

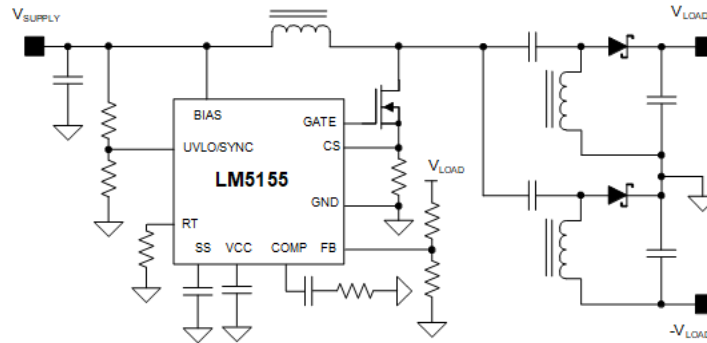
Test Report: PMP40488

6-W Dual-Output SEPIC Converter Reference Design



Description

This reference design employs LM5155 Boost/Flyback/SEPIC controller to provide 6-W outputs with dual-output SEPIC topology. The input is 12-VDC, and outputs are ± 60 V/50 mA. The switching frequency is set at 500k Hz. This design achieves 88.2% peak efficiency. The cross regulation of -60-V rail is within $\pm 4\%$ at the total load range. External voltage control pin is optional to regulate output voltage from 0–60 V. The high efficiency and small PCB dimensions (25mm*14mm*4.5mm) make the design suitable for portable ultrasound probe application.



Top View



Bottom View



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1 Test Prerequisites

1.1 Voltage and Current Requirements

Table 1. Voltage and Current Requirements

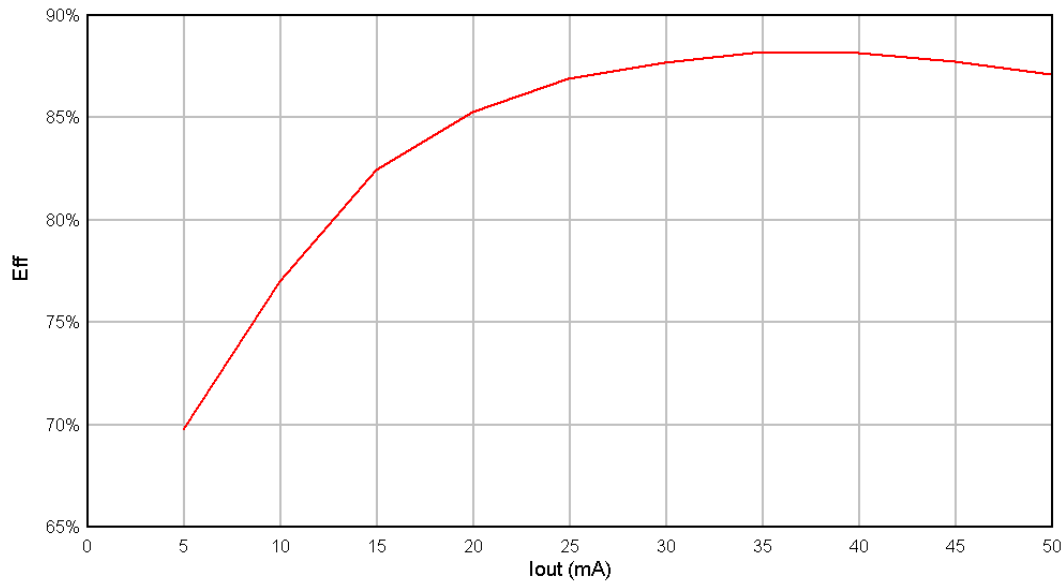
| PARAMETER | SPECIFICATIONS |
|--------------------------|----------------|
| Input Voltage | 12 Vdc |
| Output 1 Voltage | 60 Vdc |
| Maximum Output 1 Current | 0.05 A |
| Output 2 Voltage | -60 Vdc |
| Maximum Output 2 Current | -0.05 A |

1.2 Required Equipment

- Multi-meter (current): Fluke 287C
- Multi-meter (voltage): Fluke 287C
- DC Source: Chroma 62006P-100-25
- E-Load: Chroma 63105A module
- Oscilloscope: Tektronix DPO3054
- Electrical Thermography: Fluke Ti9

2 Testing and Results

2.1 Efficiency Graphs



2.2 Efficiency Data

| V _{IN} /V | I _{IN} /mA | P _{IN} /mW | V _{OUT1} /V | I _{OUT1} /mA | V _{OUT2} /V | I _{OUT2} /mA | P _{OUT} /mW | Loss/mW | Eff |
|--------------------|---------------------|---------------------|----------------------|-----------------------|----------------------|-----------------------|----------------------|---------|--------|
| 12.003 | 16.36 | 196.33 | 60.02 | 0.005 | -59.99 | -0.005 | 0.60 | 195.73 | |
| 12.003 | 71.66 | 860.13 | 60.03 | 4.937 | -59.97 | -5.067 | 600.24 | 259.90 | 69.78% |
| 11.998 | 129.80 | 1557.34 | 60.03 | 9.940 | -59.88 | -10.058 | 1198.97 | 358.37 | 76.99% |
| 12.004 | 181.57 | 2179.57 | 60.04 | 14.944 | -59.79 | -15.055 | 1797.38 | 382.19 | 82.46% |
| 11.998 | 234.05 | 2808.13 | 60.05 | 19.951 | -59.73 | -20.042 | 2395.17 | 412.97 | 85.29% |
| 11.998 | 287.15 | 3445.23 | 60.06 | 24.910 | -59.71 | -25.080 | 2993.62 | 451.60 | 86.89% |
| 12.006 | 340.92 | 4093.09 | 60.07 | 29.913 | -59.62 | -30.066 | 3589.41 | 503.68 | 87.69% |
| 12.002 | 395.29 | 4744.27 | 60.06 | 34.920 | -59.53 | -35.065 | 4184.71 | 559.56 | 88.21% |
| 12.006 | 451.70 | 5423.11 | 60.06 | 39.920 | -59.49 | -40.057 | 4780.59 | 642.52 | 88.15% |
| 11.999 | 510.70 | 6127.89 | 60.07 | 44.934 | -59.44 | -45.045 | 5376.66 | 751.23 | 87.74% |
| 12.000 | 571.30 | 6855.60 | 60.08 | 49.933 | -59.40 | -50.047 | 5972.77 | 882.83 | 87.12% |

2.3 Cross Regulation

 V_{OUT1}

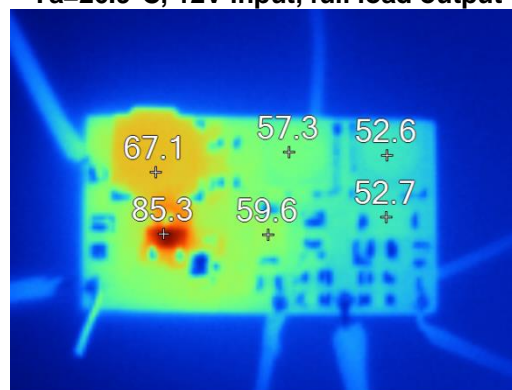
| I _{OUT1} \ I _{OUT2} | 0mA | 10mA | 20mA | 30mA | 40mA | 50mA |
|---------------------------------------|-------|-------|-------|-------|-------|-------|
| 0mA | 60.03 | 60.03 | 60.03 | 60.03 | 60.03 | 60.03 |
| 10mA | 60.03 | 60.03 | 60.03 | 60.04 | 60.04 | 60.04 |
| 20mA | 60.02 | 60.03 | 60.03 | 60.04 | 60.05 | 60.05 |
| 30mA | 60.03 | 60.03 | 60.04 | 60.05 | 60.05 | 60.06 |
| 40mA | 60.03 | 60.04 | 60.05 | 60.06 | 60.06 | 60.07 |
| 50mA | 60.05 | 60.05 | 60.06 | 60.07 | 60.08 | 60.08 |

V_{OUT2}

| $I_{OUT1} \backslash I_{OUT2}$ | 0mA | 10mA | 20mA | 30mA | 40mA | 50mA |
|--------------------------------|--------|--------|--------|--------|--------|--------|
| 0mA | -59.99 | -59.56 | -59.12 | -58.64 | -58.16 | -57.67 |
| 10mA | -60.41 | -59.89 | -59.46 | -59.04 | -58.61 | -58.29 |
| 20mA | -60.63 | -60.16 | -59.73 | -59.34 | -58.93 | -58.53 |
| 30mA | -60.89 | -60.41 | -60.00 | -59.62 | -59.22 | -58.82 |
| 40mA | -61.18 | -60.69 | -60.28 | -59.89 | -59.49 | -59.10 |
| 50mA | -61.47 | -60.94 | -60.55 | -60.15 | -59.77 | -59.40 |

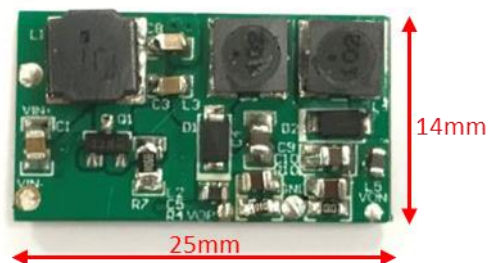
2.4 Thermal Images

$T_a=26.9^\circ\text{C}$, 12V input, full load output



2.5 Dimensions

The dimension of this board is 25mm (length)*14mm (width)*4.5mm (height).

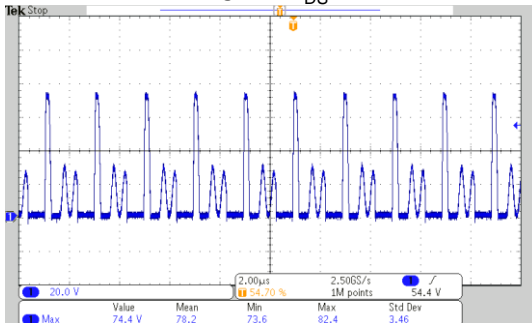


3 Waveforms

3.1 Switching

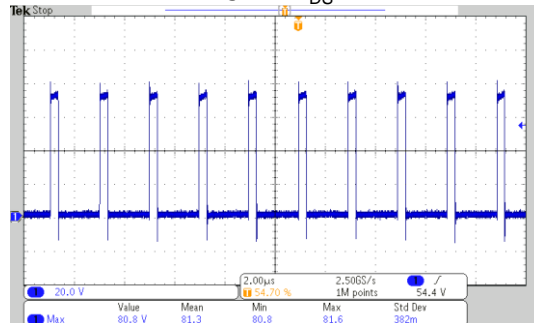
12V input, No load

CH1: V_{DS}



12V input, Full load

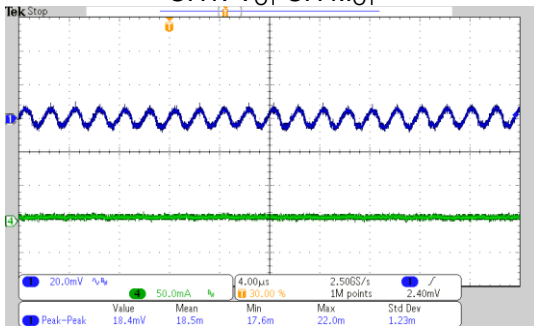
CH1: V_{DS}



3.2 Output Voltage Ripple

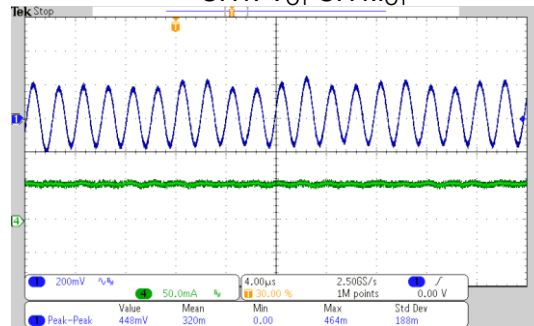
Output 1, No Load

CH1: V_{O1} CH4: I_{O1}



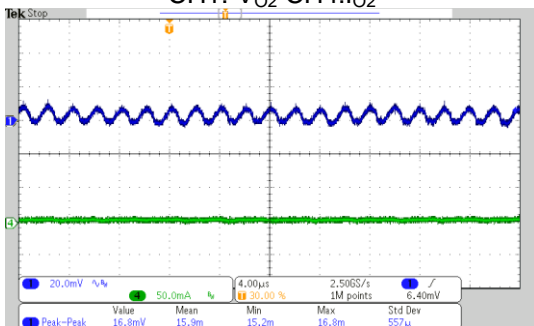
Output 1, 60V0.05A output

CH1: V_{O1} CH4: I_{O1}



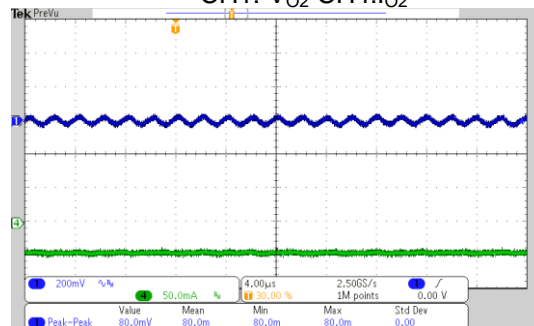
Output 2, No Load

CH1: V_{O2} CH4: I_{O2}



Output 2, -60V0.05A output

CH1: V_{O2} CH4: I_{O2}



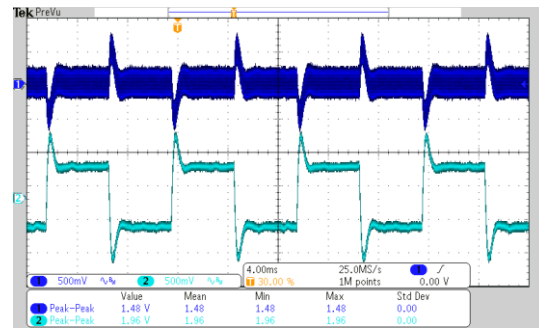
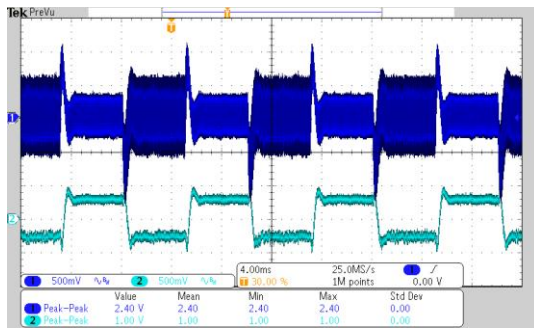
3.3 Load Transients

Output 1 0.025A~0.05A, Output 2 0.05A

CH1: V_{O1} CH2: V_{O2}

Output 1 0.05A, Output 2 0.025A~0.05A

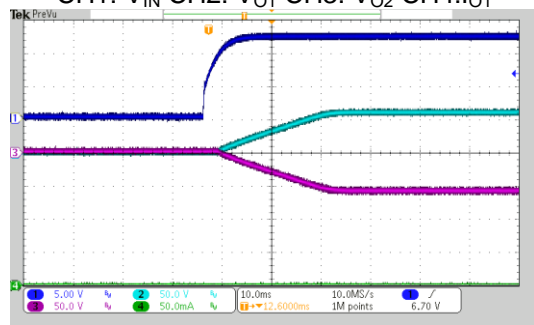
CH1: V_{O1} CH2: V_{O2}



3.4 Start-up Sequence

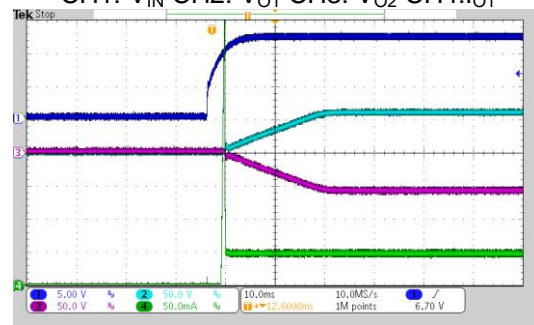
12V input, No Load

CH1: V_{IN} CH2: V_{O1} CH3: V_{O2} CH4: I_{O1}



12V input, Full Load

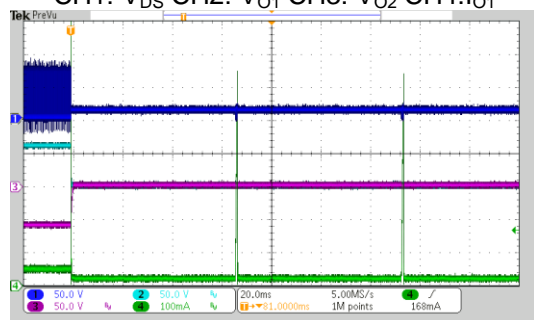
CH1: V_{IN} CH2: V_{O1} CH3: V_{O2} CH4: I_{O1}



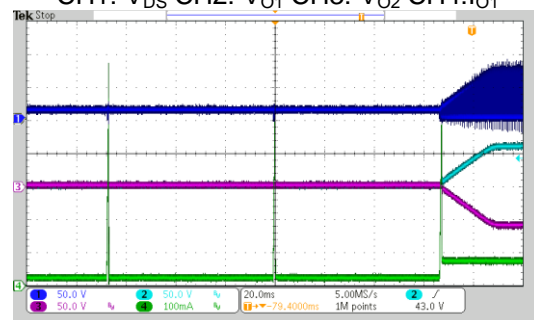
3.5 Output Short-circuit Protection

Test Condition: this function only tested with **LM51551** with Hiccup mode which can enter protection and auto-restart during short-circuit.

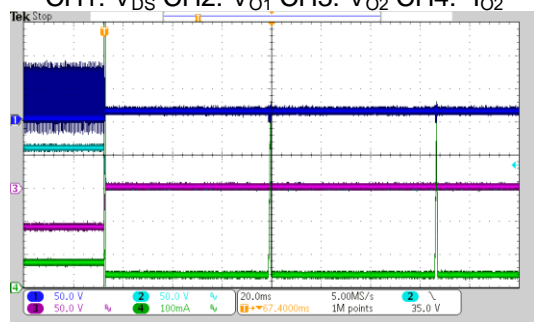
Output 1 Short-circuit Entry
CH1: V_{DS} CH2: V_{O1} CH3: V_{O2} CH4: I_{O1}



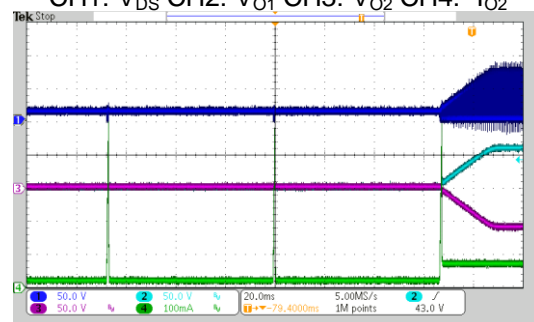
Output 1 Short-circuit Recovery
CH1: V_{DS} CH2: V_{O1} CH3: V_{O2} CH4: I_{O1}



Output 2 Short-circuit Entry
CH1: V_{DS} CH2: V_{O1} CH3: V_{O2} CH4: $-I_{O2}$

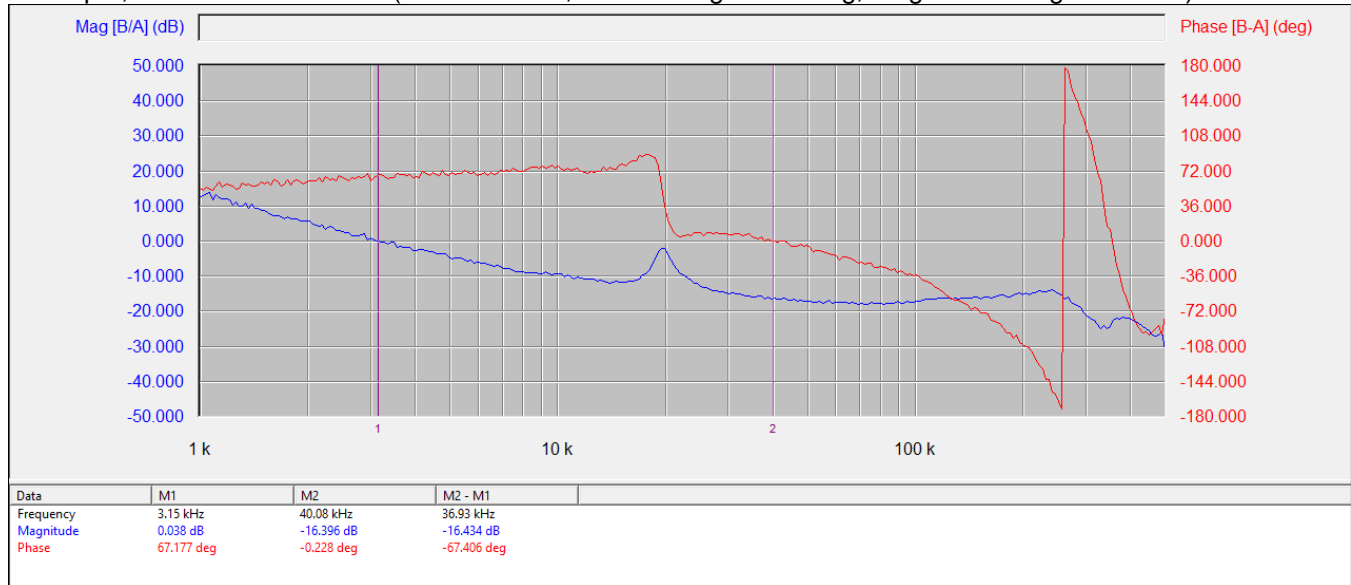


Output 2 Short-circuit Recovery
CH1: V_{DS} CH2: V_{O1} CH3: V_{O2} CH4: $-I_{O2}$



3.6 Control Loop Gain and Stability

12V input, full load (BW=3.15k Hz, Phase margin=67.2deg, Magnitude Margin=16.4dB)



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