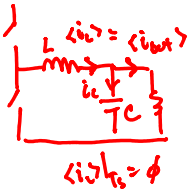
Active Clamp Flyback

L_m, C_1, C_2 → larger filter elements

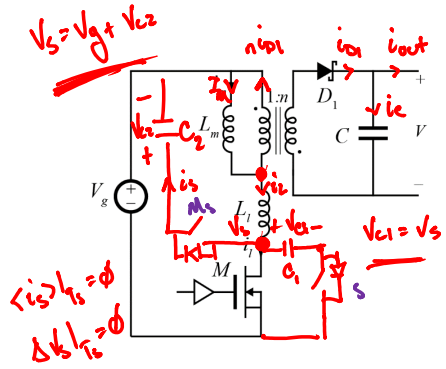
Buck:



$\langle i_L \rangle|_{T_s} = \phi$

Capacitor Charge Balance

$V_s = V_g + V_{c2}$



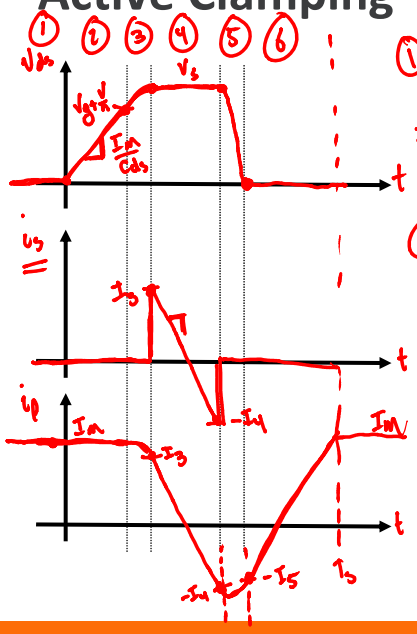
$\langle i_{C2} \rangle|_{T_s} = \phi$

$\Delta v_{C2}|_{T_s} = \phi$

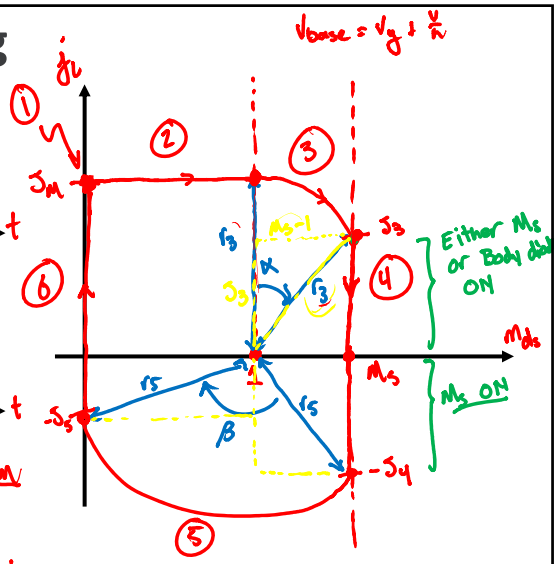
$V_{c1} = V_s$

$C_s = C_1$ or C_2

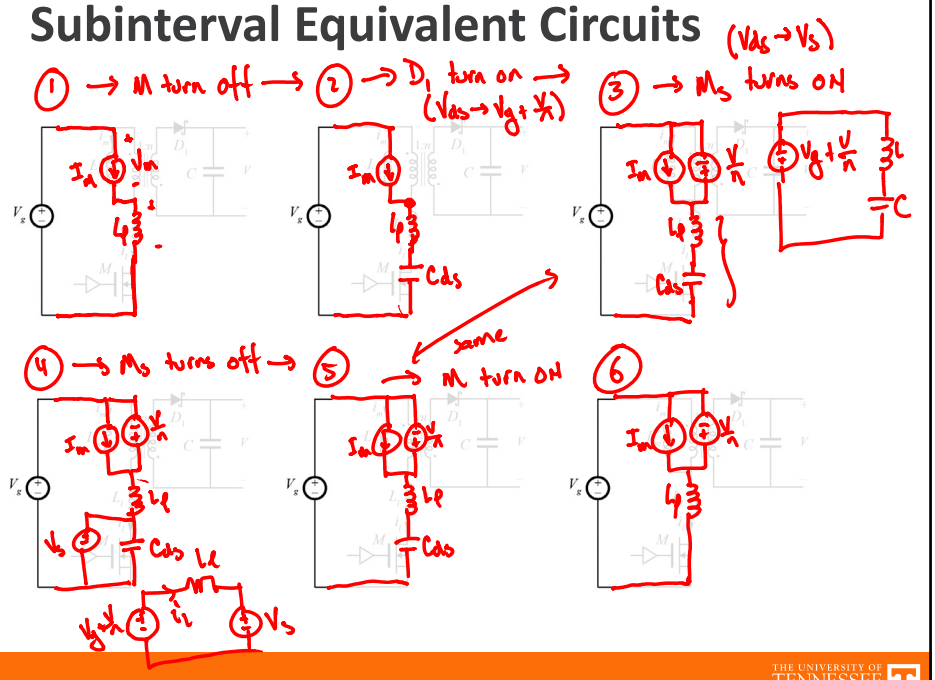
Active Clamping



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



Subinterval Equivalent Circuits



ZVS Conditions

③ M_3 turn-on ZVS condition

$$S_m \geq M_3 - 1$$

⑤ M turn-on ZVS condition

$$r_5 \geq 1$$

Analysis: Intervals 1-3

① Nothing yet

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

$\frac{J_m}{C_{ds}}t_2 = 1\ R_0$

$J_m t_2 = \sqrt{\frac{L_p}{C_{ds}}}C_{ds} = \sqrt{L_p C_{ds}} = \frac{1}{\omega_0} \rightarrow \boxed{\theta_2 = \frac{1}{J_m}}$

③ $\boxed{\alpha = \tan^{-1}\left(\frac{M_3 - 1}{J_3}\right)}$

$r_3^2 = \boxed{J_m^2 = (M_3-1)^2 + J_3^2}$

Analysis: Interval 4

④ $\frac{V_s - \left(V_g + \frac{V_r}{n}\right)}{L_p}t_4 = I_3 + I_4$

$\boxed{J_3 + J_4 = (M_3 - 1)\theta_4}$

Analysis: Interval 5-6

⑤ $r_5^2 = (M_5 - 1)^2 + J_4^2 = 1 + J_5^2$

$\beta = \tan^{-1}\left(\frac{M_5 - 1}{J_4}\right) + \tan^{-1}\left(\frac{1}{J_5}\right)$

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

$\theta_6 = J_5 + J_m$

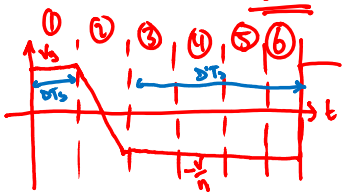
$\frac{2\pi}{P} = \theta_1 + \theta_2 + \alpha + \theta_4 + \beta + \theta_6$

Analysis: Averaging Cs and Lm

Cap-Q balance on C_s: $\langle i_{C_s} \rangle|_{T_s} = 0 \rightarrow I_3 = I_4$ or $J_3 = J_4$

$J_3 = J_4 \rightarrow r_3 = r_5$

Volt-second balance on Lm: $\langle v_m \rangle|_{T_s} = 0$



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

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

Conversion ratio $\leftarrow \frac{V}{n V_g} = \frac{t_1 + \frac{t_2}{2}}{\frac{t_2}{2} + t_3 + t_4 + t_5 + t_6} \frac{\omega_s}{\omega_s} = \frac{\theta_1 + \frac{\theta_2}{2}}{\frac{\theta_2}{2} + \alpha + \theta_4 + \beta + \theta_6} \approx \frac{A}{A}$

Analysis: Averaging I_{out}

$n i_{D1} = I_m - i_L$

$\langle n i_{D1} \rangle|_{T_s} = n I_{out} = I_m - \langle i_L \rangle$

$n I_{out} = \frac{1}{T_s}\left[\int_0^{T_s} n i_{D1}\, dt\right]$

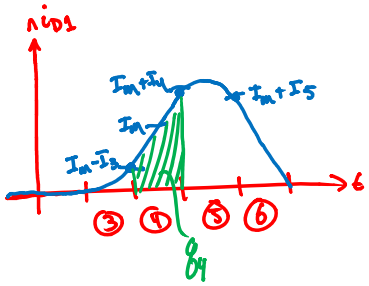
$= \frac{1}{T_s}\left[q_3 + q_4 + q_5 + q_6\right]$

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

$q_4 = I_m t_4$

$q_5 = I_m t_5 + C_{ds}\left(V_s\right)$

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



$J = \frac{n I_{out}}{I_{base}} =$

$J = J_m \frac{I}{\pi}\left(\alpha + \beta + \theta_4 + \frac{\theta_4}{2}\right) + \frac{F}{2\pi} + J_5 \frac{F}{2\pi} \frac{\theta_6}{2}$