# Snubber Circuit Design



## Snubber Design Tips

Snubbers are used to limit switching transients and help lower EMI.

**1)** Measure the ring frequency at the top of the MOSFET switch node (SW) turn-off waveform. Solder a good quality COG or film type capacitor from the MOSFET SW node to GND, causing the ring frequency to be half of the original value. The effective capacitance at this node is 1/3 of the external capacitor value. The stray inductance is calculated using:

$$F_{RING} = \frac{1}{2\pi\sqrt{L_S \times C_T}}$$

where $C_T$ is the total (effective plus external) capacitance.

**2)** In order to critically damp the ringing, double the size of the external cap. Use a series R calculated from:

$$d = \frac{R}{2} \times \sqrt{\frac{L_S}{C_S}}$$

where d is the damping factor, set to a value of 1. $C_S$ is the calculated effective capacitance at the SW node, **not** the external snubber capacitance.

**3)** Install the snubber resistor in the ground side of the RC circuit. If the ringing is not critically damped, the external capacitor value is too low. However, increasing this value may not be practical. Measure the positive and negative voltage spikes across the snubber resistor, which will be highest at the maximum input voltage. The power dissipated in the resistor is calculated by:

$$P(R_{SNUB}) = \frac{1}{2} \times C_{SNUB} \times (V_P^2 + V_N^2) \times F_{SW}$$

where $V_P$ and $V_N$ represent the positive and negative voltage spikes across the snubber resistor, and $F_{SW}$ is the switching frequency. This could be an unacceptably high amount of power dissipation. If so, a compromise between efficiency and damping may be required.

For parallel damping, the relationship is:

$$d = \frac{1}{2R} \times \sqrt{\frac{L_S}{C_S}}$$

or

$$R_{SNUB} = \frac{1}{2d} \times \sqrt{\frac{L_S}{C_S}}$$

**For critical damping (d = 1):**

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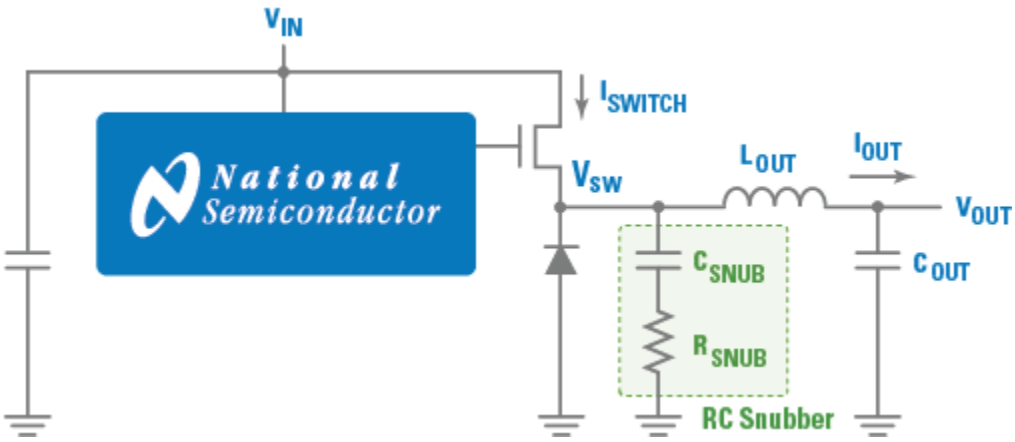
$$C_{SNUB} \geq 5 \times C_S$$

$$R_{SNUB} = \frac{1}{2} \times \sqrt{\frac{L_S}{C_S}}$$

## Buck Regulator Snubber Circuit Design Example




Measure the switching signal at the MOSFET/inductor junction. You will see a voltage spike and ringing at the top of this signal. Let's say you measure a ring period of 7 ns, which represents 143 MHz. Solder a capacitor directly across the low side FET from the switch node to ground. Let's say 330 pF causes the period to double to 14 ns.

Calculate $C_S$ from:

$$C_S = C_{EXT} / 3 = 330\ pF / 3 = 110\ pF$$

Calculate $L_S$ from:

$$L_S = \frac{1}{C_S \times (2\pi \times F_{RING})^2} = \frac{1}{110\ pF \times (6.28 \times 143\ MHz)^2} = 11.2\ nH$$

Calculate $C_{SNUB}$ from:

$$C_{SNUB} \geq 5 \times C_S$$

$$C_{SNUB} \geq 5 \times 110\ pF = 550\ pF\ ;\ use\ 560\ pF$$

Calculate $R_{SNUB}$ from:

$$R_{SNUB} = \frac{1}{2} \times \sqrt{\frac{L_S}{C_S}} = \frac{1}{2} \times \sqrt{\frac{11.2\ nH}{110\ pF}} = 5\ ohms$$

Install $R_{SNUB}$ and $C_{SNUB}$.

Lets say at 40V input you measure Vpos = 40V and Vneg = 20V across the resistor.

For 150 kHz operation:

$$P(R_{SNUB}) = \frac{1}{2} \times C_{SNUB} \times (V_P^2 + V_N^2) \times F_{SW} = \frac{1}{2} \times 560\ pF \times (1600+400) \times 150\ kHz = 0.084\ watts$$

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