1.A sinusoidal modulating frequency is modulated with a carrier frequency having a peak

voltage of 8V and a modulation index of 50%. The output is connected to a 5KΩ load.

Determine each of the following

i. The power in the carrier frequency

ii. The power in each sideband

iii. The total power

iv. The efficiency of the modulator. To solve this problem, we'll need to use the formulas for amplitude modulation (AM) power calculations:

i. The power in the carrier frequency:

Pc = (Vc/√2)^2/R

Where Pc is the power in the carrier frequency, Vc is the peak voltage of the carrier, and R is the load resistance.

Given that the peak voltage of the carrier is 8V and the load resistance is 5KΩ, we have:

Pc = (8/√2)^2/5000 = 0.0256W = 25.6mW

ii. The power in each sideband:

Ps = (Vm/√2)^2/2R

Where Ps is the power in each sideband, Vm is the peak voltage of the modulating frequency, and R is the load resistance.

The modulation index is 50%, which means that the peak deviation of the modulating frequency is 50% of the peak voltage of the carrier:

Vm = 0.5*8 = 4V

Therefore, the power in each sideband is:

Ps = (4/√2)^2/2*5000 = 0.016W = 16mW

The total power in both sidebands is twice this amount, or 32mW.

iii. The total power:

The total power is the sum of the power in the carrier frequency and the power in both sidebands:

Pt = Pc + 2*Ps = 25.6mW + 32mW = 57.6mW

iv. The efficiency of the modulator:

The efficiency of the modulator is the ratio of the power in the sidebands to the total power:

Efficiency = 2*Ps / Pt = 2*16mW / 57.6mW = 0.5556 or 55.56%

Therefore, the efficiency of the modulator is approximately 55.56%.

2.derivation

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5. We can start by writing the expression for the angle modulated signal u(t) as:

u(t) = 100cos[2πfct+4sin(2000πt)]

where fc = 10MHz.

(i) Average transmitted power:

The average power of a sinusoidal signal is given by the square of its amplitude divided by two, so the average power of u(t) is:

Pavg = (100^2/2) = 5000 W

(ii) Peak phase deviation:

The peak phase deviation Δϕ is given by the amplitude of the modulation signal times the maximum frequency deviation, which for small deviations is equal to the maximum phase deviation. In this case, the maximum phase deviation is:

Δϕ = 4 radians

(iii) Peak frequency deviation:

The peak frequency deviation Δf is given by the maximum frequency component of the modulation signal, which in this case is 2000 Hz. The peak frequency deviation is:

Δf = 2000 Hz

(iv) FM or PM signal:

The signal u(t) is a frequency modulated (FM) signal, because the frequency deviation is proportional to the amplitude of the modulation signal, as seen from the expression for the instantaneous frequency:

$f(t) = fc + (\Delta f/fm)\sin(2\pi fm\ t + \Delta\phi)$

where Δf is the frequency deviation, fm is the frequency of the modulation signal, and $\Delta\phi$ is the phase deviation. In this case, the frequency deviation is proportional to the amplitude of the modulation signal, which is characteristic of FM modulation. Additionally, PM modulation results in constant amplitude signal with a varying phase which is not the case here.

7.

To calculate the required parameters, we need to use the equations of amplitude modulation:

$$\text{Modulation index } m = \frac{\text{Amplitude of modulating signal}}{\text{Amplitude of carrier signal}} = \frac{A_m}{A_c}$$

$$\text{Sideband frequencies } f_{\text{SB}} = f_c \pm n f_m$$

$$\text{Amplitude of sidebands } A_{\text{SB}} = \frac{m}{2} A_c J_n(m)$$

where f_c is the carrier frequency, f_m is the modulating frequency, A_c is the peak amplitude of the carrier wave, A_m is the amplitude of the modulating signal, n is an integer representing the number of sidebands, and $J_n(m)$ is the n-th order Bessel function of the first kind with modulation index m.

Using the given values, we can calculate:

i. Modulation index:

$$m = \frac{A_m}{A_c} = \frac{6\text{V}}{10\text{V}} = 0.6$$

ii. The frequencies of sidebands:

The two sidebands will be at frequencies $f_{\text{SB}} = 10\text{MHz} \pm 5\text{kHz}$. Therefore, the two sidebands are at frequencies 10.005 MHz and 9.995 MHz.

iii. The amplitude of sidebands:

$$A_{\text{SB}} = \frac{m}{2} A_c J_n(m) = \frac{0.6}{2} \cdot 10\text{V} \cdot J_n(0.6) \approx 0.56\text{V}$$

iv. Construct the spectrum of the amplitude modulated wave:

The spectrum of the amplitude modulated wave can be constructed by plotting the amplitude of the carrier wave and the two sidebands at their respective frequencies. The amplitude of the carrier wave is 10V, and the amplitudes of the two sidebands are 0.56V. Therefore, the spectrum would look like the following:

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     9.995MHz    10.000MHz    10.005MHz
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The carrier wave is at the center frequency of 10 MHz, and the two sidebands are located symmetrically around the center frequency at 9.995 MHz and 10.005 MHz. The amplitudes of the sidebands are smaller than the amplitude of the carrier wave, which is why the spectrum appears to have two smaller peaks on either side of the larger peak at 10 MHz.

Regenerate response

8. To answer these questions, we need to first determine the expression for the amplitude modulated signal.

Let the carrier frequency be denoted by $c(t) = Vc \cos(2\pi fct)$ and the modulating frequency by $m(t) = Vm \cos(2\pi fmt)$, where Vc is the peak voltage of the carrier, Vm is the peak voltage of the modulating signal, fc is the carrier frequency, and fm is the modulating frequency.

Then, the amplitude modulated signal can be expressed as:

$s(t) = (Vc + m(t))\cos(2\pi fct)$

Expanding this expression using the trigonometric identity $\cos(a + b) = \cos(a)\cos(b) - \sin(a)\sin(b)$, we get:

$s(t) = Vc \cos(2\pi fct) + Vm \cos(2\pi fmt) \cos(2\pi fct) - Vm \sin(2\pi fmt) \sin(2\pi fct)$

We can see that this signal contains three frequency components: the carrier frequency fc, and two sideband frequencies $fc \pm fm$.

i. The power in the carrier frequency:

The power in the carrier frequency is given by $Pcarrier = Vc^2/2R$, where R is the load resistance. Substituting $Vc = 6V$ and $R = 600\Omega$, we get:

$Pcarrier = (6^2/2) / 600 = 0.03W$

ii. The power in each sideband:

The power in each sideband is given by $Psideband = Vm^2/4R$, where R is the load resistance. Substituting $Vm = 1V$ and $R = 600\Omega$, we get:

$Psideband = (1^2/4) / 600 = 4.17 \times 10^{-4}$ W

iii. The total power:

The total power is the sum of the power in the carrier and the power in both sidebands. Substituting the values we calculated, we get:

Ptotal = Pcarrier + 2Psideband = 0.03 + 2(4.17 x 10^-4) = 0.031W

iv. Representing the spectrum:

The spectrum of the amplitude modulated signal will have three peaks corresponding to the carrier frequency and the two sideband frequencies. The amplitudes of these peaks will be proportional to the power in each frequency component. A graphical representation of the spectrum is shown below:

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   fc-fm     fc      fc+fm
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The peak at fc represents the carrier frequency, while the peaks at fc ± fm represent the upper and lower sidebands, respectively. The amplitudes of these peaks can be calculated using the expressions we derived for the power in each frequency component.