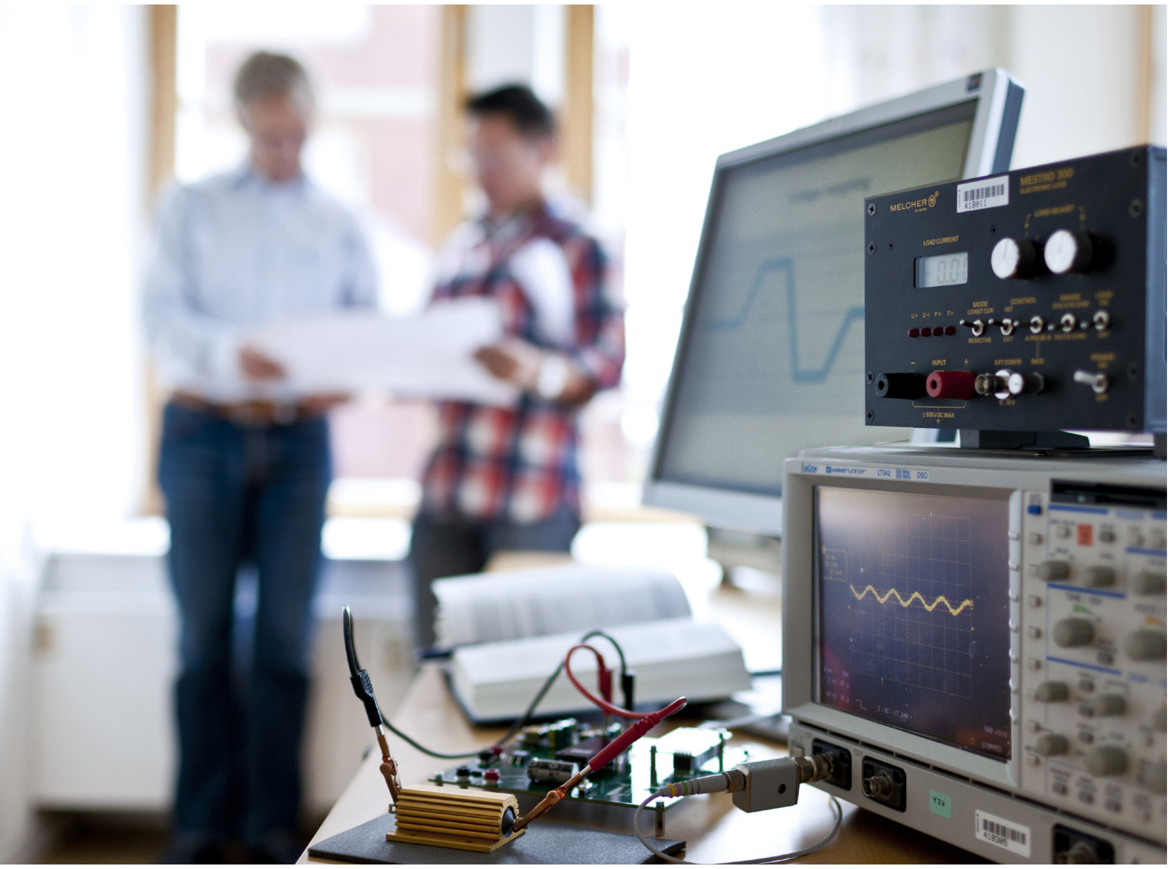
Test Methods for DC/DC Power Modules



Design Note 027

Flex Power Modules

Abstract

A user may have the desire to verify or characterize the performance of DC/DC power modules outside the system environment. This design note addresses techniques and considerations for accomplishing such testing, and should be used in conjunction with the Technical Specification for the particular product being evaluated as well as other Flex design notes that will be referenced. Contents include precautions that should be kept in mind when testing DC/DC power modules, the appropriate test setup and test equipment, and a procedural outline for performing many of the most common types of tests. By following the guidelines presented here, valid test results that may be compared to the parameters listed in the product Technical Specification will be obtained.

Precautions

Flex DC/DC power modules are reliable and robust when used within their design ratings. Testing DC/DC power modules in a bench top environment is in some respects more difficult than monitoring their performance within a system since specialized interconnections and adjustable power sources and test instrumentation are typically used instead of the well-defined interfaces of the system application.

Care must be taken to insure that all of the connections to the DC/DC power module are correct and that external power sources are adjusted properly prior to application of power to the product.

If these safeguards are not followed the product may be damaged or the personnel conducting the test exposed to potentially hazardous situations. Specifically, the following precautions should be taken:

- Be absolutely certain that the input and output connections are correct, including the input and output return configuration and polarity, the remote control signal if used, and the remote sensing connections. The pinout diagram and typical application circuit specified in the Technical Specification may be used as a reference.

- Flex DC/DC power modules do not contain internal fuses on the input. Make sure that the voltage source used to power the product contains either a fuse or electronic current limiting set to the appropriate value to protect the product and the interconnecting wiring.

- Before applying power to the product, make sure that the input voltage source is set to the appropriate voltage for the test being performed and is not above the maximum input voltage rating of the product.

- Unless evaluating remote sense performance, the remote sense pins should be jumpered directly to output pins as close to the product as possible.

- DC input and output voltage measurements should be taken with both positive and negative test leads positioned directly at the interface pins to prevent any voltage drops in high current circuits from adversely affecting the readings.

- Depending upon the power level being used for the test and the design of the product, cooling air may be required to prevent the over temperature protection from being activated and nullifying the test. A small fan positioned to blow air directly across the product should satisfy this requirement. Consult the thermal design information in the product Technical Specification to determine if external cooling will be needed for the particular product and test conditions being considered.

- Do not touch the DC/DC power module's baseplate or components when power is applied to avoid contact with high voltage levels or potentially harmful temperatures. Even after power has been removed, the baseplate may sustain an elevated temperature a number of minutes.

Test Setup

Details of the test setup will depend upon the nature of the test being performed and on the DC/DC power module type being tested. The product Technical Specification should be used as the final authority to determine the test conditions and the required setup and test equipment. Some generalized test setup guidelines, that can be useful for many tests and product types, are shown in Figure 1. In addition to the precautions listed above and the details specified in the product Technical Specifications and other references, the following items should be kept in mind when designing the test setup:

- An electronic load is normally the preferred method of loading the product. Compared to resistive loading, it is easier to set up and much more flexible.

- Unless specified differently in the Technical Specification, a good general value to use for the input capacitor, C_1, is 1 µF per watt of input power. For example, with a product drawing 60 W a 60 µF capacitor would be used.

- C_2 and C_3 are standardized values of capacitance used directly at the oscilloscope probe for the purposes of obtaining repeatable ripple and noise measurements as will be discussed later in this design note. A typical application would include much more output decoupling capacitance than this – up to perhaps 100 µF per amp of output current. For many tests, such as turn-on and turn-off waveforms, dynamic loading, etc. additional capacitance may be added if the intent is to simulate the system application as closely as possible. Although C_2 and C_3 should be directly at the probe point and as close to the product as possible, the position of the bulk decoupling capacitance is less critical and can be located further away at the load device.

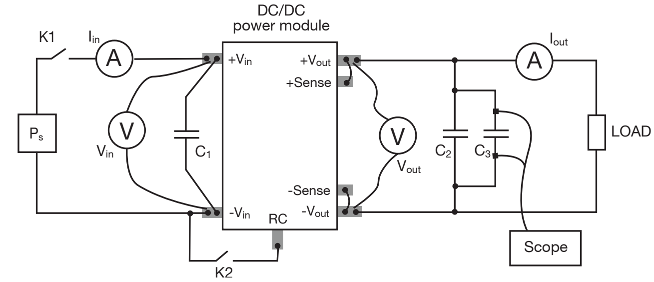


Figure 1

Performance Verification

Unless otherwise noted, the test descriptions below assume that the generalized test setup of Figure 1 is being used and that all of the connections have been properly made and the power sources and adjustable components set to the proper nominal values.

Turn-on Input Voltage
Adjust the load to the desired value – usually either minimum or maximum. While monitoring the output voltage, slowly increase the input voltage from zero until the output voltage comes into the specified regulation range. Record the input voltage.
The measured input voltage should be within the range specified in the product Technical Specification.

Turn-off Input Voltage
Adjust the load to the desired value – usually either minimum or maximum. With the input power source set to a voltage within the input range of the product, turn on the power. The output voltage should be within the specified regulation range.
While monitoring the output voltage, slowly decrease the input voltage until the product swiches off. Record the input voltage.
The measured input voltage should be within the range specified in the product Technical Specification.

Start-up
Adjust the load to the desired value – usually either minimum or maximum. Set the input power source to the desired voltage within the input range of the product, usually minimum, nominal or maximum. Monitor both the input voltage to the product and the product output voltage by means of two channels on the oscilloscope. Turn the product on either by applying the input voltage or by switching the remote control line. Measure the time difference between the input and output waveforms at the

voltage points identified in the product Technical Specification. Record the start-up time. The measured start-up time should be within the range specified in the product Technical Specification.

Shutdown

Adjust the load to the desired value – usually either minimum or maximum. Set the input power source to the desired voltage within the input range of the product, usually minimum, nominal or maximum, and power up the product. Monitor both the input voltage to the product and the product output voltage by means of two channels on the oscilloscope. Turn the DC/DC power module off either by removing the input voltage or by switching the remote control line. Measure the time difference between the input waveform and the output voltage dropping to 90% of its nominal value. Record the shutdown time. The measured shutdown time should be within the range specified in the product Technical Specification.

Line Regulation

Adjust the load to the desired value – usually either minimum or maximum. Set the input power source to a value within the input range of the product and power up the product.
While monitoring the product output voltage, slowly vary the input voltage between the specified minimum and maximum values. Record the maximum difference in the output voltage between the two extremes of input voltage. The measured output voltage change should be within the range specified in the product Technical Specification.

Load Regulation

Adjust the load to a current value within the specified range.
Set the input power source to the desired value – usually minimum, nominal or maximum rated voltage. Power up the product. While monitoring the product output voltage, slowly vary the output load between the specified minimum and maximum current values. Record the maximum difference in the output voltage between the two extremes of output load current. The measured output voltage change should be within the range specified in the product Technical Specification.

Efficiency

Adjust the load to either 50% or 100% of the maximum rating.
Set the input power source to the desired value – usually minimum, nominal or maximum rated voltage. Power up the product.
Measure and record the input voltage, input current, output voltage and output current. The efficiency, η, can then be calculated by using the following formula:

$$\eta\ (\%) = \frac{V_O \times I_O}{V_I \times I_I} \times 100$$

The calculated efficiency should be within the range specified in the product Technical Specification.

Remote Control Operation

Most Flex DC/DC power modules offer a remote control function by means of a RC pin. The implementation of this feature varies somewhat by product type, as there is no industry-wide standardization regarding operation or the voltage and current levels on the RC interface. Information on how to configure
the product for remote control operation can be found in the individual product Technical Specifications and in
Design Note 021. See references 1 and 2.

Output Ripple and Noise

Adjust the load to 100% of the maximum rating. Set the input power source to the desired value – usually maximum rated voltage.
To obtain repeatable data on ripple and noise the impedance at the measurement point and the measurement bandwidth must be specified and controlled. This is accomplished by making the measurement across a capacitor network as shown in Figure 1 and by using the 20 MHz bandwidth setting on the oscilloscope.
The capacitor network consists of a 10 µF tantalum capacitor in parallel with a 0.1 µF ceramic capacitor installed within 5 cm of the output pins. The peak-to-peak envelope of the ripple and noise waveform is then measured and recorded.
The measured ripple and noise should be within the range specified in the product Technical Specification. Additional information on ripple and noise measurement techniques can be found in Design Note 021 referenced below.

Output Voltage Trimming

Most Flex DC/DC power modules have the capability to adjust or trim the output voltage by means of an external resistor.
The product Technical Specification for the product being tested should be consulted to determine the connection of the trimming resistor and the equation for calculating the resistor value for the desired output voltage. By using the appropriate range of resistor values, the product output should be adjustable over the output adjust range given in the product Technical Specification.
The circuite diagram for adjusting output voltage is found in the product Technical Specification.

Load Transient Response

An electronic load connected as shown in Figure 1 is used to generate the changing load current required for this test. The Technical Specification for the product being tested will define the two current levels as well as the slew rate between them.
Adjust the electronic load to achieve this current waveform at a repetition frequency convenient for monitoring with the oscilloscope.
The oscilloscope should be connected across the capacitors as shown. Using the oscilloscope, measure the maximum positive and negative voltage deviations from the nominal output voltage.
Also measure the time needed for the voltage to recover to within the DC regulation band. Both the load transient voltage deviation and the load transient recovery time should be within the range specified in the product Technical Specification.
Flex Technical Specifications normally contain a graph of the typical voltage transient response.

Over Voltage Protection (OVP)
The output trimming function can be used to test the over voltage trip point. Use a variable voltage trim resistor such as is shown in Figure 1. Consult the product Technical Specification to determine the connection points and a suitable value. While monitoring the output voltage with a DC voltmeter, slowly increase the output voltage with the trim resistor. Record the highest voltage achieved prior to the product shutting down due to activation of the over voltage protection circuit. The measured voltage should be within the range specified in the product Technical Specification.

Over Current Protection (OCP)
Set the input power source for the desired input voltage. Slowly increase the load current above the normal specified operating band while monitoring the output voltage. Record the output current at which the output voltage decreases to a value below the output voltage tolerance specified in the product Technical Specification for the current limit threshold. The measured current should be within the current limit threshold range specified in the product Technical Specification.

Thermal Evaluation

It is possible to evaluate the thermal performance of a DC/DC power module on the bench, but it will require more preparation and attention to setup details than what was required for the preceding tests. Before attempting a thermal evaluation, thoroughly read the thermal considerations information specified in the product Technical Specification. This information may include such items as derating curves, product orientation considerations, mounting and thermal interface requirements, airflow requirements for various amounts of power dissipation and maximum "hot spot" temperatures at various locations on the product. Also be sure to read Design Note 019, referenced below, for further information on how to perform thermal measurements. Some specific items to keep in mind are listed here:

- All DC/DC power modules contain a heat conduction path through the pins or SMD connection pads which accounts for some of the heat transfer from the product. The effectiveness of this path depends upon the board size, number of copper layers and thickness of the copper in the test fixture board. To obtain meaningful data, the test board should be configured to simulate either the test conditionsused for the product Technical Specification or the actual system application. To obtain the best thermal performance, all pins should be soldered to the board even if they are not needed for electrical functionality.

- The DC/DC power module efficiency, and consequently its power dissipation, varies slightly with the input voltage. Most products will have slightly lower efficiency close to min. and/or max input voltages.

- The convection cooling effectiveness will vary significantly as a function of air speed and direction. Consult the product Technical Specification to determine the recommended airflow orientation. Accurately measuring cooling air velocity may require ducting or other sophisticated approaches.

- For free convection tests, the best cooling effect is achieved with the DC/DC power module oriented vertically.

- Thermocouples should be placed at critical component locations on the product as defined in the product Technical Specification. Typical locations are the PCB, transformer, MOSFET, output diode, etc. These thermocouples may be monitored under various load conditions to determine how close the product is to activation of it's over temperature protection circuit.

In Case of Difficulty

If the test methods and precautions discussed above are followed, there should not be any difficulty in making the desired measurement on the product. Occasionally, however, there may be confusing results or a problem with obtaining proper operation. The first thing to do in such a situation is to recheck all of the connections in the test setup including those to the instrumentation. If that fails to resolve the problem, the hints that follow may help. They are grouped by the major symptom discovered during the testing.

No Output Voltage
- Make sure that the input power source is set to a voltage within the operating range of the product.

- Make sure that the remote control (RC) pin is configured properly so that the product will be turned on.

- If the trim function is being used, verify that the resistive programming is set to a value within the output voltage range of the product.

- Make sure that the over voltage protection (OVP) has not been activated. This can be done by observing the output of the product with an oscilloscope when power is applied.

Low Output Voltage
- Make sure that the input power source is set to a voltage within the operating range of the product.

- Make sure that the load current is set to a value within the output current range of the product.

- If the trim function is being used, verify that the resistive programming is set to the proper value.
- Make sure that the voltage measurement is being made at the sense pins so that voltage drops from the output to the sense point are not included in the measurement.

High Output Voltage

- If the trim function is being used, verify that the resistive programming is set to the proper value.
- Verify that the remote sense pins are connected to the positive and negative outputs of the product.

Excessively High Ripple & Noise

- Make sure that you are using the measurement method consistent with the product Technical Specification and Design Note 022, including using the capacitor network and the 20 MHz oscilloscope bandwidth.
- Make sure that the input voltage source is stable. Using an oscilloscope, observe the input voltage without the product connected to check for excessive ripple or noise on the voltage source.

Excessively High Line & Load Regulation

- Make sure that the input power source is set to a voltage within the operating range of the product.
- Make sure to measure input and output voltage directly on the input and output terminals to avoid any voltage drops in the connection wires.

Conclusion

The methodology and suggestions presented in this design note should enable bench top testing of Flex DC/DC power modules and verification of their major specified parameters. The reader is encouraged to also make use of the extensive information in the product Technical Specification and the design notes referenced here. If there are still difficulties or uncertainties about the test results, please contact your local Flex Power Modules sales office for further assistance.

References

1) Power Module Technical Specifications, Flex Power Modules, various dates

2) Design Note 021, On/Off Control using the Remote Control (RC) pin on Flex power modules, July 2010

3) Design Note 022, Output Ripple and Noise Measurement Methods for Flex power modules, July 2010

4) Design Note 019, Thermal Characterization of Flex power modules, July 2010

Formed in the late seventies, Flex Power Modules is a division of Flex that primarily designs and manufactures isolated DC/DC converters and non-isolated voltage regulators such as point-of-load units ranging in output power from 1 W to 700 W. The products are
aimed at (but not limited to) the new generation of ICT (information and communication technology) equipment where systems' architects are designing boards for optimized control and reduced power consumption.

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