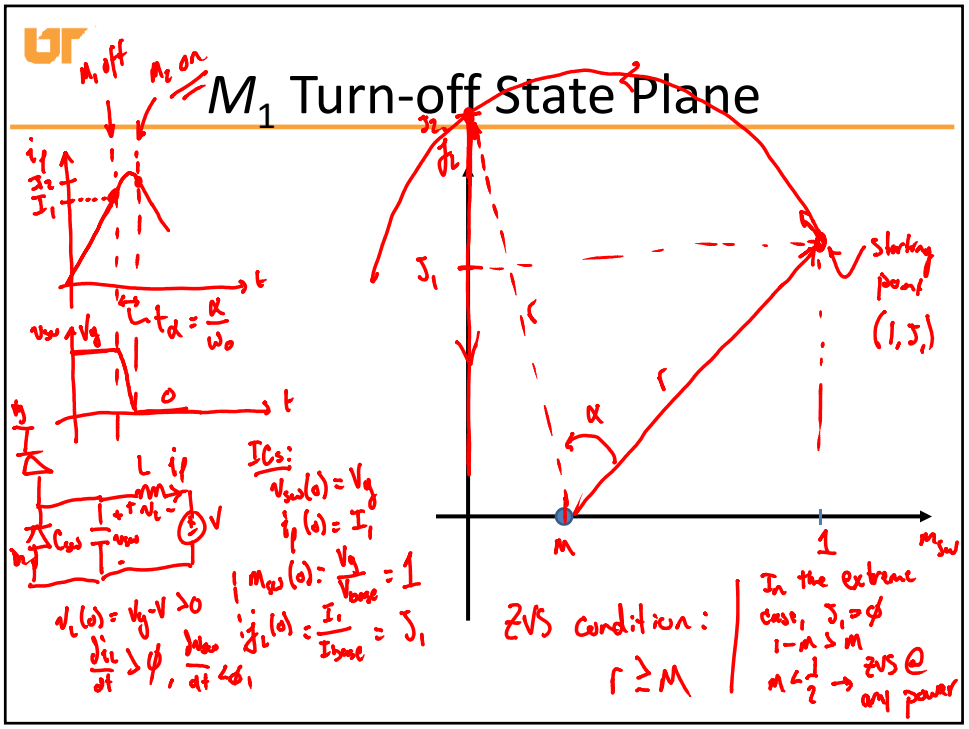
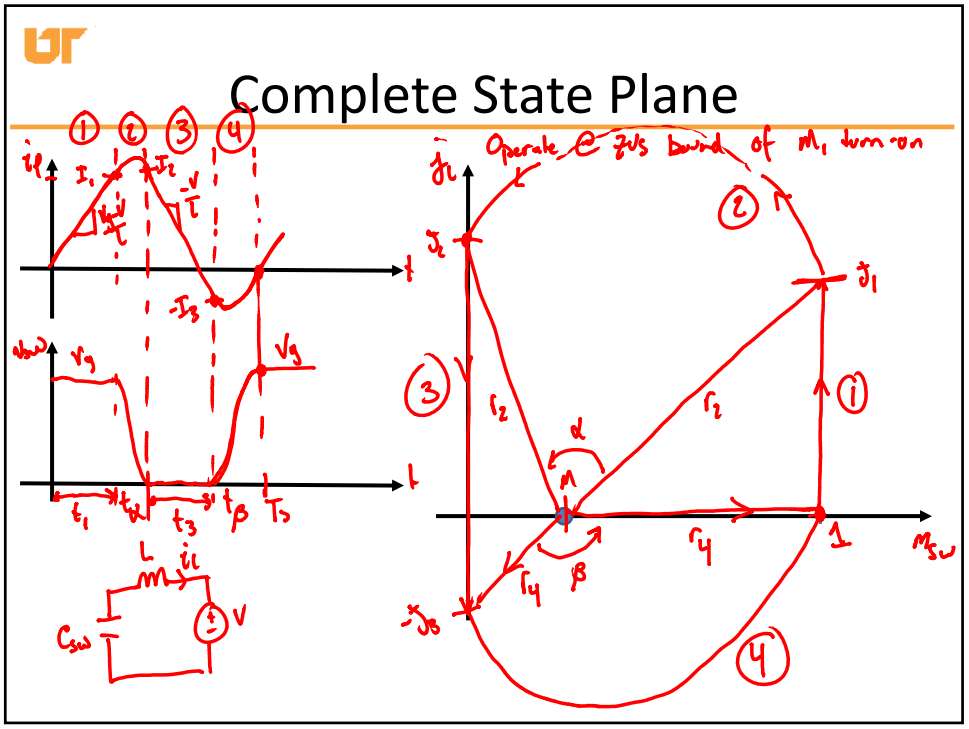
M_1 Turn-off State Plane



Complete State Plane



State Plane Solution: Intervals 1 and 2

① $\frac{I_1}{I_{base}} = \frac{\frac{V_g - V}{L} t_1 \cdot R_o}{V_g}$ $\quad J_1 = \frac{V_g - V}{V_g} \frac{R_o}{L} t_1$ $\quad \sqrt{\frac{L}{C}} \frac{1}{\sqrt{L^2}} = \frac{1}{\sqrt{LC}} = \omega_o$

$$J_1 = (1-M)\,\theta_1$$

② $r_2^2 = J_1^2 + (1-M)^2$ $\quad r_2^2 = J_2^2 + M^2$

$$J_1^2 + (1-M)^2 = J_2^2 + M^2$$

$$\alpha = \pi - \tan^{-1}\left(\frac{J_1}{1-M}\right) - \tan^{-1}\left(\frac{J_2}{M}\right)$$

State Plane Solution: Intervals 3 and 4

③ $\frac{I_2 + I_3}{I_{base}} = \frac{\frac{V}{L} t_3}{I_{base}} \Rightarrow J_2 + J_3 = M\theta_3$

④ $r_4^2 = (1-M)^2$ $\quad r_4^2 = J_3^2 + M^2$

$$(1-M)^2 = J_3^2 + M^2$$

$$\beta = \pi - \tan^{-1}\left(\frac{J_3}{M}\right)$$

State Plane Solution: Averaging Step

$$I_{out} = \frac{1}{T_s}\int_0^{T_s} i_{out}\,dt = \frac{1}{T_s}\int_0^{T_s} i_p\,dt$$

$$I_{out} = \frac{1}{T_s}\left[\underbrace{\frac{1}{2}I_1 t_1}_{①} + \underbrace{Q_{sw}}_{②} + \underbrace{\frac{(I_2-I_3)}{2}t_3}_{③} + \underbrace{-Q_{sw}}_{④}\right]$$

$$I_{out} = \frac{1}{T_s}\left[\frac{1}{2}I_1 t_1 + (I_2-I_3)\frac{t_3}{2}\right]\frac{\omega_0}{\omega_0}$$

$$\boxed{I_{out} = \frac{t_s}{4\pi f_0}\left[\, I_1\theta_1 + (I_2-I_3)\theta_3 \,\right]}$$