First Semester Examination
Academic Session 2018/2019

December 2018/January 2019

EEE440 – MODERN COMMUNICATION SYSTEMS
(SISTEM PERHUBUNGAN MODEN)

Duration : 3 hours
(Masa : 3 jam)

Please check that this examination paper consists of THIRTEEN (13) pages and SEVEN (7) pages of printed appendices material before you begin the examination.

[Sila pastikan bahawa kertas peperiksaan ini mengandungi TIGABELAS (13) muka surat dan TUJUH (7) muka surat lampiran yang bercetak sebelum anda memulakan peperiksaan ini.]

Instructions: This question paper consists of **SIX (6)** questions. Answer **FIVE (5)** questions. All questions carry the same marks.

[***Arahan:*** *Kertas soalan ini mengandungi* ***ENAM (6)*** *soalan. Jawab* ***LIMA (5)*** *soalan. Semua soalan membawa jumlah markah yang sama.]*

In the event of any discrepancies, the English version shall be used.

[Sekiranya terdapat sebarang percanggahan pada soalan peperiksaan, versi Bahasa Inggeris hendaklah digunapakai.]

1. (a) In your own words describe the orbiting for following satellite;

Dengan menggunakan perkataan anda sendiri terangkan pengorbitan untuk satelit yang berikut;

(i) Low Earth Orbiting (LEO Satellite)

Pengorbitan bumi rendah (LEO satelit)

(5 marks/*markah*)

(ii) Geostationary Orbiting (GEO Satellite)

Pengorbitan geostationari (GEO satelit)

(5 marks/*markah*)

(iii) Medium Earth Orbiting (MEO Satellite)

Pengorbitan bumi sederhana rendah (MEO satelit)

(5 marks/*markah*)

(iv) Highly Elliptical Earth Orbit (HEO Satellite)

Pengorbitan bumi dengan Elips Tinggi (HEO Satelit)

(5 marks/*markah*)

(a) Show the following by using appropriate diagrams;

Tunjukkan yang berikut dengan gambarajah-gambarajah yang sesuai;

(i) Structure of a fiber optic.

Struktur sesuatu gentian optik.

(10 marks/*markah*)

(ii) Multimode fiber optic.

Gentian optik pelbagai mod.

(10 marks/*markah*)

(iii) Singlemode fiber optic.

Gentian optik mod tunggal

(10 marks/*markah*)

(b) A geostationary satellite is located at 90°W. The earth-station (ES) antenna is located at latitude 40°S and longitude 120°W. For the situation specified;

Sebuah satelit geostationari terletak di 90°W. Antena stesen bumi terletak di latitud 40°S dan longitud 120°W. Untuk keadaan yang ditentukan ini;

(i) Based on Figure 1, indicate the suitable figure that represents the location of the described ES.

Berdasarkan Rajah 1, tunjukkan rajah yang sesuai yang mewakili lokasi ES yang diterangkan.

(5 marks/*markah*)

(ii) Confirm the selected location of ES by calculating the parameters B and λ_E of Table 1.

Sahkan lokasi ES yang dipilih dengan mengira parameter B dan λ_E dari Jadual 1.

(5 marks/*markah*)

(iii) Calculate the azimuth angle for the earth-station antenna.

Hitungkan sudut azimut bagi antena stesen bumi.

(10 marks/*markah*)

(iv) Find the range between earth station and the satellite, given the earth radius *R*=6371 Km, and distance from the earth center to the satellite $a_{GSO} = 42164$ Km.

Cari jarak di antara stesen bumi dan satelit, diberikan jejari bumi R = 6371 Km, dan jarak dari pusat bumi ke satelit $a_{GSO} = 42164$ Km.

(15 marks/*markah*)

(v) Find the elevation angle of the earth-station antenna.

Cari sudut ketinggian antena stesen bumi

(15 marks/*markah*)

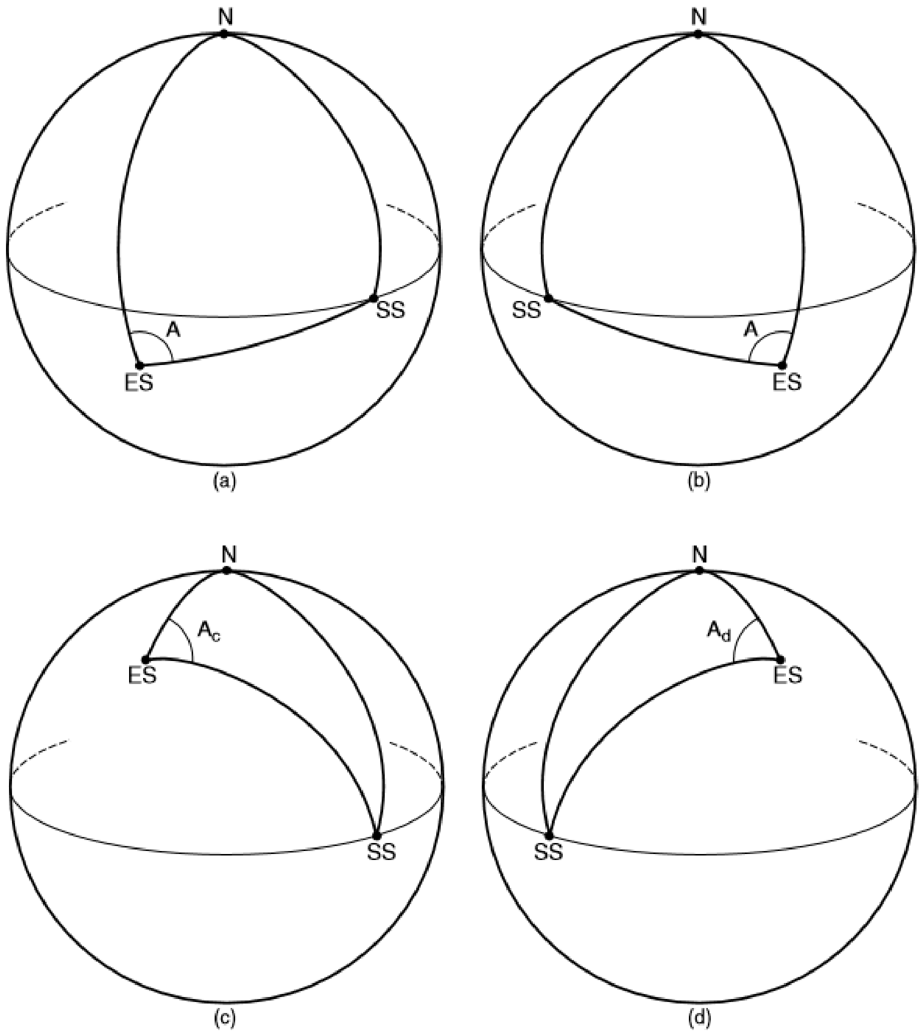

Figure 1 Possible location of Earth Station (ES) relative to the Sub-Satellite point.
Rajah 1 Lokasi kemungkinan stesen bumi (ES) berbanding dengan titik Sub-Satelit

Jadual 1 Azimuth Angles A_z dari Rajah 1

TABLE 1 **Azimuth Angles A_z from Fig.1**

Fig. 3.3	λ_E	B	A_z, degrees
a	<0	<0	A
b	<0	>0	$360° - A$
c	>0	<0	$180° - A$
d	>0	>0	$180° + A$

2. (a) A satellite uplink operates at 14 GHz with a transmit power of 15W. The transmit antenna has a gain of 40 dB. The satellite receiver has its $\left[\frac{G}{T}\right]$ equals -6.7 dB/K. The range between the ground station and the satellite is 42,000 Km. Assume other losses are negligible.

Pautan naik satu satelit beroperasi pada 14 GHz dengan kuasa penghantar 15W. Antena penghantar mempunyai gandaan sebanyak 40 dB. Jarak antara stesen bumi dan satelit adalah 42,000 Km. Anggapkan kehilangan yang lain adalah diabaikan.

Calculate the following;

Kira yang berikut;

(i) EIRP in dBW.

EIRP dalam dBW.

(10 marks/*markah*)

(ii) The free-space loss $[FSL]$ in dB.

Kehilangan ruang bebas $[FSL]$ *dalam dB.*

(10 marks/*markah*)

(iii) Carrier-to-noise density ratio.

Nisbah ketumpatan pembawa-ke-hingar.

(10 marks/*markah*)

(b) The satellite uplink in part a) above has a new requirement that the Carrier-to-noise density ratio $\left[\frac{C}{N_o}\right] = 81$ dBHz. Using similar assumption as part (a) above, determine the following;

Pautan naik satelit pada bahagian a) diatas mempunyai keperluan yang baharu iaitu nisbah ketumpatan pembawa ke hingar $\left[\frac{C}{N_o}\right] = 81$ dBHz. *Dengan menggunakan anggaran pada bahagian (a) di atas, tentukan berikut;*

(i) The additional EIRP in dBW and Watts.

EIRP tambahan dalam dBW dan Watt.

(20 marks/*markah*)

(ii) Has the system saturates? [Hint: Assume the new EIRP as saturation, then show the related parameter to have positive value]

Adakah sistem telah tepu? [Petunjuk: Anggapkan EIRP baharu sebagai tepu, kemudian tunjukkan parameter berkaitan mempunyai nilai positif]

(30 marks/*markah*)

(c) The Carrier-to-noise density ratio measures the performance of the satellite circuit.

Nisbah ketumpatan pembawa ke hingar mengukur keupayaan litar satelit itu.

(i) Discuss theoretically how the noise power density (N_o) can be adjusted to increase the ratio. ? [Hint: See Appendix, item 3]

Bincangkan secara teori bagaimana ketumpatan kuasa hingar (N_o) boleh diubah untuk menaikkan nisbah. [Petunjuk: Lihat Apendik, item 3]

(10 marks/*markah*)

(ii) Discuss in real application that the noise power density (N_o) can be only control from increasing by introducing an additional hardware component in the receiver structure. [Hint: See Appendix, item 3]

Bincangkan dalam aplikasi nyata ketumpatan kuasa hingar (N_o) hanya boleh dikawal daripada menaik dengan memperkenalkan peranti tambahan dalam struktur penerima. [Petunjuk: Lihat Apendik, item 3]

(10 marks/*markah*)

3. (a) A multiple carrier satellite circuit operates in the 6/4-GHz band with the following characteristics.

Litar satelit pelbagai pembawa beroperasi dalam jalur 6/4-GHz dengan ciri-ciri berikut;

Uplink:

Pautan menaik

Saturation flux density -67.5 dBW/m^2; input BO 11 dB; satellite G/T -11.6 dB/K.

Ketumpatan fluk tepu -67.5 dBW/m^2; kemasukkan BO 11 dB; satelit G/T -11.6 dB/K

.

Downlink:

Pautan menurun:

Satellite saturation EIRP 26.6 dBW; output BO 6 dB; free space loss 196.7 dB; earth station G/T 40.7 dB/K.

EIRP tepu 26.6 dBW; keluaran BO 6 dB, Kehilangan ruang bebas 196.7 dB*; stesen bumi G/T 40.7 dB/K.*

The carrier to intermodulation noise density ratio introduced to the system is 24 dB. Assuming other losses are negligible, calculate the carrier-to-noise density ratios for;

Nisbah kepadatan pembawa ke hingar antara-pemodulatan yang diperkenalkan kepada sistem adalah 24 dB. Anggap kehilangan lain boleh diabaikan. Kirakan nisbah ketumpatan pembawa-ke-hingar untuk;

(i) Uplink.

Pautan menaik.

(20 marks/*markah*)

(ii) Downlink.

Pautan menurun.

(20 marks/*markah*)

(iii) Combined.

Tergabung.

(10 marks/*markah*)

(b) A satellite transponder has a bandwidth of 50 MHz and a saturation EIRP of 27 dBW. The earth-station receiver has a [G/T] of 30 dB/K, and the total link losses are 196 dB. The transponder is accessed by FDMA carriers each having 5-MHz bandwidth, and 6 dB output backoff is employed. The carrier-to-noise ratio determined for a single-carrier downlink operation may be taken as the reference value. It may be assumed that the uplink noise and intermodulation noise are negligible.

Satu transponder satelit mempunyai lebar jalur 36 MHz dan EIRP ketepuan 27 dBW. Penerima stesen bumi mempunyai [G/T] 30 dB/K, dan jumlah kehilangan pautan adalah 196 dB. Transponder dicapai oleh pembawa-pembawa FDMA setiap satu mempunyai 3-MHz lebar jalur, dan mempunyai 6 dB keluaran undur. Nisbah ketumpatan pembawa-ke-hingar yang diperolehi untuk sistem pembawa tunggal pautan menurun diambil sebagai nilai rujukan. Juga boleh dianggap bahawa hingar pautan menaik dan hingar antara pemodulatan diabaikan.

(i) Calculate the downlink carrier-to-noise ratio for a single carrier operation.

Kirakan nisbah ketumpatan pembawa-ke-hingar dalam pautan turun untuk operasi pembawa tunggal.

(10 marks/*markah*)

(ii) Find the number of carriers which can be accommodated in the FDMA system, assuming that the TWTA operates in the linear region.

Cari bilangan pembawa yang boleh dimuatkan di dalam sistem FDMA, dengan andaian bahawa TWTA beroperasi di dalam rantau linear.

(10 marks/*markah*)

(iii) Calculate the downlink carrier-to-noise ratio for one of the carriers in the FDMA system.

Kira nisbah ketumpatan pembawa-ke-hingar dalam pautan menurun untuk salah satu daripada pembawa di sistem FDMA.

(10 marks/*markah*)

(iv) Calculate the number of carriers if TWTA is assumed to works in the saturation region.

Kira bilangan pembawa jika TWTA diandaikan bekerja dalam rantau ketepuan.

(10 marks/*markah*)

(v) Comment on the advantage and disadvantage of having a satellite FDMA multicarrier system which forces its TWTA to operate in the saturation region.

Ulas pada kelebihan dan kelemahan sistem satelit FDMA pelbagai pembawa yang memaksa TWTA untuk beroperasi di rantau tepu.

(10 marks/*markah*)

4. (a) Briefly describe the following:

Secara ringkas, terangkan perkara berikut:

(i) Hand-off strategies

Strategi penyerahan (10 marks/*markah*)

(ii) Frequency Reuse

Penggunaan semula frekuensi (10 marks/*markah*)

(iii) Cell splitting

Pemecahan sel (10 marks/*markah*)

(iv) Cell sectoring

Pensektoran sel (10 marks/*markah*)

(v) Co-channel interference (CCI) and adjacent channel intererence.

Gangguan sama-saluran dan gangguan saluran bersebelahan

(10 marks/*markah*)

(b) A GSM system has the following specifications:

Sistem GSM mempunyai spesifikasi seperti berikut:

- One way system bandwidth = 12 MHz

  Lebar jalur sistem sehala = 12 MHz

- The channel spacing = 180 kHz

  Jarak saluran = 180 kHz

- Each channel is allocated for 4 users
  Setiap saluran diperuntukkan kepada 4 pengguna

- Three channels per cell are allocated for control channels
  3 saluran per sel diperuntukkan kepada saluran kawalan

- Omnidirectional receiver
  Penerima semua arah

- Cell radius = 4 km, and the total coverage area is 4000 km^2.
  Jejari sel = 4 km, dan jumlah keluasan liputan adalah 4000 km^2

- Average number of calls /hour = 1.2, and the average holding time of a call is 100 seconds.

  Purata bilangan panggilan/jam = 1.2, dan purata masa pemegang bagi satu panggilan adalah 100 saat

- Call blocking probability is 3%.
  Kebarangkalian sekatan panggilan adalah 3%

- Frequency reuse factor = 0.25
  Faktor guna semula frekuensi = 0.25

- Calculate the cell spectral efficiency.
  Tentukan kecekapan spektrum sel.

(50 marks/*markah*)

5. (a) Different Linear Feedback Shift Register (LFSR) can be used to generate m-sequence. Lets assume the initial state of 10000 in the LFSR of Figure 2(a) and Figure 2(b). Show how the output sequence is produced for both figures and that they are different from each other.

Daftar Anjakan Suap Balik Lelurus (LFSR) berbeza boleh digunakan untuk menghasilkan urutan-m. Anggap keadaan mula adalah 10000 di LFSR di dalam Rajah 2(a) dan Rajah 2(b). Tunjukkan bagaimana urutan keluaran dihasilkan bagi kedua-dua rajah dan keluaran adalah berbeza untuk setiap rajah.

(60 marks/*markah)*

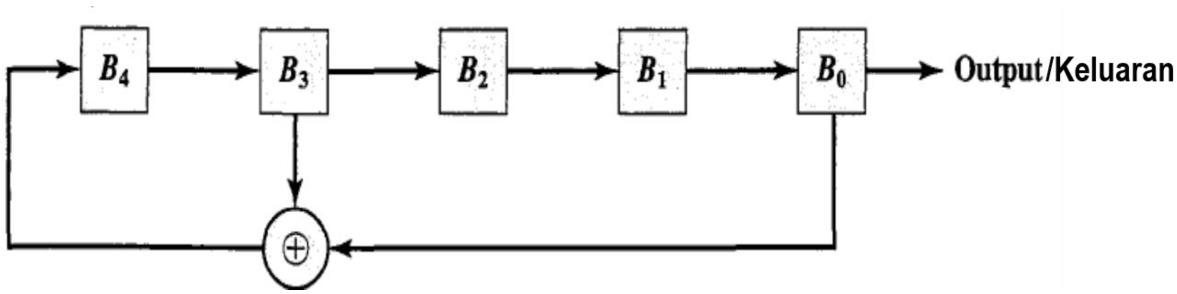

Figure 2(a)

Rajah 2(a)

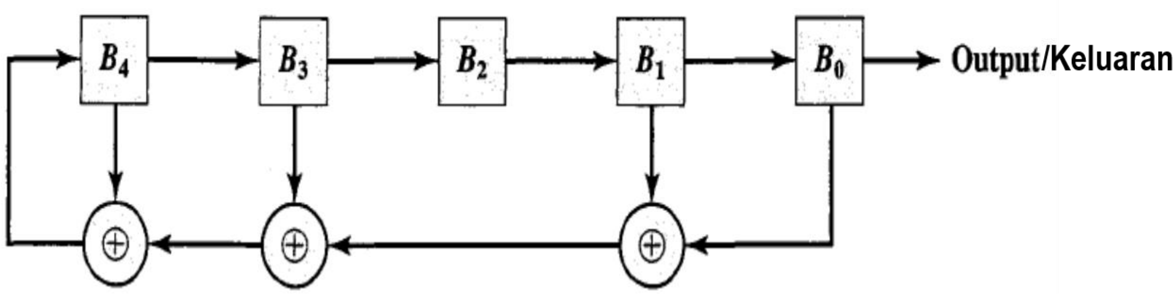

Figure 2(b)

Rajah 2(b)

(b) Using illustrations, describe the following multiplexing schemes by commenting on their advantages and disadvantages (two for each scheme):

Dengan menggunakan gambarajah, terangkan skema yang berikut dengan menjelaskan kebaikan dan keburukan bagi setiap skema (dua untuk setiap skema):

(i) Frequency Division Multiple Access (FDMA)

Pembahagian Frekuensi Pelbagai Capaian

(20 marks/*markah*)

(ii) Time Division Multiple Access

Pembahagian Masa Pelbagai Capaian

(20 marks/*markah)*

6. (a) In GSM cellular mobile radio, access to the RF air interface is based on the CDMA /TDMA. If 60 radio frequency bands, each of 200 kHz bandwidth, are divided into 8 time slots, determine:

Di dalam radio mudah alih selular GSM, capaian ke antaramuka udara RF adalah berdasarkan kepada CDMA/TDMA. Jika 60 jalur frekuensi radio, setiap satu mempunyai jalur lebar sebanyak 200 kHz, dan dibahagi kepada 8 slot masa, tentukan:

(i) The total bandwidth requirement

Jumlah jalur lebar yang diperlukan

(10 marks/*markah*)

(ii) The total number of channels

Jumlah bilangan saluran

(10 marks/*markah*)

(b) A FDD cellular mobile system allocates a bandwidth of 32 MHz that uses 50 kHz simplex channels for voice communication. Assume each user averages 1 call/hour and each call lasting 3 minutes on average. The system also uses 5 clusters with a cluster size of N=16. On a separate note, traffic study requested by Ameritech Co. informs the cellular mobile system that the traffic intensity is too high. An alternative to this is to use sectorized cells. Therefore, the system is redesigned using 120° cell sectoring and a new cluster size of N=4 is used.

(i) What is the blocking probability if the number of users in a cell is increased 3 times compared to the original system?

(70 marks/*markah*)

(ii) Discuss the changes you have observed in the blocking probability.

(10 marks/*markah*)

Satu sistem mudah alih selular FDD memperuntukkan jalur lebar sebanyak 32 MHz dan menggunakan saluran simplex berfrekuensi 50 kHz bagi perhubungan suara. Anggap setiap pengguna berpurata sebanyak 1 panggilan/jam dan setiap panggilan mengambil masa 3 minit. Sistem tersebut menggunakan 5 kluster bersaiz, N=16. Di samping itu, kajian lalu lintas yang diminta oleh Ameritech Co. memaklumkan kepada sistem mudah alih selular bahawa keamatan trafik adalah terlalu tinggi. Satu kaedah altenatif dengan menggunalan sel bersektor. Oleh itu, sistem rekasemula dengan menggunakan sel bersektor 120° dan saiz kluster yang baru iaitu N=4.

(i) *Apakah kebarangkalian sekatan jika bilangan pengguna di dalam satu sel ditingkatkan 3 kali berbanding sistem asal?*

(70 marks/*markah*)

(ii) *Bincangkan perubahan pada kebarangkalian sekatan.*

(10 marks/*markah*)

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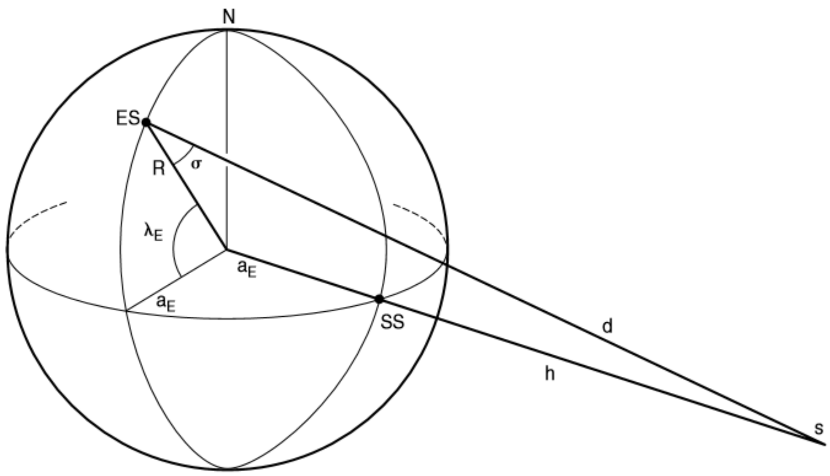

Figure A.1 The geometry used in determining the look angles for a geostationary satellite.

1. Earth station latitude - λ_E
2. Earth-station longitude - ϕ_E
3. Subsatellite point longitude - ϕ_{SS}

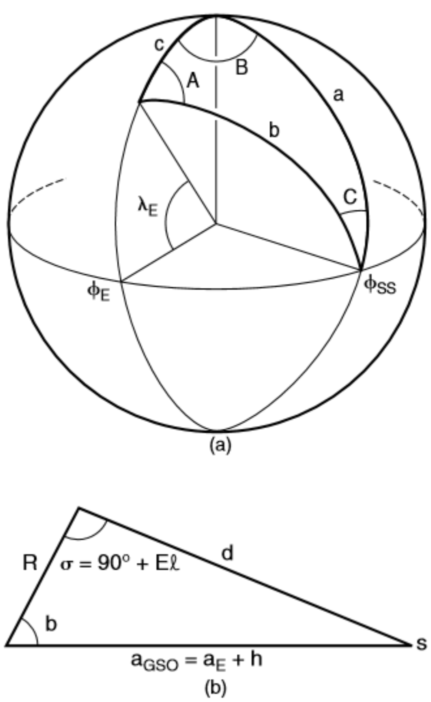

Figure A.2 (*a*) The spherical geometry **and (b)** The plane triangle obtained from Fig **A**.1.

$$a = 90^o$$
$$c = 90^o - \lambda_E$$
$$B = \phi_E - \phi_{SS}$$

Napier's rule:

$$b = \cos^{-1}(\cos B \cos \lambda_E)$$

$$A = \sin^{-1}\left(\frac{\sin|B|}{\sin b}\right)$$

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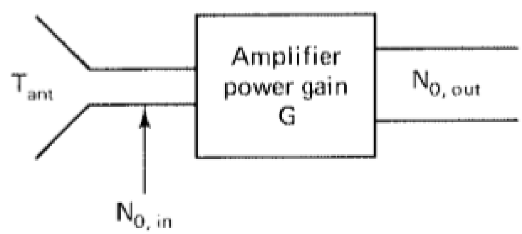
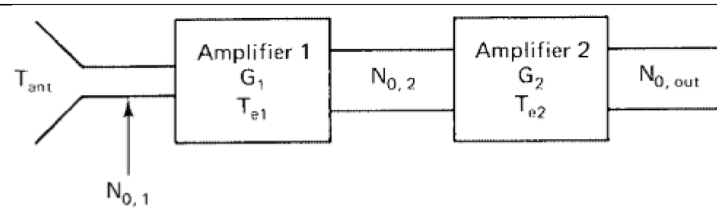
LINK BUDGET EQUATIONS

1	Equivalent Isotropic Radiated Power	$[EIRP] = [P_S] + [G]$
2	Received power of link Budget	$[P_R] = [EIRP] + [G_R] - [LOSSES]$
3	Thermal noise	
	Thermal noise power	$P_N = kT_N B_N$
	Noise power spectral density	$N_0 = \frac{P_N}{B_N} = kT_N \ [J]$
	Boltzmann's Constant	$k = 1.38 \times 10^{-23} J/K$
	Total noise referred to the input $N_{o,in}$	 $N_{o,in} = k(T_{ant} + T_e)$
	Total input noise T_s	 $T_s = T_{ant} + T_{e1} + \frac{T_{e2}}{G_1} + \frac{T_{e3}}{G_1 G_2}$
4	Free Space Loss (r in Km, f MHz)	$[FSL] = 32.4 + 20\log_{10} r + 20\log_{10} f$
5	Carrier-to-Noise Spectral density Ratio (General: uplink/Downlink)	$\left[\frac{C}{N_o}\right] = [EIRP] + \left[\frac{G}{T}\right] - [LOSSES] - [k]$
	Carrier-to-Noise ratio (conversion)	$\left[\frac{C}{N_o}\right] = \left[\frac{C}{N}\right] + [B_N]$

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6	Uplink (single carrier)	
	link budget	$\left[\frac{C}{N_o}\right]_U = [EIRP]_U + \left[\frac{G}{T}\right]_U - [LOSSES]_U - [k]$
	Input power saturation	$[EIRP_S]_U = [\psi_S] + [A_o] + [LOSSES] - [RFL]$
	Affective Aperture (in f GHz)	$A_o = -(21.45 + 20\log_{10} f)$
	Amplifier Operates in Linear region	$\left[\frac{C}{N_o}\right]_U = [\psi_S] + [A_o] - [BO]_i + \left[\frac{G}{T}\right]_U - [k] - [RFL]$
7	Downlink (single carrier)	
	link budget	$\left[\frac{C}{N_o}\right]_D = [EIRP]_D + \left[\frac{G}{T}\right]_D - [LOSSES]_D - [k]$
	Amplifier Operates in Linear region	$\left[\frac{C}{N_o}\right]_D = [EIRP_S]_D - [BO]_o + \left[\frac{G}{T}\right]_D - [LOSSES]_D - [k]$
8	Combined Uplink & downlink	$\frac{N_o}{C} = \frac{P_N}{P_R} = \left(\frac{N_o}{C}\right)_U + \left(\frac{N_o}{C}\right)_D + \left(\frac{N_o}{C}\right)_{IM}$
9	Multicarrier System	$[BO]_i = [BO]_o + 5\text{dB}$
	Uplink	$[EIRP]_u = [EIRP_S]_U - [BO]_{in}$
	Downlink	$[EIRP]_D = [EIRP_S]_D - [BO]_o - [K]$
	Other	$[\alpha] \leq [BO]_o$
		$KB = \alpha B_{TR}$

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Course Outcomes (CO) – Programme Outcomes (PO) Mapping

Pemetaan Hasil Pembelajaran Kursus – Hasil Program

Questions *Soalan*	**CO**	**PO**
1	1	3
2	2	4
3	1	3
4	2	4
5	2	4
6	2	4

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CELLULAR CONCEPT – EQUATIONS

1. Area (hexagon) = 2.6 R^2
2. Perimeter (hexagon) = 6R
3. $N = i^2 + ij + j^2$;where i, j are integers

i	j	$N = \left(i^2 + ij + j^2\right)$	$Q = D/R = \sqrt{3N}$
1	0	1	1,73
1	1	3	3,00
2	0	4	3,46
2	1	7	4,58
3	0	9	5,20
2	2	12	6,00
3	1	13	6,24
4	0	16	6,93
3	2	19	7,55
4	1	21	7,94
3	3	27	9,00

4. $D = R\sqrt{3N}$
5. Q = D/R = 1/N
6. S/I = 1/6 $(D/R)^n$ for equidistance
7. For worst case (not equidistance),

$$\frac{S}{I} = \frac{R^{-n}}{\sum D_i^{-n}} = \frac{R^{-n}}{2(D-R)^{-n} + 2(D+R)^{-n} + 2D^{-n}}$$

$$\frac{S}{I} = \frac{1}{2(Q-1)^{-4} + 2(Q+1)^{-4} + 2Q^{-4}}$$

8. With 120^0 sector,

$$\frac{S}{I} = \frac{R^{-4}}{D^{-4} + (D+0.7R)^{-4}} = \frac{1}{Q^{-4} + (Q+0.7)^{-4}}$$

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9. With 60^0 sector,

$$\frac{S}{I} = \frac{R^{-4}}{(D+0.7R)^{-4}} = (Q+0.7)^4$$

10. Number of channels,

$$N = \frac{B_t - 2B_g}{B_c}$$

11. Radio capacity, m

For n=4:

$$m = \frac{B_t}{B_c\,[2/3\,(C/I)_{min}]^{1/2}}$$

12. Without sector (CDMA),

$$N = 1 + \frac{W/R}{E_b/N_o}$$

13. With sector (CDMA),

$$N_S = 1 + (1/\alpha)\frac{W/R}{E_b/N_o}$$

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Erlang B Chart