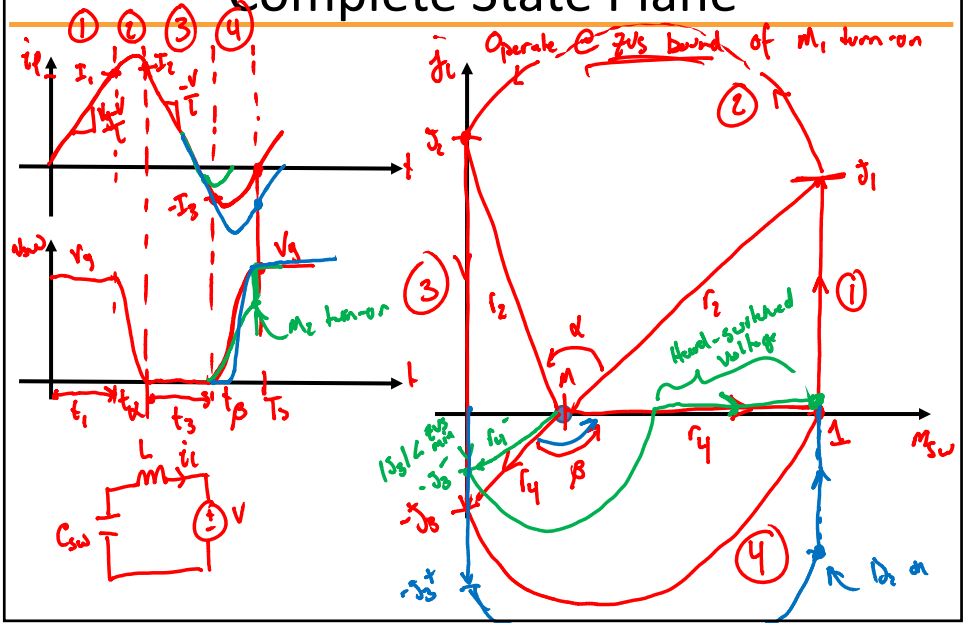
Complete State Plane



Normalizing Switching Period

$$\omega_0 T_s = (t_1 + t_\alpha + t_3 + t_\beta)\omega_0$$

$$\omega_0 T_s = \theta_1 + \alpha + \theta_3 + \beta$$

$$\frac{2\pi f_0}{f_s} = \boxed{\frac{2\pi}{F} = \theta_1 + \alpha + \theta_3 + \beta}$$

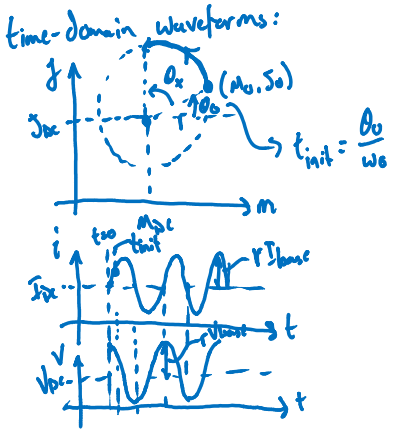
Define $F = \frac{f_s}{f_0}$

Denormalizing

Points: $j_x I_{base} = I_x$ $\quad m_x V_{base} = V_x$

$\theta_x \frac{1}{\omega_0} = t_x$

time-domain waveforms:



$j(\theta) = J_{DC} + r\sin(\theta + \theta_0)$

$m(\theta) = M_{DC} + r\cos(\theta + \theta_0)$

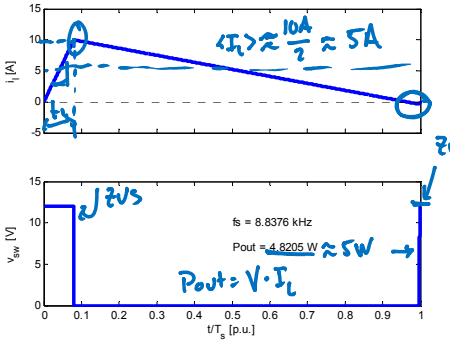
⇓ denormalize

$i(t) = I_{base}\, j(\omega t) = I_{DC} + rI_{base}\sin(\omega t + \theta_0)$

$v(t) = V_{DC} + rV_{base}\cos(\omega t + \theta_0)$

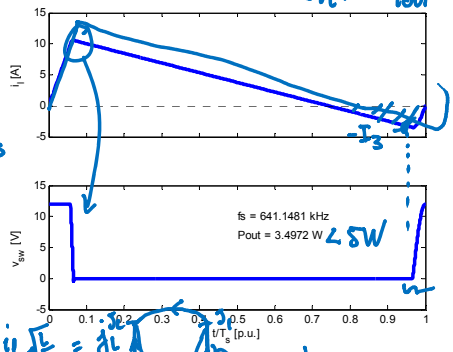
Waveforms with I_1=10 A

→ L = 10 µH



→ L = 100 nH

$\langle i_L \rangle = \langle i_{out} \rangle$



$V_g = 12V$

$V = 1V$

$C_{sw} = 10nF$

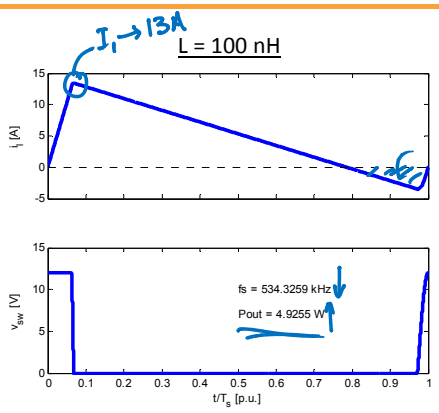
$i_L \frac{L}{V_g C_{sw}} = j_L$

Large L

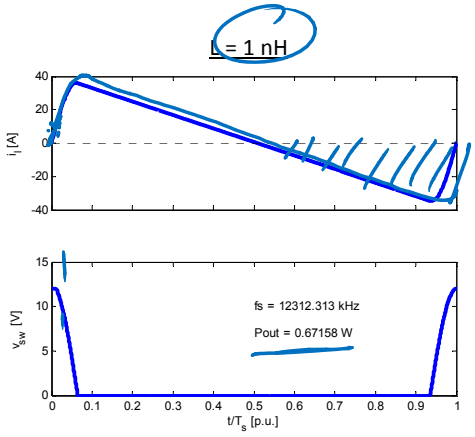
$m_{sw} = \frac{v_{sw}}{V_g}$

Increasing Peak Current

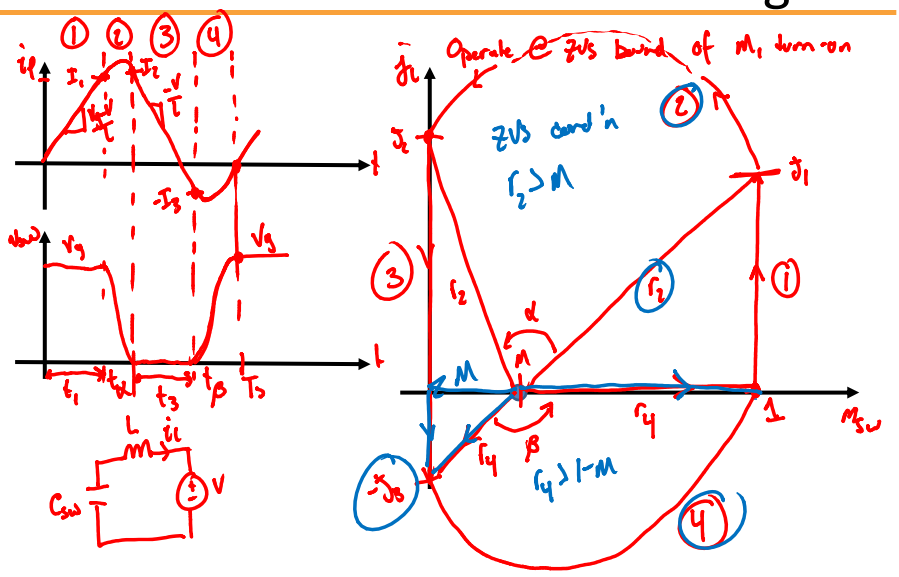
L = 100 nH



L = 1 nH



ZVS Conditions: Denormalizing



$r_4 \geq 1-M$

$V_{base}^2 \sqrt{M^2 + J_3^2}^2 \geq (1-M)^2 V_{base}^2$ $\quad (V_{base} = V_g)$

$V^2 + J_3^2 V_g^2 \geq V_g^2 (1-M)^2$

$V^2 + \left(\frac{I_3}{V_g} R_0\right)^2 V_g^2 \geq V_g^2 (1-M)^2$

$V^2 + I_3^2 \left(\frac{1}{C_{sw}}\right) \geq V_g^2 (1-M)^2$

$\frac{1}{2} L I_3^2 \geq \frac{1}{2} C_{sw} V_g^2 (1-M)^2 - \frac{1}{2} C_{sw} V^2$

- $\frac{1}{2} L I_3^2$: Initial Energy in L
- $\frac{1}{2} C_{sw} V_g^2 (1-M)^2$: Energy needed to go from DC op pt to ZVS
- $\frac{1}{2} C_{sw} V^2$: DC energy in C_{sw}