EEE/ECE F311
Communication Systems
Tutorial-6

Date : 11/09/2025

Date : 16/09/2025

Tutorial-6

1. An angle-modulated signal is described by

$$x_c(t) = 10\cos[2\pi(10^6)t + 0.1\sin(10^3)\pi t]$$

(*a*) Considering $x_c(t)$ as a PM signal with $k_p = 10$, find $m(t)$.

(*b*) Considering $x_c(t)$ as an FM signal with $k_f = 10\pi$, find $m(t)$.

BITS Pilani
Hyderabad Campus

Tutorial-6

Solution 1(a)

$$10m(t) = 0.1\sin\left(10^{3}\pi t\right)$$

$$\Rightarrow \boxed{m(t) = 0.01\sin\left(10^{3}\pi t\right)}$$

Solution 1(b)

$$\therefore \boxed{m(t) = 10\cos\left(10^{3}\pi t\right)}$$

Tutorial-6

2. A carrier is frequency-modulated with a sinusoidal signal of 2 kHz, resulting in a maximum frequency deviation of 5 kHz.

(a) Find the bandwidth of the modulated signal.

(b) The amplitude of the modulating sinusoid is increased by a factor of 3, and its frequency is lowered to 1 kHz. Find the maximum frequency deviation and the bandwidth of the new modulated signal.

Tutorial-6

Solution 2(a)

Bandwidth of the FM signal

$$B_T = 2f_m(\beta + 1)$$
$$= 14 \text{ kHz}$$

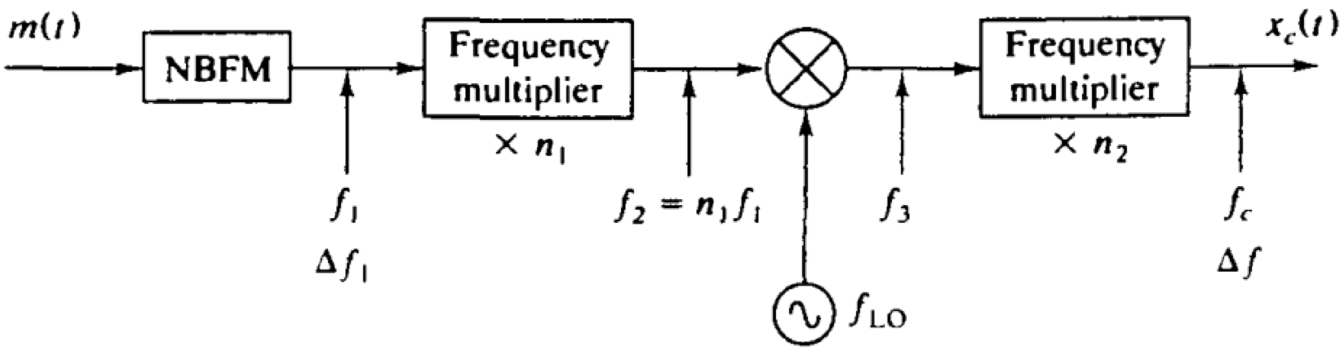
Solution 2(b)

$$\Delta f^{new} = \beta_1 f_m^{new} = 15 \text{ kHz}$$

$$B_T^{new} = 2f_m^{new}(\beta_1 + 1)$$
$$= 32 \text{ kHz}$$

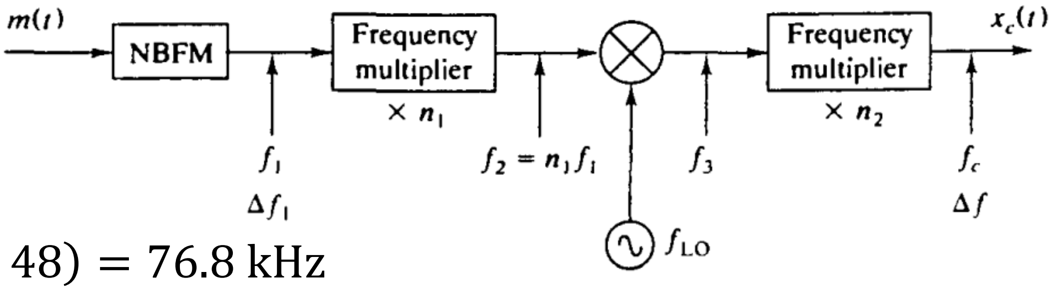
Tutorial-6

3. A block diagram of an indirect (Armstrong) FM transmitter is shown below. Compute the maximum frequency deviation Δf of the output of the FM transmitter and the carrier frequency f_c. if f_1 = 200 kHz, f_{LO} = 10.8 MHz, Δf_1 = 25 Hz, n_1 = 64, and n_2 = 48.



Tutorial-6

Solution 3



$$\Delta f = \Delta f_1 n_1 n_2 = (25 \times 64 \times 48) = 76.8\ \text{kHz}$$

$$f_c = n_2 f_3 = (48 \times 2.0)\ \text{MHz} = 96\ \text{MHz}$$

Tutorial-6

4. The message signal input to a modulator is $m(t) = 4\cos(4\pi \times 10^4 t)$; $k_f = 500\pi$, and the carrier is $16\cos(2\pi \times 10^8 t)$. Verify that the modulated signal is NBFM. What should be the bandwidth of the modulated signal?

Tutorial-6

Key Concept

- To identify the nature of the FM signal, we need to find the β.
- If $\beta \leq 0.3$, then the signal is called NBFM
- If $\beta \geq 5$, then the signal is called WBFM

Solution 4

$$\begin{aligned} B_T &= 2f_m(\beta + 1) \\ &= 42 \text{ kHz} \end{aligned}$$

Tutorial-6

5. A 2 kHz sinusoidal signal phase modulates a carrier at 100 MHz with a peak phase deviation of $\pi/4$ (rad/sec). What will be the approximate BW of the signal?

Tutorial-6

Solution 5

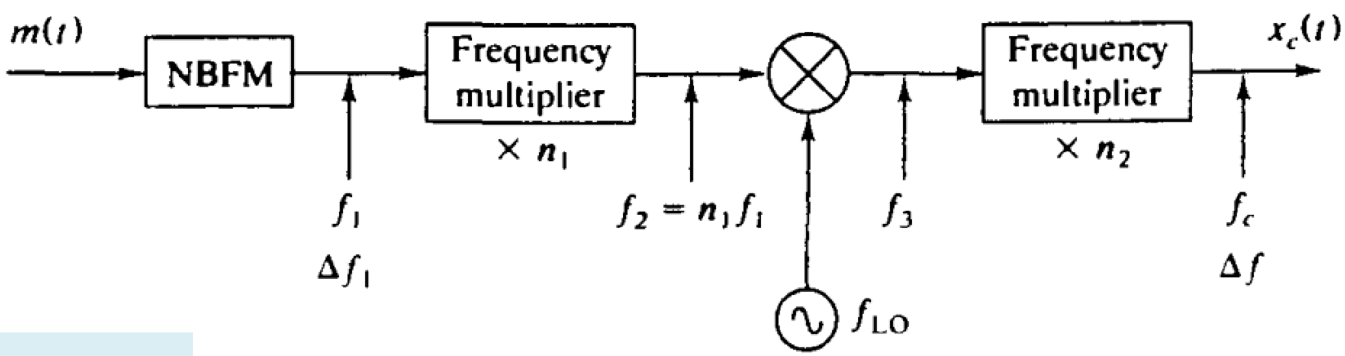
As per the problem statement, $\beta_P = \frac{\pi}{4} = 0.785$

Bandwidth as per the Carson's rule is given by,

$$\begin{aligned} B_T &= 2f_m(\beta+1) \\ &= \left[2\times 2\times 10^3 \times (0.785+1)\right] \text{ Hz} \\ &= 7.14 \text{ kHz} \end{aligned}$$

Practice Problem

Design (the block diagram with carrier frequency and frequency deviation at each point) an Armstrong indirect FM modulator to generate a Deccan Radio 107.8 MHz for Hyderabad. A NBFM generator is available at a carrier frequency of 180 KHz with frequency deviation 9.25 Hz. The available oscillator has an adjustable frequency in the range of 20 MHz to 22 MHz. There are plenty of frequency doublers are available. Designer is not allowed to use more than two frequency multiplier blocks. Each frequency multiplier block can contain only frequency doublers (≥1).



Solution

N1= 128 and N2= 64