



FINAL
 Examination Paper

(COVER PAGE)

Session : August 2017

Programme : Diploma in Electrical and Electronic Engineering (DEEI)

Course : EEE2111: Telecommunication Systems

Date of Examination : 12 December 2017 (Tuesday)

Time : 8:00am – 10:00am

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) : Alan Wong Kam Mun

Moderator : Prof. Ir. Dr. Mandeep Singh Jit Singh

This paper consists of 6 printed pages, including the cover page.

INTI INTERNATIONAL COLLEGE PENANG

DIPLOMA IN ELECTRICAL AND ELECTRONIC ENGINEERING PROGRAMME (DEEI)
 EEE2111: TELECOMMUNICATION SYSTEMS
 FINAL EXAMINATION: AUGUST 2017 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) Define isotropic radiator. (3 marks)
- b) Sketch a quarter wave antenna. Calculate the approximate length of the antenna at 150MHz. (6 marks)
- c) A carrier of 150 MHz with amplitude of $E_c = 3V$ is frequency modulated by a signal, $m(t) = 2\cos(6\pi 10^3 t)$, with a modulation index of 1.5. Calculate the:
- Frequency deviation (2 marks)
 - Frequency modulation sensitivity (2 marks)
 - Maximum and minimum instantaneous frequencies (4 marks)
 - Bandwidth with Carson's rule (4 marks)
 - Bandwidth using Bessel function table (4 marks)

Question 2:

- a) Why does one need to convert digital information to analog signals when transmitting wireless data? (6 marks)
- b) Why is a telephone channel, normally sampled at a rate of 8k samples per second? What is the impact if the sampling is done at a lower rate? (6 marks)
- c) A signal has a bandwidth of 4.5 kHz. Calculate the Nyquist sampling rate. If the signal is digitized to 8 bit resolution, how many bits are generated per second? (4 marks)
- d) Define aliasing and how it can be prevented? (3 marks)
- e) An analogue signal, band limited to a frequency of 3.5 kHz is sampled at the usual rate and coded into 8 bit samples.
- How many quantization levels are there? (2 marks)
 - What is the quantization interval for a 10V range? (2 marks)
 - What is the minimum data rate required for the coded samples? (2 marks)

Question 3:

- a) In a certain communication system, 96 analog signals are multiplexed to a digital transmission line. Each channel is bandlimited to 3.5 kHz and digitized using Pulse Code Modulation (PCM) of 8 bits/sample. Determine the following parameters of the communication system:
- The minimum sampling rate for each signal? (2 marks)
 - The minimum bit rate for the time-multiplexed output? (3 marks)
 - The minimum bandwidth required at the time-multiplexed output assuming bandwidth = data rate required? (2 marks)
- b) Compare the techniques, advantages and disadvantages of Time Division Multiplexing (TDM), Frequency Division Multiplexing (FDM). Provide also, two application examples of where each multiplexing techniques are used. (10 marks)
- c) Why is time synchronization very important in time division multiplexing? (3 marks)
- d) Describe ground wave propagation method in brief and explain two application areas. (5 marks)

Question 4:

- a) Discuss any three environmental factors that can affect the transmission and reception of wireless wave in electronic communication. (6 marks)
- b) What are the four basic modes that a radio wave is able to propagate from a transmitter to a receiving antenna? (8 marks)
- c) Calculate the minimum height of transmitting antenna and receiving antenna to ensure a Line Of Sight (LOS) condition of microwave repeaters 48 km apart. Given the height of both transmitting and receiving antenna is the same. (5 marks)
- d) Define polarization of electromagnetic wave and how to receive the maximum transmitted signal. (6 marks)

Question 5:

- a) Draw and explain Double Side Band Amplitude Modulation and prove mathematically that the amplitude modulated signals consists of three different frequency components. (10 marks)
- b) Draw and explain the architecture of a super heterodyne receiver and explain how intermediate frequency (IF) is generated. (10 marks)
- c) A frequency modulation super heterodyne receiver architecture has an IF (Intermediate Frequency) of 455 kHz. With the LO (Local Oscillator) tuned to 99.255MHz, it receives the frequency modulated broadcast of 98.8MHz. Calculate the Image Frequency that may cause interference to the receiver. (5 marks)

Question 6:

a) Delta modulation and PCM modulation are widely used analog to digital conversion techniques.

i. Show the block diagram and describe the operation of a delta modulator. (10 marks)

b) Consider a base station transmitting to a mobile station in free space.

The following parameters relate to this communication system:

- Distance between base station and mobile station: 8 km
- Transmitter frequency: 1.5 GHz
- Base station transmitting power: 10 W
- Total system losses: 8 dB
- Mobile receiver noise figure: 5 dB
- Mobile receiver antenna temperature: 290 K
- Mobile receiver bandwidth : 1.25 MHz
- Antenna gains are 8 dB and 0 dB for the base station and mobile station respectively
- antenna height at the base station and mobile station are 30 m and 3m respectively.

Calculate the :-

i. Received signal power at the mobile receiver antenna (based on the two-ray model). (6 marks)

ii. Signal-to-Noise ratio (SNR) of the received signal. (9 marks)

--THE END--

Physical Constants

Speed of light, $c = 2.998 \times 10^8$ m/s
 Ambient Temperature, $T_0 = 290$ K
 Boltzmann's Constant, $k = 1.38 \times 10^{-23}$ J/K
 Gravitational Parameter, $\mu = 398613.52$ km³ s⁻²
 Radius of the Earth is 6370 km

Bessel Function Table

Bessel Functions $J_n(\beta)$ shown to 4 decimal places.

| β | $J_0(\beta)$ | $J_1(\beta)$ | $J_2(\beta)$ | $J_3(\beta)$ | $J_4(\beta)$ | $J_5(\beta)$ | $J_6(\beta)$ | $J_7(\beta)$ | $J_8(\beta)$ | $J_9(\beta)$ | $J_{10}(\beta)$ | |
|---------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|-----------------|--|
| 0.1 | 0.9975 | 0.0499 | 0.0012 | | | | | | | | | |
| 0.2 | 0.9900 | 0.0995 | 0.0050 | 0.0002 | | | | | | | | |
| 0.4 | 0.9604 | 0.1960 | 0.0197 | 0.0013 | 0.0001 | | | | | | | |
| 0.6 | 0.9120 | 0.2867 | 0.0437 | 0.0044 | 0.0003 | | | | | | | |
| 1.0 | 0.7652 | 0.4401 | 0.1149 | 0.0196 | 0.0025 | 0.0002 | | | | | | |
| 1.5 | 0.5118 | 0.5579 | 0.2321 | 0.0610 | 0.0118 | 0.0018 | 0.0002 | | | | | |
| 2.0 | 0.2239 | 0.5767 | 0.3528 | 0.1289 | 0.0340 | 0.0070 | 0.0012 | 0.0002 | | | | |
| 3.0 | -0.2601 | 0.3391 | 0.4861 | 0.3091 | 0.1320 | 0.0430 | 0.0114 | 0.0025 | 0.0005 | 0.0001 | | |
| 4.0 | -0.3971 | -0.0660 | 0.3641 | 0.4302 | 0.2811 | 0.1321 | 0.0491 | 0.0152 | 0.0040 | 0.0009 | 0.0002 | |
| 5.0 | -0.1776 | -0.3276 | 0.0466 | 0.3648 | 0.3912 | 0.2611 | 0.1310 | 0.0534 | 0.0184 | 0.0055 | 0.0015 | |
| 6.0 | 0.1506 | -0.2767 | -0.2429 | 0.1148 | 0.3576 | 0.3621 | 0.2458 | 0.1296 | 0.0565 | 0.0212 | 0.0070 | |
| 7.0 | 0.3001 | -0.0047 | -0.3014 | -0.1676 | 0.1578 | 0.3479 | 0.3392 | 0.2336 | 0.1280 | 0.0589 | 0.0235 | |
| 8.0 | 0.1717 | 0.2346 | -0.1130 | -0.2911 | -0.1054 | 0.1858 | 0.3376 | 0.3206 | 0.2235 | 0.1263 | 0.0608 | |
| 9.0 | -0.0903 | 0.2453 | 0.1448 | -0.1809 | -0.2655 | -0.0550 | 0.2043 | 0.3275 | 0.3051 | 0.2149 | 0.1247 | |
| 10.0 | -0.2459 | 0.0435 | 0.2546 | 0.0584 | -0.2196 | -0.2341 | -0.0145 | 0.2167 | 0.3179 | 0.2919 | 0.2075 | |

Trigonometric Identities and Formulas

Formulas and Identities

Tangent and Cotangent Identities

$$\tan \theta = \frac{\sin \theta}{\cos \theta} \quad \cot \theta = \frac{\cos \theta}{\sin \theta}$$

Reciprocal Identities

$$\csc \theta = \frac{1}{\sin \theta} \quad \sin \theta = \frac{1}{\csc \theta}$$

$$\sec \theta = \frac{1}{\cos \theta} \quad \cos \theta = \frac{1}{\sec \theta}$$

$$\cot \theta = \frac{1}{\tan \theta} \quad \tan \theta = \frac{1}{\cot \theta}$$

Pythagorean Identities

$$\sin^2 \theta + \cos^2 \theta = 1$$

$$\tan^2 \theta + 1 = \sec^2 \theta$$

$$1 + \cot^2 \theta = \csc^2 \theta$$

Even/Odd Formulas

$$\sin(-\theta) = -\sin \theta \quad \csc(-\theta) = -\csc \theta$$

$$\cos(-\theta) = \cos \theta \quad \sec(-\theta) = \sec \theta$$

$$\tan(-\theta) = -\tan \theta \quad \cot(-\theta) = -\cot \theta$$

Periodic Formulas

If n is an integer.

$$\sin(\theta + 2\pi n) = \sin \theta \quad \csc(\theta + 2\pi n) = \csc \theta$$

$$\cos(\theta + 2\pi n) = \cos \theta \quad \sec(\theta + 2\pi n) = \sec \theta$$

$$\tan(\theta + \pi n) = \tan \theta \quad \cot(\theta + \pi n) = \cot \theta$$

Double Angle Formulas

$$\sin(2\theta) = 2 \sin \theta \cos \theta$$

$$\cos(2\theta) = \cos^2 \theta - \sin^2 \theta$$

$$= 2 \cos^2 \theta - 1$$

$$= 1 - 2 \sin^2 \theta$$

$$\tan(2\theta) = \frac{2 \tan \theta}{1 - \tan^2 \theta}$$

Degrees to Radians Formulas

If x is an angle in degrees and t is an angle in radians then

$$\frac{\pi}{180} = \frac{t}{x} \quad \Rightarrow \quad t = \frac{\pi x}{180} \quad \text{and} \quad x = \frac{180t}{\pi}$$

Half Angle Formulas (alternate form)

$$\sin \frac{\theta}{2} = \pm \sqrt{\frac{1 - \cos \theta}{2}} \quad \sin^2 \theta = \frac{1 - \cos(2\theta)}{2}$$

$$\cos \frac{\theta}{2} = \pm \sqrt{\frac{1 + \cos \theta}{2}} \quad \cos^2 \theta = \frac{1 + \cos(2\theta)}{2}$$

$$\tan \frac{\theta}{2} = \pm \sqrt{\frac{1 - \cos \theta}{1 + \cos \theta}} \quad \tan^2 \theta = \frac{1 - \cos(2\theta)}{1 + \cos(2\theta)}$$

Sum and Difference Formulas

$$\sin(\alpha \pm \beta) = \sin \alpha \cos \beta \pm \cos \alpha \sin \beta$$

$$\cos(\alpha \pm \beta) = \cos \alpha \cos \beta \mp \sin \alpha \sin \beta$$

$$\tan(\alpha \pm \beta) = \frac{\tan \alpha \pm \tan \beta}{1 \mp \tan \alpha \tan \beta}$$

Product to Sum Formulas

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

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

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

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

Sum to Product Formulas

$$\sin \alpha + \sin \beta = 2 \sin \left(\frac{\alpha + \beta}{2} \right) \cos \left(\frac{\alpha - \beta}{2} \right)$$

$$\sin \alpha - \sin \beta = 2 \cos \left(\frac{\alpha + \beta}{2} \right) \sin \left(\frac{\alpha - \beta}{2} \right)$$

$$\cos \alpha + \cos \beta = 2 \cos \left(\frac{\alpha + \beta}{2} \right) \cos \left(\frac{\alpha - \beta}{2} \right)$$

$$\cos \alpha - \cos \beta = -2 \sin \left(\frac{\alpha + \beta}{2} \right) \sin \left(\frac{\alpha - \beta}{2} \right)$$

Cofunction Formulas

$$\sin \left(\frac{\pi}{2} - \theta \right) = \cos \theta \quad \cos \left(\frac{\pi}{2} - \theta \right) = \sin \theta$$

$$\csc \left(\frac{\pi}{2} - \theta \right) = \sec \theta \quad \sec \left(\frac{\pi}{2} - \theta \right) = \csc \theta$$

$$\tan \left(\frac{\pi}{2} - \theta \right) = \cot \theta \quad \cot \left(\frac{\pi}{2} - \theta \right) = \tan \theta$$