ABSTRACT

This application report provides a summary of CISPR25-Radiated Emissions test results using the TPS54160-Q1 high-frequency buck converter. Similar results can be achieved using other devices in this family. This family of buck converters is capable of passing CISPR25 and other automotive electromagnetic-compatibility (EMC) test specifications. The TPS54160 family of devices does not require the use of programmable slew rate or frequency modulation. These devices can pass EMC tests by optimizing external components selection, placement, and board layout.

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1 Schematics and Printed Circuit Board (PCB) Description

PMP6990 EMC reference board was designed for passing EMC as required by automotive specification CISPR25. PMP6990 Revision-A printed-circuit board (PCB) was used for all testing. Devices that can be tested on this board include:

- **Non-automotive**: TPS54040, TPS54060, TPS54140, TPS54160, TPS54240, TPS54260
- **Automotive**: TPS57040-Q1, TPS57060-Q1, TPS57140-Q1, TPS57160-Q1, TPS54140-Q1, TPS54160-Q1, TPS54240-Q1, TPS54260-Q1

1.1 Schematics for PMP6990

![Figure 1. PMP6990 Schematic](image_url)
# 1.2 Bill of Materials for PMP6990

## Table 1. PMP6990 BOM

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<thead>
<tr>
<th>Designator</th>
<th>Quantity</th>
<th>Value</th>
<th>Description</th>
<th>Size and Package</th>
<th>Part Number</th>
<th>Manufacturer</th>
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<tr>
<td>C5</td>
<td>3</td>
<td>0.015 µF</td>
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<td>603</td>
<td>C1608X7R1H153K</td>
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<tr>
<td>C10</td>
<td>0.015 µF</td>
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<td>TDK</td>
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<tr>
<td>C11</td>
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<td>Capacitor, ceramic, 50-V, X7R, 10%</td>
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<td>C1608X7R1H153K</td>
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<td>C6</td>
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<td>TDK</td>
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<td>TDK</td>
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<td>4.7 µF</td>
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<td>C3216X7R1E475K</td>
<td>TDK</td>
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<tr>
<td>C3</td>
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<td>C3216X7R1E475K</td>
<td>TDK</td>
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<td>C9</td>
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<td>10 µF</td>
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<td>Capacitor, aluminum electrolytic, 25-V, 20%</td>
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<td>2S2L220M8x11.5</td>
<td>Rubycon</td>
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<td>D1</td>
<td>1</td>
<td>MBRA140LT3</td>
<td>Diode, Schottky, 1-A, 40-V</td>
<td>SMA</td>
<td>MBRA140LT3</td>
<td>ON Semi</td>
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<td>1.5 µH</td>
<td>Inductor, SMT, 4-A, 33-mΩ</td>
<td>0.255 × 0.270 inch</td>
<td>IHP2525AH-01</td>
<td>Vishay</td>
</tr>
<tr>
<td>L2</td>
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<td>4.7 µH</td>
<td>Inductor, SMT, 3-A, 77-mΩ</td>
<td>0.255 × 0.270 inch</td>
<td>IHP2525AH-01</td>
<td>Vishay</td>
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<td>Resistor, chip, 1/16-W, 1%</td>
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<td>Standard</td>
<td>Standard</td>
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<td>R11</td>
<td>1</td>
<td>10</td>
<td>Resistor, chip, 1/16-W, 1%</td>
<td>603</td>
<td>Standard</td>
<td>Standard</td>
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<td>10k</td>
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<td>Standard</td>
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<td>R6</td>
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<td>348k</td>
<td>Resistor, chip, 1/16-W, 1%</td>
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<td>Standard</td>
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<td>ED1514</td>
<td>Terminal block, 2-pin, 6-A, 3.5-mm</td>
<td>0.27 × 0.25 inch</td>
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<td>OST</td>
</tr>
<tr>
<td>J2</td>
<td>1</td>
<td>ED1514</td>
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<td>0.27 × 0.25 inch</td>
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<td>OST</td>
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<tr>
<td>TP1</td>
<td>4</td>
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<td>0.1 × 0.1 inch</td>
<td>5001</td>
<td>Keystone</td>
</tr>
<tr>
<td>TP2</td>
<td></td>
<td>5001</td>
<td>Test point, black, through-hole color keyed</td>
<td>0.1 × 0.1 inch</td>
<td>5001</td>
<td>Keystone</td>
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<tr>
<td>TP3</td>
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<td>Test point, black, through-hole color keyed</td>
<td>0.1 × 0.1 inch</td>
<td>5001</td>
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<td>Keystone</td>
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<td>TPS54160DGQR1</td>
<td>IC, DC-DC converter, 60-V 1.5-A</td>
<td>MSOP-10</td>
<td>TPS54160DGQR1</td>
<td>Ti</td>
</tr>
</tbody>
</table>
1.3 PCB Layout

Figure 2. Top Assembly

Figure 3. Top-Layer Silkscreen and Routing
Figure 4. Layer 2 Routing

Figure 5. Layer 3 Routing
1.4 **R-C Snubber Added From PH to GND**

![Schematic of R-C Snubber Added](image)

**Figure 7. With Snubber Added**
2 Description and Setup for Radiated Emissions Measurements

PMP6990 Revision-A board was used for all radiated emissions testing. The test results confirm that the board can pass CISPR25, Class 4 according to the bill of materials listed in Table 1. In order to pass CISPR25, Class 5, an additional R-C snubber (R = 10 Ω, C = 1.5 nF) was added in parallel across diode D1. The snubber was used to slow down the rise and fall times of the switching voltages and currents generated by the PH pin which resulted in lower noise in the 30-MHz to 200-MHz range.

Figure 7 shows the buck-converter circuit using the R-C snubber. This snubber circuit is included in the new PMP6990 Revision-B reference board.

Section 2.1 and Section 2.2 list the setup conditions and test results.

2.1 Setup Conditions

Device under test (DUT)— PMP6990, Revision A using the TPS54160-Q1 device

Input voltage— Car battery, (BAT+) = 13.5 V, (BAT–) = GND

Switching frequency—f_{sw} = 2 MHz

Output voltage— V_{O} = 5 V

Load current— I_{O} = 1 A

Length of wire harness— (BAT+/BAT–) = 1.7 m

CISPR25 line-impedance stabilization networks (LISN) placed between BAT+/BAT– and wire harness

Wire harness and DUT are placed on 50 mm of insulation with respect to the test table.

Figure 8. Test Setup
### 2.2 Test Results

#### Figure 9. CISPR25 Bicon Horizontal Results
- No R-C Snubber

#### Figure 10. CISPR25 Bicon Horizontal Results
- With R-C Snubber

#### Figure 11. CISPR25 Bicon Vertical Results
- No R-C Snubber

#### Figure 12. CISPR25 Bicon Vertical Results
- With R-C Snubber
### Summary

The TPS54160-Q1 device family passes the CISPR25 Class-4 and Class-5 Radiated Emissions required for automotive. Passing results can be achieved using careful components selection, placement, and PCB layout. In some cases, an R-C snubber is required to help further suppress high frequency noise.

PMP6990 EMC test board has been revised to Revision B, which includes footprints for the R-C snubber circuit. For more information on the PMP6990 Revision-B board go to [www.ti.com](http://www.ti.com).
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