Technical Article

Effects of IC Package on EMI Performance

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The origin of electromagnetic interference (EMI) in switched-mode power supplies can be traced back to the transient voltages (dv/dt) and currents (di/dt) generated during the switching of power metal-oxide semiconductor field-effect transistor (MOSFET) devices. With ever-growing demand for more power as well as higher switching frequencies, it is becoming increasingly challenging to address EMI in regards to device performance and meeting regulatory requirements. In this article, I'll present an overview of the most widely used package types used for power electronics devices and their influence on EMI.

There are three common package types used in power electronics today:

- Thin-shrink small-outline package (TSSOP).
- Quad-flat no lead (QFN).
- Flip-chip on lead (FCOL QFN) or TI HotRod™ package.

TSSOP

Figure 1 is a cross-section of a TSSOP and the main building blocks in this type of package design. As you can see, the integrated circuit (IC) is mounted on a lead frame (mainly using some type of epoxy) with pins protruding through the plastic housing, enabling a connection of the IC to the printed circuit board (PCB). The die connects to the lead frame using gold, aluminum or copper wires. From this cross section, you can see that the connection between the IC and a certain point on the PCB consists of the IC die (with its corresponding parasitic components); the wire-bond connection between the IC and the lead frame; and finally, the leaded physical connection between the IC package and PCB. All of these components in the connection path contribute to a generally higher resistance path, as well as increased parasitic inductance. This package is popular because of ease of assembly, relatively low cost and good thermal performance.

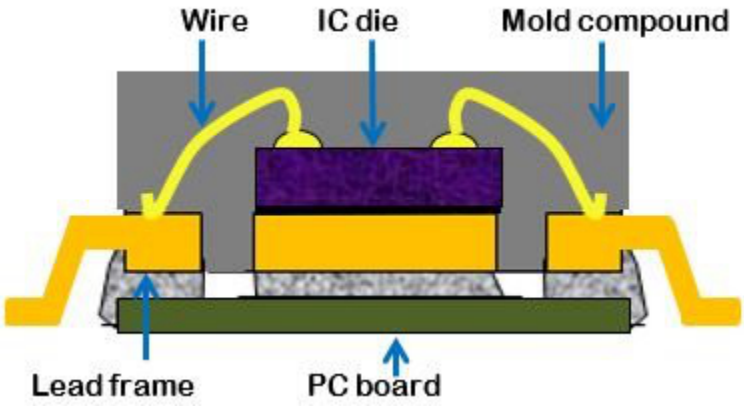

Figure 1. TSSOP Package Cross Section

The question is, how do all of these TSSOP characteristics affect device EMI performance? Increased parasitic inductance will result in larger overshoot on the switch node. Package parasitic components are just a part of the overall picture, however; board layout also plays a very important role.

Figure 2 is an oscilloscope screenshot showing a switch-node waveform on a DC/DC converter in TSSOP. Increased ringing on the switch node will have a direct effect on resulting EMI performance, making it more challenging to meet required EMI regulatory compliance (for example, Comité International Spécial des

Perturbations Radioélectriques [CISPR] 25 class 5 requirements). The observed ringing frequency is in the 150MHz-250MHz range.

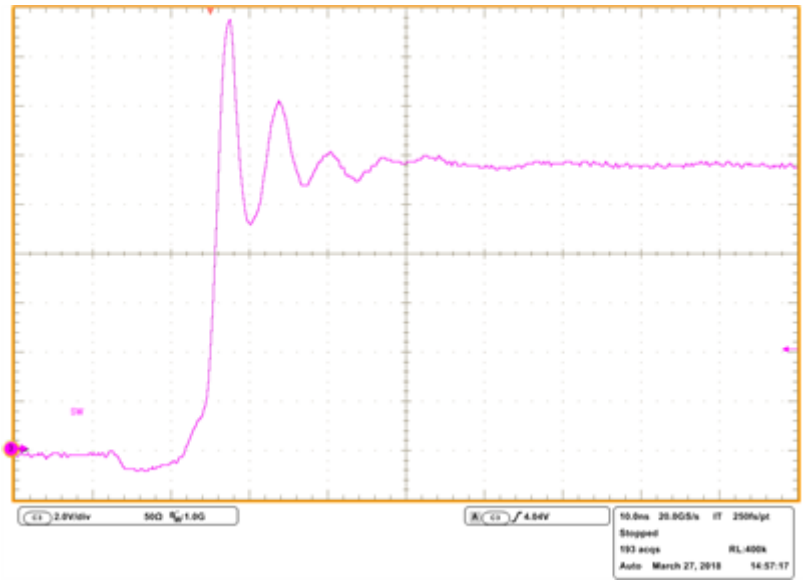

Figure 2. Switch Node Waveform for the TSSOP Package

QFN Package

The internal construction of a QFN package is very similar to TSSOP. Figure 3 shows a simplified cross-section of this package. The active side of the IC die connects to the lead frame using wire bonds. A QFN package does not have leaded pins to connect the device to the PCB; it has connection pads on the lead frame. The main advantages of this type of package are ease of use in assembly, good thermal performance and the ability to achieve fine pitch between the package pads.

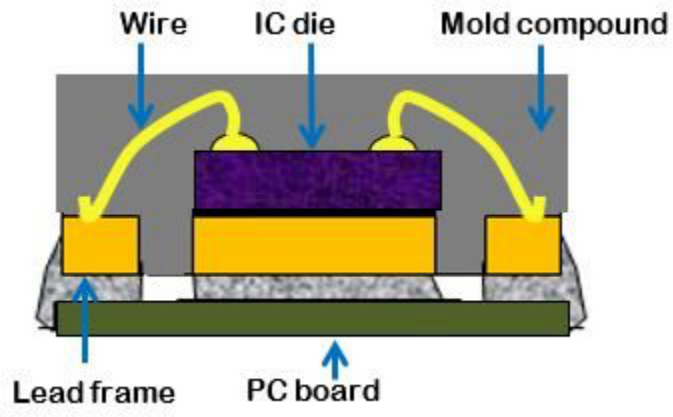

Figure 3. QFN Package Cross Section

The absence of leaded external pins results in reduced parasitic inductance/resistance. This is visible in reduced overshoot when observing the switch node (as shown in Figure 4). The ringing frequency is noticeably different from the values observed for leaded devices, generally in the 200MHz-250MHz range. Newer device generations such as TI's LM76002 or LM76003 are manufactured using this package, and Figure 4 shows switch-node ringing waveform.

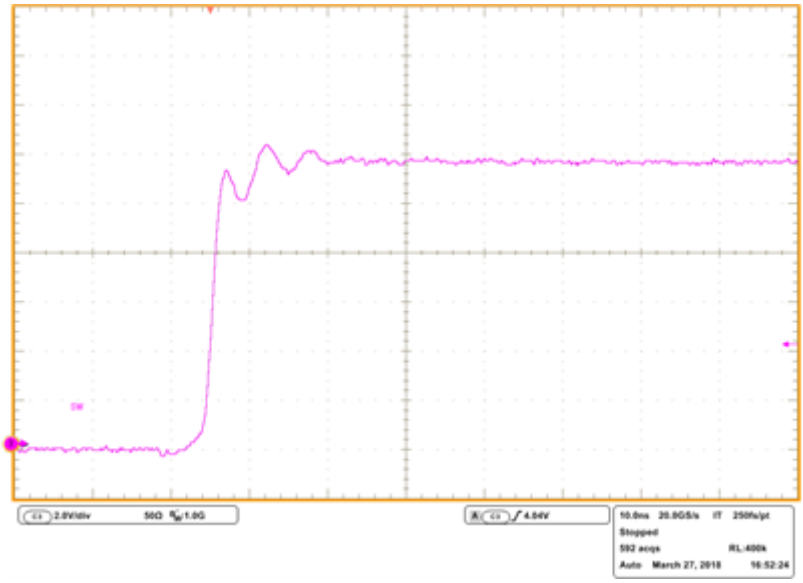

Figure 4. Switch Node Waveform for the QFN Package

FCOL QFN (TI Brands This Package as HotRod)

The FCOL QFN package was developed in an effort to further reduce switch-node ringing (as one of the contributors to EMI). In this type of package, there are no wires to connect the IC to the lead frame. Solder bumps are placed on the IC die; the die is then flipped and attached to the lead frame. Figure 5 is a package cross section.

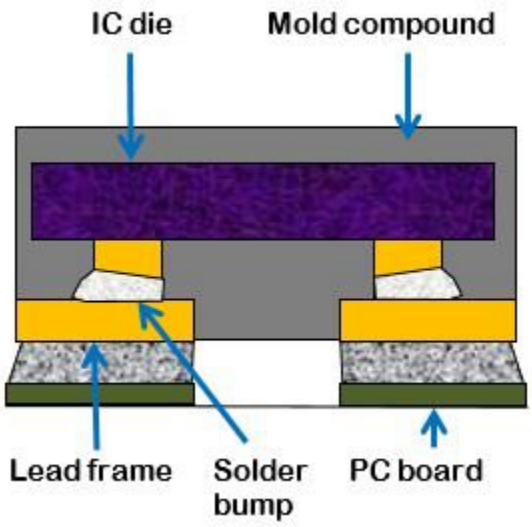

Figure 5. FCOL QFN Package Cross Section

The resulting performance, from the perspective of switch-node ringing, is measurably improved because there are no wires connecting the IC to the lead frame and PCB. The connection is much shorter and direct between the IC and outside world. Not surprisingly, when observing the switch-node waveform (under the same conditions as for TSSOP and QFN), there is a significant reduction (almost a complete absence) of switch-node ringing. Figure 6 shows switch-node ringing on the LM53635 device.

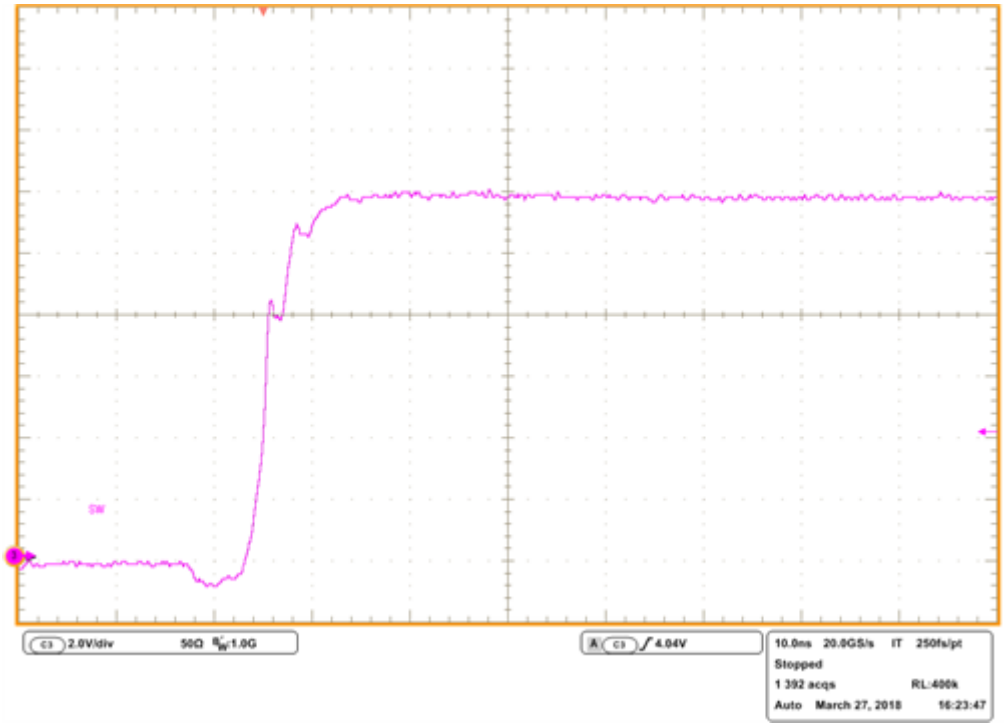

Figure 6. Switch Node Waveform for the FCOL QFN Package

Based on your desired performance and application constraints, you should carefully consider package type an important selection criteria. The new device generations show significantly improved performance in terms of switch-node ringing.

Understand, however, that switch-node ringing is just one of the performance parameters that will affect EMI performance in the end application. You will need to account for several other factors such as proper input filtering, board layout and the appropriate selection of passive components for optimum performance. Download the application report, “Designing High-Performance, Low-EMI Automotive Power Supplies.”

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