UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2011/2012

COURSE NAME : SATELLITE COMMUNICATION SYSTEM

COURSE CODE : BEP 4243

PROGRAMME : BEE

EXAMINATION DATE : JUNE 2012

DURATION : 3 HOURS

INSTRUCTION : ANSWER **FIVE (5)** QUESTIONS ONLY

THIS PAPER CONSISTS OF **SEVEN** (7) PAGES

Q1 (a) Explain the THREE (3) laws that was derived by Johannes Kepler (1571 – 1630) that are able to show the rotation of satellite around the Earth. Use figures or mathematic models to enhance the definition.

(10 marks)

(b) The following are Two Line Element (TLE) set for a particular satellite.

```
NOAA   14
1 23455U 94089A   97320.90946019 .00000140  00000-0  10191-3  0  2621
2 23455 99.0090  272.6745 0008546 223.1686 136.8816 14.23304826148495
```

Calculate:

(i) epoch day in Julian day,

(3 marks)

(ii) semi-major axis, a, and

(3 marks)

(iii) true anomaly using approximated equation for near circular orbit for an epoch of 5 seconds.

$$v \cong M + 2e\sin M + \frac{5}{4}e^2 \sin 2M$$

(4 marks)

Q2 (a) Sketch and analyze the perifocal coordinate system in **P**, **Q** and **W** frames (or **PQW** frame), where **P**, **Q** and **W** are unit vectors.

(4 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 given that the epoch corresponds to 10s, estimate:

(i) true anamoly, v,

(3 marks)

(ii) radius vector, r,

(3 marks)

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

(4 marks)

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

(6 marks)

Q3 (a) The rain attenuation exceeded 0.01% for a point rain rate of 11.3 mm/h. The altitude of the Earth station is 600 m from the sea level. The antenna elevation angle at the Earth station is fixed to 21°. For a carrier frequency of 15 GHz and the rain height of 3 km, estimate:

(i) horizontal polarization,

(5 marks)

(ii) vertical polarization, and

(3 marks)

(iii) circular polarization.

(6 marks)

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

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

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

(6 marks)

Q4 (a) Faraday rotation causes the Ionospheric Depolarization of a radio signal in the Ionosphere. In the tropospheric layer, the rain drop can cause the Tropospheric Depolarization for any radio signal. Compare between Ionospheric and Tropospheric Depolarizations.

(6 marks)

(b) A geostationary satellite is fixed at a longitude of 105°W. Whereas, the Earth station is located at the latitude of 18° N and longitude 73° W. Evaluate the angle of polarization, ξ, at the Earth station. Given a_{GSO} = 42164 km and the mean radius of spherical Earth, R = 6371 km.

(14 marks)

Q5 (a) Compare between FOUR (4) main losses that need to be included in the link-power budget calculation of a satellite link.

(6 marks)

(b) To determine the performance of a satellite link, the ratio of a carrier power to noise spectral density at the receiver end will be calculated. Formulate the Carrier-to-Noise ratio by taking into consideration all possible parameters in a typical satellite link.

(6 marks)

(c) The free-space loss is 192 dB, the antenna pointing loss is 1 dB and the atmospheric absorption is 4 dB in a link-budget calculation at 15 GHz. The receiver [G/T] is 23.7 dB/K and the receiver feeder losses are 3 dB. The EIRP is 59 dBW. Calculate the Carrier-to-Noise spectral density ratio, $[C/N_0]$. Boltzmann's constant, k, is given as 228.6 dBJ/K.

(8 marks)

Q6 (a) Carrier-to-Interference is the parameter to determine the interference level from the neighbouring unwanted network to the wanted network. Calculate the overall $[C/I]_{ant}$ when the $[C/I]_U$ is given as 27.53 dB and the $[C/I]_D$ is given as 23.53 dB.

(5 marks)

(b) Transmission gain, γ, is the factor that is used to refer the noise-temperature rise at the satellite receiver input to the Earth-station receiver input. By using relevant block diagram of a satellite circuit, formulate the γ.

(5 marks)

(c) Given that $L_U = 200$ dB, $L_D = 196$ dB, $G_E = G'_E = 25$ dB, $G_S = G'_S = 9$dB, $G_{TE} = G_{RE} = 48$ dB, $G_{RS} = G_{TS} = 19$ dB, $U_S = U'_S = 1$ µJ, and $U'_E = 10$ µJ. Estimate the transmission gain, γ, the interference levels, I_1 and I_2, and the overall equivalent temperature rise.

(10 marks)

FINAL EXAMINATION

SEMESTER / SESSION : SEM II / 2011 / 2012
COURSE : SATELLITE COMMUNICATION SYSTEM

PROGRAMME : BEE
COURSE CODE : BEP 4243

Table 1 : Reduction Factors

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

Table 2 : 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

SEMESTER / SESSION : SEM II / 2011 / 2012
COURSE : SATELLITE COMMUNICATION SYSTEM
PROGRAMME : BEE
COURSE CODE : BEP 4243

Table 3: Julian Dates at the beginning of each year (Jan 0.0 UT) for the years 1986 - 2000

Year	Julian date (days)
	2 400 000.+
1986	46 430.5
1987	46 795.5
1988	47 160.5
1989	47 526.5
1990	47 891.5
1991	48 256.5
1992	48 621.5
1993	48 987.5
1994	49 352.5
1995	49 717.5
1996	50 082.5
1997	50 448.5
1998	50 813.5
1999	51 178.5
2000	51 543.5

FINAL EXAMINATION

SEMESTER / SESSION : SEM II / 2011 / 2012
COURSE : SATELLITE COMMUNICATION SYSTEM

PROGRAMME : BEE
COURSE CODE : BEP 4243

Constant values and formulas:

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

R = 6371 km (mean Earth radius)

$K_1 = 66063.1704\ \mathrm{km^2}$ (Earth's constant)

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

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

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