



**FINAL
ALTERNATIVE ASSESSMENT**

(COVER PAGE)

Session : August 2021

Programme : Diploma in Electrical & Electronic Engineering (DEEI)

Course : EEE2111: Telecommunication Systems

Date of Examination : 9 December 2021 (Thursday)

Time : 8.00am – 11.00am Reading Time : Nil

Duration : 3 Hours

Special Instructions :

This paper consists of **FOUR (4)** questions. Answer all **FOUR (4)** questions. All questions carry equal marks.

Material permitted : Non-Programmable Scientific Calculator

Materials provided : Nil

Examiner(s) : Chong Kok Ming

Chief Moderator : Dr. Solahuddin

This paper consists of 7 printed pages, including the cover page

INTI INTERNATIONAL COLLEGE PENANG

DIPLOMA IN ELECTRICAL AND ELECTRONIC ENGINEERING (DEEI)
 EEE2111: TELECOMMUNICATION SYSTEMS
 FINAL ALTERNATIVE ASSESSMENT: AUGUST 2021 SESSION

Instructions: This paper consists of **FOUR (4)** questions. Answer all **FOUR (4)** questions. All questions carry equal marks.

Question 1

- a.) A carrier signal of 1.1 MHz, 1.0 Volt peak is AM (Amplitude Modulation) modulated with a 1 kHz sine wave tone at modulation index of 50%.
- i.) Write the AM signal equation in the terms of carrier frequency, lower sideband frequency and upper sideband frequency. (3 marks)
 - ii.) Sketch the AM signal in time domain and label the amplitude of the carrier and envelope of the signal accordingly. (2 marks)
 - iii.) Sketch the AM signal spectra and label the frequency and amplitude of carrier, lower sideband and upper sideband accordingly. (2 marks)
 - iv.) Given the frequency of the IF (Intermediate Frequency) is 455 kHz, Sketch the frequency spectrum at the output of mixer before IF filter. (4 marks)
 - v.) Calculate the image frequency seen by the receiver when tuned to the 1.1 MHz carrier frequency. (2 marks)
- b.) Sketch the block diagram of an AM SSB-SC (Single side band suppressed carrier) receiver demodulator and explain its functionality. (4 marks)
- c.) An AM SSB-SC transmitter is broadcasting a voice program at the carrier frequency of 1.2 MHz, 50% modulation index. The transmitter uses a balanced modulator to generate AM DSB-SC (Double side band suppressed carrier) and a bandpass filter to extract the upper side band frequency for AM SSB-SC transmission.
- i.) Sketch the spectrum of the AM DSB-SC signal and the frequency response of a suitable band pass filter to produce the AM SSB-SC signal. Label the center frequency and bandwidth of the band pass filter. (3 marks)
 - ii.) The carrier frequency has an amplitude of 1.0 Volt peak and the antenna impedance is 50Ω . Calculate the power of the SSB-SC signal. (2 marks)
 - iii.) Calculate the power saving of SSB-SC signal in comparison to the transmission of AM DSB (Double Sideband) with the same carrier of 1.2 MHz and 50% modulation index. (3 marks)

Question 2

- a.) An FM (Frequency Modulation) signal is expressed as

$$V(t) = 100 \sin(\pi \times 10^8 t + 3 \sin 6 \times 10^4 t) \text{ Volt.}$$

Calculate the: -

- i.) Modulating frequency (2 marks)
 - ii.) Carrier frequency (2 marks)
 - iii.) Modulation index (1 mark)
 - iv.) Maximum frequency deviation. (2 marks)
 - v.) FM signal bandwidth using Bessel function (2 marks)
 - vi.) FM signal bandwidth using Carson's rules (2 marks)
 - vii.) Signal power with load impedance of 50 Ω . (2 marks)
- b.) FM radio has a standard reception band of 87.5 MHz to 108.0 MHz. Determine the minimum and maximum bandwidth of a tuned radio frequency receiver that has a bandpass filter with Q factor of 500. (4 marks)
- c.) An engineer tested an FM transmitter at 100 MHz using 3.4 kHz tone with the modulation index set at 5.
- i.) Calculate the maximum frequency deviation. (2 marks)
 - ii.) Calculate the channel bandwidth using Bessel function. (2 marks)
 - iii.) Recommend a solution in order for this FM transmission to fit into the narrow band FM transmission with 20 kHz channel bandwidth. (4 marks)

Question 3

- a.) A voice signal with frequency range of 300 Hz to 3.4 kHz has a maximum signal level of 1.0 V is encoded with PCM (Pulse Code Modulation) using an 8 bits words. Calculate the: -
- i.) Minimum sampling rate (2 marks)
 - ii.) Quantization resolution in mV (2 marks)
 - iii.) Dynamic range in dB (2 marks)
 - iv.) Bandwidth required for transmission (2 marks)
 - v.) Binary word coding for an input signal of 380 mV (2 marks)
 - vi.) Quantization error at 380 mV (2 marks)
- b.) Determine the changes needed to upgrade the PCM system mentioned in 3-a.) above so that music signal with frequency range of 50 Hz to 15 kHz can be digitized and produced sound quality with 24 dB of improvement in dynamic range. (4 marks)
- c.) An 8 bits binary word 1-0-0-1-1-1-0-0 is to be sent out using DPSK (Differential Phase Shift Keying) coding method.
- i.) Use a table to generate the DPSK encoded data word. (3 marks)
 - ii.) Draw the timing waveform of the encoded DPSK signal, whereby $+\sin(\omega_c t)$ represent data bit 1 and $-\sin(\omega_c t)$ represent data bit 0. (3 marks)
 - iii.) Use a table to show the DPSK decoding process to recover data from the signal sent out above. (3 marks)

Question 4

- a.) A microwave telecommunication link is set up between 2 towers. Tower A has a height of 120 m and the tower B is 150 m.
- i.) Calculate the maximum Line of Sight (LOS) distance (2 marks)
 - ii.) Calculate the maximum Radio frequency Line of Sight distance. (2 marks)
 - iii.) Explain the working principle that extends the transmission range from Line of Sight to Radio frequency Line of Sight. (3 marks)

- b.) A telecommunication link is established between point P and Q via a satellite link. The satellite is located at a distance of 40,000 km from P and 35,000 km from Q. The satellite downlink frequency is 5.5 GHz, and the antenna power gain is 30,000X.
- i.) Sketch a diagram showing the communication link of P and Q via satellite. (2 marks)
 - ii.) Calculate the time delay of conversation between P and Q. (2 marks)
 - iii.) Calculate the power received by Q, if the satellite transmitter is 1 kW and the receiver antenna power gain is 100X. (5 marks)
- c.) A half wavelength dipole antenna has an isotropic radiation pattern with power gain of 2.15 dB is radiating a signal of 150 MHz at power level of 100W. Another same type of half wavelength dipole antenna is placed at a location 10 km away for reception. Calculate the: -
- i.) Size of the dipole antenna. (2 marks)
 - ii.) Distance where far field radiation is detected. (2 marks)
 - iii.) Signal power received at the receiving antenna (75Ω impedance). (2 marks)
 - iv.) Voltage level at the receiving antenna terminal, given the dipole antenna impedance is 75Ω . (3 marks)

~THE END~

Constants and Formulas

- 1.) Speed of light, $c = 3 \times 10^8 \text{ m/sec}$
- 2.) Earth's radius = 6371 km
- 3.) Fourier Series

$$f(t) = a_0 + \sum_{n=1}^{\infty} a_n \cos(n\omega t) + \sum_{n=1}^{\infty} b_n \sin(n\omega t)$$

- $a_0 = \frac{1}{T} \int_{t_0}^{t_0+T} f(t) \cdot dt$
- $a_n = \frac{2}{T} \int_{t_0}^{t_0+T} f(t) \cos(n\omega t) \cdot dt \quad n = 1, 2, 3 \dots$
- $b_n = \frac{2}{T} \int_{t_0}^{t_0+T} f(t) \sin(n\omega t) \cdot dt \quad n = 1, 2, 3 \dots$

- 4.) Trigonometry identity

- $\sin \alpha \cdot \sin \beta = \frac{1}{2} [\cos(\alpha - \beta) - \cos(\alpha + \beta)]$

- 5.) Integration by parts: $\int u \, dv = u \cdot v - \int v \, du$
- 6.) Mixer output with non-linear devices

$$f_{out} = |nf_c \pm mf_m| \quad \text{where } n, m \text{ are integers } 0, 1, 2 \dots$$

- 7.) AM signal power $P_T = P_C(1 + \frac{m^2}{2})$
- 8.) Thermal noise power $P_n = kTB$, $k = \text{Boltzmann's constant } (1.38 \times 10^{-23} \text{ J/K})$
- 9.) $LOS = 3.57(\sqrt{h_B} + \sqrt{h_L})$, Radio $LOS = 4(\sqrt{h_B} + \sqrt{h_L})$
- 10.) Kepler's Constant $K_s = \frac{r_a^2}{r_a^3} = \frac{r_b^2}{r_b^3}$
- 11.) Power equation for SATCOM link

$$\left(\frac{P_R}{P_T}\right)_{dB} \cong (G_T)_{dB} + (G_R)_{dB} - [32.5 + 20\log_{10}d + 20\log_{10}f] \text{ dB}$$

- 12.) Far field distance $R > \frac{2D^2}{\lambda}$
- 13.) Parabolic Antenna $A_p \cong 6\left(\frac{D}{\lambda}\right)^2$, beamwidth $\cong \frac{70\lambda}{D}$
- 14.) Power received by antenna in free space, $P_r = \frac{P_t G_t G_r \lambda^2}{(4\pi d)^2} \text{ W}$

Bessel Functions Table

Mod. index	Sideband amplitude														
	Carr.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
0.00	1.00														
0.25	0.98	0.12													
0.5	0.94	0.24	0.03												
1.0	0.77	0.44	0.11	0.02											
1.5	0.51	0.56	0.23	0.06	0.01										
2.0	0.22	0.58	0.35	0.13	0.03										
2.41	0.00	0.52	0.43	0.20	0.06	0.02									
2.5	-0.05	0.50	0.45	0.22	0.07	0.02	0.01								
3.0	-0.26	0.34	0.49	0.31	0.13	0.04	0.01								
4.0	-0.40	-0.07	0.36	0.43	0.28	0.13	0.05	0.02							
5.0	-0.18	-0.33	0.05	0.36	0.39	0.26	0.13	0.05	0.02						
5.53	0.00	-0.34	-0.13	0.25	0.40	0.32	0.19	0.09	0.03	0.01					
6.0	0.15	-0.28	-0.24	0.11	0.36	0.36	0.25	0.13	0.06	0.02					
7.0	0.30	0.00	-0.30	-0.17	0.16	0.35	0.34	0.23	0.13	0.06	0.02				
8.0	0.17	0.23	-0.11	-0.29	-0.10	0.19	0.34	0.32	0.22	0.13	0.06	0.03			
8.65	0.00	0.27	0.06	-0.24	-0.23	0.03	0.26	0.34	0.28	0.18	0.10	0.05	0.02		
9.0	-0.09	0.25	0.14	-0.18	-0.27	-0.06	0.20	0.33	0.31	0.21	0.12	0.06	0.03	0.01	
10.0	-0.25	0.04	0.25	0.06	-0.22	-0.23	-0.01	0.22	0.32	0.29	0.21	0.12	0.06	0.03	0.01