Jordan University of Science and Technology
Department of Electrical Engineering

Satellite Communication Systems (EE558) 2nd Exam

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Q1

a) Draw a block diagram for a satellite wideband receiver and calculate the output frequency if the input frequency is 6125 MHz and the local frequency is 2225 MHz.

b) Draw a block diagram for the input demultiplexer used in a satellite transponder showing the channel distribution at its outputs.

Q2

a) Draw a block diagram for a home receiving system of a direct broadcast satellite service (DBS) showing the frequency range at the output of the different stages assuming Ku band (12.2-12.7 GHz).

b) What are the four beam coverage methods used in satellites? What is the type of antenna used for global coverage and what is the value of its beamwidth?

Q3 A receiving system consists of an antenna having a noise temperature of 100K, a low noise block (LNB) having a noise figure of 3 dB and a gain of 20 dB, a coaxial feeder having a loss of 6 dB, and a main receiver having a noise figure of 10 dB and gain of 50 dB. Calculate the system noise temperature and the noise power referred to the input of the LNB if the bandwidth is 36 MHz.

Q4 A satellite uplink has the following parameters: earth station HPA with a saturation power output of 50 W and a back-off of 3 dB, a transmitter feeder loss of 2 dB, a 3 meters transmitter dish antenna, a 0.5 meter receiver dish antenna, a receiver feeder loss of 1 dB, atmospheric absorption loss of 1.5 dB, antenna misalignment loss of 1 dB, polarization mismatch loss of 0.5 dB, a range of 38000 Km, and a frequency of 6 GHz.
Calculate the earth station EIRP, the electric flux density at the input of the satellite antenna, and the received power at the input of LNA.

Q5 A satellite system has the following parameters:
Uplink: EIRP= 72 dBW, G/T = - 6 dB/K, FSL = 200 dB, RFL= 2 dB, AA = 1 dB, AML = 0.5 dB, PL = 0.5 dB.
Downlink: EIRP= 52 dBW, G/T = 12 dB/K, FSL = 198 dB, RFL= 2 dB, AA = 1 dB, AML = 0.5 dB, PL = 0.5 dB.

a) Calculate the overall C/N_o and C/N if the bandwidth is 36 MHz.

b) Calculate the bit error rate (BER) assuming a QPSK modulation and a bit rate of 72 Mb/s.

c) Recalculate the overall C/N_o if a rain attenuation of 2 dB is added for both uplink and downlink. and $T_s = 400$ K.

2nd-Exam EE558

$$EIRP = P_s + G \ \text{dBW}, \quad G = 0.6\left(\frac{\pi D}{\lambda}\right)^2$$

$$FSL = 10\log_{10}\left(\frac{4\pi r}{\lambda}\right)^2, \quad P_N = kTB$$

$$P_R = EIRP + G_R - \text{losses}, \quad k = 1.38\times10^{-23}$$

$$\text{losses} = FSL + RFL + AML + AA + PL$$

$$T_s = T_1 + \frac{T_2}{G_1} + \frac{T_3}{G_1 G_2} + \cdots, \quad N_0 = kT$$

$$F = F_1 + \frac{F_2 - 1}{G_1} + \frac{F_3 - 1}{G_1 G_2} + \cdots, \quad T_e = (F-1)T_0$$

$$T_{NW,i} = T_0(L-1), \quad NF = 10\log_{10} F$$

$$\frac{C}{N_0} = EIRP + \frac{G}{T} - \text{losses} - 10\log_{10} k$$

$$\frac{C}{N} = \frac{C}{N_0} - 10\log_{10} B_N,$$

~~$\Psi_M = EIRP - FSL - A_0$~~ $, \quad A_0 = 10\log_{10}\left(\frac{\lambda^2}{4\pi}\right)$

$$EIRP = \Psi_M + A_0 + \text{losses} - RFL$$

$$EIRP = EIRP_S - BO$$

$$P_{TWTA} = (EIRP)_D - (G_T)_D + (TFL)_D \quad \text{(sat)}$$

$$(P_{TWTA})_S = P_{TWTA} + (BO)_0$$

$$P_{HPA} = \underbrace{EIRP}_{P_s + G} - G_T + TFL, \quad P_{HPA,sat} = P_{HPA} + BO$$

$$\frac{C}{N_0} = \frac{E_b}{N_0} + 10\log_{10} R_b, \quad BER\Big|_{QPSK} = Q\left(\sqrt{\frac{2E_b}{N_0}}\right)$$

$$T_{rain} = T_0\left(1 - \frac{1}{A}\right), \quad Q(x) = \frac{1}{\sqrt{\pi}} e^{-x^2}$$

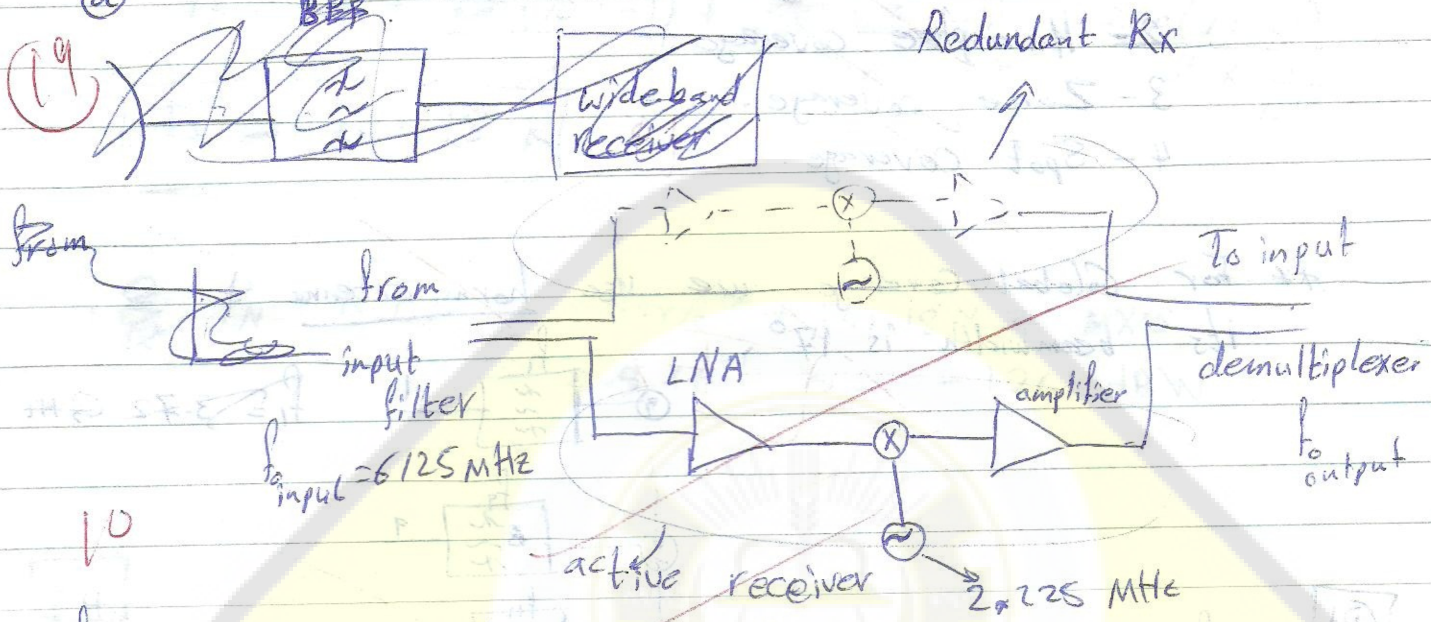
$$\left(\frac{C}{N_0}\right)_{overall} = \frac{(C/N_0)_U \times (C/N_0)_D}{(C/N_0)_U + (C/N_0)_D}$$

95

Q1

(a)

19



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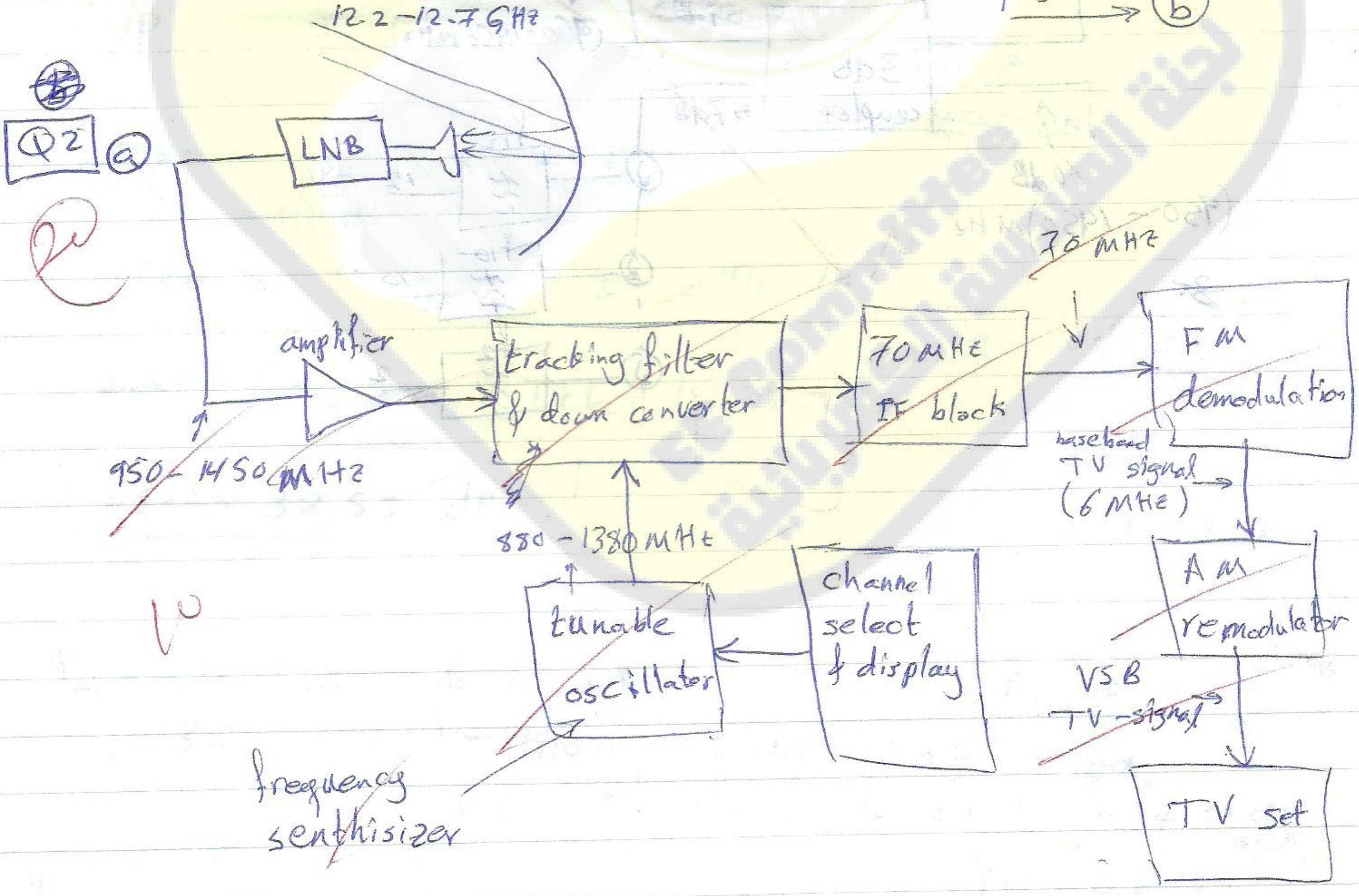
$f_{o\,output} = 6125 - 2225 = 3900$ MHz.

page (2) → (b)

Q2 (a)

20



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Q2

(b) 1- Global coverage.
2- Hemisphere coverage.
3- Zone coverage.
4- Spot coverage.

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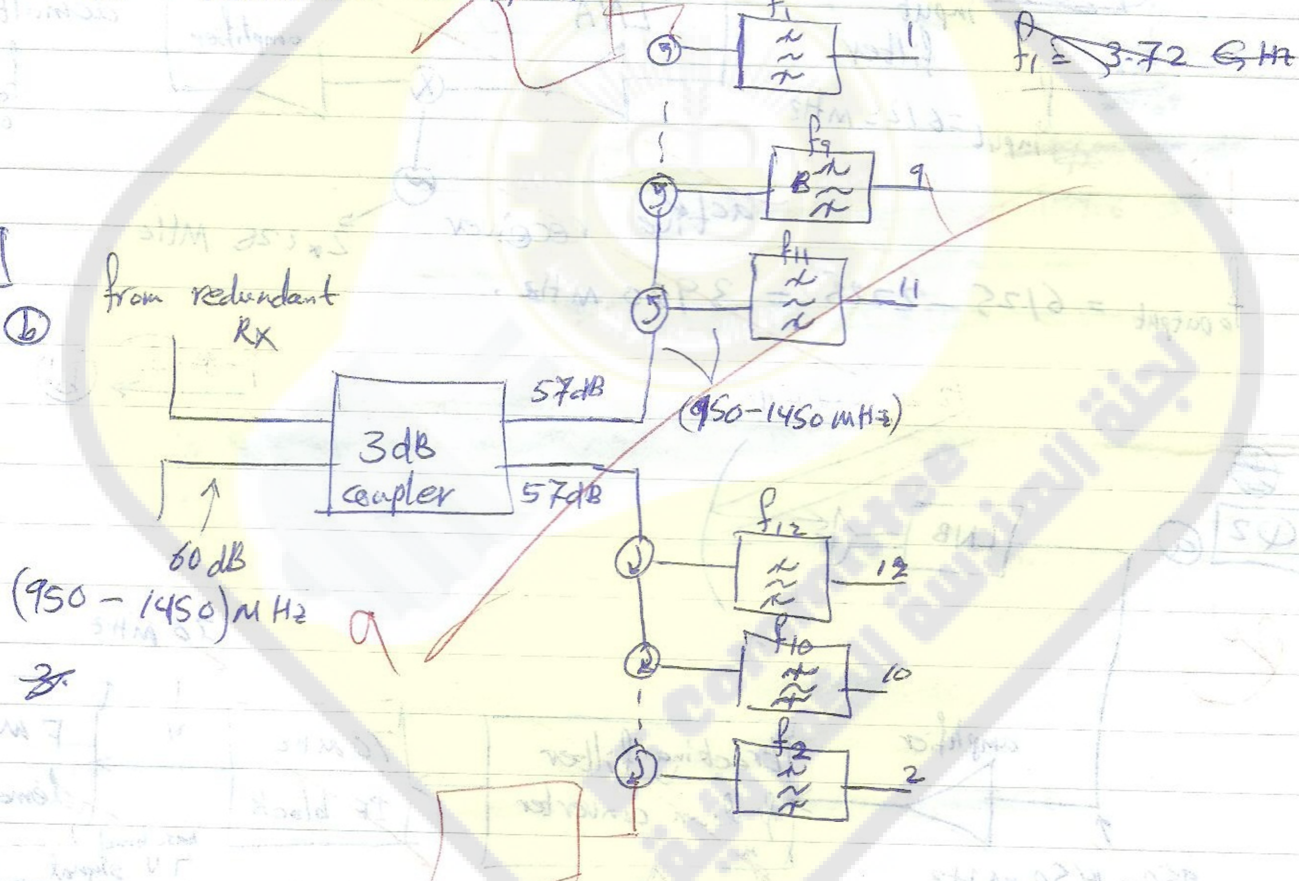
** For Global coverage we use horn antenna & its beamwidth is 17°.

Q1

(b)



Q3

$$T_s = 100 + \frac{290(10^{0.3}-1)}{1} + \frac{290(10^{0.6}-1)}{10^2} + \frac{290(10^1-1)}{10^2 \times \frac{1}{10^{0.6}}}$$

$$T_s = 501.18\ K$$

$$P_N = kTB = 1.38\times10^{-23} \times 501.18 \times 36\times10^6$$
$$= 2.5\times10^{-13}\ W = -126\ dBW$$

Q4

$$P_{HPA} = P_{HPA,sat} - BO$$

$$P_{HPA} = 10\log 50 - 3 = 14\ dB$$

$$EIRP = P_{HPA} + G_T - TFL = 14 + 20.53 - 2$$

$$EIRP = 32.53\ dBW$$

$$G_T = 0.6\left(\frac{\pi \times 3}{\frac{3\times10^8}{6\times10^9}}\right)^2 = 113.1 = 20.53\ dB$$

$$\Psi_M = EIRP - A_o - losses + RFL$$
$$= 32.53 - (-37.01) - 199.6 - 1 - 1 - 1.5 - 0.5 + 1$$

(FSL, RFL, AML, AA, PL, RFL)

$$A_o = 10\log\frac{\lambda^2}{4\pi} = -37.01\ dB$$

$$FSL = 10\log\left(\frac{4\pi r}{\lambda}\right)^2 = 199.6\ dB$$

$$\Psi_M = -133.06\ dBW/m^2$$
$$= 4.94\times10^{-14}\ W/m^2$$

4

Q4

$P_R = EIRP + G_R - losses$

$= 32.53 + 27.72 - 199.6 - 1 - 1 - 1.5 - 0.5$

$P_R = -143.35 \text{ dBW}$

$P_R = 4.624 \times 10^{-15} \text{ W}$

$G_R = 0.6\left(\frac{\pi \times 0.5}{\lambda}\right)^2$, $\lambda = \frac{3\times10^8}{6\times10^9}$

$= 592.18$

$= 27.72 \text{ dB}$

$FSL = 10\log\left(\frac{4\pi r}{\lambda}\right)^2$, $\lambda = \frac{3\times10^8}{6\times10^9}$

$= 199.6 \text{ dB}$

Q5 Uplink

(a) $\left(\frac{C}{N_o}\right) = 72 + (-6) - 200 - 2 - 1 - 0.5 - 0.5 - (-228.6)$

$= 90.6$ dB Hz

17

$\left(\frac{C}{N}\right) = \left(\frac{C}{N_o}\right) - 10\log B_N = 90.6 - 10\log(36\times10^6)$

$= 15.04$ dB

10

Downlink

$\left(\frac{C}{N_o}\right) = 52 + 12 - 198 - 2 - 1 - 0.5 - 0.5 - (-228.6)$

$= 90.6$ dB Hz

$\left(\frac{C}{N}\right) = 15.04$ dB

$\left(\frac{C}{N_o}\right)_{overall} = \frac{10^{9.06} * 10^{9.06}}{10^{9.06} + 10^{9.06}} = 574\times10^6 =$ **87.6 dB Hz**

$\left(\frac{C}{N}\right)_{overall} = \frac{10^{1.504} * 10^{1.504}}{10^{1.504} + 10^{1.504}} = 15.96 =$ **12.03 dB**

(b)

$BER = Q\left(\sqrt{\frac{2E_b}{N_o}}\right)$ $\rightarrow \frac{E_b}{N_o} = \frac{C}{N_o} - 10\log R_b$

$= 87.6 - 10\log(72\times10^6)$

$= 9$ dB

$= 7.94$

$BER = Q\left(\sqrt{2*7.94}\right)$

$= Q(4)$

5

$= \frac{1}{\sqrt{\pi}} e^{-(4)^2}$

$BER = 6.35\times10^{-8}$

6

(C)

$$T_{rain} = 290\left(1 - \frac{1}{10^{0.2}}\right) = 107.02$$

2

$$T_{s\,new} = 507.02 \qquad 10\log \frac{507.02}{400} = 1.03$$

Uplink

$$\left(\frac{C}{N_o}\right) = \left(\frac{C}{N_o}\right) - 1.03 = 91.63$$

A

$$= \left(\frac{C}{N_o}\right)$$ Downlink

$$\left(\frac{C}{N_o}\right)_{overall} = 88.62 \text{ dB Hz.}$$