UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 8 Examination in Engineering: November 2017

Module Number: EE8209 **Module Name: Microwave Communication**

[Three Hours]

[Answer all questions, each question carries 10 marks]

- All the notations have their usual meanings.
- Assume permittivity of free space is $\frac{10^{-9}}{36\pi}\ F/m$

Q1 a) A TV antenna is connected to a receiver using a 10 m long cable with a booster. The carrier-to-noise ratio at the antenna terminal is 3 dB. The loss of the cable is 3.77 dB/m. The noise factor of the booster is 3 dB. Calculate the minimum gain of the booster to obtain a carrier-to-noise ratio not less than 3 dB at the input of the receiver.

[5 Marks]

b) A circular copper waveguide has a radius 0.4 cm. It is filled with a dielectric material with $\xi_r = 1.5$ and $\tan\delta = 0.002$.

i) Determine the first four propagation modes and their cut-off frequencies of the waveguide.

[3 Marks]

ii) Calculate the total attenuation for the dominant mode.

[2 Marks]

Q2 a) Discuss about Ionospheric wave propagation. [2 Marks]

b) Use the perturbation method to find the attenuation constant.

[3 Marks]

c) A radio transmitter is connected to an antenna having an impedance (80 + j 40) Ω with a 50 Ω coaxial cable. If the 50 Ω transmitter delivers 30 W when it is connected to a 50 Ω load, how much power is delivered to the antenna?

[5 Marks]

Q3 a) Briefly explain the following parameters of a transmission line.

i) Intrinsic impedance
ii) Wave impedance
iii) Characteristics impedance

[3 Marks]

b) The parameters of a Satellite communication link is given below.

Antenna gain to noise temperature ration = 1.6 dB/K
Satellite saturation effective isotropic radiated power $(EIRP)_s$ = 44 dBW
Transmitting antenna uplink gain G_u = 57.6 dB (at 14 GHz)
Transmitting antenna downlink gain G_d = 56.3 dB (at 12 GHz)
Carrier power in antenna = 174 W
System noise temperature = 160 K
Tracking loss in the uplink = 1.2 dB
Tracking loss in the downlink = 0.9 dB
Noise bandwidth = 36 MHz.
Uplink and downlink slant range = 37500 km

i) Compute the downlink carrier power. [2 Marks]

ii) Compute the overall carrier-to-noise ratio (CNR) in the satellite link.

[5 Marks]

Q4 a) Find the width of a 50 Ω copper stripline conductor with b = 0.32 cm and ε_r = 2.2. If the dielectric loss tangent is 0.001 and the operating frequency is 10 GHz, calculate the attenuation in dB/λ. Assume a conductor thickness is 0.01 mm.

[5 Marks]

b) Calculate the group velocity for an air-filled waveguide in propagating mode. Compare this velocity with the phase velocity and the speed of light.

[5 Marks]

Q5 A two-port network consists of the following scattering matrix.

$$[S] = \begin{bmatrix} 0.15\angle 0^\circ & 0.85\angle -45^\circ \\ 0.85\angle 45^\circ & 0.2\angle 0^\circ \end{bmatrix}$$

a) Determine whether the network is reciprocal and lossless.

[5 Marks]

b) If the port 2 is terminated with a matched load, what is the return loss seen at the port 1?

[3 Marks]

c) If the port 2 is terminated with a short circuit, what is the return loss seen at the port 1?

[2 Marks]

Table 1: Summary of results for circular waveguide.

Quantity	TE_{nm} Mode	TM_{nm} Mode
k	$\omega\sqrt{\mu\epsilon}$	$\omega\sqrt{\mu\epsilon}$
k_c	$\frac{p'_{nm}}{a}$	$\frac{p_{nm}}{a}$
β	$\sqrt{k^2 - k_c^2}$	$\sqrt{k^2 - k_c^2}$
λ_c	$\frac{2\pi}{k_c}$	$\frac{2\pi}{k_c}$
λ_g	$\frac{2\pi}{\beta}$	$\frac{2\pi}{\beta}$
v_p	$\frac{\omega}{\beta}$	$\frac{\omega}{\beta}$
α_d	$\frac{k^2 \tan\delta}{2\beta}$	$\frac{k^2 \tan\delta}{2\beta}$
E_z	0	$(A\sin n\phi + B\cos n\phi)J_n(k_c\rho)e^{-j\beta z}$
H_z	$(A\sin n\phi + B\cos n\phi)J_n(k_c\rho)e^{-j\beta z}$	0
E_ρ	$\frac{-j\omega\mu n}{k_c^2\rho}(A\cos n\phi - B\sin n\phi)J_n(k_c\rho)e^{-j\beta z}$	$\frac{-j\beta}{k_c}(A\sin n\phi + B\cos n\phi)J'_n(k_c\rho)e^{-j\beta z}$
E_ϕ	$\frac{j\omega\mu}{k_c}(A\sin n\phi + B\cos n\phi)J'_n(k_c\rho)e^{-j\beta z}$	$\frac{-j\beta n}{k_c^2\rho}(A\cos n\phi - B\sin n\phi)J_n(k_c\rho)e^{-j\beta z}$
H_ρ	$\frac{-j\beta}{k_c}(A\sin n\phi + B\cos n\phi)J'_n(k_c\rho)e^{-j\beta z}$	$\frac{j\omega\epsilon n}{k_c^2\rho}(A\cos n\phi - B\sin n\phi)J_n(k_c\rho)e^{-j\beta z}$
H_ϕ	$\frac{-j\beta n}{k_c^2\rho}(A\cos n\phi - B\sin n\phi)J_n(k_c\rho)e^{-j\beta z}$	$\frac{-j\omega\epsilon}{k_c}(A\sin n\phi + B\cos n\phi)J'_n(k_c\rho)e^{-j\beta z}$
Z	$Z_{\text{TE}} = \frac{k\eta}{\beta}$	$Z_{\text{TM}} = \frac{\beta\eta}{k}$

Table 2: value of P_{nm} for TM modes of circular waveguide.

n	p_{n1}	p_{n2}	p_{n3}
0	2.405	5.520	8.654
1	3.832	7.016	10.174
2	5.135	8.417	11.620

Table 3: Valiue of p'_{nm} for TE modes of circular waveguide.

n	p_{n1}	p_{n2}	p_{n3}
0	2.405	5.520	8.654
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