GATE

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CONTENTS

CHAPTER - 1
AMPLITUDE MODULATION

1.1 INTRODUCTION

Modulation is a process of varying one of the characteristics of high frequency sinusoidal (the carrier) in accordance with the instantaneous values of the modulating (the information) signal. The high frequency carrier signal is mathematically represented by the equation (i)

$c(t) = A_c \cos(2\pi f_c t + \phi)$ …(i)

Where c(t) instantaneous values of the cosine wave

A_c is its maximum value is peak value

f_c is carrier frequency

ϕ is phase relation with respect to the reference

Any of the last three characteristics or parameters of the carrier can be varied by the modulating (message) signal, giving rise to amplitude, frequency or phase modulation respectively.

1.2 NEED FOR MODULATION

1. Practicability of Antenna

In the audio frequency range, for efficient radiation and reception, the transmitting and receiving antennas must have sizes comparable to the wavelength of the frequency of the signal used. It is calculated using the relation $f\lambda = c$. The wavelength is 75 meters at 1MHz in the broadcast band, but at 1 KHz, the wavelength turns out to be 300 Kilometers. A practical antenna for this value of wavelength is unimaginable and impossible.

2. Modulation for ease of Radiation

For efficient radiation of electromagnetic waves, the antenna dimension required is of the order of $\lambda/4$ to $\lambda/2$. It is possible to construct practical antennas only by increasing the frequency of the base band signal.

3. Modulation for Multiplexing

The process of combining several signals for simultaneous transmission on a single channel is called multiplexing. In order to use a channel to transmit the different base band signals (information) at the same time, it becomes necessary to translate different signals so as to make them occupy different frequency slots or bands so that they do not interfere. This is a accomplished by using carrier of different frequencies.

4. Narrow Banding

Suppose that we want to transmit audio signal ranging from $50 - 10^4$ Hz using suitable antenna. The ratio of highest to lowest frequency is 200. Therefore an antenna suitable for use at one end of the frequency range would be entirely too short or too long for the other end. Suppose that the audio spectrum is translated so that it occupies the range from $50 + 10^6$ to $10^4 + 10^6$ Hz. Then the ratio of highest to lowest frequency becomes 1.01. Thus the process of frequency translation is useful to change wideband signals to narrow band signals.

At lower frequencies, the effects of flicker noise and burst noise are severe.

GATE QUESTIONS

1. Consider the following amplitude modulated signal:
$s(t)=\cos(2000\pi t) + 4\cos(2400\pi t) + \cos(2800\ \pi t)$
The ratio (accurate to three decimal places) of the power of the message signal to the power of the carrier signal is __________.
[GATE - 2018]

2. Let $c(t) = A_c\cos(2\pi f_c t)$ and $m(t) = \cos(2\pi f_m t)$. It is given that $f_c >> 5f_m$, The signal $c(t) + m(t)$ is applied to the input of a non-linear device, whose output $v_0(t)$ is related to the input $v_i(t)$ as $v_0(t) = avi\ (t) + bv_i^2(t)$, where a and b are positive constants. The output of the non-linear device is passed through an ideal band-pass filter with center frequency f_c and bandwidth $3f_m$, to produce an amplitude modulated (AM) wave. If it is desired to have the sideband power of the AM wave to be half of the carrier power, then a/b is
(GATE - 2018)
(a) 0.25 (b) 0.5
(c) 1 (d) 2

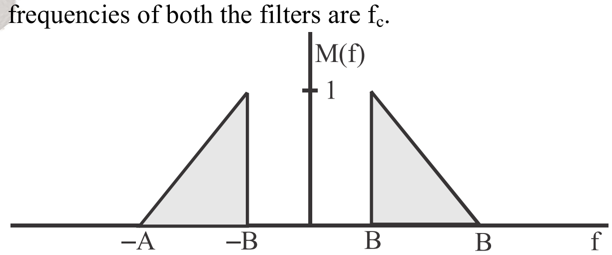
3. The un modulated carrier in an AM transmitter is 5k W. This carrier is modulated by a sinusoidal modulating signal. The maximum percentage of modulation is 50%. If it is reduced to 40%, then the maximum unmodulated carrier power (in kW) that can be used without over loading the transmitter is____
[GATE - 2017]

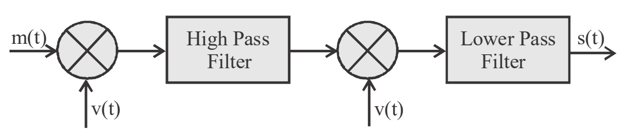
4. In a sinusoidal amplitude modulation scheme (with carrier) the modulated signal is given by $A_m\ (t) = 100\cos(\omega_c t) + 50\cos(\omega_m t)$, where ω_c is the carrier frequency and ω_m is the modulation frequency. The power carried by the sidebands in % of total power is____ %.
[GATE - 2017]

5. A message signal $m(t) = A_m \sin(2\pi f_m t)$ is used to modulate the phase of a carrier $A_C \cos(2\pi f_C t)$ to get the modulated signal $y(t) = A_C \cos(2\pi f_C t + m(t))$. The bandwidth of y(t).
[GATE - 2015]
(a) Depends on A_m but not on f_m
(b) Depends of f_m but not on A_m
(c) Depends on both A_m and f_m
(d) Does not depends on A_m or f_m

6. Consider sinusoidal modulation in an AM system. Assuming no over modulation, the modulation index (μ) when the maximum and minimum values of the envelope, respectively, are 3 V and 1V, is ______.
(GATE - 2014)

7. In the figure, M(f) is the Fourier transform of the message signal m(t) where A=100Hz and B=40Hz. Given $v(t) = \cos(2\pi f_c t)$ and $w(t) = \cos(2\pi(f_c + A)t)$, where $f_c > A$. The cut off frequencies of both the filters are f_c.





The bandwidth of the signal at the output of the modulator (in Hz) is ______
(GATE - 2014)

8. Consider an FM signal
$f(t)=\cos[2\pi f_c t + \beta_1 \sin 2\pi f_1 t + \beta_2 2\pi f_2 t]$

CHAPTER - 2
ANGLE MODULATION

2.1 INTRODUCTION

Angle modulation is a method of analog modulation in which either the phase or frequency of the carrier wave is varied according to the message signal. In the method of modulation the amplitude of the carrier wave maintained constant.

Angle Modulation is a method of modulation in which either frequency or phase of the carrier wave is varied according to the message signal.

In general form, an angle modulated signal can represented as

$s(t) = A_c \cos[\theta(t)]$ …(i)

Where A_c is the amplitude of the carrier wave and $\theta(t)$ is the angle of the modulated carrier and also the function of the message signal.

The instantaneous frequency of the angle modulated signal, s(t) is given by

$$f_i(t) = \frac{1}{2\pi}\frac{d\theta(t)}{dt} \quad \text{…(ii)}$$

The modulated signal, s(t) is normally considered as a rotating phasor of length A_c and angle $\theta(t)$. The angular velocity of such a phasor is $d\theta(t)/dt$, measured in radians per second.

An un-modulated carrier has the angle $\theta(t)$ defined as

$\theta(t) = 2\pi f_c t + \phi_c$ …(iii)

F_c is the carrier signal frequency and ϕ_c is the value of $\theta(t)$ at t = 0.

The angle modulated signal has the angle, $\theta(t)$ defined by

$\theta(t) = 2\pi f_c t + \phi(t)$ …(iv)

There are two commonly used methods of angle modulations:

1. Frequency Modulation, and
2. Phase Modulation.

2.2 PHASE MODULATION (PM)

In phase modulation the angle is varied linearly with the message signal m(t) as:

$\theta(t) = 2\pi f_c t + k_p m(t)$ …(v)

where k_P is the phase sensitivity of the modulator in radians per volt.

Thus the phase modulated signal is defined as

$s(t) = A_c \cos[2\pi f_c t + k_p m(t)]$ …(vi)

2.3 FREQUENCY MODULATION (FM)

In frequency modulation the instantaneous frequency $f_i(t)$ is varied linearly with message signal, m(t) as:

$f_i(t) = f_c + k_f m(t)$ …(vii)

where k_f is the frequency sensitivity of the modulator in hertz per volt.

The instantaneous angle can now be defined as

$$\theta(t) = 2\pi f_c t + 2\pi k_f \int_0^t m(t)\,dt \quad \text{…(viii)}$$

and thus the frequency modulation signal is given by

$$s(t) = A_c \cos\left[2\pi f_c t + 2\pi k_f \int_0^t m(t)dt\right] \quad \text{…(ix)}$$

ASSIGNMENT

1. A 10 MHZ carrier is frequency modulated by a sinusoidal signal of 500 Hz, the maximum frequency deviation being 50 KHz. The bandwidth required, as given by the cars's rule is ____________(KHZ).

2. PLL can be used to demodulate
(a) PAM signals
(b) PCM signals
(c) FM signals
(d) DSB – SC signals

3. An AM signal and a NBFM signal with identical carriers, modulating signals and modulation index of 0.1 are added to gather. The resultant signal can be closely approximated by
(a) Broadband FM
(b) SSB with carrier
(c) DSB-SC
(d) SSB without carrier

4. Consider an angle modulated signal
$x(t) = 6 \cos(2\pi \times 10^6 t + 2 \sin (8000 \pi t) + 4 \cos (8000 \pi t)]$ volt. The average power of x(t) is _________(watt).

5. Consider a FM signal
$f(t) \cos(2\pi f_c t + \beta_1 \sin 2\pi f_1 t + \beta_2 \sin 2\pi f_2 t)$
The maximum deviation of the instantaneous frequency from the carrier frequency f_c is
(a) $\beta_1 f_1 + \beta_2 f_2$ (b) $\beta_2 f_2 + \beta_2 f_1$
(c) $\beta_1 + \beta_2$ (d) $f_1 + f_2$

6. A carrier $A_c \cos wq_c t$ and a signal $x(t) = 2 \cos (\pi \,.\, 10^4 t)$ volts is applied to an FM modulator with the sensitivity constant of 10 KHZ/volt. Then the modulation index of the FM wave is
(a) 4 (b) 2
(c) $\frac{4}{\pi}$ (d) $\frac{2}{\pi}$

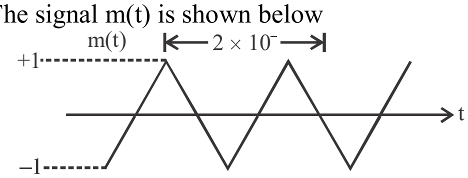
7. An FM signal with modulation index 9 is applied to a frequency tripper. The modulation index in the output signal is _____?

8. An angle modulated signal is given by $s(t) = \cos 2\pi(2 \times 10^6 t + 30 \sin 150 t + 40 \cos 150 t)$. The maximum frequency and phase deviations of s(t) are ______(KHz) and _____(rad) ?

9. Two sinusoidal signal of same amplitude and frequencies 10 KHZ and 10.1 KHZ are added together. The combined signal is given to an ideal frequency detector. The output of the detector is _______
(a) 0.1 KHZ sinusoid
(b) 20.1 KHZ sinusoid
(c) A linear function of time
(d) A Constant

10. An angle modulated signal is expressed by $f_a(t) = \cos (2 \times 10^8 \pi t + 75 \sin 2 \times 10^3 \pi t)$. The peak frequency deviation of the carrier is then
(a) 1 KHZ (b) 7.5 KHZ
(c) 75 KHZ (d) 100 MHZ

Common Data for Q. 11 and 12
The signal m(t) is shown below



The constant k_f and K_p are $2 \pi \times 10^5$ and 10π, respectively, and $f_c = 100$ MHZ.

GATE QUESTIONS

1. Let $c(t) = A_c\cos(2\pi f_c t)$ and $m(t) = \cos(2\pi f_m t)$. It is given that $f_c >> 5f_m$, The signal c(t) + m(t) is applied to the input of a non-linear device, whose output $v_0(t)$ is related to the input $v_i(t)$ as $v_0(t) = av_i(t) + bv_i^2(t)$, where a and b are positive constants. The output of the non-linear device is passed through an ideal band-pass filter with center frequency f_c and bandwidth $3f_m$, to produce an amplitude modulated (AM) wave. If it is desired to have the sideband power of the AM wave to be half of the carrier power, then a/b is

[GATE - 2018]

(a) 0.25 (b) 0.5
(c) 1 (d) 2

2. A modulating signal given $x(t) = 5\sin(4\pi 10^3 t - 10\pi\cos 2\pi 10^3 t)$ V is fed to a phase modulator with phase deviation constant k_p = 5rad/V. If the carrier frequency is 20 kHz, the instantaneous frequency (in kHz) at t = 0.5ms is____

[GATE - 2017]

3. An angle modulated signal with carrier frequency $\omega_c = 2\pi\times10^6$ rad/s is given by $\varphi_m(t) = \cos(\omega_c t + 5\sin(1000\pi t) + 10\sin(2000\pi t))$. The maximum deviation of the frequency in the angle modulated signal from that of the carriers is _____ kHz

[GATE - 2017]

4. In the system shown in figure (a), m(t) is a low-pass signal with bandwidth WHz. The frequency response of the band-pass filter H(f) is shown in figure (b). If it is desired that the output signal z(t)=10 x(t), the maximum value of W (in Hz) should be strictly less than ___________.

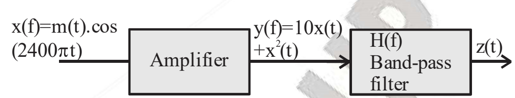


Fig.(a)

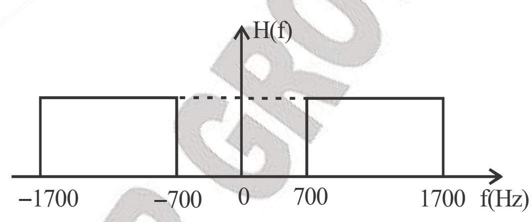


Fig. (b)

(GATE - 2015)

5. A modulated signal is $y(t) = m(t)\cos(4000\pi t)$, where the baseband signal m(t) has frequency component less than 5kHz only. The minimum required rate (in kHz) at which y(t) should be sampled to recover m(t) is ______

(GATE - 2014)

6. The phase response of a passband waveform at the receiver is given by
$\varphi(f) = -2\pi\alpha(f - f_c) - 2\rho\beta f_c$
Where f_c is the centre frequency, and α and β are positive constants. The actual signal propagation delay from the transmittance to receiver is

(GATE - 2014)

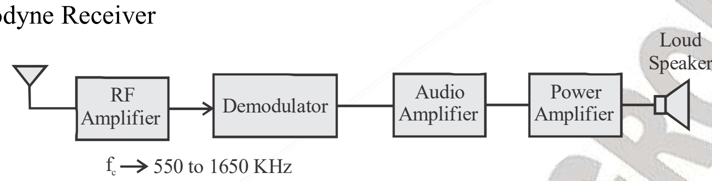
(a) $\frac{\alpha-\beta}{\alpha+\beta}$ (b) $\frac{\alpha\beta}{\alpha+\beta}$
(c) α (d) β

7. The signal m(t) as shown is applied to both, a phase modulator (with k_p as the phase constant) and a frequency modulator (with k_f as the frequency constant) having the same carrier frequency.

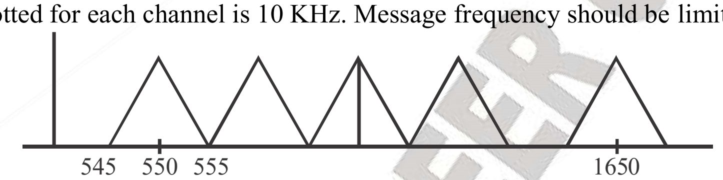
[GATE - 2012]

CHAPTER - 3
RECEIVERS

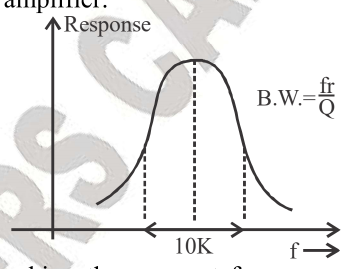
3.1 AM RECEIVERS
1. Tuned Radio Frequency (TRF) Receiver
2. Super Heterodyne Receiver



3.2 TRF RECEIVER
Bandwidth allotted for each channel is 10 KHz. Message frequency should be limited to 5 KHz.

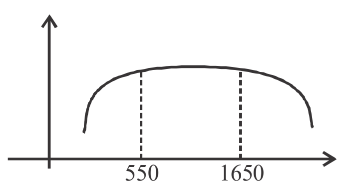


Ionospheric propagation is used for medium wave. No two stations can have same carrier frequency. The received signal strength is of the order of mW or μW.
RF amplifier must be low noise amplifier. RF amplifier itself acts as BPF, consists of a tuned circuit. Thus it is called tuned Rf amplifier.



By tuning arrangement we are making the resonant frequency of the tuned circuit equal to the carrier frequency of the required channel. The bandwidth of the tuned circuit should be 10 KHz.

3.2.1 Characteristic Parameters of Receiver
Super Heterodyne Receive



In the super heterodyne receiver the signal voltage is combined with the local oscillator voltage and converted into a signal of lower fixed frequency. The signal at this termediate frequency contains the same modulation as the original carrier and is now amplified and detected to

WORKBOOK

Example 1. A Rx is tuned to 1200K station corresponding IF = 455 KHz, find f_1 and f_{si}

Solution.

Given Fs = 1200K

IF = 455K

$f_I = f_s + IF = 1655K$

$f_{si} = f_s + 2IF = 2110K$

Example 2. A Rx is tuned to 555 KHz station corresponding frequency is 1010 KHz.

(i) Find IF and f_{si}

(ii) Find IRR if Q = 50

Solution.

Given $f_s = 555K$

$f_I = 1010K$

(i) $\therefore IF = f_I - f_s = 455K$

$f_{si} = f_s + 2IF = 1465$ KHz

(ii) Q = 50

$$P = \frac{f_{s_i}}{f_s} - \frac{f_s}{f_{s_i}} = \frac{1465}{55K} - \frac{555K}{1465K} = 2.26$$

$$\propto = \sqrt{1+P^2Q^2} = \sqrt{1+(2.26)^2(50)^2} = 113$$

Example 3. A Rx is tuned to 700K station, corresponding image frequency is 1700KHz.

(i) Find f_I and IF

(ii) Find IRR if two tuned amplifiers having Q-factors 60 & 80 respectively are connected in cascade.

Solution.

Given $f_s = 700K$

$f_{s_i} = 1700K$

(i) $\therefore IF = \frac{f_{s_i} - f_s}{2} = 500K$

$f_I = f_s + IF = 1200K$

(ii) $Q_1 = 60$; $Q_2 = 80$

$$P = \frac{1700K}{700K} - \frac{700K}{1700K} = 2.01$$

$$\alpha = \sqrt{i+(2.01)^2(60^2)}\sqrt{1+(2.01)^2(80)^2}$$

$= 19,200$

Example 4. A Rx is tuned to 1MHz station, IF = 455KHz, Q = 100

(i) Find IRR

(ii) Find IRR if the Rx is tuned to 25 MHz station

Solution.

(i) $f_s = 1MHz$; IF = 455 KHz; Q = 100

$f_{s_i} = f_s + 2IF = 1910KHz$

$$P = \frac{f_{s_i}}{f_s} - \frac{f_s}{f_{s_i}} = \frac{1910K}{1000K} - \frac{1000K}{1910K} = 1.386$$

$\alpha = \sqrt{P^2Q^2} \approx PQ$

$\therefore \alpha = 138.6$

(ii) $f_s = 25$ MHz

If = 455 KHz; Q = 100

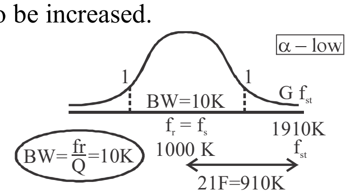
$f_{s_i} = 25MHz + 0.91MHz = 25.91MHz$

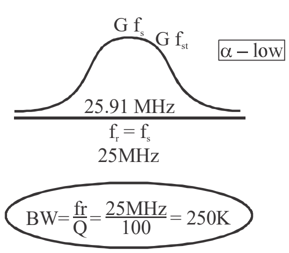
$$P = \frac{25.91}{25} - \frac{25}{25.91} = 0.07$$

$\alpha = PQ = 7$

If the 2[nd] case where the Rx tuned to 25 MHz station corresponding α is small.

For proper re-construction of the desired signal α has to be increased.





fs & IF should definitely in the same order then only ∝ will be high. If not, then ∝ will be low.

ASSIGNMENT

1. The correct sequence of subsystems in an FM receiver is
(a) Mixer, RF amplifier, limiter, IF amplifier, discriminator, audio amplifier
(b) RF amplifier, mixer, IF amplifier, limiter, discriminator, audio amplifier
(c) R amplifier, mixer, limiter, discriminator, IF amplifier, audio amplifier
(d) Mixed, IF amplifier, limiter, audio amplifier, discriminator

2. The local oscillator in an all wave superheterodyne receiver is tuned to a frequency ($f_s + f_i$) rather than ($f_s - f_i$)
(a) To permit easy tracking
(b) To help image signal rejection
(c) To get the IF signal
(d) To allow adequate frequency coverage without switching.

3. In a superheterodyne receiver the IF stage has better selectivity than RF stage because:
(a) Frequency has been increased
(b) Frequency has been decreased
(c) Constant pass band is possible
(d) High L to C ratio possible because of fixed frequency operation.

4. In a superheterodyne receiver, the IF is 455 kHz. If it is tuned to 1200 kHz, the image frequency will be
(a) 1655kHz (b) 2110kHz
(c) 745kHz (d) 910kHz

5. The sensitivity of a superheterodyne receiver is determined by
(a) The gain of IF amplifier
(b) The gain of RF amplifier
(c) The noise figure
(d) all of the above

6. Frequency fogging is used in carrier system to:
(a) Conserve frequencies
(b) Reduce distortion
(c) Reduce cross talk
(d) None of the above

7. The image frequency rejection in superheterodyne receiver comes
(a) IF stages
(b) RF stages only
(c) Detector and RF stages only
(d) Detector RF and IF stages

8. Pre-selector stage in a receiver
(a) Provide higher selectivity
(b) Provide higher fidelity
(c) Improve linearity
(d) Larger pass band

9. Consider the following statements:
Stagger tuning is used,
(i) To obtain sharp fall in the frequency response.
(ii) To obtain a wider pass band
(iii) In the IF amplifiers of radio receivers.
Of these statements
(a) 1 alone is correct
(b) 1 and 3 are correct
(c) 2 alone is correct
(d) 1, 2 and 3 are correct

10. Double spotting in superheterodyne receivers is caused by
(a) Poor front - end rejection
(b) Misalignment of receiver
(c) Detuning of one or more IF stages
(d) Non-functioning of AGC

11. A superheterodyne receiver has an IF of 465 kHz. If it is tuned to a station broadcasting at 500 kHz and its oscillator is operating at 965 kHz, then the 1430 KHz frequency would be the
(a) Adjacent channel frequency
(b) Image frequency

ASSIGNMENT

1. The IF frequency for a super heterodyne receiver is 455KHz and the receiver is tuned to 500KHz. Find the Image rejection ratio when Q of the tuned circuit is 50.
(a) 123.5 (b) 130
(c) 132 (d) 136.5

2. A signal with amplitude variation in the range-A to A is to be transmitted using PCM. The quantization error should be less than or equal to 0.1% of the peak amplitude. If the signal is band limited to 5KHz, the minimum bit rate is
(a) 10 Kbps (b) 20Kbps
(c) 130 Kbps (d) 100 Kbps

3. A source generates four equiprobable symbols. If the source coding is used, the average code length is.
(a) 6 bits/symbol (b) 4 bits/symbol
(c) 3 bits/symbol (d) 2 bits/symbol

4. The Image Channel selectivity of superheterodyne receiver depends upon
(a) IF amplifiers only
(b) RF and IF amplifiers only
(c) Preselector, RF and IF amplifiers
(d) Preselector and RF amplifies only

5. In a superheterodyne A M receiver, the image channel selectivity is determined by:
(a) The preselector and RF stages
(b) The preselector, RF and IF stages
(c) The IF stages
(d) All the stages

6. A superheterodyne radio receiver with an intermediate frequency of 455 KHZ is tuned to a station operating at 1200 KHZ. The associated image frequency is______kHz

GATE QUESTIONS

1. Consider the signal $s(t)=m(t)\cos(2\pi f_c t)+\hat{m}(t)\sin(2\pi f_c t)$ where $\hat{m}(t)$ denotes the Hilber transform of m(t) is very small compared to f_c. The signal s(t) is a

(GATE - 2015)

(a) High-pass signal
(b) Low-pass signal
(c) Band-pass signal
(d) Double sideband suppressed carrier signal

2. Two sinusoidal signals of same amplitude and frequencies 10 kHz and 10.1kHz are added together. The combined signal is given to an ideal frequency detector. The output of the detector is

[GATE - 2004]

(a) 0.1 kHz sinusoid
(b) 20.1 kHz sinusoid
(c) A linear function of time
(d) A constant

3. Choose the correct one from among the alternative A, B, C, D after matching an item in Group 1 with most appropriate item in Group 2.

Group-I
A. Ring modulator
B. VCO
C. Foster-Seely discriminator
D. Mixer

Group-II
(i) Clock recovery
(ii) Demodulation of FM
(iii) Frequency conversion
(iv) Summing the two inputs
(v) Generation of FM
(vi) Generation of DSB-Sc

[GATE - 2003]

Codes:
(a) A-i; B-iii; C-ii; D-iv
(b) A- vi; B-v; C -ii; D-iii
(c) A-vi; B-i; C-iii; D-ii
(d) A-v; B-vi; C-i; D-iii

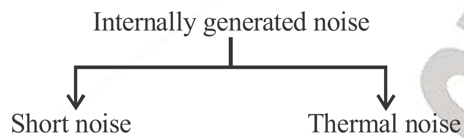
4. A superheterodyne receiver is to operate in the frequency range 550 kHz-1650 khz, with the intermediate frequency of 450 kHz. Let R = C_{max}/C_{min} denote the required capacitance ratio of the local oscillator and I denote the image frequency 9in khz) of the incoming signal. If the receiver is tuned to 700 kHz, then

[GATE - 2003]

(a) R = 4.41, I = 1600
(b) R = 2.10, I – 1150
(c) R = 3.0, I = 600
(d) R 9.0, I = 1150

CHAPTER - 4
NOISE IN ANALOG MODULATION

4.1 NOISE
4.1.1 Two Source (Man-Made and Natural)
Of all the noises voltages the one the one that is more internally generated due to circuit components and reactive components like inductors and capacitors noise as they are wattles components not Resistors, translators, value and conductors are the noise.



4.1.1.1 Shot Noise
1. In valves and transistor
2. Due to flow of discrete electrons of diffusion of electrons and holes.
R.M.S. of current Randomly Fluctuating $\left(1^2{}_{SN}\right) = 2eI_0\Delta f$ amp
e - electron charge
1_0 - mean value of current (dc)
Δf - bandwidth of the device in Hz

4.1.1.2 Thermal Noise
1.Due to random motion of electrons being temperature dependent
2.This type of noise due to random motion of electrons is called thermal noise, also known as Gautam who studied it experimentally

4.1.1.2.1. Power Spectral Density of Thermal Noise
$G_{v(f)} = 2RKT\left(V^2/Hz\right)$

Thermal Noise power = $\dfrac{G_v(f)}{4R} = \dfrac{2RKT}{4R} = \dfrac{kT}{2}$ w / Hz

Hence thermal noise power depends only on absolute temperature independent of resistor value whereas noise voltage depends on R.

1. Noise Analysis of AM

The output signal to noise ratio must be as high as possible. Assume that the channel as AWGN (Additive White Gaussian Noise) channel.
Thermal noise is white noise. It affects all frequencies equally.
$P = K\,T_eB$; KT = PSD of thermal noise
T_e = Noise equivalent temperature of the receiver
$T_e = (F - 1)\,T_0$; F = Noise figure

ASSIGNMENT

1. The figure of merit of a Phase modulated signal for single tone modulation is
(a) $3\ K^2_P P$ (b) $3\ K_p P$
(c) $3K^2_P P/2$ (d) $3\ K^2_P P^2$
P = power of the message signal Kp = phase sensitivity of the modulator

2. The capacity of an analog communication channel with 4 kHz bandwidth and 15 dB SNR is approximately
(a) 20,000 bps (b) 10,000 bps
(c) 16,000 bps (d) 8,000 bps

3. Consider a random sinusoidal signal $x(t) = \sin(\omega_0 t + \phi)$, where a random variable ϕ is uniformly distributed in the range $\pm \frac{\pi}{2}$. The mean value of x(t) is
(a) 0 (b) $\frac{\pi}{2}\cos\omega_0 t$
(c) $\frac{2}{\pi}\sin\omega_0 t$ (d) $\frac{2}{\pi}$

4. The noise figure of a receiver is 1.6. Its equivalent noise temperature is
(a) 464.00 K (b) 108.75K
(c) 174.00K (d) 181.25K

5. Match List-I (Modulation) with List-II (Characteristic) and select the correct answer the codes given below the lists
List-I
A. AM
B. FM
C. Noise in FM
D. Noise in AM & FM
List-II
(i) Mobile communication
(ii) Constant carrier frequency
(iii) Triangular noise power spectrum
(iv) Rectangular noise-power spectrum
Codes:
(a) A-ii, B-I, C-iv, D-iii
(b) A-i, B-ii, C-iii, D-iv
(c) A-i, D-ii, C-iv, D-iii
(d) A-ii, B-i, C-iii, D-iv

6. The noise figure of an amplifier is 3 dB. Its noise temperature will be about
(a) 145 K (b) 580 K
(c) 290 K (d) 870 K

7. The variance of a random variable x is σ_x^2. Then the variance of - Kx (where K is a positive constant) is
(a) σ_x^2 (b) $K\ \sigma_x^2$
(c) $-K\sigma_x^2$ (d) $K^2\sigma_x^2$

8. A system has a receiver noise resistance of 50Ω. It is connected to an antenna with an input resistance of 50Ω. The noise figure of the system is,
(a) 1 (b) 50
(c) 2 (d) 101

9. The auto correlation function $R_X(\tau)$ of the signal $x(t) = V \sin \omega t$ is given by,
(a) $\frac{1}{2}V^2\cos\omega\tau$ (b) $V^2\cos^2\omega\tau$
(c) $V^2\cos\omega\tau$ (d) $2V^2\cos^2\omega\tau$

10. A telephone channel has bandwidth B of 3 kHz and SNR of 30 dB. It is connected to a teletype machine having 32 different symbols. The symbol rate required for errorless transmissions is nearly
(a) 1800symbol/s (b) 3000 symbol/s
(c) 5000 symbol/s (d) 6000 symbol/s

11. Which one of the following statements regarding the threshold effect in demodulators is correct?
(a) It is exhibited by all demodulators when the input signal to noise ratio is low
(b) It is the rapid fall on output signal to noise ratio falls below a particular value

ASSIGNMENT

1. A 10 mW signal having a bandwidth of 100MHz is transmitted through a transmitter through a cable that has 40dB loss. $\frac{no}{2} = 0.5\times10^{-20}\,\omega/\text{Hz}$. The signal to noise ratio at the input of the receiver is
(a) 10^6 (b) 10^7
(c) 10^5 (d) 10^8

2. If the number of bits in a PCM system is increased from n to n + 1, then the signal-to-quantization noise ratio will be increased by a factor of?
(a) $\frac{(n+1)}{n}$ (b) 2
(c) $\frac{(n+1)^2}{n^2}$ (d) 4

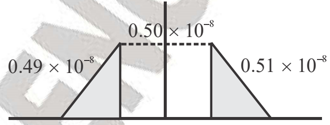
Linked Answer Questions
Statement for Linked Answer Question 3 & 4

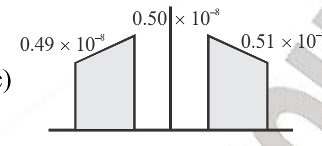
$$S_N(f) = \begin{cases} 10^{-8}\left[1+\frac{|F|-10^8}{10^8}\right] \\ 0 \text{ otherwise} \end{cases}$$

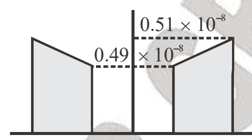
$-10^8 < f < 10^8$
The noise is passed through a unity gain ideal BPF centered at 50 MHz and having a bandwidth of 2 MHz.

3. Power spectral density of noise at the output of filter is

(a)

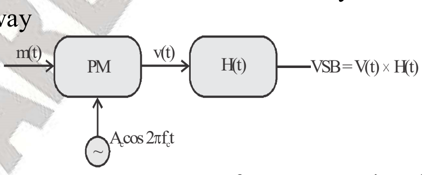

(b)


(c)


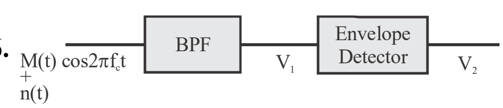
(d)


4. The output noise power is
(a) 40 m watts (b) 10 m watts
(c) 20 m watts (d) 100 m watts

5. Generation of USB is done by the following way



For exact recovery of message signal at the receiver end
(a) $H(f-f_c) + H(f+f_c) = 0$
(b) $H(f-f_c) + H(f+f_c) = K$
(c) $H(f-f_c) + H(f+f_c) = 1$
(d) None

6.


Then V_2 is
(a) $|m(t)+n_c(t)|$ (b) $M(t)+n_c(t)$
(c) $\frac{1}{2}|m(t)+n_c(t)|$ (d) $\frac{1}{2}|m(t)+n_s(t)|$

7. A Random variable is uniformity distributed [–5 ,5]. The mean of the random variable is
(a) 0 (b) 25
(c) 50 (d) 100

GATE QUESTIONS

1. Passengers try repeatedly to get a seat reservation in any train running between two stations until they are successful. If there is 40% chance of getting reservation in any attempt by a passenger, then the average number of attempts that passengers need to make to get a seat reserved is_____

[GATE - 2017]

2. In binary frequency shift keying (FSK), the given signal wave forms are $u_0(t) = 5\cos(20000\pi t)$; $0 \le t \le T$, and $u_1(t) = 5\cos(22000\pi t)$; $0 \le t \le T$, where T is the bit-duration interval and t is in seconds. Both $u_0(t)$ and $u_1(t)$ are zero outside the internal $0 \le t \le T$. With a matched filter (correlator) based receiver, the smallest positive value of T (in milliseconds) required to have $u_0(t)$ and $u_1(t)$ uncorrelated is

(a) 0.25 ms (b) 0.5 ms
(c) 0.75 ms (d) 1.0 ms

[GATE - 2017]

3. The variance of the random variable X with probability density function $f(x) = \frac{1}{2}|x|e^{-|x|}$ is ______.

(GATE - 2015)

4. A fair die with faces {1,2,3,4,5,6} is thrown repeatedly till '3' is observed for the first time. Let X denote the number of times the die is thrown. The expected value of X is _______.

(GATE - 2015)

5. A random binary wave y(t) is given by

$$y(t) = \sum_{n=-\infty}^{\infty} X_n p(t - nT - \phi),$$

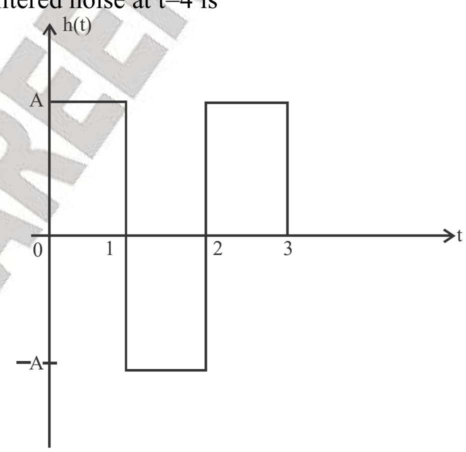
where $p(t) = u(t) - u(t-T)$, $u(t)$ is the unit step function and ϕ is an independent random variable with uniform distribution in [0,7]. The sequence consists of independent and identically distributed binary valued random variables with $P\{X_n = +1\} = P\{X_n = -1\} = 0.5$ for each n.

The value of the auto correction

$$R_{YY}\left(\frac{3T}{4}\right) \triangleq E\left[y(t)y\left(t - \frac{3T}{4}\right)\right] \text{equals } \_\_\_\_\_.$$

(GATE - 2015)

6. A zero mean white Gaussian noise having power spectral density $\frac{N_0}{2}$ is passed through and LTI filter whose impulse response h(t) is shown in the figure. The variance of the filtered noise at t=4 is



(GATE - 2015)

(a) $\frac{3}{2}A^2N_0$ (b) $\frac{3}{4}A^2N_0$
(c) A^2N_0 (d) $\frac{1}{2}A^2N_0$

7. Let $X \in \{0,1\}$ and $Y \in \{0,1\}$ be two independent binary random variables. If $P(X=0) = p$ and $P(Y=0) = q$, then $P(X+Y \ge 1)$ is equal to

(GATE - 2015)

(a) $pq(1-p)(1-q)$ (b) pq
(c) $p(1-q)$ (d) $1 - pq$