UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 6 Examination in Engineering: December 2015

Module Number: EE6301 **Module Name: Communication Systems**

[Three Hours]

[Answer **all questions**, each question carries 10 marks]

Q1 a) Explain clearly how the same Smith chart can be used to mark the admittance value for a given load instead of the impedance value of the load.

[1.5 Marks]

b) A transmission line is matched to a load using a single stub tuner as shown in Figure Q1. The characteristic impedance of the line is 50 Ω. The length of the short-circuited stub is 0.125λ and the distance from the stub to the load is 0.074λ. Use the provided Smith chart to determine the following.

i) The normalized admittance at AA in the absence of the stub

ii) The admittance and impedance of the load

[6.0 Marks]

c) Using the same Smith chart calculations in part b), it is possible to generate another set of solutions for a single stub tuner. Give the stub length and the location of the stub for the solution.

[2.5 Marks]

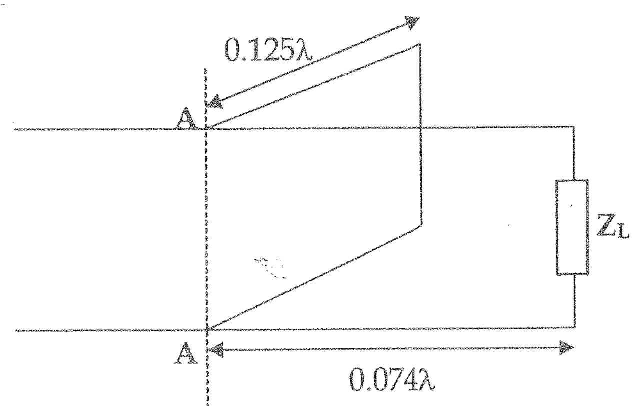


Figure Q1 : Single stub tuner

Q2 a) Briefly explain the following terms with respect to antenna theory.

i) Radiation intensity
ii) Directivity
iii) Gain
iv) Half-power beamwidth
v) Isotropic antenna
vi) Polarization

[4.5 Marks]

b) What are the field regions of an antenna? Explain the properties of each region using a diagram.

[1.5 Marks]

c) The radial component of the radiated power density of an infinitesimal linear dipole of length $l \ll \lambda$ is

$$W_{av} = \hat{a}_r W_r = \frac{\hat{a}_r A_0 \sin^2\theta}{r} \qquad \text{W/m}^2$$

where A_0 is the peak value of the power density, θ is the angle in a spherical coordinate system and $\hat{a}_r$ is the radial unit vector. The antenna radiation efficiency is 90%.

i) Determine the maximum directivity of the antenna and express the directivity as a function of the directional angles θ and ϕ.
ii) Calculate the gain of the antenna at maximum directivity.

[4.0 Marks]

Q3 a) Explain how the parameters of space wave propagation, radio horizon and effective radius of the earth considering the refractive index profile in the troposphere.

[2.0 Marks]

b) i) Determine the maximum range of communication between two antennas of heights 150 m and 60 m respectively.
ii) What is the radio horizon for an operating frequency of 300 MHz? Assume a standard atmosphere.

[3.0 Marks]

c) Define the following terms used in ionospheric wave propagation.

i) Skip distance
ii) Maximum usable frequency

[2.0 Marks]

d) An ionosphere layer has a maximum electron density of 5×10^{10} electrons per cubic meter. The vertical height h of the layer is 100 km.

i) Show that the Maximum Usable Frequency (MUF) for a flat earth surface is

$$\text{MUF} = f_c\left[1+\left(\frac{D}{2h}\right)^2\right]^{1/2}$$

where f_c is the critical frequency and D is the skip distance.

ii) Determine the maximum usable frequency for communicating with a receiver situated 200 km away.

[3.0 Marks]

Q4 a) With the aid of a diagram, briefly explain the following terms for a pulse radar system.
   i) Pulse length
   ii) Pulse Repetition Interval (PRI)
   iii) Duty cycle
   iv) Average power

[2.0 Marks]

b) i) What is meant by range ambiguity in a pulse radar system?
   ii) A radar system has an unambiguous range of 100 km. The pulse length of the transmitting pulse is 2 μs. Determine the Pulse Repetition Frequency (PRF) and the range resolution of the system.

[2.5 Marks]

c) The conventional Continuous Wave (CW) radar systems are not capable of predicting the distance to an obstacle. The Frequency Modulated Continues Wave (FMCW) radar systems are capable of predicting the distance to an obstacle.
   i) Explain why CW radar systems are not capable of calculating the distance to an obstacle when compared to pulse radar systems.
   ii) Explain the method of distance calculation used in FMCW for a linear modulated system.

[2.5 Marks]

d) Table Q4 provides details of a radar system. Calculate the Signal to Noise Ratio (SNR) at the radar receiver. All symbols have their usual meanings.

[3.0 Marks]

Table Q4

Radar Range Equation Parameter	Value
P_T	10^6 W
G_T	6309.6
G_R	6309.6
f_c	8GHz
σ	3.98 m^2
R	60×10^3 m
kT_0	4×10^{-21} W.s
B	2.5×10^6 Hz
F_n	6.31
$L = L_t L_r L_{other}$	5.01

Q5 a) Explain the basic functions of a satellite transponder with the aid of a block diagram.

[2.0 Marks]

b) Explain the three basic forms of connectivity used in satellite communication.

[2.0 Marks]

c) A typical Ku-band link budget for the downlink of a small Direct-to-Home (DTH) receiver is shown in Table Q5.

i) What is the transmit power of the satellite in Watts?

ii) What is meant by Effective Isotropic Radiated Power (EIRP) of the satellite?

iii) Determine the downlink Carrier-to-Noise $(C/N)_d$ of the satellite link. Explain clearly how you complete each row entry and obtain the value of $(C/N)_d$ starting with the Friis free space equation.

[3.5 Marks]

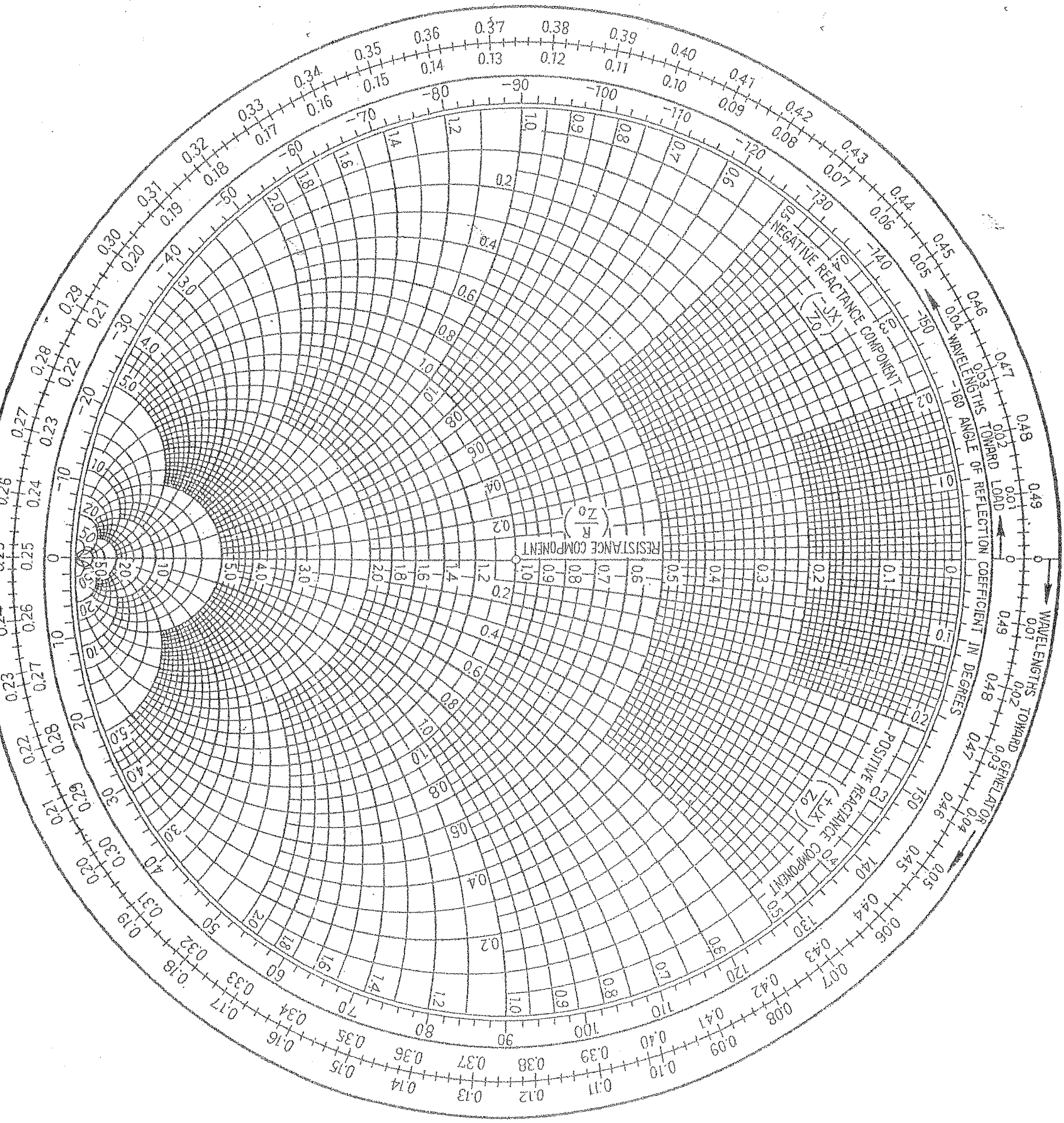
d) i) Given that carrier-to-noise ratios of the uplink and the downlink of a satellite link are $(C/N)_u = 26$ dB and $(C/N)_d = 24$ dB respectively, determine the overall carrier-to-noise ratio of the satellite link in dB.

ii) What is the overall carrier-to-noise ratio of the satellite link, if the transmit power of the satellite is halved?

[2.5 Marks]

Table Q5

Parameter	Units	Relative Value (Expressed as a gain)	Absolute Value
Transmit power	dBW		24.0
Transmit waveguide loss	dB	-1.0	
Transmit antenna gain	dBi	30.0	
EIRP	dBW		
Free space loss	dB	-205.6	
Atmospheric loss	dB	-0.1	
Receiver antenna gain	dBi		32.7
Receiver waveguide loss	dB	-0.5	
Received power (clear sky)	dBW		
Bandwidth (27 MHz)	dB(Hz)		74.3
System noise temperature (140K)	dB(K)		21.5
Boltzmann's constant	$dB(HzK)^{-1}$		-228.6
Received noise power	dBW		
$(C/N)_d$	dB		


WAVELENGTHS TOWARD GENERATOR
WAVELENGTHS TOWARD LOAD
ANGLE OF REFLECTION COEFFICIENT IN DEGREES
NEGATIVE REACTANCE COMPONENT
POSITIVE REACTANCE COMPONENT
RESISTANCE COMPONENT