

EE 4036 Test 1

Question 1 (50 marks)

(A) Tropospheric wave propagation

A1) A tropospheric wave propagation with ground reflected wave is shown in Fig. Q1A, assume that the electric field reflection coefficient is $\Gamma = |\Gamma| [\phi]$ at the point of reflection, derive the phase difference, ϕ_s , in terms of heights of transmitting antenna (h_T) and receiving antenna (h_R). Explain the phenomenon that may occur.

(20 marks)

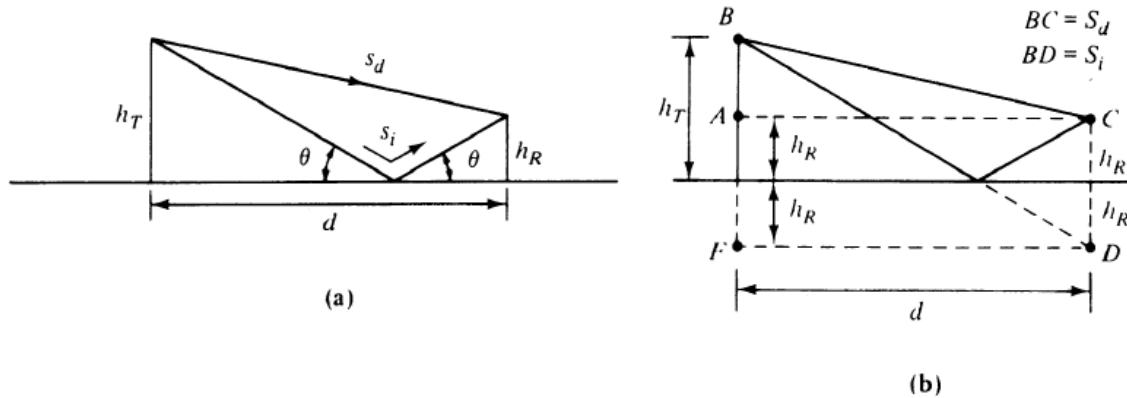
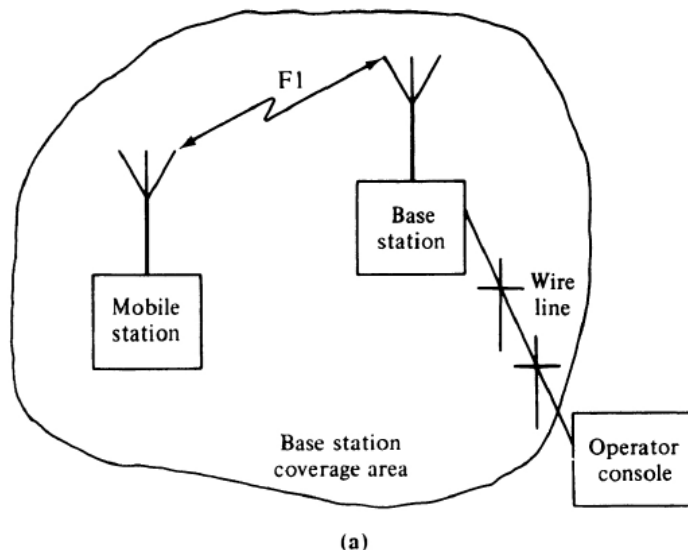


Fig. Q1A Tropospheric wave propagation

(A2) For the Tropospheric Propagation VHF/UHF Radio Systems shown in Fig. Q1B, explain :

- how you may expand the coverage by three (3) times by using one additional frequency.
- how you may double the coverage without using additional frequency.



(a)

Fig Q1B

(5 marks)

(B) Ionospheric wave propagation

Assume that you are a member of a research team, and you are sent to a place called “Station 3”. You need to communicate with “Station 1” twice per day. “Station 1” communicates with “Station 3” via “Station 2”. The time between each communication is 4 hours and a single-hop ionosphere wave is used (see Fig Q1B) between each station communication. The Optimum Working Frequency (OWF) is 12.15MHz and the critical frequency is 10MHz.

- The transmission starts at $t = 0:00$, draw the geometrical relationship diagram to explain the transmission and hence find the minimum distance between “Station 1” and “Station 3” at $t = 0:00$ (see Table Q1B).
- Explain quantitatively whether the second communication will fail or not? (All stations may recover signals at ± 10 Km offset)

Assume radius of earth = 6000km

Given: $MUF = \frac{f_c}{\cos \theta}$; OWF ~ use 90 % practice, 2 d.p. are required for all answers

Use Table Q1B to find heights of ionosphere in zone 1 (h_1) and zone 2 (h_2).
(25 marks)

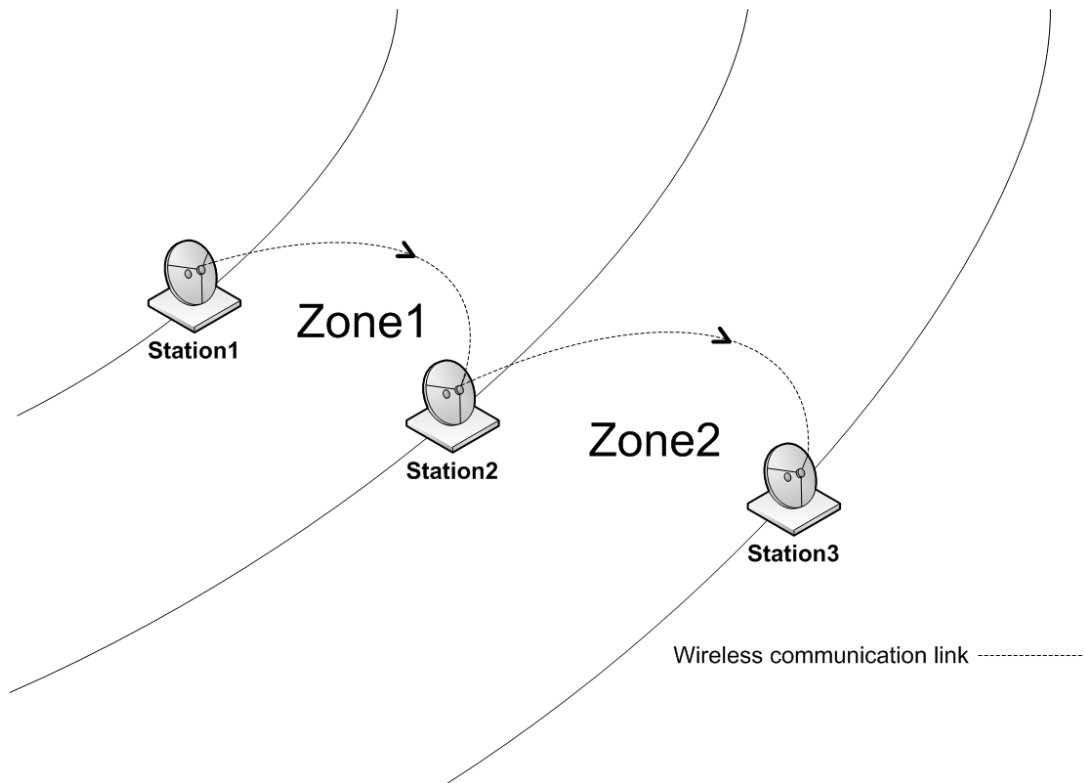


Fig Q1B

Time	0:00	1:00	2:00	3:00	4:00	5:00
h_1 (km)	270	270	275	280	285	290
h_2 (km)	300	300	295	290	285	280
Time	6:00	7:00	8:00	9:00	10:00	11:00
h_1 (km)	295	300	300	300	300	300
h_2 (km)	275	270	270	270	270	270
Time	12:00	13:00	14:00	15:00	16:00	17:00
h_1 (km)	300	300	300	300	300	295
h_2 (km)	270	270	270	270	270	275
Time	18:00	19:00	20:00	21:00	22:00	23:00
h_1 (km)	290	285	280	275	270	270
h_2 (km)	280	285	290	295	300	300

h_1 = height of ionosphere in zone 1 ; h_2 = height of ionosphere in zone 2

Table Q1B: Height of Ionosphere in a day

Question 2 (50 marks)

(A) The parameters the uplink communication and the downlink communication using a passive transponder are shown in Table Q2 and Fig. Q2.

- (i) Calculate the link budget, C/N, of the uplink and the downlink;
- (ii) It is required that $C/N \geq 10\text{dB}$ for minimum signal reception. If another signal B operating at 12GHz and with 16-PSK modulation @ $C/N=12\text{dB}$ has reached the downlink receiver simultaneously, comment on whether the signal reception of (A) (i) is good or not.

All answers should include up to two (2) decimal places.

NB: C/N difference of two signals $\leq 3\text{dB}$ cannot be distinguished`

(40 marks)

Uplink:

Table Q2

For Earth Station

Earth station transmitter output power at saturation	100 W
Loss between amplifier and antenna	0.5dB
Earth station back-off loss	2 dB
Tx Antenna Diameter	15m
Tx Antenna Efficiency, η	0.65
Tx Antenna Elevation	20°
Earth station transmission frequency	14 GHz
Bit rate	120 Mbps
Modulation scheme`	16-PSK
Earth station branching and feeder losses	1 dB
Additional uplink atmospheric losses	0.6 dB
Transmission Distance from earth station	350 km

Satellite:

Rx Antenna Diameter	0.7m
Rx Antenna Efficiency, η	0.6
Equivalent noise temperature	580K

Downlink:

For the satellite

Satellite transmitter output power at saturation	10 W
Loss between amplifier and antenna	1 dB
Satellite back-off loss	1 dB
Additional downlink atmospheric losses	0.4 dB
Tx Antenna Diameter	0.7 m
Tx Antenna Efficiency, η	0.6
Satellite transmission frequency	12 GHz
Bit rate	120 Mbps
Modulation scheme	16-PSK
Transmission Distance from satellite	400 km

For Earth Station

Rx Antenna Diameter	4 m
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Rx Antenna Efficiency, η	0.65
Rx Antenna Elevation	30°
Equivalent noise temperature	580K
Loss between amplifier and antenna	0.5 dB

(B) Explain why the frequency of uplink and downlink are different in typical satellite communication system.

(2 marks)

(C) With the aid of the diagram, describe briefly the functional blocks in the satellite transponder.

(8 marks)

Given:

$$\frac{C}{N_0} = \text{ERIP} \times \frac{1}{L} \times \frac{G}{T} \times \frac{1}{K}$$

$$K \text{ (Boltzman constant)} = 1.38 \times 10^{-23} \text{ J/K}$$

$$\frac{E_b}{N_0} = \frac{C}{N_0} \times \frac{1}{f_b}$$

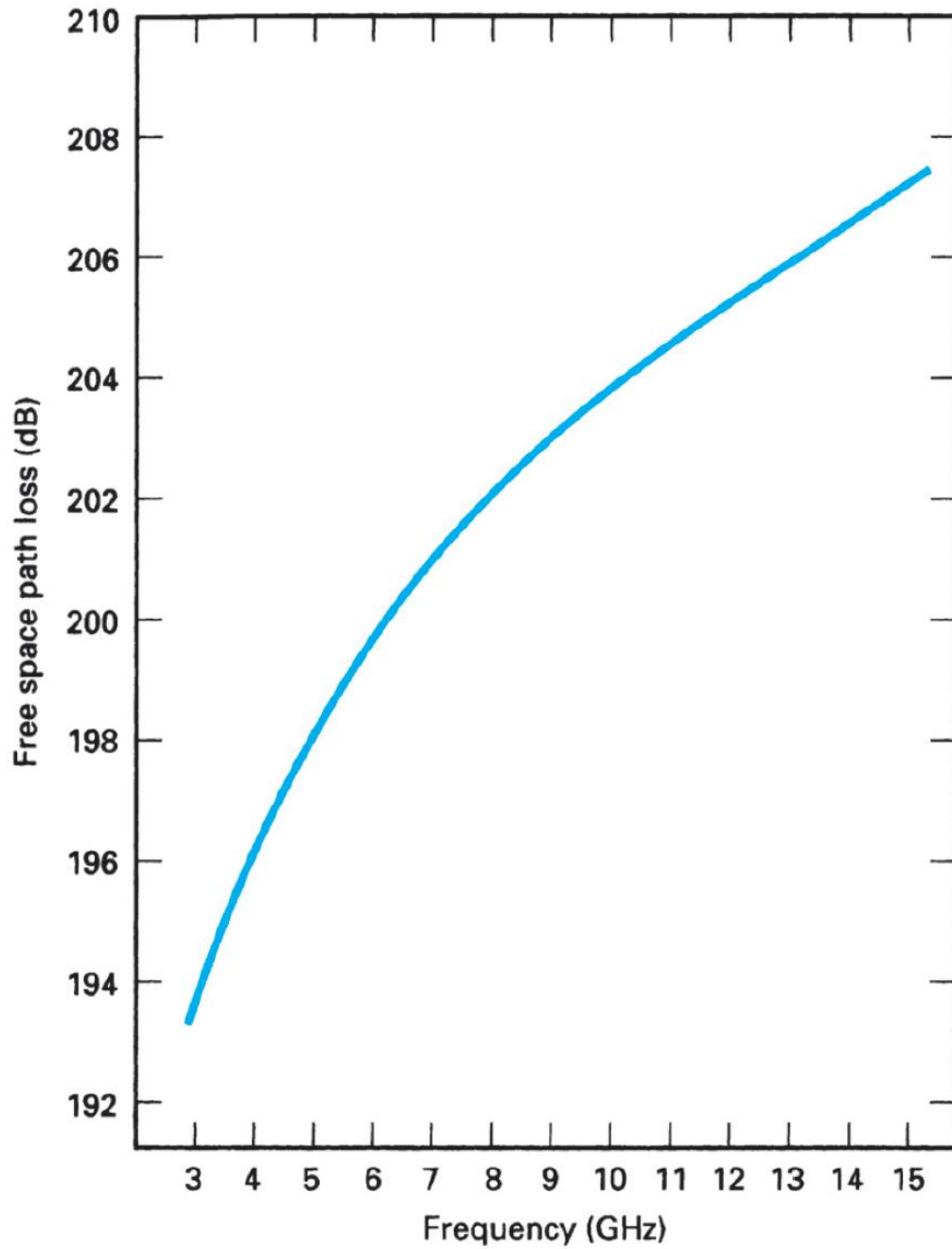
$$E_b = P_t T_b, N_0 = K T_e$$

$$\frac{C}{N} = \frac{E_b}{N_0} \times \frac{f_b}{B} \text{ where } B = \frac{f_b}{n}$$

$$\frac{C}{N_{TOTAL}} = \frac{1}{\frac{N_1}{C} + \frac{N_2}{C} + \dots + \frac{N_n}{C}}$$

$$Gain_{antenna} = \eta \left(\frac{\pi D}{\lambda} \right)^2, \text{ D: Diameter of dish antenna, } \lambda : \text{ wavelength}$$

$$\left(\frac{E_b}{N_0} \right)_{total} = \frac{\left(\frac{E_b}{N_0} \right)_1 \left(\frac{E_b}{N_0} \right)_2}{\left(\frac{E_b}{N_0} \right)_1 + \left(\frac{E_b}{N_0} \right)_2}; \quad \frac{G}{T}(\text{satellite}) = \frac{G_{RX}}{T} = G_{RX} - 10 \log T$$



Elevation angle correction:

Angle	+dB
90°	-0.45dB
45°	0.44dB
0 °	1.33dB

Fig. Q2

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