UNIVERSITY OF BUEA
COLLEGE OF TECHNOLOGY
ENTRANCE EXAMINATION INTO THIRD YEAR OF BTECH PROGRAM

SPECIALTY: TELECOMMUNICATIONS
DATE: 25/09/19
TIME ALLOWED: 4 HOURS **TIME:** 08.00 – 12.00
COEFFICIENT: 4

INSTRUCTIONS:
- In section A, mark an X on the letter corresponding to the correct answer in your answer booklet
- Answer ANY THREE questions in Section B

SECTION A: MULTIPLE CHOICE QUESTIONS (2 marks each)

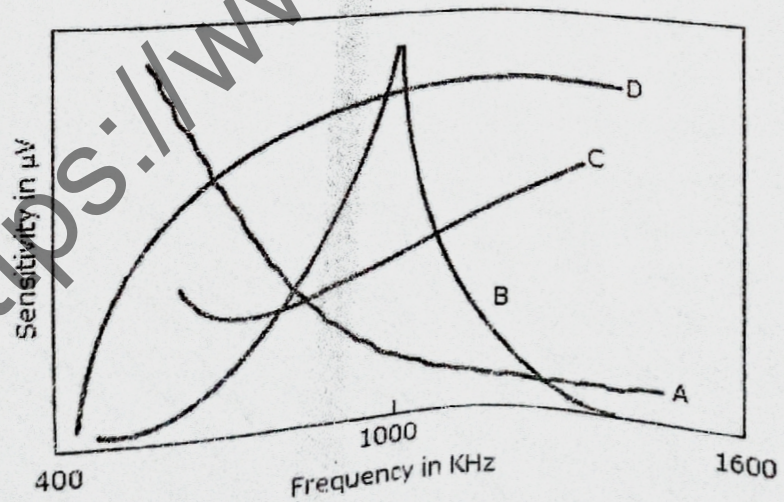
1. The function of an AM detector circuit is to
   A. rectify the input signal
   B. discard the carrier
   C. provide audio signal
   D. all of the above

2. Most popular IF for receivers tuning to 540 to 1650 kHz is
   A. 433 kHz
   B. 455 kHz
   C. 545 kHz
   D. 555 kHz

3. In a broadcast superheterodyne receiver
   A. the local oscillator operates below the signal frequency
   B. local oscillator frequency is normally double the IF
   C. RF amplifier normally works at kHz above the carrier frequency
   D. mixer input must be tuned to the signal frequency

4. RF amplifiers are used in radio receivers for
   A. improved image frequency rejection
   B. improved rejection of adjacent unwanted signals
   C. prevention of re-radiation of the local oscillator through the antenna of the receiver
   D. all of the above

5. The sensitivity curve of a standard receiver is represented by



   A. curve A
   B. curve B

C. curve C
D. curve D

6. Which of the following cannot be used to demodulate SSB?
A. Complete phase-shift generator
B. Product detector
C. Diode balanced modulator
D. Bipolar transistor balanced modulator

7. In a communication system, noise is most likely to affect the signal
A. at the transmitter
B. in the channel
C. in the information source
D. at the destination

8. Modulated carrier power in FM
A. increases with modulating signal power
B. decreases with modulating signal power
C. is independent of the modulating signal power
D. none

9. A notch filter is sometimes used in communication receivers to
A. reduce receiver gain at some specific frequency
B. increase receiver gain at some specific frequency
C. made selectivity more precise
D. spread the bandwidth

10. The analog signal $m(t)$ is given below $m(t) = 4 \cos 100 \pi t + 8 \sin 200 \pi t + \cos 300 \pi t$, the Nyquist sampling rate will be
A. 1/100 B. 1/200 C. 1/300 D. 1/600

11. The analog signal given below is sampled by 600 samples per second for $m(t) = 3 \sin 500\pi t + 2 \sin 700 \pi t$ then folding frequency is
A. 500 Hz
B. 700 Hz
C. 300 Hz
D. 1400 Hz

12. A cordless telephone using separate frequencies for transmission in base and portable units is known as
A. duplex arrangement
B. half duplex arrangement
C. either (a) or (b)
D. neither (a) nor (b)

13. A modem is classified as low speed if data rate handled is
A. upto 100 bps
B. upto 250 bps
C. upto 400 bps
D. upto 600 bps

14. VSB modulation is preferred in TV because
A. it reduces the bandwidth requirement to half
B. it avoids phase distortion at low frequencies
C. it results in better reception
D. none of the above

15. In colour TV receiver, varactor diode is used for
A. detection
B. rectification
C. tuning
D. both (a) and (b)

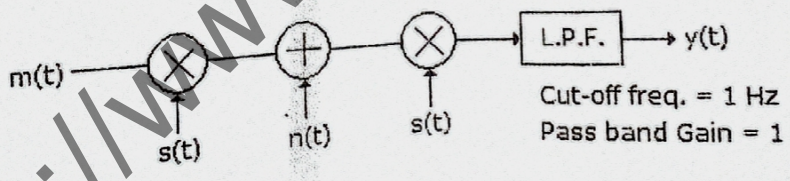
16. A 400 W carrier is amplitude modulated with $m = 0.75$. The total power in AM is
A. 400 W
B. 512 W
C. 588 W
D. 650 W

17. A telephone exchange has 9000 subscribers. If the number of calls originating at peak time is 10, 000 in one hour, the calling rate is
A. 0.9 B. 10/9 C. 0.81 D. 0.1

18. If C is capacity of noisy channel, (bits/s), δf is bandwidth Hz and S/N is signal to noise ratio, then
A. $C = (\delta f) \log_2 \left(1 + \frac{S}{N}\right)$
B. $C = 2(\delta f) \log_2 \left(1 + \frac{S}{N}\right)$
C. $C = \log_2 \left(1 + \frac{S}{N}\right)$
D. $C = (\delta f) \log_{10} \left(1 + \frac{S}{N}\right)$

19. The range of a cordless telephone is about
A. 1000 m
B. 500 m
C. 100 m
D. 10 m

20. In the figure $m(t) = \frac{2 \sin 2\pi t}{t}$, $s(t) = \cos 200\pi t$ and $n(t) = \frac{\sin 199\pi t}{t}$, the output $y(t)$ will be



A. $\frac{a \sin 2\pi t}{t}$
B. $\frac{\sin 2\pi t}{t} + \frac{\sin \pi t}{t} \cos 3\pi t$
C. $\frac{\sin 2\pi t}{t} + \frac{\sin 0.5\pi t}{t} \cos 1.5\pi t$
D. $\frac{\sin 2\pi t}{t} + \frac{\sin \pi t}{t} \cos 0.75\pi t$

SECTION B

QUESTION 1

A) Figure 1 below depicts the block diagram of a nonlinear Double-sideband suppressed carrier (DSB-SC) modulator.

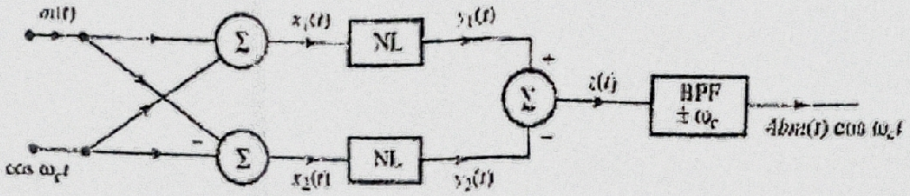


Figure 1

Let the input-output characteristics of either of the nonlinear (NL) elements be approximated by a power series

$$y(t) = ax(t) + bx^2(t)$$

where x(t) and y(t) are the input and output respectively of the nonlinear (NL) element.

i) Establish the expression of the summer output z(t)

ii) If the spectrum of m(t) is centered at the origin, establish the spectrum of z(t)

B) You are asked to design a DSB-SC modulator to generate a modulated signal $km(t)\cos\omega_c t$, where m(t) is a signal band-limited to B Hz. Figure 2 shows a DSB-SC modulator available in the stock room. The carrier generator available generates not $\cos\omega_c t$, but $\cos^2\omega_c t$.

i) What kind of filter is required in figure 2

ii) Determine the signal spectra at points b and c, and indicate the frequency bands occupied by these spectra

iii) What is the minimum usable value of ω_c?

iv) Would this scheme work if the carrier generator were $\cos^2\omega_c t$? Explain

v) Would this scheme work if the carrier generator were $\cos^n\omega_c t$ for any integer $n \geq 2$?

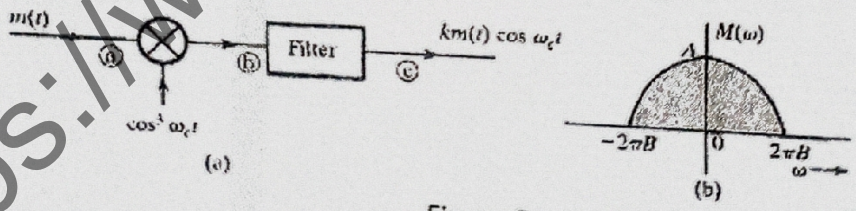


Figure 2

QUESTION 2

A) Two signals $m_1(t)$ and $m_2(t)$, both band-limited to 5000 rad/s, are transmitted simultaneously over a channel by multiplexing scheme shown in Figure 3. The signal at point b is the multiplexed signal, which now modulates a carrier of frequency 20,000 rad/s. The modulated signal at point c is transmitted over a channel.

i) Sketch signal spectra at points a, b, and c.

ii) What must be the bandwidth of the channel?

iii) Design a receiver to recover the signal

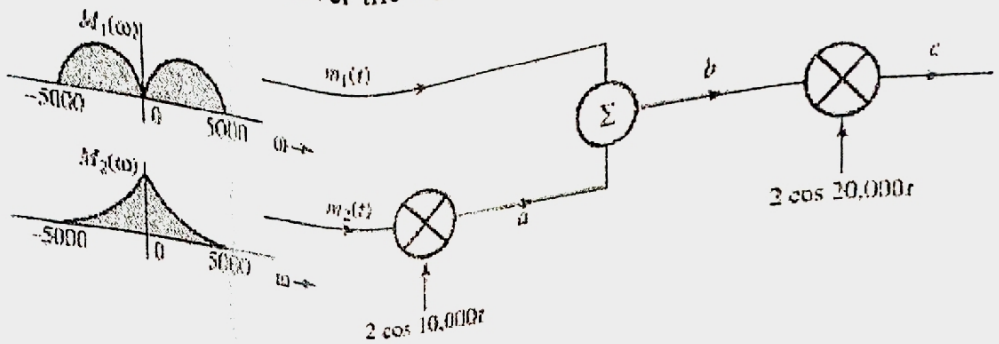


Figure 3

B) A leased telephone of bandwidth 3 kHz is used to transmit binary data. Calculate the data rate (in bits per second) that can be transmitted if polar signal with rectangular half-width pulses are used.

QUESTION 3

A) Using the value of 6370 km for the earth's radius, derive that the optical line of sight can be expressed as $d = 3.57\sqrt{h}$, where d is the distance between an antenna and the horizon in kilometers and h is the antenna height in meters.

B) If a transmitter produces 50 W of power, express the transmit power in units of
i) dBm, and
ii) dBW.
iii) If 50 W is applied to a unity gain antenna with a 900 MHz carrier frequency, find the received power in dBm at a free space distance of 100 m from the antenna.
iv) What is P_r(10 km)? Assume unity gain for the receiver antenna.

C) Determine the maximum distance between two antennas for LOS transmission if one antenna is 100 m high and the other is at ground level.

D) Determine the isotropic free space loss at 4 GHz for the shortest path to a synchronous satellite from earth (35,863 km).
What is the power at the receiving antenna? (Assume antenna gain of both the satellite- and ground-based antennas are 44 dB and 48 dB, respectively and a transmit power of 250 W at the earth station.)

QUESTION 4

A) Consider a standard TV receiver which is tuned to channel 4 with a frequency span from 66 – 72 MHz and having the synthesizer local oscillator set to 113 MHz.
i) Calculate the intermediate frequencies (IFs) for sound and picture signals
ii) The sound and picture IF signals are fed to a sound detector circuit. Explain how the sound and picture parts of the signal are recovered

B) Name the three main television standards in use across the world. What is the biggest compatibility problem between TV standards

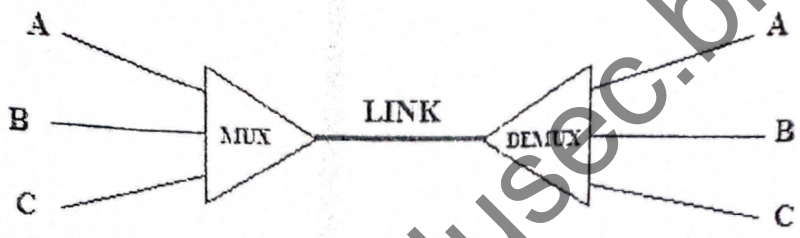
C) i) Distinguish between chrominance signal and luminance signal
ii) Define the terms saturation and hue. State their expressions in terms of E_R, E_Y and E_B, where E_R, E_Y and E_B are the outputs of cameras for red, yellow and blue colours.

iii) Use a figure to illustrate the relationship of I and Q signals to colour-difference signals
iv) Draw the spectral characteristics of colour TV signal, clearly showing how the chrominance and luminance signals could be transmitted within the prescribed TV signal bandwidth. (HINT: In addition to the two signals, the characteristics should show the video carrier, chrominance carrier and audio carrier)

QUESTION 5

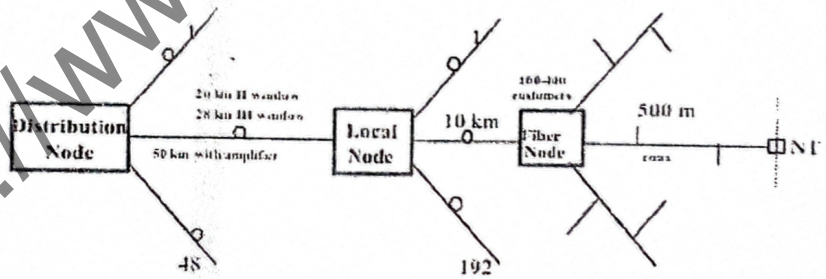
A) Use a circuit-switched network to connect eight telephones in a small area. Communication is through 4-kHz voice channels. Assume that each link uses FDM to connect a maximum of two voice channels. What is the bandwidth of each link? Sketch a figure which shows the situation where telephone 1 is connected to telephone 7; 2 to 5; 3 to 8; and 4 to 6.

B) The figure below depicts a circuit-switching network using time division multiplexing.



a. Deduce the structure of three frames transmitted through the link
b. The channels A, B, and C are PCM voice channels with 8 bits per sample and 8000 samples per second. Calculate the bitrate of the link.

C) Calculate the number of customers covered in the following access network



D) i) Sketch the basic architecture Passive Optical Network (PON), showing clearly how ONU and OLT are connected.
ii) What is the maximum length between OLT and ONU
iii) State two characteristics of PONs