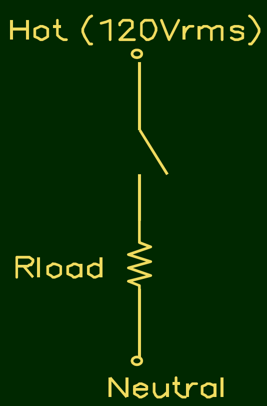
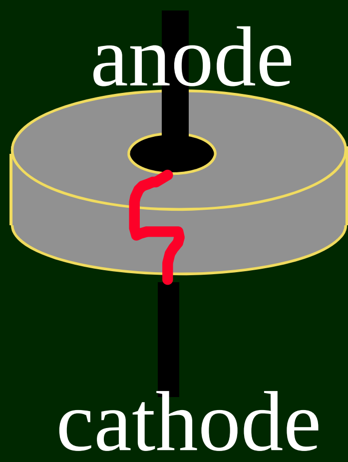
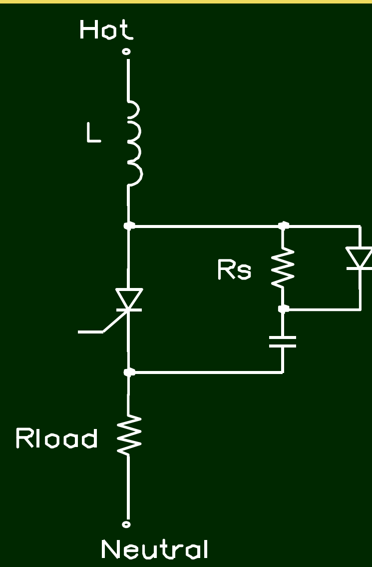
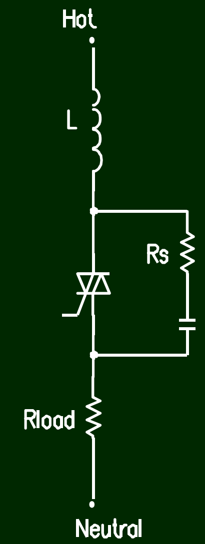
SCR & Triac Snubbing





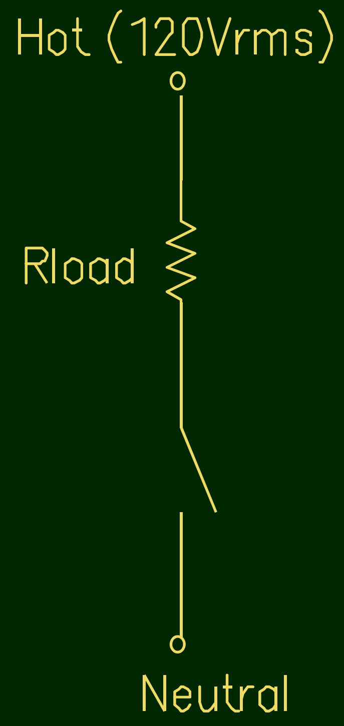




Overview

- High side vs low side switch
- Critical Rate of Rise of Current
  - problem
  - SCR schematic solution
- Critical Rate of Rise of Voltage
- Triac

Low Side Switch



Switch closed

$V_{\text{across Rload}}$ =

120V

Switch opened

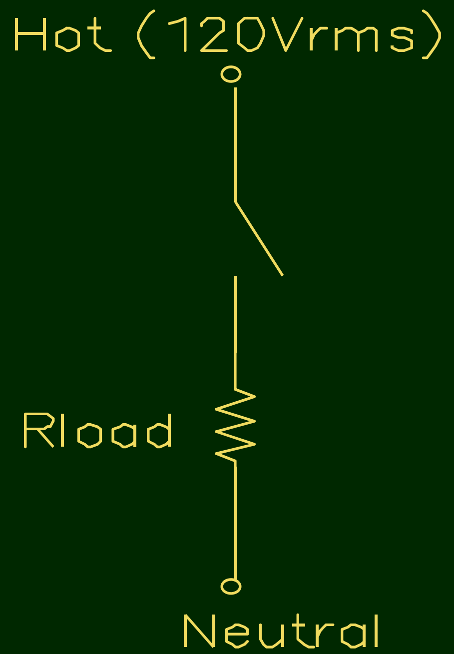
$V_{\text{across Rload}}$ = 0V

$V_{\text{on bottom of load}}$ =

120V !

even though load is off

High Side Switch



Switch closed

$V_{across\ Rload}$ = 120V

Switch opened

$V_{across\ Rload}$ = 0V

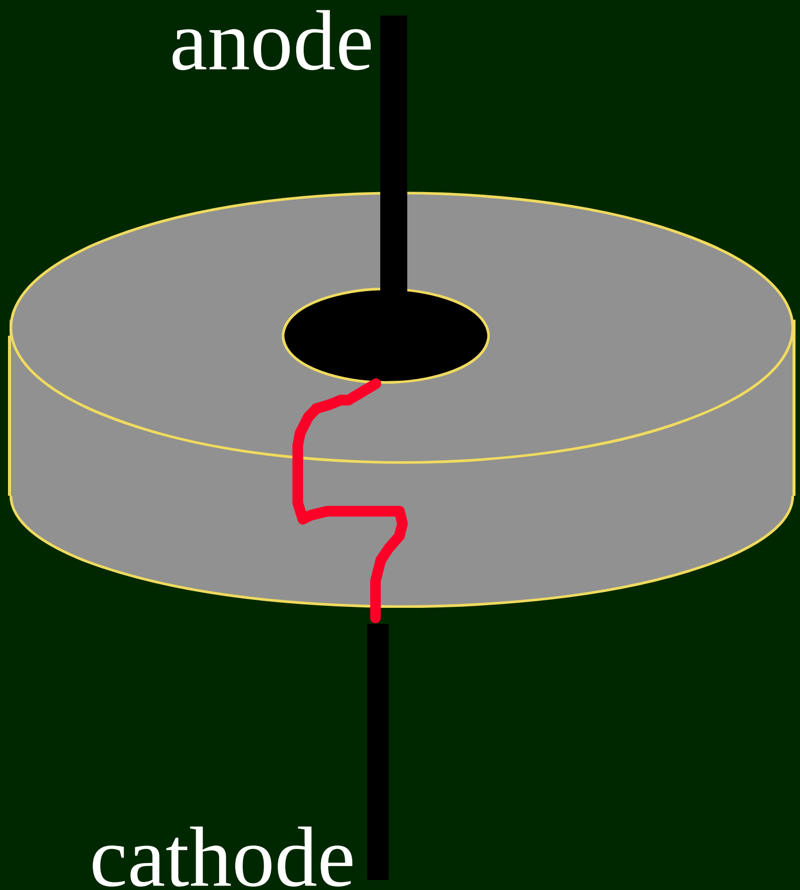
$V_{on\ \ load}$ = 0V

Do it this way!

Overview

- High side vs low side switch
- Critical Rate of Rise of Current
  - problem
  - SCR schematic solution
- Critical Rate of Rise of Voltage
- Triac

Critical Rate of Rise of Current



$^{di}/_{dt}$

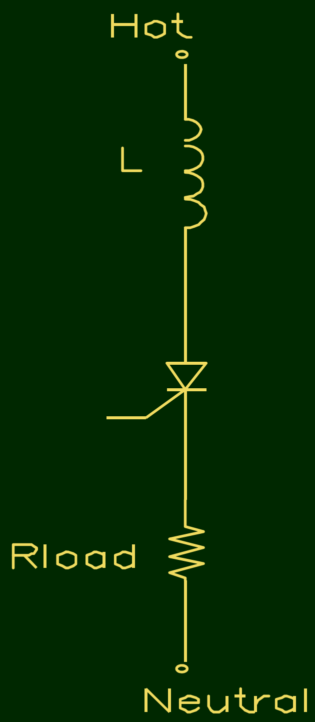
I => T => R down

=> I up => T up

=> R down => I up

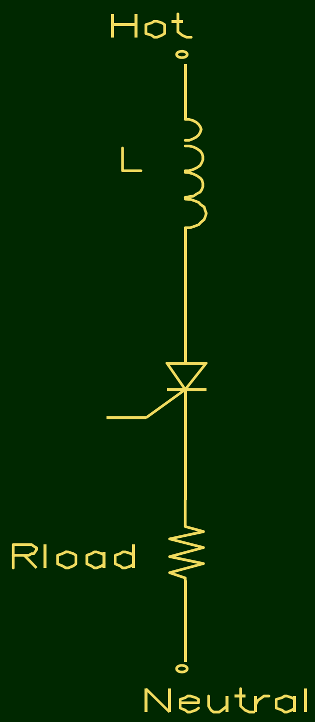
burns out a channel

Critical Rate of Rise of Current - Fix



Inductors oppose Δ I

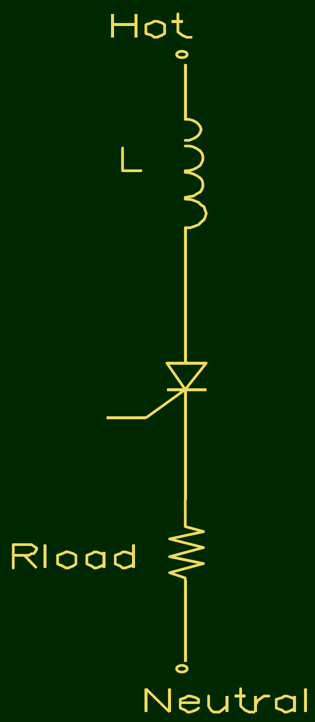
Critical Rate of Rise of Current - Fix



Inductors oppose Δ I

$$v_L = L\frac{di}{dt}$$

Critical Rate of Rise of Current - Fix

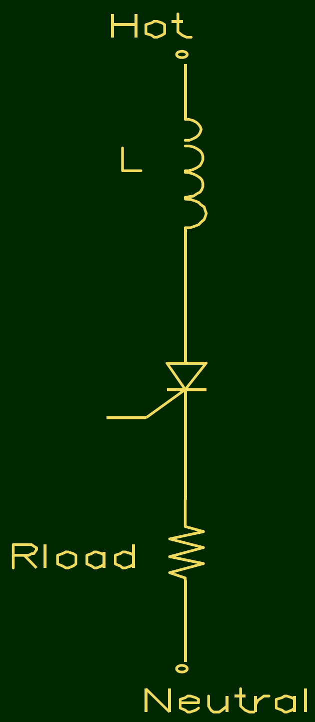


Inductors oppose Δ I

$$v_L = L\frac{di}{dt}$$

$$L = \frac{V_{line\ peak}}{\frac{di}{dt}_{SCR\,spec}}$$

Critical Rate of Rise of Current - Fix



Inductors oppose Δ I

$$v_L = L\frac{di}{dt}$$

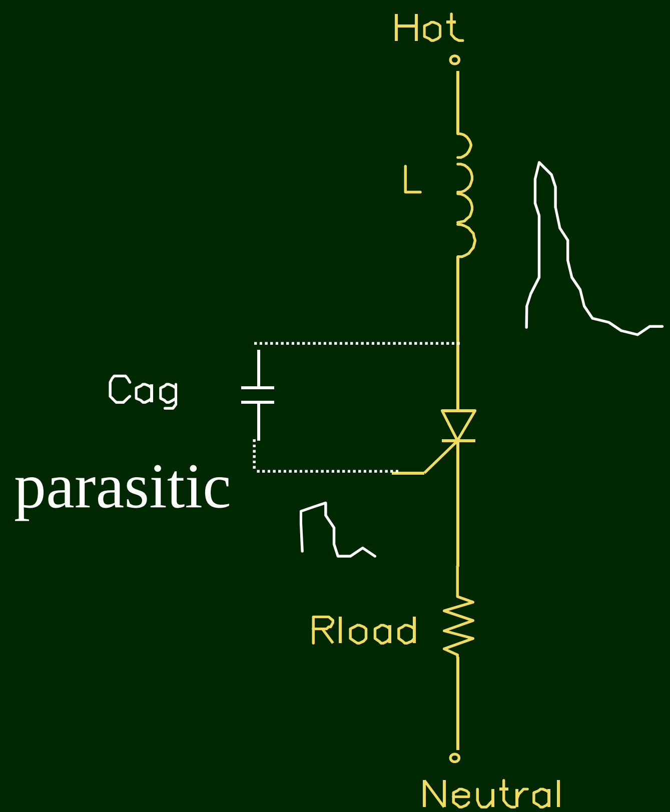
$$L = \frac{v_{line\ peak}}{\frac{di}{dt}_{SCR\,spec}}$$

If load is motor, separate L not needed.

Overview

- High side vs low side switch
- Critical Rate of Rise of Current
  - problem
  - SCR schematic solution
- Critical Rate of Rise of Voltage
- Triac

Critical Rate of Rise of Voltage



Parasitic $C_{anode - gate}$

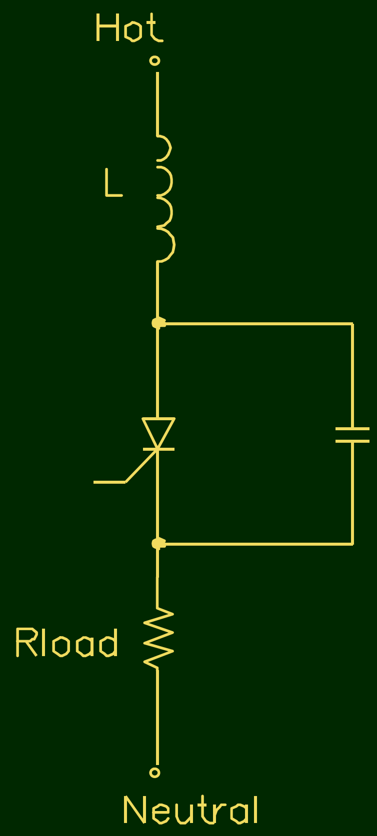
noise on anode coupled to gate

+ noise => + v_{gate} =>

SCR ON

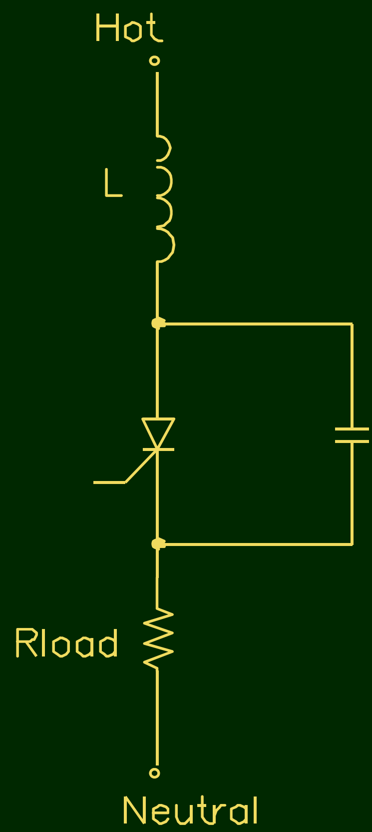
crane fatality

Critical Rate of Rise of Voltage - fix



Capacitors oppose Δv

Critical Rate of Rise of Voltage - fix

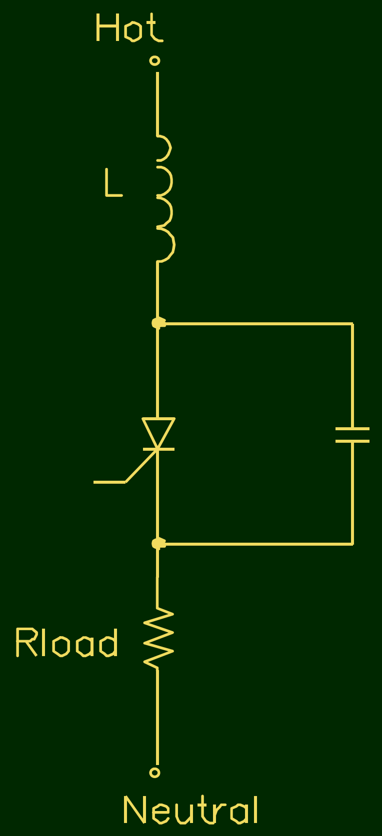


Capacitors oppose Δv

Ignoring L, given a ***step*** at V_{anode}

$$v_c = V_P\left(1 - e^{-\frac{t}{RC}}\right)$$

Critical Rate of Rise of Voltage - fix



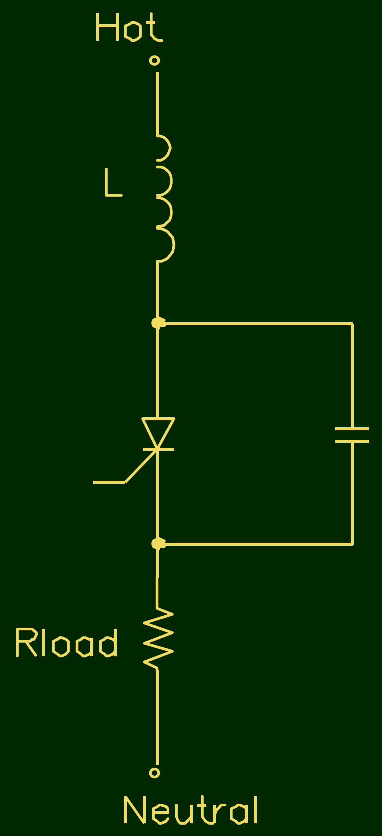
Capacitors oppose Δv

Ignoring L, given a ***step*** at V_{anode}

$$v_C = V_P\left(1 - e^{-\frac{t}{RC}}\right)$$

$$\frac{dv_C}{dt} = \frac{V_P}{RC}e^{-\frac{t}{RC}}$$

Critical Rate of Rise of Voltage - fix



Capacitors oppose Δv

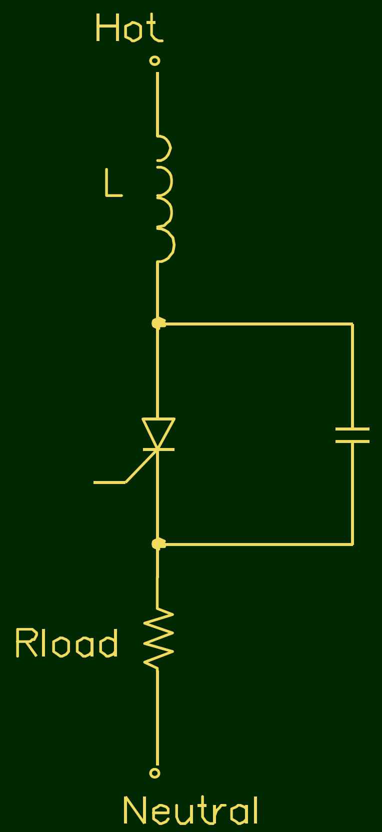
Ignoring L, given a ***step*** at V_{anode}

$$v_c = V_P\left(1 - e^{-\frac{t}{RC}}\right)$$

$$\frac{dv_c}{dt} = \frac{V_P}{RC} e^{-\frac{t}{RC}}$$

$$\left.\frac{dv_c}{dt}\right|_{worst} = \left.\frac{V_P}{RC}\right|_{t=0}$$

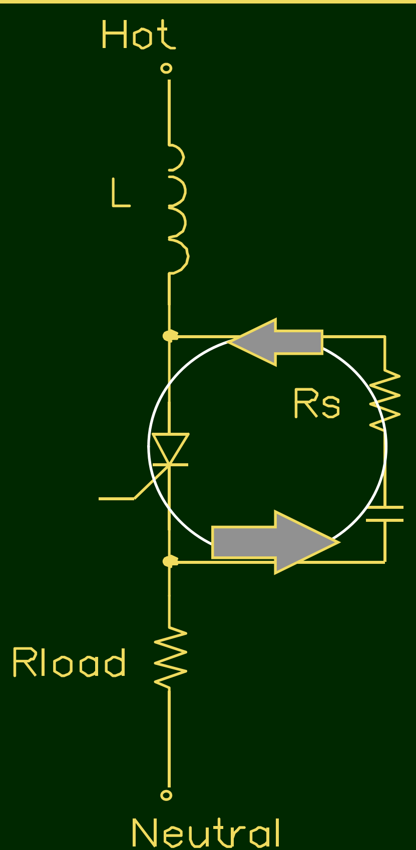
Critical Rate of Rise of Voltage - fix



$$\left.\frac{dv_c}{dt}\right|_{worst} = \left.\frac{V_P}{RC}\right|_{t=0}$$

$$C = \frac{V_{DRM}}{R_{load} \times \frac{dv}{dt}_{SCRspec}}$$

Cap *Discharge*



During charge, V_C may = $V_{line\ pk}$

When SCR fired

R_{SCR} 0.x Ω

C rapidly discharges through SCR

$I_{C\ discharge} \sim V_{line\ pk}/R_{SCR\ on}$

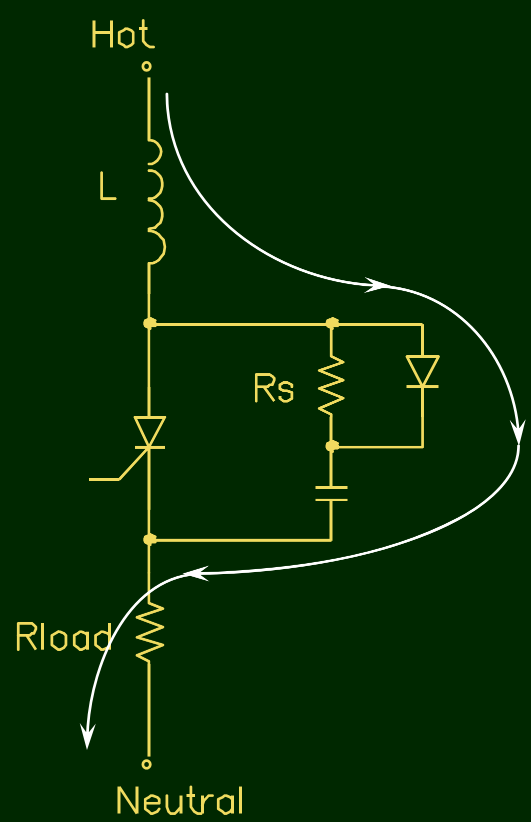
$= 160V / 0.2\Omega = 320A$!

$I_{SCR} = I_{load} + I_{C\ discharge}$

R_S limits $I_{SCR} < I_{TSM}$

$$R_s > \frac{V_{line\ pk}}{I_{TSM} - I_{load\ pk}} \approx \frac{10V_{line\ pk}}{I_{TSM} - I_{load\ pk}}$$

R_S bypass during charge



C must be directly across SCR during charge to short out spikes

R limits I during *discharge*

Bypass R with diode

$I_{diode\ pk} = V_{DRM} / X_C$

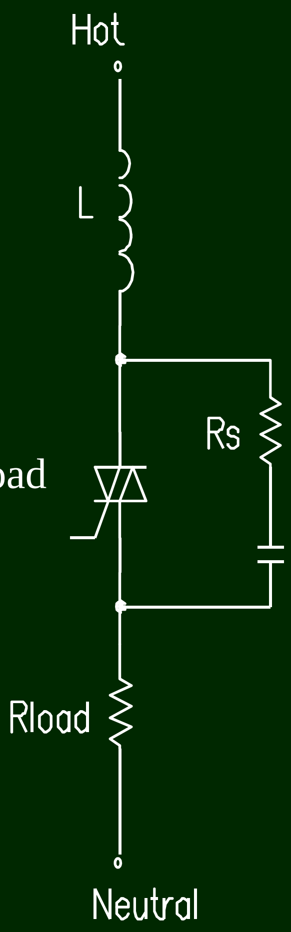
Overview

- High side vs low side switch
- Critical Rate of Rise of Current
  - problem
  - SCR schematic solution
- Critical Rate of Rise of Voltage
- Triac

Triac Snubbing

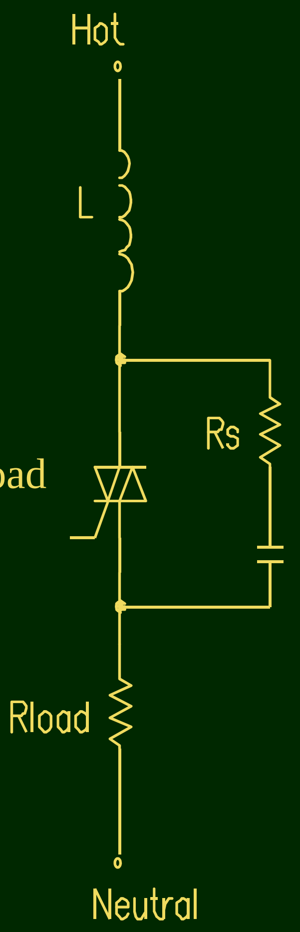
Use if

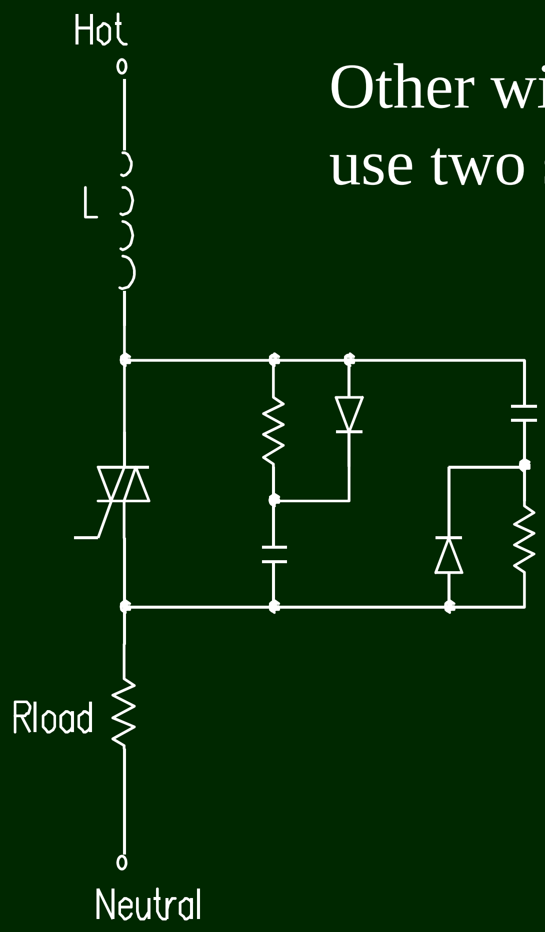
$R_S << R_{load}$



Triac Snubbing

Use if
$R_S << R_{load}$





Other wise
use two snubbers.