Final Assignment
Date: 24/06/2020

Course Details

Course Title: Radar and Satellite Communications **Module:** 8th
Instructor: ______ **Total Marks:** 50

Student Details

Name: ______ **Student ID:** ______

Student Signature: ______

Q1		Answer the following questions: **a)** Is there any difference between Backscatter and Clutter, if yes then briefly discuss it? (02 Marks) **b)** A RADAR system may receive multiple forms of interference signals, so what can be those types of interfering signals discuss any three of them? (03 Marks) **c)** Discuss both Range resolution and Doppler resolution. How come they are important in target detection on the basis of their basic criteria? (03 Marks)	Marks 15 CLO 01
Q2.		Calculate the following antenna parameters: a) the gain in dBi of a 3m parabolic reflector antenna at frequencies of 8 GHz and 14 GHz; b) the effective area of an antenna with 46 dBi gain at 12 GHz. An efficiency factor of 0.55 can be assumed.	Marks 10 CLO 02
Q3.		Determine the range and free space path loss, uplink path loss and downlink path loss for the following satellite link: The service and feeder links between an Iridium satellite located at 760 km altitude and a ground location with a 70° elevation angle. The service link frequency is 1600MHz and the feeder link frequencies are 29.2 GHz uplink and 19.5 GHz downlink.	Marks 05 CLO 02
Q4.		A VSAT network operates with a satellite downlink consisting of a 3.2m satellite transmit antenna and a 1.2m ground receive antenna. The carrier frequency is 12.25 GHz, noise bandwidth of the downlink is 20 MHz, and the elevation angle for the ground station network ranges from 25–40°. Determine the minimum RF transmit power required for each terminal to maintain a minimum C/N_0 of 55 dBHz for any of the terminals in the network. The system noise temperature is 400 K. Assume an atmospheric path loss of 1.2 dB for the link. Line losses can be neglected. Antenna efficiency for the satellite antenna is 0.65 and for the ground antennas is 0.55.	Marks 10 CLO 02

Q5		Given below are the specifications of a RADAR system and a target which this RADAR will attempt to detect.		Marks 10 CLO03
		RADAR specifications: Transmit power 2MW Antenna gain 3000 Antenna effective aperture 15m2 Transmit frequency 1.27GHz Transmit pulse width 2.5µs Pulse repetition frequency 350pps Receiver noise factor is 3.	**Target Specifications:** RCS is 10m2 Range from RADAR is 350nmi.	
		Determine the following. Effective radiated power of RADAR. (02 Marks) Forward power density of RADAR. (02 Marks) Total power reflected. (02 Marks) Power received/capture from target (04 Marks)		

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Question No 1

(a) Difference between blackscatter and clutter. :-> Backscatter is the portion of the outgoing radar signal that the target redirects directly back towards the radar antenna. The scattering cross section in the direction towards the radar is called the back scattering cross section. If the signal formed by backscatter is undesired it is called clutter.

Question No 1

(b) (*) Rang Resolution :-

Rang resolution is the ability of a radar system to distinguish between two or more target on the same bearing but at different ranges. The degree of range resolution depend on width of the transmitted pulse

$$S_r \geq \frac{C_0 \cdot P_w}{2} \; [m] \quad \text{—— (1)}$$

(*) Doppler Resolution :-

Doppler ~~frequency~~ ~~is~~ Resolution usually depends on the dwell time T_{dwell}. The time for which the radar is going to stare (look) at the target. Therefore the doppler resolution is $f_d/(N/2)$. More pulses you are able to send to the target better is the doppler resolution.

Question No 1

(b)

(i) Electrical interference :- Electrical interferance does not benefit anyone and its almost never intentional.

(ii) Intermodulation :- Intermodulation is interwork is a type of interferance sometimes encontured in wireless

(iii) Radio frequency interferance :-

This type of interferance cause by radar (RF) signal on near to the frequency of the effected wireless receiver. The interfacing signal might have been transmitted

Question No 2

(a) The gain in dBi of a 3m parabolic reflector antenna at frequency of 8 GHz and 14 GHz. Calculate the antenna Perameters ?.

Solution :-

Given Data.

$d = 3m$

$f_1 = 8\ GHz$

$f_2 = 14\ GHz$

Formula

$$g = \eta_A \left(\frac{\pi d}{\lambda}\right)^2$$

Seince $\lambda = c/f$

$c = 3\times10^{8}\ m/s$

$$g = \eta_A \left(\frac{\pi d}{c/f}\right)^2$$

$$g = \eta_A \left(\frac{\pi f d}{c}\right)^2$$

$$g = \eta_A \left(\frac{\pi^2 f^2 d^2}{c^2}\right)$$

$$g = \frac{(3.14)^2 \times f^2 d^2 \eta_A}{(3\times10^{8})^2}$$

$g = 109.55 \times f^2 d^2 \eta_A$

Now find Gain dB.

$G = 10 \log(109.55 f^2 d^2 \eta_A)$

We know that

$\eta_A = 0.55 \quad d = 3m$

So for f_1 :-

$G = 10 \log(109.55 (8)^2 (3) \times (0.55))$

$= 10 \log(34705.44)$

$G_1 = 45.40\ dBi$ —— (1)

For f_2 :-

$G_2 = 10 \log(109.55 (14)^2 (3)^2 (0.55))$

$G_2 = 50.26\ dBi$ —— (2)

Question No 2
(b)

Solution :- Given Data.

Gain = 46 dB
f = 12 GHz
η_A = 0.55

Required :- $A_e = ?$

We know that

$$G = 10 \log (109.66 \times f^2 \times d^2 \times \eta_A)$$

$$46 = 10 \log (109.66 \times (12)^2 \times d^2 \times 0.55)$$

$$46 = 10 \log (8685.072 \, d^2)$$

Take antilog b.s.

$$8685.072 \, d^2 = 10^{4.6}$$

$$d^2 = \frac{10^{46}}{8685.072}$$

$$d^2 = 4.5858$$

$$\boxed{d = 2.14\ m}$$

we know that

$$A_e = \eta A$$

So

$$A = \frac{\pi d^2}{4}$$

$$A = \frac{3.14 \times (2.14)^2}{4}$$

$$\boxed{A = 3.59\ m^2}$$

So

$$A_e = (0.55)(3.59)$$

$$\boxed{A_e = 1.977\ m^2}$$

Question No 3:-

Given Data.

$r = 760$ Km.

Feeder link freq UL $= 29.2$ GHz

Service link freq $= 1600$ MHz $= 1.6$ GHz

Feeder link freq DL $= 19.5$ GHz

Requried:-

$L_{FS} = ?$

$L_{FS}(UL) = ?$

$L_{FS}(DL) = ?$

Formula

$$L_{FS} = 20\log(f) + 20\log(r) + 92.44$$

$$= 20\log(1.6) + 20\log(760) + 92.44$$

$$= 4.0823 + 57.6162 + 92.44$$

$$L_{FS} = 154.138 \text{ dB}$$

$$L_{FS}(DL) = L_{FS} + 20\log(f_d/f_s)$$

$$= 154.138 + 20\log\left(\frac{29.24\ GHz}{1.6\ GHz}\right)$$

$$= 154.138 + 20\log(18.275)$$

$$= 154.138 + 25.23$$

$$\boxed{L_{FS(DL)} = 179.368\ dB}$$

Question No 4

Solution: First we have to find the transmitted power Pt.

We know that VSAT Network.

$$\left(C/N_o\right) = \left[\frac{\eta_t \eta_r A_t A_r}{L_o K}\right]$$

Given Data

$\eta_t = 0.65$

$\eta_r = 0.55$

$r = 35900$ Km

$d_t = 3.2$ Km.

$d_r = 1.2$ Km

$K = 1.39 \times 10^{-23}$ J/K

$C/N_o = 55$ dB Hz

$t_s = 400$ K

$f = 12.25$ Hz

$L_o = 1.2$ dB

$$A_t = \frac{\pi d^2}{4} \Rightarrow \frac{\pi (3.2)^2}{4} \Rightarrow \frac{(3.14)(3.2)^2}{4}$$

$$\boxed{A_t = 8.038\ m^2}$$

$$A_r = \frac{\pi d_r^2}{4} \Rightarrow \frac{\pi (1.2)^2}{4} \Rightarrow \frac{(3.14)(1.2)^2}{4}$$

$$\boxed{A_r = 1.1304\ m^2}$$

Now

$$\lambda = c/f$$

$$= \frac{3 \times 10^8}{12.25 \times 10^9}$$

$$\boxed{\lambda = 0.024\ m}$$

$$L_o = 1.2\ dB$$

$$L_o = 10^{0.2/10}$$

$$L_o = 1.318$$

$$C/N_o = 10^{5.5}$$

$$C/N_o = 316227.76$$

From eq (1)

P_t can be written as.

$$P_t = \left(C/N_o\right) \frac{\lambda^2 r^2 t_s L_o K}{\eta_t \eta_r A_t A_r}$$

$$P_t = \frac{31622.76 \times (0.024)^2 (35900)^2 \times 400 (1.318)(1.39 \times 10^{-23})}{(0.65)(0.55)(1.1304)(8.038)}$$

$$\boxed{P_t = 5.295 \times 10^{-10}\ \omega}$$ Ans

Question No 5:-

Given Data.

Transmitted power = 2MW

Antenna Gain = 3000 W

Antenna effective Aperture = $15m^2$

Transmitted freq = 1.27 GHz

Transmitted ~~pulse~~ pulse width = 2.5 dB

pulse repetition freq = 350 pps

Receiver noise factor = 3

Rcs is = $10m^2$

Range from radar = 350 nmi

Required:-

(i) Effective Radiated power = ?

(ii) Forward power density = ?

(iii) Total power reflected = ?

(iv) power received = ?

Solution :-

(1) $ERP = P_T G_T$

$ERp = 2 \times 10^6 \times 3000$

$$ERp = 6 \times 10^9 W$$

(2) Forward power density = ?

$$P/A_F = \frac{P_T}{4\pi R_T^2 / G_T} \quad \text{———} \quad (*)$$

1 nmi = 1852 m

350 nmi = 648200 m

A spere of radius 648200 m has surface area of :

$A = 4\pi r^2 \Rightarrow 4 \times 3.14 \times (648200)^2$

$$A = 5.27 \times 10^{12} m^2$$ = surface area.

The radar cross section is $10m^2$

The antenna beam illiminates $\frac{1}{3000} = ?$.
that area ~~me~~. means the
illiminated area.

$$Area = \frac{1}{3000} \times 5.27 \times 10^{12}$$

$$= 1756,666,667 \ m^2$$

The tatall transmitted power is
2000 000 Ws.

So the power per unit area in the
beam at the target range is

$$= \frac{2000\,000}{1756\,666\,667}$$

$$= 0.00113852 \ w/m^2$$

OR.

We can also use the direct formula of forward power density.

$$P/A_F = \frac{P_T}{4\pi R_T^2/G_T}$$

$$= \frac{2000000 \times 3000}{4 \times 3.14 \times (648200)^2}$$

$$P/A_F = 0.00113852 \ W/m^2$$

③ Power Reflected = ?

$$P_{TgT} = \frac{P_T G_T \delta}{4\pi R_T^2} \quad \text{———— \#}$$

So the illumination power density at the target is $0.00113852 \ W/m^2$.

The target has $Rcs = 10 m^2$

So the capture echo is $= 0.00113852 \times 10$

$= 0.011385 \ W$

radiated by target

The target Now transmitted the power ~~density at the target~~ :

= 0.011385 W The range from target to radar = 648200 m

So

$$P/_{AB} = P_{Tgt} \frac{1}{4\pi R_R^2} =$$

$$= 0.011385 \times \frac{1}{4\pi(648200)^2}$$

$$\boxed{P/_{AB} = 2.157 \times 10^{-15} \, W/m^2}$$

(4) Power Received = ?

$$P_R = P/_{AB} \cdot A_E$$

So effective area of radar $15 m^2$
Power density of echo = $2.157 \times 10^{-15} \, W/m^2$
So Power recived is

$$P_R = 2.157 \times 10^{-15} \times 15$$

$$\boxed{P_R = 3.23555 \times 10^{-14} \, W}$$

Ans