INTI International College Penang

FINAL
ALTERNATIVE ASSESSMENT

(COVER PAGE)

Session	:	**August 2020**
Programme	:	Diploma in Electrical & Electronic Engineering (DEEI)
Course	:	**EEE2111: Telecommunication Systems**
Date of Examination	:	16 December 2020 (Wednesday)
Time	:	2.00pm – 5.00pm 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 2020 SESSION

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

Question 1

a.) Draw the block diagram of a super heterodyne AM (Amplitude Modulation) receiver and explain the functionality of each block.

(6 marks)

b.) Given that a super heterodyne AM receiver's IF (Intermediate Frequency) is 455 kHz and is tuned to a station at 1.200 MHz, sketch the spectrum of all signal components produced at the IF mixer output.

(5 marks)

c.) An AM DSB (Double Side Band) signal is expressed as

$$V(t) = 300(1 + sin\,3000\pi t) \cdot sin\,3 \times 10^6 t \text{ (Volt)}$$

i.) Write the equation in the terms of carrier frequency, lower sideband frequency and upper sideband frequency.

(3 marks)

ii.) Determine the modulation index, modulating frequency and carrier frequency.

(3 marks)

iii.) The upper side band of the above AM DSB signal is used to transmit as an AM SSB-SC (Single Side Band Suppressed Carrier) signal. Calculate the power saving percentage compared to the AM DSB transmission.

(4 marks)

d.) Explain how an AM SSB-SC receiver demodulator works with a diagram.

(4 marks)

Question 2

a.) A 100 MHz sinewave carrier with an amplitude of 10 Vp is frequency modulated with a 2 kHz sinewave signal with a maximum frequency deviation of 10 kHz.

i.) Calculate the modulation index. (m_f)

(2 marks)

ii.) Write the time domain signal equation of the above FM signal.

(3 marks)

iii.) Calculate the FM signal bandwidth using Bessel function and Carson's rule.

(4 marks)

iv.) Comment on the differences between the FM signal bandwidth calculated above using those two aforementioned methods.

(3 marks)

v.) Calculate the power radiated when the above FM signal is loaded on a 50 Ω antenna.

(2 marks)

b.) The FM standard broadcast frequency band is from 87.5 MHz to 108.0 MHz. Determine the minimum and maximum bandwidth of a tuned radio frequency receiver that has a tuned RF amplifier with a Q factor of 200.

(4 marks)

c.) Explain four points on how super heterodyne receiver can overcome the limitations of tuned radio frequency receivers.

(4 marks)

d.) Explain one significant drawback of super heterodyne receiver concept

(3 marks)

Question 3

a.) A stereo signal is sampled at 8 kHz and PCM (Pulse Code Modulation) encoded using an 8 bits ADC (Analogue to Digital Converter) for voltage range of 0-2 V. The left channel is a sinewave signal L(t) = $2\sin(2000\pi)\,t$ and the right channel is a sinewave signal R(t) = $\sin(1000\pi)\,t$. One data frame consists of 1 sync bit, one left channel data with even parity and one right channel data with even parity. Determine the: -

i.) Quantization resolution in mV

(2 marks)

ii.) Dynamic range in dB

(2 marks)

iii.) Data transmission rate required to send the data frame defined.

(2 marks)

iv.) Voltage of left and right channel samples at the sampling time of 0.25 ms.

(2 marks)

v.) Value of each bit in the data frame that is sampled at 0.25 ms, assuming the sync bit is set to "0" at all times.

(5 marks)

b.) BPSK stage "1" is modulated as $\sin(\omega_c t)$ signal and stage "0" as $-\sin(\omega_c t)$.

i.) Show the mathematical derivation for stage "1" as a positive DC output value using a low pass filter, and similarly stage "0" for negative DC output value.

(5 marks)

ii.) An 8 bits data stream "0110 1100" is modulated using BPSK technique. Draw the digital base band time signal waveform and the corresponding BPSK waveform diagram. Label $\sin(\omega_c t)$ and $-\sin(\omega_c t)$ on the diagram accordingly.

(3 marks)

c.) The same data stream "0110 1100" is modulated using QPSK technique. Given the Q/I mapping diagram for QPSK as below, draw the QPSK time domain waveform.

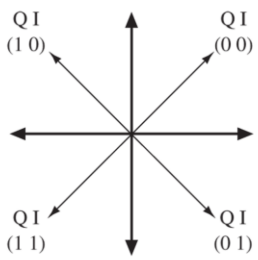

Figure 3c

Question 4

a.) Ground station A transmits an uplink frequency of 5.5 GHz to a satellite located at a distance of 40,000 km away from satellite. The satellite is equipped with an uplink receiver with 10 pW sensitivity and receiving antenna gain of 100 times. It is also equipped with a downlink transponder operating at frequency of 6 GHz with a transmitting antenna gain of 1,000 times. B is the downlink receiving ground station located at a distance of 35,000 km from the satellite. B is equipped with a receiving antenna gain of 10,000X. Station B receiver sensitivity is 20 pW. Calculate the: -

i.) Time delay between A and B teleconversation.

(2 marks)

ii.) Transmitter antenna gain required at A if the station is transmitting 1 kW power signal for uplink.

(4 marks)

iii.) Transmission power required for the downlink transponder on the satellite.

(4 marks)

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

i.) Kepler's constant for earth in min^2 / km^3 unit.

(2 marks)

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

(3 marks)

c.) A half wavelength dipole antenna has an isotropic radiation pattern with power gain of 2.15 dB is transmitting 100W of signal power at 200 MHz. Another same type 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 is detected.

(2 marks)

iii.) Signal power received at the receiving antenna.

(3 marks)

iv.) Voltage level of the received antenna.

(3 marks)

v.) Sketch the dipole antenna radiation pattern in 2D and 3D view.

(3 marks)

~THE END~

Constants and Formulas

1.) Speed of light, c = $3 \times 10^8\ m/sec$

2.) Earth's radius = 6371 km

3.) Fourier Series

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

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

4.) Trigonometry identity

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

5.) Integration by parts: $\int u\ dv = u.v - \int v\ du$

6.) Mixer output with non-linear devices

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

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

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

9.) $LOS = 3.57(\sqrt{h_B} + \sqrt{h_L})$, Radio $LOS = 4(\sqrt{h_B} + \sqrt{h_L})$

10.) Kepler's Constant $K_s = \frac{T_a^2}{r_a^3} = \frac{T_b^2}{r_b^3}$

11.) Power equation for SATCOM link

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

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, $P_r = \frac{P_t G_t G_r \lambda^2}{(4\pi d)^2} W$

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