Satellite & Mobile Communication Network

02.09.2020

1. Carrier Signal:

   $$c(t) = Csin(2\pi f_e t + \phi_e) \qquad \text{[eqn 1]}$$

2. Music Signal:

   $$s(t) = Ssin(2\pi f_{sm} t) \qquad \text{[eqn 2]}$$

   where, s(t) = music signal

   f_{sm} = music signal maximum frequency (20 kHz)

3. Let amplitude modulated signal be

   $$m_a = [C + k_a s(t)]sin(2\pi f_c t + \phi_c)$$

   Here the amplitude of the carrier is varied according to the instantaneous value of the music signal s(t).

   And f_c and Φ_c = constant.

4. Assume $\phi_c = 0$

   $$m_a = [C + k_a s(t)]sin(2\pi f_c t)$$

   $$= [C + k_a Ssin(2\pi f_{sm} t)]sin(2\pi f_c t)$$

   $$= Csin(2\pi f_c t) + k_a Ssin(2\pi f_{sm} t) * sin(2\pi f_c t)$$

   $$\Rightarrow \quad m_a = Csin(2\pi f_c t) + \frac{k_a}{2} 2sin(\phi)sin(\theta)$$

   where, $\phi = 2\pi f_c t$

   $\theta = 2\pi f_{sm} t$

   $$\Rightarrow \quad m_a = Csin(2\pi f_c t) + S'[cos(\phi - \theta) - cos(\phi + \theta)]$$

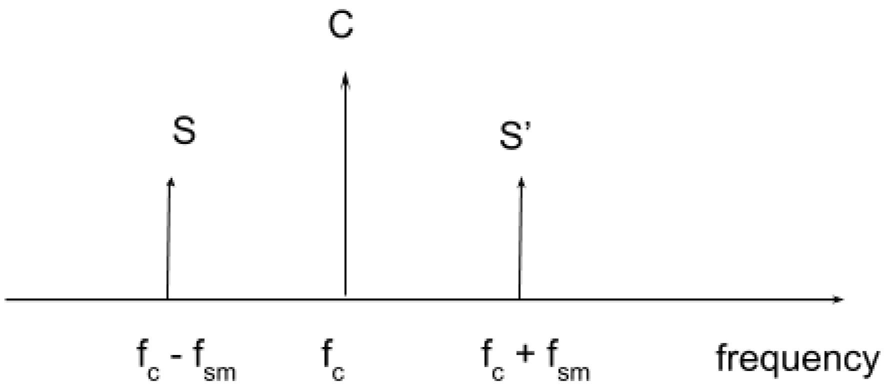
   where, $S' = \frac{k_a}{2}$

   $$\Rightarrow \quad m_a = Csin(2\pi f_c t) + S'cos(2\pi(f_c - f_{sm})t) - S' cos(2\pi(f_c + f_{sm})t)$$

   $$= Csin(2\pi f_c t) + S'sin(2\pi(f_c t - f_{sm})t + \frac{\pi}{2}) + S'sin(2\pi(f_c + f_{sm})t + \frac{\pi}{2})$$

Time domain representation of the modulated signal.

5. Frequency domain representation of the modulated signal



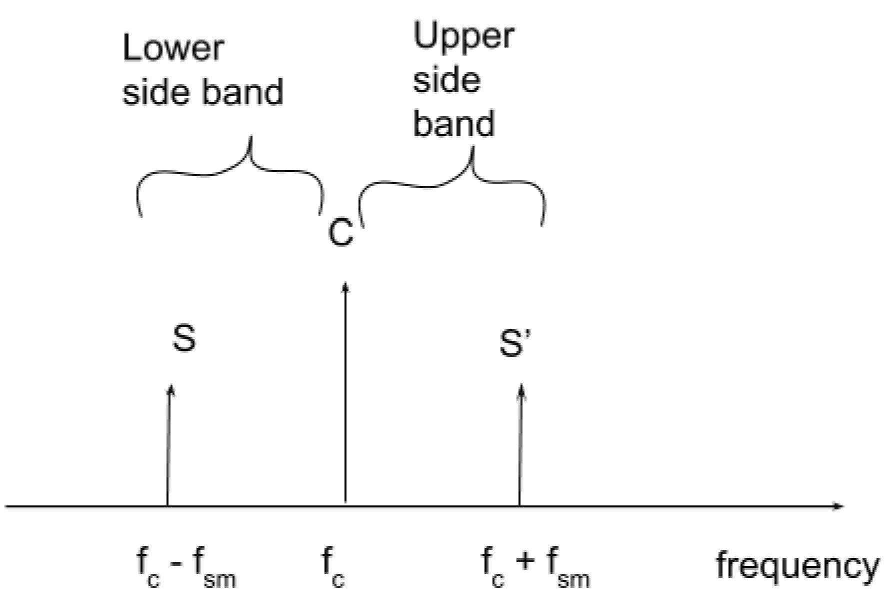
where, f_{sm} = 20 kHz

6. So, bandwidth of the modulated signal

$$m_a(t) = (f_c + f_{sm}) - (f_c - f_{sm})$$

$$= 2f_{sm} = BW\ of\ the\ channel$$

7. Bandwidth of the original signal= f_{sm}
8. So, bandwidth of the channel = 2 x BW of the music signal
9.



10. In a modulated signal, $(f_c - f_{sm})$ to $(f_c + f_{sm})$ preserves the characteristics of the signal f_{sm} along with the carrier.
11. Demodulation:

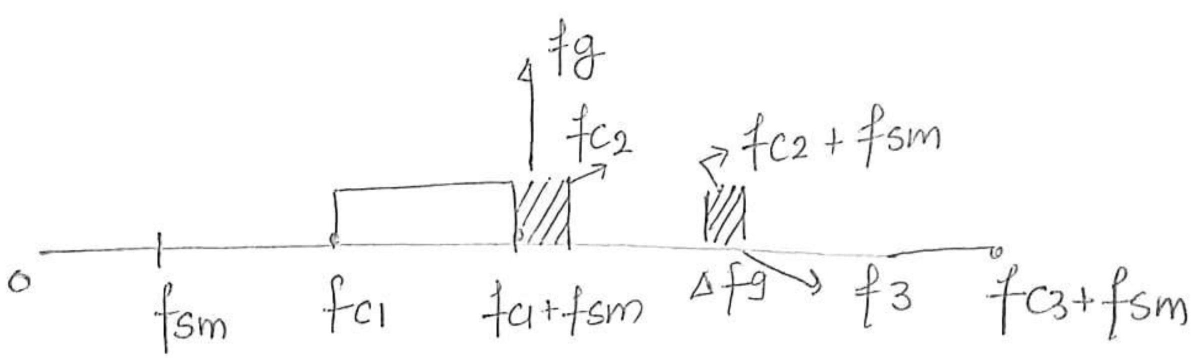
    Eliminating the carrier signal f_c from eqn 2 of the modulation and getting back f_{sm}.

    But BW = $2f_{sm}$.
12. From the upper side band also, we can do demodulation: f_c to $(f_c - f_{sm})$.

    Eliminate the carrier frequency f_c and we get back f_{sm}.

    But BW required = f_{sm} only.

    But some loss of quality.
13. We can do demodulation from the lower side band also with some loss of quality.
14. Therefore, with loss of some quality, instead of transmitting the whole of $m_a(t)$, we can send the upper side band or lower side band and demodulate the receiver end.
15. Assume we always send the upper side band in the FDM system.



Question :

Assume in a FDM system of music transmission

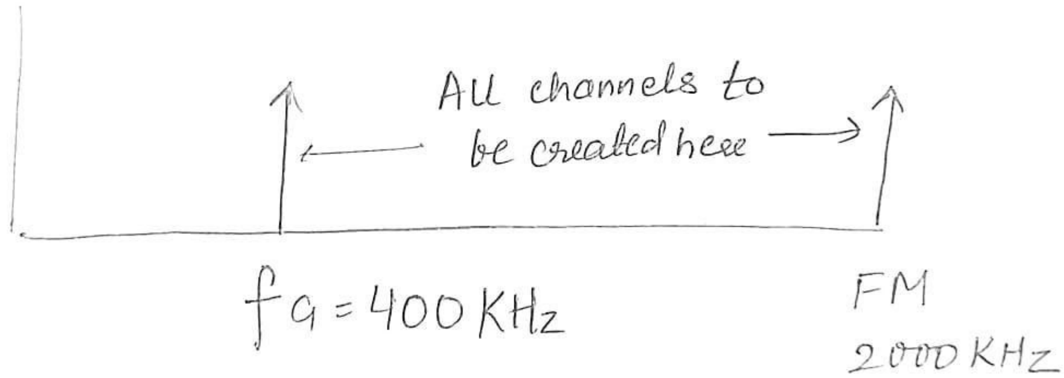
f_{c1} = lowest carrier = 400 kHz

f_{sm} = bandwidth of the music signal = 20 kHz

Guard band = 2 kHz

f_M = highest frequency of the medium = 2 MHz

Calculate how many channels n can be created using FDM?



$$f_M - f_c = n f_{sm} + (n - 1)\Delta f_g$$

where there are n channels and (n - 1) guard bands.

2000 – 400 = 20n + (n - 1)x2

n = 72

⇒ We take the floor value of n (round off the lower integer).