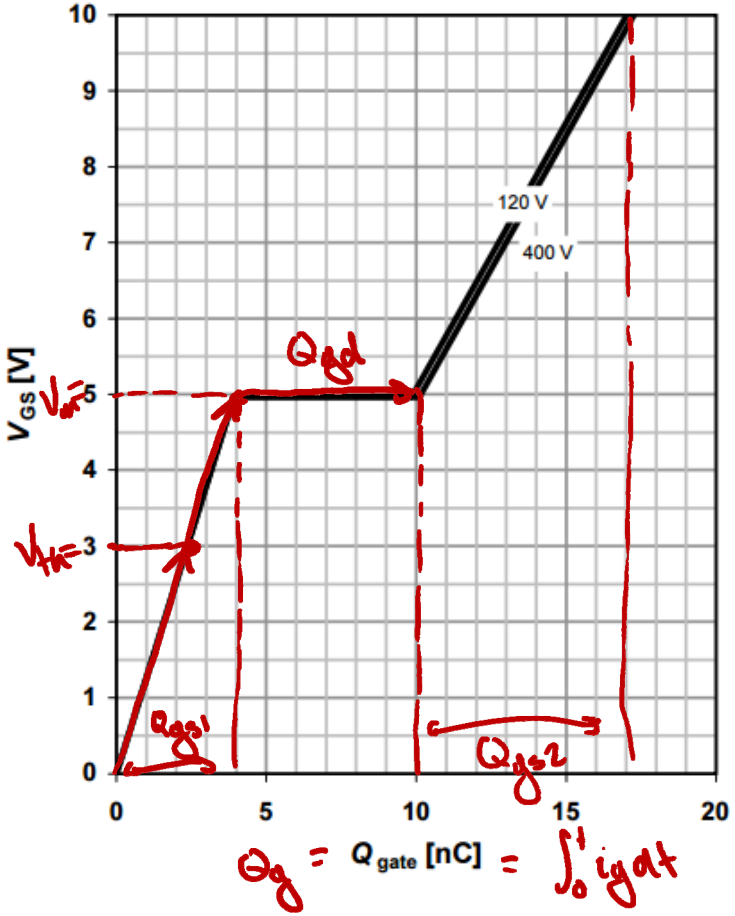
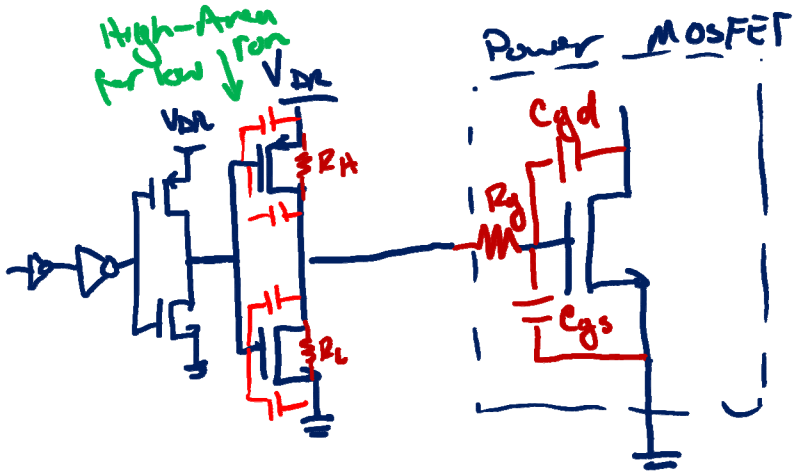
Gate Charge

9 Typ. gate charge

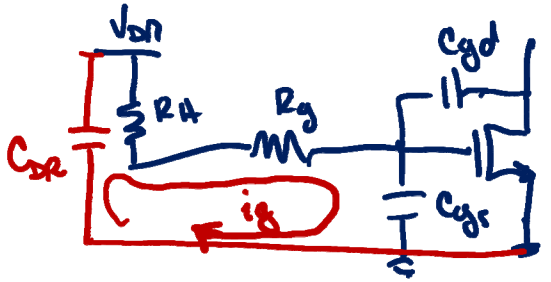
V_{GS}=f(Q_{gate}); I_D=5.2 A pulsed

parameter: V_{DD}





Turn-ON



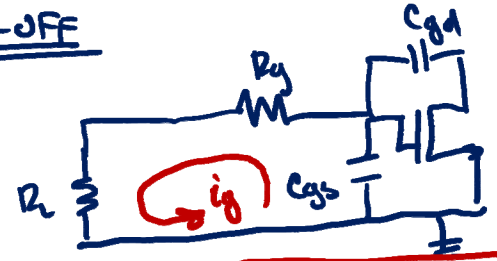
$$E_{DR,on} = \int_{on} V_{DR} \cdot i_g \, dt$$

$$= V_{DR} \int i_g \, dt$$

$$= V_{DR} Q_g$$

$$\simeq \frac{1}{2} C_{gs} V_{gs}^2 \text{ still in } C_{gs}$$

Turn-OFF



all of the energy lost

$$P_g = Q_g V_{DR} f_s$$ → From GD supply

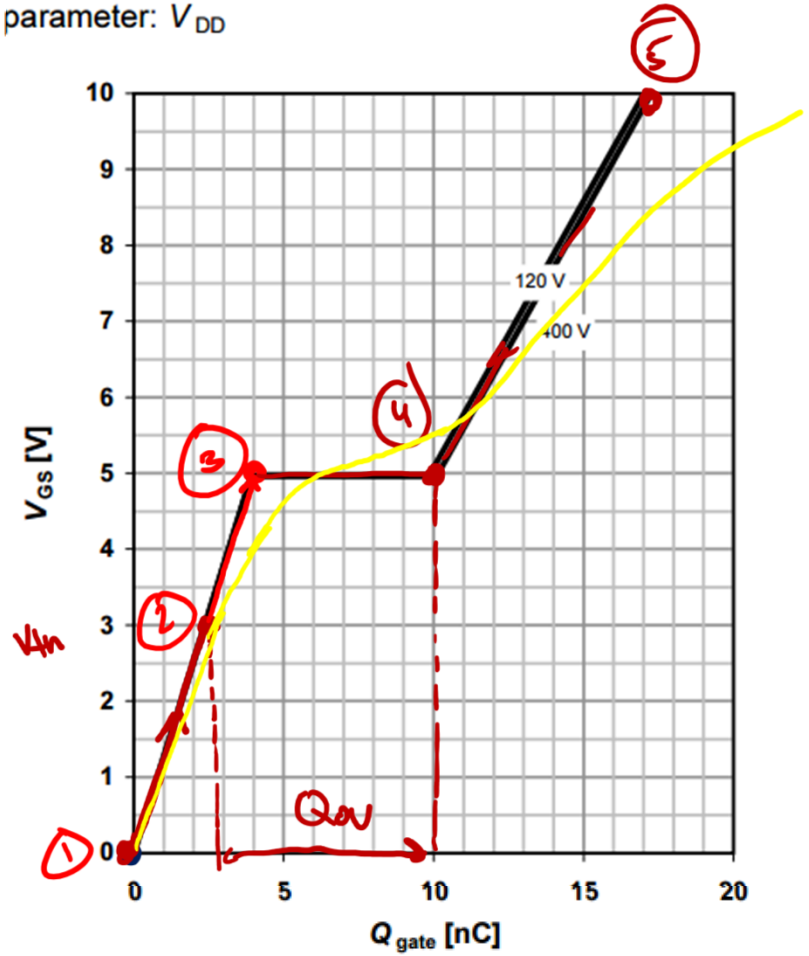
Overlap Time

Gate threshold voltage	$V_{GS(th)}$	$V_{DS}=V_{GS}$, $I_D=0.34$ mA	2.5	3	3.5	
Gate resistance	R_G	$f=1$ MHz, open drain	-	1.8	-	Ω

9 Typ. gate charge

$V_{GS}=f(Q_{gate})$; $I_D=5.2$ A pulsed

parameter: V_{DD}



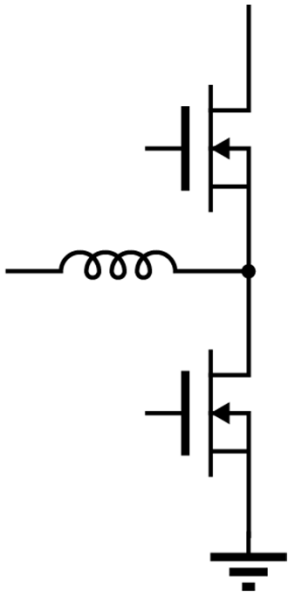
Assume gate driver supplies a constant current Ig

$$Q_g = \int_0^t i_g(t)\,dt = I_g t$$

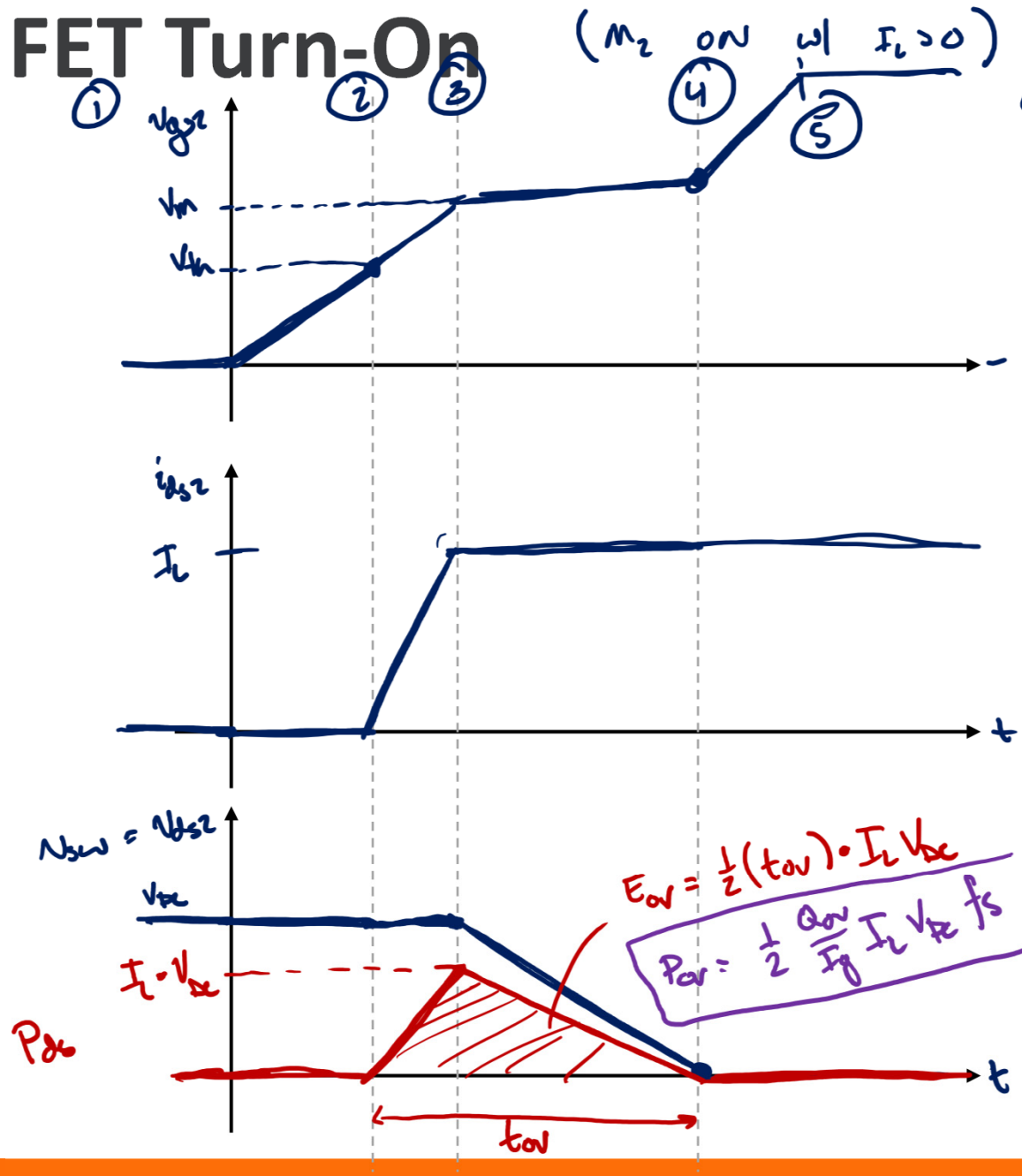
$$t_{ov} = \frac{Q_{ov}}{I_g}$$

for most of tov

$$I_g \simeq \frac{V_{DR} - V_m}{R_g + R_H}$$



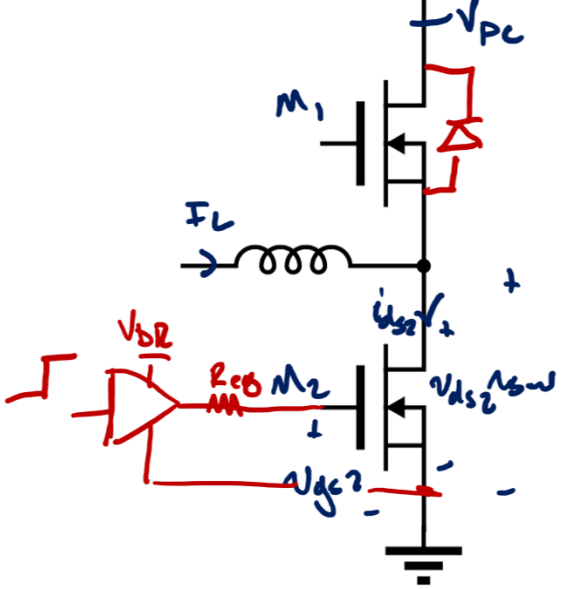
FET Turn-On

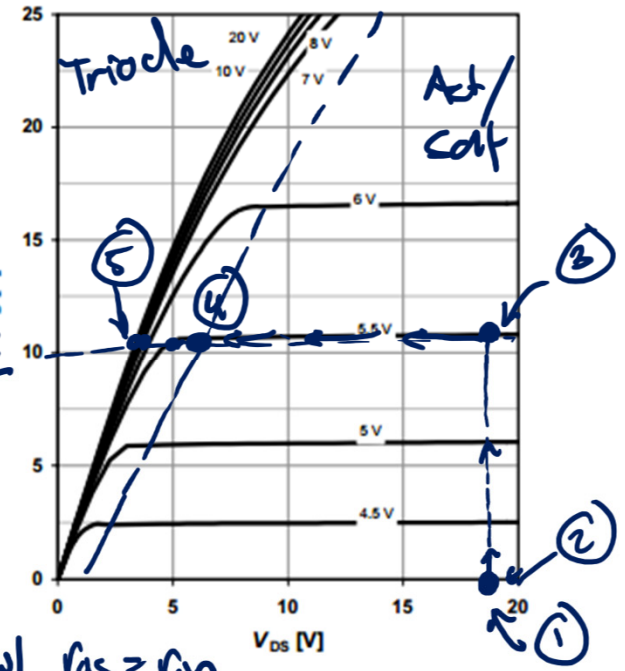


$$E_{ov} = \frac{1}{2}(t_{ov}) \cdot I_L V_{bc}$$

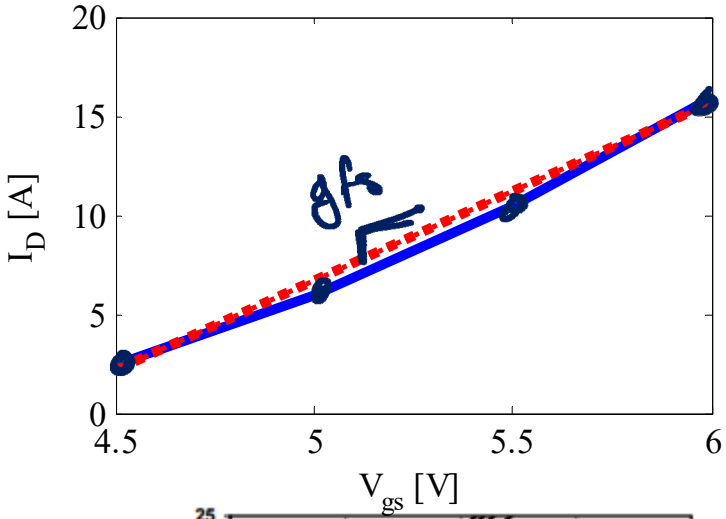
$$P_{ov} = \frac{1}{2}\frac{Q_{ov}}{I_g} I_L V_{bc} f_s$$

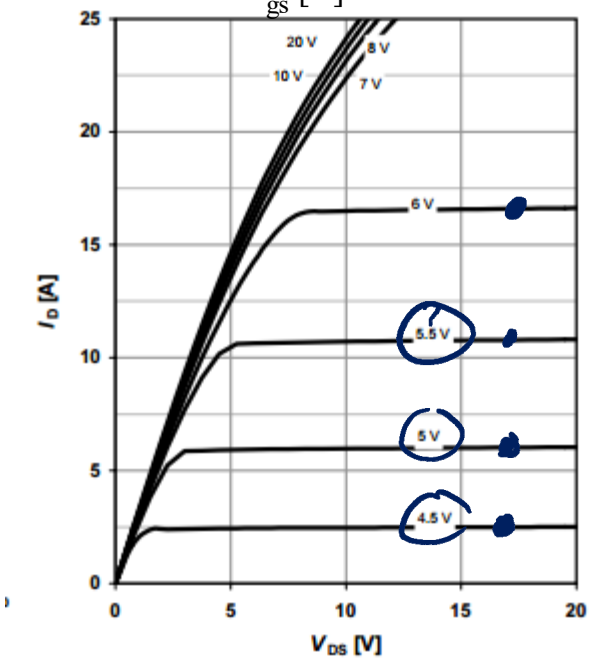
1. Device in cutoff
   - Gate drive begins supplying I_g
2. $v_{gs} \rightarrow V_{th}$
   - Device comes out of cutoff into Act/Sat
3. $v_{gs} = V_m = V_{th} + g_{fs} I_L$
   - Diode off
   - v_{ds} drops & $\frac{dV_{gd}}{dt}$ takes all I_g into C_{gd}
4. Device enters triode
5. Device on w/ $r_{as} > r_{sn}$



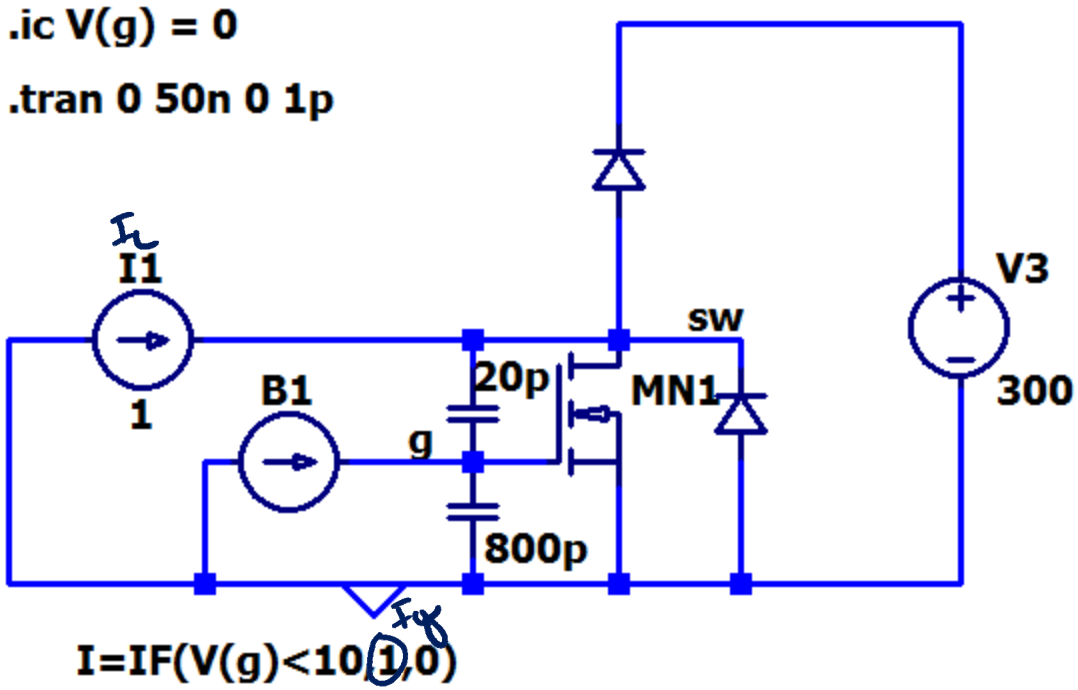


Device Transconductance

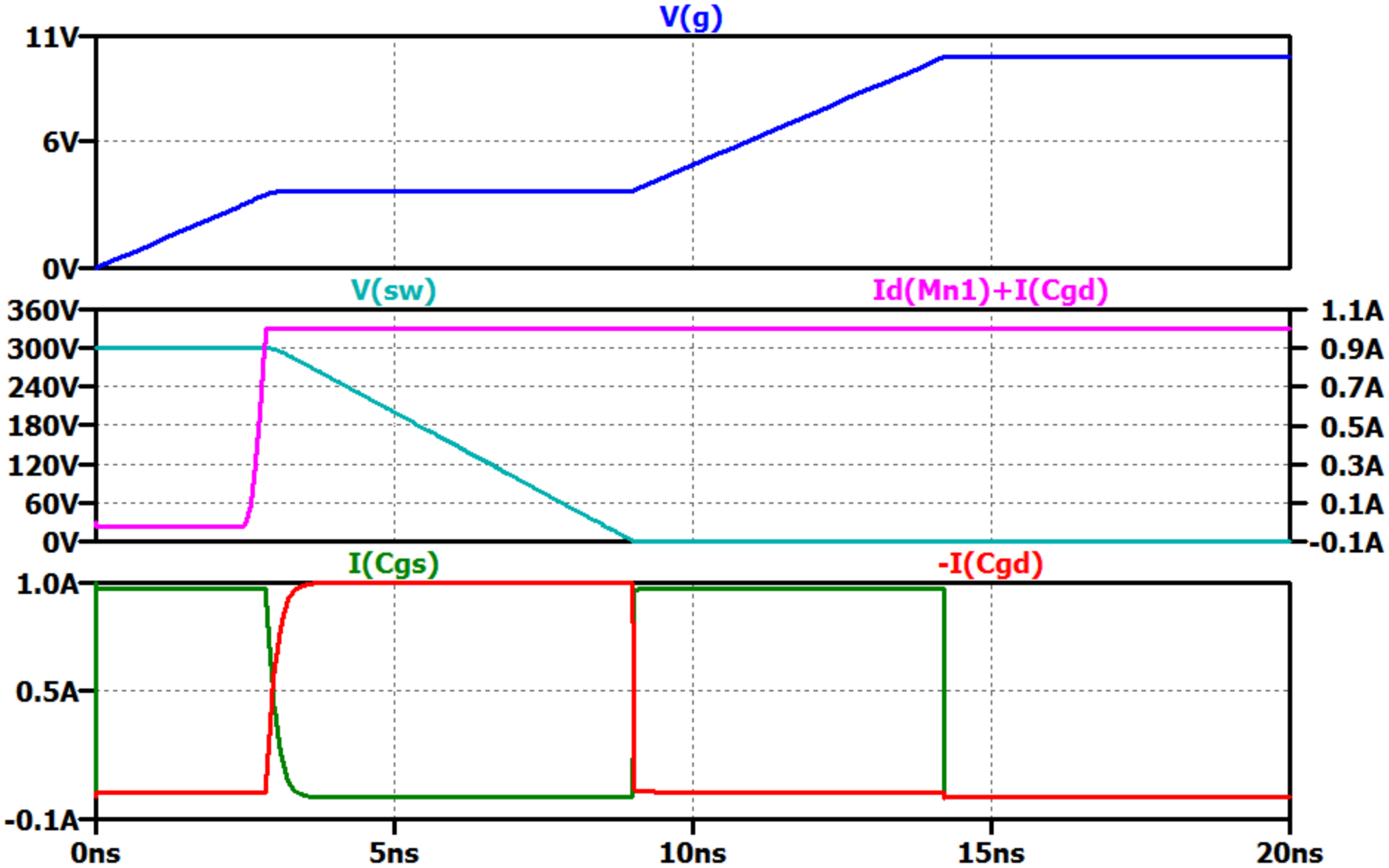




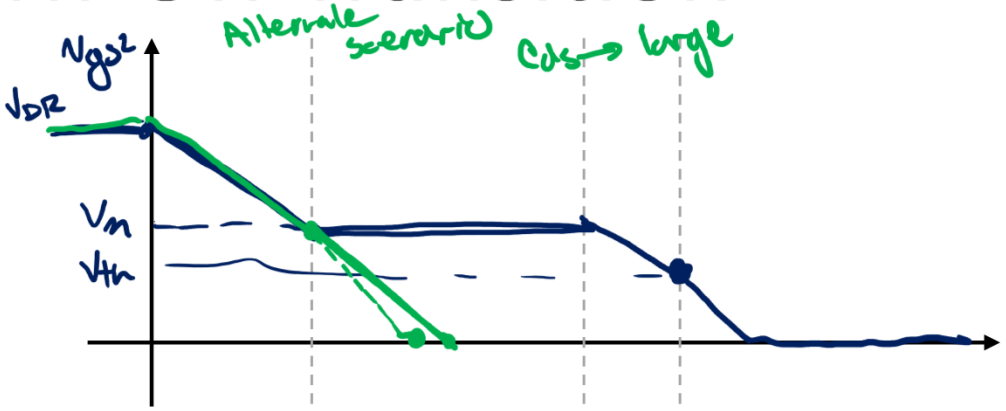
Example Simulation

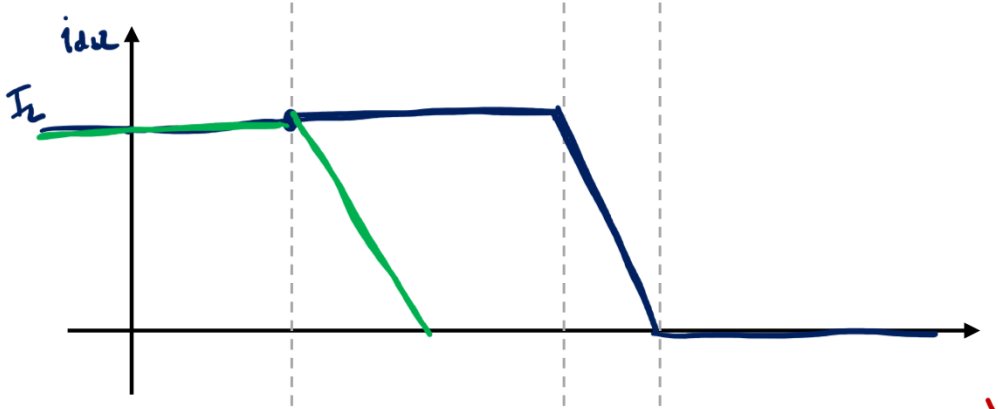


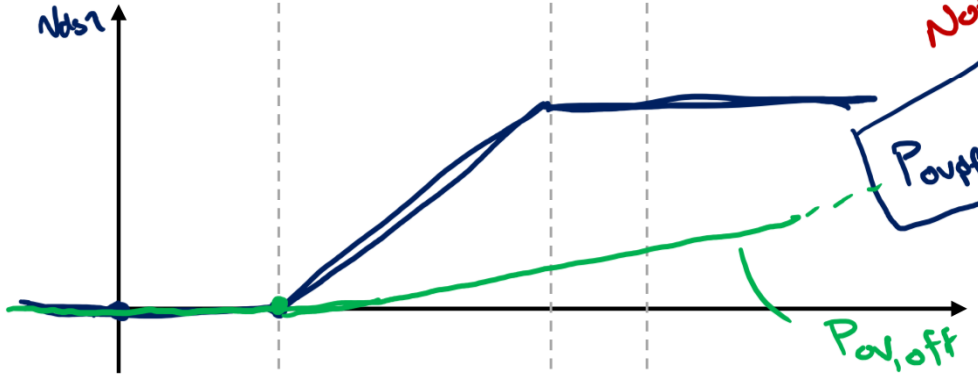
Simulation Waveforms – Turn On



Turn-Off Transition



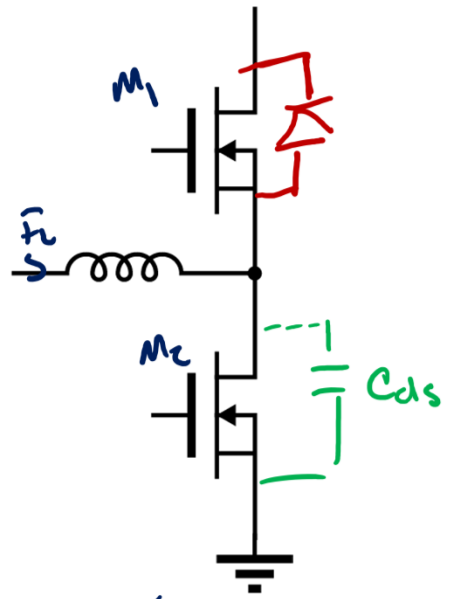


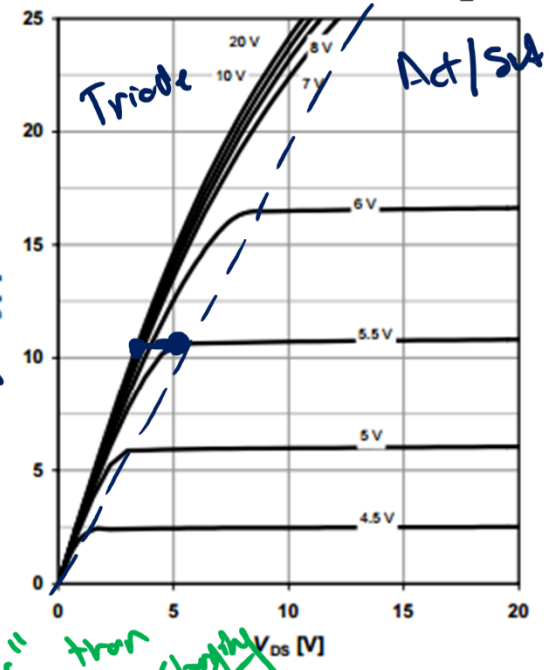


Not necessary

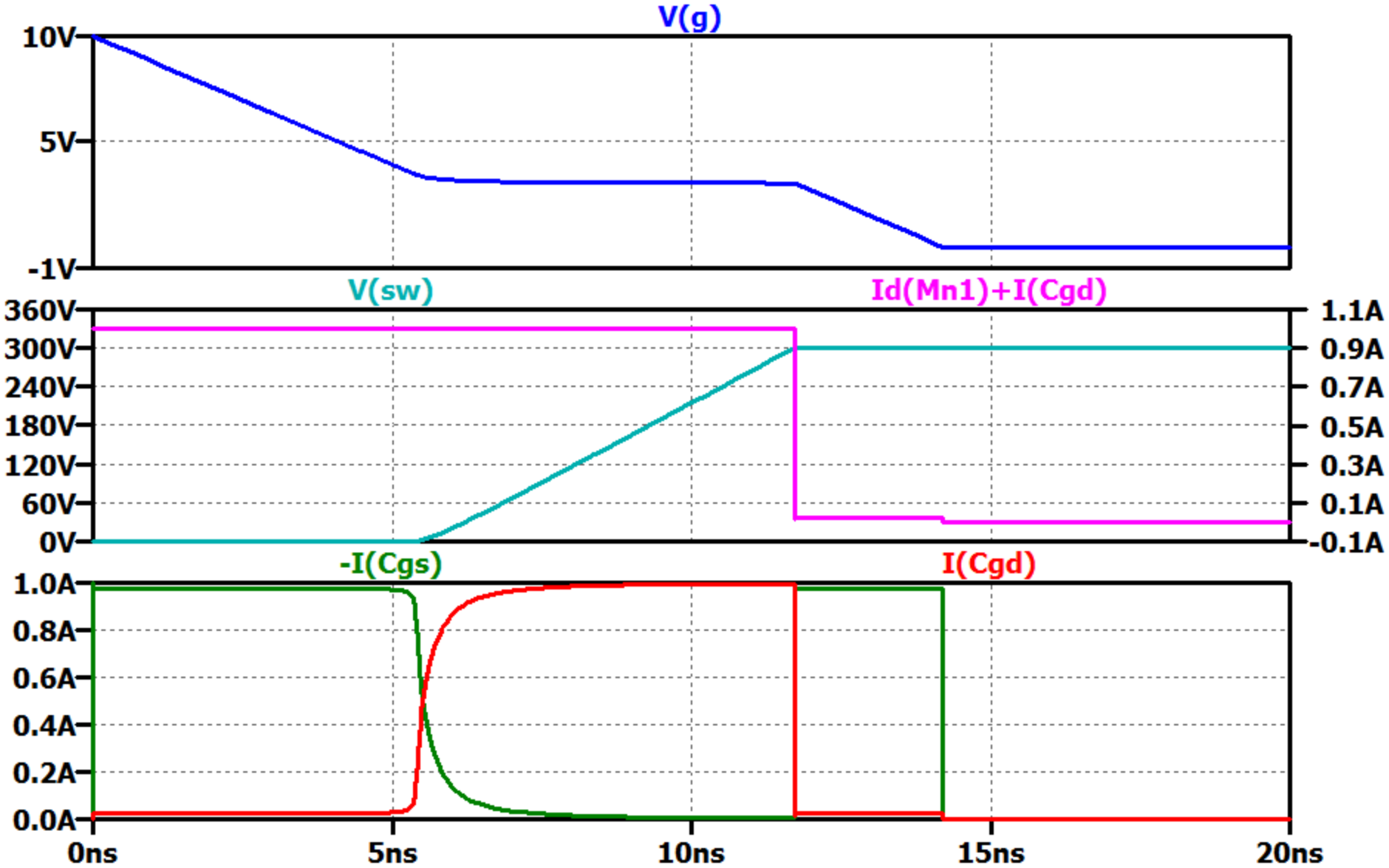
$$P_{ovoff} = \frac{1}{2}\frac{Q_{ov}}{I_g} V_{DD} I_L f_s$$

$P_{ov,off} \ll \frac{1}{2}\frac{Q_{ov}}{I_g} V_{DD} I_L f_s$ if gate driver "faster" than C_{ds} charging





Turn-Off


V(g)
10V
5V
-1V
V(sw)
Id(Mn1)+I(Cgd)
360V
300V
240V
180V
120V
60V
0V
1.1A
0.9A
0.7A
0.5A
0.3A
0.1A
-0.1A
-I(Cgs)
I(Cgd)
1.0A
0.8A
0.6A
0.4A
0.2A
0.0A
0ns
5ns
10ns
15ns
20ns

Turn-Off (Drain Dominated)