UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2010/2011

COURSE	:	SATELLITE COMMUNICATION SYSTEM
COURSE CODE	:	BEP 4243
PROGRAMME	:	4 BEP
EXAMINATION DATE	:	NOVEMBER / DECEMBER 2010
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER FIVE (5) QUESTIONS ONLY

THIS PAPER CONSISTS OF SEVEN (7) PAGES

Q1 (a) There are seven elements which could determine the orbit of a spacecraft around the Earth. They are termed as Keplerian elements. With the aid of diagrams, describe the meaning of three Keplerian elements as given below:

(i) orbital inclination, i,

(2 marks)

(ii) right ascession of the ascending node, Ω and

(3 marks)

(iii) argument of perigee, ω.

(3 marks)

(b) A satellite is orbiting above the Earth with an inclination, i, of 98.6328°, eccentricity, e, of 0.0011501, mean motion (rev/day), NN, of 14.23304826 and semi major axis, a, of 7192.335km. The Ω_o = 251.5324° and ω_o = 113.5534°. Using those information given, calculate:-

(i) rate of regression of the nodes,

(5 marks)

(ii) rate of rotation of the line of apsides, and

(2 marks)

(iii) the new values for Ω and ω one period after epoch.

(5 marks)

Q2 (a) Distinguish the advantages and disadvantages of geostationary and low earth orbitting satellites. Name one application for each orbit type.

(6 marks)

(b) The following elements apply to a satellite in inclined orbit ; n = 0.001034 rad/s, M_o = 309°, i = 63°, e = 0.08182, Ω = 300°, ω = 60° and a = 7130 km. An Earth station is situated at 45°N, 80°W, and at zero height above the sea level. Assuming a perfectly spherical Earth of uniform mass and radius of 6371 km, and give that the epoch corresponds to a GST of 116°, estimate:

(i) true anamoly, v,

(3 marks)

(ii) radius vector, r,

(2 marks)

(iii) position vector of the satellite in **PQW** frame, and

(3 marks)

(iv) position vector of the satellite in **IJK** frame.

(6 marks)

Q3 (a) Compare the rain attenuation which is exceeded for 0.01% of the time in any year for horizontal, vertical and circular polarizations when the rain height and rain rate is 5.6 km and 11.2 mm/h, respectively. The altitude of the Earth station is 375 m above the mean sea level with the elevation angle of the antenna is 21°. The polarization of those signals is at 25 GHz.

(13 marks)

(b) (i) Define Cross-polarization Discrimination, XPD.

(2 marks)

(ii) By using the rain attenuation for the circular polarization from **Q3**(a) above, assess the cross-polar discrimination, XPD, in unit dB. Given;

$$V = \begin{cases} 20 \ \ for\ 8 \le f < 15GHz \\ 23 \ \ for\ 15 \le f \le 35GHz \end{cases}$$

$$U = 30\log f - 10\log(0.5 - 0.4697\cos 4\tau) - 40\log(\cos\theta)$$

(5 marks)

Q4 (a) Depolarization is an effect of orthogonal component that may be generated from the transmitted polarization. Compare in between Ionospheric, Rain and Ice depolarizations.

(6 marks)

(b) Design a complete satellite circuit using both uplink and downlink. From the design, prove that C/N_0 at the groud receiver is;

$$\left(\frac{P_R}{(\gamma P_{NU} + P_{ND})}\right)$$

Define the meaning of each parameters in the equation, whenever necessary.

(6 marks)

(c) A satellite circuit has parameters as in **Table 1**. Calculate the overall $[C/N_o]$. Given [k] = - 228.6 dB.

(8 marks)

Q5 (a) Design satellite circuits block diagram which contain both wanted and unwanted network and explain the B_1 and B_2 modes of interference in those circuits.

(3 marks)

(b) (i) The Equivalent Isotrophic Radiated Power [EIRP] from a satellite S_1 is 45.6 dBW and the gain of the ground station receiving antenna, B is 37.4 dB in the desired direction and 19.75 dB toward the interfering satellite S_2. The interfering satellite also radiates an [EIRP] of 43.5 dBW. The polarization discrimination is 3.8 dB. Calculate the downlink Carrier-to-Interference ratio [C/I] at the ground receiving antenna.

(3 marks)

(ii) An Earth station A transmits 24 dBW power with an antenna gain of 54 dB, and Earth station C transmits 30 dBW power. The off-axis gain in the S_1 direction is 24.47 dB, and the polarization discrimination is 4 dB. Calculate the [C/I] on the uplink.

(3 marks)

(iii) Using the uplink and downlink values from (b) (i) and (ii) above, calculate the overall [C/I].

(3 marks)

(c) Given that L_U = 200 dB, L_D = 196 dB, $G_E = G'_E$ = 25 dB, $G_S = G'_S$ = 9dB, $G_{TE} = G_{RE}$ = 48 dB, $G_{RS} = G_{TS}$ = 19 dB, $U_S = U'_S$ = 1 μJ, and U'_E = 10 μJ. Given [k] = - 228.6 dB. Estimate:

(i) transmission gain, γ,

(3 marks)

(ii) the interference levels, $[I_1]$ and $[I_2]$, and

(2 marks)

(iii) the equivalent temperature rise overall.

(3 marks)

Q6 (a) Global Positioning Satellites (GPS) is a Satellite Communication System that can be used for so many applications such as for Navigation, Surveying, Tracking, Construction, Machine Control, Container Handling and Mining. However, the atmosphere which functions as the medium of propagation for GPS does effect the overall performance of GPS.

(i) Evaluate the statement above by referring to ionospheric effect to Navigation in GPS application.

(6 marks)

(ii) Propose 2 methods that can be implemented in order to mitigate the ionospheric error and to improve the performance of the GPS system.

(4 marks)

(iii) Analyse the reasons or factors that contribute to the difference in GPS positioning inaccuracy over the equatorial and mid-latitude region.

(6 marks)

(b) One of the advantage of satellite communication system is the provision of service to remote or rural areas. Propose on how the advantage of satellite communication system can be implemented to improve the economy of the rural area.

(4 marks)

FINAL EXAMINATION

SEMESTER / SESSION : SEM 1 / 2010 / 2011
COURSE : SATELLITE COMMUNICATION SYSTEM

PROGRAMME : 4 BEP
COURSE CODE : BEP 4243

Table 1 : Satellite circuit parameters for Q4

Parameters	Uplink (decilogs)	Downlink (decilogs)
[EIRP]	54	34
[G/T]	40.7	17
[FSL]	210	195
[RFL]	2	1.75
[AA]	0.75	0.65
[AML]	0.75	0.65

Table 2 : Reduction Factors

For p = 0.001%	$r_{0.001} = \frac{10}{10 + L_G}$
For p = 0.01%	$r_{0.01} = \frac{90}{90 + 4L_G}$
For p = 0.1%	$r_{0.1} = \frac{180}{180 + L_G}$
For p = 1%	$r_1 = 1$

Table 3 : Specific Attenuation Coeficients

Frequency, GHz	a_h	a_v	b_h	b_v
8	0.00454	0.00395	1.327	1.31
10	0.0101	0.00887	1.276	1.264
12	0.0188	0.0168	1.217	1.2
15	0.0367	0.0335	1.154	1.128
20	0.0751	0.0691	1.099	1.065
25	0.124	0.113	1.061	1.03
30	0.187	0.167	1.021	1

FINAL EXAMINATION

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COURSE : SATELLITE COMMUNICATION SYSTEM

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Constant values and formulas:

$\mu = 3.986005 \times 10^{14}$ m^3 sec^{-2} (Gravitational parameter)

R = 6371 km (mean Earth radius)

$K_1 = 66063.1704$ km^2 (Earth's constant)

r = (r cos v) **P** + (r sin v) **Q**

$$\begin{bmatrix} r_I \\ r_J \\ r_K \end{bmatrix} = \vec{R} \begin{bmatrix} r_P \\ r_Q \end{bmatrix}$$

$$\vec{R} = \begin{bmatrix} (\cos\Omega\cos\omega - \sin\Omega\sin\omega\cos i) & (-\cos\Omega\sin\omega - \sin\Omega\cos\omega\cos i) \\ (\sin\Omega\cos\omega + \cos\Omega\sin\omega\cos i) & (-\sin\Omega\sin\omega + \cos\Omega\cos\omega\cos i) \\ (\sin\omega\sin i) & (\cos\omega\sin i) \end{bmatrix}$$