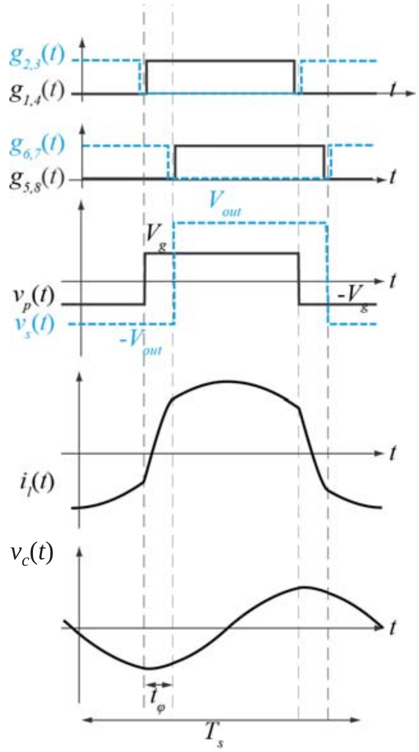
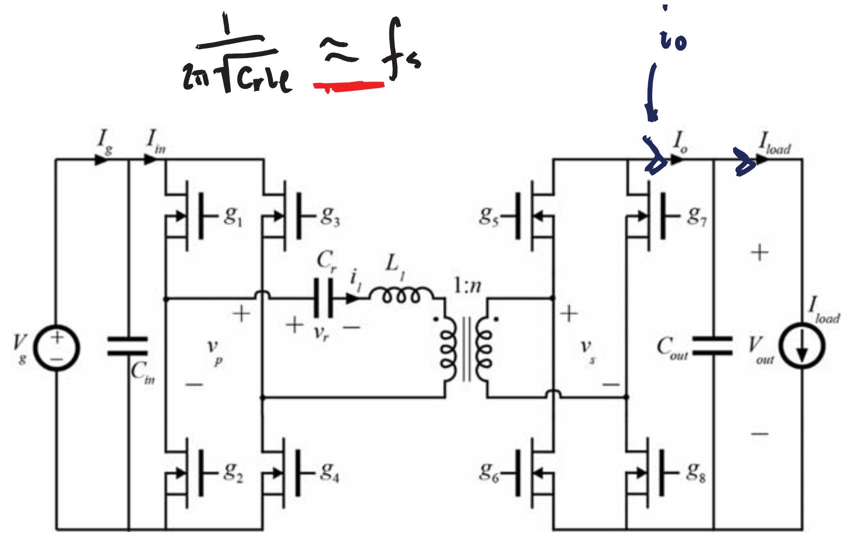
Series Resonant Converter

$\frac{1}{2\pi\sqrt{C_r L_r}} \approx f_s$



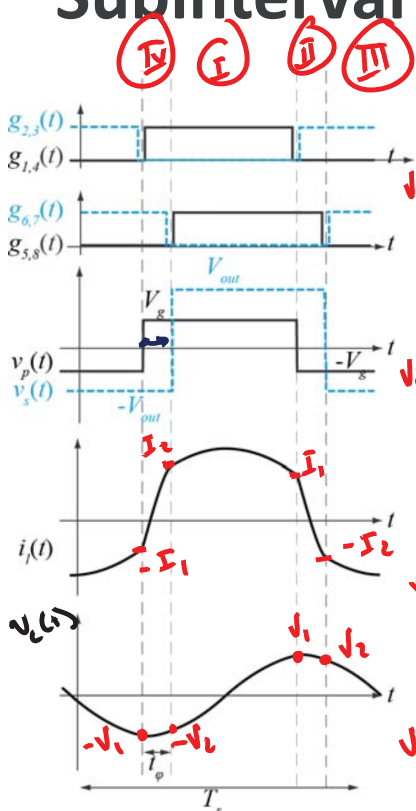


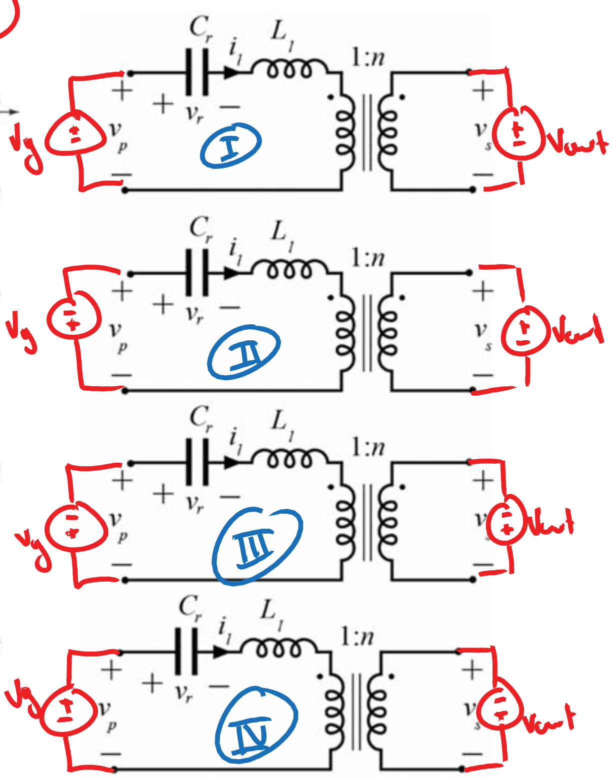
Assumptions:

- $V_{out} = nV_g$
- Devices are ideal → no C_{oss}

Subinterval Equivalent Circuits

$V_{base} = V_g$





DC solution

$M_{DC} = \frac{V_g - \frac{V_{out}}{n}}{V_{base}} = 0$

$S_{DC} = \emptyset$

$M_{DC} = \frac{-V_g - \frac{V_{out}}{n}}{V_{base}} = -2$

$S_{DC} = \emptyset$

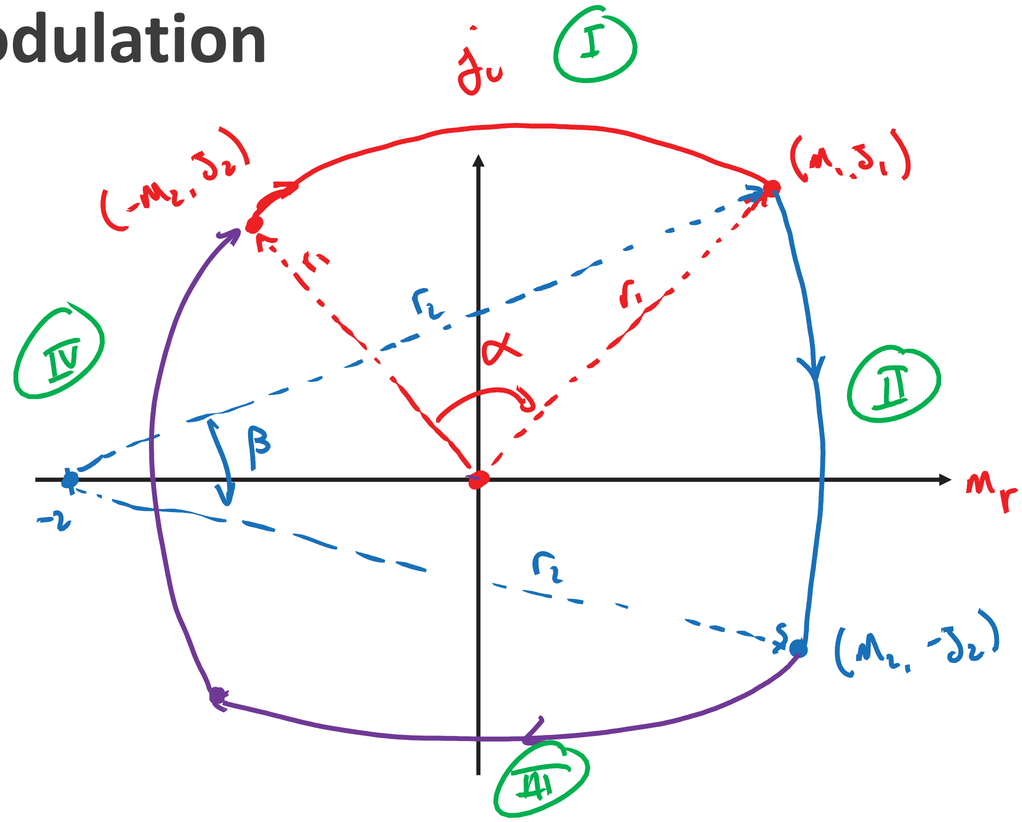
$M_{DC} = \frac{-V_g - \left(-\frac{V_{out}}{n}\right)}{V_{base}} = 0$

$S_{DC} = \emptyset$

$M_{DC} = \frac{V_g - \left(\frac{-V_{out}}{n}\right)}{V_{base}} = 2$

$S_{DC} = \emptyset$

Complete State Plane – Phase Shift Modulation



State Plane Solution

I:

$$r_1^2 = M_2^2 + J_2^2 = M_1^2 + J_1^2$$

$$\alpha = \tan^{-1}\left(\frac{M_2}{J_2}\right) + \tan^{-1}\left(\frac{M_1}{J_1}\right)$$

II:

$$r_2^2 = (2+M_1)^2 + J_1^2 = (2+M_2)^2 + J_2^2$$

$$\beta = \tan^{-1}\left(\frac{J_1}{2+M_1}\right) + \tan^{-1}\left(\frac{J_2}{2+M_2}\right)$$

$$\frac{\pi}{F} = \alpha + \beta$$

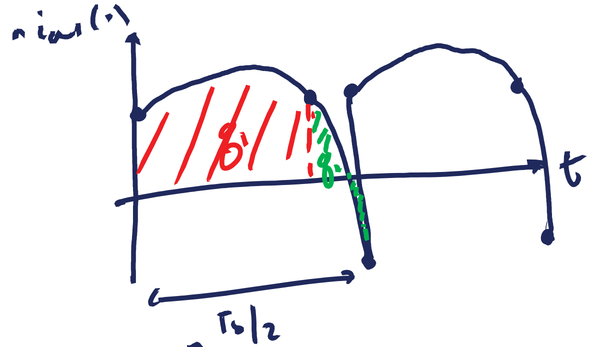
$$M_1^2 + J_1^2 = M_2^2 + J_2^2$$

$$-\quad 4 + M_1^2 + 4M_1 + J_1^2 = 4 + M_2^2 + 4M_2 + J_2^2$$

$$-4 - 4M_1 = -4 - 4M_2$$

$$\therefore M_1 = M_2 \quad \& \quad J_1 = J_2$$

Averaging Step



$$n\langle i_{out}\rangle = \frac{2}{T_s}\int_0^{T_s/2} i_c(t)\,dt$$

$$= \frac{2}{T_s}\left[q_1 + q_2\right]$$

$$= \frac{2}{T_s}\left[\underbrace{C_r(V_1+V_2) + C_r(V_1-V_2)}\right]$$

$$\underbrace{\quad}_{2V_1} \qquad \underbrace{\quad}_{\emptyset}$$

$$n\langle i_{out}\rangle = \frac{2}{T_s}\,2C_rV_1$$

$$J = \frac{n\langle i_{out}\rangle}{I_{base}} = \frac{2}{T_s}\,\frac{2C_rV_1}{V_g}\sqrt{\frac{L_r}{C_r}} = \boxed{\frac{F}{\pi}2M_1 = J}$$

Complete Solution

$$J = \frac{F}{\pi}2M_1$$

$$\frac{\pi}{F} = \alpha + \beta$$

$$\alpha = 2\tan^{-1}\left(\frac{M_1}{J_1}\right)$$

$$\beta = 2\tan^{-1}\left(\frac{J_1}{2+M_1}\right)$$

$$\tan\left(\frac{\alpha}{2}\right) = \frac{M_1}{J_1} \qquad \tan\left(\frac{\beta}{2}\right) = \frac{J_1}{2+M_1}$$

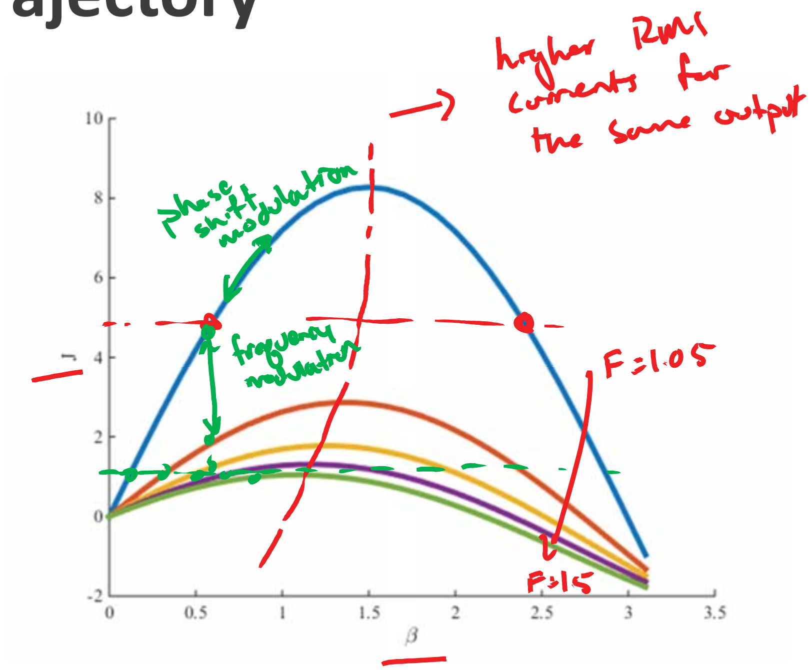
$$M_1 = \tan\left(\frac{\alpha}{2}\right)\tan\left(\frac{\beta}{2}\right)(2+M_1)$$

$$M_1 = \frac{2\tan\left(\frac{\alpha}{2}\right)\tan\left(\frac{\beta}{2}\right)}{1-\tan\left(\frac{\alpha}{2}\right)\tan\left(\frac{\beta}{2}\right)}$$

$$\boxed{J = \frac{F}{\pi}2\left(\frac{2\tan\left(\frac{\pi}{2F}-\frac{\beta}{2}\right)\tan\left(\frac{\beta}{2}\right)}{1-\tan\left(\frac{\pi}{2F}-\frac{\beta}{2}\right)\tan\left(\frac{\beta}{2}\right)}\right)}$$

$$J_{pk} = r_1 = \sqrt{M_1^2 + J_1^2}$$

SRC Control Trajectory



SRC Current Stress