Solving Unique Challenges Inherent in HEV/BEV Power Bus Testing

Introduction

The advent of high voltage DC power busses in hybrid and full electric vehicles (HEV/BEV), as well as the continued electrification of previously crank driven accessories such as vehicle HVAC, steering, brakes, and active suspension systems, brings some unique testing challenges. In particular, specifying and acquiring compact, high voltage (200 Vdc to 600 Vdc), high current sources capable of providing fast slew rate transient test signals is a potential product development bottleneck.

Typically, to simulate a fast transient DC pulse from a DC source requires a full linear or linear post regulator equipped switch mode power architecture (hybrid) supply. However, at high voltage and high currents these can be extremely large and inefficient. Switch mode power supplies (SMPS) for these power levels offer compact size and efficiency. However, because of the large output capacitance and filtering typically employed to reduce the ripple and noise from the high frequency switching conversion, slew times are fairly slow…in the several 10s or more of milliseconds.

In this application note we explore using an electronic load (eLOAD1) as a series modulation element to provide fast transient 200 A current pulses from a 400 V dc SMPS source. In essence, the eLOAD becomes an external linear post regulator that can be sized and optimized for the type of device to be tested. The eLOAD also conveniently provides a built-in transient modulator, greatly facilitating appropriate test signal generation.

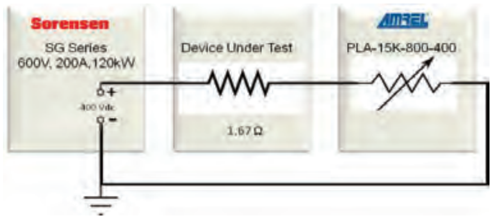
The test setup and results are presented here along with observations and considerations when specifying equipment for conducting similar testing.

Application Requirement

The application statement is simply to generate a 200 Adc pulse string or repetitive square wave signal using a 400 Vdc source. The rise and fall time is to be less than 150 microseconds.

Application Solution

The block diagram for the solution to be tested is straightforward and shown above, right:



The test setup consists of a high power Sorensen 0 to 600 Vdc, 120kW DC programmable supply set at 400 Vdc and operating in constant voltage mode. The device under test (DUT) was simulated by combining power resistors in series / parallel combination to achieve a resistance of 1.67 Ohms. The electronic load is an AMREL brand air cooled model set to operate in a constant current mode. As noted before, the eLOAD has an internal transient generator. In transient operation the eLOAD offers 7 modes: continuous, toggle, step, step auto, step once and trigger. For this test the continuous mode was used. That is, the eLOAD switched between the main level and transient level based on frequency, duty cycle and slew time as defined by the user. In this case, the current was switched between 2A and 200A at a 20 Hz rate with 50% duty cycle.

Results

In summary, the test setup achieved current pulses of the defined amplitude with rise and fall times of approximately 110 microseconds as can be seen in the scope captures in figure 1. Note that the waveforms are very clean with minimal to no overshoot.

The eLOAD transient generator was set to its fastest slew rate setting of 50 µsec. To see what impact the DUT reactive impedance was having on the rise time, the test was repeated without the DUT in the loop. Refer to Figure 2. Note that the achievable rise and fall times were cut in half. As noted previously, the DUT simulated load was made up of multiple power resistors in a series / parallel combination. In fact, there were 60, 1 Ohm resistors used. The resistors used were helical coil types so the DUT was not a pure resistive load but had an inductive reactance as well. Also contributing to the inductive component in the load circuit was the heavy cabling used to handle the high currents.

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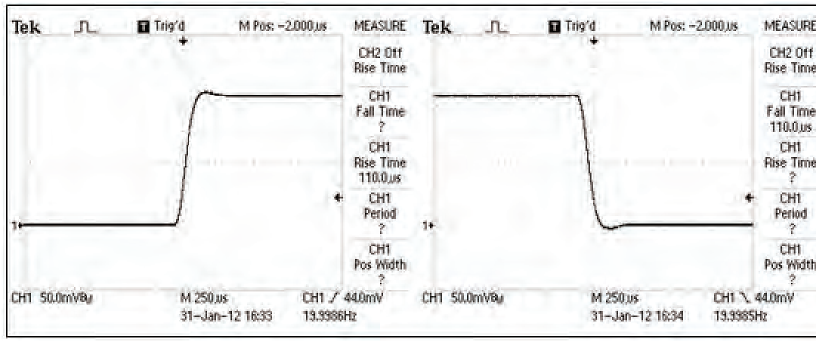

Figure 1

Current Pulse Rise and Fall Time

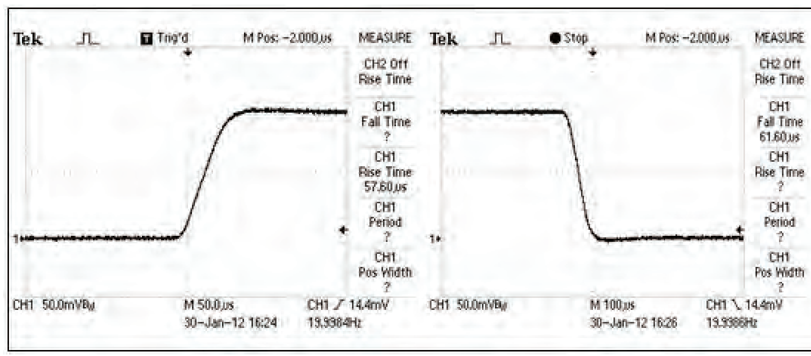

Figure 2

Current Pulse Rise and Fall Times w/o DUT in Circuit

Note: Charts use different time base settings. Refer to scope calculated rise and fall times

Conclusions

It has been demonstrated that It is quite feasible to generate high voltage, high current, fast transient test pulses using an eLOAD combined with a compact, high power programmable switch mode power supply thereby taking advantage of the compact size, efficiency and lower cost of this type of equipment when compared to high power linear sources.

Additional observations:

1. While conceptually simple, the practical high power engineering details can be fairly complex and should be discussed with a power engineer who understands the application and system requirements.

2. The use of off- the-shelf power products affords flexibility for configuring the equipment for specific test requirements. For instance:
a. The series eLOAD, when controlled in constant resistance mode, could be used to simulate a battery series resistance turning the “stiff” power supply into a battery simulator
b. When combined with appropriate switches, the system could provide charge and discharge (multi- quadrant) operation

3. Careful consideration must be given to sizing the equipment appropriately for the DUT and type of test to be conducted.

4. A detailed understanding of the DUT electrical characteristics is important in determining the limitations or test envelope that can be achieved.

About AMETEK Programmable Power Division (PPD)

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