UNIT II ANALOG COMMUNICATION

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Objective

1. Solving Problems related to AM

Q1. A 400 W carrier is modulated to a depth of 75 percent. Calculate the total power in the modulated wave?

A carrier signal with power of 40W is amplitude modulated by a sinusoidal signal. Compute the power of modulated signal if the modulation index is 0.7. (May/June-16)

Given:

Carrier Power $P_c =$ 400W,

Depth of modulation=75%, hence modulation index $m =$ 0.75

Answer:

Total power in the modulated wave,

$$P_T = P_C\left(1 + m^2/2\right)$$

$$= 400\left(1 + 0.75^2/2\right)$$

$$P_T = 512.4W$$

Q2. A broadcast radio transmitter radiates 10kilowatts when the modulation percentage is 60. Calculate the carrier power.

Given: $P_T = 10kW = 10\times10^3$

Modulation index $(m) = 0.6$

Answer:

We know, $P_T = P_C\left(1 + m^2\!\big/2\right)$

Then, $P_C = \dfrac{P_T}{\left(1+m^2/2\right)}$

$$= \frac{10\times10^3}{\left(1+\dfrac{0.6^2}{2}\right)}$$

$P_C = 8.47kW$

Q3. A 1 MHz carrier with an amplitude of 1 volt peak is modulated by a 1 kHz signal with modulation index 0.5. Sketch the frequency spectrum.

Given:

Carrier frequency- $f_c = 1MHz$

Carrier amplitude- $E_c = 1V$

Message signal frequency- $f_m = 1kHz$

Answer:

Upper side band component: $f_c + f_m = 1000kHz + 1kHz = 1001kHz$

Upper sideband amplitude $= \frac{mE_C}{2}$

$$= \frac{0.5 \times 1}{2} = 0.25V$$

Lower sideband component: $f_c - f_m = 1000kHz - 1kHz = 999kHz$

Lower sideband amplitude $= \frac{0.5 \times 1}{2} = 0.25V$

- Q4. An amplitude modulated wave is described by the equation

$$e_{AM} = 10\left(1 + 0.4\cos 1000t + 0.2\cos 800t\right)\cos 10^{6}t$$

Specify different frequencies present in the AM signal.

$$f_{m1} = \frac{1000}{2\pi} = 159.09 \ Hz$$

$$f_{m2} = \frac{800}{2\pi} = 127.27 \ Hz$$

$$f_c = \frac{10^6}{2\pi} = 159.09 \ kHz$$

$$BW = 2 \times f_{m(\max)} = 2 \times 159.09 Hz = 318.18 Hz$$

Q5. The output modulated wave of a standard AM transmitter is represented

$$S(t) = 500(1 + 0.4\sin 3140t)\cos 6.28 \times 10^{7} t$$

This voltage is fed to a load of 600Ω. Find

1) Modulating frequency
2) Carrier frequency
3) Mean power output.

May/June-16

- A 1000 kHz carrier is simultaneously modulated with 300 Hz, 800 Hz and 2 kHz audio sine waves. Find the frequencies present in the output.

- Q6. *AM radio channel bandwidth is 10 kHz. What is the maximum modulation frequency?*

Answer:

Bandwidth of AM signal $= 2 f_m$

$$f_m = \frac{Bandwidth}{2}$$

$$= {}^{10kHz}\!\big/_{2} = 5kHz$$

Q7. *For an AM DSB-FC transmitter with an un-modulated carrier power* $P_c = 100W$ *that is modulated simultaneously by three modulating signals with coefficient of modulation* $m_1 = 0.2, m_2 = 0.4$ *and* $m_3 = 0.5,$ *determine,*

i) Total coefficient of modulation

ii) Upper and lower sideband power

iii) Total transmitted power

Given: Carrier power $P_c = 100W$

Modulation indices: $m_1 = 0.2, m_2 = 0.4$ and $m_3 = 0.5$

Answer:

Modulation index $(m) = \sqrt{(m_1^2 + m_2^2 + m_3^2)}$

$$= \sqrt{(0.2^2 + 0.4^2 + 0.5^2)}$$

$$m = 0.67$$

Upper and lower sideband power $P_{USB} = P_{LSB} = P_C \dfrac{m^2}{4}$

$$=11.25W$$

Total transmitted power $P_T = P_C \left(1 + m^2/2\right)$

$$P_T = 122.45W$$

Q8. What is the efficiency of AM system, when the modulation index is one?

$$\eta = \frac{m^2}{2+m^2} \times 100$$

$$\eta = \frac{1}{2+1} \times 100 = \frac{1}{3} \times 100 = 33.33\%$$

Q9. A Modulating signal $20\sin\left(2\pi\times10^{3}t\right)$ is used to modulate a carrier signal $40\sin\left(2\pi\times10^{4}t\right)$. Find out,

i) Modulation index

ii) Percentage modulation

iii) Frequencies of sideband and their amplitudes

iv) Bandwidth of modulating signal

v) Draw the spectrum of AM wave.

Given: Modulating signal : $20\sin\left(2\pi\times10^{3}t\right)$

Carrier signal $40\sin\left(2\pi\times10^{4}t\right)$

Given information's are compared with generalized expression of modulating and carrier signal.

$$e_m = E_m \cos 2\pi f_m t$$

$$E_m = 20 \qquad f_m = 10^3$$

$$e_c = E_c \cos 2\pi f_c t$$

$$E_c = 40; \quad f_c = \mathbf{10^4}$$

Modulation index $m = \dfrac{E_m}{E_c} \quad m = \dfrac{20}{40} = \frac{1}{2} = 0.5$

Percentage of modulation $= m \times \mathbf{100} \; = 0.5 \times 100 = 50\%$

Frequencies of sidebands

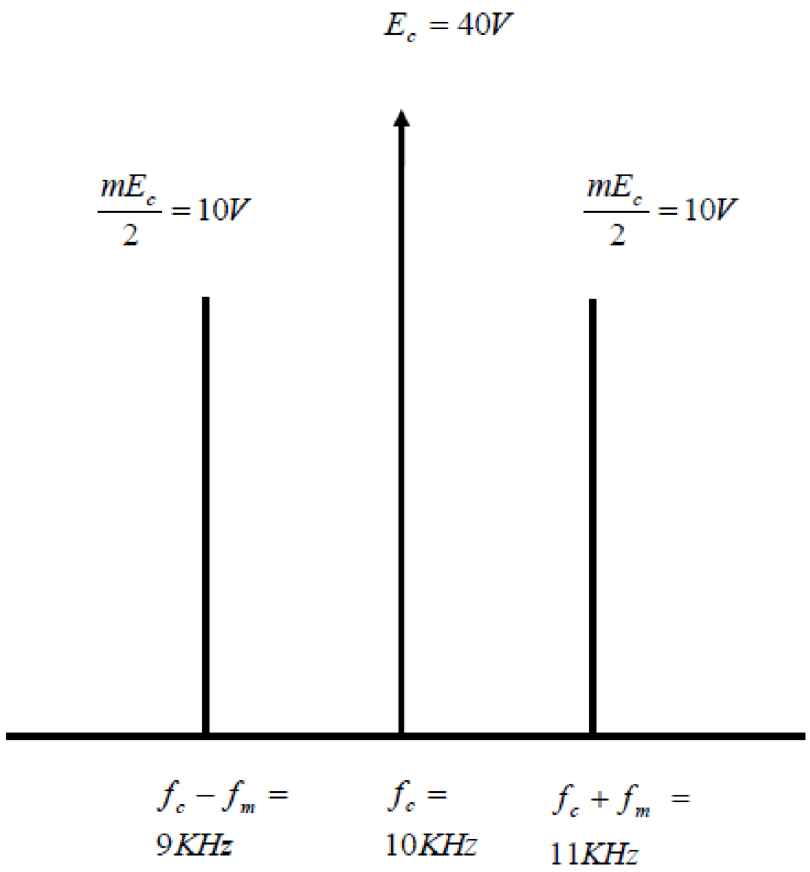
Upper sideband $f_c + f_m = 10^4 + 10^3 = 10kHz + 1kHz = 11kHz$

Lower sideband $f_c - f_m = \mathbf{10}kHz + \mathbf{1}kHz = \mathbf{9}kHz$

Sideband amplitudes $= \dfrac{mE_C}{2} = \dfrac{0.5\times40}{2} = 10V$

Bandwidth $= 2f_m = 2\times1kHz = 2kHz$

- Frequency spectrum:



Q10. An AM signal with a carrier of 1kW has 200W in each sideband. What is the percentage of modulation?

m=89.44%

Q11. In AM signal, power in upper sideband is 500 W for 100% modulation. Determine the power in carrier.

Given

$$P_{USB} = 500W, m = 1, P_C = ?$$

As we know,

$$P_{USB} = \frac{m^2 P_C}{4}$$

$$P_C = 2000\,W$$

Q12. *A complex modulating signal consisting of a sine-wave of amplitude 3V peak and frequency 1 kHz, and a cosine wave of amplitude 5V and frequency 3 kHz modulates a 500 kHz and 10 V peak carrier voltage. Plot the spectrum of AM signal.*

Given

Modulating signal:

$$E_{m1} = 3V;\ f_{m1} = 1kHz$$

$$E_{m2} = 5V;\ f_{m2} = 3kHz$$

Carrier signal: $E_c = 10V;\ f_c = 500kHz$

Answer: $m_1 = \frac{E_{m1}}{E_c} = \frac{3}{10} = 0.3$ $\quad m_2 = \frac{E_{m2}}{E_c} = \frac{5}{10} = 0.5$

Total modulation index: $m = \sqrt{(m_1^2 + m_2^2)}$ $\quad m = \sqrt{(0.3^2 + 0.5^2)} = 0.583$

Upper sideband components; $f_c + f_{m1} = 500kHz + 1kHz = 501kHz$

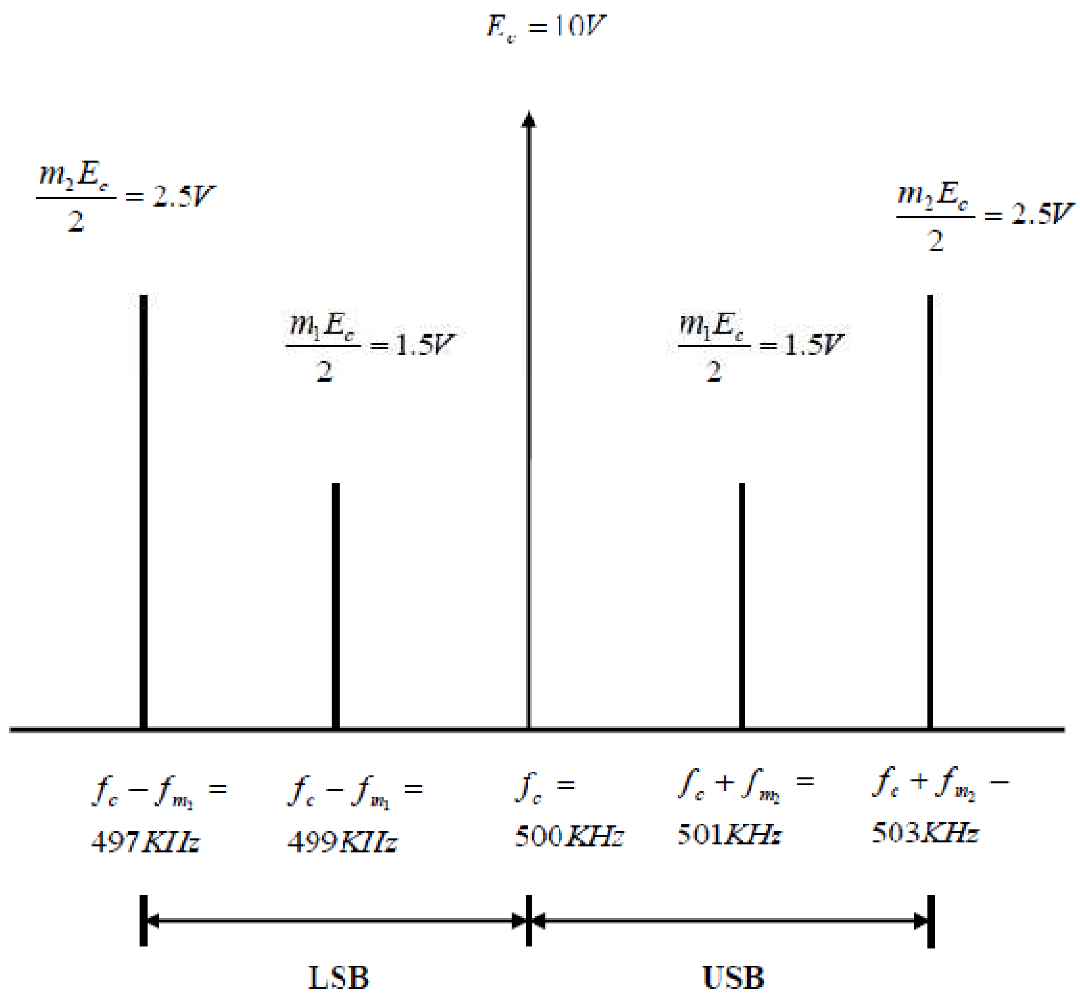
$$f_c + f_{m2} = 500kHz + 3kHz = 503kHz$$

Lower sideband components;

$$f_c - f_{m1} = 500kHz - 1kHz = 499kHz$$

$$f_c - f_{m2} = 500kHz - 3kHz = 497kHz$$

Bandwidth $= 2 \times f_{m(\max)}$


$E_c = 10V$
$\frac{m_2 E_c}{2} = 2.5V$
$\frac{m_1 E_c}{2} = 1.5V$
$\frac{m_1 E_c}{2} = 1.5V$
$\frac{m_2 E_c}{2} = 2.5V$
$f_c - f_{m_2} = 497KHz$
$f_c - f_{m_1} = 499KHz$
$f_c = 500KHz$
$f_c + f_{m_1} = 501KHz$
$f_c + f_{m_2} = 503KHz$
LSB
USB