Preliminary Work

1. In the laboratory, you will use Function Generator as VCO. You are free to choose the frequency and magnitude of the carrier and message signals.

2. Design an active filter using an op-amp to be used as a slope detector.

3. Build your active filter in PSpice and plot the transfer function of it.

4. Design an envelope detector to extract the information from the signal at the output of the slope detector. (You are asked to simulate only the filter in PSpice not the entire circuit!)

5. Prepare a Preliminary Report which includes: Your design decisions, circuit, plots, and expected results.

ATTENTION

- Each group will submit only one report which will be completed on this experiment document.

1 THEORY

In this experiment you will demodulate the FM signal using either slope detector or phase locked loop (PLL).

FM Detection Using a Slope Detector

Any filter (low-pass, high-pass, and band-pass) can be turned into an FM detector. The FM signal is chosen to be in the cutoff region of the filter (Fig. 1) and therefore any frequency deviation is translated into an amplitude variation. The filter is then followed by an AM detector and the modulation signal is recovered. While this is the simplest technique available, it is non-linear since a first order low-pass filter response falls as $\frac{1}{\omega}$ and this results in second and third-order frequency components. For example, let us operate a low-pass filter
(with a corner frequency $\omega_1$) at $\omega_0$ and take a frequency deviation of $\delta \omega$. The filter response is therefore:

$$\frac{V_o}{V_i} = H(\omega) = \frac{1}{1 + j\omega/\omega_1} \approx \frac{1}{|j\omega/\omega_1|} = \frac{\omega_1}{\omega} \quad \omega \gg \omega_1$$

and for $\omega = \omega_0 + \delta \omega$,

$$\frac{V_o}{V_i} = |H(\omega)| = \frac{\omega_1}{\omega_0 + \delta \omega} \approx \frac{\omega_1}{\omega_0} \left(1 - \left(\frac{\delta \omega}{\omega_0}\right) - \left(\frac{\delta \omega}{\omega_0}\right)^2 - \left(\frac{\delta \omega}{\omega_0}\right)^3 + \cdots\right) \quad (\omega_1, \omega_0 \text{ are fixed})$$

The peak of the envelope occurs for a negative $\delta \omega$ and is

$$V_i \left(\frac{\omega_1}{\omega_0}\right) \left(1 + \frac{\left|\delta \omega\right|}{\omega_0}\right)$$

The minimum of the envelope occurs for a positive $\delta \omega$ and is

$$V_i \left(1 - \frac{\left|\delta \omega\right|}{\omega_0}\right)$$

Notice that for a frequency deviation of +/- 10% of the center frequency ($\frac{\delta \omega}{\omega_0} = 0.1$), the second order component is only 10x below the first order component resulting in a -20 dB
distortion level. Therefore, this technique is valid only for a small frequency deviation from the center frequency (e.g. $\frac{\delta \omega}{\omega_0} = 3\%$). Another pitfall of this technique is that it does not have any rejection of unwanted AM signals (noise). If a high pass filter is used, the demodulation process is much more linear since the high-pass function is:

$$V_o = H(\omega) = \frac{j\omega/\omega_2}{1 + j\omega/\omega_2} \approx \frac{\omega}{\omega_2} \quad \text{for} \quad \omega << \omega_2 \text{ high-pass filter}$$

(4)

and for $\omega = \omega_0 + \delta \omega$,

$$\frac{V_o}{V_i} = |H(\omega)| = \frac{\omega_0 + \delta \omega}{\omega_2} = \frac{\omega_0}{\omega_2} \left(1 + \frac{\delta \omega}{\omega_0}\right) \quad (\omega_2, \omega_0 \text{ are fixed})$$

(5)

which is a linear process. However, this technique still suffers from having no rejection to AM noise.

**FM Detection Using PLL**

If we denote the modulated signal as,

$$y(t) = \cos \left(2\pi f_c t + 2\pi k_c \int_0^t m(t) dt \right)$$

(6)

where $m(t)$ is the message signal, the demodulation process will use the phase-locked loop method:

![Figure 3: Block Diagram of Phase Locked Loop](image)

You can use LM565 PLL IC. As long as the frequency deviation of the FM signal does not cause the PLL to exceed its tracking range, the output at the modulator and the VCO output of the PLL at the demodulator should remain frequency locked together.

**2 PROCEDURE**

a. Build the circuit you designed in your preliminary.

b. Measure the frequency and amplitude of your message signal. Note them below.

    amplitude=
    frequency=

c. Measure the frequency and amplitude of your carrier signal. Note them below.
d. Now connect the 50Ω output of the signal generator of message signal to the sweep input of the carrier signal generator. Obtain the FM output from the 50Ω output of the signal generator of the carrier signal.

e. Observe the output of your FM demodulator circuit. Draw both message and demodulated signal below.

Figure 4: message signal versus demodulated signal
3 Conclusion

3.1 Student Name and ID:
3.2 Student Name and ID:
3.3 Student Name and ID: