

TL1451AEVM-166

3.3-V/1.8-V Dual Buck EVM Using the TL1451A

User's Guide

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Preface

About This Manual

This user's guide describes the TL1451AEVM–166 buck converter evaluation module.

How to Use This Manual

- Chapter 1—Introduction
- Chapter 2—Schematic
- Chapter 3—Test Results
- Chapter 4—Bill of Materials

Information About Cautions and Warnings

This book may contain cautions and warnings.

This is an example of a caution statement.

A caution statement describes a situation that could potentially damage your software or equipment.

This is an example of a warning statement.

A warning statement describes a situation that could potentially cause harm to you.

The information in a caution or a warning is provided for your protection. Please read each caution and warning carefully.

Related Documentation From Texas Instruments

- TL1451A datasheet (literature number SLVS024)
- TL5001C application report (literature number SLVA034)



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Introduction

This user's guide describes the TL1451AEVM-166 buck converter evaluation module (SLVP166). The SLVP166 provides a convenient method for evaluating the performance of a dual buck converter using the TL1451A PWM regulator controller. A complete designed and tested power supply is presented. The power supply is a dual step-down dc-dc converter that can deliver up to 1.5 A of continuous output current at 3.3-V output and up to 1 A of continuous output current at 1.8-V output with an input range of 4.5 V to 5.5 V.

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1.1 Performance Specification Summary

This section summarizes the performance specifications of the SLVP166 converter. Table 1–1 gives the performance specifications of the converters.

Table 1–1. Performance Specification Summary

| Specifications | Test Conditions | Min | Typ | Max | Unit |
|---------------------------|---|----------|-------|-------|------------------|
| Input voltage range | | 4.5 | | 5.5 | V |
| Output voltage, set point | $I_{O1} = 0$ A | 3.178 | 3.31 | 3.442 | V |
| | $I_{O2} = 0$ A | 1.730 | 1.802 | 1.874 | V |
| Line regulation | V_{O1} with $V_I = 4.5$ V to 5.5 V, $I_{O1} = 1.5$ A | | 0.01% | 0.02% | |
| | V_{O2} with $V_I = 4.5$ V to 5.5 V, $I_{O2} = 1$ A | | 0.01% | 0.02% | |
| Load regulation | V_{O1} with $V_I = 5$ V, $I_{O1} = 0 - 1.5$ A | | 0.5% | 0.7% | |
| | V_{O2} with $V_I = 5$ V, $I_{O1} = 0 - 1$ A | | 0.4% | 0.6% | |
| Transient response | $I_{O1} = 150$ mA to 1.5 A, $T_{(rise)} = 30$ μ s | | 10 | | mV _{PK} |
| | | | 150 | | μ s |
| | $I_{O2} = 100$ mA to 1 A, $T_{(rise)} = 30$ μ s | | 10 | | mV _{PK} |
| | | | 150 | | μ s |
| Output current range | $V_I = 4.5$ V to 5.5 V | I_{O1} | 0 | 1.5 | A |
| | | I_{O2} | 0 | 1 | |
| Output ripple | $V_I = 5$ V, $I_{O1} = 1.5$ A | | 30 | 60 | mV _{PP} |
| | $V_I = 5$ V, $I_{O2} = 1$ A | | 30 | 50 | |
| Soft-start rise time | $V_I = 5$ V, $I_{O1} = 1.5$ A, $I_{O2} = 1$ A | | 0.6 | 1 | ms |
| Operating frequency | $V_I = 5$ V, $I_{O1} = 1.5$ A, $I_{O2} = 1$ A | 255 | 300 | 345 | kHz |
| Efficiency, full load | $V_I = 5$ V, $I_{O1} = 1.5$ A, $I_{O2} = 1$ A | 80% | 85% | | |

Schematic

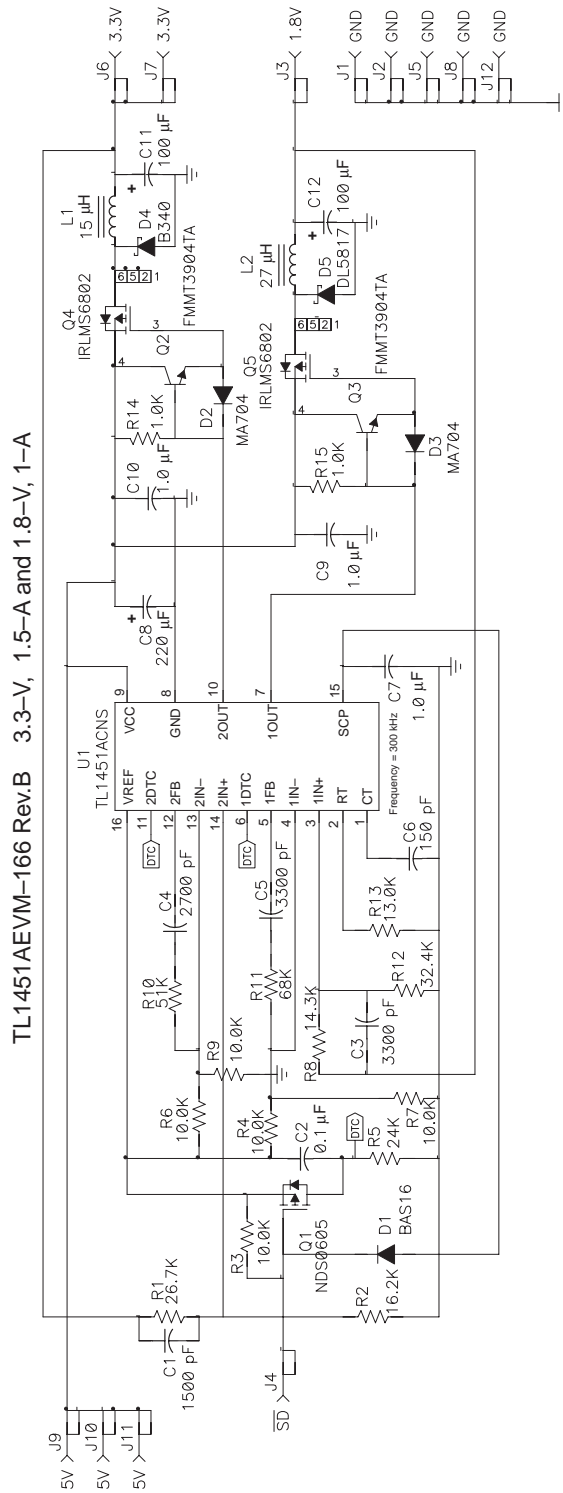


This chapter contains the schematic diagram for the SLVP166 EVM.

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2.1 Schematic

Figure 2–1. SLVP166 Schematic Diagram

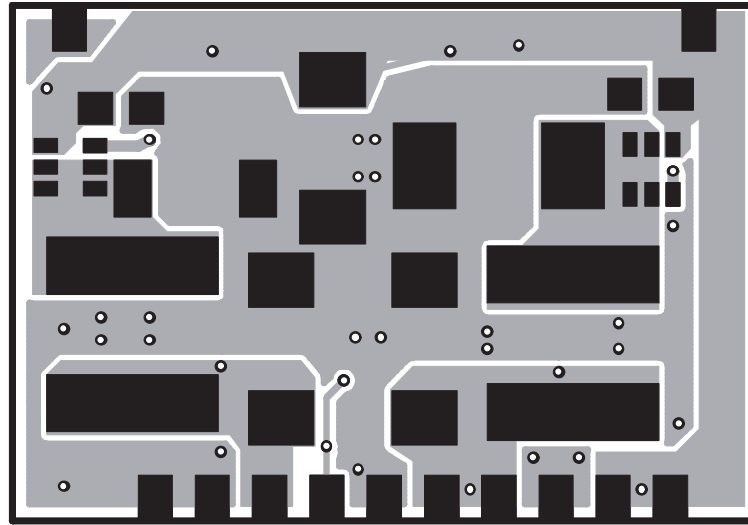


- Notes:**
- 1) A low signal on J4 will shut down the power supply.
 - 2) When a change in the output voltage is required, R2 and/or R12 should be changed instead of R1 and/or R8 due to the compensation networks.

2.2 Board Layout

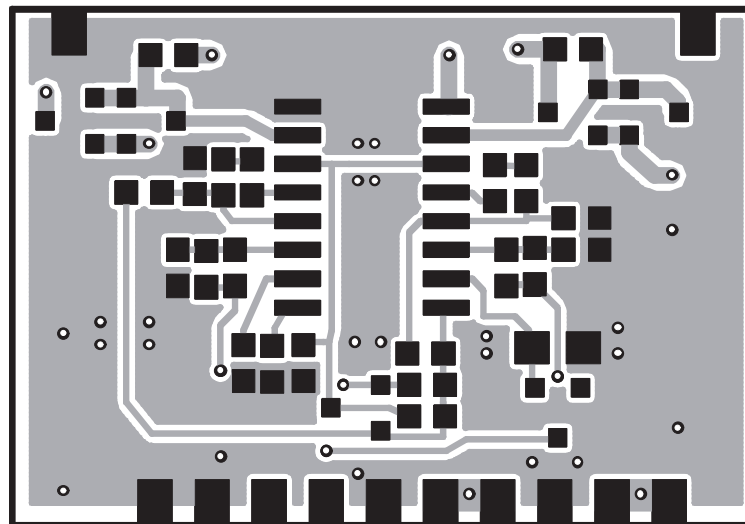
The power supply module consists of one PWB. Figure 2–2 shows the top layer (front view) of the SLVP166 PWB. Figure 2–3 shows the bottom layer (top view) of the SLVP166 PWB. Figure 2–4 shows the SLVP166 top and bottom assembly views.

Figure 2–2. SLVP166 Board Layout Top Layer



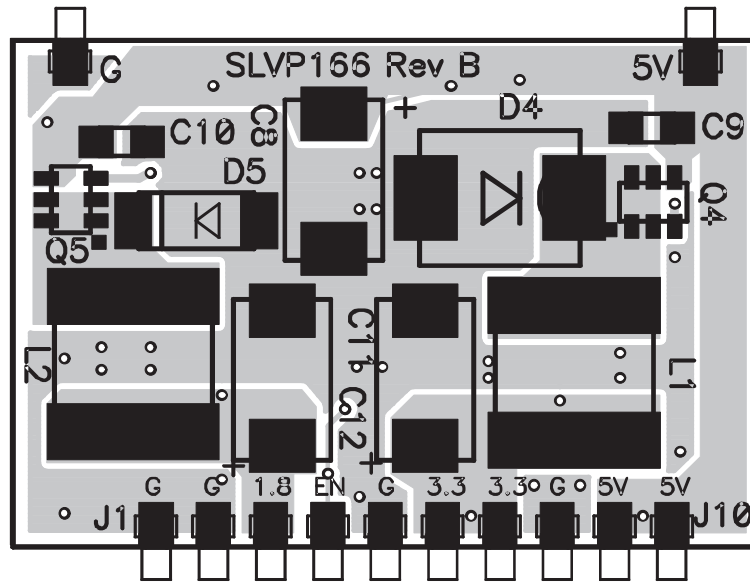
Top Layer

Figure 2–3. SLVP166 Board Layout Bottom Layer

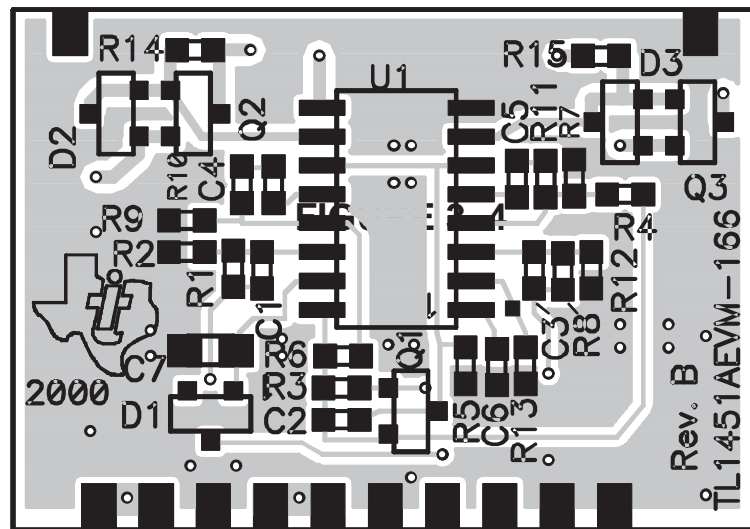


Bottom Layer (Top View)

Figure 2–4. SLVP166 Top and Bottom Assembly Views



Top Assembly



Bottom Assembly (Bottom View)

Test Results

This chapter shows the test setups used, and the test results obtained, in designing the SLVP166 EVM.

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3.1 Test Summary

The detailed test results are presented in Figures 3–2 to 3–6 for the SLVP166. The following are summarized results.

3.1.1 Static Line and Load Regulation

The load regulation from no load to full load current does not exceed 0.6%. The line regulation is less than 0.015% for the input voltage range from 4.5 V to 5.5 V. Line and load regulation curves are shown in Figures 3–1 and 3–2. The set point tolerance is approximately 4%.

Figure 3–1. SLVP166 Measured Line Regulation

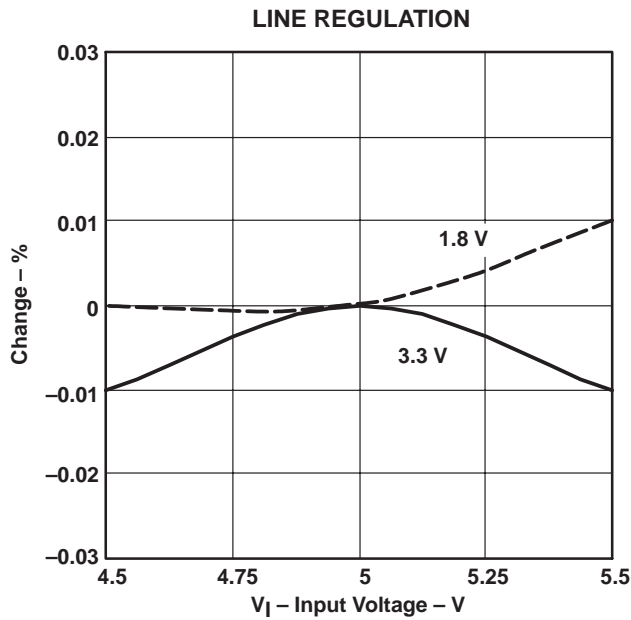
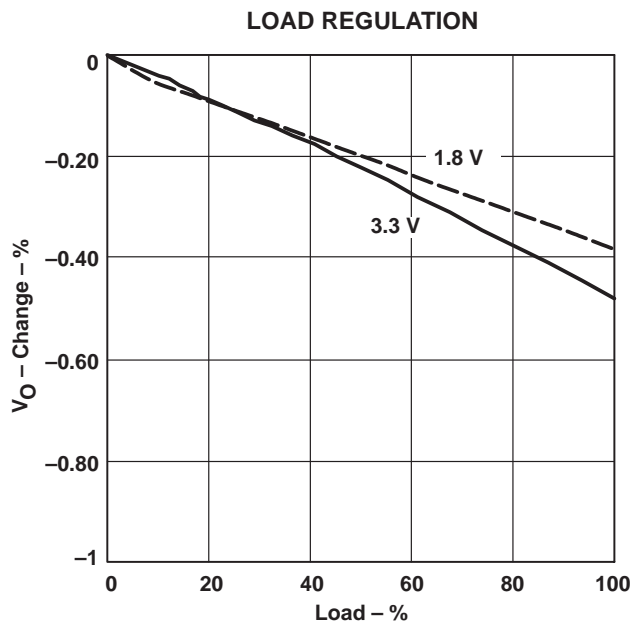


Figure 3–2. SLVP166 Measured Load Regulation



3.1.2 Output Voltage Ripple

The output voltage peak to peak ripple is approximately 30 mV on both outputs. This is a typical value but the converter can be optimized for lower ripple applications.

Figure 3–3. 3.3-V Ripple Voltage

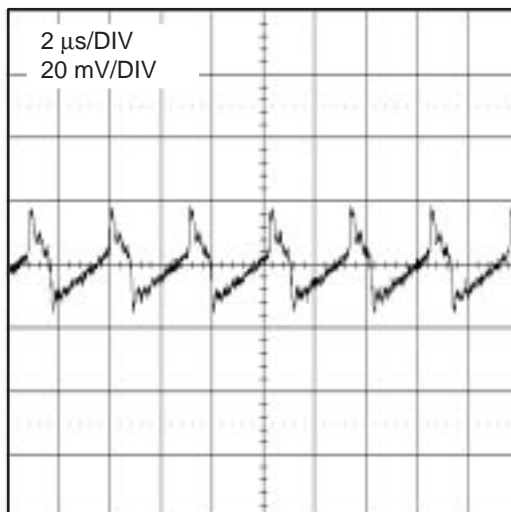
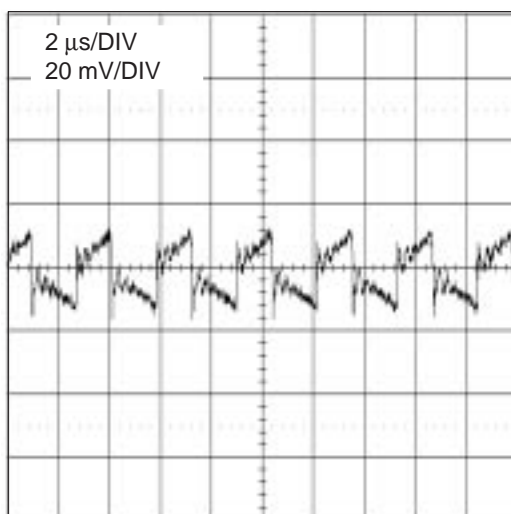


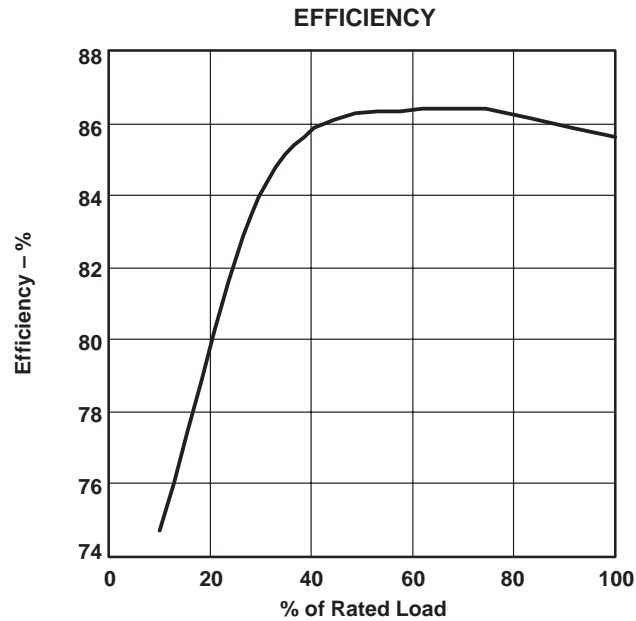
Figure 3–4. 1.8-V Ripple Voltage



3.1.3 Efficiency and Power Losses

Efficiency and power losses for 5-V input voltage and maximum output current on both outputs gives an efficiency of 85.6% resulting in an onboard power loss of 1.12 W maximum.

Figure 3–5. SLVP166 Measured Load Regulation



Low power loss in each component decreases their temperature rise and improves long term reliability. The EVM does not require forced air cooling at room temperature with good margin.

3.1.4 Output Start-Up and Overshoot

Output voltage rise time does not depend on the load current and ramps up in a linear fashion. There is no discernable overshoot in the waveform. In this application, output voltage rise time is set to approximately 600 μ s with an external capacitor.

3.1.5 Transient Response

Although this controller was not designed for high-speed transient response, it does do a good job at low power levels such as with this design. A transient load that varied from 10% to 100% of full load was applied to each output of the EVM. Results are shown in Figure 3–6 and Figure 3–7.

Figure 3–6. 3.3-V Transient Response

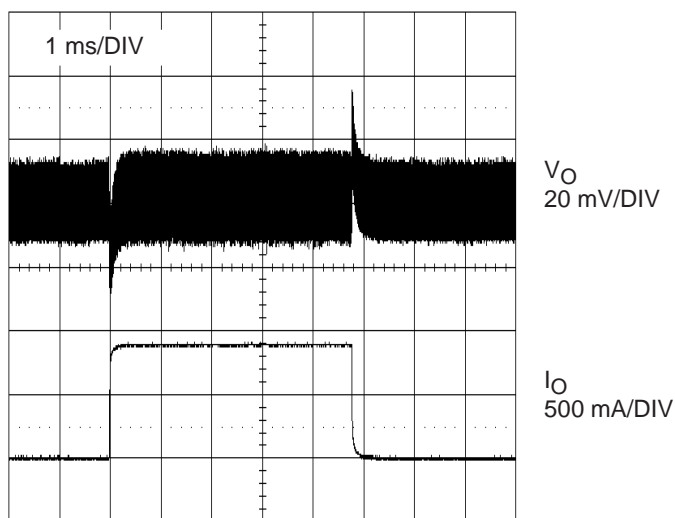
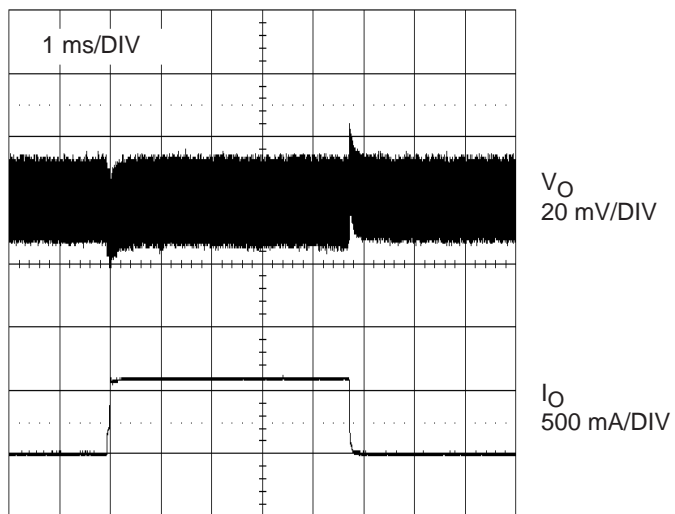


Figure 3–7. 1.8-V Transient Response



3.1.6 Frequency Variation

The onboard oscillator is set by two external components, R13 and C6. The nominal frequency is set to 300 kHz but has a tolerance of $\pm 15\%$.

3.1.7 Conclusion

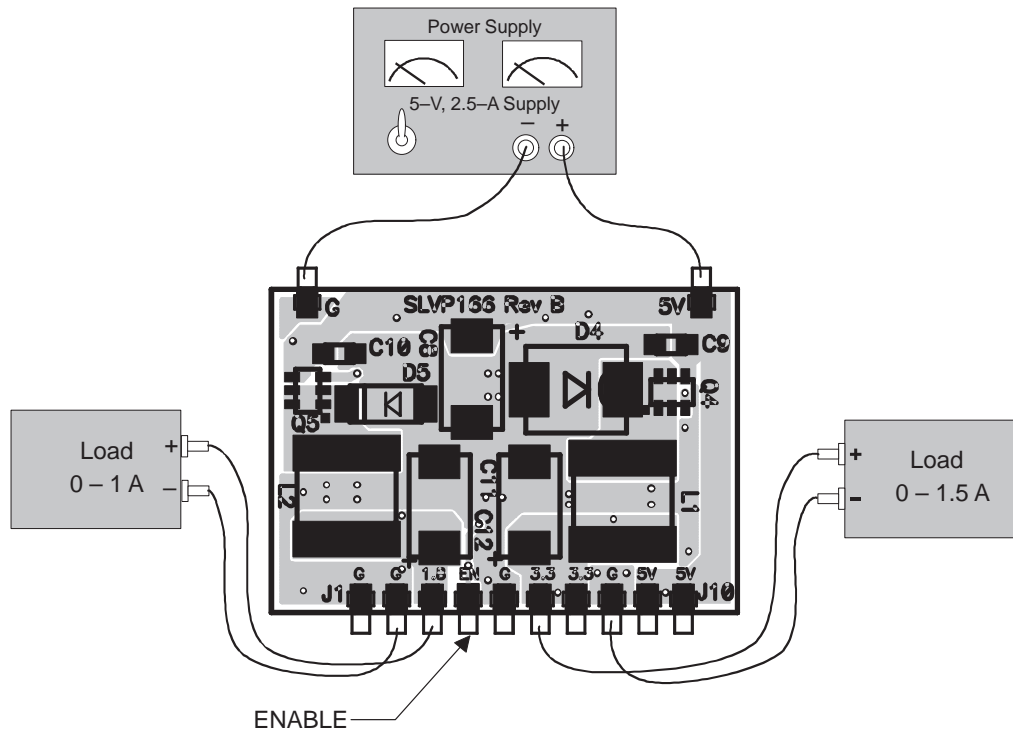
The test results of the SLVP166 EVM demonstrate the advantages of the TL1451A controller to meet dual-output supply requirements to power supplies. The power system designer has a good solution to optimize the system for his particular application. Detailed information on how to design a dc-dc buck converter is available in the application report, *Designing with the TL5001C PWM Controller, SLVA034*.

3.2 Test Setup

Follow these steps for initial power up of the SLVP166:

- Step 1:** Connect an electronic load from 1.8 V to G (J3 to J2) adjusted to draw approximately 1 A at 1.8 V. Connect an electronic load from 3.3 V to G (J6 to J8) adjusted to draw approximately 1.5 A at 3.3 V. The exact current is not critical; any nominal current is sufficient. A fixed resistor can also be used in place of the electronic loads. The output current drawn by the resistors is $I_L = \frac{V_O}{R}$ where R is the value of the load resistor. The resistor power rating, P_R should be at least $\frac{2 \times V_O^2}{R}$ watts.
- Step 2:** Connect a 5-V lab power supply to the 5-V input (J11 referenced to GND, J12) of the SLVP166. Adjust the current limit to approximately 2 A.
- Step 3:** Turn on the 5-V power supply and ramp the input voltage up to 5 V.
- Step 4:** Verify that the SLVP166 output voltages (measured at the module output pins) are within the output voltage tolerances.
- Step 5:** Refer to the test results for selected typical waveforms and operating conditions for verification of proper module operation.

Figure 3–8. SLVP166 Test Setup





Bill of Materials

This chapter contains the bill of materials for the SLVP166 EVM.

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| 4.1 Bill of Materials | 4-2 |

4.1 Bill of Materials

Table 4–1 lists materials required for the SLVP166 EVM.

Table 4–1. SLVP166 Bill of Materials

| Qty | RefDes | Part Number | Description | MFR | Size |
|-----|------------------|-----------------|---|---------------|--------|
| 1 | C1 | GRM39X7R152K50 | Capacitor, ceramic, 1500 pF, 50 V, 10%, X7R | Murata | 603 |
| 1 | C2 | GRM39X7R104K16 | Capacitor, ceramic, 0.1 μ F, 16 V, 10% X7R | Murata | 603 |
| 2 | C3,C5 | GRM39X7R332K50 | Capacitor, ceramic, 3300 pF, 50 V, 10%, X7R | Murata | 603 |
| 1 | C4 | GRM39X7R272K50 | Capacitor, ceramic, 2700 pF, 50 V, 10%, X7R | Murata | 603 |
| 1 | C6 | GRM39COG151J50 | Capacitor, ceramic, 150 pF, 50 V, 5%, COG | Murata | 603 |
| 3 | C7,C9, C10 | ECJ-JVF1C105Z | Capacitor, ceramic, 1 μ F, 16 V, +80%–20%, Y5V | Panasonic | 805 |
| 1 | C8 | 10TPB220M | Capacitor, POSCAP, 220 μ F, 10 V, 40-m Ω , 20% | Sanyo | D Case |
| 2 | C11,C12 | TPSD107M010R100 | Capacitor, Tantalum, 100 μ F, 10 V, 10-m Ω , 20% | AVX | D Case |
| 1 | D1 | BAS16 | Diode, switching, 10-mA, 75-V, 350-mW | Vishay-Liteon | TO-236 |
| 2 | D2,D3 | MA704 | Diode, Schottky, 30-mA, 15-V | Panasonic | TO-236 |
| 1 | D4 | B340 | Diode, Schottky, 3-A, 40-V | Vishay-Liteon | SMC |
| 1 | D5 | DL5817 | Diode, Schottky, 1-A, 20-V | Vishay-Liteon | DL41 |
| 12 | J1-J12 | CA26DA-D36W-0FC | Clip, surface-mount, 0.040 board, 0.090 stand-off | NAS Interplex | |
| 1 | L1 | CTGS75-150K | Inductor, SMT, 15 μ H, 1.8-A, 90-m Ω | Central Tech | CD75 |
| 1 | L2 | CTGS75-270K | Inductor, SMT, 27 μ H, 1.3-A, 120-m Ω | Central Tech | CD75 |
| 1 | R1 | STD | Resistor, chip, 26.7 k Ω , 1/16 W, 1% | | 603 |
| 1 | R2 | STD | Resistor, chip, 16.2 k Ω , 1/16 W, 1% | | 603 |
| 5 | R3,R4, R6,R7, R9 | STD | Resistor, chip, 10.0 k Ω , 1/16 W, 1% | | 603 |
| 1 | R5 | STD | Resistor, chip 24 k Ω , 1/16 W, 5% | | 603 |
| 1 | R8 | STD | Resistor, chip, 14.3 k Ω , 1/16 W, 1% | | 603 |
| 1 | R10 | STD | Resistor, chip, 51 k Ω , 1/16 W, 5% | | 603 |
| 1 | R11 | STD | Resistor, chip, 68 k Ω , 1/16 W, 5% | | 603 |
| 1 | R12 | STD | Resistor, chip, 32.4 k Ω , 1/16 W, 1% | | 603 |
| 1 | R13 | STD | Resistor, chip, 13.0 k Ω , 1/16 W, 1% | | 603 |
| 2 | R14,R15 | STD | Resistor, chip, 1.0 k Ω , 1/16 W, 5% | | 603 |

Table 4–1. SLVP166 Bill of Materials (Continued)

| Qty | RefDes | Part Number | Description | MFR | Size |
|-----|--------|-------------|---|-----------|--------------|
| 1 | Q1 | NDS0605 | MOSFET, P-ch, 60-V, 180-mA, 5 Ω | Fairchild | SOT-23 |
| 2 | Q2, Q3 | FMMT3904TA | Bipolar, NPN, 40-V, 200-mA, 300-mW | Zetex | SOT-23 |
| w | Q4,Q5 | IRLMS6802 | MOSFET, P-ch, 20-V, 5.6-A, 50-m Ω | IR | MICRO6 |
| 1 | U1 | TL1451ACNS | IC, Dual channel PWM controller with open-collector outputs | TI | SOP-16 |
| 1 | NA | SLVP166 | PCB, TL1451AEVM-166B, 2 layers, 2 ounce copper | | 1.30 × 0.900 |

