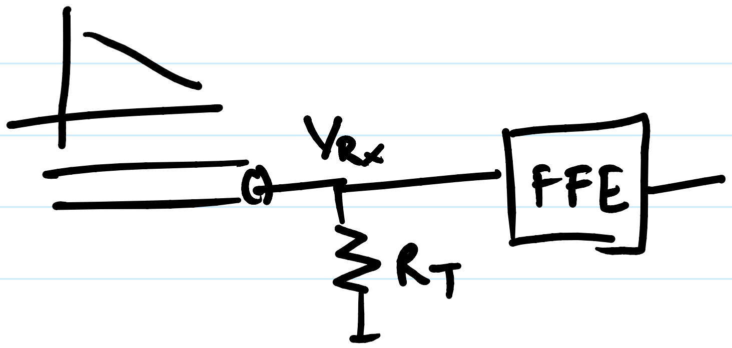
Lecture 40

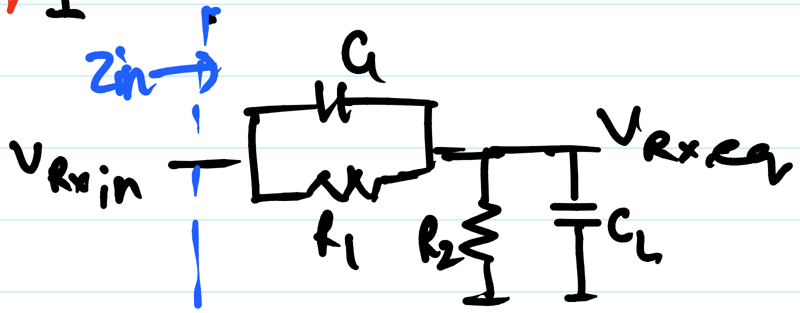
Wednesday, October 26, 2016 7:44 AM

Equalization on Rx side



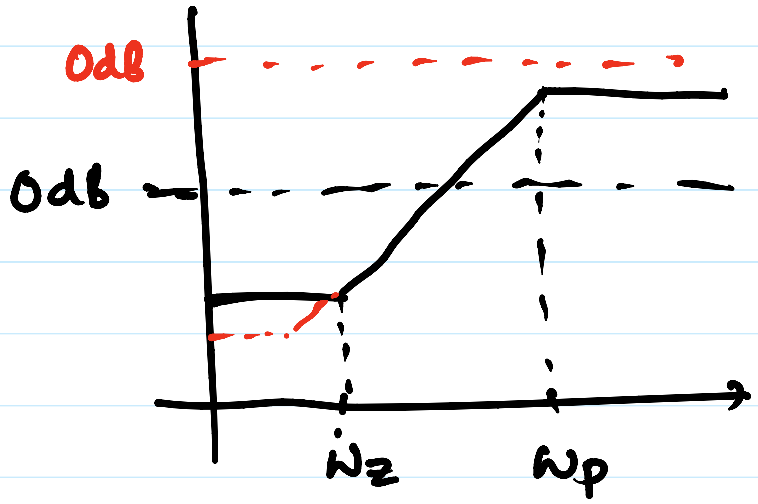
1. FFE after channel termination

2. Passive equalization w/ high filter.



$$\frac{V_{Rxeq}(s)}{V_{Rx,in}(s)} = \frac{R_2}{R_1+R_2} \frac{(1+sC_1R_1)}{\left(1+s(C_1+C_L)\frac{R_1R_2}{R_1+R_2}\right)}$$

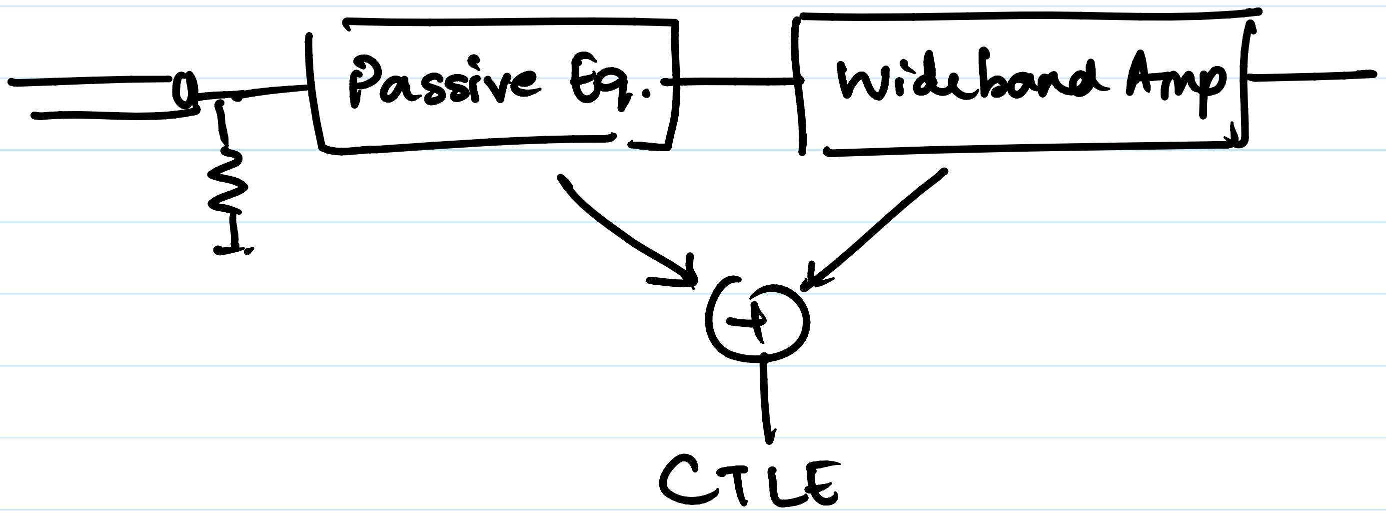
$$\omega_z = \frac{1}{C_1R_1}, \quad \omega_p = \frac{1}{(C_1+C_2)\frac{R_1R_2}{R_1+R_2}}, \quad A_{DC} = \frac{R_2}{R_1+R_2}$$



$$= \frac{R_2}{R_1+R_2} \frac{C_1R_1}{(C_1+C_2)\frac{R_1R_2}{R_1+R_2}} = \frac{C_1}{C_1+C_2}$$

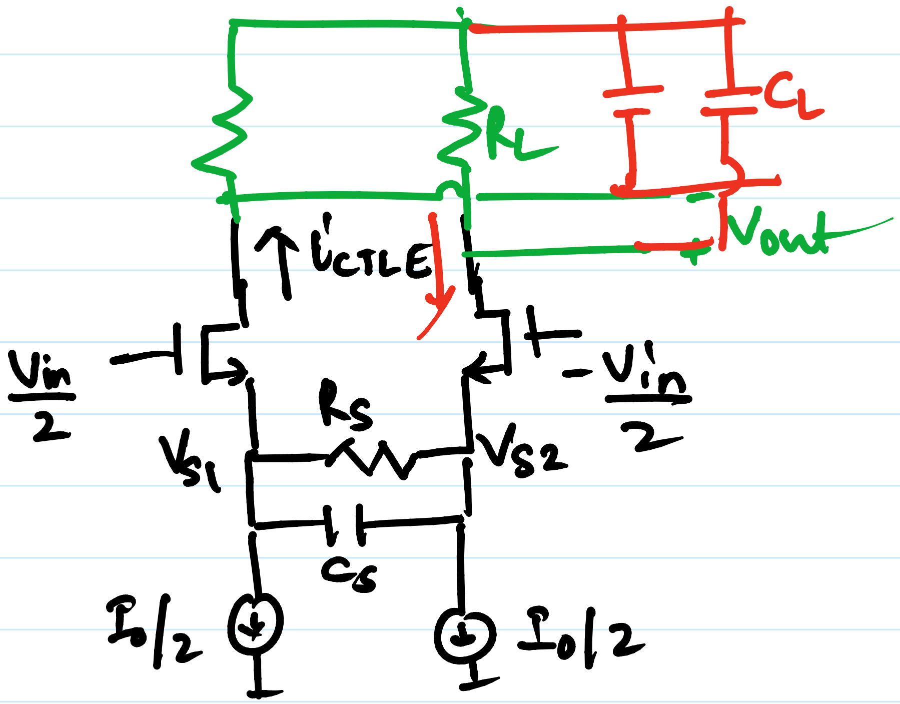
* DC gain $\Rightarrow R_2 \to \infty$, $\omega_p = \frac{1}{(C_1+C_2)R_1} < \omega_z$

* Zin of passive eq. is constrained by



* Z_{in} of passive eq. is constrained by termination

Continuous time linear equalization

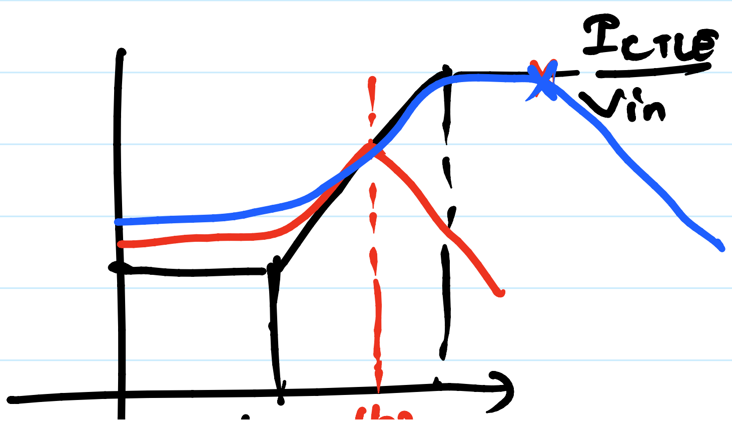


$$I_{CTLE}(s) = \frac{g_m\left(R_s/2 \parallel \frac{1}{2sC_s}\right)}{1+g_m\left(R_s/2 \parallel \frac{1}{2sC_s}\right)} \times \frac{V_{in}}{2}$$

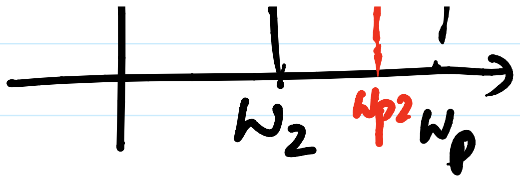
$$= \frac{g_m}{1+g_m \frac{R_s/2}{1+sC_sR_s}} \times \frac{V_{in}}{2}$$

$$\frac{\frac{R_s}{2} \times \frac{1}{2sC_s}}{\frac{R_s}{2} + \frac{1}{2sC_s}} = \frac{R_s/2}{1+sC_sR_s}$$

$$= \frac{g_m(1+sC_sR_s)}{(1+g_mR_s/2)+sC_sR_s} \times \frac{V_{in}}{2}$$



$$\frac{I_{CTLE}(s)}{V_{in}(s)} = \frac{g_m/2}{1+g_mR_s/2} \cdot \frac{1}{1+\frac{sC_sR_s}{(1+g_mR_s/2)}} \times (1+sC_sR_s)$$



$$\frac{\cdots}{(1+g_mR_s/2)}$$

$$A_{DC} = \frac{g_m/2}{1+g_mR_s/2}, \quad \omega_z = \frac{1}{C_sR_s}, \quad \omega_{p1} = \frac{1+g_mR_s/2}{C_sR_s} = \gamma\omega_z$$

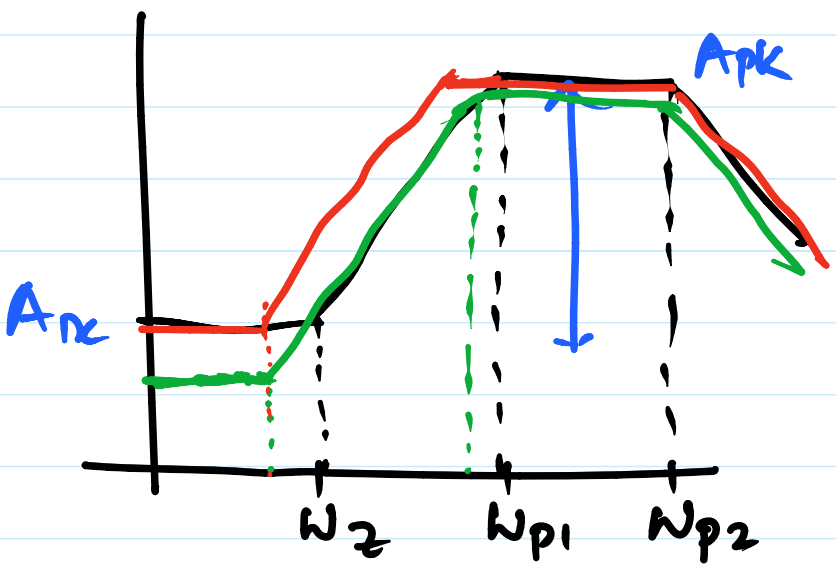
$$\frac{V_{out}(s)}{V_{in}(s)} = \frac{g_mR_L}{1+g_mR_s/2}\,\frac{(1+s/\omega_z)}{(1+s/\gamma\omega_z)} \times \frac{1}{(1+sC_LR_L)}$$

$$\omega_{p2} = \frac{1}{C_LR_L}$$

$$\left|\frac{V_{out}(s)}{V_{in}(s)}\right|_{s=j\omega_{p1}} = A_{DC}\,\frac{|1+j\omega_{p1}/\omega_z|}{|1+j\omega_{p1}/\omega_{p1}|}$$

1) $\omega_z < \omega_{p1} < \omega_{p2}$

2) $\omega_z < \omega_{p2} < \omega_{p1}$



$$\omega_z = \frac{1}{R_sC_s}, \quad \omega_{p1} = \frac{\gamma}{R_sC_s}, \quad \omega_{p2} = \frac{1}{R_LC_L}$$

$$A_{DC} = \frac{g_mR_L}{1+g_mR_s/2}$$

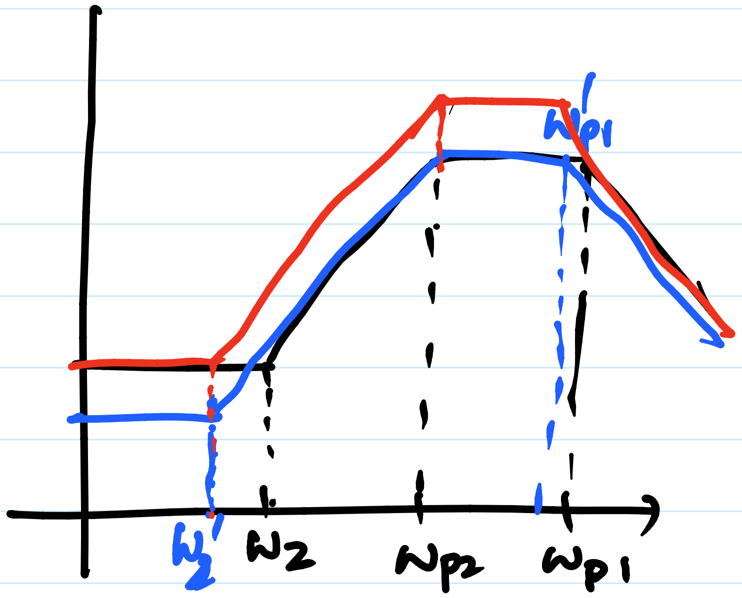
$$\frac{A_{pk}}{A_{DC}} = \frac{A_{DC}\,(\omega_{p1}/\omega_z)}{A_{DC}} = \frac{(1+g_mR_s/2)/C_sR_s}{1/C_sR_s}$$

$$= 1+g_mR_s/2$$

Increase R_s ⟶ A_{pk} increases

A_{DC}

ω_{pk} – frequency w/ max. gain.

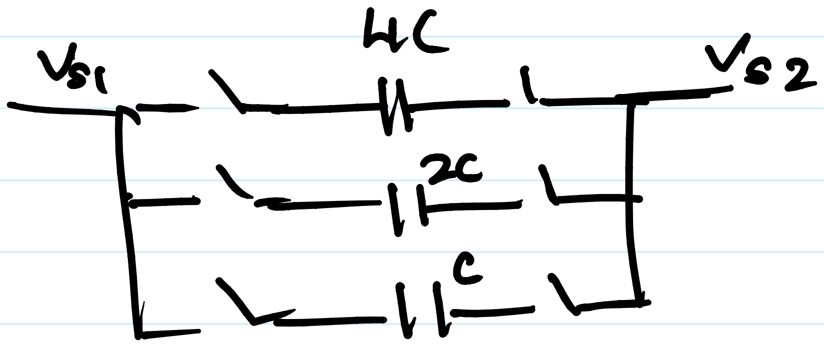


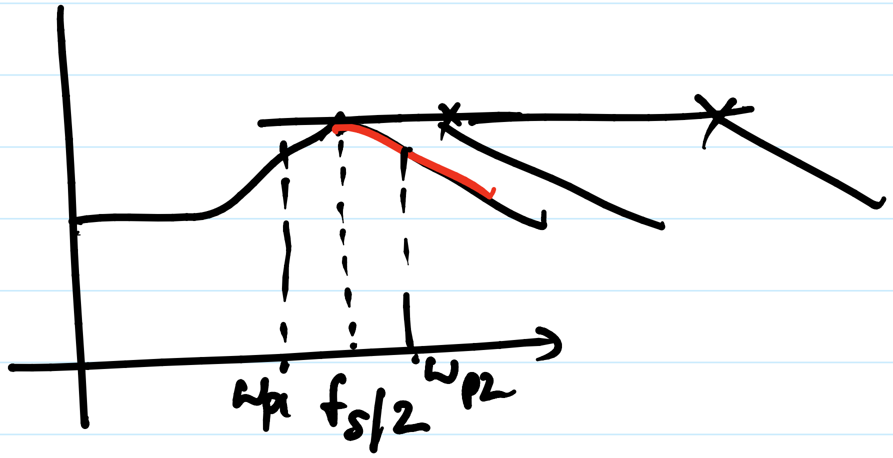
$$\frac{A_{pk}}{A_{DC}} \approx \frac{\cancel{A_{DC}}}{\cancel{A_{DC}}} \frac{(\omega_{p2}/\omega_z)}{\omega_{p2}/\omega_{p2}} = \frac{\omega_{p2}}{\omega_z} = \frac{R_s}{R_L} \frac{C_s}{C_L}$$

$$\frac{A_{pk}}{A_{DC}} \approx \frac{\min(\omega_{p1}, \omega_{p2})}{\omega_z}$$

Increase R_s ⟶ $\frac{A_{pk}}{A_{DC}}$ increases, ω_{pk} unchanged

Increase C_s ⟶ $\frac{A_{pk}}{A_{DC}}$ Increase, ω_{pk} unchanged





$$H_{CTLE}(s) = A_{DC} \frac{(1 + s/\omega_z)}{(1 + s/\gamma\omega_z)(1 + s/\omega_{p2})}$$

$$\frac{d}{d\omega_{pk}} \left(|H_{CTLE}(\omega)| \right) = 0 \quad -(1)$$

$$|H_{CTLE}(s)|_{\omega=\omega_{pk}} = 10\,dB \quad (\text{from channel loss}) \quad -(2)$$

} $\frac{\omega_z}{\omega_{pk}}$, $\frac{\omega_{p2}}{\omega_{pk}}$

$|H_{CTLE}(s)|_{\omega=\omega_{pk}} = 10\,dB$ (from channel loss) — (5)

A_{DC} (choose any value)