Department of Communications Engineering

Communication Systems

Third Year Class

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Lecture 10

Phase Locked Loop

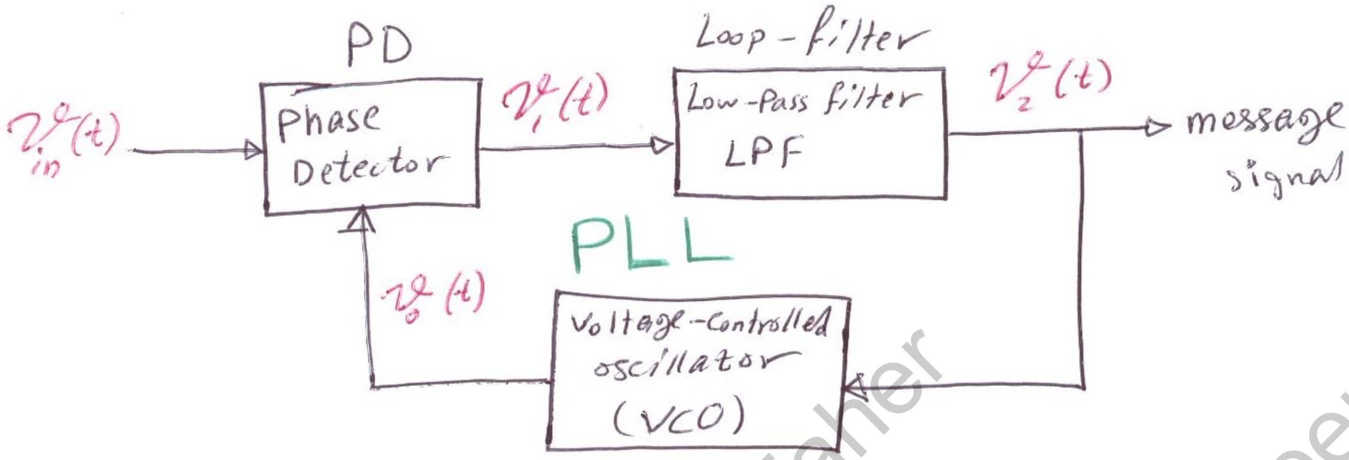
Phase-Locked Loop : PLL

* All the previous methods are non-coherent Demodulation method for FM signals.

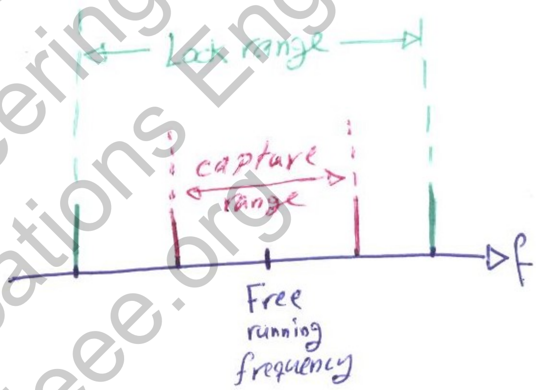
* PLL is a coherent method indirect FM Demodulation.

* PLL consists of :
  1. Phase Detector (PD).
  2. Loop Filter (Low pass filter).
  3. Voltage Controlled oscillator (VCO).

* There are two types of PLL
  1. Analog
  2. Digital



The PLL has three States :



① Free running state,

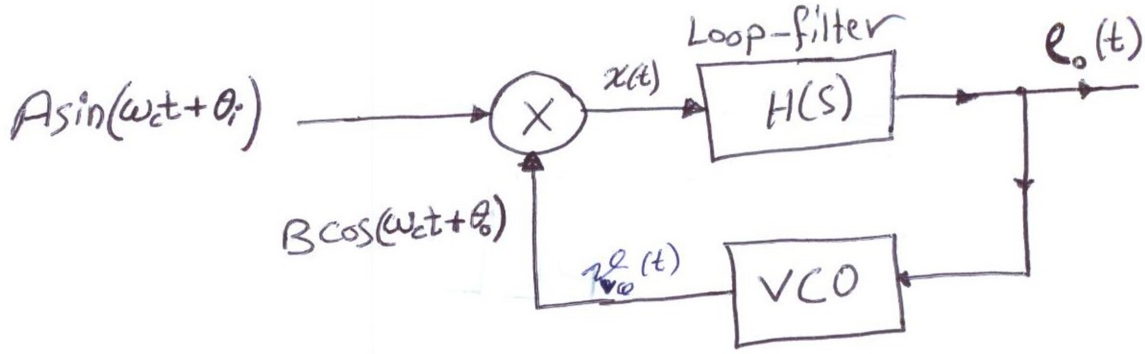
② Capture state, and

③ Lock range (Hold-in range) State

(② and ③ will be defined soon)

* Free running : is the frequency when there is no input to the VCO.

or $v_2(t) = 0$.



* suppose the VCO frequency oscillation is :

$$\omega(t) = \omega_c + c\, e_o(t) \quad \text{——(1)}$$

c is the VCO constant
ω_c is the free running VCO frequency.

* Let the VCO output be

$$v_{vco}(t) = B\cos(\omega_c t + \theta_o) \quad \text{——(2)}$$

* Let the input to the PLL be

$$v_{in}(t) = A\cos(\omega_c t + \theta_i) \quad \text{——(3)}$$

$$\therefore\ x(t) = AB\sin(\omega_c t + \theta_i)\cos(\omega_c t + \theta_o)$$

$$x(t) = \frac{AB}{2}\left[\sin(\theta_i - \theta_o) + \underbrace{\sin(2\omega_c t + \theta_i + \theta_o)}\right] \quad \text{——(4)}$$

suppressed by the narrowband LPF Loop filter

$$\therefore\ e_o(t) = \frac{AB}{2}\sin\underbrace{(\theta_i - \theta_o)}_{\theta_e} \quad \text{——(5)}$$

* Suppose that the Loop is **Locked** :

∴ input frequency to the PD & output frequency from the PLL are identical.

∴ θ_i , θ_o , & θ_e are constants

* Suppose the input frequency increased suddenly :

$$v_{in}(t) = A\cos[(\omega_c + k)t + \theta_i] \longrightarrow (6)$$

or

$$v_{in}(t) = A\cos(\omega_c t + \hat{\theta}_i) \longrightarrow (7)$$

where $\hat{\theta}_i = kt + \theta_i \longrightarrow (8)$

Thus, the increase in the incomming frequency causes θ_i to increase

$\theta_i \longrightarrow \theta_i + kt \longrightarrow \theta_e$ increased

Hence $e_o(t)$ increases, Leading to increase in the output of the VCO frequency

* Suppose the incomming frequency decreased suddenly :-

$\therefore \theta_i \longrightarrow \theta_i - kt \longrightarrow \theta_e$ decreased

$\therefore$ the output frequency of the VCO decreased

Thus, the PLL tracks the input sinusoid. The two signals are said to be mutually Phase Coherent or in phase Lock.

* A PLL Can track the incomming frequency over a finite range:

* the PLL tracks the frequency change over a range of frequencies,
* the tracking range is called Hold-in or Lock range.

* If input/output frequencies are not close enough the Loop may not Lock.

The range of frequencies over which the input will cause the Loop to Lock is called pull-in or capture range.