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B.Sc. TE. (2-Yr), 1st Sem. Date: December 22, 2023 (Morning)

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)
ORGANISATION OF ISLAMIC COOPERATION (OIC)

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

Semester Final Examination — Winter Semester, A. Y. 2022-2023
Course No.: EEE 4597 — Time: 3 Hours
Course Title: Telecommunication Principles — Full Marks: 150

There are **8 (eight)** questions. Answer **any 6 (six)** questions. All questions carry equal marks. Marks in the margin indicate full marks. Programmable calculators are not allowed. Do not write on this question paper. All symbols bear their usual meanings. Make reasonable approximation(s) for missing information.

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1. a) How can we distinguish narrowband and wideband FM in terms of their modulation index values? Write the bandwidth expression from Carson's rule considering both sinusoidal modulation and non-sinusoidal modulation. Why is pre-emphasis necessary? What are the equivalent filter types for both pre-emphasis and de-emphasis networks? 10

   b) For the FM signal, $s(t) = A_c \cos[2\pi f_c t + \beta \sin(2\pi f_m t)]$; derive the equation of narrowband FM. 7

   c) Consider an FM signal obtained from a modulating signal frequency of 2 kHz and maximum amplitude of 5 V. Find the bandwidth using Carson's rule and considering the significant sideband frequencies. Also comment on the accuracy of different methods in determining the bandwidth. [Hints: datasheet attached with the question can be used] 8

2. a) Derive the expression for sideband power and total power for amplitude modulation and from them, find the expression for modulation efficiency. Show that a major portion of the power is utilized for transmitting the carrier in amplitude modulation. 9

   b) An audio frequency signal $10\sin(10^3\pi t)$ is used to amplitude modulate a carrier of $50\sin(2\pi 10^5 t)$. Calculate: 11
   i) Modulation index, ii) Sideband frequencies, iii) Sideband amplitudes, iv) Bandwidth required, v)Total power delivered to the load of 500 Ω and vi) Modulation efficiency.

   c) For an analog sinusoidal signal show its PAM and PWM version. What is clipped PPM? 5

3. a) Through a time-frequency resource grid in LTE based OFDMA; explain radio frame, subframe, sub-carrier spacing, resource block and slot. 10

   b) Compare normal and extended cyclic prefix for OFDMA in LTE. Name the cellular technologies for various generations of 3GPP and 3GPP2 starting from 2.75G. 3+5

   c) Name a cellular technology deployed with TDD version only. Mention 3GPP cellular technologies along with their generations using TDMA/FDMA as multiplexing techniques. 7

4. a) Show a representation of 16-QAM using 2 amplitude, 8 phase level and 3 amplitude, 12 phase level. 7

   b) Show the ASK, PSK, FSK representation for the binary NRZ code 101001. 6

c) If 3.4 KHz is the modulating signal bandwidth, find out the after-modulation bandwidth requirements for DSB, SSB, QAM and VSB scheme? Mention the filter types used in VSB modulation and demodulation process. Define the in-phase and quadrature channels for QAM. 6+3+3

5. a) Design a DSB-SC modulator for generating a modulated signal $km(t)\cos\omega_c t$; where m(t) is a signal band-limited to B Hz and the carrier generator generates $\cos^3\omega_c t$. Explain how you can generate the desired signal including filter type, signal spectra before and after filtering. Also find whether this scheme will work if the carrier generator produced $\cos^2\omega_c t$ in place of $\cos^3\omega_c t$ and measure the minimum usable value of ω_c. 15

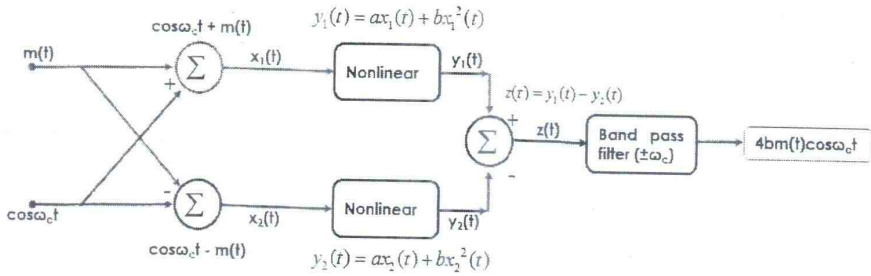
b) Explain maximum radian frequency deviation of the angle modulated signal. How can we express the angle modulated signals incorporating their respective deviation constants? 10

6. a) Derive Rayleigh-Jeans approximation from Planck's Blackbody radiation law. From this find a measure of the power delivered to the load resistor in bandwidth B at an equivalent noise temperature T. 12

b) What are the drawbacks of PCM? How does DPCM overcome that? Mention the advantages of DM over DPCM. Explain adaptive delta modulation. 13

7. a) Explain the operation of an envelope detector. Mention the repeater spacing, original wire bandwidth, number of channels multiplexed and net total bandwidth of T1 TDM. 13

b) Show how you can get $4bm(t)\cos\omega_c t$ after bandpass filtering z(t) from the following non-linear modulator circuit. Why is it called a single balanced modulator? 12



8. a) A certain AM transmitter radiates 10 kW with the carrier un-modulated, and 11.8 kW when the carrier is sinusoidally modulated. Calculate the modulation index. If another sine wave, corresponding to 30% modulation, is transmitted simultaneously, determine the radiated power. 7

b) The output current of 60% modulated AM generator is 1.5 A. To what value will this current rise if the generator is modulated additionally by another audio wave, whose modulation index is 0.7? What will be the percentage power saving if the carrier and one of the sidebands are now suppressed? 12

c) A carrier wave of frequency 91 MHz is frequency modulated by a sine wave of amplitude 10 volts and frequency 15 kHz. The frequency sensitivity of the modulator is 3 kHz / V. 6

i. Determine the approximate bandwidth of FM wave using Carson's rule.

ii. Repeat part (i), assuming that the amplitude of the modulating wave is doubled, and frequency is halved.

Datasheet for Question 1(c):

Number of Significant Side Frequencies
of a Wide-band FM Signal for Varying Modulation Index

Modulation Index β	Number of Significant Side Frequencies $2n_{max}$
0.1	2
0.3	4
0.5	4
1.0	6
2.0	8
5.0	16
10.0	28
20.0	50
30.0	70