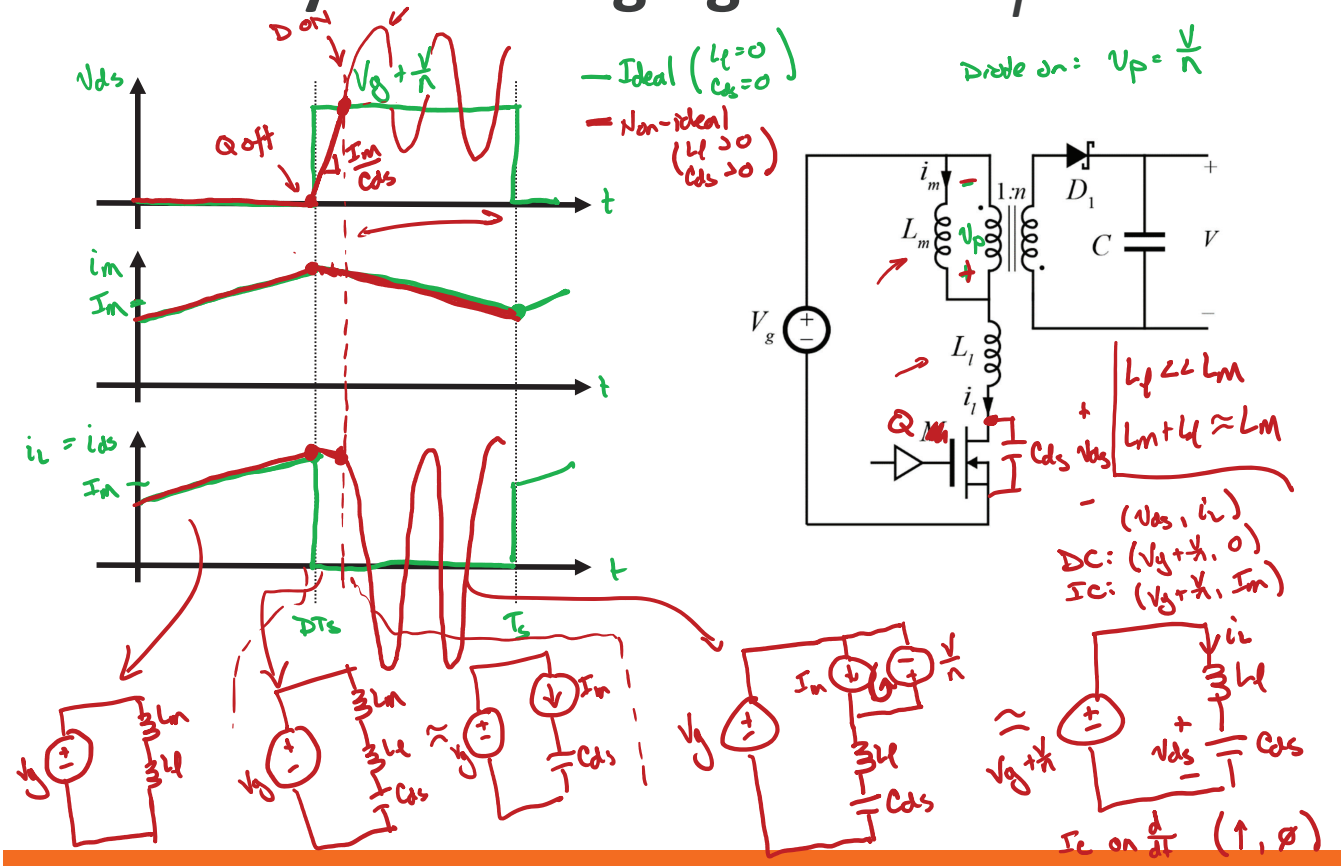
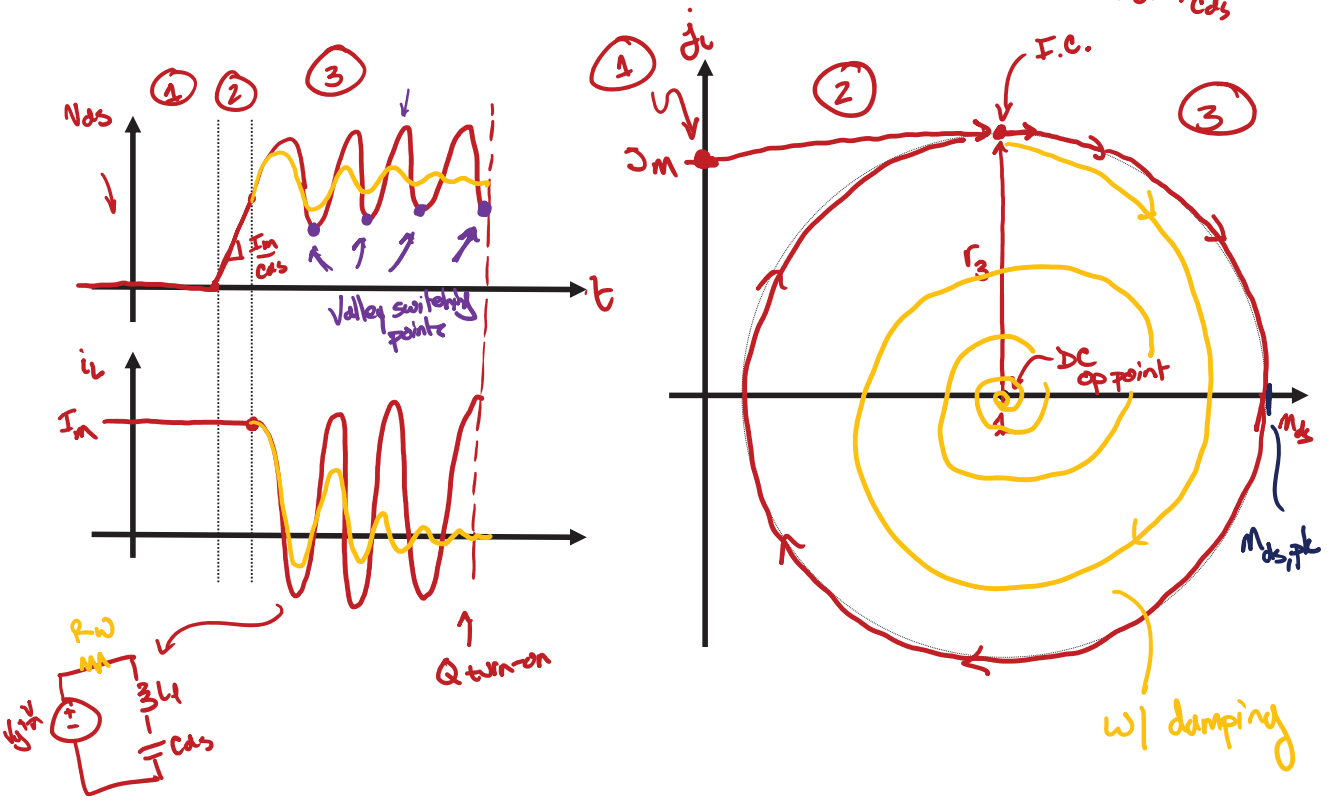
CCM Flyback: Ringing Due to L_l



MOSFET Turn-off

$V_{base} = V_g + \frac{V}{n}$, $I_{base} = \frac{V_{base}}{R_0}$

$R_0 = \sqrt{\frac{L_l}{C_{ds}}}$



Leakage Voltage Stress

$M_{dsp} = 1 + r_3 = 1 + J_m$

$$V_{ds,pk} = V_g + \frac{V}{n} + I_m R_o$$

$J_m = \frac{I_m}{V_g + V_h} R_o$

example design:

$V_g = 400\,V$

$V = 10\,V$

$P = 100\,W$

$f_s = 1\,MHz$

$n = \frac{1}{40}$, $D = 0.5$

$C_{ds} = 100\,pF$

$L_m = 1.6\,mH$

$L_\ell = 35\,\mu H$ (2% of L_m)

$R_o = \sqrt{\frac{L_\ell}{C_{ds}}} = 600\,\Omega$

$I_m = \frac{nI_{out}}{D'} = 500\,mA$

$V_{base} = V_g + \frac{V}{n} = 800\,V$

$V_{ds,pk} = 800V + (0.5A)(600\Omega)$

$= 1.1\,kV$!

Leakage Switching Loss

For the fully damped case (i.e. ringing dies out before Q turns on)

From state plane:

$$E_{start} = \frac{1}{2} C_{ds} \left(V_g + \frac{V}{n}\right)^2 + \frac{1}{2} L_\ell I_m^2$$

$$E_{end} = \frac{1}{2} C_{ds} \left(V_g + \frac{V}{n}\right)^2$$

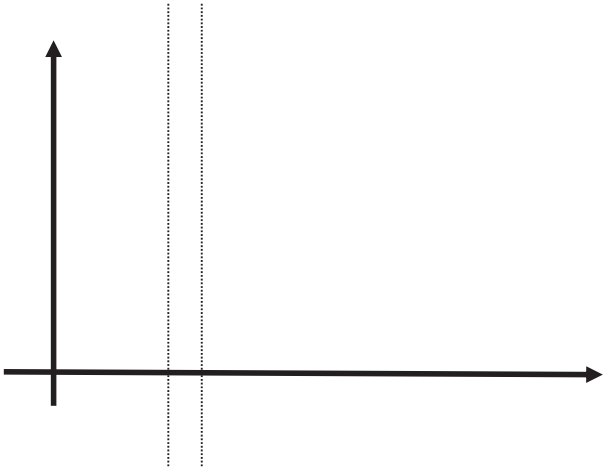
$\rightarrow E_{loss} = \frac{1}{2} L_\ell I_m^2$

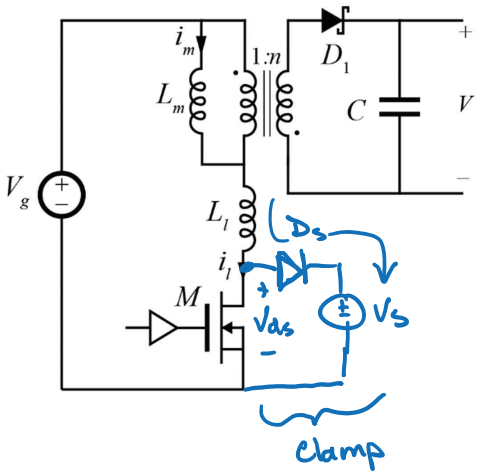
Note: be careful → where did the energy go?

$E_{loss} = 4.4\,\mu J$

$\hookrightarrow P_{loss} = E_{loss} f_s = 4.4\,W$

CCM Flyback: Clamping Circuit





$V_g + \frac{V}{n} \leq V_3 \leq V_{ds,pk}$ (from unclamped case)

Clamped State Plane