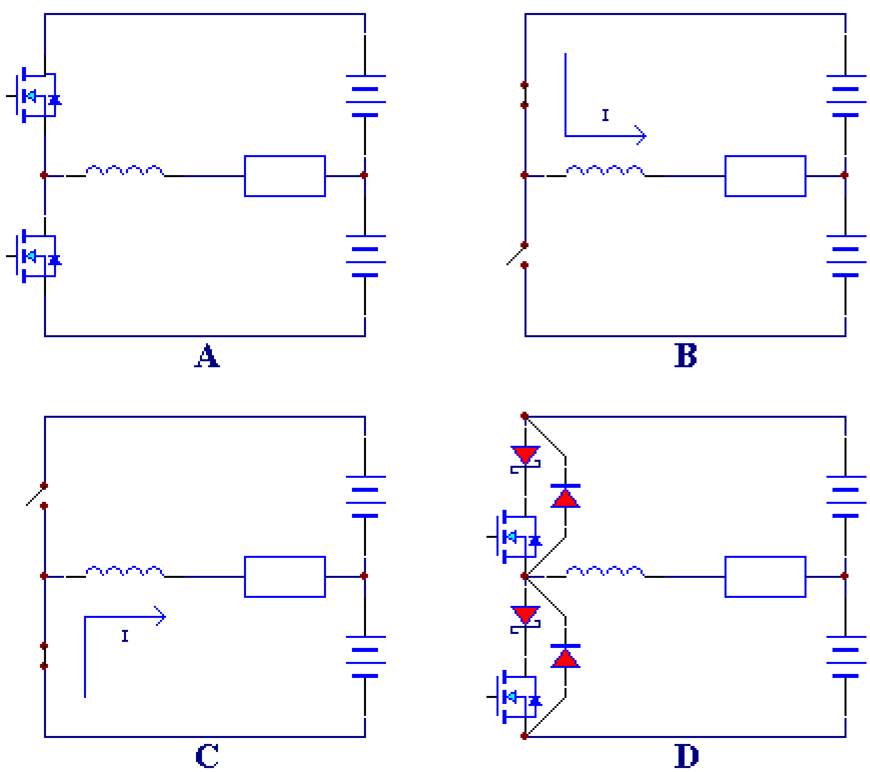
# MOSFET Body Diode

Joey White

*Hephaestus Audio*

The body diode of a typical MOSFET is very slow.  In order to maintain fast switching for high-efficiency, it is necessary to select MOSFETs with fast intrinsic body diodes, or to add additional circuitry to ensure the body diode will never conduct.  A short dead-time interval also helps with this, but may adversely impact reliability.  Also, this approach may fail to work at all with higher voltage MOSFETs, where the voltage drop across the channel can easily exceed that of the diode when conducting in the reverse direction.

Unfortunately, it is not always an option to use a MOSFET with a fast intrinsic body diode.  The following diagrams show two ways of dealing with a slow body diode:




**A** Typical class-D half-bridge output stage.

**B** The upper MOSFET is turned on and current flows in the forward direction through the channel.

**C** The dead-time is maintained at a small value in order to minimize conduction through the body diode and thus the stored charge Qrr.

**D** An alternative scheme involves the use of a series Schottky diode to ensure the body diode of the MOSFET does not conduct.  A fast recovery diode is then placed in parallel with the combination.

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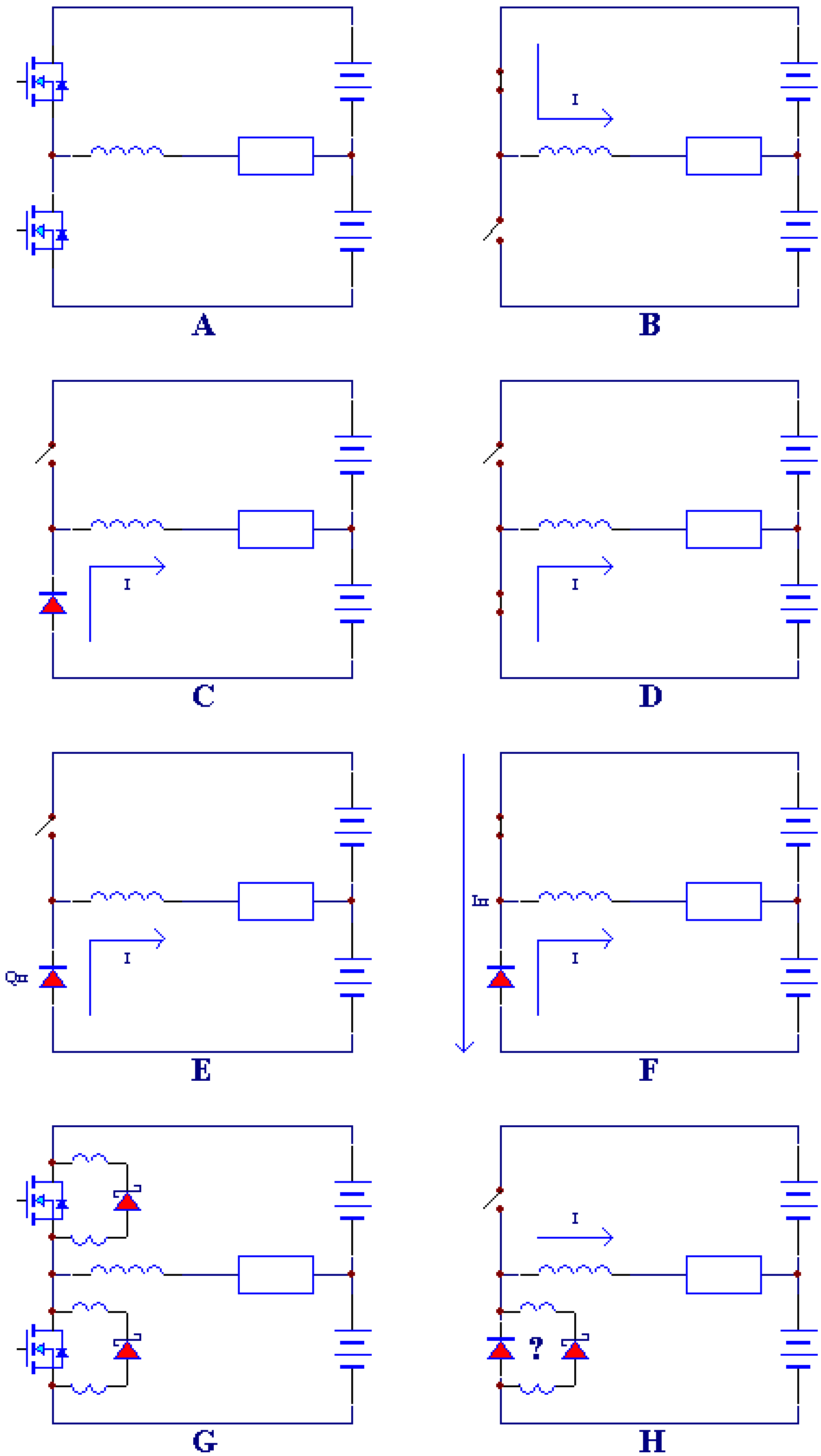
The following diagrams show the issue of the slow MOSFET body diode in greater detail:

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**A** Typical class-D output stage that utilizes the body diodes of the MOSFETs.

**B** The upper MOSFET is on and current flows in the forward direction through the channel.

**C** The upper MOSFET switches off and the inductor forces the current to continue flowing via the intrinsic body diode of the lower MOSFET.

**D** The lower MOSFET switches on after the dead-time interval and takes over the current flowing through the body diode.

**E** The lower MOSFET switches off and the inductor again forces the current to flow through the body diode, storing reverse recovery charge Qrr.

**F** After the dead-time interval, the upper MOSFET switches on. Unfortunately, the lower body diode is in reverse recovery, resulting in a large reverse recovery current Irr.

**G** Some designs have made use of external Schottky diodes in parallel with the MOSFETs to prevent conduction of the body diode. The thought is that the lower forward drop of the Schottky diode will ensure that it is the first to conduct.

**H** When the lower MOSFET is conducting in the reverse direction through the channel (D) and is then switched off (E), the inductor forces the current to continue flowing. It has two choices – remain within the MOSFET package and flow through the body diode, or leave the MOSFET, go through the parasitic inductance of the MOSFET package and the external diode package, and then through the external Schottky diode.

Simple analysis shows that the current will flow through the body diode of the MOSFET rather than the external Schottky diode, due to the parasitic inductance of the device packages.

$$v = L \cdot \frac{di}{dt} \approx L \cdot \frac{\Delta i}{\Delta t}$$

$L$ Assume the lead-to-lead parasitic inductance is 10nH for the MOSFET and also 10nH for the external Schottky diode, for a total of **20nH**.

$\Delta i$ Assume the current being switched off is **10A**.

$\Delta t$ Assume the time to switch off the MOSFET is **20nS**.

$$v = (20nH) \cdot \frac{(10A)}{(20nS)} = 10V$$

When this voltage drop is added to that of the Schottky diode, it is clear that the body diode will conduct before the Schottky diode, resulting in stored charge and reverse recovery issues. Also, note that the above analysis assumes a "perfect" layout with no parasitic inductance. A real layout will add even more parasitic inductance and therefore more voltage drop to the Schottky path.

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