LM25117,LM25119,LM5117,LM5119

Application Note 2065 LM5119 Evaluation Board



Literature Number: SNVA444A

LM5119 Evaluation Board

National Semiconductor Application Note 2065 Eric Lee September 28, 2010



Introduction

The LM5119EVAL evaluation board provides the design engineer with a fully functional dual output buck converter, employing the LM5119 Dual Emulated Current Mode Synchronous Buck Controller. The evaluation board is designed to provide both 10V and 5V outputs over an input range of 14V to 55V. Also the evaluation board can be easily configured for a single 10V, 8A regulator.

Performance of the Evaluation Board

- Input Voltage Range: 14V to 55V
- Output Voltage: 10V (CH1), 5V (CH2)
- Output Current: 4A (CH1), 8A (CH2)
- Nominal Switching Frequency: 230 KHz
- Synchronous Buck Operation: Yes
- Diode Emulation Mode: Yes
- Hiccup Mode Overload Protection: Yes
- External VCC Sourcing: Yes

Powering and Loading Consideration

When applying power to the LM5119 evaluation board, certain precautions need to be followed. A misconnection can damage the assembly.

PROPER BOARD CONNECTION

The input connections are made to the J1 (VIN) and J2 (RTN/ GND) connectors. The CH1 load is connected to the J3 (OUT1+) and J4 (OUT1-/GND) and the CH2 load is connected to the J6 (OUT2+) and J5 (OUT2-/GND). Be sure to choose the correct connector and wire size when attaching the source power supply and the load.

SOURCE POWER

The power supply and cabling must present low impedance to the evaluation board. Insufficient cabling or a high impedance power supply will droop during power supply application with the evaluation board inrush current. If large enough, this droop will cause a chattering condition during power up. During power down, insufficient cabling or a high impedance power supply will overshoot. This overshoot will cause a non-monotonic decay on the output.

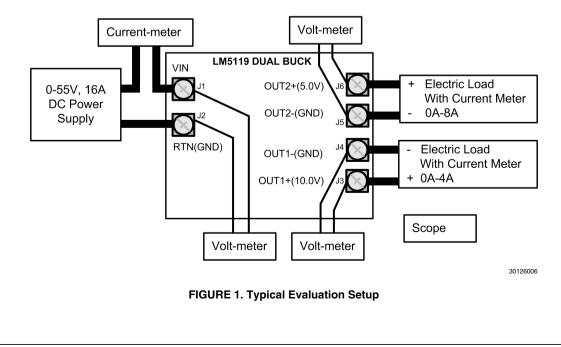
An additional external bulk input capacitor may be required unless the output voltage droop/overshoot of the source power is less than 0.7V. In this board design, UVLO setting is conservative while UVLO hysteresis setting is aggressive. Minimum input voltage can goes down with an aggressive design. Minimum operating input voltage depends on the output voltage droop/overshoot of the source power supply and the forced off-time of the LM5119. Refer to the LM5119 datasheet for complete design information.

LOADING

When using an electronic load, it is strongly recommended to power up the evaluation board at light load and then slowly increase the load. If it is desired to power up the evaluation board at maximum load, resistor banks must be used. In general, electronic loads are best suited for monitoring steady state waveforms.

AIR FLOW

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



QUICK START-UP PROCEDURE

STEP 1: Set the power supply current limit to at least 16A. Connect the power supply to J1 and J2.

STEP 2: Connect one load with a 4A capacity between J3 and J4. Connect another load with an 8A capacity between J6 and J5.

STEP 3: Set input voltage to 24V and turn it on.

STEP 4: Measure the output voltages. CH1 should regulate at 10V and CH2 should regulate at 5V.

STEP 5: Slowly increase the load current while monitoring the output voltages. The outputs should remain in regulation up to full load current.

STEP 6: Slowly sweep the input voltage from 14V to 55V while monitoring the output voltages. The outputs should remain in regulation.

Waveforms

SOFT START

When applying power to the LM5119 evaluation board a certain sequence of events occurs. Soft-start capacitors and other components allow for a linear increase in output voltages. The soft-start time of each output can be controlled independently. *Figure 2* shows the output voltage during a typical start-up with a load of 3Ω on the 10V output, and 1Ω on the 5V output, respectively.

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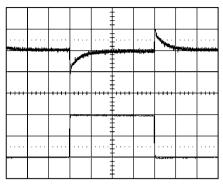
Conditions:

Input Voltage = 24VDC 3Ω Load on 10V output 1Ω Load on 5V output **Traces:** Top Trace: 10V Output Voltage, Volt/div = 5V Bottom Trace: 5V Output Voltage, Volt/div = 5V Horizontal Resolution = 1 ms/div

FIGURE 2. Start-Up with Resistive Load

LOAD TRANSIENT

Figure 3 shows the transient response for a load of change from 2A to 6A on 5V output. The upper waveform shows output voltage droop and overshoot during the sudden change in output current shown by the lower waveform.



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Conditions:

Input Voltage = 24VDC Output Current 2A to 6A

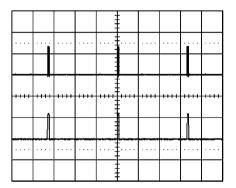
Traces:

Top Trace: 5V Output Voltage, Volt/div = 100mV, AC coupled Bottom Trace: Output Current, Amp/div = 2A Horizontal Resolution = 0.5 ms/div

FIGURE 3. Load Transient Response

OVERLOAD PROTECTION

The evaluation board is configured with hiccup mode overload protection. The restart time can be programmed by C11. *Figure 4* shows hiccup mode operation in the event of an output short on CH2 output. One channel may operate in the normal mode while the other is in hiccup mode overload protection.



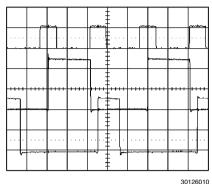
Conditions:

Input Voltage = 24VDC Output Short on 5V **Traces:** Top Trace: SW Voltage on CH2, Volt/div = 20V Bottom Trace: Inductor Current, Amp/div = 10A Horizontal Resolution = 20 ms/div

FIGURE 4. Short Circuit

EXTERNAL CLOCK SYNCHRONIZATION

A TP1 (SYNC) test point has been provided on the evaluation board in order to synchronize the internal oscillator to an external clock. *Figure 5* shows the synchronized switching operation. Each channel operates 180 degrees out of phase from the other.



Conditions:

Input Voltage = 24VDC 4A on 10V Output 8A on 5V Output Traces:

Top Trace: SYNC pulse, Volt/div = 5V Middle Trace: SW voltage on CH1, Volt/div = 10V Bottom Trace: SW voltage on CH2, Volt/div = 10V Horizontal Resolution = 1 µs/div

FIGURE 5. Clock Synchronization

SHUTDOWN

Figure 6 shows the shutdown procedure by powering off the source power. When UVLO pin voltage is less than 1.26V, the switching stops and soft-start capacitors are discharged by internal switches.

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Conditions:

Input Voltage = 24VDC 1Ω Load on 5V Output **Traces:** Top Trace: Input Voltage, Volt/div = 20V Middle Trace1: 5V Output, Volt/div = 2V Middle Trace2: VCC, Volt/div = 5V Bottom Trace: SS Voltage, Volt/div = 5V Horizontal Resolution = 20 ms/div

FIGURE 6. Shutdown

Performance Characteristics

Figure 7 shows the efficiency curves. The efficiency of the power converter is 96% at 24V with full load current. Monitor the current into and out of the evaluation board. Monitor the voltage directly at the input and output terminals of the evaluation board.

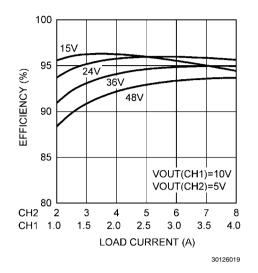


FIGURE 7. Typical Efficiency vs Load Current

Board Configuration

INTERLEAVED BUCK OPERATION FOR SINGLE 10V 8A OUTPUT

The evaluation board is designed to be easily converted to a 10V, 8A single output regulator with the interleaved operation. Proper electronic load connection is shown in *Figure 8*. Connecting the electronic load at the center of shorting bar is recommended to prevent a voltage difference between CH1 and CH2 output. In order to produce a single 10V output with 8A maximum output current, populate R21 and R22 with 0 Ω resistor and open R6, C15 and C14. The electronic load should have over 8A capability to test the interleaved operation.

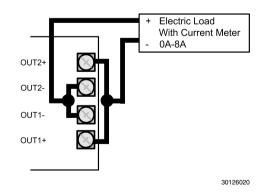


FIGURE 8. Load Connection for Single Output

EXTERNAL VCC SUPPLY & VCC DISABLE

External VCC supply helps to reduce the temperature and the power loss of the LM5119 at high input voltage. By populating D3 and D4, VCC can be supplied from an external power supply. Use TP3 as an input of the external VCC supply with 0.1A current limit. R36, R35 and C45 should be populated with proper value when the voltage of the external VCC is smaller than 7V. The voltage at the VCCDIS pin can be monitored at TP2. To prevent a reverse current flow from VCC to VIN through the internal diode, the external VCC voltage should always be lower than VIN. In this LM5119 evaluation board, VCC1 and VCC2 are supplied from the 10V output to achieve high efficiency.

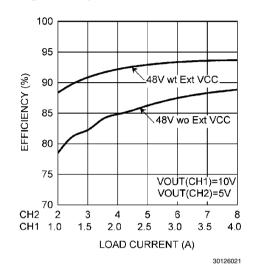


FIGURE 9. Efficiency Comparison at 48V with External VCC vs Without External VCC

LOOP RESPONSE

TP5 and TP6 (TP7 and TP8) have been provided in order to measure the loop transfer function of CH1 (CH2). Refer to AN-1889 for detail information about the loop transfer function measurement.

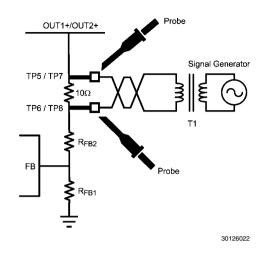
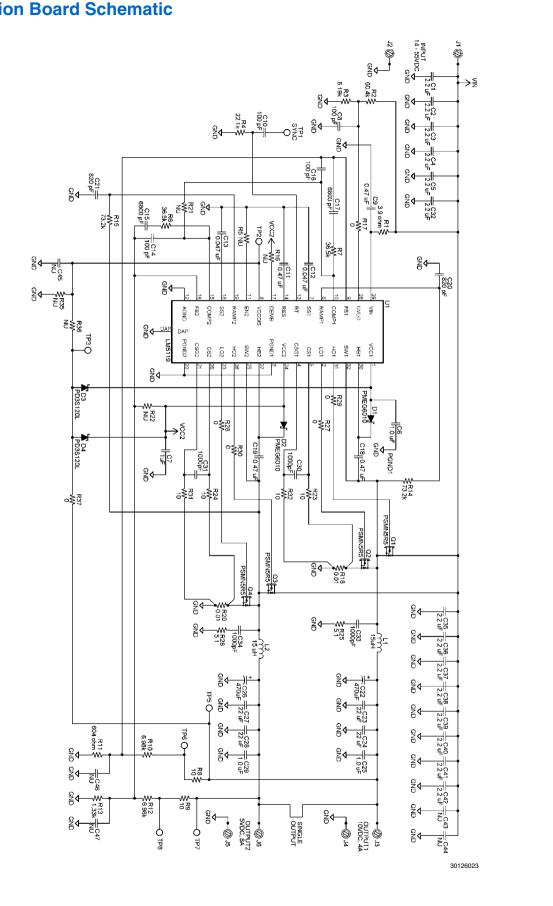


FIGURE 10. Loop Response Measurement Setup

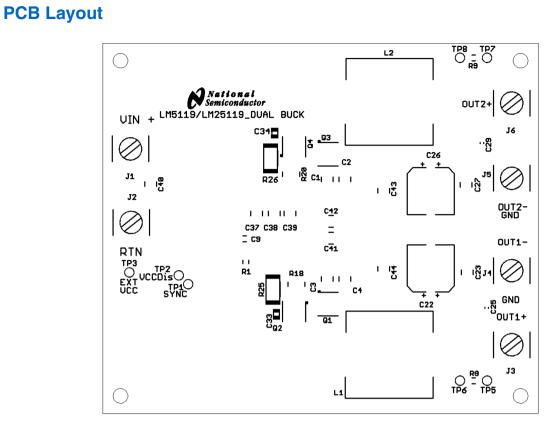


Evaluation Board Schematic

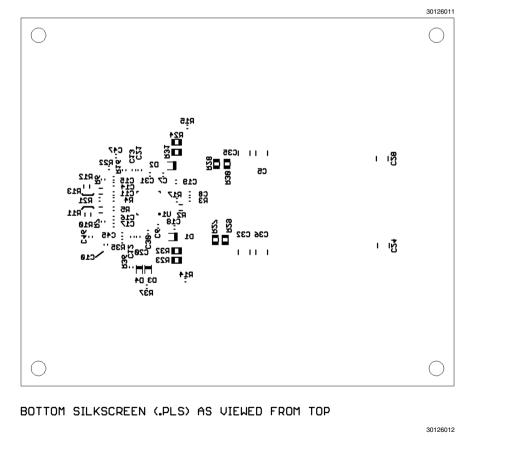
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Bill of Materials

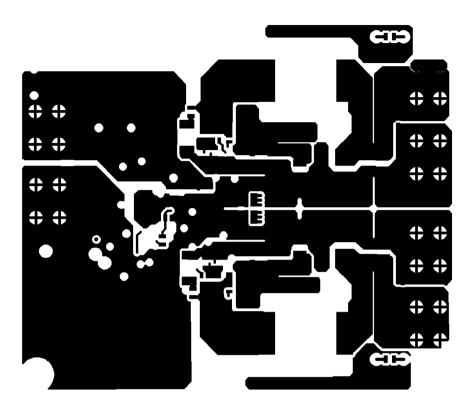
| Part | Value | Package | Part Number | Manufacturer |
|--|-------------------|------------|-------------------|-----------------|
| C1, C2, C3, C4,C5, C32, C35,C36, C37, C38, C39, C40, C41, C42 | C37, | | C3225X7R2A225K | TDK |
| C6, C7, C25,C29 | 1µF, 16V, X7R | 0603 | C1608X7R1C105K | TDK |
| C8, C10, C14, C16 | 100pF, 50V, C0G | 0603 | C1608C0G1H101J | TDK |
| C9 | 0.47µF, 100V, X7R | 0805 | GRM21BR72A474KA73 | Murata |
| C11, C18, C19 | 0.47µF, 25V, X7R | 0603 | GRM188R71E474KA12 | Murata |
| C12,C13 | 0.047µF, 16V, X7R | 0603 | C1608X7R1C473K | TDK |
| C15,C17 | 6800pF, 25V, C0G | 0603 | C1608C0G1E682J | TDK |
| C20,C21 | 820pF, 50V, C0G | 0603 | C1608C0G1H821J | TDK |
| C22,C26 | 470µF, 16V | Ф10 | PCG1C471MCL1GS | Nichicon |
| C23,C24,C27,C28 | 22µF,16V, X7R | 1210 | C3225X7R1C226K | TDK |
| C30,C31 | 1000pF, 50V, X7R | 0603 | C1608X7R1H102K | TDK |
| C33,C34 | 1000pF,100V, C0G | 0805 | C2012C0G2A102J | TDK |
| C43,C44,C45,C46,C47 | NU | | | |
| R1 | 3.9 ohm, 5% | 0805 | CRCW08053R90JNEA | Vishay |
| R2 | 60.4k, 1% | 0805 | CRCW080560K4FKEA | Vishay |
| R3 | 6.19k, 1% | 0603 | CRCW06036K19FKEA | Vishay |
| R4 | 22.1k, 1% | 0603 | CRCW060322K1FKEA | Vishay |
| R5,R16,R21,R22,R35, R36 | NU | | | |
| R6,R7 | 36.5k, 1% | 0603 | CRCW060336K5FKEA | Vishay |
| R8,R9,R23,R24,R31, R32 | 10 ohm, 5% | 0805 | CRCW080510R0JNEA | Vishay |
| R10,R12 | 6.98k, 1% | 0805 | CRCW08056K98FKEA | Vishay |
| R11 | 604 ohm, 1% | 0805 | MCR10EZHF6040 | Rohm |
| R13 | 1.33k, 1% | 0805 | MCR10EZHF1331 | Rohm |
| R14,R15 | 73.2k, 1% | 0603 | CRCW060373K2FKEA | Vishay |
| R17,R37 | 0 ohm | 0603 | MCR03EZPJ000 | Rohm |
| R18,R20 | 0.01 ohm, 1W, 1% | 0815 | RL3720WT-R010-F | Susumu |
| R25,R26 | 5.1 ohm, 1W, 1% | 2512 | ERJ-1TRQF5R1U | Panasonic — ECG |
| R27,R28,R29,R30 | 0 ohm | 0805 | MCR10EZPJ000 | Rohm |
| D1,D2 | 60V, 1A | SOD123F | PMEG6010CEH | NXP |
| D3,D4 | 20V, 1A | PowerDI323 | PD3S120L | Diodes |
| L1,L2 | 15µH, 14A | 18.2x18.3 | 74435571500 | WE |
| Q1,Q3, Q2,Q4 | 60V, 100A | LFPAK SO-8 | PSMN5R5-60YS | NXP |
| U1 | | LLP32 | LM5119 | NSC |
| J1,J2,J3,J4,J5,J6 | 15A | | 7693 | Keystone |
| TP1,TP2,TP3 | | Ф0.1 | 5002 | Keystone |
| TP5,TP6,TP7,TP8 | | | 1040 | Keystone |



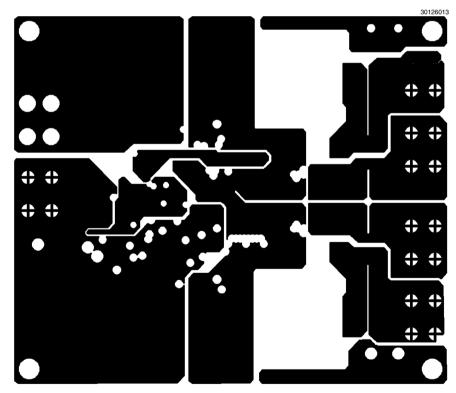
TOP SILKSCREEN (.PLC) AS VIEWED FROM TOP



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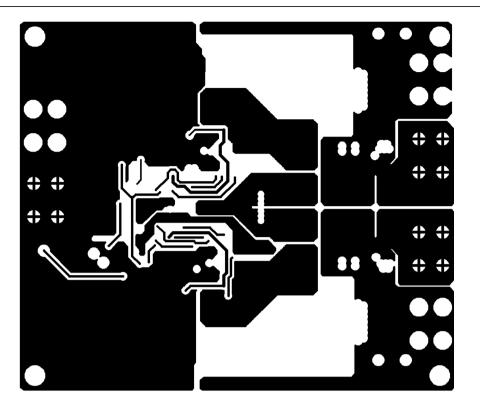
TOP COMPONENT LAYER (.CMP) AS VIEWED FROM TOP



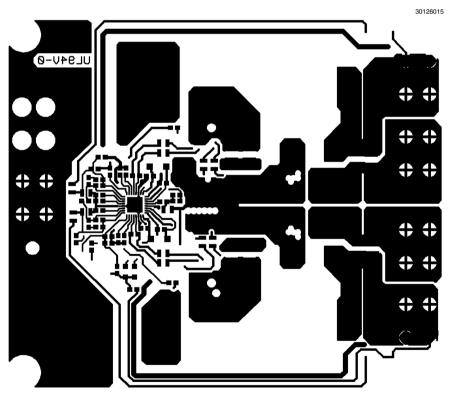
LAYER 2 (.LY2) AS VIEWED FROM TOP

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LAYER 3 (.LY3) AS VIEWED FROM TOP



BOTTOM SOLDER LAYER (.SOL) AS VIEWED FROM TOP

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