RC SNUBBERS (SMPS)

Snubbers are energy-absorbing circuits used to suppress the voltage spikes caused by the circuit's inductance when a switch, electrical or mechanical, opens. The most common snubber circuit is a capacitor and resistor connected in series across the switch (transistor).

![Diagram of RC snubber](image)

The design procedure is as follows:

If you assume the source has negligible impedance, the worst-case peak current in the snubber circuit is:

\[ I_{PK} = \frac{V_0}{R_S} \quad (1) \]

\[ R_S = \text{snubber resistance} \]

\[ V_0 = \text{open circuit voltage} \]

and the circuit \( \frac{dv}{dt} \) is determined from the following:

\[ I_p = C \frac{dv}{dt} \quad (2) \]

substituting (1) into (2)

\[ \frac{dv}{dt} = \frac{V_0 C}{R_S} \]

The energy stored in the capacitor is:

\[ E = \frac{1}{2} C(V_0)^2 \]

Ohm's Law says that the snubber resistance is equal to:

\[ R = \frac{V_0}{I} \quad I = \text{switching current} \]

\[ V_0 = \text{open circuit voltage} \]

The amount of energy the snubber resistance is to dissipate is the amount of energy stored in the snubber capacitor. It is recommended that you choose a capacitance value that causes the resistor to dissipate one half the wattage rating of the resistor.

\[ P = \frac{1}{2} C(V_0)^2 f \quad \text{Where} \quad f = \text{switching frequency} \]

\[ = C(V_0)^2 f \quad 2f = \text{number of transitions per cycle} \]

\[ C = \frac{P}{f(V_0)^2} \]
The snubber capacitance has to meet two requirements. First, the energy stored in the snubber capacitor must be greater than the energy in the circuit's inductance.

\[
\frac{1}{2} C(V_0)^2 > \frac{1}{2} L I^2 \\
C > \frac{L I^2}{(V_0)^2}
\]

Where \(V_0\) = open circuit voltage
\(I\) = closed circuit current
\(L\) = circuit inductance

Secondly, the time constant of the snubber circuit should be small compared to the shortest on time expected, usually 10% of the on time.

\[
R C < \frac{T_{on}}{10}
\]

Where \(T_{on}\) = shortest on-time expected
\(R\) = snubber resistance
\(C\) = snubber capacitance