Online Lecture #1 - Implementation of FM Modulator

Wednesday, March 18, 2020 9:02 AM

Voltage controlled oscillator:

$$s_{FM}(t) = A_c \cos\Big(2\pi f_c t + \underbrace{2 k_f \int_0^t m(\tau)d\tau}_{=\theta(t)}\Big)$$

$$f_i(t) = \frac{1}{2\pi}\frac{d\theta(t)}{dt} = f_c + k \cdot m(t)$$ ← varies linearly with $m(t)$.

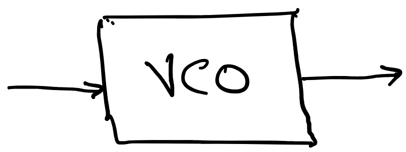
To implement an FM modulator, we need an oscillator with an oscillation frequency that can vary vs. time.

For this purpose we use a voltage controlled oscillator (VCO).

V_{ctrl}

$m(t)$

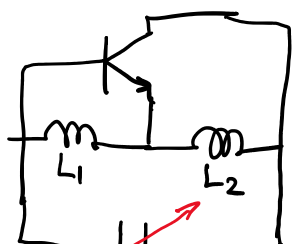
varying vs time



$s_{out}(t)$ signal that has a frequency f_i = function of V_{ctrl}

linear relationship → $f_i(t) = f_c + \Delta f \cdot m(t)$

Example of a VCO: Hartly Oscillator



$f_{osc} = f(L_1, L_2, C)$

$C(t)$

$\propto \cdot m(t)$

→ $f_i(t) = f(C(t))$

We can show that if $C(t) = C_0 + \Delta C \cos(2\pi f_m t)$ — linear relationship

Then we can approximate: $\boxed{f_i(t) \simeq f_0 + \Delta f \cdot \cos(2\pi f_m t)}$

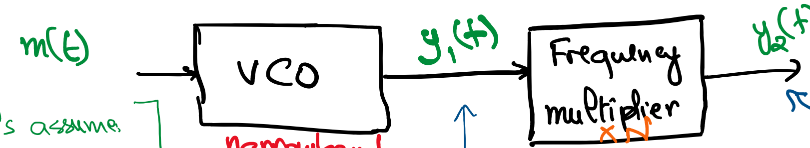
this approximation is valid only when: $\left|\frac{\Delta f}{f_0}\right| = \left|\frac{\Delta C}{2C_0}\right| \ll 1$

$\neq \beta$

Δf should be small → more suitable for narrowband FM

Δf should be small $\rightarrow$ more suitable for narrowband FM $\neq \beta$

* Implementation of wideband FM:



wider band than $y_1(t)$.

[let's assume $\max_t |m(t)| = 1$]

narrowband FM modulator

$$f_{i_1}(t) = f_0 + \Delta f \cdot m(t)$$

$$\beta_1 = \frac{\Delta f}{f_m}$$

$$f_{i_2}(t) = f_{i_1}(t) \cdot N$$
$$= N f_0 + N \Delta f \; m(t)$$

$$\beta_2 = \frac{N \cdot \Delta f}{f_m} = N \cdot \beta_1$$