1 Introduction

The LM5116 evaluation board is designed to provide the design engineer with a fully functional power converter based on emulated current mode control to evaluate the LM5116 controller IC. The evaluation board provides a 5V output with a 7A current capability. The wide input voltage ranges from 7V to 60V. The design operates at 250kHz, a good compromise between conversion efficiency and solution size. The printed circuit board consists of 4 layers, 2 ounce copper top and bottom, 1 ounce copper internal layers on FR4 material with a thickness of 0.06 inches. This application note contains the evaluation board schematic, Bill-of-Materials (BOM) and a quick setup procedure. Refer to the LM5116 Wide Range Synchronous Buck Controller (SNVS499) data sheet for complete circuit design information.

![Efficiency with 6 µH Cooper Inductor](image)

**Figure 1. Efficiency with 6 µH Cooper Inductor**

The performance of the evaluation board is as follows:

- **Input Range:** 7V to 60V
- **Output Voltage:** 5V
- **Output Current:** 0 to 7A
- **Frequency of Operation:** 250 kHz
- **Board Size:** 2.55 X 2.65 X 0.5 inches
- **Load Regulation:** 1%
- **Line Regulation:** 0.1%
- **Over Current Limiting**
2 **Powering and Loading Considerations**

Read this entire page prior to attempting to power the evaluation board.

2.1 **Quick Setup Procedure**

**Step 1:** Set the power supply current limit to 15A. Turn off the power supply. Connect the power supply to the $V_{IN}$ terminals.

**Step 2:** Connect the load, with a 7A capability, to the $V_{OUT}$ terminals. Positive connection to P3 and negative connection to P4.

**Step 3:** The EN pin should be left open for normal operation.

**Step 4:** Set $V_{IN}$ to 48V with no load applied. $V_{OUT}$ should be in regulation with a nominal 5V output.

**Step 5:** Slowly increase the load while monitoring the output voltage, $V_{OUT}$ should remain in regulation with a nominal 5V output as the load is increased up to 7 Amps.

**Step 6:** Slowly sweep the input voltage from 7 to 60V, $V_{OUT}$ should remain in regulation with a nominal 5V output.

**Step 7:** Temporarily short the EN pin to GND to check the shutdown function.

**Step 8:** Increase the load beyond the normal range to check current limiting. The output current should limit at approximately 11A. Cooling is critical during this step.

2.2 **Air Flow**

Prolonged operation with high input voltage at full power will cause the MOSFETs to overheat. A fan with a minimum of 200 LFM should always be provided.

![Figure 2. Efficiency with 5.6 µH Pulse Inductor](image)
2.3 Powering Up

Using the enable pin provided will allow powering up the source supply with the current level set low. It is suggested that the load be kept low during the first power up. Set the current limit of the source supply to provide about 1.5 times the anticipated wattage of the load. As you remove the connection from the enable pin to ground, immediately check for 5 volts at the output.

A quick efficiency check is the best way to confirm that everything is operating properly. If something is amiss you can be reasonably sure that it will affect the efficiency adversely. Few parameters can be incorrect in a switching power supply without creating losses and potentially damaging heat.

For operation at 7V_{in} with full load, a 100 µF aluminum electrolytic capacitor installed across V_{in} will prevent input filter oscillation for a typical bench test setup. See LM5116 Wide Range Synchronous Buck Controller (SNVS499) for complete design information.
2.4 Over Current Protection

The evaluation board is configured with over-current protection. The output current is limited to approximately 11A. The thermal stress is quite severe while in an overloaded condition. Limit the duration of the overload and provide sufficient cooling (airflow).

![Figure 5. Short Circuit at 24V<sub>IN</sub> Room Temperature](image1)

![Figure 6. Short Circuit at 48V<sub>IN</sub> 125°C](image2)

For sustained short circuit protection, adding C7 \( \geq 1 \mu F \) will limit the short circuit power dissipation. D2 should be installed when using C7.
2.5 **VCCX**

This test point supports evaluation of an auxiliary supply voltage derived from $V_{OUT}$. For output voltages between 7V and 14V, a zero ohm resistor may be installed for R12. The selected MOSFETs need greater than 6V gate drive to fully enhance them for lowest $R_{DS(ON)}$, so R12 is not recommended for the 5V output.

Under no circumstances should an external voltage source be connected to VCCX when $V_{IN} < VCC$. Damage to the controller will result. A series diode from the input voltage source to pin 1 is required to accommodate $V_{IN} < VCC$.

2.6 **Synchronization**

A SYNC pin has been provided on the evaluation board. This pin can be used to synchronize the regulator to an external clock. Refer to the *LM5116 Wide Range Synchronous Buck Controller (SNVS499)* data sheet for complete information.
2.7 Active Loads

Figure 12 shows a typical start-up characteristic into a constant current active load. This type of load can exhibit an initial short circuit, which is sustained well beyond the normal soft-start cycle. Overshoot of the output voltage is possible with this condition. Increasing the soft-start time to be longer than the initial short circuit period of the active load will minimize any possible overshoot. When using C7, the hiccup off-time may also need adjustment.

3 Typical Performance Waveforms

![Typical Performance Waveforms](image)

Figure 9. Full Synchronous Operation at 48V\textsubscript{IN} with JMP1 Removed

![Typical Performance Waveforms](image)

Figure 10. Discontinuous Operation using Diode Emulation Mode at 60V\textsubscript{IN} with JMP1 Installed
Figure 11. Transient Response at 24V\textsubscript{IN}

Figure 12. Start-up into Active Load at 24V\textsubscript{IN}
5  Bill of Materials

Table 1. Bill of Materials for 7V-60V Input, 5V 7A Output, 250kHz

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<tr>
<th>ID</th>
<th>Part Number</th>
<th>Type</th>
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<th>Parameters</th>
<th>Qty</th>
<th>Vendor</th>
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