

INTI
International College Penang

FINAL
Examination Paper

(COVER PAGE)

Session : **August 2019**

Programme : **Diploma in Electrical and Electronic Engineering (DEEI)**

Course : **EEE2111: Telecommunication Systems**

Date of Examination : **12 December 2019 (Thursday)**

Time : **11:00am – 1:00pm**

Duration : **2 Hours** Reading Time : **Nil**

Special Instructions :

This paper consists of SIX (6) questions. Answer any FOUR (4) questions in the answer booklet provided. All questions carry equal marks.

IMPORTANT NOTE : THIS PAPER SHOULD NOT BE TAKEN OUT OF THE EXAMINATION HALL

Materials Permitted : **Non Programmable Scientific Calculator**

Materials Provided : **Nil**

Examiner(s) : **Chong Kok Ming**

Moderator : **Prof. Ir. Dr. Mandeep Singh A/L Jit Singh**

This paper consists of 8 printed pages, including the cover page.

INTI INTERNATIONAL COLLEGE PENANG

DIPLOMA IN ELECTRICAL AND ELECTRONIC ENGINEERING PROGRAMME (DEEI)
 EEE2111: TELECOMMUNICATION SYSTEMS
 FINAL EXAMINATION: AUGUST 2019 SESSION

Instructions: This paper consists of **SIX (6)** questions. Answer any **FOUR (4)** questions in the answer booklet provided. All questions carry equal marks.

Question 1

a.) An AM (Amplitude Modulation) DSB (Double Side Band) signal is expressed as

$$V(t) = 200(1 + \sin 10000t) \cdot \sin 3 \times 10^6 t \text{ (Volt)}$$

- i.) Determine the modulation index, modulating frequency and carrier frequency. (3 marks)
 - ii.) Write the signal equation in the terms of carrier frequency, lower sideband frequency and upper sideband frequency. (3 marks)
 - iii.) Draw the signal spectrum and label the amplitude and frequency accordingly. (2 marks)
 - iv.) Calculate signal power when it is loaded on an antenna with 50Ω impedance. (2 marks)
 - v.) The AM DSB signal is converted to AM SSB-SC (Single Side Band-Suppressed Carrier) without losses. Calculate the power of the AM SSB-SC signal and the power saving percentage compare to AM DSB. (4 marks)
- b.) State three (3) advantages and three (3) disadvantages of AM SSB-SC compared to AM DSB. (6 marks)
- c.) Draw the current flow direction in a balanced AM DSB-SC (Double Side Band-Suppressed Carrier) balanced modulator in following conditions:-
- i.) Modulation input is zero, positive cycle of carrier. (2 marks)
 - ii.) Positive modulation signal applied, positive cycle of carrier. (3 marks)

Question 2

- a.) Draw a block diagram of a FM (Frequency Modulation) super heterodyne receiver and explain how this architecture can overcome the limitations of Tuned Radio Frequency receivers. (7 marks)
- b.) A 5 kHz sine wave tone with amplitude of $1V_p$ is FM modulated on a 90 MHz carrier signal with $10 V_p$ with a modulation depth of 10 kHz/V.
- i.) Write the equation of the FM instantaneous frequency. (2 marks)
 - ii.) Calculate the modulation index (m_f). (2 marks)
 - iii.) Calculate the FM signal bandwidth using Bessel function and Carson's rule. (4 marks)
 - iv.) Sketch the spectrum of the FM signal with reference to Bessel Function table. Label the frequency and amplitude accordingly. (3 marks)
- c.) An engineer tested an FM transmitter at 150 MHz using 3.4 kHz tone with the modulation index set at 5.
- i.) Calculate the maximum frequency deviation and channel bandwidth of the system. (4 marks)
 - ii.) What do you recommend him to change, in order to fulfill the requirement of 25 kHz channel bandwidth? (3 marks)

Question 3

- a.) Draw a PCM (Pulse Code Modulation) encoding system block diagram. Explain functionality of sample-and-hold and analog to digital converter. (7 marks)
- b.) Show using a table how to digitize an analog signal of 1.0V maximum using 3 bits binary words. (5 marks)
- c.) 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)

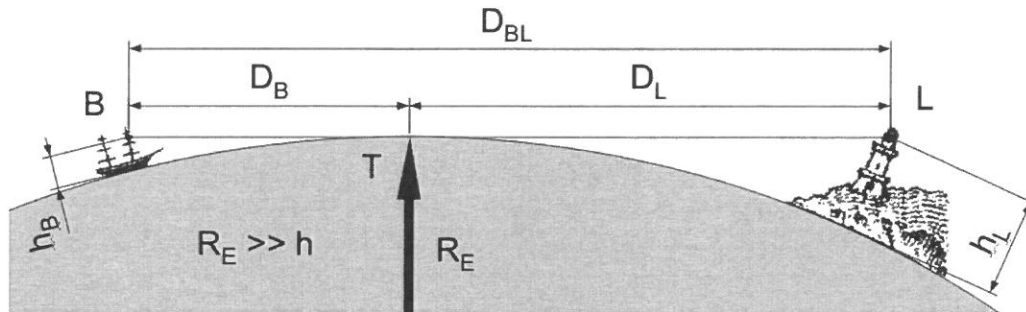
- iv.) Bandwidth required for transmission (2 marks)
- v.) Binary word coding for an input signal of 380mV (3 marks)
- vi.) Quantization error at 380mV (2 marks)

Question 4

- a.)
 - i.) Explain the working principle of Delta Modulation (DM) with a functional block diagram and timing waveform diagram. (6 marks)
 - ii.) Give 2 advantages and disadvantages of DM. (4 marks)
- b.) 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 calculate/generate the DPSK encoded data word. (4 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. (4 marks)
 - iii.) Use a table to show the DPSK decoding process to recover data from the signal sent out in question 4b. (ii) above. (4 marks)
- c.) What is the advantage of DPSK over PSK (Phase Shift Keying) modulation technique? (3 marks)

Question 5

a.) Refer to the diagram below, whereby R_E is the earth radius.



i.) Prove that distance $D_B = \sqrt{h_B^2 + 2R_E h_B}$ (4 marks)

ii.) Derive the equation for Line of Sight (LOS) distance D_{BL} is

$$D_{BL}[km] = 3.57(\sqrt{h_B} + \sqrt{h_L})$$

where h_B and h_L are height in meter and $\ll R_E$ (7 marks)

b.) A telecommunication link is setup with a transmission tower of height 120 m and the reception tower at 150 m height. Calculate the: -

i.) Line of Sight (LOS) distance (2 marks)

ii.) Radio frequency Line of Sight distance. (3 marks)

c.) Given that Geostationary (GEO) orbit is at 35,863 km above earth surface. Calculate the:-

i.) Kepler's constant for earth in unit $\text{min}^2 / \text{km}^3$. (3 marks)

ii.) Orbiting period of a satellite orbiting in an orbit 1,500 km above earth surface. (3 marks)

iii.) Number of satellites required to put in Medium Earth Orbit (MEO) at 11,000 km above earth surface to cover the earth surface for 24 hours service. (3 marks)

Question 6

- a.) Explain the following terms, express its mathematical definition and show a waveform example for each case.
- i.) Even symmetry signal (2 marks)
 - ii.) Odd symmetry signal (2 marks)
 - iii.) Proof mathematically that a deterministic signal $x(t)$ can be written as the sum of an even $x_e(t)$ and odd signal $x_o(t)$, i.e. $x(t) = x_e(t) + x_o(t)$
whereby $x_e(t) = \frac{1}{2}[x(t) + x(-t)]$ and $x_o(t) = \frac{1}{2}[x(t) - x(-t)]$ (6 marks)
- b.) A dipole antenna operating at frequency of 150 MHz.
- i.) Calculate the far field distance of the antenna (2 marks)
 - ii.) If a field intensity of $10 \mu\text{V/m}$ is detected by the antenna, calculate the voltage at the antenna terminal. (2 marks)
 - iii.) Draw the current and electric field distribute diagram on a half-wavelength dipole antenna. (2 marks)
- c.) Discuss how can you: -
- i.) Reduce the size of the dipole antenna by half. (2 marks)
 - ii.) Improve directivity of the dipole antenna. (2 marks)
 - iii.) Calculate the diameter of parabolic reflector required to send a signal at 10 GHz with a beaming of 3° . (2 marks)
 - iv.) Calculate power gain of this parabolic antenna in dB. (3 marks)

– THE END –

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

Constants and Formulas

- 1.) Speed of light, $c = 3 \times 10^8$ 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.) Mixer output with non-linear devices

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

6.) AM signal power $P_T = P_C \left(1 + \frac{m^2}{2}\right)$

7.) Thermal noise power $P_n = kTB$, $k = \text{Boltzmann's constant } (1.38 \times 10^{-23} \text{ J/K})$

8.) Radio $D_{BL} = 4(\sqrt{h_B} + \sqrt{h_L})$

9.) Kepler's Constant $K_S = \frac{r_a^2}{r_a^3} = \frac{r_b^2}{r_b^3}$

10.) Power equation for SATCOM link

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

11.) Far field distance $R > \frac{2D^2}{\lambda}$

12.) Parabolic Antenna $A_p \cong 6 \left(\frac{D}{\lambda}\right)^2$, beamwidth $\cong \frac{70\lambda}{D}$

13.) Power received by antenna in free space, $P_r = \frac{P_t G_t G_r \lambda^2}{(4\pi d)^2} W$