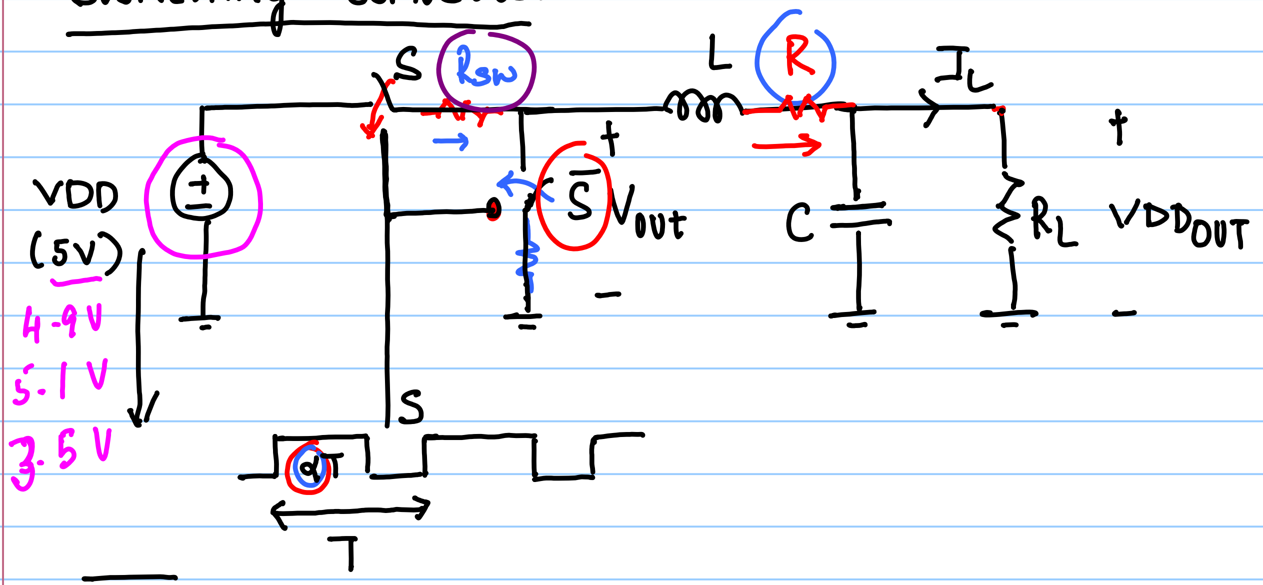
Note Title

Lecture #30

Switching Converter



$\overline{V_{OUT}} = \alpha VDD$

$VDD_{OUT} = \alpha VDD - I_L R$

$VDD_{OUT} = \alpha VDD$

VDD_{OUT} (Desired)	α
2.5	→ 0.5
1.2	$\frac{1.2}{5.0}$
0.7	$\frac{0.7}{5.0}$
1.8	$\frac{1.8}{5.0}$

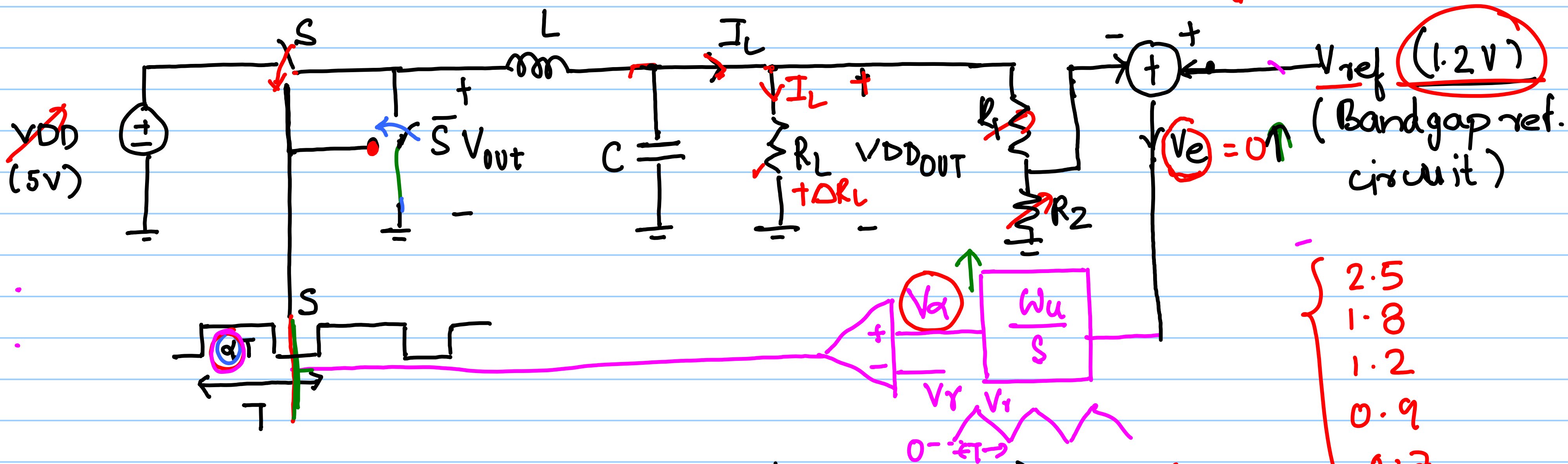
$\alpha \leq 1$

$VDD_{OUT} = \frac{2.5}{3.5}$

$0.5 \rightarrow \frac{2.5}{3.5}$

RF IC, $I_L = 100mA$, $VDD_{OUT} = 1.8V$, $\alpha = 1.8/5.0$

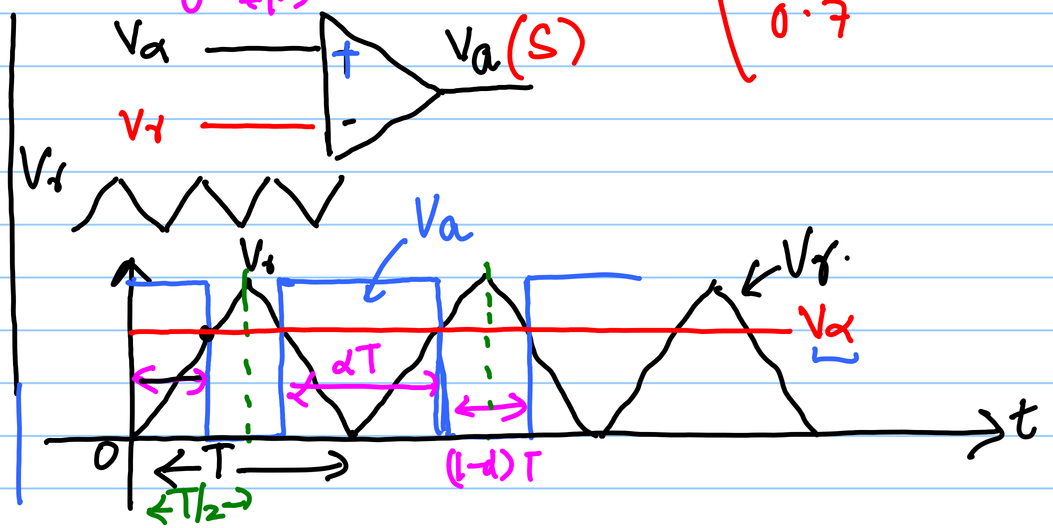
, $I_L = 1mA$, $VDD_{OUT} = 1.8V$, $\alpha = 1.8/5.0$



- 2.5
- 1.8
- 1.2
- 0.9
- 0.7

$V_e = V_{ref} - VDD_{OUT}$

$V_e > 0 \longrightarrow VDD_{OUT}$ (αVDD) $\longrightarrow \alpha$



In steady state:

$V_e = 0$

$$\frac{R_2}{R_1+R_2} VDD_{OUT} = V_{ref}.$$

$$\underline{\alpha VDD} = VDD_{OUT} = \frac{R_1+R_2}{R_2} V_{ref}$$

$$VDD_{OUT} = \left(1+\frac{R_1}{R_2}\right) V_{ref}$$

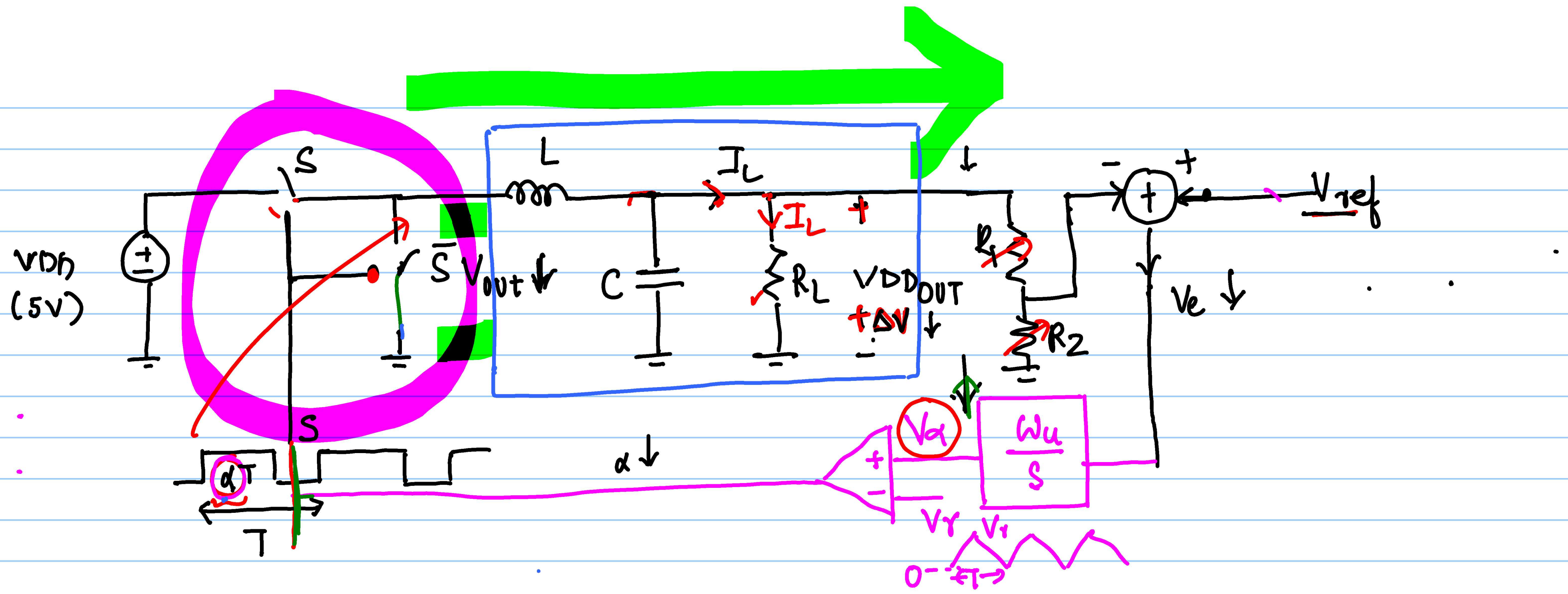
Slope of V_r = $\frac{V_r}{T/2}$

Duty cycle, α

$$\frac{\alpha T}{2} = \frac{V_\alpha}{V_r/(T/2)}$$

$$\frac{V_\alpha}{\alpha \cancel{T/2}} = \frac{V_r}{\cancel{T/2}} \Rightarrow \alpha = \frac{V_\alpha}{V_r}$$

- Switching converter in a closed loop



$$\frac{VDD_{OUT}}{V_{OUT}} = \frac{\left(R_L \| \frac{1}{sC}\right)}{sL + \left(R_L \| \frac{1}{sC}\right)} = \frac{\frac{R_L}{1+sR_2C}}{sL + \frac{R_L}{1+sR_LC}} = \frac{R_L}{sL + s^2 R_L L C + R_L} = \frac{R}{R + sL + s^2 RLC}$$

$$F(s) = \frac{VDD_{OUT}}{V_{OUT}} = \frac{1}{1 + s\frac{L}{R} + s^2 LC} = \frac{1}{1 + \frac{s}{\omega_n Q_p} + \frac{s^2}{\omega_n^2}}$$

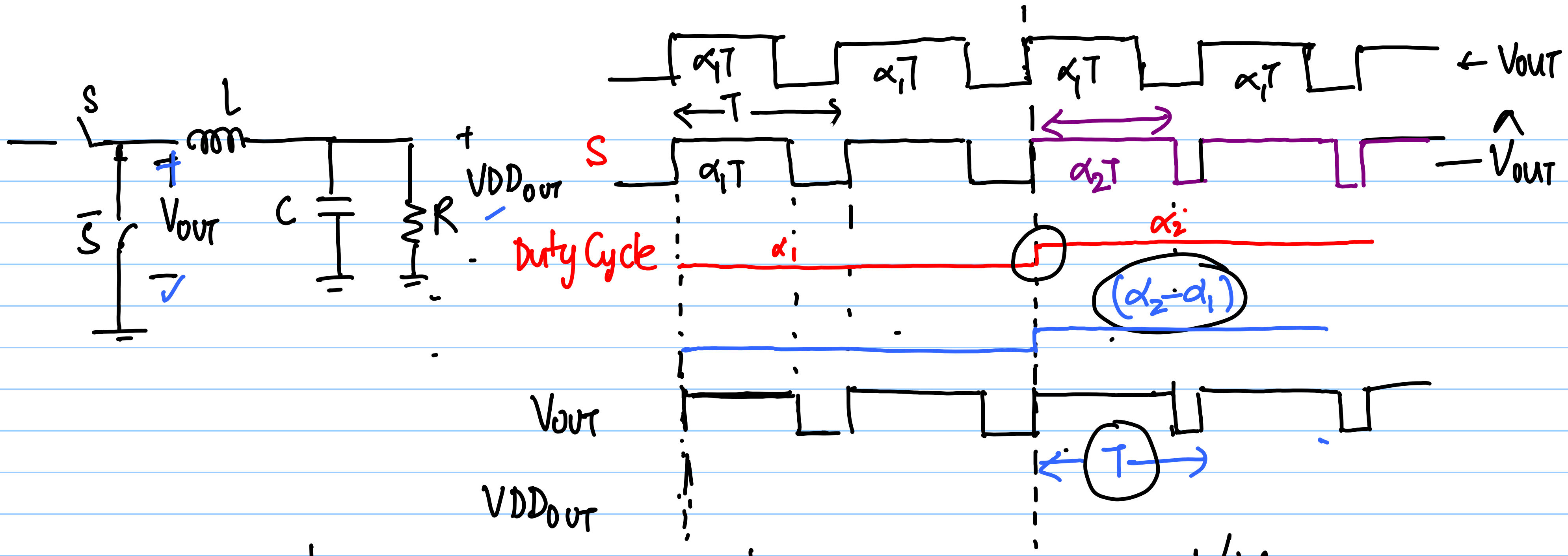
$$V_e = V_{ref} - VDD_{OUT}$$

$$\frac{V_\alpha}{V_e} = \frac{\omega_u}{s}$$

$$\underset{\sim}{\alpha} = \frac{V_\alpha}{V_r}$$

$$LG = \frac{\omega_u}{s} \frac{V_\alpha}{V_r} \left(\downarrow \right) \times f(s)$$

$$\underline{V_{OUT}} = \alpha VDD + \underbrace{\sum_{n=1} a_n \cos(n\omega_0 t) + b \sin(n\omega_0 t)}$$



$$F(S) = \frac{1}{1 + \frac{s}{\omega_n Q} + \frac{s^2}{\omega_n^2}} = \frac{1}{1 + \frac{sL}{R} + s^2 LC} = \frac{1/LC}{s^2 + \frac{s}{RC} + \frac{1}{LC}}$$

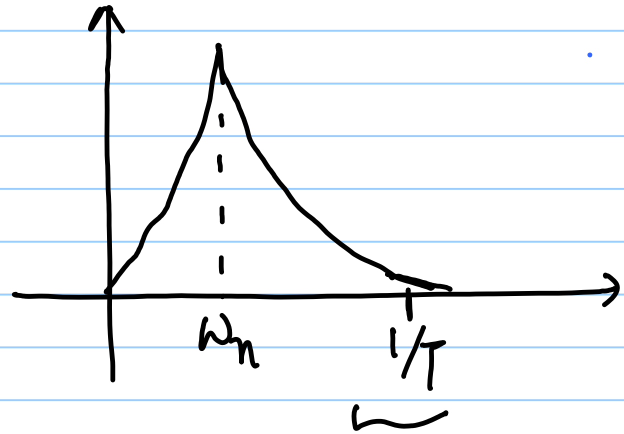
$$= \frac{1}{\left(s + \frac{1}{2RC}\right)^2 + \frac{1}{LC} - \frac{1}{4R^2C^2}} = \frac{\omega_n^2}{\left(s + \frac{1}{2RC}\right)^2 + \frac{1}{LC}\left(1 - \frac{L}{4R^2C}\right)}$$

$$= \frac{\omega_n^2}{(s+\sigma)^2 + \underbrace{\omega_n^2\left(1 - \frac{1}{4Q^2}\right)}} = \frac{\omega_n^2}{\omega_p} \cdot \underbrace{\frac{\omega_p}{(s+\sigma)^2 + \omega_p^2}}$$

$$\frac{\omega_p}{s^2+\omega_p^2} \xrightarrow{\mathcal{L}^{-1}(\ )} \sin(\omega_p t)\, u(t)$$

$$\omega_p = \omega_n \sqrt{1 - \frac{1}{(2Q_p)^2}}$$

$$\frac{\omega_p}{(s+\sigma)^2+\omega_p^2} \xrightarrow{\mathcal{L}^{-1}(\ )} \underline{e^{-\sigma t} \sin(\omega_p t)}$$



$$\underline{\Delta VDD_{OUT}(t)} = f(t) * (V_{OUT} - \hat{V}_{OUT})$$

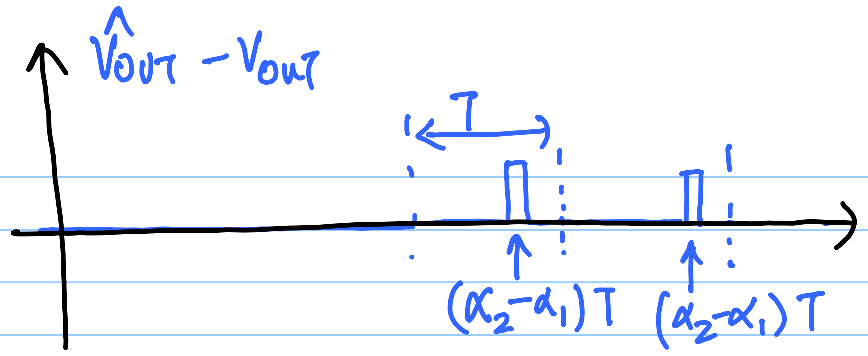
$$= \int_0^t \left(V_{out}(\tau) - \hat{V}_{out}(\tau) \right) f(t-\tau)\, d\tau$$

$$= \int_0^T \left(V_{out}(\tau) - \hat{V}_{out}(\tau) \right) f(t-\tau)\, d\tau$$

$$+ \int_T^{2T} \quad \downarrow$$

$$+ \int_{2T}^{3T} \quad \downarrow$$

$$+$$



- During a period $mT \to \overline{m+1}\,T$
  $f(t)$ remains constant

t