Optimizing EMI in Switching Regulators for Consumer and RF-Sensitive Applications

By Lily He and Charlie Wang at MPS

Introduction

The increasing popularity of modern electronic equipment brings convenience to people, but at the same time aggravates the deterioration of electromagnetic environment. Electromagnetic interference (EMI) refers to the interference phenomenon caused by the interaction of electromagnetic waves with electronic components.

Since electronic devices produce electromagnetic waves when they work, various electronic devices interfere with each other, which can cause unexpected impact on sensitive circuits, and in serious cases can prevent a circuit from operating normally. This is why reduced EMI is critical for system stability. This article discusses how EMI performance benefits consumer and RF devices, such as home appliances, alarm systems, and garage door openers.

How to Optimize EMI

When it comes to switch-mode power supplies, it is important to address EMI from both circuit design and circuit board layout. In terms of circuit design, switching speed, as well as the ringing on the switch node (see Figure 1), can impact EMI performance.

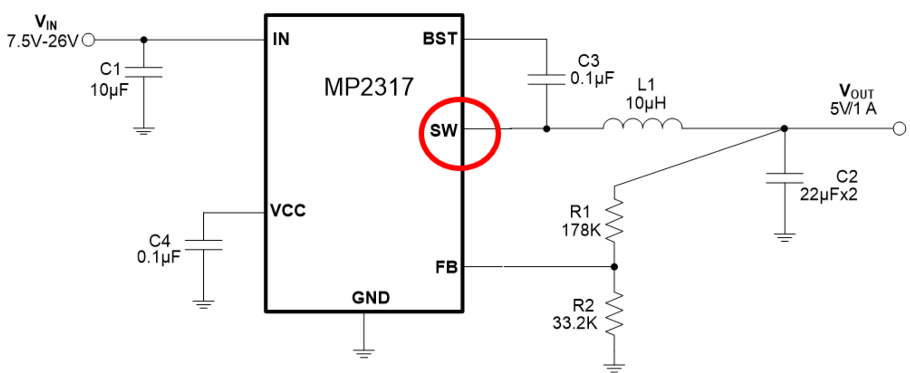

Figure 1: Typical Application Circuit

EMI can be optimized effectively in two ways: switching speed control and anti-ringing control.

Switching Speed Control

EMI is reduced by extending the switching rise time and fall time at the switch node to reduce the impact of dV/dt slew rate (see Figure 2, Figure 3, Figure 4, and Figure 5).

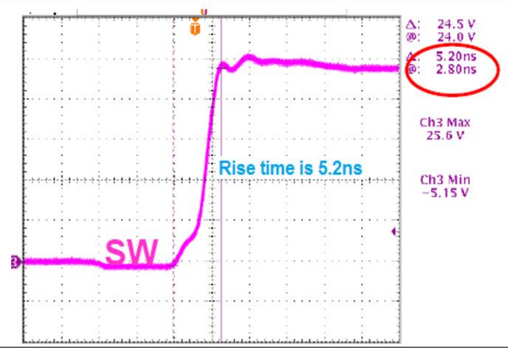

Figure 2: SW Rise Time Before Switching Speed Control

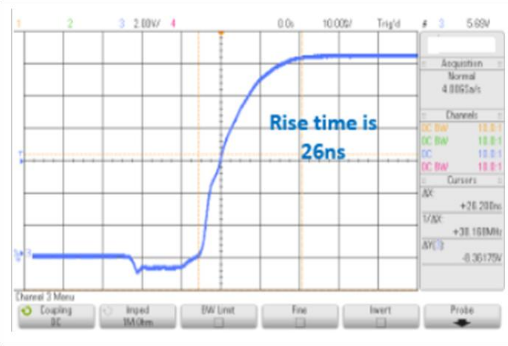

Figure 3: SW Rise Time After Switching Speed Control

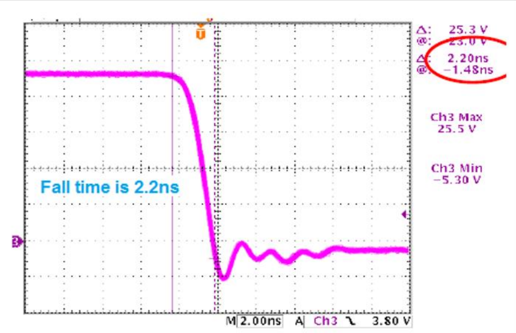

Figure 4: SW Fall Time Before Switching Speed Control

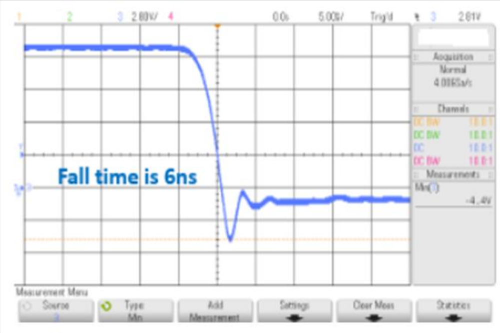

Figure 5: SW Fall Time After Switching Speed Control

Anti-Ringing Control at Light Load

Ringing on the switch node contributes to EMI. The more ringing a device has, the worse the EMI performance (see Figure 6). Adding a 1kΩ resistor (R) and another switch (S1) between SW and GND mitigates ringing. At light load, when both the HS and LS switches turn off, S1 turns on to allow some of the power of L1 to release through R and S1 to GND (see Figure 7).

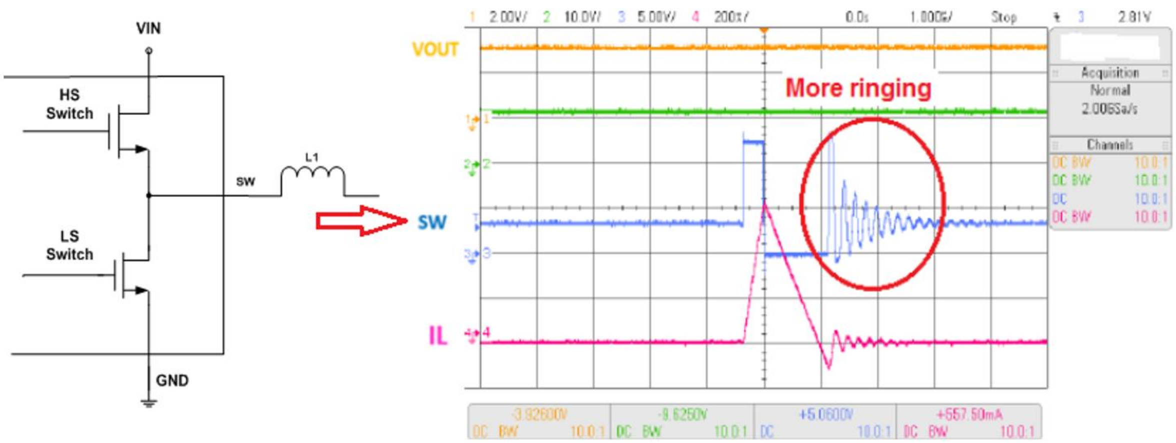

Figure 6: More Ringing on SW Before Anti-Ringing Control
(Test conditions: V_{IN} = 12V, V_{OUT} = 3.3V, I_{OUT} = 10mA)

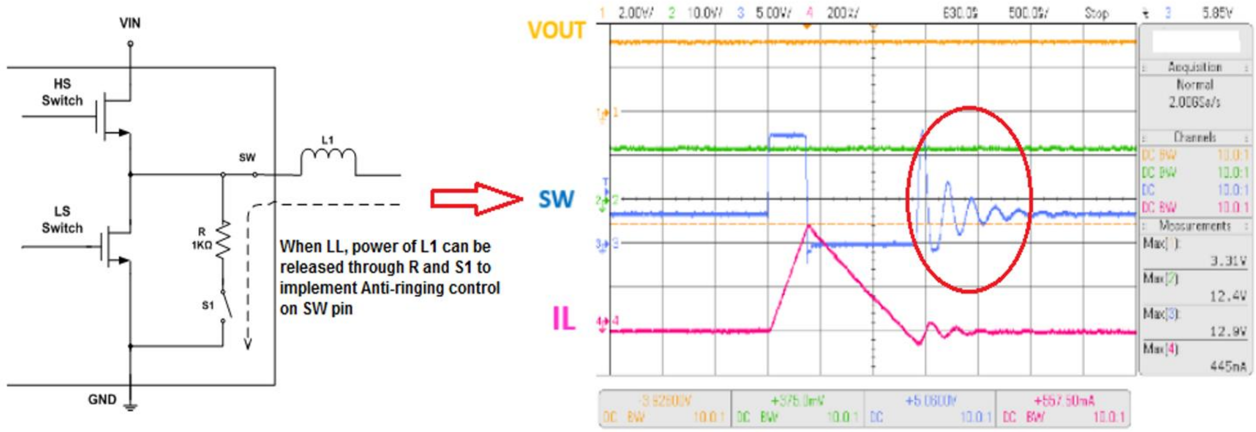

Figure 7: Less Ringing on SW After Anti-Ringing Control
(Test conditions: V_{IN} = 12V, V_{OUT} = 3.3V, I_{OUT} = 10mA)

Figure 8 and Figure 9 show the EMI reduction achieved by implementing switching speed and anti-ringing control.

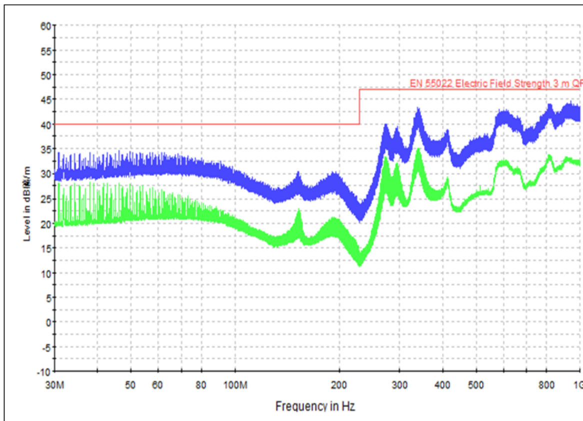

Figure 8: EMI Tests Before Switching Speed Control and Anti-Ringing Control

(Test conditions: V_{IN} = 12V, V_{OUT} = 5V, 1.2A)

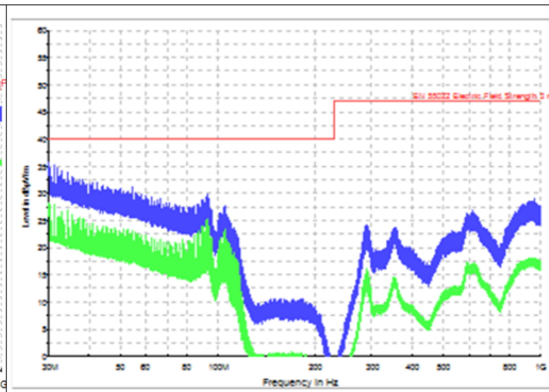

Figure 9: EMI Tests After Switching Speed Control and Anti-Ringing Control

(Test conditions: V_{IN} = 12V, V_{OUT} = 5V, 1.2A)

PCB Layout for Better EMI

The feedback signal of the switching power supply is an analog signal that is very sensitive to electromagnetic interference, and is easily disturbed by its own switching signal. A good layout can reduce this kind of interference and achieve better EMI performance. Poor layout may cause big ripples, and even prevent the power supply from working.

Below are some tips for achieving better EMI through component placement and PCB layout:

- Place the input filter capacitor close to the IC (see Figure 10).

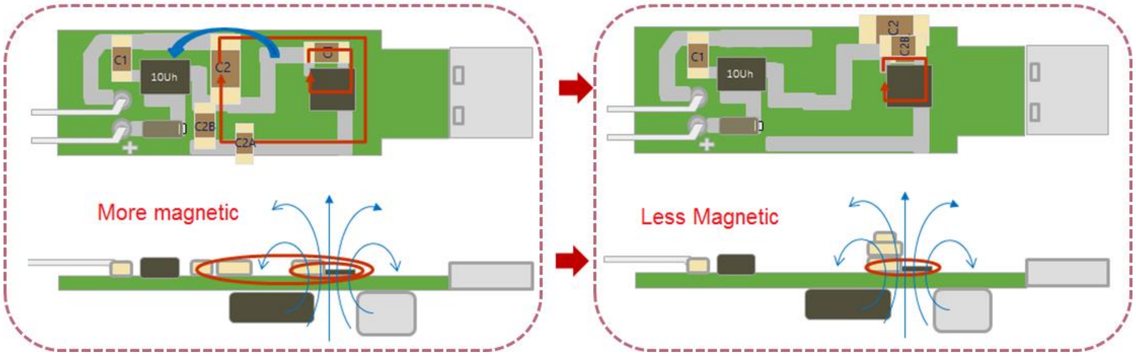

Figure 10: Less Magnetic Field when the Input Filter Capacitor Is Close to the IC

- Use a shielded inductor.
- Use a small SW pad layout (see Figure 11).

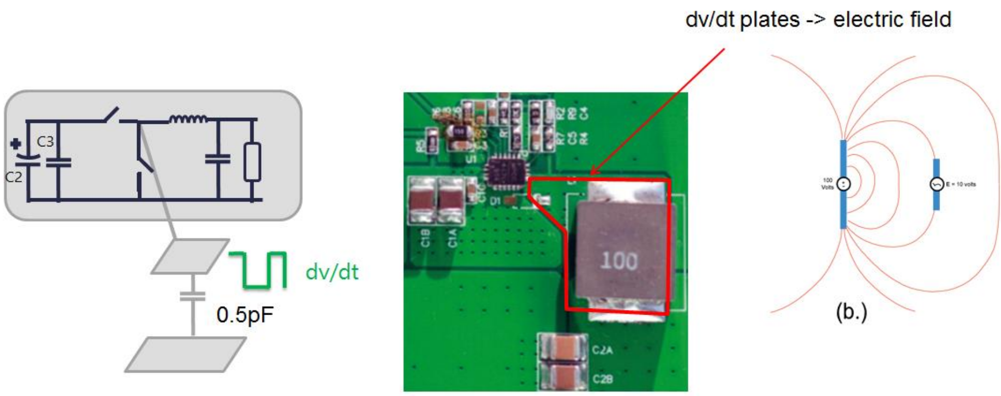

Figure 11: Small SW Pad Layout

- Use a single connection from the IC GND plane to the system GND plane.
- Keep the connection between the input ground and GND as short and wide as possible.
- Connect the V_{CC} capacitor's ground to the IC's ground with multiple vias or wide traces.
- Keep the connection between the input capacitor and IN as short and wide as possible.
- Ensure all feedback connections are short and direct.
- Place the feedback resistors and compensation components as close to the chip as possible.
- Route SW away from sensitive analog areas, such as FB.

Optimization for Consumer and RF-Sensitive Applications

In a world with so many electronic devices around — from household appliances to consumer electronics and RF-sensitive devices, such as garage door openers and alarm systems — EMI issues can cause the systems to have unwanted interaction and operation problems. The MP2317 family addresses this by optimizing EMI performance while allowing easy and cost-effective manufacturing with simple packaging and single-layer PCB.

The MP2317 family can be used as a secondary-side DC/DC regulator (see Figure 12).

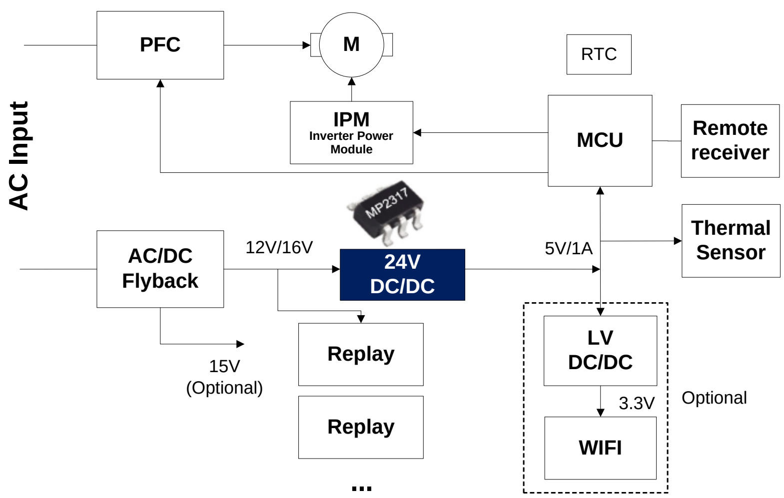

Figure 12: Application in Air Conditioner

MP2317 Family Key Features:

- 7.5V to 26V wide input operation range
- 150µA low quiescent current
- Excellent load and line regulation, as well as transient response (see Figure 15)
- High efficiency: 96% peak, 80% at 12V to 5V/20mA (see Figure 13)
- Full protections (OTP, UVLO, OCP) for higher reliability and longevity

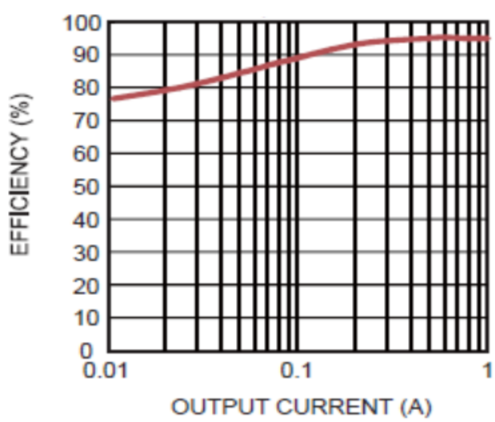

Figure 13: MP2317 Efficiency
(Test conditions: V_{IN} = 12V, V_{OUT} = 5V)

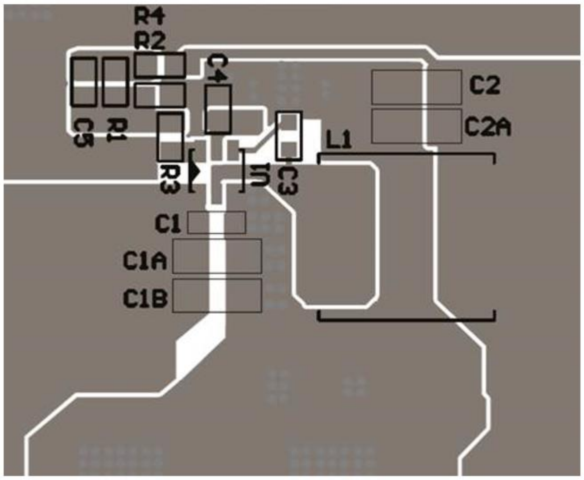

Figure 14: MP2317 (U1) for Single-Layer Layout

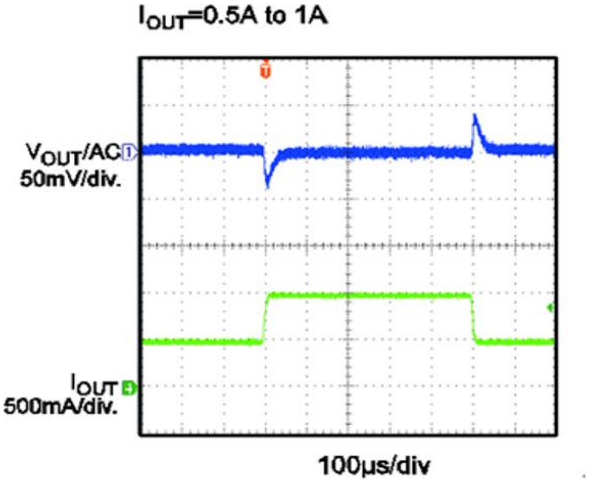

Figure 15: MP2317 Quick Load Transient Response
(Test conditions: V_{IN} = 12V, V_{OUT} = 5V, L = 10µH)

Conclusion

In addition to EMI optimization, which is critical for reliable circuit operation, ease of manufacturing is also important. The MP2317, MP2344, and MP2345 family of high-efficiency, 26V switching regulators from MPS offer pin-to-pin compatible 1A/2A/2.5A in small 6-pin SOT23 package and a large pin pitch (0.95mm), which enables simple manufacturing using single-layer PCB layout to save cost. Three levels of output current in the same footprint provides systems engineers the flexibility to switch to different devices without PCB changes, save additional time and cost.

