CONFIDENTIAL

Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION (ONLINE) SEMESTER II SESSION 2020/2021

COURSE NAME	:	SATELLITE COMMUNICATION AND NAVIGATION
COURSE CODE	:	BEJ 41403
PROGRAMME CODE	:	BEJ
EXAMINATION DATE	:	JULY 2021
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTIONS. EACH QUESTION WILL BE PUBLISHED AND IS TO BE SUBMITTED AT THE PREDETERMINED INTERVAL.

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

Q1 (a) Describe **FOUR (4)** advantages of satellite communication system as an alternative to the conventional communication network.

(8 marks)

(b) Describe the reason why a satellite does not fall down to Earth but instead it follows the orbit that has been set.

(4 marks)

(c) Global Positioning Satellite (GPS) is a system that uses a constellation of satellites to fix a position which can then be used for navigation.

(i) Briefly describe the process of obtaining a position fix by using a GPS system.

(5 marks)

(ii) State **THREE (3)** factors that can affect the accuracy of the GPS system.

(3 marks)

(iii) Reason the choice of orbit for the GPS system.

(5 marks)

Total Marks : 25
Time (including submission) : 40 minutes

Q2 (a) The Two Line Element (TLE) data set for MEASAT 3B satellite is given as below:

```
MEASAT-3B
1 40147U 14054B   21131.10971678 -.00000236  00000-0  00000+0 0  9998
2 40147   0.0377  32.0497 0002603 355.4215 332.6548  1.00272606 24490
```

(i) Extract the Keplerian elements from the TLE set and calculate its true anomaly.
(9 marks)

(ii) Determine the exact altitude, h of the satellite from sea level (at zenith).
(1 marks)

(b) An Astro TV subscriber wants to watch TV programmes broadcasted by the MEASAT 3B from his home in Parit Raja, Batu Pahat (elevation 7 m). In order for that to happen, he needs to align his parabolic dish antenna to the exact satellite location in space. From the data obtained in **Q2(a)**, determine the following parameters;

(i) the slant range, d,
(3 marks)

(ii) azimuth angle, A_z,
(3 marks)

(iii) elevation angle, θ of the earth station, and
(2 marks)

(iv) tilt angle, T.
(2 marks)

(c) (i) Estimate the loss for the user in **Q2(b)** due to rain for a circularly polarized signal if the rain height is 5 km with reduction factor, $p = 0.01\%$ for a point rate of 125mm/h.
(7 marks)

(iii) Discuss techniques that can be implemented by the service provider to mitigate the effect of rain attenuation for user in **Q2(b)**.
(3 marks)

Total Marks : 30
Time (including submission) : 50 minutes

Q3 (a) A ground station in Parit Raja, Malaysia is equipped with a 60 cm in diameter parabolic dish antenna with an efficiency of 55%. The station receives a Broadcasting Satellite Service (BSS) at KU-band frequency of 12 GHz from the MEASAT 3B satellite (longitude 91.5° E). The effective isotropic radiated power (EIRP) is given in **Figure Q3(a)**.

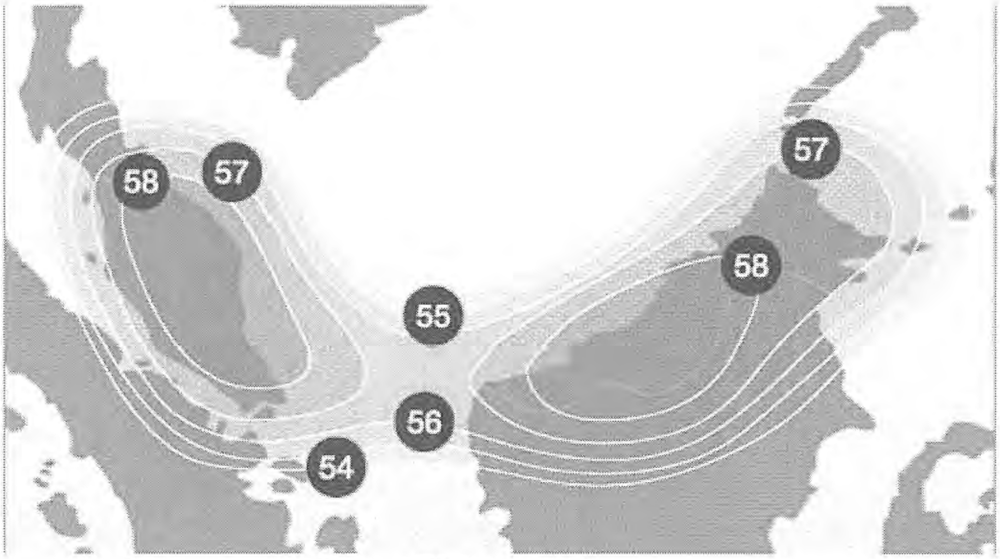

Figure Q3(a)

(i) Calculate the gain of the receiver's parabolic dish antenna in dB.

(3 marks)

(ii) Analyze the carrier-to-noise density ratio (C/N_0) at the dish interface. Assume $T_s = 400\ K$, antenna pointing loss of 0.36 dB, atmospheric loss is 0.2 dB and rain fade of 30 dB is predicted for 99.99% availability.

(5 marks)

(iii) Calculate the receiver's G/T ratio. Discuss the significant of G/T ratio in a satellite communication link.

(5 marks)

(b) The MEASAT 3B satellite in **Q3(a)** receives an uplink broadcasting signal at 14 GHz from a ground station located in Bukit Jalil, Malaysia. The ground station has an antenna with a gain of 60 dB and the distance between the ground station and satellite is 35,776.601 km. The antenna has an input power of 140 W and other transmission losses are estimated at 12 dB.

(i) Calculate the flux density at the input of the satellite antenna.

(3 marks)

(ii) If the satellite antenna has a gain of 20 dB for both transmit and receive modes, calculate the amount of gain the travelling wave tube amplifier (TWTA) must deliver to produce the stated satellite's EIRP.

(5 marks)

(c) A satellite TWTA has to operate at its linear curve to reduce intermodulation noise. Power received by the satellite can either fall short or exceed the optimum working range of the satellite TWTA.

(i) Discuss the term 'saturation flux density' in satellite link design.

(2 marks)

(ii) Describe ways to ensure the TWTA will work in the linear region for both cases stated in **Q3(c)** as well as producing a signal that achieves the stated satellite's effective isotropic radiated power (EIRP) contour.

(2 marks)

Total Marks : 25
Time (including submission) : 50 minutes

Q4 (a) In a Frequency Division Multiple Access (FDMA) network, a satellite transponder capability is said to be either bandwidth limited or power limited. Explain both limitations and their effects on transponder operation.

(4 marks)

(b) In an FDMA scheme, the carriers utilize equal powers and equal bandwidths. The bandwidth for each channel is 5 MHz and the transponder bandwidth is 36 MHz. The saturation EIRP for the downlink is 34 dBW, and an output backoff of 6 dB is employed. The downlink losses are 201 dB, and the destination earth station has a G/T ratio of 35 dBK^{-1}. Determine;

(i) the carrier-to-noise ratio, $[C/N]$ assuming this is set by a single carrier operation.

(3 marks)

(ii) the number of carriers which can access the system and state, with reasons, whether the system is power limited or bandwidth limited.

(3 marks)

(c) Code Division Multiple Access (CDMA) is a technique used to increase signals resistance to interference. One popular CDMA method is the direct-sequence spread spectrum (DS/SS).

(i) Describe the generation process of DS/SS CDMA signal using suitable diagram.

(4 marks)

(ii) Sketch the power density of a signal after undergoing the spreading process.

(2 marks)

(d) The code waveform in a CDMA system spreads the carrier over the full 36 MHz bandwidth of a transponder channel, and the roll-off factor for the filtering is 0.4. The information bit rate is 64 kb/s, and the system uses binary phase shift keying (BPSK) modulation TECHNIQUE. Calculate the processing gain in decibels.

(4 marks)

Total Marks : 20
Time (including submission) : 40 minutes

- END OF QUESTIONS -

FINAL EXAMINATION

SEMESTER / SESSION : 2/ 2020/2021 PROGRAMME CODE : BEJ
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CONSTANTS

Earth equatorial radius, $R_e = 6378.137$ km
Earth polar radius, $R_p = 6356.752$ km
Earth mean radius, $R_E = 6371.009$ km
Gravitational parameter, $\mu = 3.986 \times 10^{14}$ m^3s^{-2}
Earth rotation rate around the Sun = $0.9856°$ /day
Boltzmann's constant, $k = 1.3806 \times 10^{-23}$ m^2 kg s^{-2} K^{-1}
Speed of light, $c = 3 \times 10^8$ ms^{-1}

FORMULAE

Orbital Formulae

For near circular orbit where the eccentricity is small, an approximation for true anomaly ν directly in terms of M (in radians) is

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

Radius, velocity and period

$$r = \frac{a(1-e^2)}{1 + e\cos\nu} \qquad v = \sqrt{\mu\left(\frac{2}{r} - \frac{1}{a}\right)} \qquad T = 2\pi\sqrt{\frac{a^3}{\mu}}$$

Coordinate Transformation

$$\mathbf{r} = (r\cos\nu)\mathbf{P} + (r\sin\nu)\mathbf{Q}$$

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

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

Space Link

Power flux density:

$$\Psi_{iso} = \frac{P_T}{4\pi r^2} \mathrm{W/m^2}$$

Carrier to noise ratio:

$$\frac{C}{N} = \frac{P_T G_T G_R}{k T_S B}\left(\frac{\lambda}{4\pi d}\right)^2$$

Gain of centre-fed paraboloidal antenna:

$$G = \frac{4\pi}{\lambda^2}\eta\, Area = \eta\left(\frac{\pi D}{\lambda}\right)^2$$