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Introduction

This user's guide contains background information for the TPS54326 as well as support documentation for the TPS54326EVM-540 evaluation module. Also included are the performance specifications, schematic and the bill of materials for the TPS54326EVM-540.

1.1 Background

The TPS54326 is a single, adaptive on-time D-CAP2™ mode synchronous buck converter requiring a very low external component count. The D-CAP2™ control circuit is optimized for low ESR output capacitors such as POSCAP, SP-CAP or ceramic types and features fast transient response with no external compensation. The switching frequency is internally set at a nominal 700 kHz. The high-side and low-side switching MOSFETs are incorporated inside the TPS54326 package along with the gate drive circuitry. The low drain-to-source on resistance of the MOSFETs allow the TPS54326 to achieve high efficiencies and helps keep the junction temperature low at high output currents. The TPS54226 also has an Auto-Skip mode to enable higher efficiency at light loads. The TPS54326 dc/dc synchronous converter is designed to provide up to a 2A output from an input control voltage source of 4.5V to 18V, input power voltage source of 2V to 18V and output voltage from 0.76V to 5.5V. Rated input voltage, output voltage and output current range for the evaluation module are given in Table 1.

Table 1. Input Voltage and Output Current Summary

<table>
<thead>
<tr>
<th>EVM</th>
<th>Input Voltage Range</th>
<th>Output Voltage and Current Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>TPS54326EVM-540</td>
<td>VIN = 4.5V to 18V</td>
<td>Vout = 1.05 V, 0A to 2A</td>
</tr>
</tbody>
</table>

1.2 Performance Specification Summary

A summary of the TPS54326EVM-540 performance specifications is provided in Table 2. Specifications are given for an input voltage of VIN = 12V and an output voltage of 1.05V, unless otherwise noted. The ambient temperature is 25°C for all measurement, unless otherwise noted.

Table 2. TPS54326 EVM and Performance Specifications Summary

<table>
<thead>
<tr>
<th>Specifications</th>
<th>Test Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input voltage range (VIN)</td>
<td></td>
<td>4.5</td>
<td>12</td>
<td>18</td>
<td>V</td>
</tr>
<tr>
<td>CH1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output voltage</td>
<td></td>
<td>1.05</td>
<td></td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>Operating frequency</td>
<td>VIN = 12V, <em>I</em></td>
<td>700</td>
<td></td>
<td></td>
<td>kHz</td>
</tr>
<tr>
<td>Output current range</td>
<td></td>
<td>0</td>
<td>3</td>
<td></td>
<td>A</td>
</tr>
<tr>
<td>Over current limit</td>
<td>VIN = 12V</td>
<td></td>
<td>4.1</td>
<td></td>
<td>A</td>
</tr>
<tr>
<td>Output ripple voltage</td>
<td>VIN = 12V, <em>I</em></td>
<td></td>
<td></td>
<td>7</td>
<td>mVpp</td>
</tr>
</tbody>
</table>
1.3 Modifications

These evaluation modules are designed to provide access to the features of the TPS54326. Some modifications can be made to this module.

1.3.1 Output Voltage Set Point

To change the output voltage of the EVMs, it is necessary to change the value of resistor R1. Changing the value of R1 can change the output voltage above 0.765V. The value of R1 for a specific output voltage can be calculated using Equation 1 and Equation 2.

For output voltage from 0.76V to 2.5V:

\[ V_O = 0.765 \times \left(1 + \frac{R1}{R2}\right) \]  

(1)

For output voltage over 2.5V:

\[ V_O = (0.763 + 0.0017 \times V_O) \times \left(1 + \frac{R1}{R2}\right) \]  

(2)

Table 3 lists the R1 value for some common output voltages. For higher output voltages, a feed forward capacitor is required. Pads for this component (C2) are provided on the printed circuit board. C2 is used for faster load transient response and is recommended for auto skip mode stability. Note that the values given in Table 3 are standard values, and not the exact value calculated using Table 3.

Table 3. Output Voltages

<table>
<thead>
<tr>
<th>Output Voltage (V)</th>
<th>R1 (kΩ)</th>
<th>R2 (kΩ)</th>
<th>C2 (pF)</th>
<th>L1 (µH)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>6.81</td>
<td>22.1</td>
<td></td>
<td>1.5</td>
</tr>
<tr>
<td>1.05</td>
<td>8.25</td>
<td>22.1</td>
<td></td>
<td>1.5</td>
</tr>
<tr>
<td>1.2</td>
<td>12.7</td>
<td>22.1</td>
<td></td>
<td>1.5</td>
</tr>
<tr>
<td>1.8</td>
<td>30.1</td>
<td>22.1</td>
<td>150-220</td>
<td>2.2</td>
</tr>
<tr>
<td>2.5</td>
<td>49.9</td>
<td>22.1</td>
<td>68-100</td>
<td>2.2</td>
</tr>
<tr>
<td>3.3</td>
<td>73.2</td>
<td>22.1</td>
<td>47 - 68</td>
<td>2.2</td>
</tr>
<tr>
<td>5.0</td>
<td>121</td>
<td>22.1</td>
<td>33 - 47</td>
<td>3.3</td>
</tr>
</tbody>
</table>

2 Test Setup and Results

This section describes how to properly connect, set up, and use the TPS54326EVM-540. The section also includes test results typical for the evaluation modules and efficiency, output load regulation, output line regulation, load transient response, output voltage ripple, input voltage ripple, start up and switching frequency.

2.1 Input / Output Connections

The TPS5326EVM-540 is provided with input/output connectors and test points as shown in Table 4. A power supply capable of supplying 3 A must be connected to J1 through a pair of 20 AWG wires. The load must be connected to J2 through a pair of 20 AWG wires. The maximum load current capability is 3 A. Wire lengths must be minimized to reduce losses in the wires. Test point TP1 provides a place to monitor the \( V_{in} \) input voltages with TP2 providing a convenient ground reference. TP8 is used to monitor the output voltage with TP9 as the ground reference.
2.2 Start Up Procedure
1. Make sure the jumper at JP1 (Enable control) is set from EN to OFF.
2. Apply appropriate VIN voltage to VIN and PGND terminals at J1.
3. Move the jumper at JP1 (Enable control) to cover EN and ON. The EVM will enable the output voltage.

2.3 Efficiency

Figure 1 shows the efficiency for the TPS54326EVM-540 at an ambient temperature of 25°C.

![Efficiency graph](image_url)
2.4 Load Regulation

The load regulation for the TPS54326EVM-540 is shown Figure 2.

![Figure 2. TPS54326EVM-540 Load Regulation](image)

2.5 Line Regulation

The line regulation for the TPS54326EVM-540 is shown Figure 3.

![Figure 3. TPS54326EVM-540 Line Regulation](image)
2.6 Load Transient Response

The TPS54326EVM-540 response to load transient is shown in Figure 4. The current step is from 0.75 A to 2.25 A (25% to 75% of rated load). Total peak-to-peak output voltage variation is as shown.

![Graph of load transient response](image)

Figure 4. TPS54326EVM-540 Load Transient Response

2.7 Output Voltage Ripple

The TPS54326EVM-540 output voltage ripple is shown in Figure 5. The output current is the rated full load of 3A.

![Graph of output voltage ripple](image)

Figure 5. TPS54326EVM-540 Output Voltage Ripple
2.8 Input Voltage Ripple

The TPS54326EVM-540 input voltage ripple is shown in Figure 6. The output current is the rated full load of 3A.

![Input Voltage Ripple Graph](image1)

Figure 6. TPS54326EVM-540 Input Voltage Ripple

2.9 Start Up

The TPS54326EVM-540 start up waveform is shown in Figure 7.

![Start Up Graph](image2)

Figure 7. TPS54326EVM-540 Start Up
2.10 Switching Frequency

The TPS54326EVM-540 switching frequency is shown in Figure 8.

\[ I_0 = 1 \text{ A} \]

\[ V_0 = 1.8 \text{ V} \]

\[ V_0 = 3.3 \text{ V} \]

3 Board Layout

This section provides description of the TPS54326EVM-540, board layout, and layer illustrations.

3.1 Layout

The board layout for the TPS54326EVM-540 and is shown in Figure 9 through Figure 14. The top layer contains the main power traces for VIN, VO and ground. Also on the top layer are connections for the pins of the TPS54326 and a large area filled with ground. Many of the signal traces are also located on the top side. The input decoupling capacitor are located as close to the IC as possible. The input and output connectors, test points and most of the components are located on the top side. R3, the 0-Ω resistor that connects VIN to VCC and R4, the power good pull up, are located on the back side. Analog ground and power ground are connected at a single point on the top layer near pin 5 of the TPS54326. The internal layer 1 is a split plane containing analog and power grounds. The internal layer 2 is primarily power ground. There are also a fill area of VIN and a trace routing VCC to the enable control jumper JP1. The bottom layer is primarily analog ground. There are also traces to connect VIN to VCC through R3, traces for the power good signal and the feedback trace from VOUT to the voltage setpoint divider network.
Figure 9. Top Assembly

Figure 10. Top Layer
Figure 11. Internal Layer 1

Figure 12. Internal Layer 2
Figure 13. Bottom Layer

Figure 14. Bottom Assembly
4  Schematic, Bill of Materials and Reference

This section presents the TPS54326EVM-540 schematic, bill of materials and reference.

4.1  Schematic

Figure 15 is the schematic for the TPS54326EVM-540.

Figure 15. TPS54326EVM-540 Schematic Diagram
## 4.2 Bill of Materials

### Table 5. Bill of Materials

<table>
<thead>
<tr>
<th>RefDes</th>
<th>QTY</th>
<th>Value</th>
<th>Description</th>
<th>Size</th>
<th>Part Number</th>
<th>MFR</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1, C3</td>
<td>2</td>
<td>10uF</td>
<td>Capacitor, Ceramic, 25V, X5R, 20%</td>
<td>1210</td>
<td>C3225X5R1E106M</td>
<td>TDK</td>
</tr>
<tr>
<td>C11</td>
<td>0</td>
<td>Open</td>
<td>Capacitor, Ceramic</td>
<td>1206</td>
<td>Std</td>
<td>Std</td>
</tr>
<tr>
<td>C2, C4, C8</td>
<td>0</td>
<td>Open</td>
<td>Capacitor, Ceramic</td>
<td>0603</td>
<td>Std</td>
<td>Std</td>
</tr>
<tr>
<td>C5</td>
<td>1</td>
<td>3300pF</td>
<td>Capacitor, Ceramic, 25V, X7R, 10%</td>
<td>0603</td>
<td>Std</td>
<td>Std</td>
</tr>
<tr>
<td>C6</td>
<td>1</td>
<td>1uF</td>
<td>Capacitor, Ceramic, 16V, X7R, 10%</td>
<td>0603</td>
<td>Std</td>
<td>Std</td>
</tr>
<tr>
<td>C7</td>
<td>1</td>
<td>0.1uF</td>
<td>Capacitor, Ceramic, 50V, X7R, 10%</td>
<td>0603</td>
<td>Std</td>
<td>Std</td>
</tr>
<tr>
<td>C9, C10</td>
<td>2</td>
<td>22uF</td>
<td>Capacitor, Ceramic, 6.3V, X5R, 20%</td>
<td>1206</td>
<td>C3216X5R0J226M</td>
<td>TDK</td>
</tr>
<tr>
<td>J1, J2</td>
<td>2</td>
<td>ED555/2DS</td>
<td>Terminal Block, 2-pin, 6-A, 3.5mm</td>
<td>0.27 x 0.25 inch</td>
<td>ED555/2DS</td>
<td>Sullins</td>
</tr>
<tr>
<td>JP1</td>
<td>1</td>
<td>PEC03SAAN</td>
<td>Header, Male 3-pin, 100mil spacing</td>
<td>0.100 inch x 3</td>
<td>PEC03SAAN</td>
<td>Sullins</td>
</tr>
<tr>
<td>L1</td>
<td>1</td>
<td>1.5uH</td>
<td>Inductor, SMT, 11.5 A, 9.7 milliohm</td>
<td>0.256 x 0.280 inch</td>
<td>SPM6530T-1R5M100</td>
<td>TDK</td>
</tr>
<tr>
<td>R1</td>
<td>1</td>
<td>8.25k</td>
<td>Resistor, Chip, 1/16W, 1%</td>
<td>0603</td>
<td>Std</td>
<td>Std</td>
</tr>
<tr>
<td>R2</td>
<td>1</td>
<td>22.1k</td>
<td>Resistor, Chip, 1/16W, 1%</td>
<td>0603</td>
<td>Std</td>
<td>Std</td>
</tr>
<tr>
<td>R3</td>
<td>1</td>
<td>0</td>
<td>Resistor, Chip, 1/16W, 1%</td>
<td>0603</td>
<td>Std</td>
<td>Std</td>
</tr>
<tr>
<td>R4</td>
<td>1</td>
<td>100k</td>
<td>Resistor, Chip, 1/16W, 1%</td>
<td>0603</td>
<td>Std</td>
<td>Std</td>
</tr>
<tr>
<td>R5</td>
<td>0</td>
<td>Open</td>
<td>Resistor, Chip, 1/16W, 1%</td>
<td>0603</td>
<td>Std</td>
<td>Std</td>
</tr>
<tr>
<td>TP1, TP3, TP4, TP6, TP7, TP8, TP9</td>
<td>3</td>
<td>5000</td>
<td>Test Point, Red, Thru Hole Color Keyed</td>
<td>0.100 x 0.100 inch</td>
<td>5000</td>
<td>Keystone</td>
</tr>
<tr>
<td>TP2, TP5, TP9</td>
<td>3</td>
<td>5001</td>
<td>Test Point, Black, Thru Hole Color Keyed</td>
<td>0.100 x 0.100 inch</td>
<td>5001</td>
<td>Keystone</td>
</tr>
<tr>
<td>U1</td>
<td>1</td>
<td>TPS54326PWP</td>
<td>IC, 2-A Output Single Sync. Step-Down</td>
<td></td>
<td>TPS54326PWP</td>
<td>TI</td>
</tr>
<tr>
<td>–</td>
<td>1</td>
<td>Shunt, 100-mil, Black</td>
<td>0.100</td>
<td>929950-00</td>
<td>3M</td>
<td></td>
</tr>
<tr>
<td>–</td>
<td>1</td>
<td>PCB, 2.76 In x 1.97 In x 0.062 In</td>
<td></td>
<td>HPAS540</td>
<td>Any</td>
<td></td>
</tr>
</tbody>
</table>

### 4.3 Reference

1. TPS54326 data sheet, *Single Synchronous Converter with Integrated High Side and Low Side MOS FET (SLVSA14)*
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