Description
This reference design shows a buck converter with adjustable output voltage using the TLV62569. The voltage can be adjusted with a PWM signal scaling an output voltage from 2.5 V through 4.3 V at maximum load currents of 1.5 A. The output voltage adjustment achieved with a PWM signal in this reference design is at given following conditions:

- PWM Frequency of 20 kHz
- Output Voltage Step of 100 mV at 5.5% duty cycle
1 Test Prerequisites

1.1 Voltage and Current Requirements

Table 1. Voltage and Current Requirements

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>SPECIFICATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input Voltage</td>
<td>VI = 5 V</td>
</tr>
<tr>
<td>Output Voltage Range</td>
<td>2.5 V to 4.3 V</td>
</tr>
<tr>
<td>Output Current</td>
<td>1.5 A</td>
</tr>
<tr>
<td>Output Voltage Step Size</td>
<td>100 mV</td>
</tr>
<tr>
<td>Switching Frequency</td>
<td>1.5 MHz</td>
</tr>
<tr>
<td>PWM Frequency</td>
<td>20 kHz</td>
</tr>
</tbody>
</table>

1.2 Required Equipment*

- Power Supply EA-PS 3032-10B
- Oscilloscope LeCroy Wavesurfer 24Xs
- Resistive Loads
- Multimeter

1.3 Considerations*

To prevent PWM ripple on output consider using a buffer stage in the injection path.
2 Testing and Results

2.1 Efficiency Graphs

![Efficiency Graph](image)

2.2 Efficiency Data

<table>
<thead>
<tr>
<th>Input Voltage</th>
<th>Input Current</th>
<th>Output Voltage</th>
<th>Output Current</th>
<th>Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.2</td>
<td>0.79</td>
<td>2.42</td>
<td>1.53</td>
<td>0.901</td>
</tr>
<tr>
<td>5.2</td>
<td>0.608</td>
<td>2.42</td>
<td>1.2</td>
<td>0.919</td>
</tr>
<tr>
<td>5.2</td>
<td>0.48</td>
<td>2.42</td>
<td>0.97</td>
<td>0.940</td>
</tr>
<tr>
<td>5.2</td>
<td>0.251</td>
<td>2.42</td>
<td>0.5</td>
<td>0.927</td>
</tr>
<tr>
<td>5.2</td>
<td>0.116</td>
<td>2.45</td>
<td>0.225</td>
<td>0.914</td>
</tr>
<tr>
<td>5.2</td>
<td>0.334</td>
<td>4.31</td>
<td>0.395</td>
<td>0.980</td>
</tr>
<tr>
<td>5.2</td>
<td>0.503</td>
<td>4.21</td>
<td>0.603</td>
<td>0.971</td>
</tr>
<tr>
<td>5.2</td>
<td>0.852</td>
<td>4.21</td>
<td>1.01</td>
<td>0.960</td>
</tr>
<tr>
<td>5.2</td>
<td>1.077</td>
<td>4.21</td>
<td>1.26</td>
<td>0.947</td>
</tr>
<tr>
<td>5.2</td>
<td>1.302</td>
<td>4.21</td>
<td>1.507</td>
<td>0.937</td>
</tr>
</tbody>
</table>
2.3 Thermal Images

The following figure shows the thermal image of the board measured at room temperature.

![Thermal Image at normal operation](image)

**Figure 1: Thermal Image at normal operation**

2.4 Dimensions

<table>
<thead>
<tr>
<th>Description</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCB</td>
<td>37 mm x 29 mm</td>
</tr>
<tr>
<td>Component Placement</td>
<td>15 mm x 14 mm</td>
</tr>
</tbody>
</table>
3 Waveforms

If not otherwise specified, following graphs show the performance of the board at nominal operating conditions at room temperature.

3.1 Switching

CH1: Switching Node (1 V/div)
Time Scale: 500 ns/div

Figure 2: Switching for $V_{OUT} = 2.5 \text{ V}$, $I_{OUT} = 1.5 \text{ A}$
Figure 3: Switching for $V_{OUT} = 4.3\, \text{V}$, $I_{OUT} = 1.5\, \text{A}$
3.2 Output Voltage Ripple

CH1: Output Voltage AC coupled (2 mV/div)
Time Scale: 500 ns/div

Figure 4: Output voltage ripple for $V_{\text{OUT}} = 2.5$ V, $I_{\text{OUT}} = 1.5$ A
Figure 5: Output voltage ripple for $V_{OUT} = 4.3\, \text{V}$, $I_{OUT} = 1.5\, \text{A}$
3.3 Load Transients*

Following graphs show the load step response of the TLV62569 at minimum output voltage and maximum output voltage and a load step of 500 mA to 1.5 A and 1.5 A to 500 mA.

3.3.1 Load Transient at $V_{OUT} = 2.5$ V

Following scope plot shows the load step response of the converter at an input voltage of 5 V. The maximum deviation is at 23.6 mV which corresponds to 0.94 %.

CH1: Output Voltage (AC coupled, 20 mV/div)
CH4: Output Current (0.5 A/div)
Time scale: 20 us/div

Figure 6: Load Transient Response at $V_{OUT} = 2.5$ V
3.3.2 Load Transient at $V_{OUT} = 4.3$ V

Following scope plot shows the load step response of the converter at an input voltage of 5 V. The maximum deviation is at 23.5 mV which corresponds to 0.55%.

CH3: Output Voltage (AC coupled, 50 mV/div)
CH4: Output Current (0.5 A/div)
Time scale: 50 us/div

Figure 7: Load Transient Response at VOUT = 4.5 V
3.4 **Bode Plot**

Following figures depicts the small signal response of the design at 500 mA output load and 1.5 A output load.

![Bode Plot](image)

**Figure 8: Bode plot at $I_o = 500$ mA**

<table>
<thead>
<tr>
<th>Test Conditions</th>
<th>Crossover Frequency</th>
<th>Phase Margin</th>
<th>Slope (20dB/decade)</th>
<th>Crossover Frequency</th>
<th>Gain Margin</th>
<th>Slope (20dB/decade)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_o = 2.5$ $V$</td>
<td>$I_o = 0.5$ $A$</td>
<td>78.1 kHz</td>
<td>50.9 deg</td>
<td>-1.2</td>
<td>454.3 kHz</td>
<td>-18.6 dB</td>
</tr>
<tr>
<td>$V_o = 4.3$ $V$</td>
<td>$I_o = 0.5$ $A$</td>
<td>77.3 kHz</td>
<td>47.9 deg</td>
<td>-1.3</td>
<td>543.1 kHz</td>
<td>-18.1 dB</td>
</tr>
</tbody>
</table>
Figure 9: Bode Plot at \(I_0 = 1.5\) A

<table>
<thead>
<tr>
<th>Test Conditions</th>
<th>Crossover Frequency</th>
<th>Phase Margin</th>
<th>Slope (20dB/decade)</th>
<th>Crossover Frequency</th>
<th>Gain Margin</th>
<th>Slope (20dB/decade)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(V_o = 2.5) V, (I_o = 1.5) A</td>
<td>85.28 kHz</td>
<td>54.28 deg</td>
<td>-1</td>
<td>485.8 kHz</td>
<td>-17.8 dB</td>
<td>-1.4</td>
</tr>
<tr>
<td>(V_o = 4.3) V, (I_o = 1.5) A</td>
<td>77.7 kHz</td>
<td>53.3 deg</td>
<td>-0.96</td>
<td>489.4 kHz</td>
<td>-18.6 dB</td>
<td>-1.7</td>
</tr>
</tbody>
</table>
3.5 Start-up Sequence

CH3: Input Voltage (1 V/div)
CH1: Output Voltage (2 V/div)
Time scale: 10 ms/div

Figure 10: Start-Up Sequence, No PWM
3.6 Shut-down Sequence

CH3: Input Voltage (1 V/div)
CH1: Output Voltage (2 V/div)
Time scale: 10 ms/div

Figure 11: Shut-down Sequence, No PWM
3.7 Other

3.7.1 PWM Output Voltage Scaling

Following graphs show the output voltage settling time at maximum output scaling.

Figure 12: Output scaling from 0% to 99%

At a PWM step from duty cycle 0% to 99% the output voltage settles from 2.5 V to 4.3 V at approximately 370 us.
Figure 13: Output scaling from 99% to 0%

At a PWM step from duty cycle 99% to 0% the output voltage settles from 4.3 V to 2.5 V at approximately 525 us.
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