Analysis: Intervals 1-3

① No quantums yet

$$\boxed{\frac{2\pi}{F} = \theta_1 + \theta_2 + \gamma + \theta_4 + \varepsilon + \theta_6}$$

② $\left(\frac{1}{I_{base}}\right)\frac{I_m}{C_{ds}} t_2 = V_g + \frac{V}{n}\left(\frac{1}{I_{base}}\right)$

$$\frac{1}{R_o C_{ds}} = \frac{1}{\sqrt{\frac{L_1}{C_{ds}}}\, C_{ds}} = \frac{1}{\sqrt{L_1 C_{ds}}} = \omega_0$$

$$J_m \frac{t_2}{C_{ds}} = (1)\, R_o$$

$$\boxed{J_m \theta_2 = 1}$$

③ $r_3^2 = \boxed{J_m^2 = J_3^2 + (M_s - 1)^2}$

$$\boxed{\gamma = \tan^{-1}\left(\frac{M_s - 1}{J_s}\right)}$$

Analysis: Intervals 4-6

4 $$\frac{V_g + \frac{V}{n} - V_s}{L_\ell} t_4 = -(I_3 + I_4)$$

$$(1 - m_s)\frac{R_0}{L_\ell} t_4 = -J_3 - J_4$$

$$\boxed{(1-m_s)\,\theta_4 = -J_3 - J_4}$$

5 $$r_5^2 = \boxed{(m_s - 1)^2 + J_4^2 = 1 + J_5^2}$$

$$\boxed{\varepsilon = \pi - \tan^{-1}\left(\frac{J_4}{m_s - 1}\right) - \tan^{-1}(J_5)}$$

6 $$\frac{V_g + \frac{V}{n}}{L_L} t_6 = I_5 + I_m$$

$$\boxed{(1)\,\theta_6 = J_5 + J_m}$$

Analysis: Averaging

Averaging applied to all small-ripple elements

Here: L_m, C_s, C

Cap-Q balance on C_s

$$\langle i_s \rangle \Big|_{T_s} = 0 = \frac{1}{T_s}\int_0^{T_s} i_s(t)\,dt$$

$$0 = \frac{1}{T_s}\int_{4} i_s(t)\,dt = \frac{1}{T_s}\left[\frac{I_3 - I_4}{2}\, t_4\right] \rightarrow \boxed{I_3 = I_4}$$

$$\boxed{J_3 = J_4}$$

Volt-sec balance on L_m

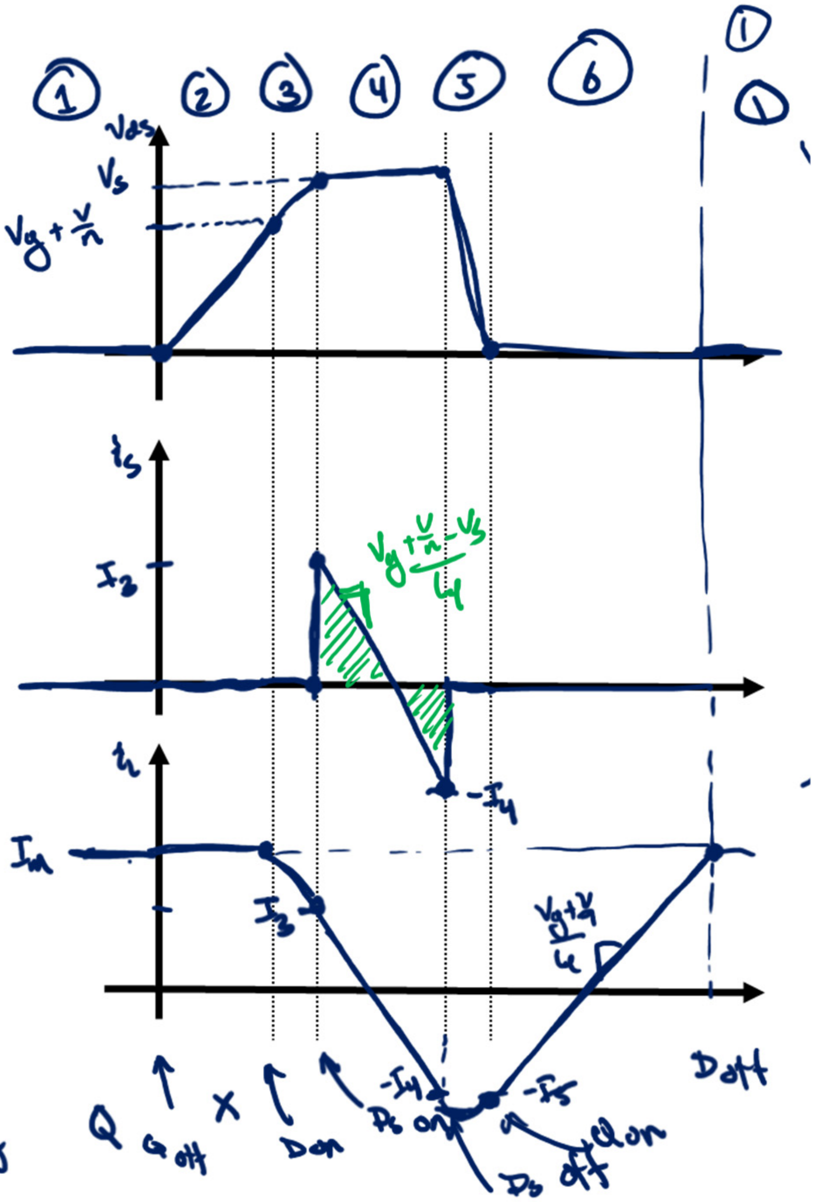
$$\langle v_{Lm} \rangle = 0 = \frac{1}{T_s}\int_0^{T_s} v_{Lm}(t)\,dt$$

$$0 = \cancel{\frac{1}{T_s}}\left[V_g t_1 + V_g t_2 - \frac{\left(V_g + \frac{V}{n}\right)}{2} t_2 + \left(\frac{-V}{n}\right)\left(t_3 + t_4 + t_5 + t_6\right)\right]$$

$$0 = V_g\left(t_1 + \frac{t_2}{2}\right) + \left(\frac{-V}{n}\right)\left(\frac{t_2}{2} + t_3 + t_4 + t_5 + t_6\right)$$

$$\boxed{\frac{V}{V_g} = n\,\frac{t_1 + \frac{t_2}{2}}{\frac{t_2}{2} + t_3 + t_4 + t_5 + t_6}}$$

~ if flyback approx as in 481 $\rightarrow \frac{V}{V_g} = n\frac{D}{D'}$



Conducting Q G_{off} X Don D_s on D_s off Qon Doff

Average Output Current

Cap-Q balance on C:

$$\langle i_C \rangle\big|_{T_s} = \emptyset = \frac{1}{T_s}\int_0^{T_s}\left(i_D(t) - \frac{V}{R}\right)dt$$

$$T_s \frac{V}{R} = \int_0^{T_s} i_D(t)\,dt$$

$$n I_{out} = \frac{1}{T_s}\int_0^{T_s} n\, i_D(t)\,dt = \int_0^{T_s}\left(I_m - i_L(t)\right)dt$$

① → ⑥

$$= \frac{1}{T_s}\underbrace{\int_{①}\left(I_m - i_L(t)\right)dt}_{q_1} + \underbrace{\int_{②}\left(I_m - i_L(t)\right)dt}_{q_2} + \dots$$

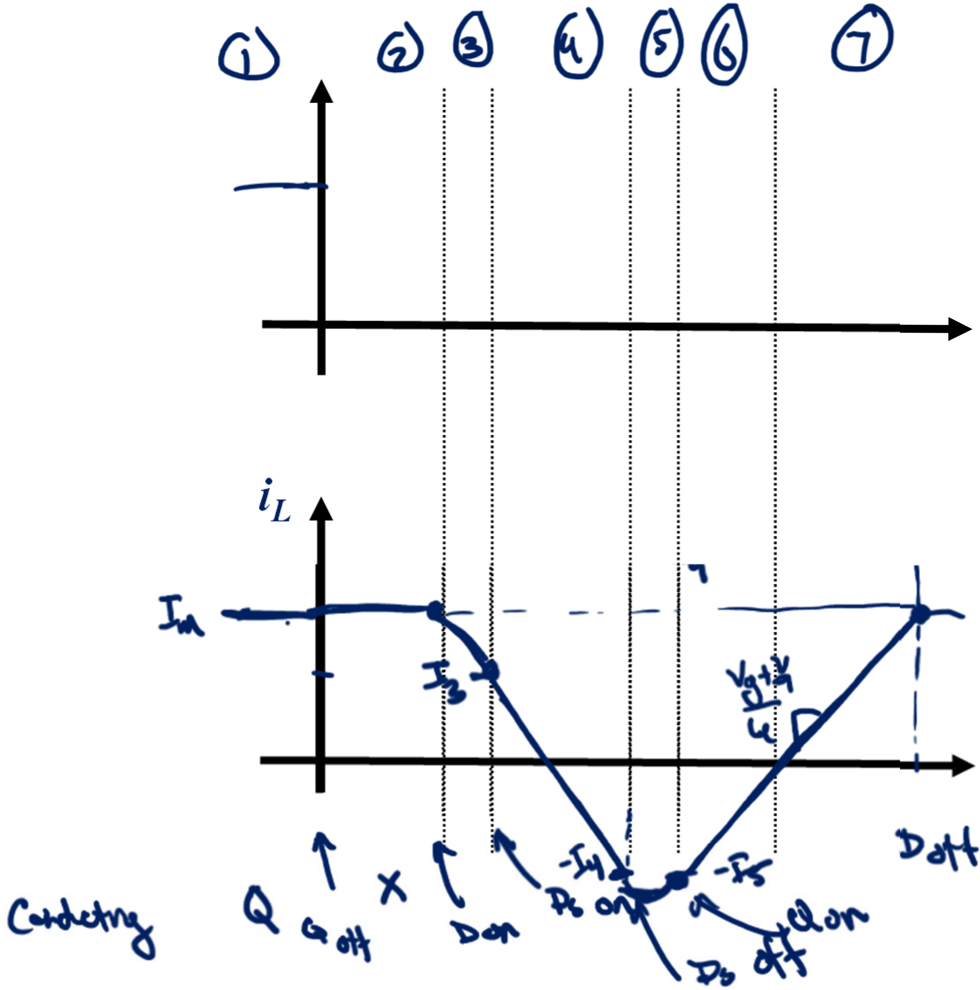
$$q_1 = \emptyset \qquad q_2 = \emptyset$$

$$q_3 = I_m t_3 - C_{ds}\left(\cancel{V_s} - V_g - \frac{V}{n}\right)$$

$$q_4 = I_m t_4 - \frac{I_3 - I_4}{2} t_4$$

$$q_5 = I_m t_5 - \cancel{C_{ds}(-V_s)}$$

$$q_6 = I_m t_6 - \frac{I_m - I_5}{2} t_6$$



$$\hat{I}_{out} = \frac{1}{T_s}\left[q_3 + q_4 + q_5 + q_6 \right]$$

$$= \frac{1}{T_s}\left[I_m t_3 + C_{ds}\left(V_y + \frac{V}{n}\right) + I_m t_4 - \frac{I_3 - I_4}{2} t_4 + I_m t_5 + I_m t_6 - \frac{I_m - I_5}{2} t_6 \right]$$

$$= \frac{1}{T_s}\left[I_m\left(t_3 + t_4 + t_5 + \frac{t_6}{2}\right) + C_{ds}\left(V_y + \frac{V}{n}\right) - \frac{I_3 - I_4}{2} t_4 + \frac{I_5}{2} t_6 \right] \frac{1}{I_{base}} \quad \frac{\omega_0}{\omega_0}$$

$$\frac{1}{I_{base}} \quad = \frac{1}{T_s}\left[J_m\left(\gamma + \theta_4 + \varepsilon + \frac{\theta_6}{2}\right) + R_0 C_{ds}(1) - \frac{J_3 - J_4}{2}(\theta_4) + \frac{J_5}{2}(\theta_6) \right]$$

$$\hat{J}_{out} = \frac{1}{\omega_0}\frac{1}{T_s}\left[J_m\left(\gamma + \theta_4 + \varepsilon + \frac{\theta_6}{2}\right) + \left(\frac{1}{\omega_0}\right) - \cancel{\frac{J_3 - J_4}{2}}\theta_4 + \frac{J_5}{2}\theta_6 \right]$$

$$\boxed{\hat{J}_{out} = \frac{F}{2\pi}\left[J_m\left(\gamma + \theta_4 + \varepsilon + \frac{\theta_6}{2}\right) + 1 - \ldots \right]}$$