Contact: Steve Grodt
Marketing Manager
Phone: (949) 600-6400
Fax: (949) 600-6401

25612 Commercentre Drive
Lake Forest, CA 92630-8813
www.chromausa.com

Chroma
Systems Solutions

Selecting Electronic Loads for Low Voltage High Current Applications

By Jim Dougherty

Introduction

Loading low voltage and high current DC power supplies requires consideration of both the power supply connection resistance to the electronic load as well as the electronic load minimum voltage capability. This paper provides design equations that can be used to assess the capability of an electronic load to sustain a maximum current at a minimum voltage in light of overall system resistance characteristics. Applications of how to select an appropriate electronic load given the system interconnect and cable resistances are also given. When a selected electronic load module and system resistance characteristic still does not support a specified maximum current at a minimum voltage, a solution is provided add multiple loads in parallel and to determine the correct number. A solution is also provided to add a boost supply to the configuration to provide added capability if needed and its disadvantages are discussed.

Background

Figure 1 shows a basic configuration of a power supply connected to an electronic load. In the figure, the DUT power supply is sourcing VO and the electronic load is set to sink IL. Due to finite series resistance between the power supply and the electronic load, VL is always less that VO.

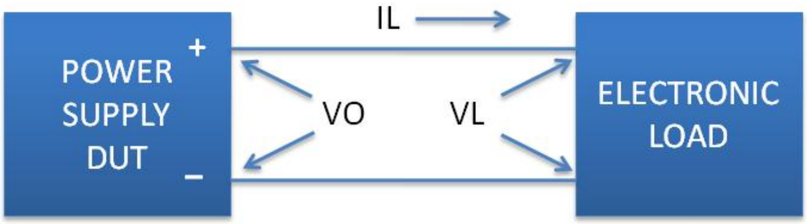

Figure 1: A dc output voltage power supply DUT configured with an electronic load

Sense connections are not shown for simplicity but are not necessary for the analysis since we are applying the load in constant current mode. The series voltage drop associated with the connections between the DUT and load, VS, is given by:

$VS = VO - VL$

And the corresponding series resistance is:

$RS = \frac{VS}{IL}$

An example ATE test station showing the elements that make up RS is shown below in Figure 2. The test station shows the various cables and interconnections that make up RS.

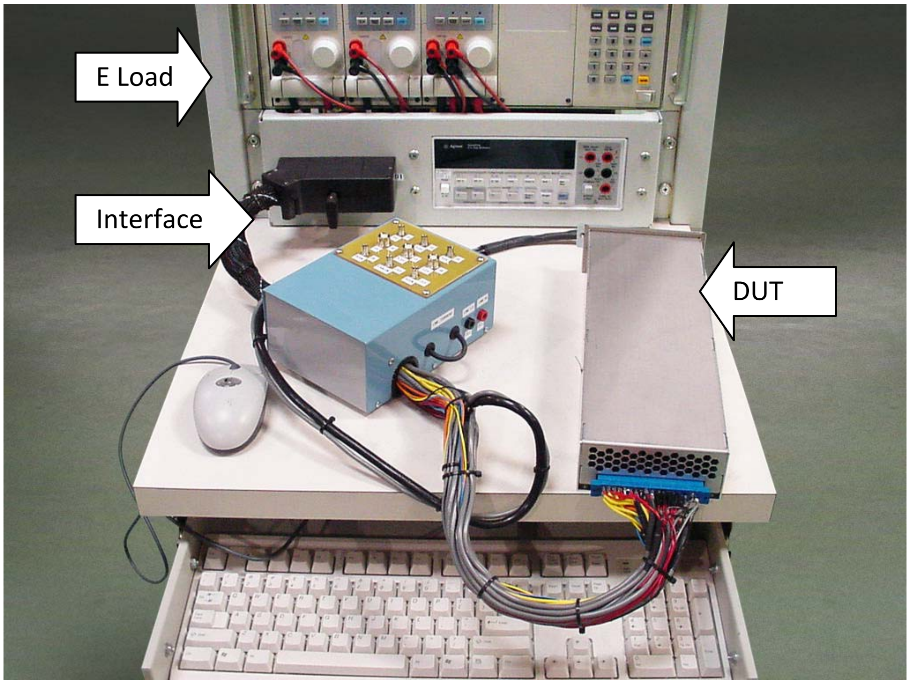

Figure 2: ATE test station showing cables and interconnections between DUT power supply and electronic load

Electronic loads are often characterized by a specification of a minimum voltage, VLMIN, which can be supported at its full load range, ILFL, at the terminals of the electronic load. This characteristic can, in turn, be restated as a load resistance, RL, by computing:

$RL = \frac{VLMIN}{ILFL}$

The value of RL can be considered constant across the entire range. The minimum DUT voltage that can therefore be supported for any given IL is given by:

$VOMIN = (RS + RL) * IL$

To achieve the lowest VOMIN for a given IL, both RS and RL should be minimized. Address the cable and interconnect resistance to minimize RS and select the appropriate electronic load to minimize RL. Given that RS has already determined, the value of RL must satisfy the expression:

$$RL <= \frac{VOMIN}{IL} - RS$$

Application Examples

Suppose you have designed and characterized your DUT interconnect and cable resistance and found that RS = .002 ohms. Furthermore assume your DUT specifications indicate that you will need to support .5V @ 60A. Applying the previous expression shows that you will need an electronic load that provides for RL <= .006 Ohms. A candidate for this application is a Chroma load module 63630-80-80 in a multi-channel mainframe 63600 which has an equivalent RL of approximately 0.005 Ohms on its 80A range. This satisfies the requirement that RL <= .006 Ohms. De-rating curves for this model and others are shown in Figure 3 below.

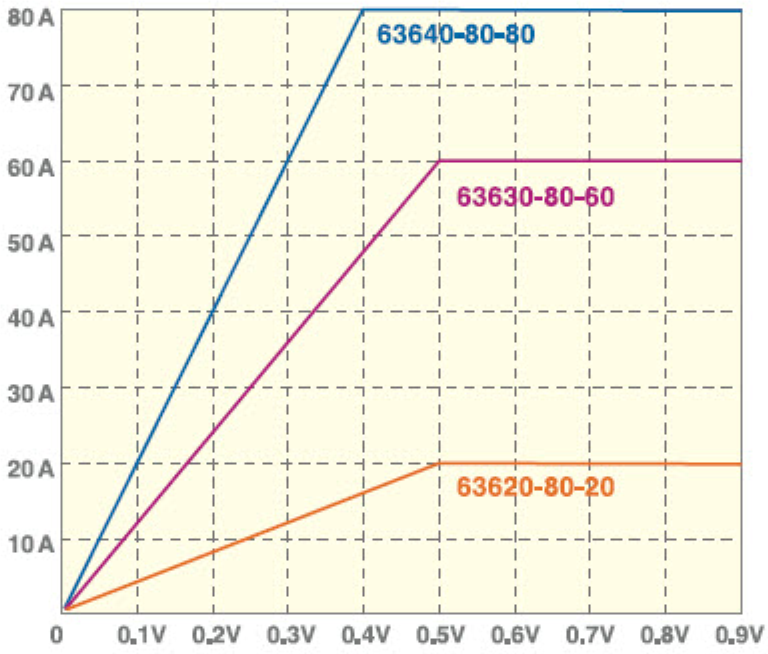

Figure 3: De-rating curves for the Chroma 63600 series electronic loads

As indicated in Figure 3, the equivalent RL can be obtained for the 63640-80-80 model by taking the ratio of .4V/80A = .005 Ohms, which is identical to the value used for the example above.

If a single load cannot support a specified minimum voltage at maximum current, you can use multiple loads in parallel. Suppose your application requires supporting .25V @ 60A and RS = .002 Ohms. The required RL is then half of the above example or RL <= .003 Ohms. Using two of the Chroma 63630-80-80 modules in parallel provides for an equivalent RL = 0.0001 Ohms which satisfies the need.

A useful multiple load application is to apply the expressions to automate enabling or connecting just the right number of loads in parallel based on setup information in software. In this manner, a multiple load system can distribute loads effectively to handle multiple output power supplies automatically.

Boost Supply

If a selected electronic load cannot support a specified minimum voltage at maximum current in light of the cable and interconnection resistances, or if zero volt-loading is required, a boost offset supply can be added as shown in Figure 4 below.

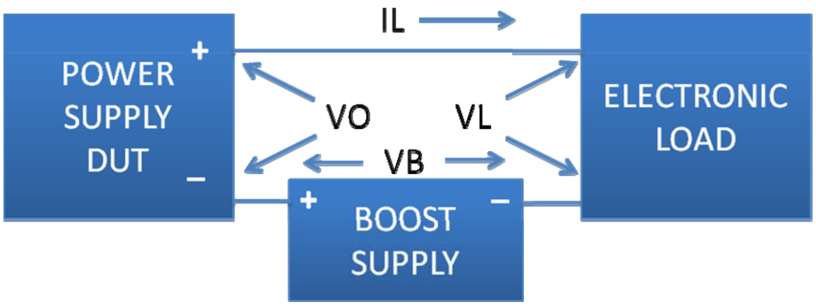

Figure 4: Boost supply configuration

For this configuration, RS is the sum of all cable and interconnection resistances in the system. The value of boost supply needed to support the load is given by:

$$VB = IL * (RS + RL) - VOMIN$$

If VB computes to > 0, a boost supply is needed according to the calculation; otherwise a boost supply is not required. The voltage across the load is approximately VO + VB so the load must now handle the power of the DUT plus the power of the boost supply and this must be considered when selecting the load model.

There are two conditions may cause damage to either the UUT or boost supply. Both conditions occur when the load is in a conductive state. First, if the boost supply is on and the UUT is turned off, the boost supply voltage appears across the UUT as a reverse voltage. Second, if the UUT is on, and the boost supply is turned off, the UUT voltage appears as a reverse voltage across the boost supply. Place a schottky diode across both the DUT output and the boost supply with the cathode at the positive terminal to protect against these occurrences.

Adding a boost supply should be considered only as a last resort for several reasons: The effective power of the load that would otherwise be available to the DUT is reduced; the inability to perform effective transient tests; noise from the boost supply affects ripple and noise measurements; and complexity and cost are increased. Therefore it is best to select an electronic load with the lowest possible de-rating profile and to manage cable lengths/ interconnection hardware, instrument locations, etc., before using a boost supply.

Conclusion

Selecting the right electronic load for low voltage high current applications requires an understanding of the DUT interconnect and cable resistances as well as how loads are specified to achieve high currents at minimum voltages. By applying the expressions in this paper, the test engineer can readily arrive at requirements for selecting the appropriate electronic load for this purpose. A boost supply may be needed if the voltage drop across the selected electronic load is not high enough to support the current but adding a boost supply should be avoided if at all possible due to its inherent disadvantages. Of course, other electronic load characteristics must be considered in order to achieve overall objectives such as current and power capability or dynamic performance, but when selecting for high current low voltage applications, this paper shows how.

End