Note Title — Lecture # 41 — 30-04-2021

Butterworth filter

Fourth-order filter

$$s^{2n} = (-1) = e^{j(2k\pi + \pi)} \qquad k: 0, 1, \ldots, 2n-1$$

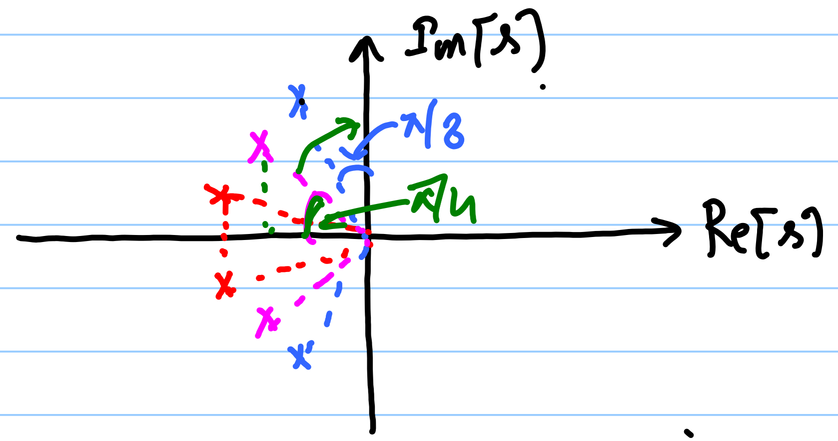
$$s = e^{j\left(\frac{k\pi}{n} + \frac{\pi}{2n}\right)}$$

$$s = e^{j\left(\frac{k\pi}{4} + \frac{\pi}{8}\right)} \qquad k: 0, 1, \ldots, 7$$

$$s = e^{j\pi/8},\ e^{j3\pi/8},\ e^{j\left(\frac{3\pi}{2} + \frac{\pi}{8}\right)},\ e^{j\left(\frac{7\pi}{4} + \pi/8\right)} \qquad \text{R.H.P}$$

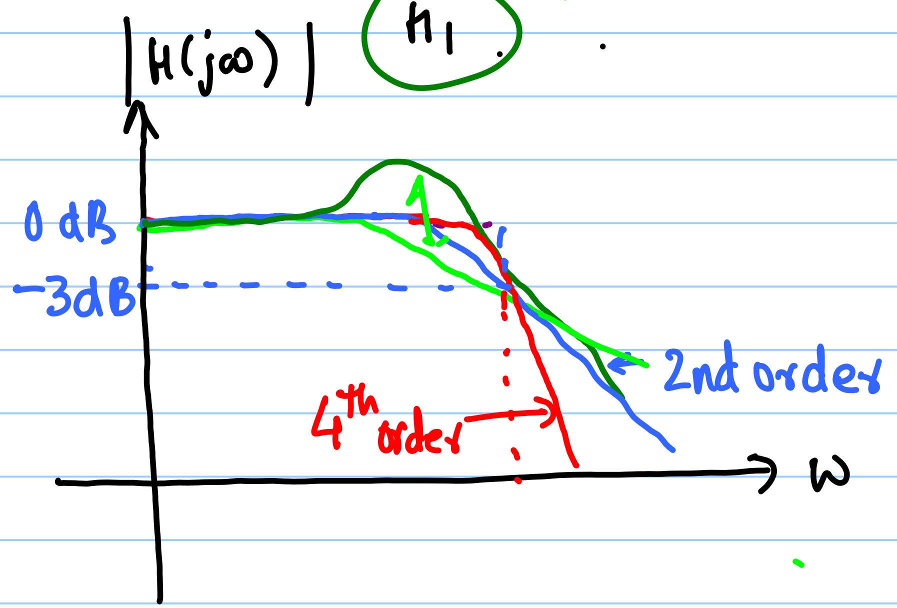
$$e^{j\left(\frac{\pi}{2} + \frac{\pi}{8}\right)},\ e^{j\left(\frac{3\pi}{4} + \frac{\pi}{8}\right)},\ e^{j(\pi + \pi/8)},\ e^{j\left(\frac{5\pi}{4} + \pi/8\right)} \qquad \text{L.H.P}$$

$$\frac{5\pi}{4} + \pi/8 = \frac{3\pi}{2} - \frac{\pi}{8}$$



$$H(s) = \frac{1}{\left\{\left(s+\cos\left(\frac{\pi}{2}+\frac{\pi}{8}\right)\right)^2 + \sin^2\left(\frac{\pi}{2}+\pi/8\right)\right\}\left\{\left(s+\cos\left(\pi-\pi/8\right)\right)^2 + \sin^2\left(\pi-\pi/8\right)\right\}}$$

H_1 $\qquad$ H_2

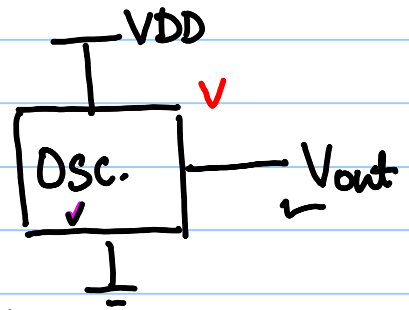


"bi-quad"

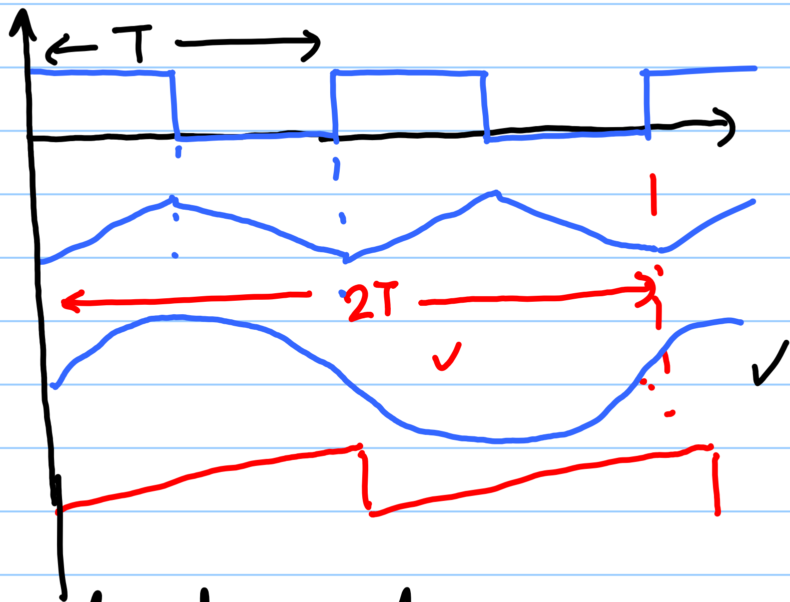
may or may not ✗

will n't have ✓

Oscillator



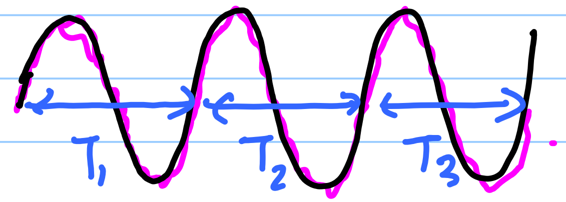
$V_{out} = A \sin(\omega_0 t)$



compare w/ ideal clock.

Vout is periodic in nature with fixed waveform in amplitude and time.

$\omega_0 = \frac{2\pi}{2T}$



$T_1 \neq T_2 \neq T_3$

- Accuracy of frequency
- Noise at the o/p
- Frequency Range

1. Crystal Oscillators : Piezo-Electric Effect

- Highly accurate ✓ $\frac{\Delta F}{F} \times 10^6$ (ppm)

$F = 10\,MHz$, 10 ppm accuracy.

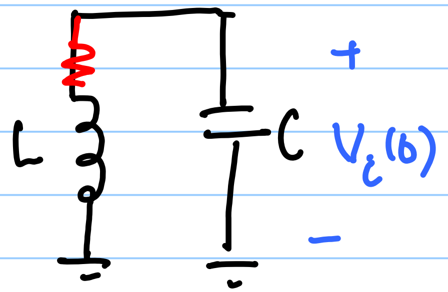
$$\frac{\Delta F}{10 \times 10^6} \times 10^6 = 10$$

$$\Delta F = 100\ Hz$$

- Low Noise.

- Frequency Range is not there

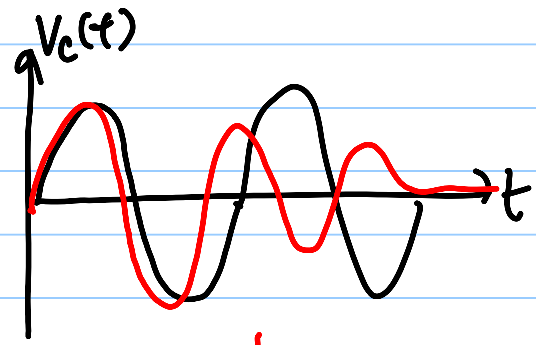
2. LC oscillators.



at $t=0$, $V_c(t) = V_c(0)$

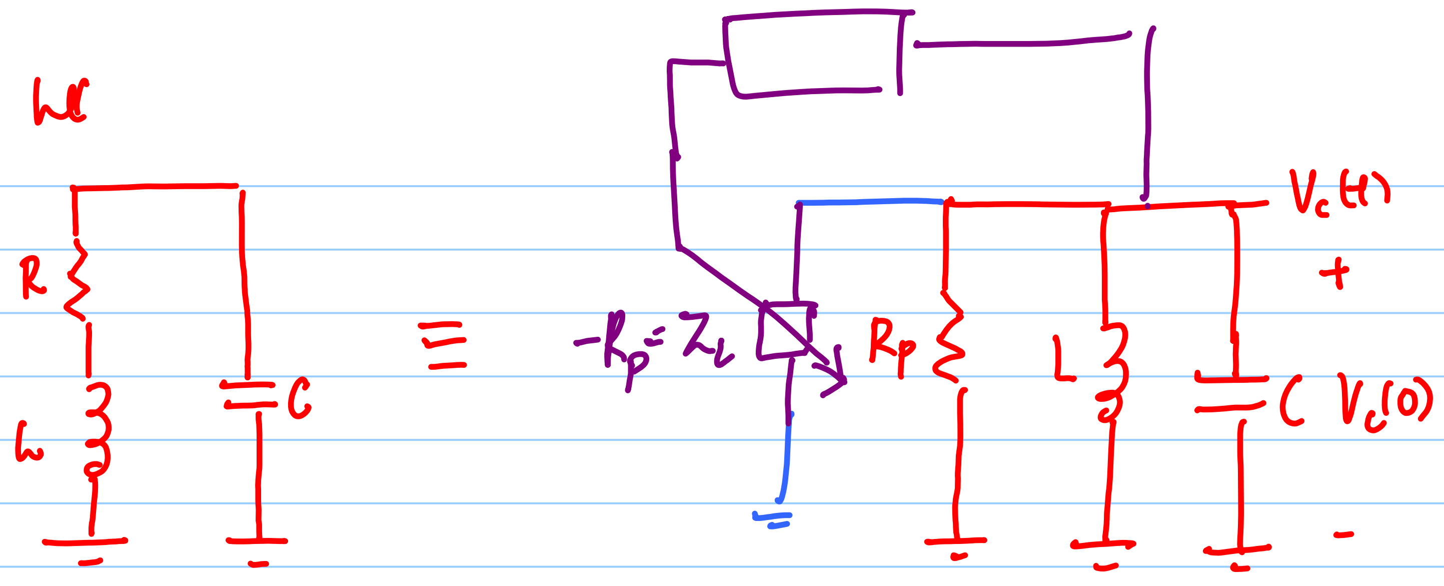
$i_L(t) = 0$

for $t>0$



$\omega_0 = \frac{1}{\sqrt{LC}}$

Real LC

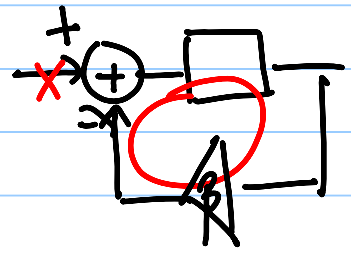


- Accuracy is moderate
- Moderate noise.
- Increased frequency range.

"Barkhausen Crit"

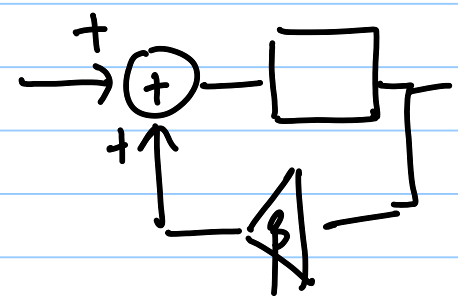
Stability Criterion.

$$\begin{cases} |LG(\omega_0)| = 1 \\ \measuredangle LG(\omega_0) = 2k\pi \end{cases}$$

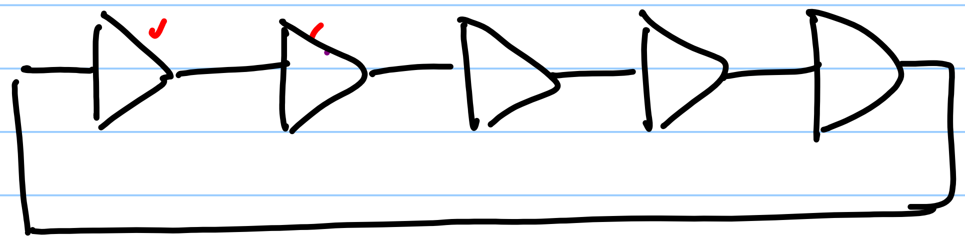


$|LG| = 1$

$\measuredangle LG = 180°$



3) Ring Oscillator



Barkhausen Criterion	Nyquist Stability Criterion
↓	↓
Sustained Oscillations	Stability of a system.
✓ $\lvert LG(\omega_0)\rvert = 1$	→ R.H.P poles.
$\angle LG(\omega_0) = 2k\pi$	→ All pole system $\Rightarrow \phi_m > 0$
	$\phi_m < 0$ ✓
	$\lvert LG(\omega_0)\rvert = 1$, $\angle LG(\omega_0) = 180^\circ$ $\Rightarrow$ Poles to $j\omega$ axis.