Snubbers and Clamps

Snubbers and clamps are used for two very different purposes. When misapplied, the reliability of the semiconductors within the power supply is greatly jeopardized.

A snubber is used to reduce the level of a voltage spike and decrease the rate of change of a voltage waveform. This then reduces the amount of overlap of the voltage and current waveforms during a transition, thus reducing the switching loss. This has its benefits in the Safe Operating Area (SOA) of the semiconductors, and it reduces emissions by lowering the spectral content of any RFI.

A clamp is used only for reducing the level of a voltage spike. It has no affect on the dV/dt of the transition.

Therefore it is not very useful for reducing RFI. It is useful for preventing components such as semiconductors and capacitors from entering avalanche breakdown.

Bipolar power transistors suffer from *current crowding* which is an instantaneous failure mode. If a voltage spike occurs during the turn–off voltage transition of greater than 75 percent of its VCEO rating, it may have too much current crowding stress. Here both the rate of change of the voltage and the peak voltage of the spike must be controlled. A snubber is needed to bring the transistor within its RBSOA (Reverse Bias Safe Operating Area) rating. Typical snubber and clamp circuits are shown in Figure 27. The effects that these have on a representative switching waveform are shown in Figure 28.
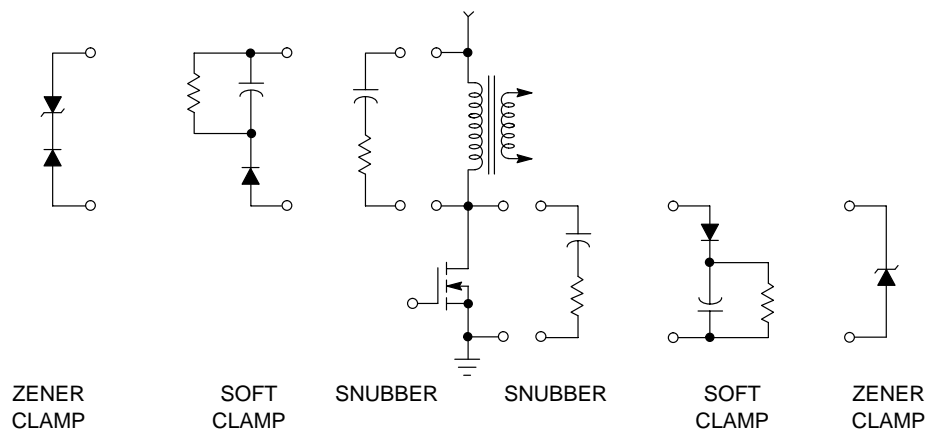

ZENER CLAMP SOFT CLAMP SNUBBER SNUBBER SOFT CLAMP ZENER CLAMP

Figure 27. Common Methods for Controlling Voltage Spikes and/or RFI

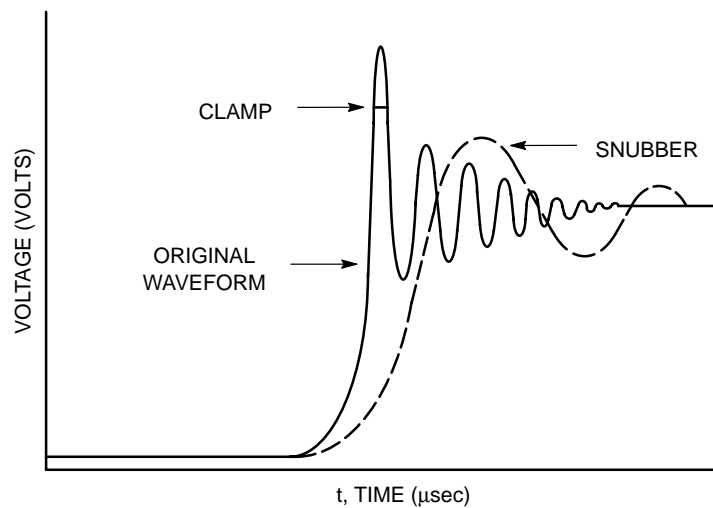**Figure 28. The Effects of a Snubber versus a Clamp**

The Lossless Snubber

A lossless snubber is a snubber whose trapped energy is recovered by the power circuit. The lossless snubber is designed to absorb a fixed amount of energy from the transition of a switched AC voltage node. This energy is stored in a capacitor whose size dictates how much energy the snubber can absorb. A typical implementation of a lossless snubber can be seen in Figure 29.

The design for a lossless snubber varies from topology to topology and for each desired transition. Some adaptation may be necessary for each circuit. The important factors in the design of a lossless snubber are:

1. *The snubber must have initial conditions that allow it to operate during the desired transition and at the desired voltages.* Lossless snubbers should be emptied of their energy prior to the desired transition. The voltage to which it is reset dictates where the snubber will begin to operate. So if the snubber is reset to the input voltage, then it will act as a lossless clamp which will remove any spikes above the input voltage.

2. *When the lossless snubber is "reset," the energy should be returned to the input capacitor or back into the output power path.* Study the supply carefully. Returning the energy to the input capacitor allows the supply to use the energy again on the next cycle. Returning the energy to ground in a boost–mode supply does not return the energy for reuse, but acts as a shunt current path around the power switch. Sometimes additional transformer windings are used.

3. The reset current waveform should be band limited with a series inductor to prevent additional EMI from being generated. Use of a 2 to 3 turn spiral PCB inductor is sufficient to greatly lower the di/dt of the energy exiting the lossless snubber.
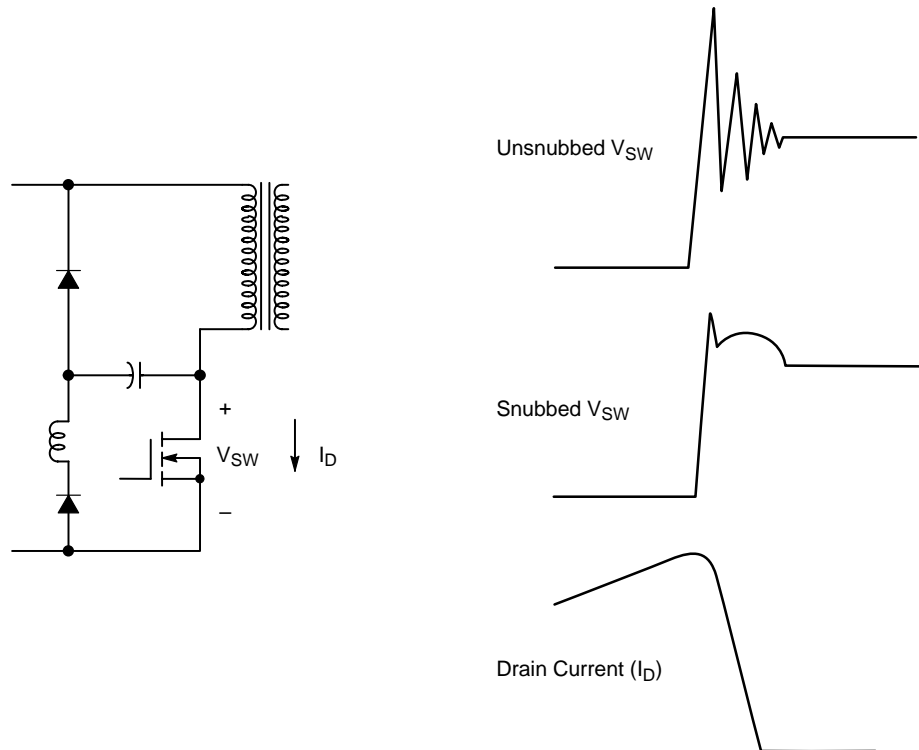

Figure 29. Lossless Snubber for a One Transistor Forward or Flyback Converter
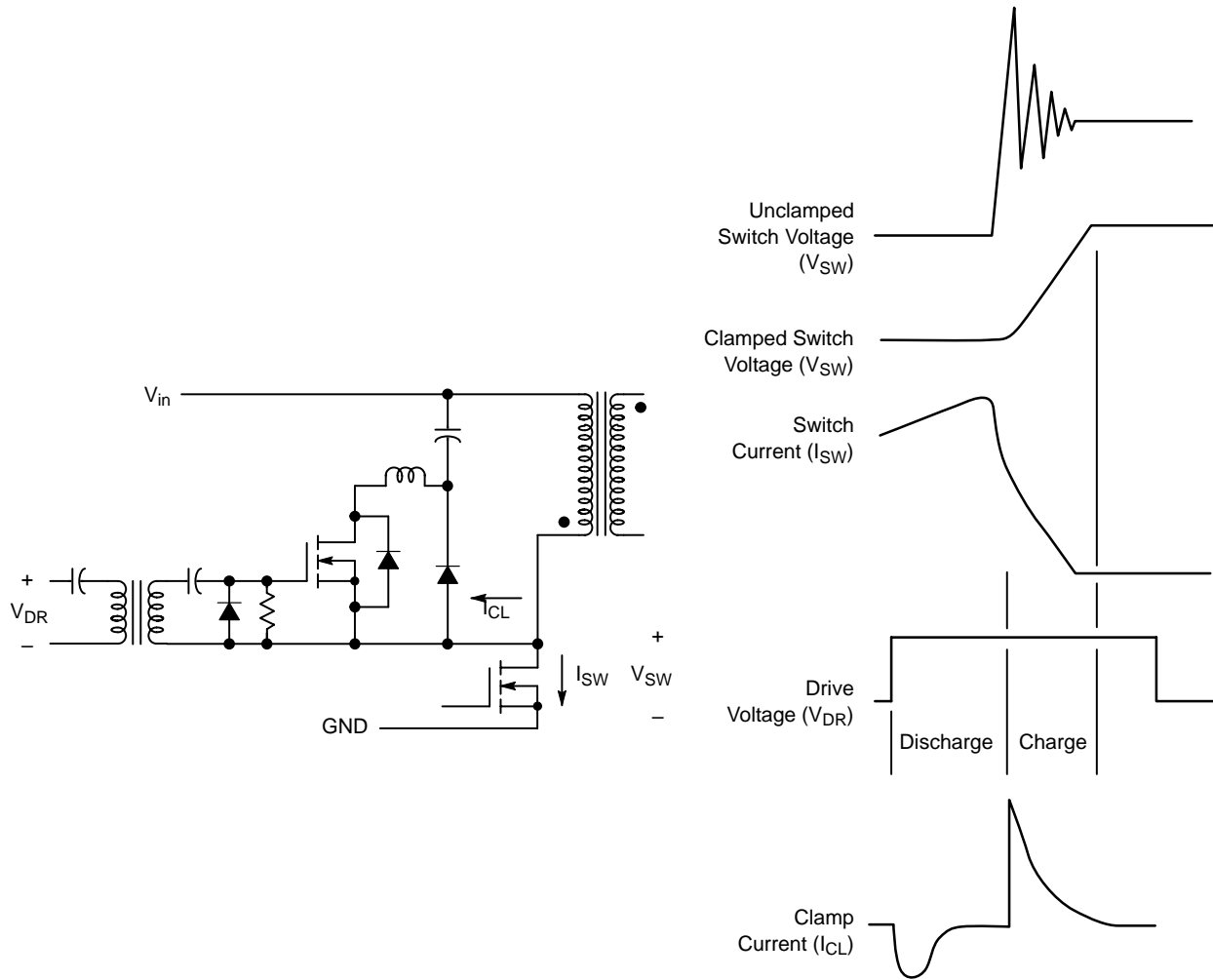
The Active Clamp

An active clamp is a gated MOSFET circuit that allows the controller IC to activate a clamp or a snubber circuit at a particular moment in a switching power supply's cycle of operation. An active clamp for a flyback converter is shown in Figure 30.

In Figure 30, the active clamp is reset (or emptied of its stored energy) just prior to the turn–off transition. It is then disabled during the negative transition.

Obviously, the implementation of an active clamp is more expensive than other approaches, and is usually reserved for very compact power supplies where heat is a critical issue.

Figure 30. An Active Clamp Used in a One Transistor Forward or a Flyback Converter