

Keysight Technologies  
Zero Volt Electronic Load

Application Note



## Introduction

Low voltage power supply testing requirements present unique challenges that are described in this product note. Increasing demand for lower voltage power supplies is pressuring test system designers to identify electronic load test equipment designed to adequately perform at these lower voltages. Additionally, information is presented on how to configure Keysight Technologies, Inc. Electronic Loads to perform accurate dynamic loading completely down to zero volts.

## Challenges of loading low voltage power sources

Most electronic loads have limited operation below three volts. Some manufacturers claim to have “zero volt loads” regardless of the limitations. These limitations are easier to understand by looking at the simplified diagram of a typical electronic load Figure 1. The FET acts like a shunt resistor across the power supply under test. As the transistor turns on harder, it draws more current from the power supply under test. The power generated by the power supply is therefore dissipated in the load transistor. As long as the power supply output voltage is sufficient to bias the load transistor everything works fine. However, if the power supply voltage across  $V_{ds}$  is low, about 3 volts or less, the load transistor can no longer regulate the current. At the point  $V_{ds}$  minimum is reached, the load transistor is turned on to full saturation and the load it presents to the Power Supply under test is simply its saturation resistance,  $R_{dson}$ . The resultant operating curve is illustrated in Figure 2 for a standard Keysight N3304A Electronic Load. Notice from Figure 2 that below 3 volts the load can be used at reduced current but it will have poor dynamic (transient) response due to the fact that the transistor is in saturation.

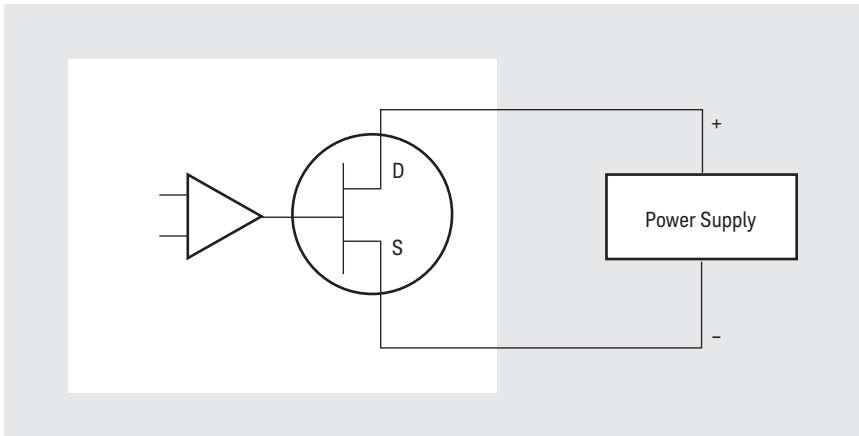


Figure 1. Electronic Load Model

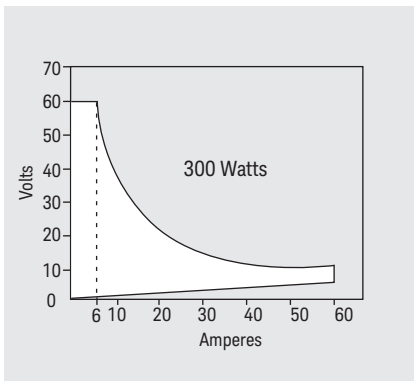


Figure 2. Keysight N3304A normal operating curve

An additional problem in testing low voltage power supplies is that the power supply may need to have a higher voltage than the load’s minimum input voltage specification. The reason is that you must account for the voltage drops in the load leads. Further complicating the issue, lower voltage power supplies often are designed to deliver substantially higher currents. In some cases it is difficult to test even a five volt high current supply because of  $I \cdot R$  voltage drops in the + and - load leads, relays, and interconnections, can be over two volts.

## A possible solution

A feasible solution to the low voltage dilemma is to insert an auxiliary boost power supply in series with the electronic load and the power supply under test as shown in Figure 3. Note that, to operate correctly in constant voltage mode, the electronic load must have its remote voltage sense leads connected across the power supply under test. The auxiliary supply can be a low-cost fixed output 3 V to 5 V power supply with current rating at least as high as the maximum peak load current needed. While this configuration will compensate for the load minimum voltage requirement and voltage drop in the power leads it has some disadvantages explained in the following configuration considerations section.

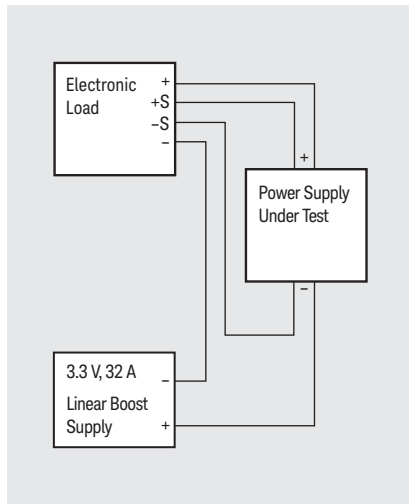


Figure 3. Zero Volt Load connections

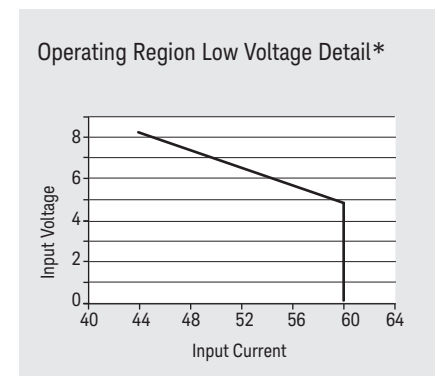
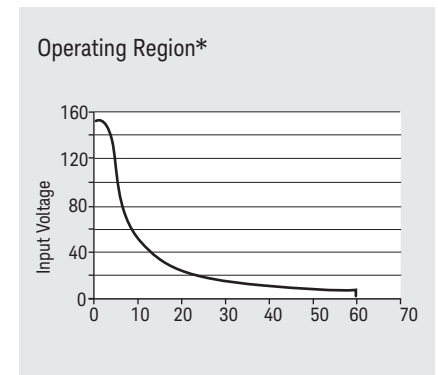
## Configuration considerations

First, any current noise from the auxiliary boost supply will affect noise measurements made on the power supply under test. This can be accounted for by selecting a supply with suitably low noise specifications.

Second, the electronic load now has to dissipate the power from both the power supply under test and the boost supply. Therefore, a higher power load may be necessary if the full rated power was originally required from the load. For example, to test a 300 watt power supply, a 300 watt load would not have enough capability to dissipate the power generated by both supplies. However, a load that is larger than the rating of the power supply under test could be used if it was rated high enough to dissipate power from both supplies. In that case, the new zero volt load combination of the load and the boost supply would have a total power rating that is lower than the original load.

Third, there is a potential that the boost supply could reverse bias the power supply under test as the voltage across the load decreases. This can occur, for example, when the power supply under test can no longer maintain its output voltage because it is in overcurrent protection mode. To protect against potential reverse biasing of the power supply under test a special detection circuit must be designed into the electronic load as described in the following paragraphs.

## Specifications



\* Curves shown reflect operation with a 3.3V auxiliary power supply not provided with a detection circuit.

## Zero Volt Loads now available

Keysight now has a zero volt load solution that includes an electronic load that can be used with an auxiliary boost power supply. This capability is included on standard models in the new N3300A family. Either way, a reverse protection circuit is added to protect the power supply under test when used with an auxiliary boost power supply. The built-in reverse protection circuitry utilizes the voltage sense capability of the electronic load to measure the voltage across the power supply under test as shown in Figure 3. The voltage information from the sense leads is used by the load to limit the current in the circuit and prevent the power supply under test from becoming reversed biased. While this solution can be used with any suitable boost supply, we have tested this solution with the 6032A and the Acopian model A3.3H3200, 3.3 volt, 32 ampere linear output power supply as a boost supply. Detailed information about the Acopian supply can be found at [www.acopian.com/single-l-goldbox-1to5vt.html](http://www.acopian.com/single-l-goldbox-1to5vt.html). Ordering information can be found at [www.acopian.com](http://www.acopian.com)

The N3304A is rated for 300 watts by itself but the total solution consisting of the load and auxiliary supply is limited to 150 watts at full current as shown in Figure 4. Total power available can be calculated by:

$$P_{\text{available}} = P_{\text{load}} - I_L \cdot V_{\text{AUX}}$$

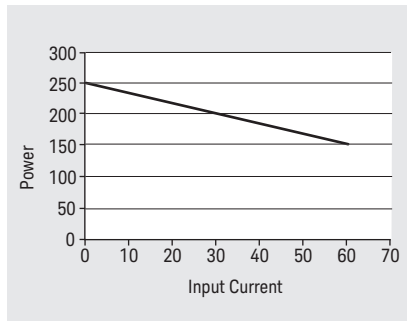


Figure 4. Power Available for Loading the Device Under Test

## Ordering information

For further information and specifications visit [www.keysight.com/find/dcelectronicloads](http://www.keysight.com/find/dcelectronicloads) for a listing of Keysight DC Electronic Loads.

For more information, call your local Keysight sales office listed in your telephone directory or a Keysight regional office listed on the last page of this document for the location of your nearest sales office.

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