UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 6 Examination in Engineering: November 2022

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

[Three Hours]

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

Notes:

- **All notations have their usual meaning.**
- **Use the provided Smith chart to answer Q1.**
- **State any assumption made in calculations clearly.**
- **Use the following parameters, if required.**
  - **Permittivity of the free space,** $\varepsilon_0 = \dfrac{1}{36\pi \times 10^9}$ F/m
  - **Permeability of the free space,** $\mu_0 = 4\pi \times 10^{-7}$ H/m
  - **Boltzmann constant,** $k = 1.380649 \times 10^{-23}$ J/K
  - **Speed of Light,** $c = 3 \times 10^8\ m/s$

Q1 a) Briefly explain how you determine the admittance from a given impedance in a Smith chart.

[2.0 Marks]

b) An air-filled two-wire line has a characteristic impedance of 50 Ω and is operated at 3 GHz. The load is $(100 + j40)\ \Omega$.

i) Mark the given load impedance on the Smith chart.

ii) What is the line impedance at a distance 2.5 cm away from the load?

iii) What is the VSWR on the line?

iv) Determine the distance to the first voltage maximum point and the first current maximum point from the load.

v) How do you locate the points stated in part b) iv) by starting with the admittance point of the load? Justify your answer.

[8. 0 Marks]

Q2 a) i) Explain the term *Cut-off Frequency* with respect to a rectangular waveguide. What happens when the frequency of operation is lower than the cut-off frequency?

[2.0 Marks]

ii) What is referred to as the *dominant mode* of a rectangular waveguide? Explain the significance of *dominant mode* operation.

[2.0 Marks]

b) A rectangular waveguide has dimensions of 22.86 mm and 10.16 mm. Answer the following questions assuming that the guide is air-filled and the frequency of operation is 25 GHz.

i) Calculate and list all possible propagating Transverse Magnetic (TM) modes in the above waveguide.

[3.5 Marks]

ii) Assuming the TM_{11} mode of operation, calculate the guided wavelength λ_g.

[2.5 Marks]

Q3 a) i) State two main factors that impact ground wave propagation for a given transmit power and explain their influence.

[2.0 Marks]

ii) "Ionospheric wave propagation can be influenced by the time of operation". Do you agree with the above claim? Justify your answer.

[1.0 Mark]

iii) Explain the terms 'Skip Distance' and 'Maximum Usable Frequency' in Ionospheric wave propagation.

[1.0 Mark]

b) A mobile is located 5 km away from a base station and uses a vertical $\lambda/4$ monopole antenna with a gain of 2.55 dB to receive cellular radio signals. The electric field at 1 km from the transmitter is measured to be 10^{-3} V/m. The carrier frequency used for this system is 900 MHz. The height of the transmitting antenna is 50 m and the receiving antenna is 1.5 m above the ground.

i) Find the electric field at the receiver at a distance of 5 km away from the transmitter assuming 2-ray ground reflection propagation model.

[2.0 Marks]

ii) Calculate the received power at the location given in b) i).

[2.5 Marks]

iii) What would be the received power at the location given in b) i), if the carrier frequency is doubled? Explain how you obtain that answer without performing calculations.

[1.5 Marks]

Q4 a) What are the main parameters required to determine the minimum range resolution and maximum detection range of a radar system?

[1.0 Mark]

b) Show that in pulse radar systems, the range resolution (ΔR) is equal to $\frac{c}{2B}$, where c is the velocity of light and B is the bandwidth.

[1.0 Mark]

c) Calculate the maximum range of Radar for the following specifications.

The peak power transmitted by the Radar (P_t) is 250 kW

The gain of transmitting Antenna (G) is 4000
The effective aperture of the receiving Antenna (A_e) is 4 m^2
The radar cross-section of the target (σ) is 25 m^2
The power of minimum detectable signal (S_{min}) is 10^{-12} W

[3.0 Marks]

d) Name the three types of fields generated by a Hertz dipole and explain how each field varies with respect to the distance from the transmitter and the frequency of operation.

[2.0 Marks]

e) A 1 cm long Hertz dipole carries a current of 10A and operates at a wavelength of 3 m. Compute the radiation resistance and the total power radiated by the dipole antenna.

[3.0 Marks]

Q5 a) Explain the usage of the Polar orbit and Low Earth Orbit (LEO) satellites.

[1.0 Mark]

b) Illustrate the satellite transponder using a block diagram and explain its four basic functions.

[2.0 Marks]

c) In a satellite receiver station, the Low Noise Amplifier (LNA) and Down Converter (DC) are placed in a single module called Low-Noise Block downconverter (LNB). Give two reasons for this arrangement.

[1.0 Mark]

d) A satellite in geostationary earth orbit is 39,000 km away from an earth station. The required flux density at the satellite to saturate one transponder at a frequency of 14.3 GHz is -90.0 dBW/m^2. The earth station has a transmitting antenna with a gain of 52 dB at 14.3 GHz.

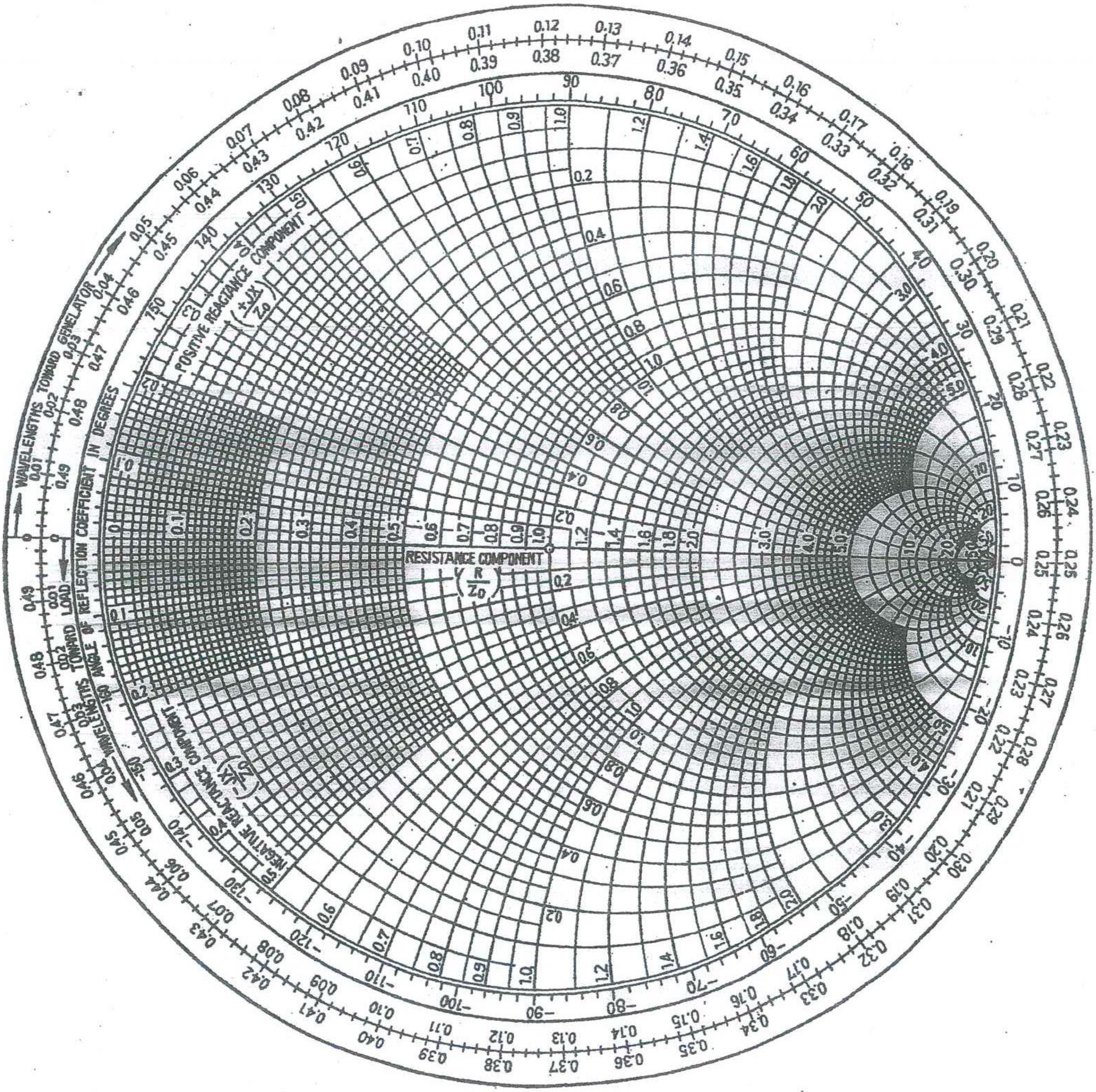
i) Calculate the Equivalent Isentropic Radiated Power (EIRP) of the earth station in dBW.

ii) Find the output power of the earth station transmitter in dBW.

[3.0 Marks]

e) A geostationary satellite carries a transmitter that operates at an output power of 10 W and drives an antenna with a gain of 30 dB at 4 GHz. An earth station is at the center of the coverage zone of the satellite, at a range of 38,500 km. Find the power received by an antenna at the earth station with a gain of 39 dB in dBW.

[3.0 Marks]



The Smith Chart