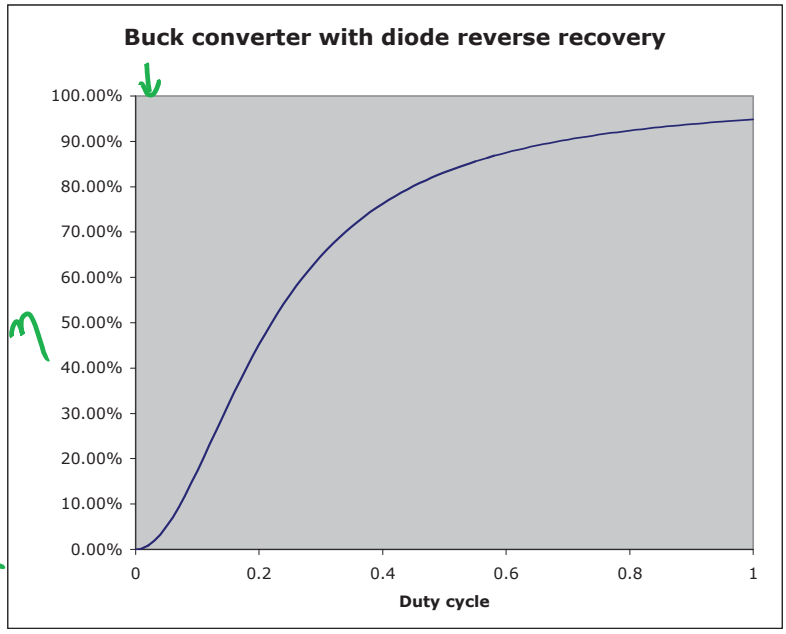
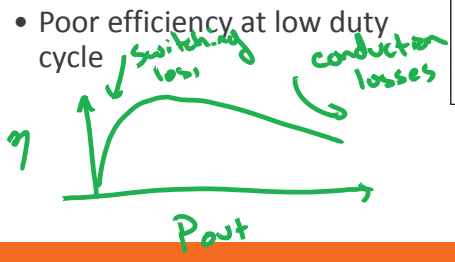
Predicted Efficiency vs Duty Cycle

- Switching frequency 100 kHz
- Input voltage 24 V
- Load resistance 15 Ω
- Recovered charge 0.75 μCoul
- Reverse recovery time 75 nsec

- (no attempt is made here to model how the reverse recovery process varies with inductor current)

- Substantial degradation of efficiency
- Poor efficiency at low duty cycle





Paralleling Diodes

Attempts to parallel diodes, and share the current so that $i_1 = i_2 = i/2$, generally don't work.

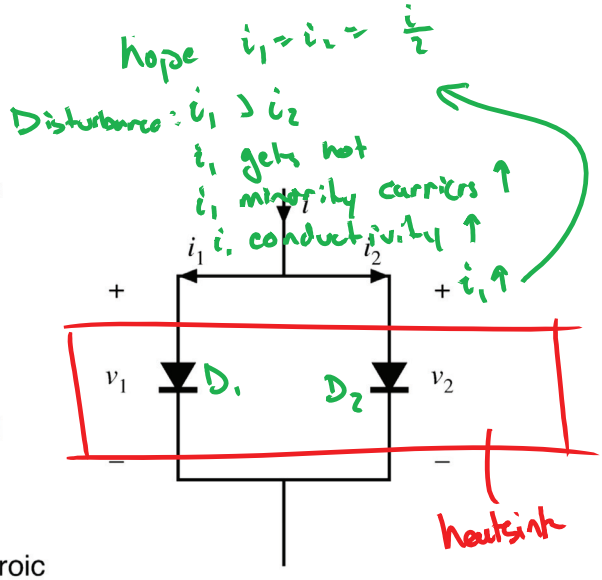
Reason: thermal instability caused by temperature dependence of the diode equation.

Increased temperature leads to increased current, or reduced voltage.

One diode will hog the current.

To get the diodes to share the current, heroic measures are required:

- Select matched devices
- Package on common thermal substrate
- Build external circuitry that forces the currents to balance



Types of Power Diodes

Potential.eecs.utk.edu

$P_{RR} = E_{RR} f_s$

p-n diodes

Standard recovery

- Reverse recovery time not specified, intended for 50/60Hz

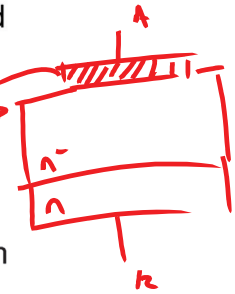
Fast recovery and ultra-fast recovery

- Reverse recovery time and recovered charge specified
- Intended for converter applications

Schottky diode

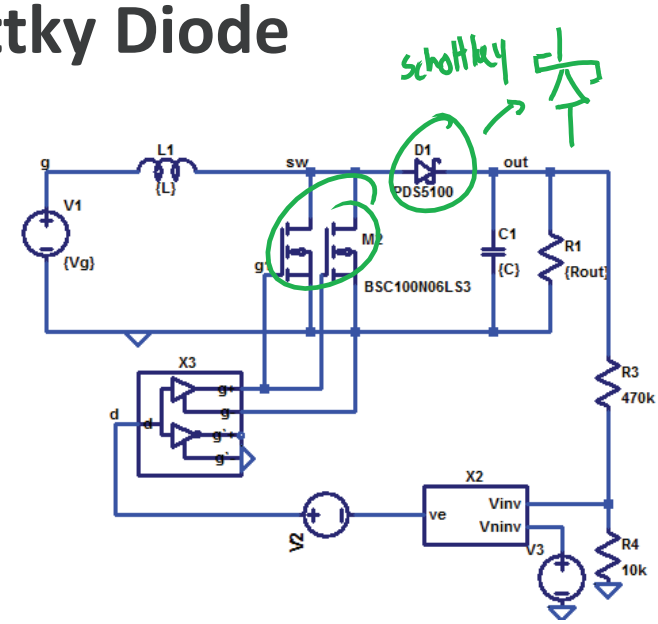
- A majority carrier device — × no conductivity modulation
- Essentially no recovered charge
- Model with equilibrium *i-v* characteristic, in parallel with depletion region capacitance
- Restricted to low voltage (few devices can block 100V or more)

metal
m-s junction



Using WBG (SiC) → 1,200V + Schottky diodes

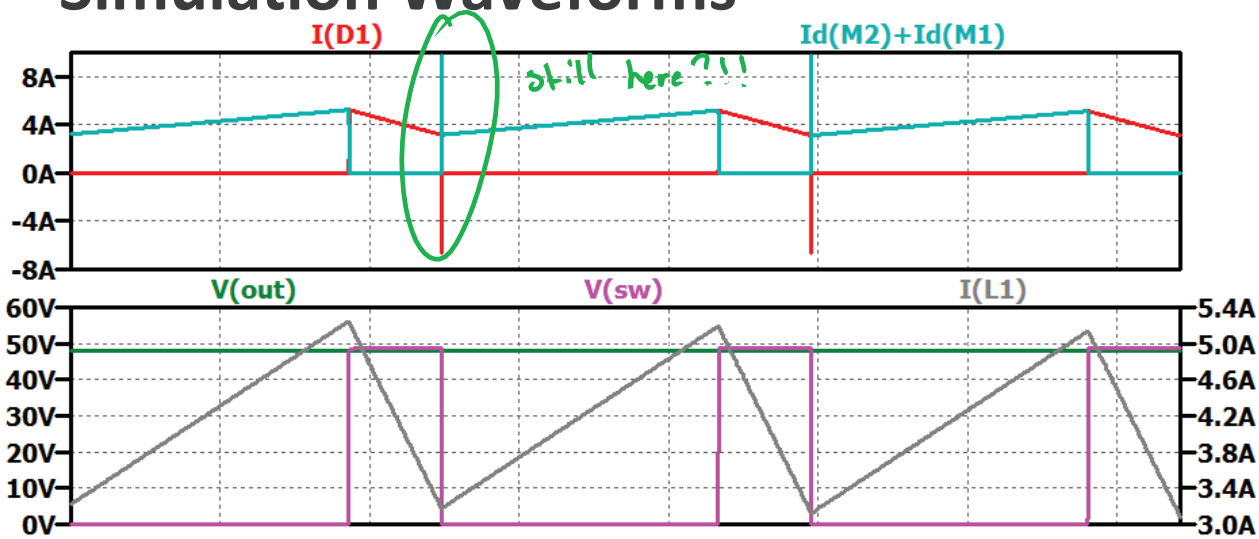
Schottky Diode



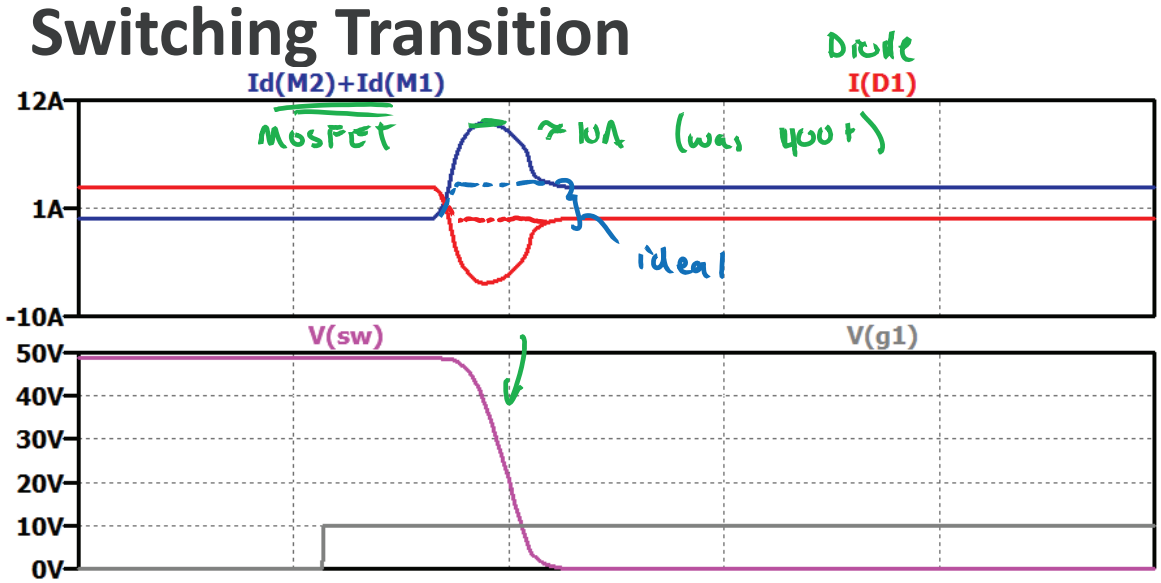
$\eta_{pred} = 97.6\%$

L	C_{out}	f_s	Diode	η (Sim)
22uH	22uF	200k	Si (FR)	93.9%
22uH	22uF	200k	Si Schottky	96.9%

Simulation Waveforms

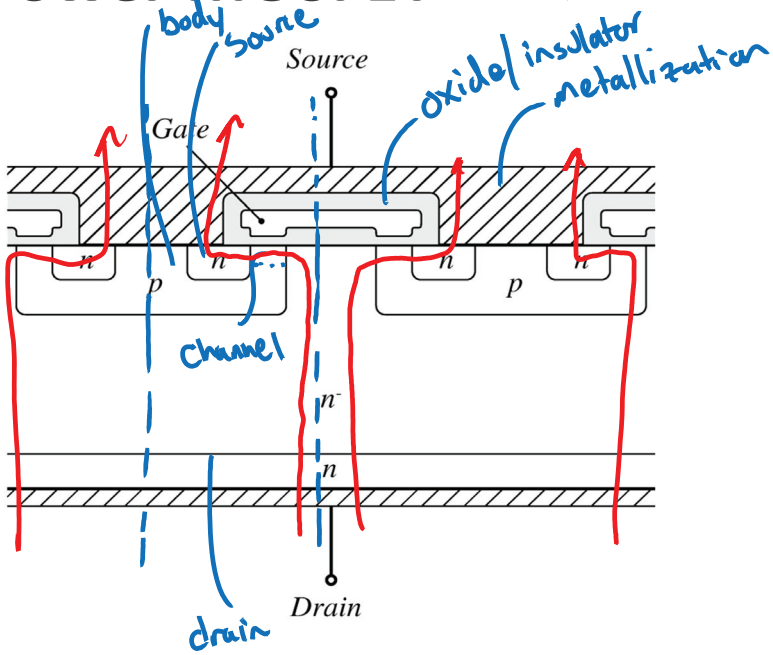


Switching Transition

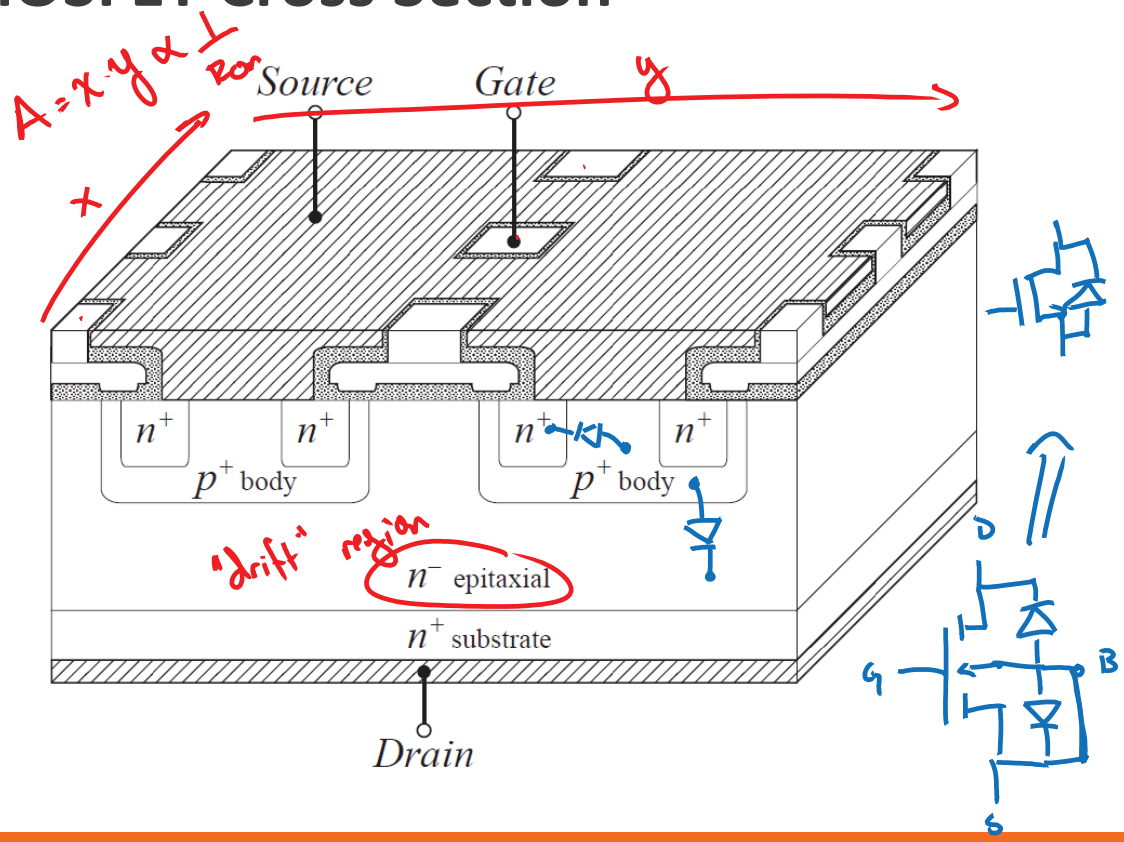


Power MOSFET

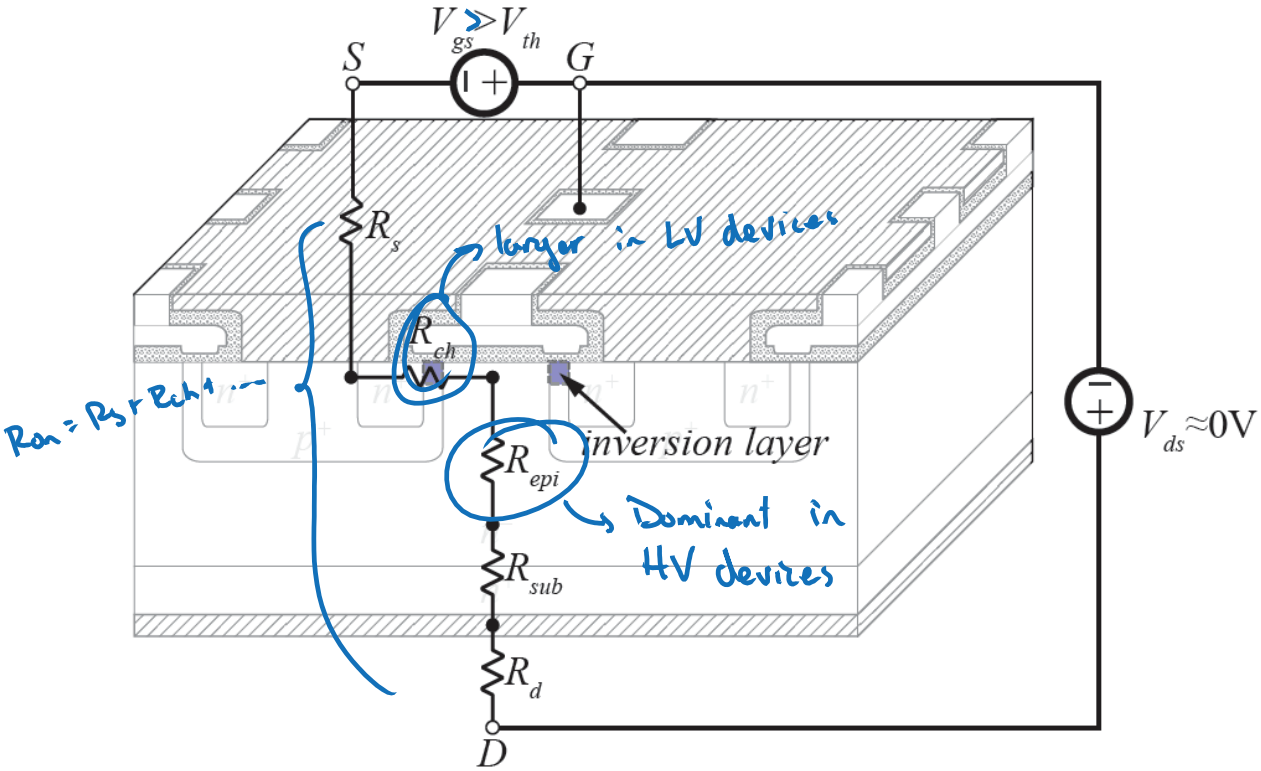
VDMOS → Vertical conduction



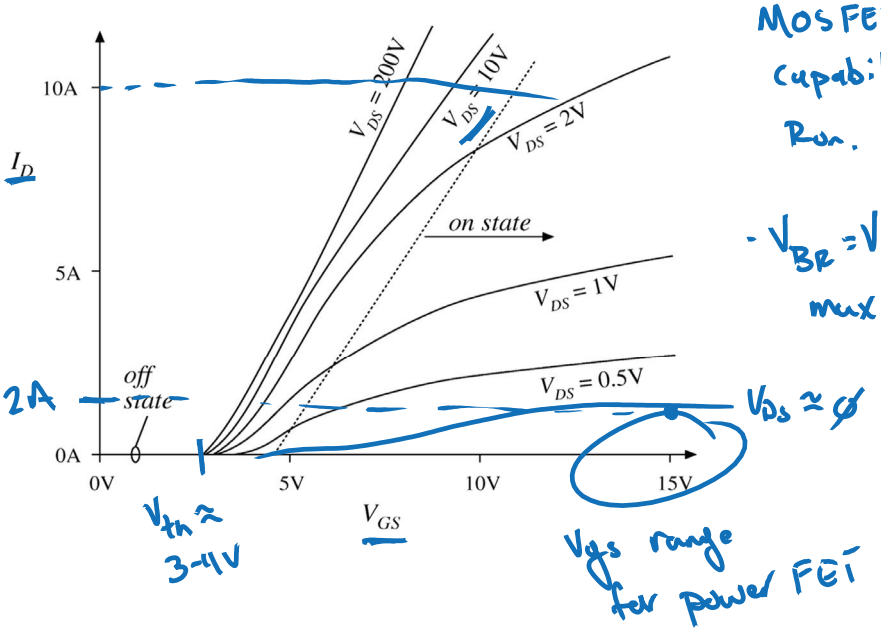
MOSFET Cross Section



Power MOSFET in Ohmic Region



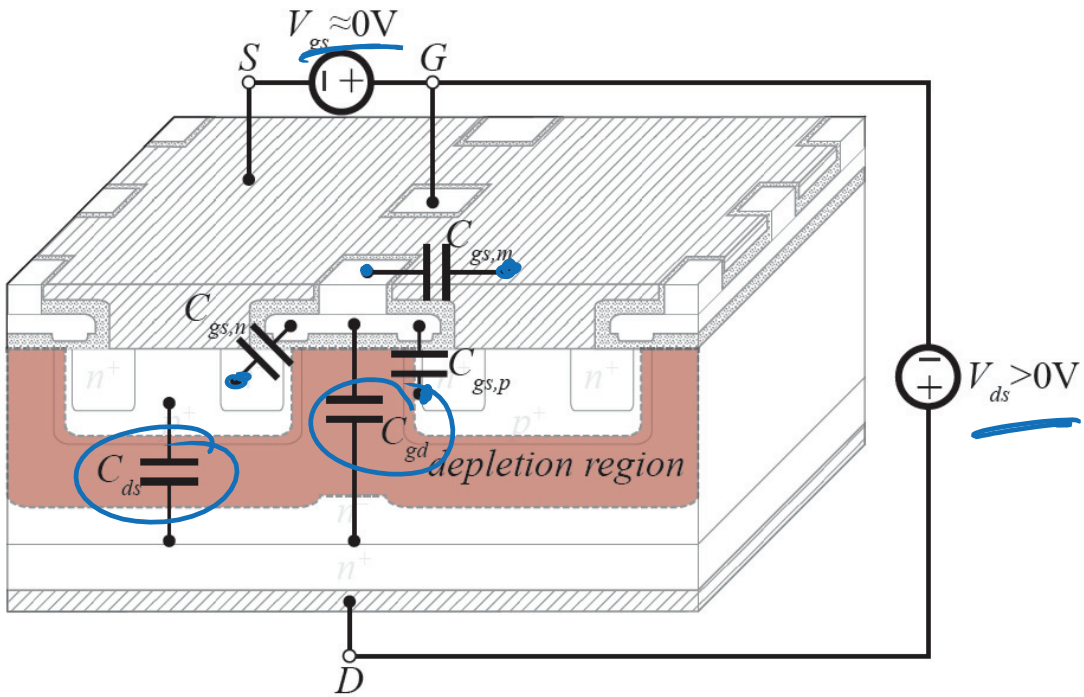
MOSFET Static Characteristics



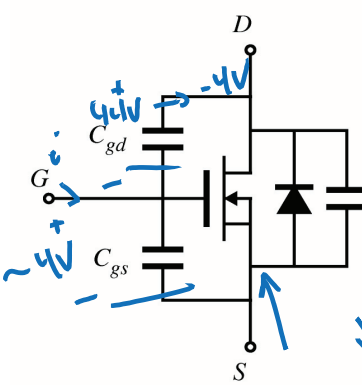
MOSFET's conduction capability assesed by Ron. not Imax

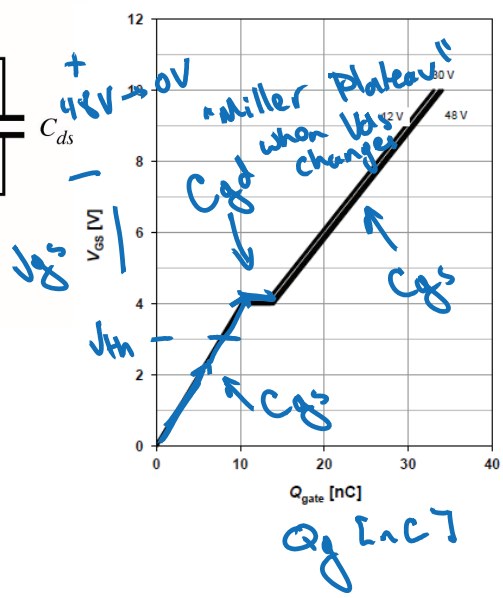
- $V_{BR} = V_{DSmax}$ is absolute maximum

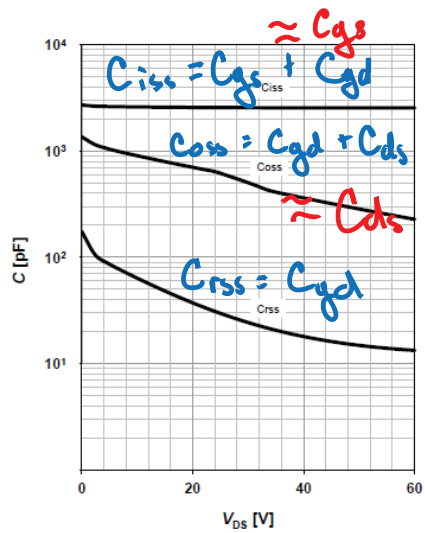
MOSFET in Cutoff Region



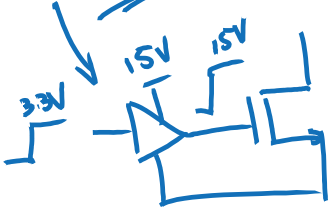
MOSFET Equivalent Circuit







gate driver



Nonlinear - C
& more advance Psi
ECE 581