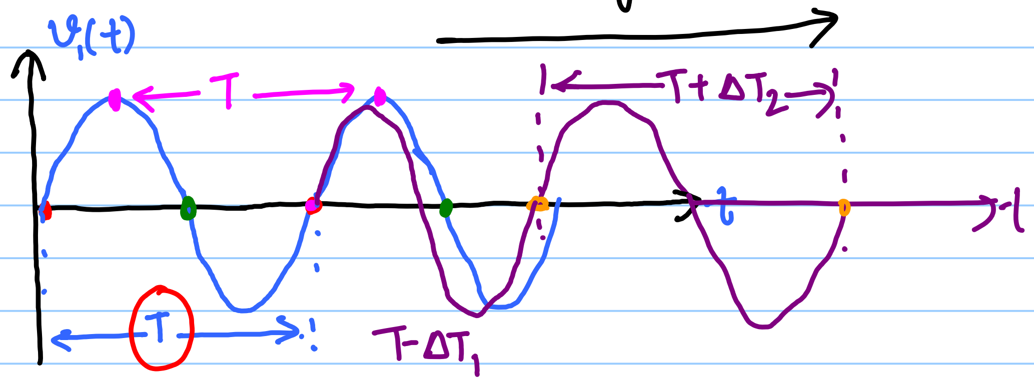
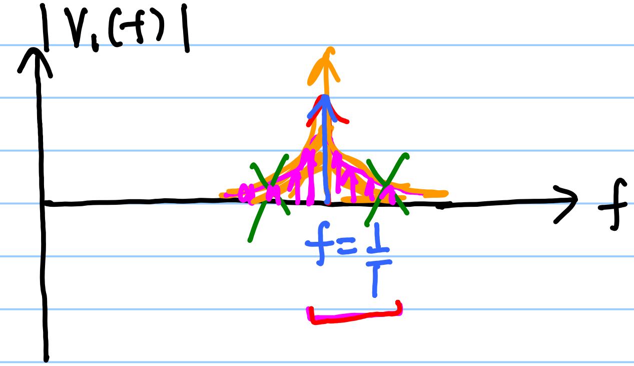
Note Title 14-05-2020

Lecture # 02

RF Ckts.



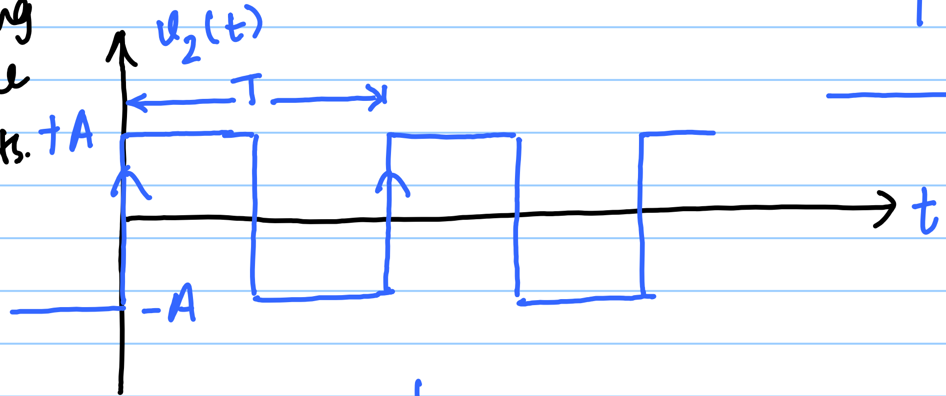
$\xrightarrow{\mathcal{F}}$



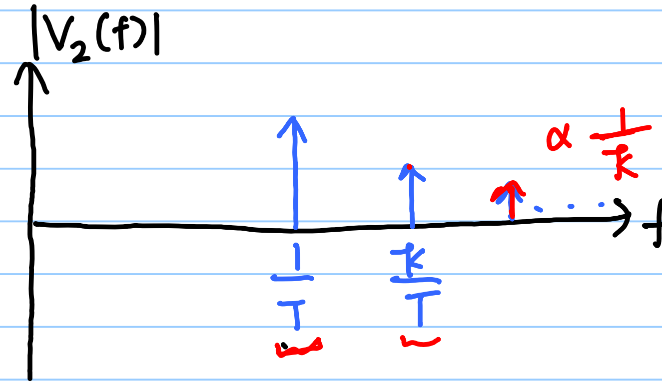
$$v_1(t) = A\sin(\omega_0 t)$$
$$= A\sin\left(2\pi \times \frac{1}{T} t\right)$$

freq. of sine wave, $f = \frac{1}{T}$

Sampling
Wireline
Dig. Ckts.



$\xrightarrow{\mathcal{F}}$



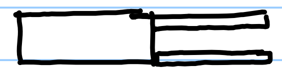
$f = \frac{1}{T}$

$$v_2(t) = \sum a_n \cos(n w_0 t) + b_n \sin(n w_0 t)$$

$$w_0 = \frac{2\pi}{T}$$

$$\boxed{0 < f = \frac{1}{T} \leq 20\text{-}30 \text{ GHz}}$$

1. <u>Crystal Oscillator.</u>



Piezo-electric devices → Voltage / Current / signal. sinusoidal

- Periodicity depends on the geometry of crystal.

$f_{crystal} \leq$ 100 MHz

- Frequency of oscillations has least variation. $E[\Delta T^2]$ is minimum, ΔT_{max} is also Limited, $E[\Delta T] = 0$

Time period of sine waves

$v_1(t)$:

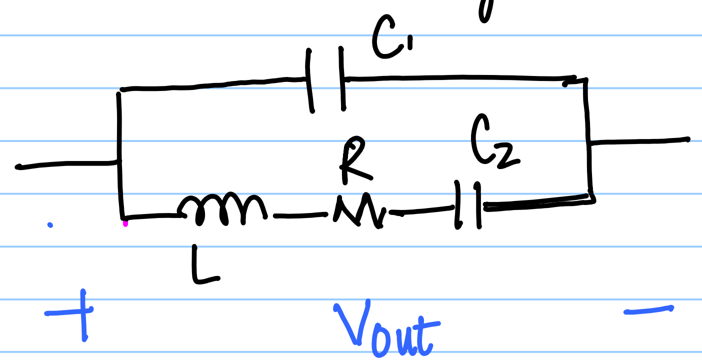
- T
- $T + \Delta T_1$
- $T + \Delta T_2$
- $T - \Delta T_3$

⋮

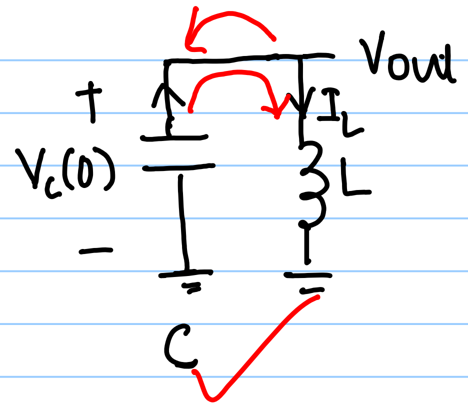
ΔT is a random variable

Avg. time period $= E[T] = \lim_{N \to \infty} \frac{1}{N} \sum_{i=0}^{N-1} T_i = T + E[\Delta T] = T$

Electrical model of a crystal osc.



- V_{out} is sinusoidal nature.
- $f \propto \frac{1}{\sqrt{LC}}$



at $t=0$, $\quad V_{out} = V_c(0)$

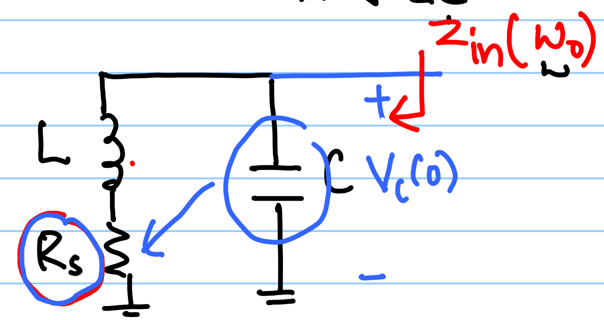
$I_L = 0$

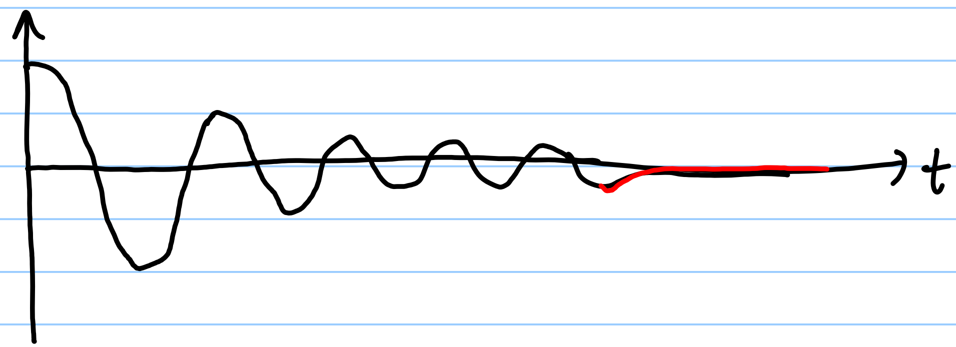
$$\left.\begin{aligned} -C\frac{dV_{out}}{dt} &= I_L \\ V_{out} &= L\frac{dI_L}{dt} \end{aligned}\right\}$$

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

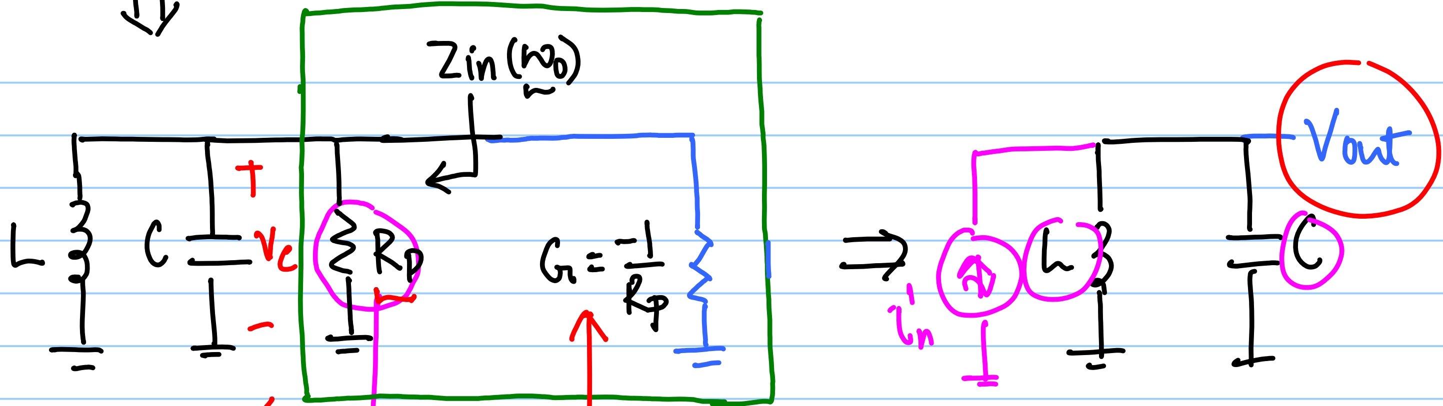
$$2\pi f_0 = \omega_0 = \frac{1}{\sqrt{LC}}$$

$$f_0 = \frac{1}{2\pi\sqrt{LC}}$$



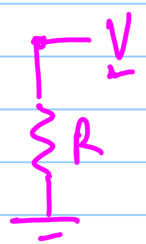


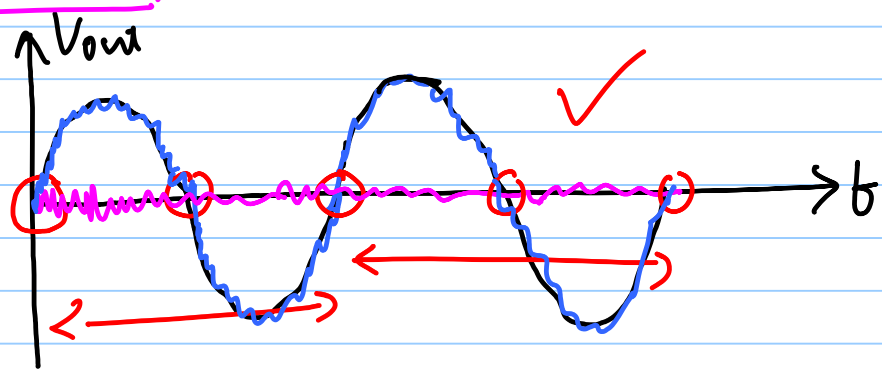
$\Downarrow$



Active Circuit.

$$\frac{\overline{v_n^2}}{\Delta f} = 4kTR$$





$$T \neq 2\pi\sqrt{LC}$$

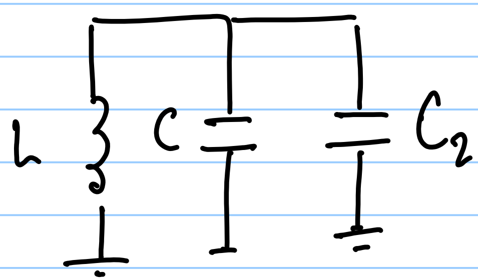
- We can realize higher frequency clock source with L & C.
- We added noise to clock source.
- Output frequency varies with L & C.

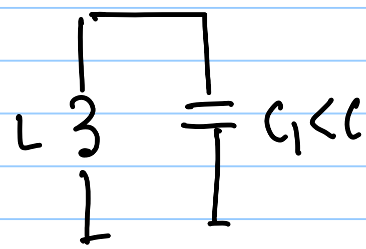
$$\omega_0 = 1\ \text{Grad/s} = \frac{1}{\sqrt{10^{-9} \times 10^{-9}}} = \frac{1}{\sqrt{1.05 \times 10^{-9} \times 1.0001 \times 10^{-9}}}$$

$10^{-9} \rightarrow$ 1nH, +0.05 nH

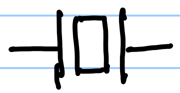
$10^{-9} \rightarrow$ 1nF, +0.1 pF

- Tunable inductor or capacitor to vary frequency.





Crystal



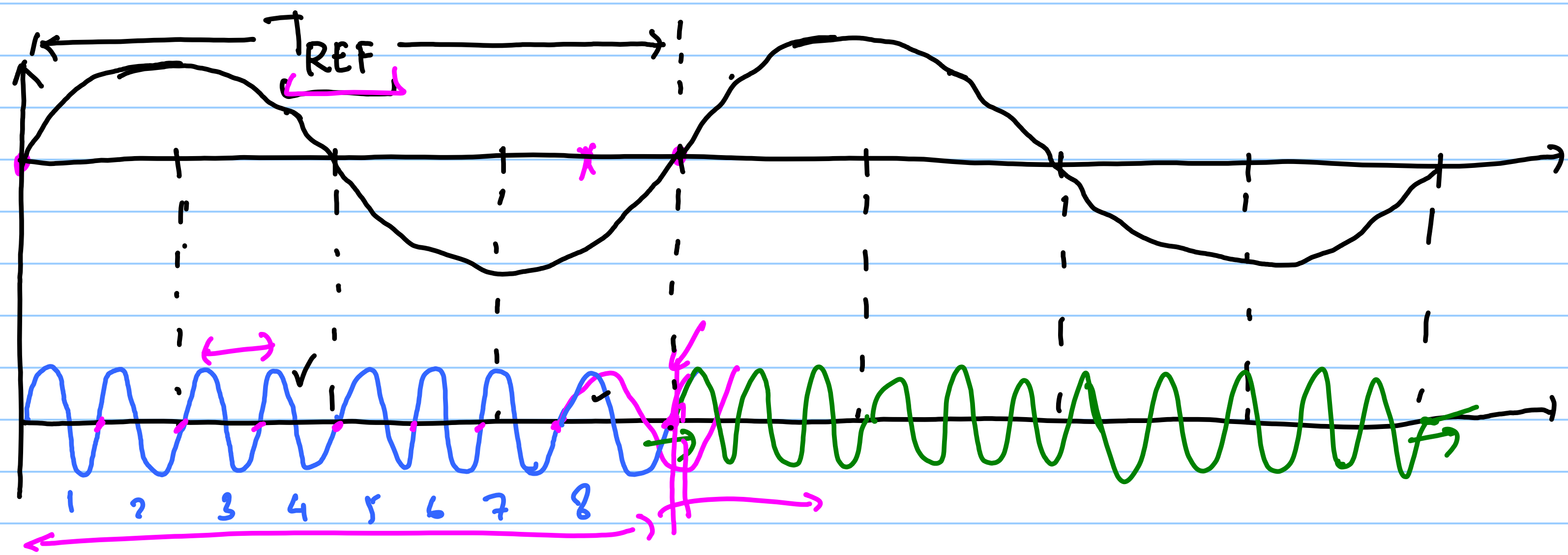
$\lesssim 100$ MHz

Least Variation in T

No tunability.

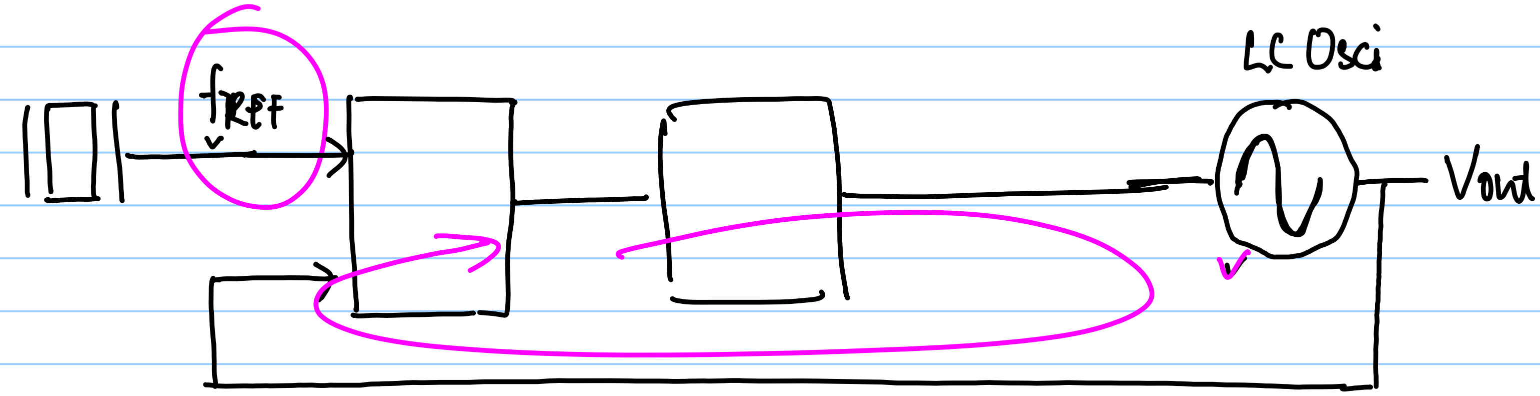
LC Oscillator

- frequency as desired.
- More variation in T
- Tunability as desired.



Choose L & C, $f_0 = \frac{8}{T_{REF}} = 8 f_{REF}$

We desire $f_0 = 8 f_{REF}$



Phase / Frequency locked loop.

$V_{ref}(t) = \sin(\omega_{ref} t)$

$V_{out}(t) = \sin(\omega_{out} t)$

$= \sin(\underbrace{\omega_0 t + \Phi_n(t)})$

fixed Variation.

$\Phi_{out}(t) = \omega_{out} t$

$= \int \omega_{out} \cdot dt$

Phase of o/p signal ; $\Phi_{out}(t) = \omega_0 t + \Phi_n(t) =$

Phase of i/p signal : $\Phi_{in}(t) = \omega_{ref} t$ ✓

Assume $\omega_0 = \omega_{ref}$, $\Phi_{out}(t) = \omega_{ref} t + \Phi_n(t)$ ✓

$\Phi_\varepsilon(t) = \Phi_{in}(t) - \Phi_{out}(t)$

$= (\omega_{ref} - \omega_0)t - \Phi_n(t)$

Frequency of output sine wave, $\omega_{out} = \dfrac{d\Phi_{out}(t)}{dt}$ ✓

$\omega_{out} = \omega_0 + \dfrac{d\Phi_n(t)}{dt}$

$W_{out} = \omega_{ref}$ I want

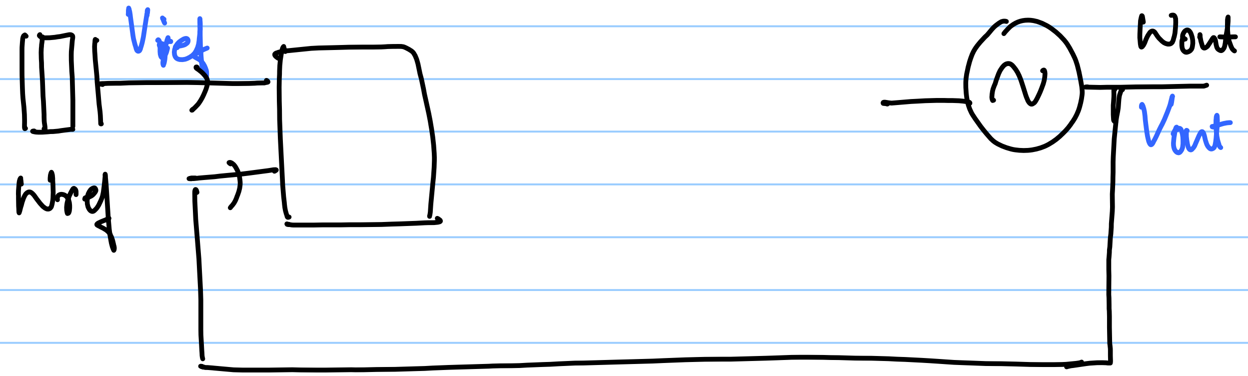
$$\cancel{W_{ot}} \; \frac{d\Phi_n(t)}{dt} = \omega_{\cancel{ref}}$$

$$\underbrace{\frac{d\Phi_n(t)}{dt} = 0}\; \not\Rightarrow \; \Phi_n(t) = 0$$

V_{out} and V_{ref} are locked in frequency and phase.

$$\downarrow \qquad\qquad\qquad \downarrow$$

$$W_{out} = \omega_{ref} \qquad \underbrace{\frac{d\Phi_E}{dt} = 0} \Rightarrow \frac{d\Phi_n(t)}{dt} = 0$$



$$\begin{cases} \omega_{out} = \omega_{ref}. \\ \dfrac{d\Phi_\varepsilon}{dt} = 0 \end{cases}$$