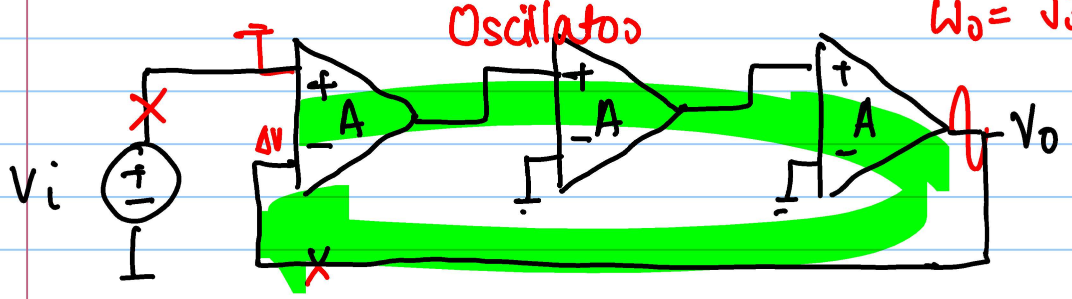
Note Title

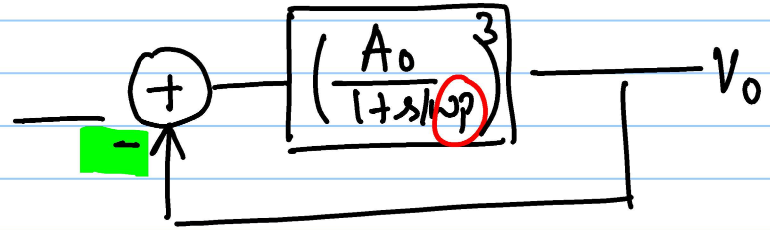
lecture # 42

Ring Oscillator.

1 Amplifier based ring oscillator

$\omega_0 = \sqrt{3}\,\omega_p$ ✓





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

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

$$\frac{V_o}{V_i} = \frac{LG}{1+LG} = \frac{1}{1+\frac{1}{LG}}$$

$$\boxed{\frac{V_o}{V_i} = \frac{1}{1+\frac{(1+s/\omega_p)^3}{\cancel{A_0^3}\ 8}}}$$

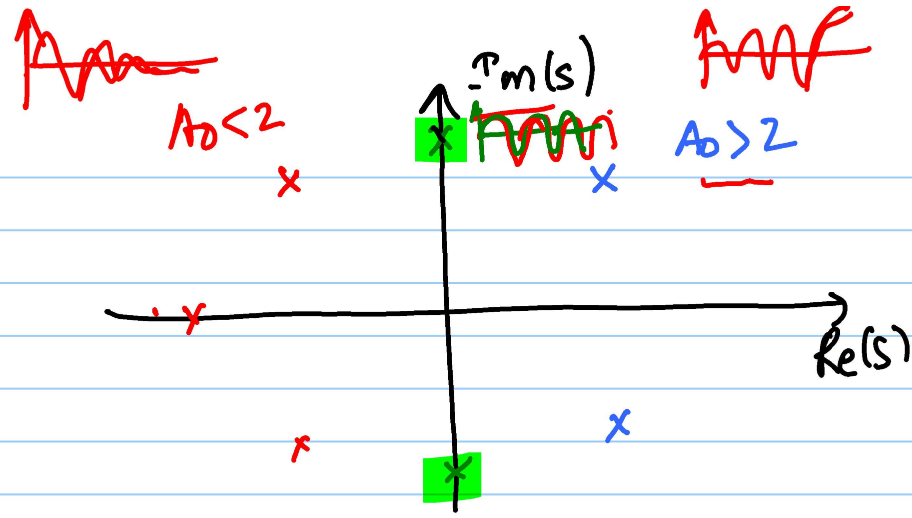
Poles for closed loop tf:

$$1 + \frac{(1+s/\omega_p)^3}{A_0^3} = 0$$

$$(1+s/\omega_p)^3 = -A_0^3 = (-1)\,A_0^3$$

$$= A_0^3\, e^{j(2k\pi + \pi)}$$

$$\frac{s}{\omega_p} = -1 + A_0 e^{j\left(\frac{2k\pi}{3} + \frac{\pi}{3}\right)} \quad ; \; k = 0, 1, 2$$



$$\frac{s}{\omega_p} = -1 + A_0 e^{j\pi/3}, \quad -1 + A_0 e^{j\left(\frac{2\pi}{3}+\frac{\pi}{3}\right)}, \quad -1 + A_0 e^{j\left(\frac{4\pi}{3}+\frac{\pi}{3}\right)}$$

$$= -1 + A_0\left(\frac{1}{2} + \frac{j\sqrt{3}}{2}\right), \quad \underbrace{-1 + A_0(-1)}_{-1-A_0}, \quad -1 + A_0\left(\frac{1}{2} - j\frac{\sqrt{3}}{2}\right)$$

Roots in R.H.P : $-1 + \frac{A_0}{2} > 0 \Rightarrow A_0 > 2$

Roots in L.H.P : $-1 + \frac{A_0}{2} < 0 \Rightarrow A_0 < 2$

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

Barkhausean Criterion.

$$|L_G(\omega_0)| = 1$$

$$\measuredangle L_G(\omega_0) = 2k\pi$$

$$|L_G(\omega_0)| = \left|\left(\frac{A_0}{1+j\frac{\omega_0}{\omega_p}}\right)^3\right| = 1$$

$$\measuredangle L_G(\omega_0) = +180^\circ - 3\tan^{-1}\left(\frac{\omega_0}{\omega_p}\right) = \pm 2k\pi$$

$$-3\tan^{-1}\left(\frac{\omega_0}{\omega_p}\right) = -180^\circ \quad ; k=0$$

$$\frac{\omega_0}{\omega_p} = \tan(60^\circ)$$

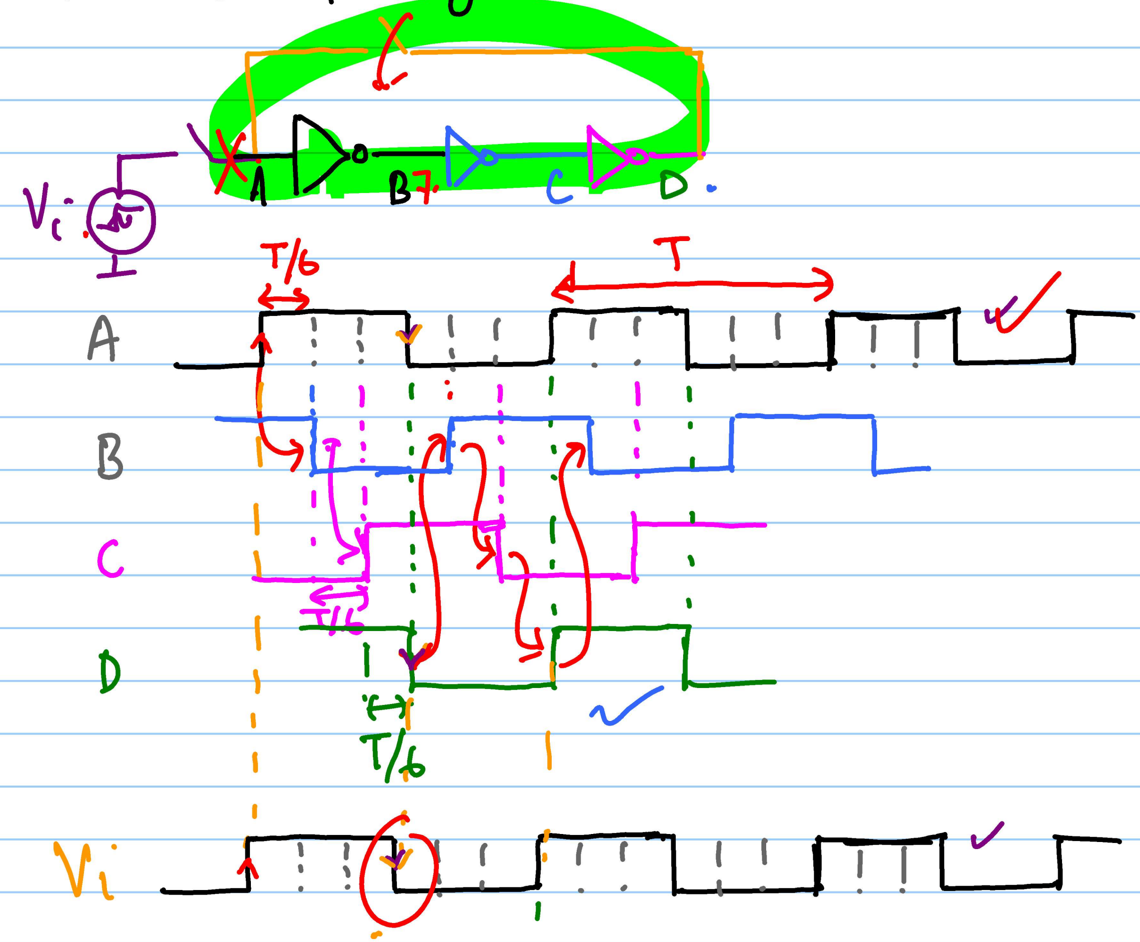
$$\boxed{\omega_0 = \sqrt{3}\,\omega_p}$$

$$\left|\left(\frac{A_0}{1+j\frac{\sqrt{3}\,\omega_p}{\omega_p}}\right)^3\right| = 1$$

$$\Rightarrow \frac{A_0^3}{2^3} = 1$$

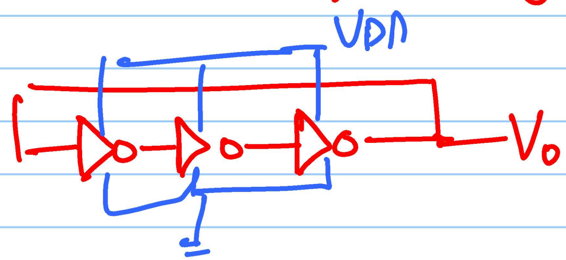
$$\boxed{A_0 = 2}$$

Inverter-based Ring Oscillator.

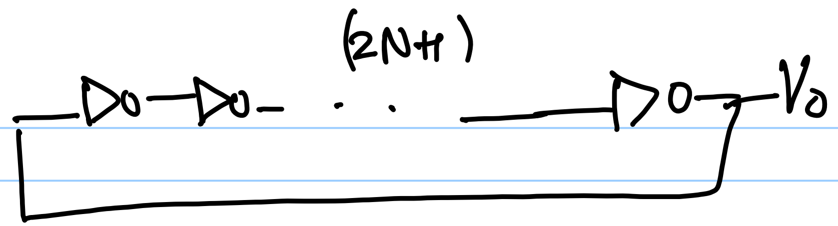


For inverter i/p to o/p delay is $T/6$

Inverter delay $= \frac{T}{6}$



$f_o = \frac{1}{T}$

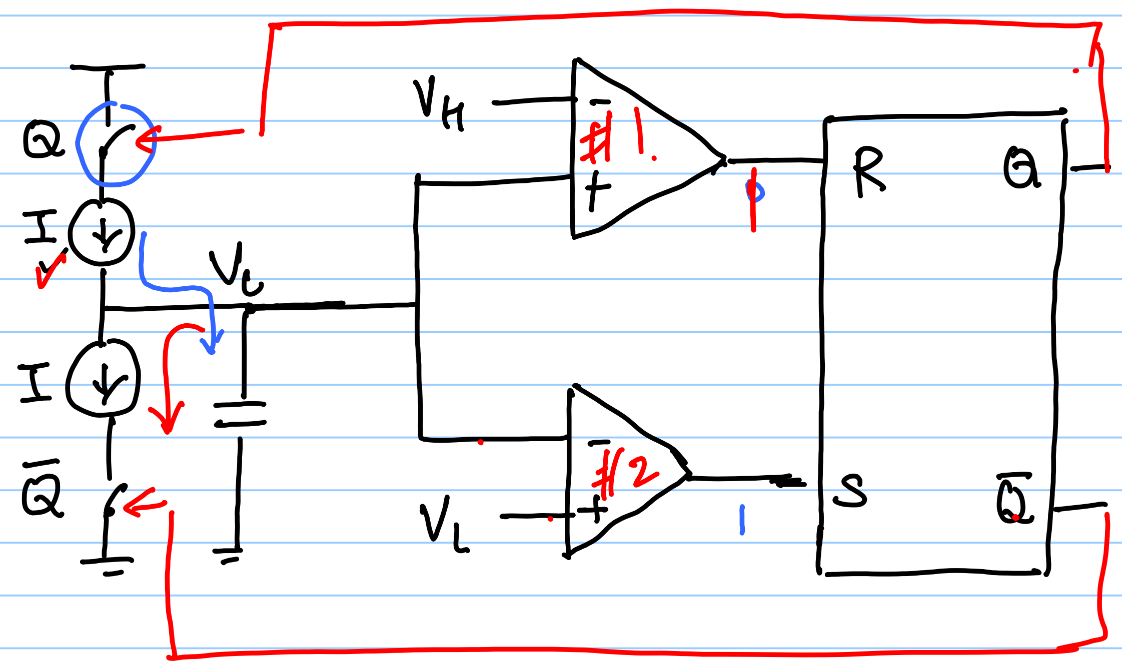


$$t_d = \frac{T}{2(2N+1)}$$

$$f_o = \frac{1}{T}$$

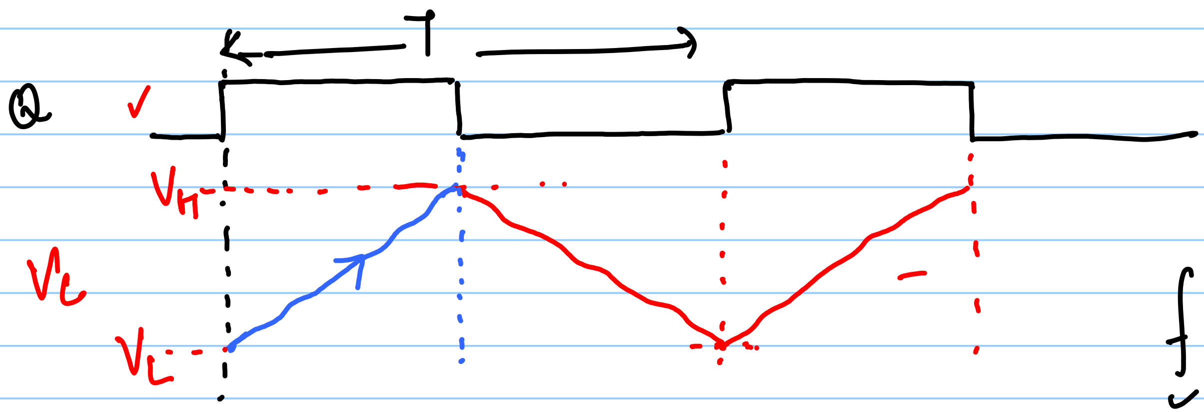
- Frequency stability ΔF (ppm) is poor
- Noise is more
- Large tunability
- Area is small.

Relaxation Oscillators.



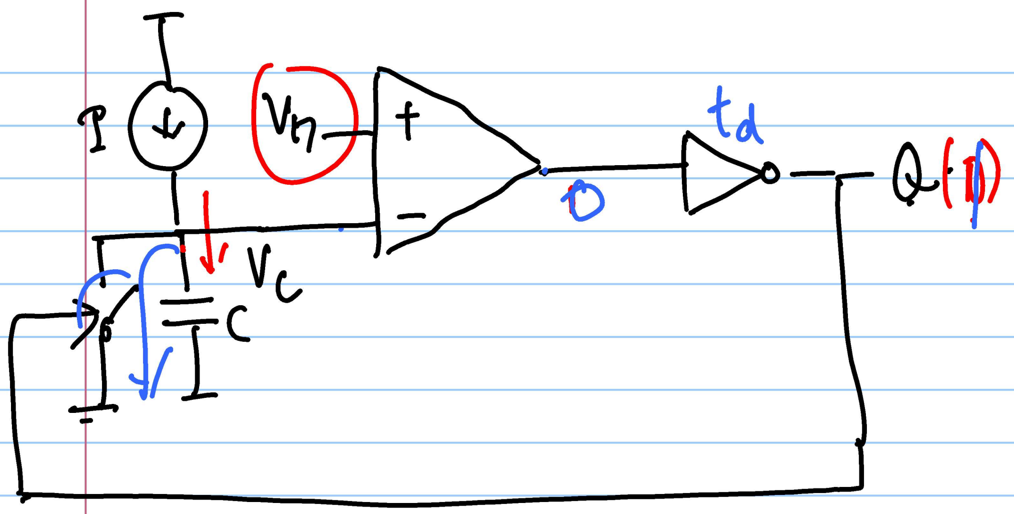
R	S	Q	$\bar{Q}$
0	0	Latch	Latch
1	0	0	1
0	1	1	0
1	1	0	0

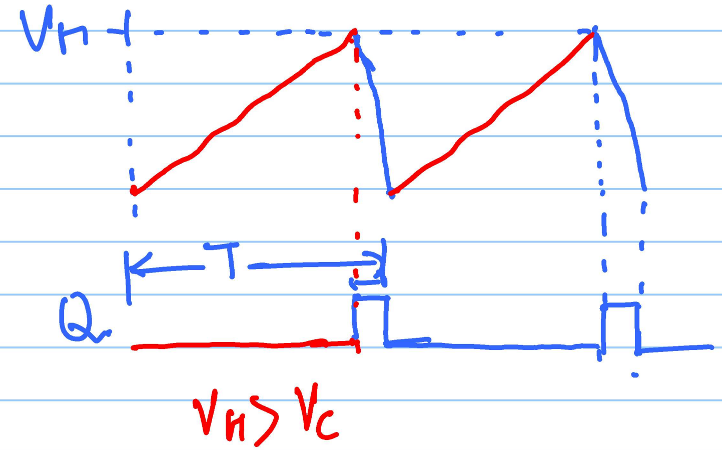
- Switch is ON for signal value 1
- Switch is Off for signal value 0.



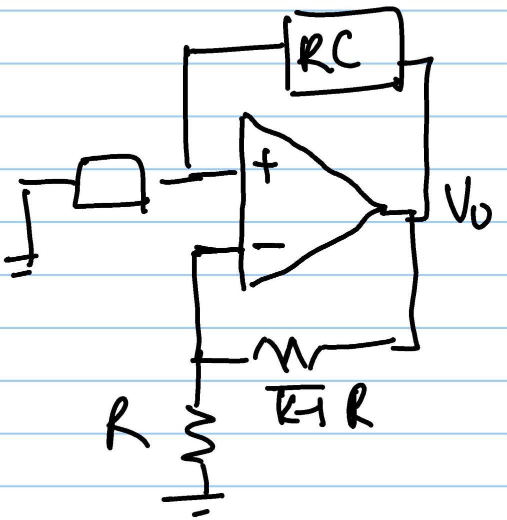
$$I \cdot \frac{T}{2} = C\,(V_H - V_L)$$

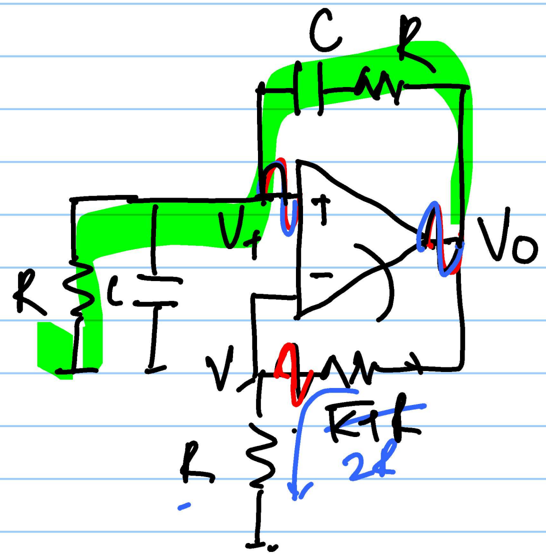
$$f = \frac{1}{T} = \frac{I}{2C\,(V_H - V_L)}$$





Wien Bridge Oscillator.





$$\frac{V_+}{V_0} = \frac{sRC}{1 + 3sRC + s^2R^2C^2}$$

$$\angle\left(\frac{V_+}{V_0}\right) = 0 \quad @ \quad \omega = \frac{1}{RC}.$$

$$\left|\frac{V_+}{V_0}\right|_{\omega = 1/RC} = \frac{V_0}{3}$$

$$V_- = \frac{V_0}{3} = \frac{1}{K} V_0$$

$K = 3$

Gain of non-inverting amp. is > 3.