Considerations for Series-Connection of IGBT and MOSFET Switches

Figure 1 shows the typical RC snubber networks for voltage sharing for switches (S) connected in series in a capacitive discharge circuit. A static voltage sharing resistor R_S is required so that the switch with the lowest leakage current is not forced into avalanche and a dynamic voltage sharing capacitor C_S is needed so that the slowest switch is not forced into avalanche voltage breakdown during turn-on. A compromise must be reached between the number of switches in series, values for R_S and C_S and cost of the total switch.

The values of the resistors R_S and capacitors C_S can be computed from the following:

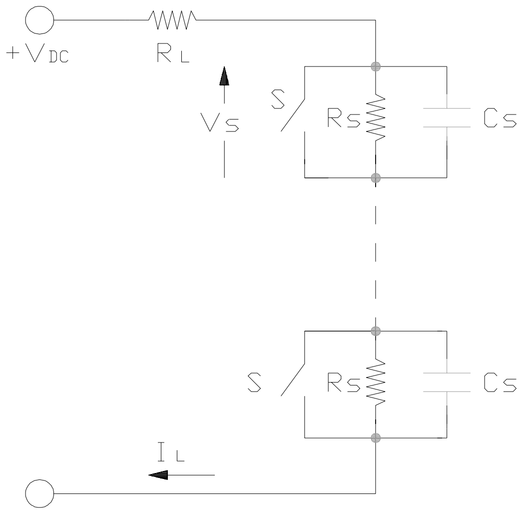

Figure 1. Definition of terms and components.

1. Static voltage sharing resistor R_S :

$$R_S \le (n\, V_{S\,(MAX)} - V_{DC})\,(n-1)^{-1}\; I_S^{-1} \quad (1)$$

where: n = number of devices in series
$V_{S\,(MAX)}$ = maximum allowable voltage across a switch (normally 80% of the maximum switch voltage rating)
I_S = maximum leakage current of a switch.

Power dissipation in resistor R_S :

$$P_D = (V_{S\,(MAX)})^2 \,/\, R_S \quad (2)$$

2. Dynamic voltage sharing capacitor C_S : Assuming no reverse current flow through the switches, than the major factor to consider in sizing capacitor C_S is the voltage buildup on the last switch to turn-on. It is desirable to prevent the MOSFET from avalanching in order to limit its turn-on losses. The worst case scenario is that the switch sustaining the highest voltage is also the slowest to turn-on.

Then: $\Delta V = I_L\; \Delta t_{D(ON)} / C_S$

where: ΔV = Avalanche voltage - $V_{S(MAX)}$
$\Delta t_{D(ON)}$ = difference in turn-on times
$I_L = (V_{DC} - V_{S(MAX)}) / R_L$

Solving for C_S: $C_S > I_L\; \Delta t_{D(ON)} / \Delta V$ (3)

Example: V_{DC} = 2,000V; R_L = 30Ω; BV_S = 1,200V; $V_{S(MAX)}$ = 960V; I_{DSS} = 1mA;
n = 3; $\Delta t_{D(ON)}$ = 200ns.

Substituting these values into the above equations:

$R_S \le$ 880K
P_D = 1.05W (use closest 2W, 5% resistors)
C_S = 28.9nF (use 33nF/2000V, low ESL type)