

# Power Tips: Calculate an R-C snubber in seven steps



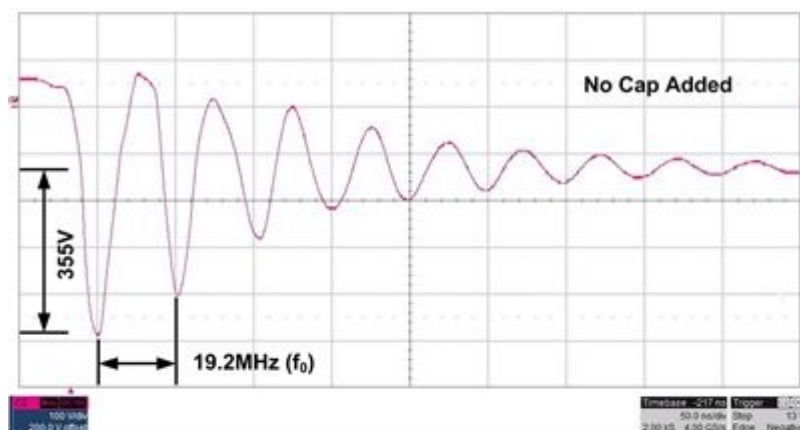
*John Betten* May 5, 2016

Ring in switching power supplies can generate radiated and conducted noise, create circuit jitter and excessive dissipation, and easily overstress components. Ringing is a major concern in applications such as audio, processor power and any design that requires electromagnetic interference (EMI) qualification.

Often, you can tame the circuit by adding a simple resistor-capacitor (R-C) snubber to “damp out the ringing.” In this post, I’ll outline a seven-step procedure that can help take the guesswork out of selecting your snubber values.

Ringing can occur in any switching converter where an inductance and a capacitance form an inductor-capacitor (L-C) tank. The inductance may be from component leads, printed circuit board traces and transformer leakage, while the capacitance may be due to nonlinear components such as rectifiers and interwinding transformer capacitance. The ring frequency and amplitude are generally unknown since most circuit parasitics are typically unknown. Two common locations where excessive ringing occurs (at least in converters such as a flyback) are across the rectifier diode and the switching FET. One simple solution to reduce this ringing is by damping or “snubbing” it with a series R-C circuit, typically placed directly across the rectifier or FET.

The seven-step procedure shown in Table 1 uses a common methodology that shifts the resonant frequency of the ringing to calculate the circuit’s parasitic capacitance ( $C_o$ ) and inductance ( $L$ ). Once you know those, you can calculate the snubber capacitor ( $C_{snub}$ ) and resistor ( $R_{snub}$ ). I took the example waveforms in Figures 1 and 2 with an R-C snubber placed in parallel with the rectifier in the [9Vdc-57Vdc Input, 56V/20W Isolated Flyback Reference Design](#), but the procedure is the same if used across the FET.



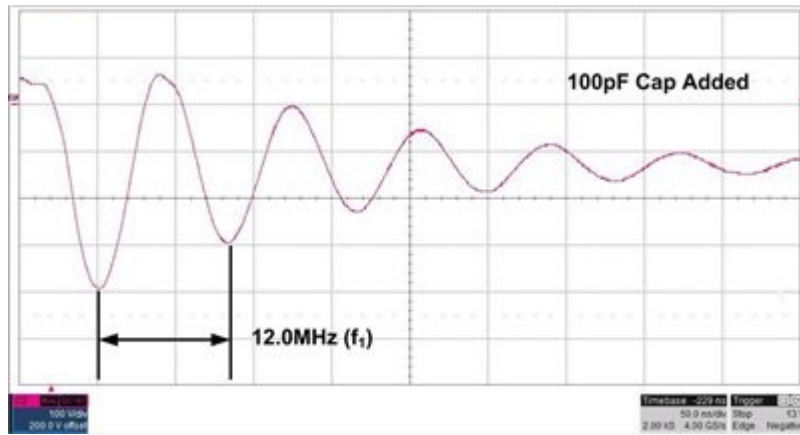
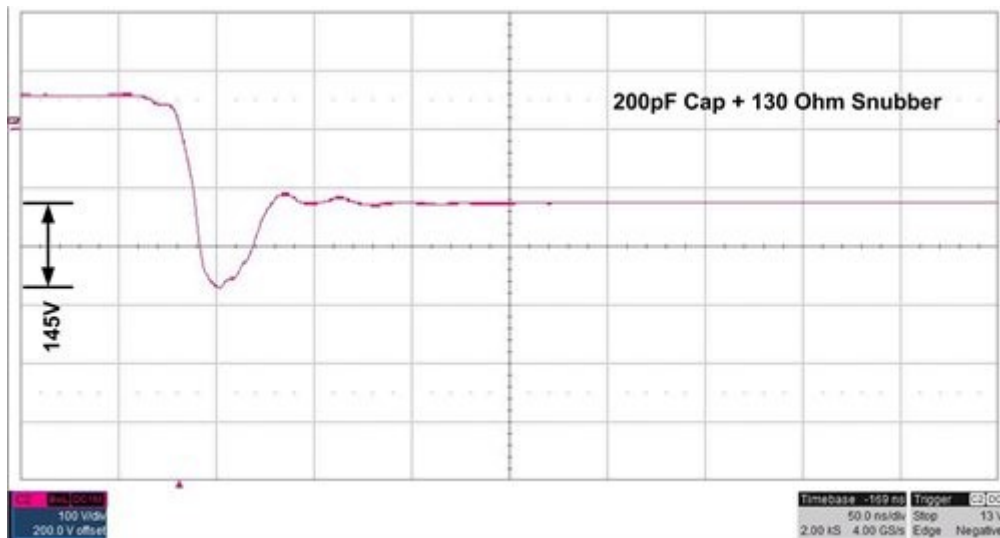


Figure 1: Unsnubbed rectifier ringing (top) and frequency-shifted ringing (bottom)

Seven steps to calculate an R-C snubber	
Step 1	Measure the circuit's oscillation frequency ( $f_0$ ). See Figure 1 (top).
Step 2	Add a capacitor ( $C_1$ ) in parallel with the rectifier or FET and measure the shifted oscillation frequency ( $f_1$ ). Select a $C_1$ value that is several times larger than the rectifier's stated typical capacitance at full-reverse voltage in the data sheet. In this example, the rectifier's reverse capacitance is 22pF, so I chose a 100pF value for $C_1$ . A frequency shift of at least 50% is reasonable. See Figure 1 (bottom).
Step 3	Calculate the frequency shift ratio: $m = \frac{f_0}{f_1}$ .
Step 4	Calculate the circuit's parasitic capacitance: $C_0 = \frac{C_1}{(m^2-1)}$ .
Step 5	Calculate the circuit's parasitic inductance: $L = \frac{(m^2-1)}{(2\pi f_0)^2 C_1}$ .
Step 6	Calculate the starting snubber capacitor value: $C_{snub} = 3 * C_0$ .
Step 7	Calculate the starting snubber-resistor value: $R_{snub} = \sqrt{\frac{L}{C_0}}$ .

Figure 2 shows the spike reduction and damping effect of the calculated values. You can adjust the ringing higher or lower by varying the  $C_{snub}$  value. Larger values for  $C_{snub}$  reduce the voltage-spike amplitude further, but increase power loss in  $R_{snub}$ .

Alternatively, you can decrease the power dissipation in  $R_{snub}$  by lowering  $C_{snub}$ , but ringing will increase. You must weigh the trade-off between acceptable voltage-ring amplitude and  $R_{snub}$  losses.



Undamped ringing in switching converters can create excessive EMI and overstress components. A properly calculated R-C snubber can be instrumental in taming these issues. I hope you'll find my seven-step procedure simple to follow and a good starting point to help you damp out the ringing. For more about the topic covered here, see my EETimes Power Tips post "[Calculating an R-C snubber.](#)"

6 comments 0 members are here



[mechanik](#) over 6 years ago

Very educative and just awesome way to learn and practice.



[DEEPAK V14](#) over 4 years ago

Thanks John



[Rajasekaran](#) over 3 years ago

Sir,

This article is very informative. We can able to select the resistor value based on the equation no 7. Could you please help us to select the power rating the resistor?



[Chenming Wu](#) 2 months ago in reply to [Rajasekaran](#)

I think  $P = 1/2 * C * V_{pk}^2 * F_{sw}$



[Hao Ye Soon](#) 8 months ago

what should the snubber capacitor's voltage rating be?



[Jackson James](#) *8 months ago*

I would agree that the inductance may be from component leads, printed circuit board traces and transformer leakage, while [stump removal](#) the capacitance may be due to nonlinear components such as rectifiers and interwinding transformer capacitance.