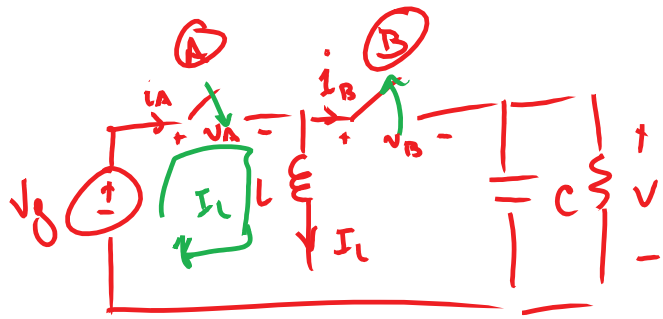


I: A on B off

II: A off B on

What voltages must it block when off
& what currents must it conduct when on

Switch

(A) $I_{on} = I_L = \frac{-V}{RD'} = V_g \frac{D}{RD'^2} \geq 0$

$V_{off} = V_g - V = V_g - \underbrace{\left(-\frac{D}{D'} V_g\right)}_{\text{Transistor}} = V_g\left(1 + \frac{D}{D'}\right) \geq 0$

Ideal Buck-Boost

$\frac{V}{V_g} = -\frac{D}{D'}$

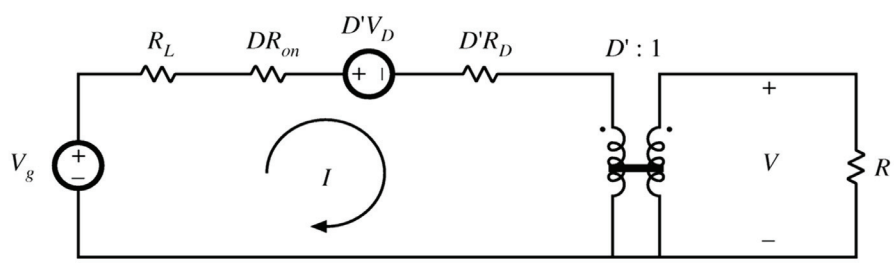
$I_L = -\frac{V}{RD'}$

(B) $I_{on} = -I_L$

$V_{off} = V_g - V$

} same thing → diode

Equivalent Circuit Model

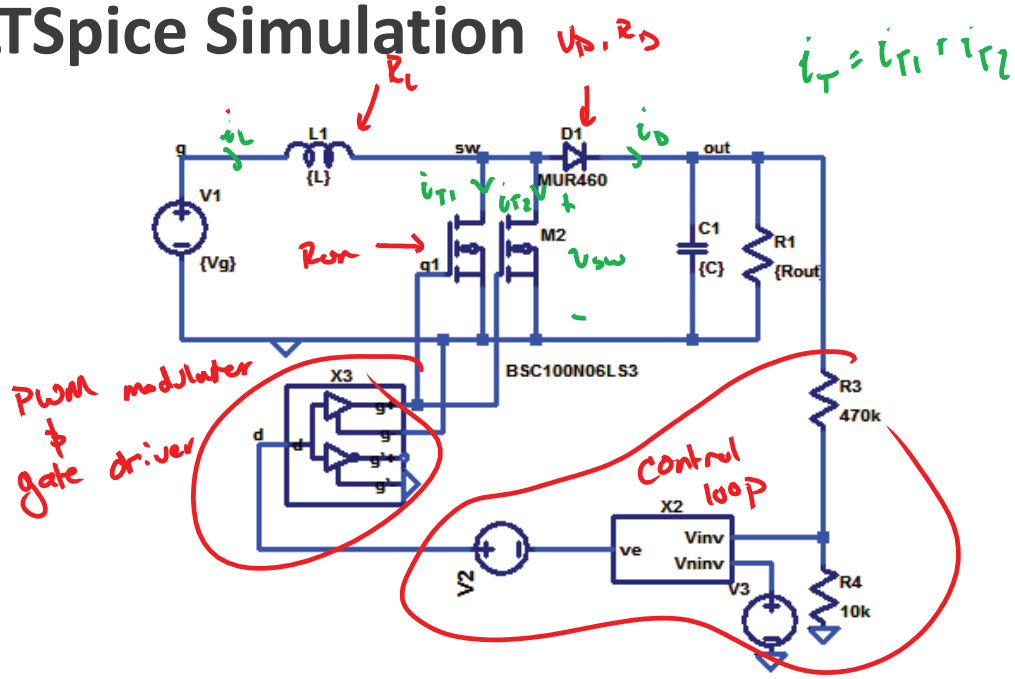


$D_{ideal} = 0.75$

$$V = \left(\frac{1}{D'}\right)\left(V_g - D'V_D\right)\left(\frac{D'^2R}{D'^2R + R_L + DR_{on} + D'R_D}\right) \rightarrow D = 0.786$$

$$M = \frac{V}{V_g} = \underbrace{\left(\frac{1}{D'}\right)}_{M_{ideal}}\underbrace{\left(1 - \frac{D'V_D}{V_g}\right)\left(\frac{1}{1 + \frac{R_L + DR_{on} + D'R_D}{D'^2R}}\right)}_{\eta} \rightarrow \eta = 97.6\%$$

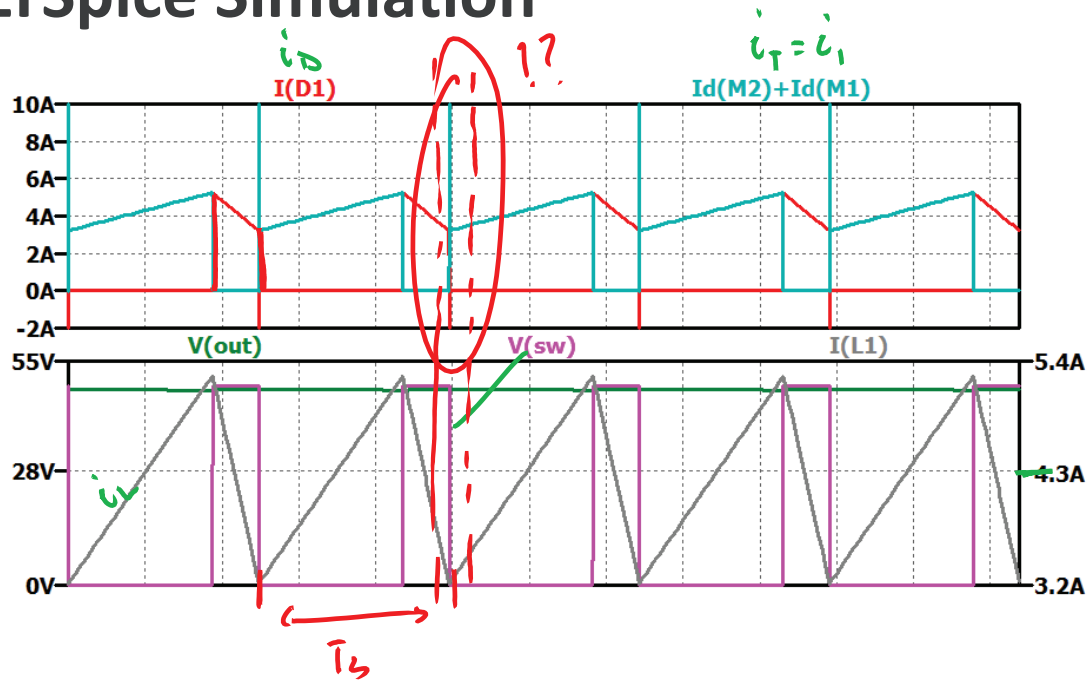
LTSpice Simulation



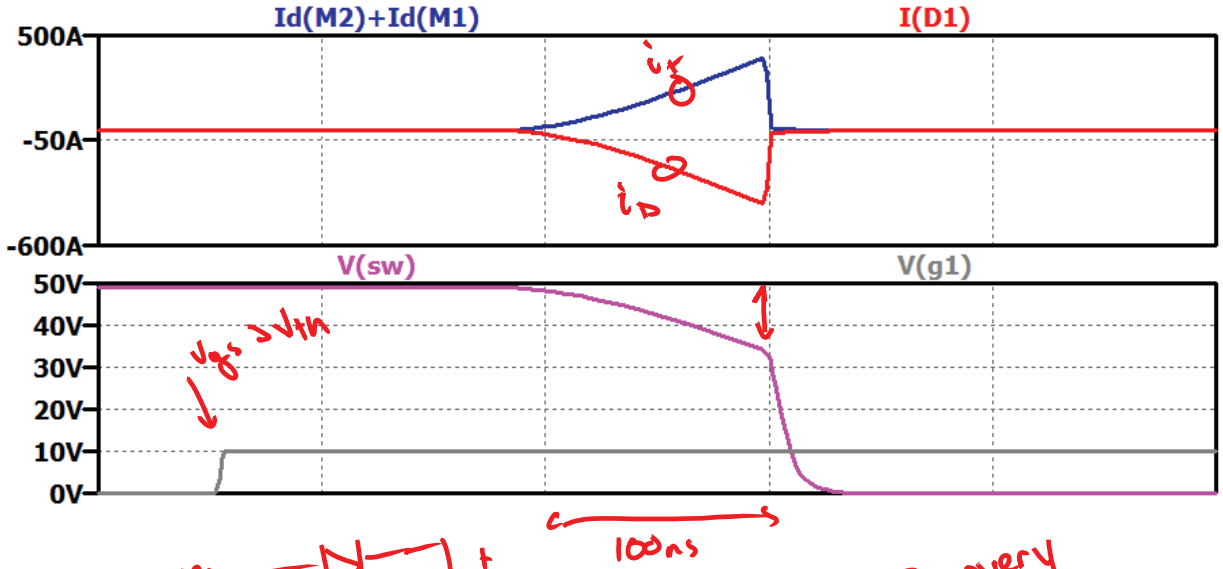
L	C_{out}	f_s	η (Sim)
22uH	22uF	200k	93.9%

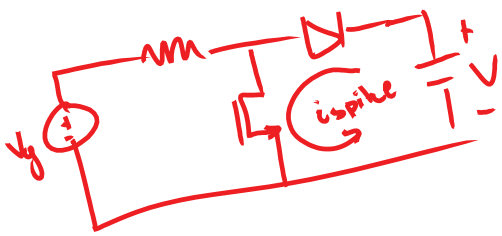
P_{loss} is 3x expected !!

LTSpice Simulation



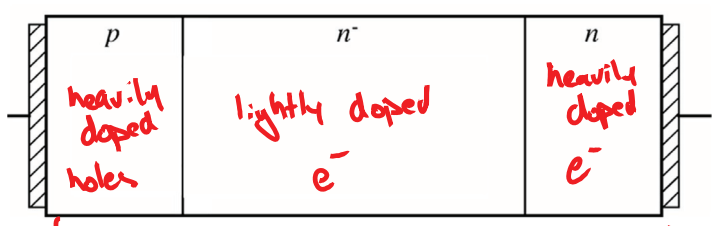
Switching Transition

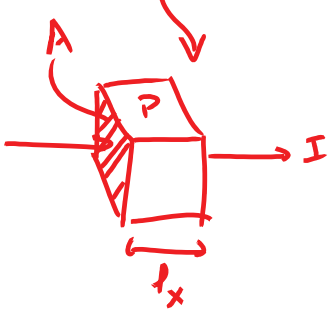




Reverse Recovery of the diode

Power Diodes





$$R = \rho \frac{l_x}{A} = \frac{1}{\mu_n n q + \mu_p p q} \frac{l_x}{A}$$

resistivity

permitivity

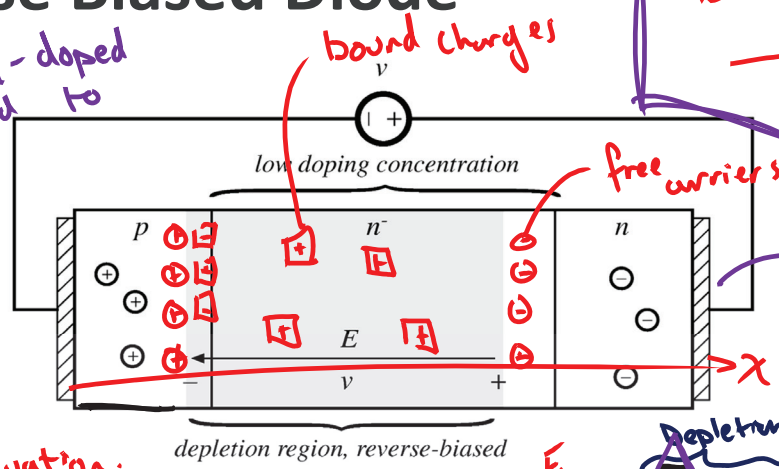
carrier concentration

→ To get low R

Design with high doping density & short length & large A

Reverse Biased Diode

Large, lightly-doped n^- region used to obtain voltage blocking capability



looks like

$C_D = f(l_{dep})$

$W_{dep} \propto \frac{1}{\text{carrier conc.}}$

Poisson's Equation:

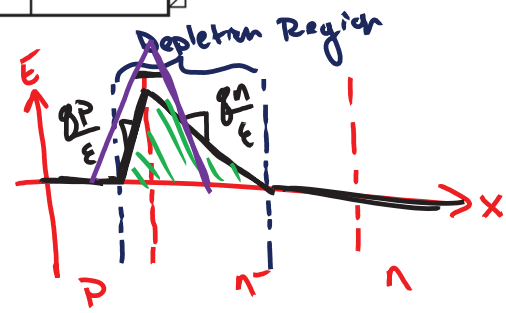
$$\nabla^2 \varphi = \frac{\rho_f}{\varepsilon}$$

Laplace operator

electric potential (or p)

charge density

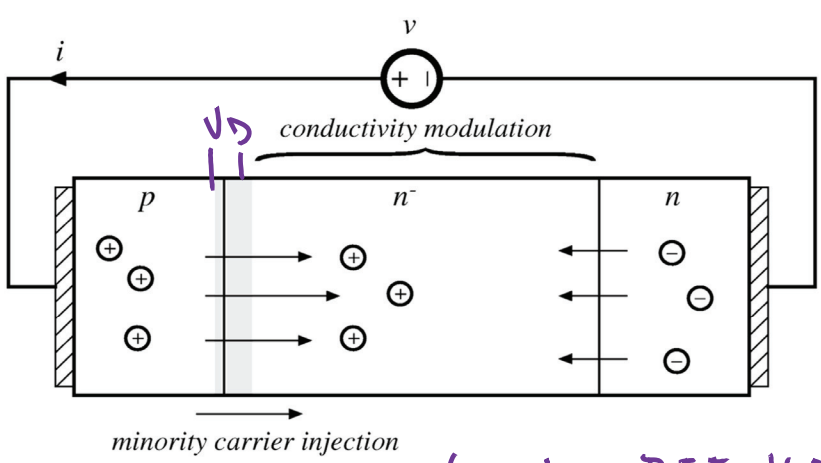
permeability



$$\frac{\partial^2 V}{\partial x^2} = \frac{q n}{\varepsilon} \rightarrow E = \frac{\partial V}{\partial x} = \int_0^x \frac{q n}{\varepsilon}$$

$V \propto \int E$

Forward Biased Diode



Minority Carrier Device: (Diodes, BJT, IGBT, ..)

+ conductivity modulation → minority carriers injected
↑ carriers at ↑ current

− stored minority charge that must be removed to turn the device off.