FIJI NATIONAL UNIVERSITY
College of Engineering, Science & Technology

SCHOOL OF ELECTRICAL & ELECTRONICS ENGINEERING

BACHELOR OF ENGINEERING
(Telecom & Networking)

EEE747 – Radio Frequency (RF) Principles

SEMESTER 1, 2015

DAY/DATE: As timetabled DURATION : Three hours
ROOM: As timetabled

INSTRUCTION TO STUDENTS

1. You are allowed 10 minutes extra reading time during which you are **NOT** to write.
2. Answer ALL questions in Section A and FOUR questions in Section B
3. **Begin the answer to each Question** on a fresh page and use both sides of the sheet.
4. Write clearly the number of the question attempted on the top of each sheet
5. Write your candidate number at the top of each sheet & attach them.
6. Insert all written foolscaps, graph paper etc. in their correct sequence and secure with a string.
7. All sheets of paper on which rough/draft work has been done, cross it through and attach all of them to your answer scripts.
8. Where ever possible, draw clear neat diagrams

Total number of pages - 4

Section A (Answer ALL questions)

1. Write down the FOUR Maxwell's equations as applied to electromagnetic fields.

(4 marks)

2. A lossless transmission line has L = 2.4 μH/m and Zo = 85 Ω. Calculate the *velocity factor* of the line. (3 marks)

3. When a load is connected to a transmission line, the voltage reflection coefficient at the load is (0.350 + j 0.606). What is the *VSWR* on the cable?

(4 marks)

4. In a laboratory experiment, the cross-sectional dimension of the waveguide is 10.8 mm × 22.6 mm. Calculate the cutoff frequency of the dominant mode

(3 marks)

5. Explain why in practical amplitude modulators, the *modulation index* $m \leq 1$.

(3 marks)

6. What is meant by angle modulation? (3 marks)

Section B (Answer FOUR question only)

B1. (i) *a*) Using the distributed parameters, draw a small section of a transmission line of length δx. Indicate all the parameter, voltages and currents and the direction of propagation of the waves.

(3 marks)

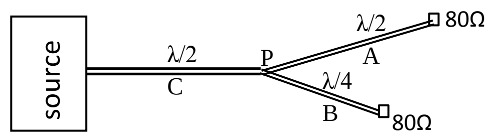
b) Write down the expressions for the change in voltages and currents along the line.

(2 marks)

(ii) If a transmission line of characteristic impedance Z_0 and length ℓ is terminated by a load Z the impedance at the other end Z_ℓ is given by:

$$\frac{Z_\ell}{Z_0} = \frac{\frac{Z}{Z_0} + j\tan\gamma}{1 + j\frac{Z}{Z_0}\tan\gamma} \quad \text{where} \quad \gamma = \frac{2\pi\ell}{\lambda}$$

Two identical antennas, each of impedance 80 Ω are connected with three lossless transmission lines A, B, C of characteristic impedance 50-Ω and varying lengths as shown in Figure. Calculate:



a) the impedance of antenna A seen at P, (4 marks)

b) the impedance of antenna B seen at P (5 marks)

c) the total impedance seen by the source. (6 marks)

B2. An RF generator operating at a frequency of 800 MHz is connected to a load of (60 + *j* 50)Ω by a lossless transmission line of characteristic impedance 50Ω and length 0.9 m. The velocity factor of the transmission line is 0.8. Using the Smith chart or otherwise, calculate:

a) the magnitude and the phase angle of the reflection coefficient at the load.

b) the normalized admittance of the load,

c) VSWR,

d) the load seen by the generator,

e) the distance of the first voltage minima from the load,

f) the distance of the first voltage maxima from the load.

It is desired to match the line to the load by using a stub constructed using a similar transmission line. Find

g) the location of the stub from the load,

h) the length of the stub.

(You must indicate clearly by a), b),..h) the relevant points on the chart)
Draw the transmission line arrangement with the stub matching. In your answer, you **must** indicate all the distances and the lengths

(20 marks)

B3. (i) a) Explain why a metallic hollow waveguide does not support TEM mode of propagation through it. (5 marks)

b) Explain the difference between TEmn and TMmn modes. (5 marks)

(ii) A tunnel is modeled as an air-filled metallic rectangular waveguide with dimensions 3m × 4m

a) Stating the reason, determine whether the tunnel will pass:

(i) a 1.5-MHz AM broadcast signal,

(ii) a 96-MHz FM broadcast signal. (5 marks)

b) If any of the signals is passed, what are the possible modes of propagation. (5 marks)

B4. (i) a) The following equation represents an AM signal

$$V = \left(V_{c\max} + V_{m\max} \sin \omega_m t\right) \sin \omega_c t$$

where the symbols have their usual meanings. Show the existence of the carrier and side band frequencies in the signal. (4 marks)

b) (i) Obtain an expression for the total power of an AM wave. (4 marks)

(ii) The total power of an AM wave with modulation index $m = 0.75$ is 500W. Calculate the power of the information signal. (4 marks)

(ii) a) Define modulation index as applied to an FM system. (2 marks)

b) A 3 kHz signal feeds an FM modulator with maximum deviation (δ) of 12 kHz.

(i) Calculate the bandwidth. (3 marks)

(ii) If the output is fed to a spectrum analyzer, draw, to approximate scale, the trace seen on the analyser. (Use the graph paper) (3 marks)

B5. (i) Write short notes on:

a) Frequency Division Multiplexing (FDM) (4 marks)

b) Time Division Multiplexing (TDM) (4 marks)

You must include in the notes, why the different multiplexings are preferred for the different types of information signals.

(ii) Scattering parameters, (or *S*-parameters) that relates to the traveling waves that are reflected by a network is inserted into a transmission line.

$$\begin{bmatrix} b_1 \\ b_2 \end{bmatrix} = \begin{bmatrix} S_{11} & S_{12} \\ S_{21} & S_{22} \end{bmatrix} \begin{bmatrix} a_1 \\ a_2 \end{bmatrix}.$$

Define **all** (b_1, b_2, S_{11}, S_{12}, S_{21}, S_{22}, a_1, a_2) quantities. (12 marks)

THE END