Application Report
SLVA629A–December 2013–Revised May 2019

Passing CISPR25-Radiated Emissions Using TPS54160-Q1

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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

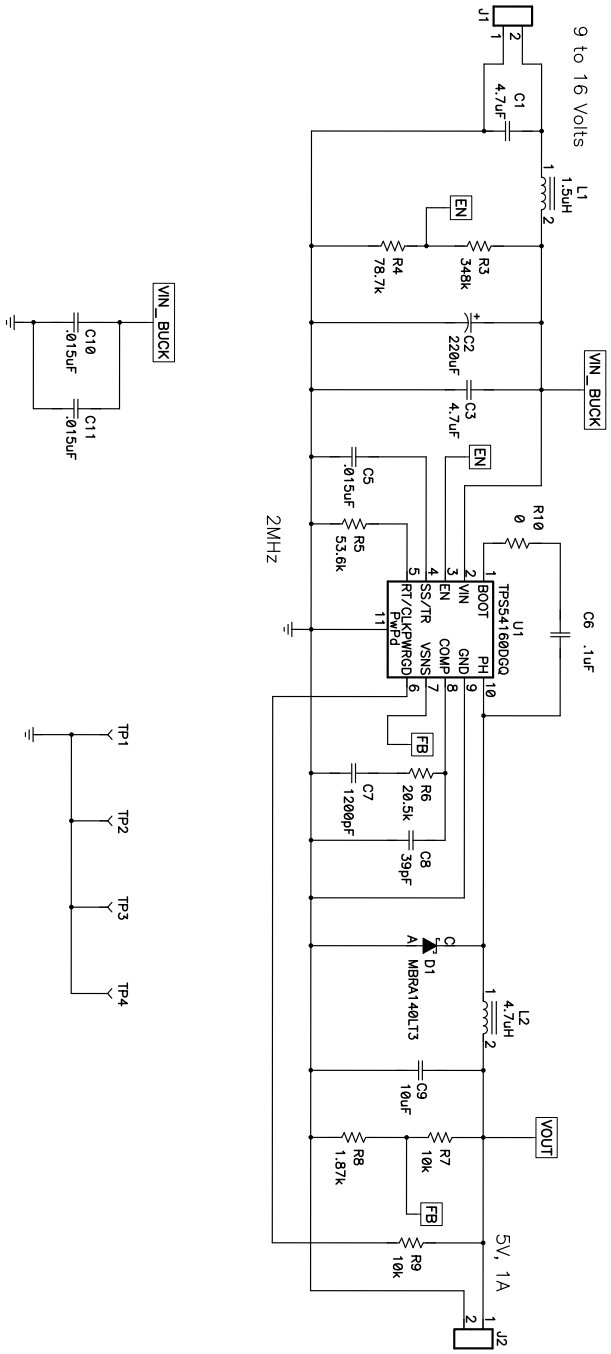

Figure 1. PMP6990 Schematic

1.2 Bill of Materials for PMP6990

Table 1. PMP6990 BOM

Designator	Quantity	Value	Description	Size and Package	Part Number	Manufacturer
C5	3	0.015 µF	Capacitor, ceramic, 50-V, X7R, 10%	603	C1608X7R1H153K	TDK
C10		0.015 µF	Capacitor, ceramic, 50-V, X7R, 10%	603	C1608X7R1H153K	TDK
C11		0.015 µF	Capacitor, ceramic, 50-V, X7R, 10%	603	C1608X7R1H153K	TDK
C6	1	0.1 µF	Capacitor, ceramic, 50-V, X7R, 10%	603	C1608X7R1H104K	TDK
C12	1	1.5 nF	Capacitor, ceramic, 50-V, X7R, 10%	603	C1608X7R1H153K	TDK
C8	1	39 pF	Capacitor, ceramic, 50-V, COG, 5%	603	C1608COG1H390J	TDK
C7	1	1200 pF	Capacitor, ceramic, 50-V, COG, 5%	603	C1608COG1H122J	TDK
C1	2	4.7 µF	Capacitor, ceramic, 25-V, X7R, 10%	1206	C3216X7R1E475K	TDK
C3		4.7 µF	Capacitor, ceramic, 25-V, X7R, 10%	1206	C3216X7R1E475K	TDK
C9	1	10 µF	Capacitor, ceramic, 16-V, X7R, 10%	1206	C3216X7R1C106K	TDK
C2	1	220 µF	Capacitor, aluminum electrolytic, 25-V, 20%	0.315 inch	25ZL220M8x11.5	Rubycon
D1	1	MBRA140LT3	Diode, Schottky, 1-A, 40-V	SMA	MBRA140LT3	ON Semi
L1	1	1.5 µH	Inductor, SMT, 4-A, 33-mΩ	0.255 × 0.270 inch	IHLP2525AH-01	Vishay
L2	1	4.7 µH	Inductor, SMT, 3-A, 77-mΩ	0.255 × 0.270 inch	IHLP2525AH-01	Vishay
R10	1	0	Resistor, chip, 1/16-W, 1%	603	Standard	Standard
R8	1	1.87k	Resistor, chip, 1/16-W, 1%	603	Standard	Standard
R11	1	10	Resistor, chip, 1/16-W, 1%	603	Standard	Standard
R7	2	10k	Resistor, chip, 1/16-W, 1%	603	Standard	Standard
R9		10k	Resistor, chip, 1/16-W, 1%	603	Standard	Standard
R6	1	20.5k	Resistor, chip, 1/16-W, 1%	603	Standard	Standard
R5	1	53.6k	Resistor, chip, 1/16-W, 1%	603	Standard	Standard
R4	1	78.7k	Resistor, chip, 1/16-W, 1%	603	Standard	Standard
R3	1	348k	Resistor, chip, 1/16-W, 1%	603	Standard	Standard
J1	1	ED1514	Terminal block, 2-pin, 6-A, 3,5-mm	0.27 × 0.25 inch	ED1514	OST
J2	1	ED1514	Terminal block, 2-pin, 6-A, 3,5-mm	0.27 × 0.25 inch	ED1514	OST
TP1	4	5001	Test point, black, through-hole color keyed	0.1 × 0.1 inch	5001	Keystone
TP2		5001	Test point, black, through-hole color keyed	0.1 × 0.1 inch	5001	Keystone
TP3		5001	Test point, black, through-hole color keyed	0.1 × 0.1 inch	5001	Keystone
TP4		5001	Test point, black, through-hole color keyed	0.1 × 0.1 inch	5001	Keystone
U1	1	TPS54160DGQRQ1	IC, DC-DC converter, 60-V 1.5-A	MSOP-10	TPS54160DGQRQ1	TI

1.3 PCB Layout

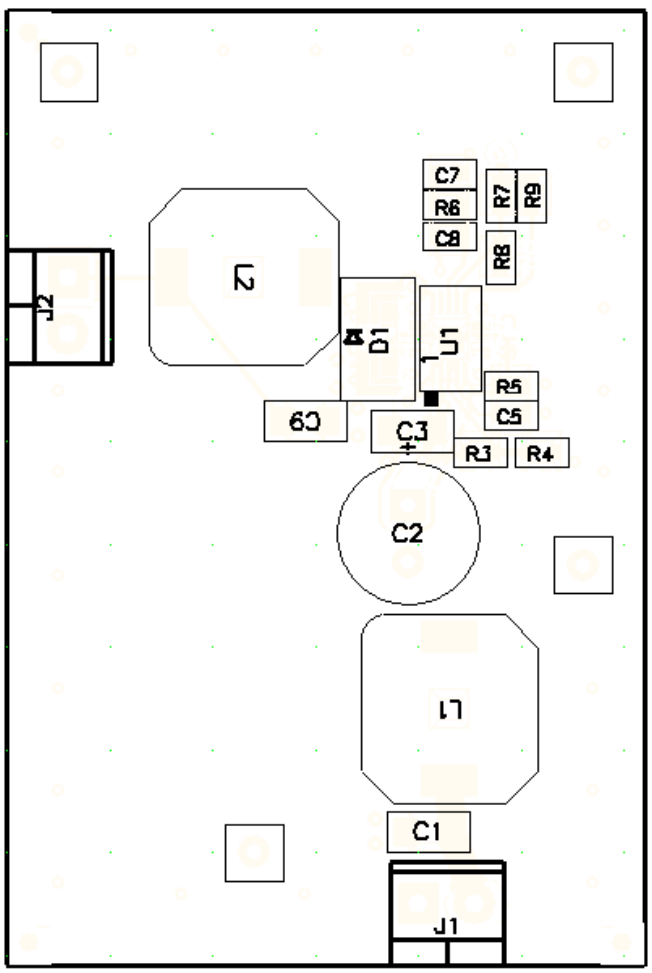

Figure 2. Top Assembly

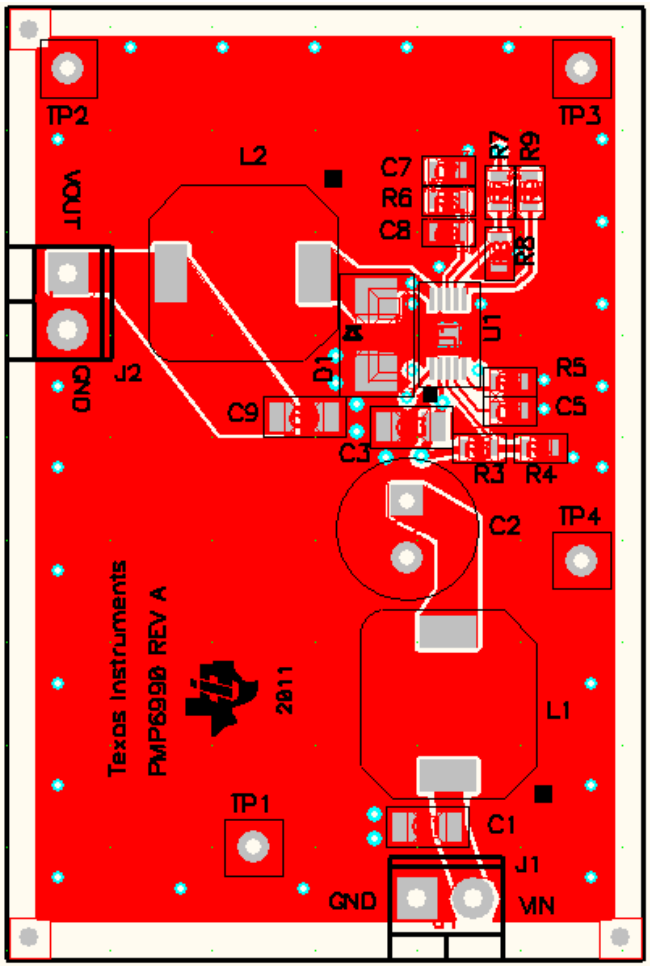

Figure 3. Top-Layer Silkscreen and Routing

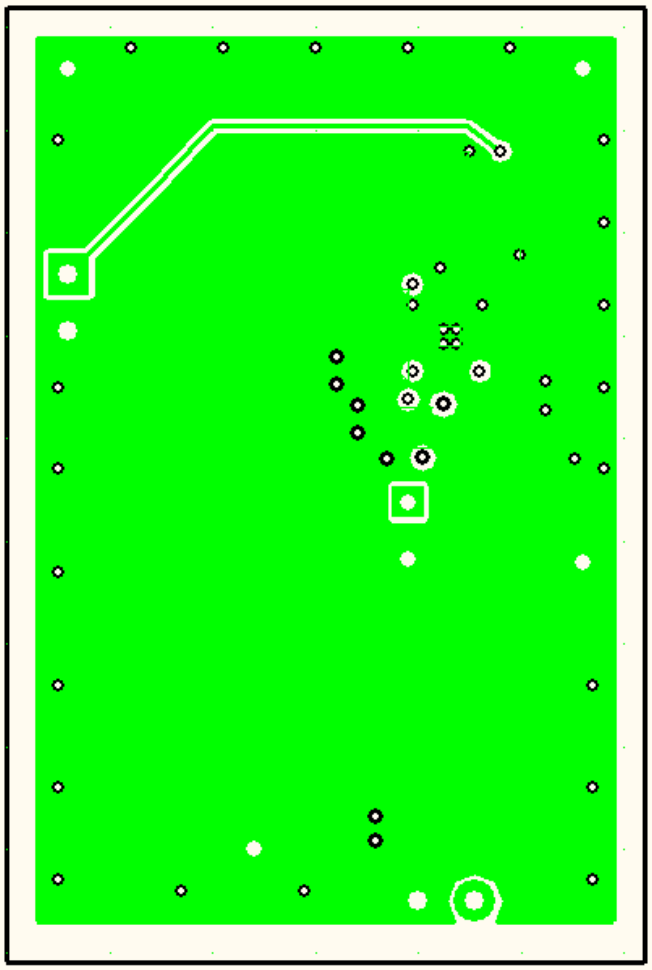

Figure 4. Layer 2 Routing

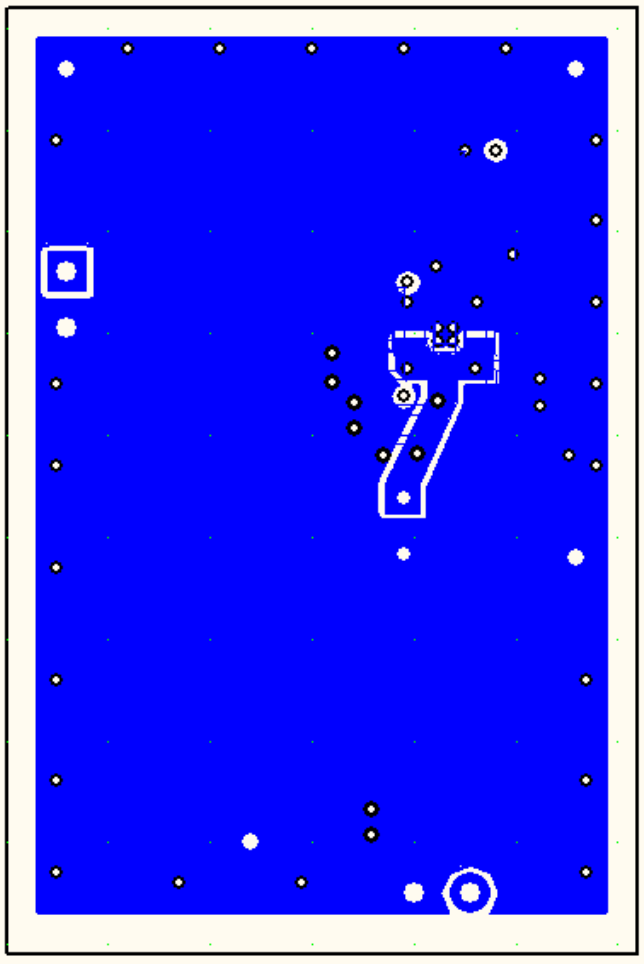

Figure 5. Layer 3 Routing

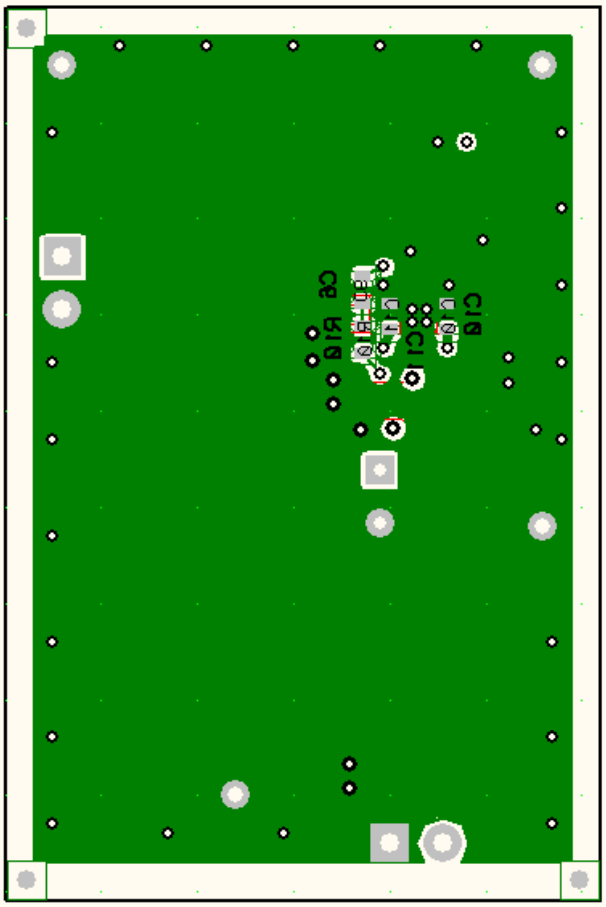

Figure 6. Bottom-Layer Silkscreen and Routing

1.4 R-C Snubber Added From PH to GND

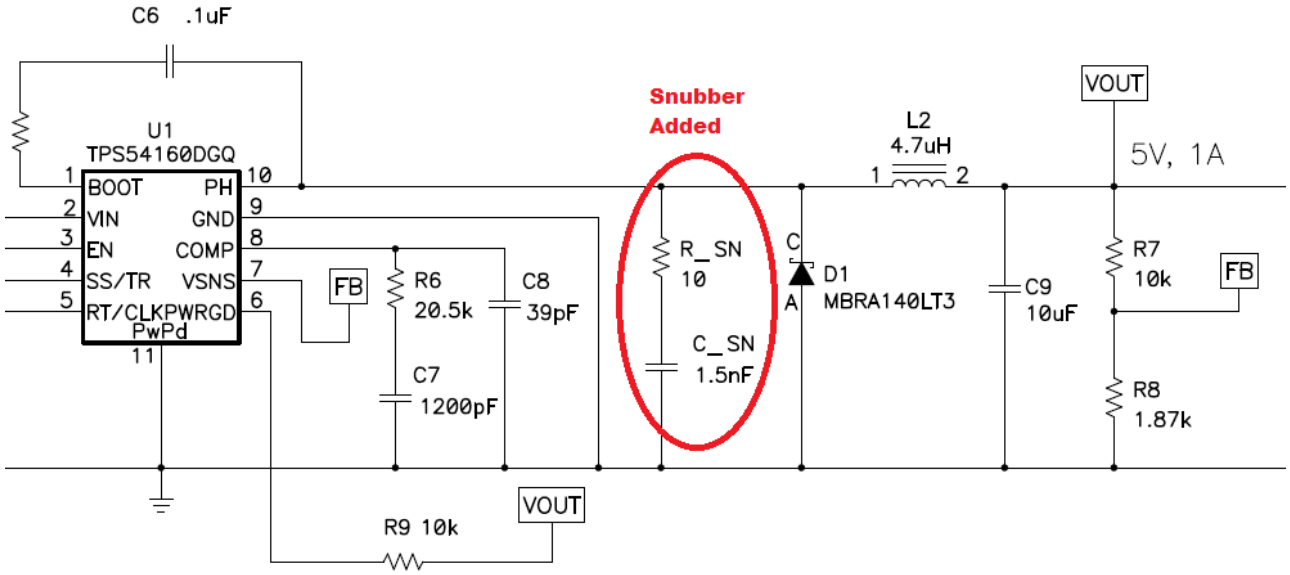

Figure 7. With Snubber Added

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. The snubber power dissipation is C_SN × $(V_{IN})^2$ × F_{SW}. At 1.5 nF and 2 MHz, the power dissipation is 432 mW, which is the power dissipated in the resistor R_SN. The power rating of the resistor is 500 mW. The capacitor can be 0603, but the resistor package is 2020.

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.

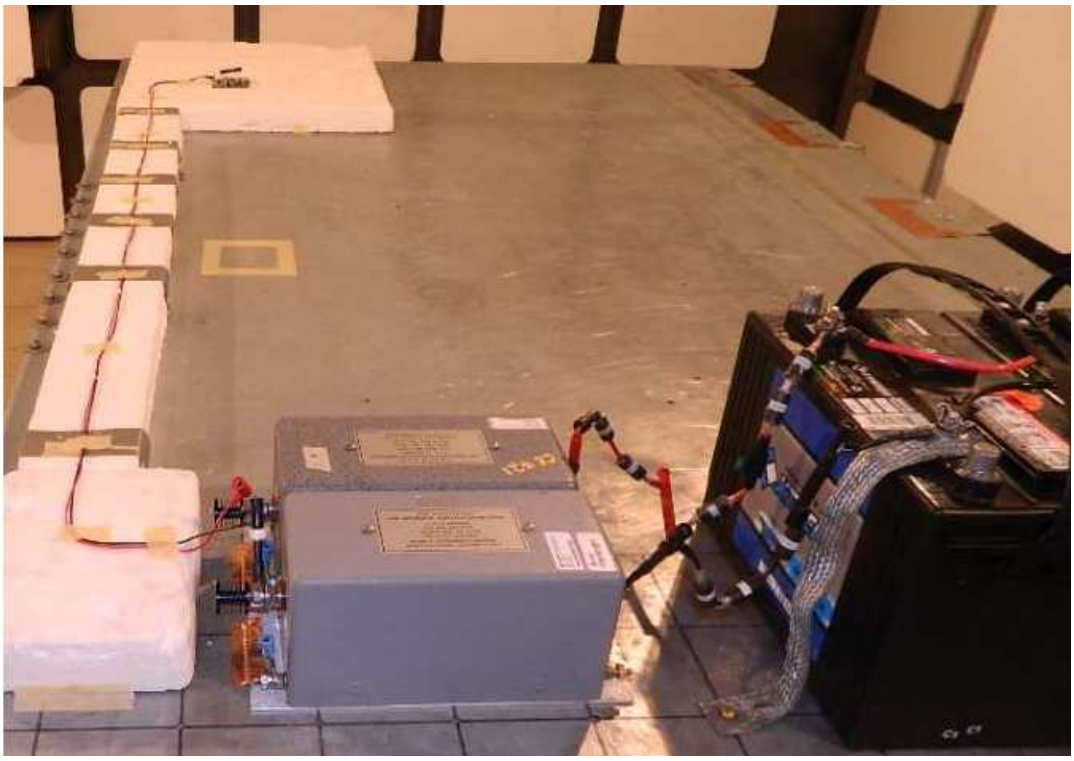

Figure 8. Test Setup

2.2 Test Results

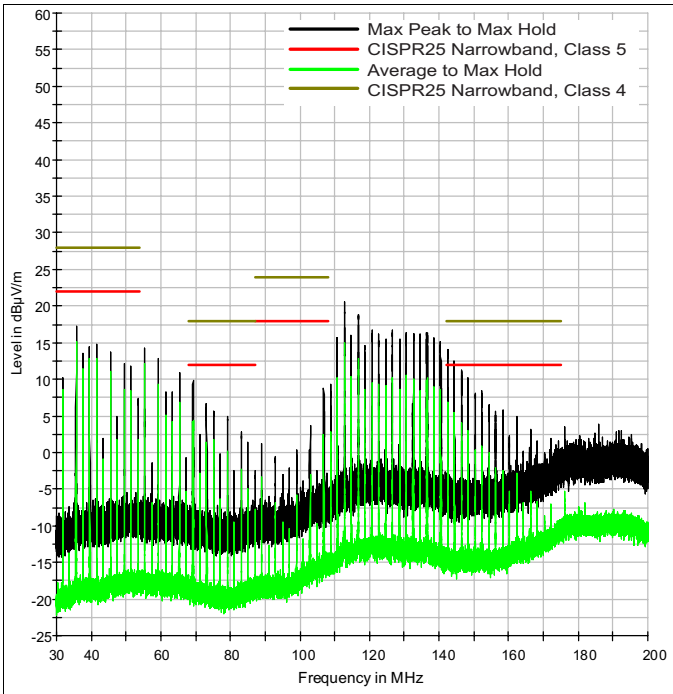

Figure 9. CISPR25 Bicon Horizontal Results No R-C Snubber

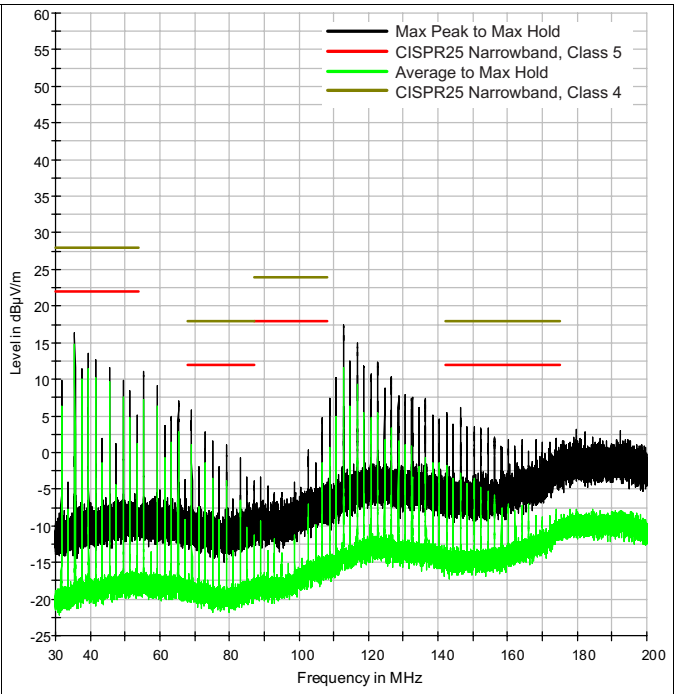

Figure 10. CISPR25 Bicon Horizontal Results With R-C Snubber

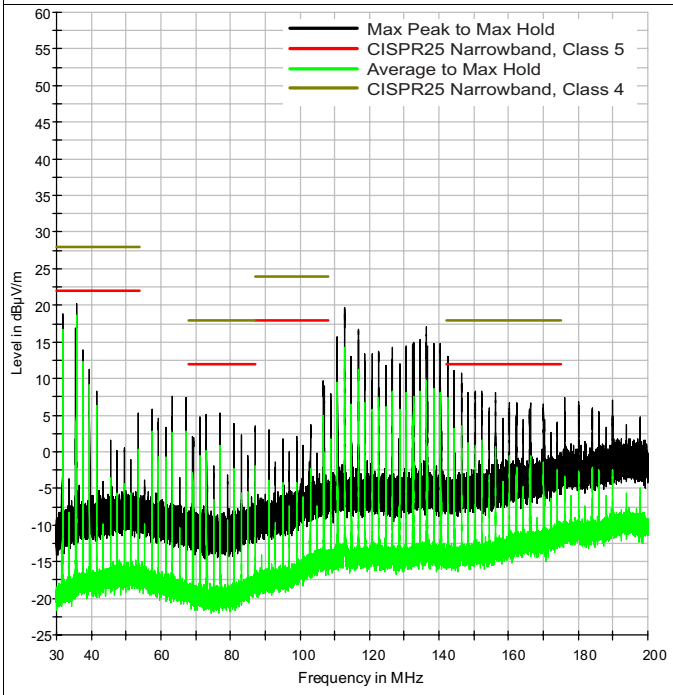

Figure 11. CISPR25 Bicon Vertical Results No R-C Snubber

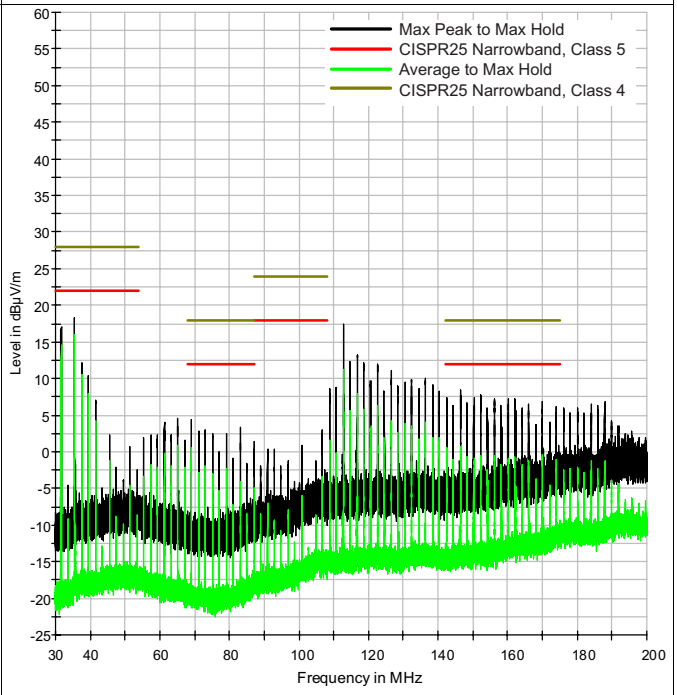

Figure 12. CISPR25 Bicon Vertical Results With R-C Snubber

Table 2. Comparison of Results, With and Without R-C Snubber

Test	No Snubber	10-Ω, 1.5-nF Snubber Added
CISPR25 Bicon H	PASS Class 4	PASS Class 4
	FAIL Class 5 at 142 MHz	PASS Class 5
CISPR25 Bicon V	PASS Class 4	PASS Class 4
	FAIL Class 5 at 142 MHz	PASS Class 5

3 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.

Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Original (December 2013) to A Revision	Page
• Added statement to the Description and Setup for Radiated Emissions Measurements section.	7

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