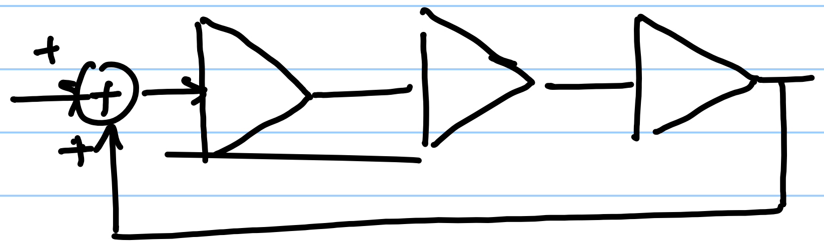
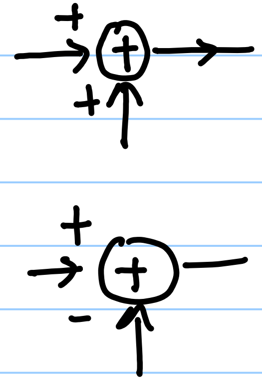
Note Title — lecture # 41 — 20-04-2022





$\frac{}{1-LG}$ ✓

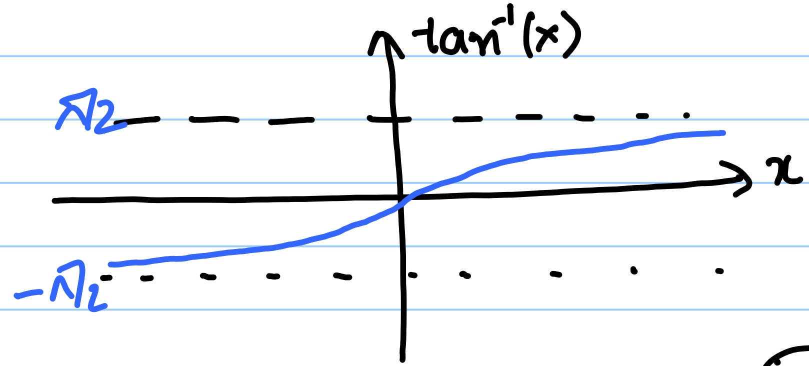
$\frac{}{1+LG}$

$$H(s) = \frac{A_0}{1+s/\omega_p}$$

$$LG = \frac{A_0^3}{(1+s/\omega_p)^3}$$

$$|LG(j\omega_0)| = 1$$

$$\measuredangle LG(j\omega_0) = 2k\pi$$



$$\measuredangle LG = -3\tan^{-1}\left(\frac{\omega}{\omega_p}\right) = +360^\circ, -360^\circ$$

$$\tan^{-1}\left(\frac{\omega}{\omega_p}\right) = 120^\circ$$

$$\tan^{-1}\left(\frac{\omega}{\omega_p}\right) = -120^\circ$$

$$\tan^{-1}(x) = -120^\circ$$

$$\measuredangle LG = -5\tan^{-1}\left(\frac{\omega}{\omega_p}\right) = -360^\circ$$

$$\tan^{-1}(\omega/\omega_p) = 72^\circ$$

$$L_a = \frac{(-A_o)^3}{(1+s/\omega_p)^3}$$

$$L_a = \frac{-A_o^3}{(1+s/\omega_p)^3}$$

$$\measuredangle L_a = -180^\circ - 3\tan^{-1}\left(\frac{\omega}{\omega_p}\right) = -360^\circ$$

$$\tan^{-1}\left(\frac{\omega}{\omega_p}\right) = 60^\circ$$

$$\omega = \sqrt{3}\,\omega_p$$

$$\left|\frac{A_o^3}{(1+j\omega/\omega_p)^3}\right| = 1$$

$$A_o^3 = |1+j\sqrt{3}|^3 \Rightarrow A_o = 2$$

<u>Poles in Closed loop:</u>

$$1+L_a = 0 \Rightarrow 1+\frac{A_o^3}{(1+s/\omega_p)^3} = 0$$

$$\left(1+\frac{s}{\omega_p}\right)^3 = (-1)\cdot A_o^3$$

$$s = \omega_p\left(-1+(-1)^{1/3}\cdot A_o\right).$$

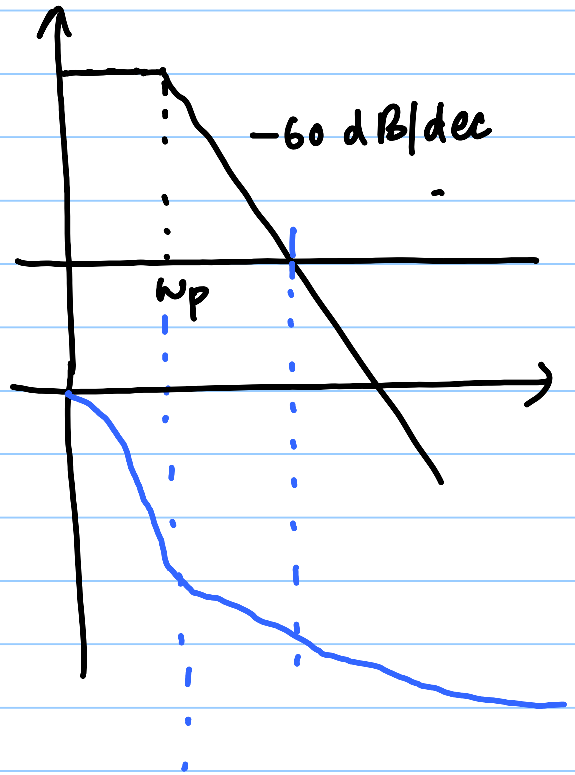
$$= \omega_p\left(-1+2\,e^{j(2m+1)\frac{\pi}{3}}\right)$$

$$= \omega_p\left(-1+2e^{j\pi/3}\right), \checkmark$$

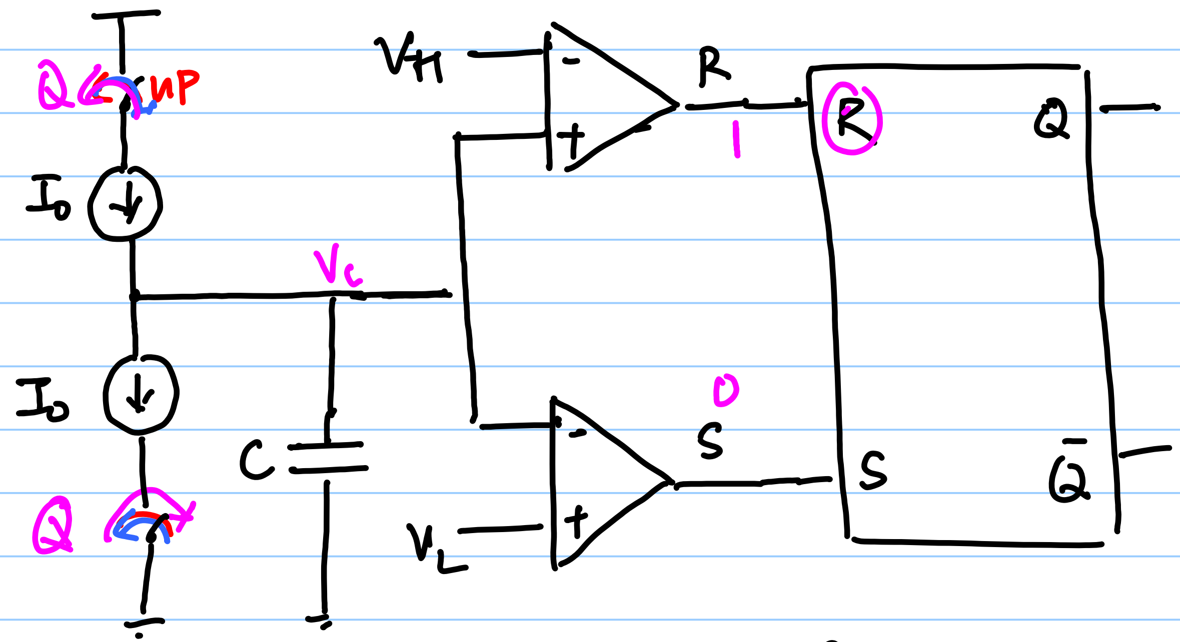
$$\omega_p\left(-1+2e^{j\pi}\right) \checkmark$$

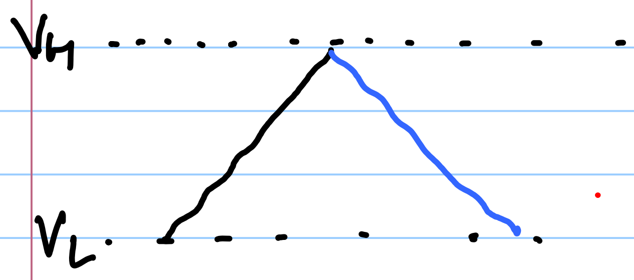
$$\omega_p\left(-1+2e^{-j\pi/3}\right) \checkmark$$

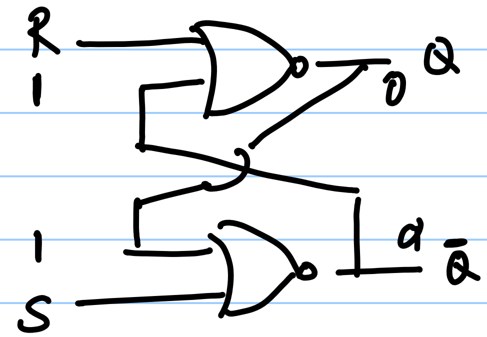
$$u_n = \frac{-A_0^3}{(1+s/\omega_p)^3}$$



Relaxation Oscillator

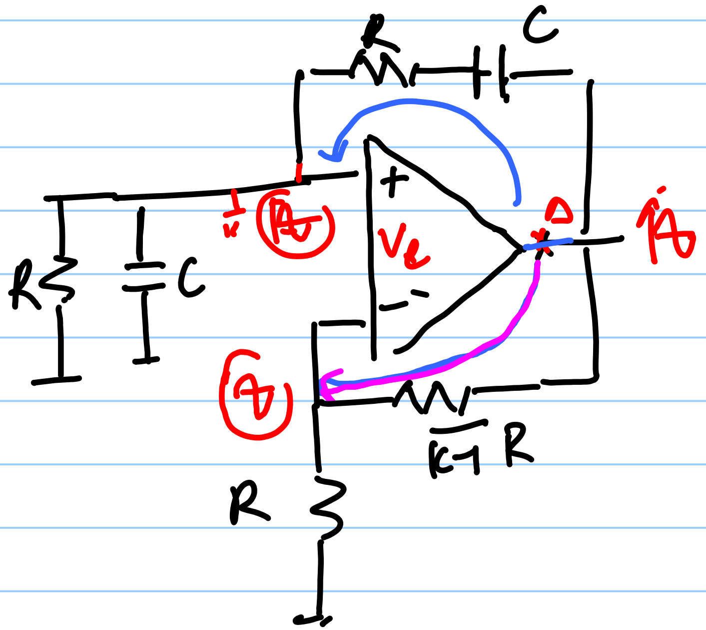


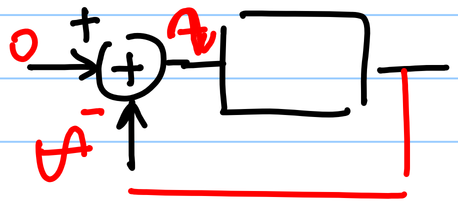




R	S	Q	$\bar{Q}$
1	1	0	0
0	1	1	0
1	0	0	1

Wien Bridge Oscillator





$|L_a| = 1$

$\phi : 2k\pi$

$L_a = \underbrace{\frac{V_+}{\Delta}}' - \frac{V_-'}{\Delta}$

$$\frac{V_+}{\Delta} = \frac{R \| \frac{1}{sC}}{\left(R \| \frac{1}{sC} + R + \frac{1}{sC}\right)}$$

$$= \frac{R / 1+sRC}{\frac{R}{1+sRC} + \frac{1+sRC}{sC}}$$

$$= \frac{sRC}{s^2R^2C^2 + 3sRC + 1}$$

$$= \frac{s/\omega_p}{\frac{s^2}{\omega_p^2} + \frac{3s}{\omega_p} + 1}$$

$\frac{V_e}{\Delta} = L_a$

$\frac{V_-}{\Delta} = \frac{1}{K}$

$$\frac{V_f}{\Delta} = \frac{s/\omega_p}{\frac{s^2}{\omega_p^2} + \frac{3s}{\omega_p} + 1}$$

$$\left|\frac{V_f}{\Delta}\right| = \left| \frac{\omega/\omega_p}{\left(1 - \frac{\omega^2}{\omega_p^2}\right) + j\frac{3\omega}{\omega_p}} \right| = \frac{1}{K} \longrightarrow \left| \frac{1}{j3} \right| = \frac{1}{K}$$

$$\measuredangle \frac{V_f}{\Delta} = 90^\circ - \tan^{-1}\left(\frac{3\omega/\omega_p}{\underbrace{1 - \frac{\omega^2}{\omega_p^2}}} \right) = 2K\pi$$