The TPS53126EVM-600 Evaluation Module presents an easy-to-use reference design for a common, dual-output power supply using the TPS53126 controller in cost-sensitive applications.

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1 Introduction

1.1 Description
The TPS53126EVM-600 evaluation board provides the user with a convenient way to evaluate the TPS53126 Dual D-CAP2™ Mode Control Step-Down Controller in a realistic, cost-sensitive application. Providing both a low core-type 1.05-V and I/O type 1.8-V output at up to 4 A from a loosely regulated 12-V (8-V to 22-V) source, the TPS53126EVM-600 includes switches and test points to assist users in evaluating the performance of the TPS53126 controller in their applications.

1.2 Applications
- Digital television
- Set-top box
- DSL and cable modems
- Cost-sensitive digital consumer products

1.3 Features
- 8-V to 22-V input
- 1.05-V and 1.8-V output
- Up to 4 A per channel output
- Switch selectable 350-kHz or 700-kHz pseudo-fixed frequency D-CAP2™ mode control
- Independent enable switches for power-on/power-off testing
# Electrical Performance Specifications

## Table 1. TPS53126EVM-600 Electrical and Performance Specifications

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Notes and Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>INPUT CHARACTERISTICS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$V_{IN}$</td>
<td>Input voltage</td>
<td>8</td>
<td>12</td>
<td>22</td>
<td>V</td>
</tr>
<tr>
<td>$I_{IN}$</td>
<td>Input Current</td>
<td></td>
<td>1.2</td>
<td>1.5</td>
<td>A</td>
</tr>
<tr>
<td>No-Load Input Current</td>
<td>$V_{IN} = 12 V$, $I_{OUT} = 0 A$, SW3 = 350 kHz</td>
<td></td>
<td>20</td>
<td></td>
<td>mA</td>
</tr>
<tr>
<td>$V_{IN,UVLO}$</td>
<td>Input UVLO</td>
<td></td>
<td>4.0</td>
<td>4.2</td>
<td>4.5</td>
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<tr>
<td><strong>OUTPUT CHARACTERISTICS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$V_{OUT1}$</td>
<td>Output Voltage 1</td>
<td></td>
<td>1.05</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>Line Regulation</td>
<td>$V_{IN} = 8 V$ to 22 V</td>
<td></td>
<td>1%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Load Regulation</td>
<td>$I_{OUT1} = 0 A$ to 4 A</td>
<td></td>
<td>1%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$V_{OUT1,rip}$</td>
<td>Output Voltage Ripple</td>
<td></td>
<td>0</td>
<td>4</td>
<td>A</td>
</tr>
<tr>
<td>$I_{OUT1}$</td>
<td>Output Current 1</td>
<td></td>
<td>1.80</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>Line Regulation</td>
<td>$V_{IN} = 8 V$ to 22 V</td>
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<td>1%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Load Regulation</td>
<td>$I_{OUT1} = 0 A$ to 4 A</td>
<td></td>
<td>1%</td>
<td></td>
<td></td>
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<tr>
<td>$V_{OUT2}$</td>
<td>Output Voltage 2</td>
<td></td>
<td></td>
<td></td>
<td>V</td>
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<tr>
<td>Line Regulation</td>
<td>$V_{IN} = 8 V$ to 22 V</td>
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<td>1%</td>
<td></td>
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</tr>
<tr>
<td>Load Regulation</td>
<td>$I_{OUT2} = 0 A$ to 4 A</td>
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<td>1%</td>
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<td>$V_{OUT2,rip}$</td>
<td>Output Voltage Ripple</td>
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<td>0</td>
<td>4</td>
<td>A</td>
</tr>
<tr>
<td>$I_{OUT2}$</td>
<td>Output Current 2</td>
<td></td>
<td>0</td>
<td>4</td>
<td>A</td>
</tr>
<tr>
<td><strong>SYSTEMS CHARACTERISTICS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>$F_{SW}$</td>
<td>Switching Frequency</td>
<td></td>
<td>200</td>
<td>350</td>
<td>400</td>
</tr>
<tr>
<td>$\eta_{pk1}$</td>
<td>Peak Efficiency of Output 1</td>
<td></td>
<td>88%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\eta_{1}$</td>
<td>Full Load Efficiency of Output 1</td>
<td></td>
<td>85%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\eta_{pk2}$</td>
<td>Peak Efficiency of Output 2</td>
<td></td>
<td>91%1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\eta_{2}$</td>
<td>Full Load efficiency of Output 2</td>
<td></td>
<td>91%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
NOTE: For Reference Only, See Table 3 for Specific Values

Figure 1. TPS53126EVM-600 Schematic
4 Connector and Test Point Descriptions

4.1 Enable Switches – SW1 and SW2

TPS5126EVM-600 includes independent enable switches for each of the two outputs. When the switch is in the DIS position, the channel is disabled and discharged per the TPS5126’s internal discharge characteristics.

To enable V_{OUT1}, place SW1 in the EN position. To enable V_{OUT2}, place SW2 in the EN position.

4.2 Switching Frequency Select Switch – SW3

TPS5126EVM-600 includes a frequency select switch (SW3) to select the frequency programmed by the TEST2 IC pin of the TPS53126. When in the 350-kHz position, the D-CAP2™ mode control selects the Ton for 350-kHz operation. When in the 700-kHz position, the D-CAP2™ mode control selects the Ton for 700-kHz operation. For more details of switching frequency verse V_{IN} and I_{OUT}, see the TPS5126 data sheet.

Do not switch the position of SW3 while the TPS5126EVM-600 module is running. To change frequency selection, disable both Channel 1 and Channel 2 before changing the switching frequency.

4.3 Test Point Descriptions

Table 2 lists the test points, their labels, uses, and where additional information is located.

<table>
<thead>
<tr>
<th>Test Point</th>
<th>Label</th>
<th>Use</th>
<th>Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>TP1</td>
<td>TEST1</td>
<td>Not Used</td>
<td></td>
</tr>
<tr>
<td>TP2</td>
<td>TEST2</td>
<td>Monitor Frequency Select Voltage (5 V or GND)</td>
<td></td>
</tr>
<tr>
<td>TP3</td>
<td>GND</td>
<td>Ground for Input Voltage</td>
<td>Section 4.3.1</td>
</tr>
<tr>
<td>TP4</td>
<td>GND</td>
<td>Ground for Channel-1 Output Voltage</td>
<td>Section 4.3.2</td>
</tr>
<tr>
<td>TP5</td>
<td>SW1</td>
<td>Monitor Switching Node for Channel 1</td>
<td>Section 4.3.4</td>
</tr>
<tr>
<td>TP6</td>
<td>GND</td>
<td>Ground for Channel-2 Output Voltage</td>
<td>Section 4.3.3</td>
</tr>
<tr>
<td>TP7</td>
<td>VOUT2</td>
<td>Monitor Output Voltage for Channel 2</td>
<td>Section 4.3.3</td>
</tr>
<tr>
<td>TP8</td>
<td>VOUT1</td>
<td>Monitor Output Voltage for Channel 1</td>
<td>Section 4.3.2</td>
</tr>
<tr>
<td>TP9</td>
<td>VIN</td>
<td>Monitor Input Voltage</td>
<td>Section 4.3.1</td>
</tr>
<tr>
<td>TP10</td>
<td>VREG5</td>
<td>Monitor Output of VREG5 Regulator</td>
<td>Section 4.3.5</td>
</tr>
<tr>
<td>TP11</td>
<td>SW2</td>
<td>Monitor Switching Node for Channel 2</td>
<td>Section 4.3.4</td>
</tr>
</tbody>
</table>

4.3.1 Input Voltage Monitoring – TP3 and TP9

TPS5126EVM-600 provides two test points for measuring the voltage applied to the module. This allows the user to measure the actual module voltage without losses from input cables and connectors. Measure all input voltage between TP9 and TP3. To use TP9 and TP3, connect a voltmeter positive terminal to TP9 and negative terminal to TP3.

4.3.2 Channel-1 Output Voltage Monitoring – TP4 and TP8

TPS5126EVM-600 provides two test points for measuring the voltage generated at the V_{OUT1} output by the module. This allows the user to measure the actual output voltage without losses from output cables and connectors. Measure all dc output voltage measurements between TP8 and TP4. To use TP8 and TP4, connect a voltmeter positive terminal to TP8 and negative terminal to TP4.

For output ripple measurements, TP8 and TP4 allow a user to limit the ground loop area by using the tip and barrel measurement technique shown in Figure 2.
4.3.3 Channel-2 Output Voltage Monitoring – TP6 and TP7

TPS53126EVM-600 provides two test points for measuring the voltage generated at the $V_{OUT2}$ output by the module. This allows the user to measure the actual output voltage without losses from output cables and connectors. Measure all dc output voltage between TP7 and TP6. To use TP7 and TP6, connect a voltmeter positive terminal to TP7 and negative terminal to TP6.

For output ripple measurements, TP7 and TP6 allow a user to limit the ground loop area by using the tip and barrel measurement technique shown in Figure 2.

4.3.4 Switching Node Monitoring – TP3, TP5, and TP11

TPS53126EVM-600 provides two test points for measuring the switching node waveform voltages. TP5 monitors the switching node of Channel 1. TP2 monitors the switching node of Channel 2. To use TP5 or TP11, connect an oscilloscope probe between TP5 or TP11 and TP3.

4.3.5 5-V Regulator Output Monitoring – TP3 and TP10

TPS53126EVM-600 provides a test point for measuring the output of the internal 5-V regulator. TP10 monitors the output voltage of the internal 5-V regulator. To use TP10, connect a voltmeter positive terminal to TP10 and negative terminal to TP3.

5 Test Setup

5.1 Equipment

5.1.1 Voltage Source

The input voltage source ($V_{IN}$) shall be a 0-V to 25-V variable dc source capable of supplying 3 Adc minimum.

5.1.2 Meters

A1: 0-Adc to 5-Adc, ammeter
V1: $V_{IN}$, 0-V to 25-V voltmeter
V2: $V_{OUT1}$, 0-V to 2-V voltmeter
V3: $V_{OUT2}$, 0-V to 2-V voltmeter

5.1.3 Loads

LOAD1: One output load is an electronic load set for constant-current mode capable of 0 Adc to 4 Adc at 1.05 Vdc.
LOAD2: The other output load is an electronic load set for constant-current mode capable of 0 Adc to 4 Adc at 1.8 Vdc.
5.1.4 Oscilloscope and Probe

The oscilloscope, analog or digital, must be set for ac-coupled measurement with 20-MHz bandwidth limiting. Use 20-mV/division vertical resolution, 1-µs/division horizontal resolution for output ripple voltage test.

Oscilloscope probes with exposed conductive ground barrels are recommended.

5.1.5 Recommended Wire Gauge

**VIN to J3** – The connection between the source voltage $V_{\text{IN}}$ and J1 of TPS53126EVM-600 can carry as much as 2 Acdc. The minimum recommended wire size is AWG 16 with the total length of wire less than 2 feet (1-foot input, 1-foot return).

**J1 to LOAD1 and J2 to LOAD2** – The connection between J1 and LOAD1, and J2 and LOAD2 of TPS53126EVM-600 can carry as much as 4 Acdc each. The minimum recommended wire size is AWG 14 with the total length of wire less than 2 feet (1-foot input, 1-foot return).

5.1.6 Other Test Equipment

**FAN** – The TPS53126EVM-600 evaluation module includes components that can get hot to touch. Because this EVM is not enclosed to allow probing of circuit nodes, a small fan capable of 200-400 lfm is recommended to reduce component temperatures when operating.

5.2 Recommended Setup

Figure 3 shows the recommended test setup to evaluate the TPS53126EVM-600. Working at an ESD workstation, ensure that any wrist straps, bootstraps, or mats are connected referencing the user to earth ground before power is applied to the EVM. An electrostatic smock and safety glasses also are recommended.
Test Procedure

6 Test Procedure

6.1 Start-up Procedure

1. Prior to connecting the dc input source \( V_{IN} \), it is advisable to limit the source current from \( V_{IN} \) to 2 Adc maximum. Ensure that \( V_{IN} \) is initially set to 0 V.
2. Ensure LOAD1 and LOAD2 are set to constant-current mode to sink 0 A before \( V_{IN} \) is applied.
3. Verify SW1, SW2, and SW3 are in the desired position.
4. Place a fan as shown in Figure 3 and turn on, making sure air is flowing across the EVM.
5. Increase \( V_{IN} \) from 0 V to 12 Vdc.

Figure 3. TPS53126EVM-600 Recommended Test Setup
6.2 Line/Load Regulation and Efficiency Measurement Procedure
1. Set up TPS53126EVM-600 per Section 5.2.
2. Start up the TPS53126EVM-600 per Section 6.1.
3. Adjust VIN to desired value between 8 Vdc and 22 Vdc.
4. Adjust LOAD1/LOAD2 to desired load between 0 A and 4 Adc.
5. Read input voltage, output voltage, and input current from V1, V2/V3, and A1, respectively.
6. Shut down the TPS53126EVM-600 per Section 6.4.

6.3 Output Ripple Voltage Measurement Procedure
1. Set up the TPS53126EVM-600 per Section 5.2.
2. Start up the TPS53126EVM-600 per Section 6.1.
3. Adjust V\text{IN} to desired value between 8 Vdc and 22 Vdc.
4. Adjust LOAD1/LOAD2 to desired load between 0 A and 4 Adc.
5. Connect the oscilloscope probe to TP8 and TP4 for V\text{OUT1}, or TP7 and TP6 for V\text{OUT2} as shown in Figure 2.
6. Measure output ripple.
7. Shut down TPS53126EVM-600 per Section 6.4.

6.4 Shutdown Procedure
1. Set SW1 to DIS.
2. Set SW2 to DIS.
3. Decrease LOAD1 to 0 A, and shut down LOAD1.
4. Decrease LOAD2 to 0 A, and shut down LOAD2.
5. Decrease V\text{IN} to 0 V, and shut down V\text{IN}.
6. Shut down the fan.

7 Performance Data and Typical Characteristic Curves
Figure 4 through Figure 11 present typical performance curves for the TPS53126EVM-600. Because actual performance data can be affected by measurement techniques and environmental variables, these curves are presented for reference and may differ from actual field measurements.

7.1 Efficiency

![Efficiency vs Load](image)

Figure 4. Efficiency vs Load (V\text{IN} = 8 V–22 V, V\text{OUT1} = 1.05 V, I\text{OUT1} = 0 A–4 A)
Figure 5. Efficiency vs Load ($V_{IN} = 8$ V–22 V, $V_{OUT2} = 1.8$ V, $I_{OUT2} = 0$ A–4 A)

7.2 Line and Load Regulation

Figure 6. Output Voltage vs Load ($V_{IN} = 8$ V–22 V, $V_{OUT1} = 1.05$ V, $I_{OUT1} = 0$ A–4 A)
7.3 Output Voltage Ripple

Figure 7. Output Voltage vs Load ($V_{IN} = 8\,V$–$22\,V$, $V_{OUT2} = 1.8\,V$, $I_{OUT2} = 0\,A$–$4\,A$)

Figure 8. Output Voltage Ripple ($V_{IN} = 12\,V$, $V_{OUT1} = 1.05\,V$, $I_{OUT1} = 4\,A$, $F_{SW} = 350\,kHz$)
7.4 **Switch Node Waveforms**

![Figure 9. Output Voltage Ripple](image1)

**Figure 9. Output Voltage Ripple** ($V_{IN} = 12$ V, $V_{OUT2} = 1.8$ V, $I_{OUT2} = 4$ A, $F_{SW} = 350$ kHz)

![Figure 10. Switching Waveform](image2)

**Figure 10. Switching Waveform** ($V_{IN} = 12$ V, $V_{OUT1} = 1.05$ V, $I_{OUT1} = 4$ A, $F_{SW} = 350$ kHz)
Figure 11. Switching Waveform \((V_{\text{IN}} = 12 \, \text{V}, \, V_{\text{OUT2}} = 1.08 \, \text{V}, \, I_{\text{OUT2}} = 4 \, \text{A}, \, F_{\text{SW}} = 350 \, \text{kHz})\)

8 EVM Assembly Drawings and Layout

The following figures (Figure 12 through Figure 17) show the design of the TPS53126EVM-600 printed-circuit board (PCB). The EVM has been designed using a 4-layer, 2-oz copper-clad circuit board of 3.5 inch by 2.7 inch to allow the user to easily view, probe, and evaluate the TPS53126 control integrated circuit in a practical application. Moving components to both sides of the PCB or using additional internal layers can offer additional size reduction for space constrained systems.

Figure 12. Top Assembly
Figure 13. Bottom Assembly

Figure 14. Top Layer
Figure 17. Internal Layer 2
9 Bill of Materials

The reference designators refer to the schematic in Figure 1 and assembly locations in Figure 12 and Figure 13. Components with a quantity of 0 listed are not populated on the PCB but are provided for reference.

<table>
<thead>
<tr>
<th>Qty</th>
<th>RefDes</th>
<th>Value</th>
<th>Description</th>
<th>Size</th>
<th>Part Number</th>
<th>MFR</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>C7, C9, C10, C14, C17, C18</td>
<td>47 µF</td>
<td>Capacitor, Ceramic, 6.3V, X5R, 20%</td>
<td>1206</td>
<td>Std</td>
<td>Std</td>
</tr>
<tr>
<td>0</td>
<td>C8, C13</td>
<td>330 µF</td>
<td>Capacitor, PXE, 4.0V, 15-mΩ, 20%</td>
<td>7343 (D)</td>
<td>APXE4R0ARA331MF61G NIPPON CHEMI-CON</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>D1, D2</td>
<td>8AT54XV2T1G</td>
<td>Diode, Schottky, 200 mA, 30 V</td>
<td>SOD523</td>
<td>BAT54XV2T1G On Semi</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>J1, J2, J3</td>
<td>ED120/2DS</td>
<td>Terminal Block, 2-pin, 15-A, 5.1mm</td>
<td>0.40 x 0.35 inch</td>
<td>ED120/2DS OST</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>L1, L2</td>
<td>3.3 µH</td>
<td>Inductor, SMT Chip Coil, ±30%</td>
<td>8 x 8mm</td>
<td>LGHB8PN3R3N38 Murata</td>
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<td>CSD17507Q5A</td>
<td>MOSFET, N-Chan, 30V, 65A, 11.8mΩQ</td>
<td>QFN-8 POWER</td>
<td>CSD17507Q5A TI</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>R1</td>
<td>1.40k</td>
<td>Resistor, Chip, 1/16W, 1%</td>
<td>0603</td>
<td>Std</td>
<td>Std</td>
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<td>Resistor, Chip, 1/16W, 1%</td>
<td>0603</td>
<td>Std</td>
<td>Std</td>
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<td>R13</td>
<td>332</td>
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<td>0603</td>
<td>Std</td>
<td>Std</td>
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<td>R14</td>
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<td>Resistor, Chip, 1/16W, 5%</td>
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<td>Std</td>
<td>Std</td>
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<tr>
<td>0</td>
<td>R15, R16</td>
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<td>Resistor, Chip, 1/8W, 5%</td>
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<td>Std</td>
<td>Std</td>
</tr>
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<td>R17, R18</td>
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<td>Resistor, Chip, 1/16W, 1%</td>
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<td>Std</td>
</tr>
<tr>
<td>0</td>
<td>R2, R7, R9</td>
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<td>Resistor, Chip, 1/16W, 1%</td>
<td>0603</td>
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<td>R3</td>
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<td>R4, R6, R8, R10</td>
<td>10.0k</td>
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<td>R5</td>
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<td>3</td>
<td>SW1, SW2, SW3</td>
<td>G12AP-RO</td>
<td>Switch, ON-ON Mini Toggle</td>
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<td>G12AP-RO Nikkai</td>
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<td>TP1, TP2, TP5, TP11</td>
<td>S012</td>
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<td>TP10</td>
<td>S013</td>
<td>Test Point, Orange, Thru Hole</td>
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<td>S013 Keystone</td>
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<tr>
<td>3</td>
<td>TP2, TP4, TP6</td>
<td>S011</td>
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<td>2</td>
<td>TP7, TP8</td>
<td>S014</td>
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<tr>
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<td>TP9</td>
<td>S010</td>
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<td>U1</td>
<td>TPS53126RGET</td>
<td>IC, Dual Synchronous Step-Down Controller for Low-Voltage Power Rails</td>
<td>QFN-24</td>
<td>TPS53126RGET TI</td>
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<td>PCB, 2.70&quot; x 3.50&quot; x 0.063&quot; FR-4</td>
<td>2.7&quot; x 3.5&quot;</td>
<td>HPA600 Any</td>
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