The tests come in two broad categories: fast rise and fall: 100 ns, <1 µs and slower events in the millisecond range. Despite a broad and powerful range of fast linear power amplifiers, often called battery simulators, for tests that defined a rise/fall time of less than a few microseconds, you're going to need a semiconductor switch. A switch is great in cases where the event needs to be a high-impedance problem like a loose contact, and fast switching times that drop to 0V, while battery simulators are best used when a dip voltage is desired. A battery simulator also has the added benefit of adjusting the rise and fall time: either due to some inherent setting in the source or by slowing the control signal using a programmed rise and fall time from an arbitrary waveform generator. The rise and fall time of a semiconductor switch is pretty much inherent to the design. You can also not set a current limit when using a switch, while you can with most quality battery simulators.

What Happens to the DUT?

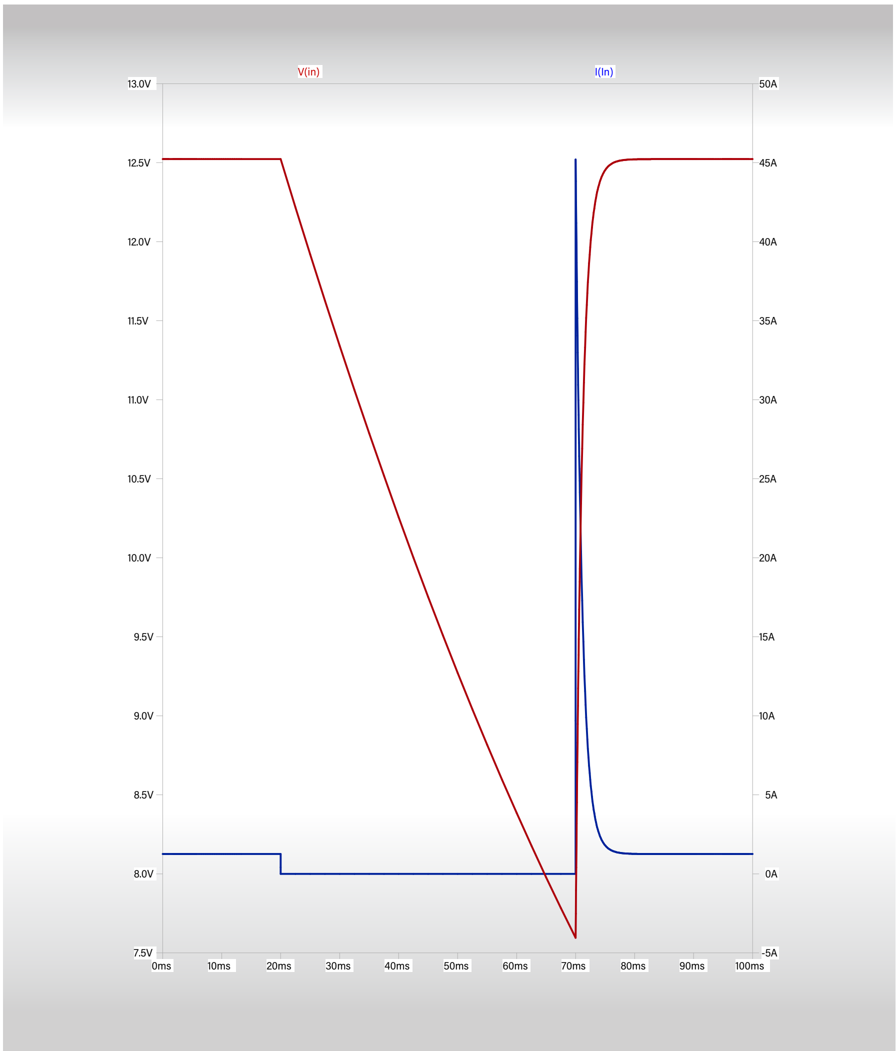
This is where it gets interesting. If the test pulse defined, or the equipment used, is a low-impedance test, the DUT will be discharged. If it's an open-circuit event, the internal buffering in the DUT can result in the internal electronics in the DUT remaining powered during the test pulse. This will obviously result in entirely different behaviors (or Status Criteria) during the test: If the power to the DUT, after buffering, drops to a certain level, the DUT will reset during the test! Also, for low-impedance testing, the faster switching time, especially the switch-off time, the higher the current will be to/from the buffer capacitors in the DUT. Depending on the input protection and voltage regulation scheme used in the DUT, massive current peaks can be experienced during the test.

The first example shows simulation of a low-impedance condition as seen by a DUT.

Here you see not only massive inrush and switch-off current, but also the supply voltage at the DUT decreases rapidly.



The second example shows a high-impedance event.



Keep in mind that all these simulations will change with different DUTs and testing methods, but one thing is obvious: with this DUT, depending on the dropout duration, there is little to no switch-off current and most importantly, the DUT wouldn't experience a hard reset with some durations. Therefore, knowing if the intent of the standard, and the behavior of the test set will help the user understand how the DUT can behave during testing. "

Are all DC Sources Created Equal?

Not at all. A future article will give more information about what 'single quadrant', 'four quadrant' and other categories mean, but it suffices to say that most power supplies are single-quadrant power supplies. This means that even if the supply voltage is switched off, the power supply has no capability to discharge the DUT. For our practical purposes, the this will act like a high-impedance switch as seen by the DUT. Also, the bandwidth is very important to the minimum switching time of the source.

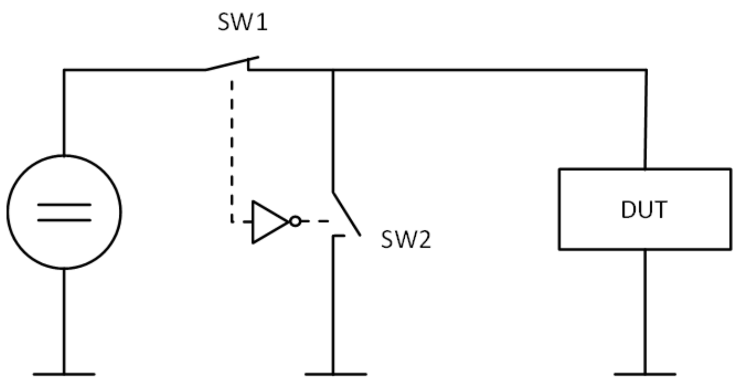
$$t_r \cong \frac{0.35}{f_{3db}}$$

where tr is fastest possible rise time between 10% and 90%, and f3db is the 3 dB bandwidth of the source. So, the higher the bandwidth, the faster the rise and fall time when using a battery simulator.

Finally, the source must have a low internal impedance Zi to properly simulate the impedance of the battery in the vehicle. It must also provide enough inrush current to avoid voltage drop due to current limits when the DUT is switched on. A future article will focus on source impedance and other battery simulator characteristics. If you want to simulate a high-impedance pulse with a four-quadrant battery simulator, you can put a forward-biased diode on the BAT+ line to block current returning to the DUT.

Are Switches Always High Impedance?

Until recently, yes. However, modern advances, driven by standards like LV 124 have demanded a new type of switch that, optionally, has a second switch negated to the main power line. This second switch immediately shorts the BAT+ to ground after the series switch is opened. These are available from both EM Test and Teseq with additional features and interesting capabilities.



Switch with Optional Negated Shorting-Circuit

Conclusion: You're probably doing it right – and wrong.

So the next time you're performing dropout testing and have a troublesome DUT, always try to consider the intent of the standards writer. Look at the specifications to try to interpret what the simulation is meant to simulate, and when in doubt, ask! Now that you know what considerations need to be made, this should help you understand how your equipment is behaving, how the DUT is reacting, and to know what to document it in the test plan. That said, both high-impedance and low-impedance events are found in the vehicle, and there are cases to be made for both.

About Tim Horacek

Tim is the Automotive Product Manager for 20 years, and expert in the ISO/TC 22/SC 32 working group. Tim has been in Test and Measurement for 30 years, starting in a military accredited calibration lab and expanding into software automation and product marketing.