Application Report
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Optimizing the Radiated EMI of TPS61178EVM

Jasper Li

ABSTRACT

EMI is a common issue in a switching power converter because of the high di/dt and dv/dt during the MOSFETs switching on/off. Proper measures can solve the EMI issue without deteriorating the performance of the converter or increasing the cost. This application report introduces some simple methods to reduce the radiated EMI in the TPS61178 evaluation board (TPS61178EVM).

Contents

List of Figures

List of Tables

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1 Introduction

The TPS61178x is a 20-V synchronous boost converter with the gate driver built-in for load disconnection. The TPS61178x integrates two 16-mΩ on-resistance power FETs and uses fixed-frequency peak-current mode control. These features make it suitable in the application of a Bluetooth speaker, motor driver, LCD display, and so forth. EMI is a concern for these application fields because the output power is higher than 30 W. Good PCB layout is the easiest and most effective method to reduce EMI noise(1)(2). It is also critical for the normal operation of the TPS61178x. Decreasing the ringing in the switching node and increasing impedance of the noisy loop will further reduce the EMI noise. This application report first measures the radiated EMI noise of the TPS61178 evaluation board (TPS61178EVM), then optimizes the EMI using RC snubber and ferrite bead.

2 Measurement and Optimization

The radiated EMI noise of the TPS61178EVM in a 3-meter chamber is shown in Figure 1 (test condition: 7.8-V input voltage, 16-V output voltage, and 2-A output current). Figure 1 details peak noise level in both the horizontal and vertical direction. The red line is the EN55022 and CISPR22 Class B limitation. The noise is much larger in the horizontal direction, but can still pass the Class B limitation. The test result shows that the strongest noise lies in the bandwidth between 150 MHz and 400 MHz.

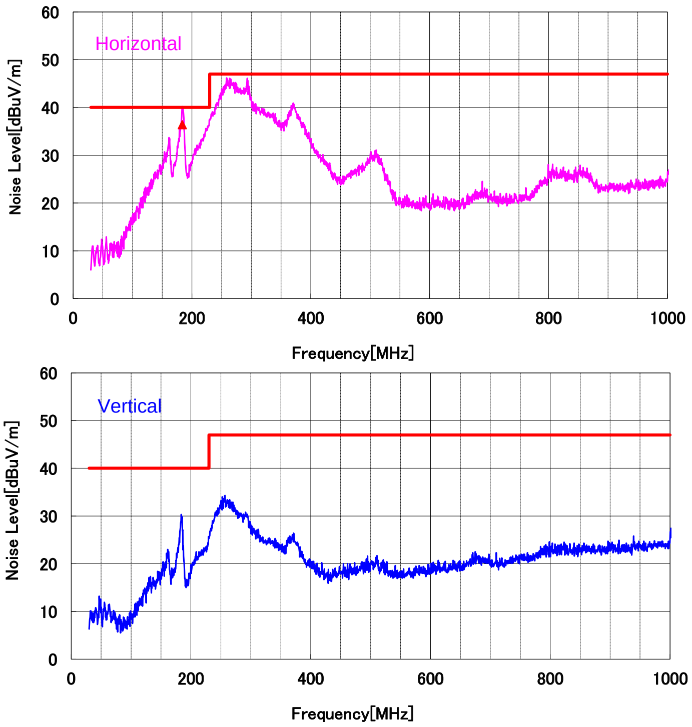

Figure 1. TPS61178EVM Radiated Noise

Figure 2 shows the simplified schematic of a boost converter and the operating waveform. The main noise sources of the boost are the square-wave voltage in SW node and current flowing through the rectifier diode. Because of the parasitic inductors and capacitor (Lpm, Lpo, Lps, Cps), the voltage in SW pin rings after the MOSFET switches on or off, and the high-frequency current flows into the cable between the output capacitor and the load. These two issues also contribute to the EMI noise.

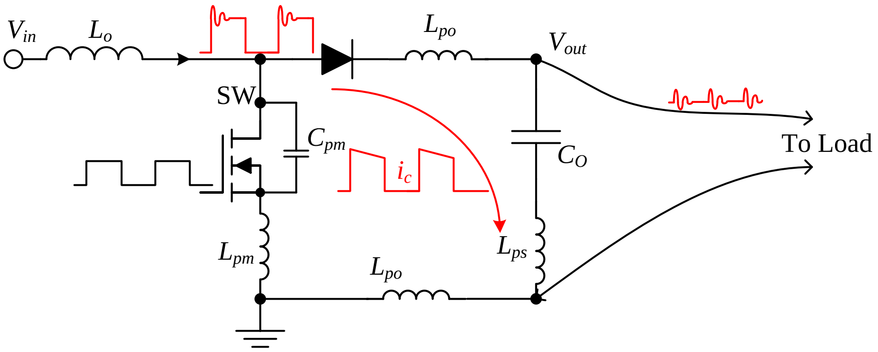

Figure 2. Simplified Boost Converter and Operating Waveform

Good PCB layout following the instruction in *Five Steps to a Good PCB Layout of a Boost Converter Application Report*, can minimize the parasitic inductance, but cannot eliminate them. The SW node waveform of the TPS61178EVM is shown in Figure 3. The ringing frequency in SW node is 294 MHz, which could be the root cause that the radiated noise is high in this frequency.

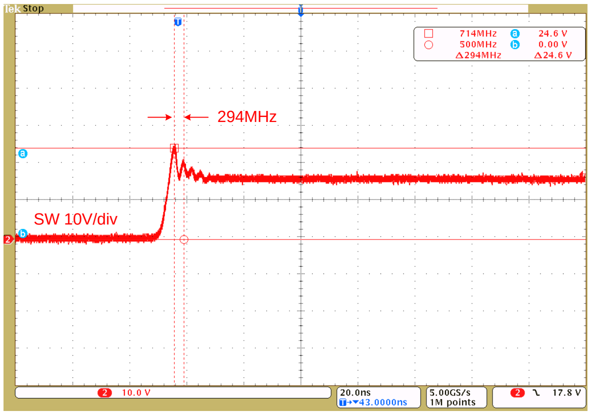

Figure 3. SW Waveform at V_{IN} = 7.8 V, V_{OUT} = 16 V, I_{OUT} = 2 A

RC snubber is a simple solution to eliminate the ringing. The method to select RC snubber value is introduced in *Minimizing Ringing at the Switch Node of a Boost Converter Application Report*:

- Place a capacitor at SW node to reduce the ringing frequency to less than half of original frequency
- Calculate the parasitic inductor and capacitor
- Calculate the resistor value of the RC snubber

Placing a 820-pF capacitor between SW to ground, the SW waveform is shown in Figure 4. The switching frequency reduces to 122 MHz. Thus, the parasitic capacitor can be calculated in Equation 1

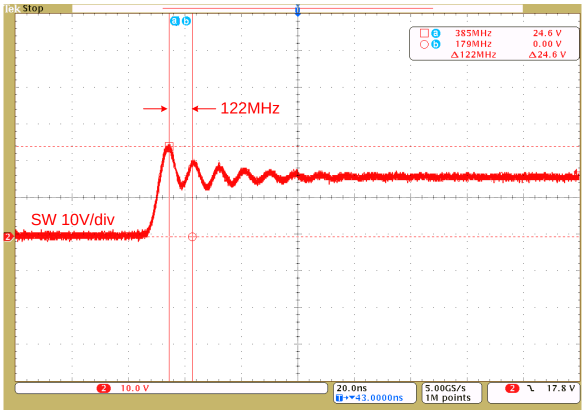

Figure 4. SW Waveform With 820 pF

$$Cp = 820\,\text{pF} \times \frac{1}{\left(\frac{294\ \text{MHz}}{122\ \text{MHz}}\right)^2 - 1} = 170\,\text{pF} \tag{1}$$

Calculate the parasitic inductor using Equation 2:

$$Lp = \frac{1}{(2\pi)^2 \times 170\ \text{pF} \times (294\ \text{MHz})^2} = 1.7\,\text{nH} \tag{2}$$

The snubber resistor is selected to avoid ringing using Equation 3.

$$Rsnubber = 2\sqrt{\frac{1.7\ \text{nH}}{820\ \text{pF} + 170\ \text{pF}}} = 2.6\ \Omega \tag{3}$$

Selecting a 2.5-Ω snubber resistor, the SW waveform is shown in Figure 5. The ring in SW pin is eliminated by the snubber circuit.

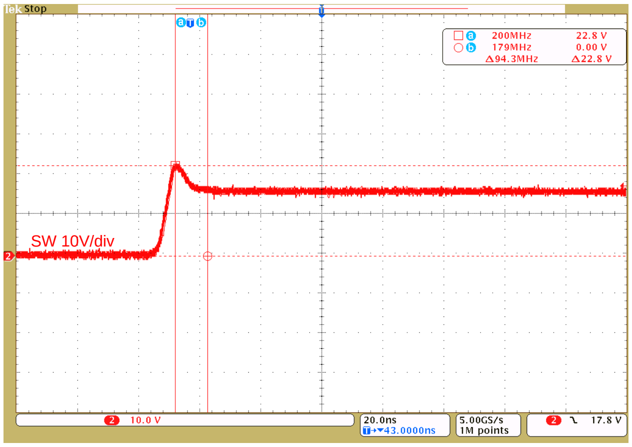

Figure 5. SW Waveform With RC Snubber

After adding the snubber circuit, the horizontal radiated noise is shown in Figure 6 (test condition: 7.8-V input voltage, 16-V output voltage, and 2-A output current). The noise between 150 MHz and 400 MHz greatly decreases, which proves the usefulness of the snubber circuit.

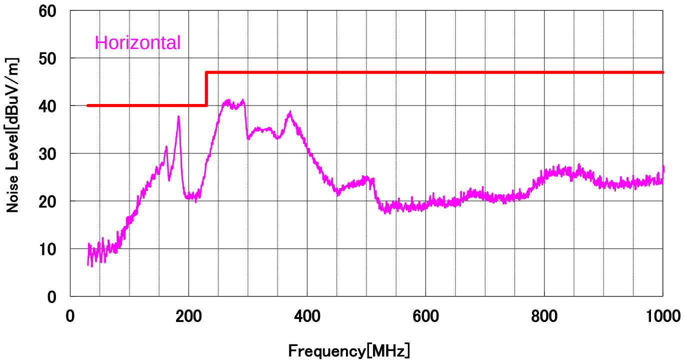

Figure 6. Radiated Noise With the RC Snubber

As shown in Figure 2, the high frequency current will flow through the cable between the converter output and the load which generates radiated noise. A ferrite bead can increase the high-frequency impedance to prevent this phenomenon. Considering the output current and radiated noise frequency, BLM18SG121TN1 is selected, which supports a 3-A DC current and has large impedance in the frequency from 150 MHz to 400 MHz as in Figure 7.

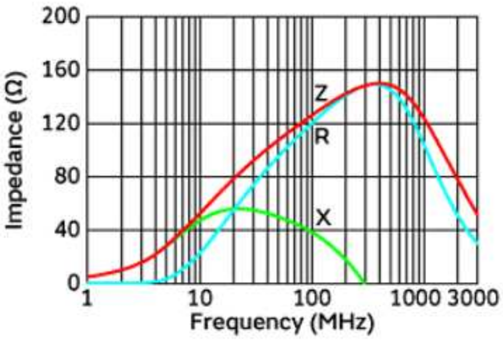

Figure 7. Characteristic of BLM18SG121TN1

To easily place the bead into the TPS61178EVM, remove the Q1 in the TPS61178EVM and replace it with the BLM18SG121TN1. The EMI test result with bead and RC snubber is shown in Figure 8 (test condition: 7.8-V input voltage, 16-V output voltage, and 2-A output current). The noise level is greatly reduced by the bead.

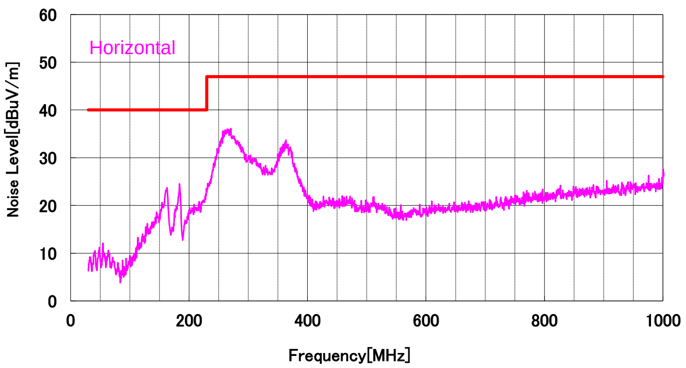

Figure 8. Radiated Noise With Bead and RC Snubber

3 Conclusion

This application report first measures the radiated EMI of the TPS61178EVM in a 3-m chamber. The test result passes the EN55022 and CISPR22 Class B limitation with a small margin. By analyzing the noise source and path, the RC snubber and bead are added to reduce the noise. Test results validate the effectiveness of the two methods.

4 References

1. Texas Instruments, *Reducing Radiated EMI in TPS61088 Boost Converter Application Report*
2. Texas Instruments, *Five Steps to a Good PCB Layout of a Boost Converter Application Report*
3. Texas Instruments, *Minimizing Ringing at the Switch Node of a Boost Converter Application Report*

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