**EE-602 (2021-2): Quiz-1**

Date 11-2-2022

Explanation/ relevant calculation is a **MUST** for MCQ. Select nearest numerical answer

Make assumptions if the data is inadequate and mention the assumption clearly

**Max Marks 10**

1. **Multiple Choice Questions Select most appropriate option(s)**

A mono-static pulsed Doppler radar operates at 3.33333 GHz with transmission pulse width of 0.667µs and pulse repetition frequency (PRF) of 1 kHz and it uses antenna with gain of 20 dB.

1 nautical mile (nmi)=1.86 km, Antenna Gain = 4πAe/λ2. Doppler frequency shift= 2 X (target velocity)/ λ). Use these specifications for Q (i) to Q (vi)

1. What is the range resolution in nautical miles?
2. 0.0537 nmi (b) 0.1 nmi (c)53.76 nmi (d) 0.186 nmi … (1 mark)
3. Assuming that this radar has ‘confirmed’ information that the targets are always approaching. Consider target ‘A’ approaching radially towards the radar and target ‘B’ approaching with angle of 60⁰ with respect to the radial approach direction. What is the maximum target velocity that can be detected unambiguously for target A and target B? Assume complex sampling. Choices are given in the format 🡪 ***v***unamb. A, ***v***unamb B.
4. 45ms-1, 52ms-1 (b) 22.5ms-1, 45ms-1 (c) 45ms-1, 22.5ms-1 (d) 45ms-1, 90ms-1 … (1 mark)
5. If the radar uses a parabolic dish antenna with diameter ‘D’. What is the most likely value of D?
6. 6 cm (b) 30 cm (c) 0.9m (d) 150 cm … (1 mark)
7. The receiver sampling frequency of this radar is upgraded to 3 MSPS (Mega Samples Per Second). All the other radar parameters are kept the same. Which of the following statement(s) is/ are true?
8. This will increase the range resolution and also the have better/ finer velocity estimation
9. It will increase the range estimation accuracy and no effect on the range resolution
10. It will increase the radar transmission bandwidth and hence the system noise.
11. It will increase range accuracy and resolution as well as velocity resolution … (1 mark)
12. Let the strength of the echo from a point-target at a distance ‘R’ is ‘P’ dBm. What will be the echo power from the same target when it is at a distance of ‘R/3’?
13. 81 P dBm (b)P+19 dBm (c)P4 dBm (d) P+12 dBm … (1 Mark)
14. Assume that there is no atmospheric refraction. This means that the EM waves propagate in a straight line. This radar is installed on the sea cost, at an altitude of 144m on the sea level. Find the maximum distance (range) at which a sailing ship (target) that can be detected by this radar.
15. 80 nmi (b) 150 km (c)42.24 km (d) 49.44 km … (1 Mark)

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1. A traffic Doppler gun (used to determine the speed of vehicles) operates at 6 GHz. What Doppler frequency shift shall be observed when it is pointed at a racing car approaching towards the radar at 144 km Hr-1?

(a) 5.76 kHz (b) 4.8 kHz (c) 1.6 kHz (d) 1.333 kHz … (1 mark)

Linear FMCW radar operates with Saw-tooth modulation. The frequency is varied linearly in the frequency band of 10±0.5GHz, over a period of 1ms and the same waveform is repeated. The radar used on a helicopter to estimate the distance to the land while landing. It is expected to operate for the altitudes (target range) of 3 m to 300 m.

Use these specifications for Q (viii) to Q (x).

1. What is the IF bandwidth of this radar? (Hint: Compute the beat frequencies (down converted IF frequencies) corresponding to 3m and 300m)

(a) 1.8 kHz (b) 2.02 MHz (c) 1.98 MHz (d) 19.8 MHz … (1 mark)

1. If the received echo is captured with ‘real sampling’ using A/D converter at the rate of 10 MSPS, what is the maximum unambiguous range for this FMCW radar?

(a) 15m (b) 375 m (c) 1.5 km (d) 750m … (1 mark)

(x) If the receiver noise figure is 3dB, what is the minimum received signal power at the input of the receiver so that the signal power is equal to the noise at IF frequency output; before the digital processing?

(a) -111 dBm (b)-141 dBm (c) -81 dBm (d) -108 dBm … (1 mark)

**EE 601 (2021-2)- Quiz1**

**Solution and the marking scheme**

**Pulse Radar:**

1. **(a)**

The range resolution depends only on the pulse width = cτ/2= 3X 108X 0.667 X 10-6 /2= 100.05m

(0.5 marks)

Converting it into nmi🡺 0.10005 / 1.86=0.0537nmi (0.5 marks)

1. **(d)**

All the targets are known to be approaching. 🡪The Doppler frequency is always positive.

Hence, the radar can detect Doppler frequencies up to 1 kHz =

@ 3.3333 GHz🡪 λ= 0.09m OR 9cm. and *f*D= 2***v***/ λ .

Hence, for radially approaching target (Target **A**), ***v***unamb= (103 X0.09)/2= 45ms-1. (0.5 marks)

Target B approaches with angle of 60⁰. Making the radial component = 0.5 ***v***target

Hence the radar measures 0.5 ***v***target 🡪 for target B, ***v***unamb= 90 ms-1. (0.5 marks)

1. **(b)**

The Gainof 20 dB= 100= 4π (4πD2/4)/λ2 🡪 D2= 100 λ2/ π2.Hence D=10 λ/π= 0.286m. (0.5 marks)

Nearest is 0.3m. Also generally physical size of antenna is generally higher.

1. **(b)**

Only this statement is true. (1 Mark)

1. **(b)**

The Echo power increases as (Range)4 🡪

Therefore, we shall have power increased by 81 times. (0.5 marks)

In dB scale🡪 P+19 dB. (0.5 marks)

1. **(c)**

For the coastal radar, targets are located on the earth’s surface. And hence, the range is limited by the horizon. In absence of refraction, we have k=1 and (0.5 marks)

Range (km) = 3.5 X H(m)0.5. 🡪 3.5 X Sqrt(144)=42 (0.5 marks)

1. **(c)**

The traffic radars operate at a single frequency and generally measures only relative velocity. 144 km.Hr-1 = 40 m.s-1. and λ│6GHz= (3X 108)/ (6X109) = 0.05m (0.5 marks)

🡺 *fD*=2 X 40/ 0.05= 1.6 kHz. (0.5 marks)

**FMCW Radar**

1. (c )

The beat frequency is given by ***fb***│3m *=* 2RΔF/cT= (2 X 3 X109)/(3 X10-3) = 20000Hz= 20kHz.

Similarly, ***fb***│3m *=* 2RΔF/cT= (2 X 3 X109)/(3 X10-3)= 2 MHz. So the Bandwidth= 1.98 MHz.

1. (d). 10 MSPS real sampling shall offer bandwidth of 5 MHz (Nyquist rate). (0.5 marks)

The range corresponding to5 MHz is 

(0.5 marks)

1. (d) The noise power for the BW of 1.98 MHz is = 1.38X 10-23X 290 X1.98X 106=7.923 X10-15 W.

= -141 dBW =-111dBm (0.5 marks)

As NF= SNRInput/SNR output. Output SNR=0dB (Power equal to noise), SNRinput= 3dB.nal to Signal input = -111+3= -108dBm. (0.5 marks)