Principles of Communication (BEC-28)

Unit-2

Angle Modulation

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Content of Unit-2

Introduction to Angle Modulation: Frequency modulation, Narrowband and Wideband FM, Generation of FM waves, direct FM and Indirect FM, FM modulators and demodulators, Phase locked loop, Angle Modulation by Arbitrary Message Signal, Phase Modulation, Pre-emphasis and De-emphasis, Linear and Nonlinear Modulation, Comparison between Angle Modulation and Amplitude Modulation, Radio Receivers.

FM Detection/Demodulation

- Is a process of getting back or regenerate the original modulating signal from the modulated FM signal.
- It can be achieved by converting the frequency deviation of FM signal to the variation of equivalent voltage.
- The demodulator will produce an output where its instantaneous amplitude is proportional to the instantaneous frequency of the input FM signal.
- To detect an FM signal, it is necessary to have a circuit whose output voltage varies linearly with the frequency of the input signal

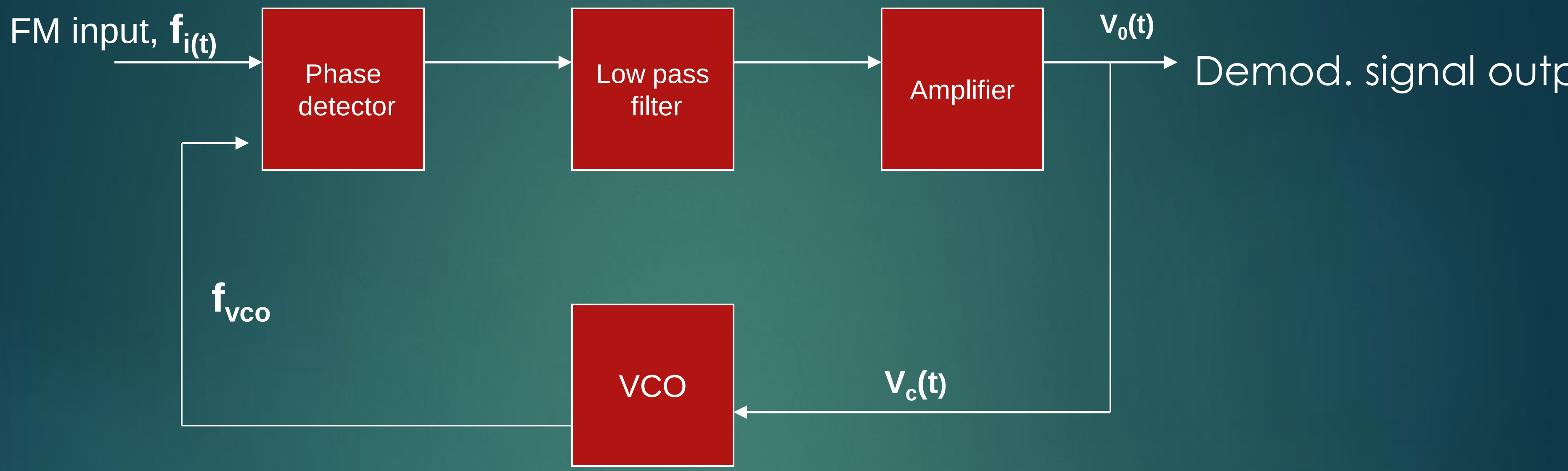
Several types of FM demodulators :

(a) PLL (Phase-Locked Loop) demodulator
(b) Slope detection / FM discriminator
(c) Foster-Seeley Phase-Shift discriminator
(d) Ratio detector
(e) Quadrature FM detector

Except for PLL, others are traditional FM detectors having tuned circuits for detection.

The most commonly used demodulator presently is the PLL demodulator because of its simplicity and small size. Can be use to detect either NBFM or WBFM.

PLL Demodulator



- The phase detector produces an average output voltage that is linear function of the phase difference between the two input signals. Then the low frequency component is passed through the LPF to get a small DC average voltage to the amplifier.
- After amplification, part of the signal is fed back through VCO where it results in frequency modulation of the VCO frequency. When the loop is in lock, the VCO frequency follows or tracks the incoming frequency.

Cont…

- Let instantaneous freq of FM Input,
  $f_i(t)=f_c + k_1 v_m(t)$,

  and the VCO output frequency,
  $f_{VCO}(t)=f_0 + k_2 V_c(t)$;
  f_0 is the free running frequency.

- For the VCO frequency to track the instantaneous incoming frequency,
  $f_{vco} = f_i$; or

- $f_0 + k_2V_c(t)= f_c + k_1v_m(t)$, so,

$$V_c(t) \propto f_c - f_0 + k_1 v_m(t)$$

- If VCO can be tuned so that $f_c=f_0$, then

$$V_c(t) \propto k_1 v_m(t)$$

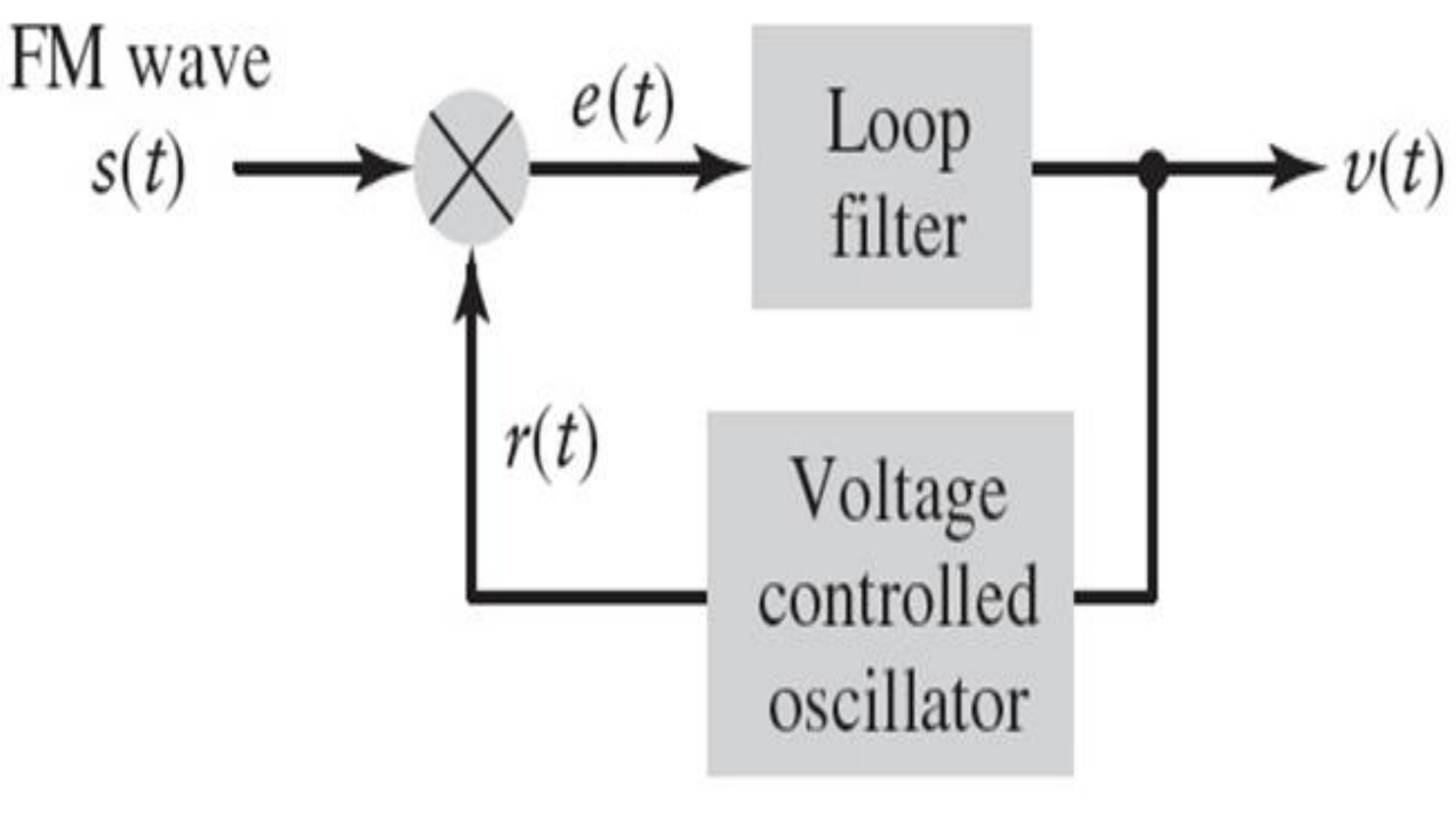
Where $V_c(t)$ is also taken as the output voltage, which therefore is the demodulated output

PLL Demodulator

- Phase-Locked Loop
  - A feedback system whose operation is closely linked to frequency modulation
  - Three major components
    - Voltage-controlled oscillator (VCO)
    - Multiplier
    - Loop filter of a low-pass kind

  - VCO has bee adjusted so that when the control signal is zero, two conditions are satisfied
    1. The frequency of the VCO is set precisely at the unmodulated carrier frequency fc of the incoming FM wave s(t)
    2. The VCO output has a 90°-degree phase-shift with respect to the unmodulated carrier wave.

Block diagram of Phase-Locked Loop



Cont...

- Suppose the incoming FM wave is

$$s(t) = A_c \sin[2\pi f_c t + \phi_1(t)]$$

$$\phi_1(t) = 2\pi k_f \int_0^t m(\tau)d\tau$$

- The FM wave produced by the VCO as

$$r(t) = A_v \cos[2\pi f_c t + \phi_2(t)]$$

$$\phi_2(t) = 2\pi k_v \int_0^t v(\tau)d\tau$$

- The multiplication of the incoming FM wave by the locally generated FM wave produces two components
  - A high-frequency component

$$k_m A_c A_v \sin[4\pi f_c t + \phi_1(t) + \phi_2(t)]$$

  - A low-frequency component

$$k_m A_c A_v \sin[\phi_1(t) - \phi_2(t)]$$

- Discard the double-frequency term, we may reduce the signal applied to the loop filter to

$$e(t) = k_m A_c A_v \sin[\phi_e(t)]$$

- The phase error is

$$\phi_e(t) = \phi_1(t) - \phi_2(t)$$
$$= \phi_1(t) - 2\pi k_v \int_0^t v(\tau) d\tau$$

$$\sin[\phi_e(t)] \approx \phi_e(t)$$

$$e(t) \approx k_m A_c A_v \phi_e(t)$$
$$= \frac{K_0}{k_v} \phi_e(t)$$

$$K_0 = k_m k_v A_c A_v$$

Loop-gain parameter of the phase lock loop

- So, the linearized feedback model of the phase-locked loop

$$v(t) = \int_{-\infty}^{\infty} e(\tau) h(t-\tau) d\tau$$

1.The inverse of this feedback path is described in the time domain by the scaled differentiator

$$v(t) = \frac{1}{2\pi k_v}\left(\frac{d\phi_2(t)}{dt}\right)$$

2.The closed-loop time-domain behavior of the phase-locked loop is described by the overall output v(t) produced in response to the angle Φ1(t) in the incoming FM wave s(t)

3.The magnitude of the open-loop transfer function of the phase-locked loop is controlled by the loop-gain parameter K0

$$v(t) \approx \frac{1}{2\pi k_v}\left(\frac{d\phi_1(t)}{dt}\right)$$

4.We may relate th v(t) to the input angle *$\Phi_1(t)$ by*

$$v(t) \approx \frac{1}{2\pi k_v}\cdot\frac{d}{dt}\left(2\pi k_f\int_0^t m(\tau)d\tau\right) = \frac{k_f}{k_v}m(t)$$


Thank You