CMR INSTITUTE OF TECHNOLOGY

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Internal Assesment Test -1

Sub:	RADAR							Code:	
Date:	14.5.2022	Duration:	90 mins	Max Marks:	50	Sem:	VIII	Branch:	ECE-A,B,C,D

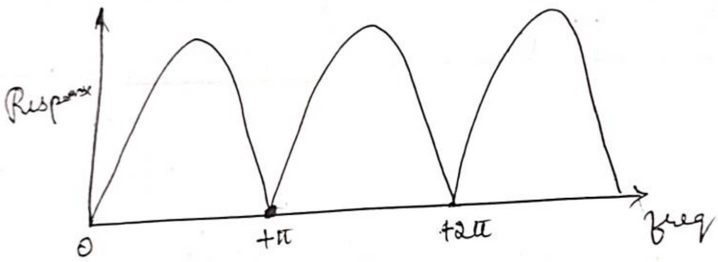
Answer Any FIVE FULL Questions

		Marks	OBE CO	OBE RBT
1.	Explain Delay line canceller.What are limitations of a Single delay line canceller.	[10]	CO3	L1
2.	Draw and explain n MTI Radar Block Diagram.	[10]	CO1	L2
3.	Write short note on- Duty Cycle & Peak transmitted power	[10]	CO1	L2
4.	Explain RADAR frequencies & applications of RADAR in detail.	[10]	CO1	L1
5.	Explain Digital MTI Processing with block diagram.	[10]	CO1	L1
6.	If the Radar operates at a frequency of 12GHZ, then find the Doppler frequency of an aircraft moving with a speed of 200KMph.	[10]	CO3	L3
7.	A 10 GHz RADAR has the following characteristics- Pt=250,Pref =1500PPs,pulse width=0.8 microsecond, power gain of antenna =2500,Smin=10^-14W,Ae=1 cm^2 and σ=2m^2 .Calculate- Run ii)Max possible range iii)Duty cycle	[10]	CO3	L3

Solution IAT-1

i) Blind Speed:

* The target is not detected and there occurs maximum clutter attenuation when the time response is 0.
* The magnitude of the response of the single-delay-line canceller is $|H(f)| = |2\sin(\pi f_d T_p)|$ becomes 0 when $\sin(\pi f_d T_p)$ is 0 at $n = 0, \pm\pi, \pm 2\pi$, etc



* There are 4 detremental ways of reducing the effect of blind speed. They are:

a) By using a radar with large wavelength/low frequency

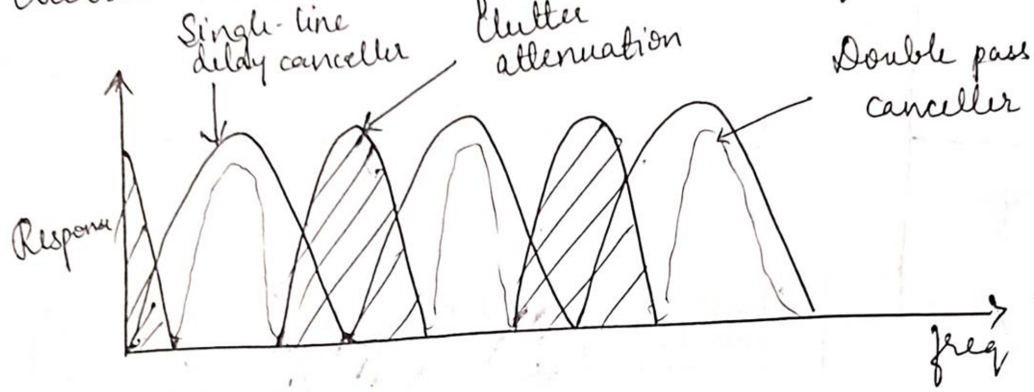
b) By using a high pulse repetitive frequency radar

c) By using more than 1 pulse repetitive frequency radar

d) By using more than 1 repetitive frequency radar.

(ii) Clutter attenuation:

* One of the limitation of single delay line canceller due to the limitation of attenuation of clutter across the finite width of the signal.



* Mathematically, clutter attenuation is expressed as:

$$W(f) = W_0 \exp\left(\frac{-f^2}{2\sigma_c^2}\right)$$

* Clutter attenuation of Single Delay Line Canceller is,

$$CA = \frac{\int_0^\infty W(f)\,df}{\int_0^\infty W(f)\,|H(f)^2|\,df}$$

$$CA = \frac{f_d^2}{4\pi^2\sigma_c^2}$$

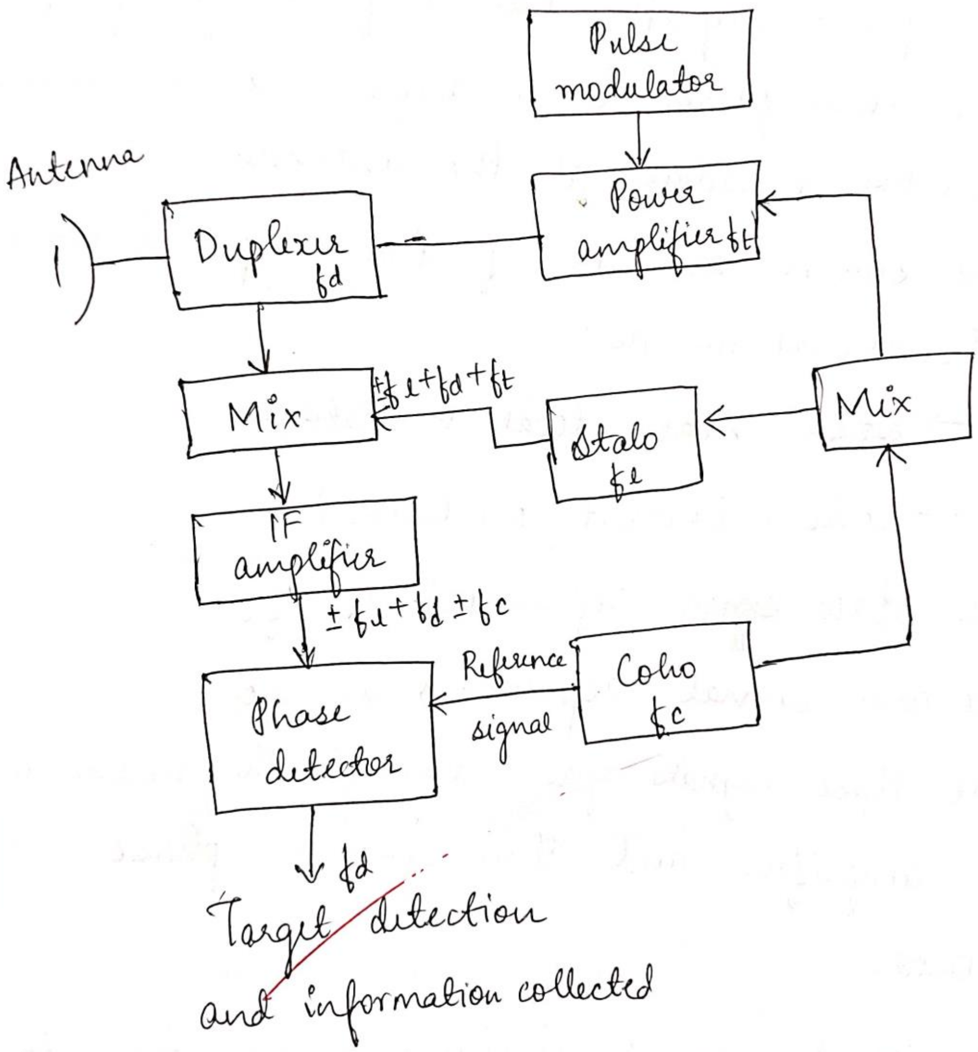
* Clutter attenuation of Double-delay canceller is,

$$CA = \frac{f_d^4}{48\pi^2\sigma_c^2}$$

Internal Assessment Test-01

QUESTION-2

2 Ans: MTI Radar Block Diagram:



= Fig. Block diagram of MTI Radar which has both static & coherant local oscillations.

* A Moving Target Indication (MTI) Radar has a power amplifier as a transmitter
* A pulse modulator regulates the power amplier with continous modulation of pulses as input
* The power amplifier has a frequency of f_t
* This then passes to a duplexer as a mixer function & radiated to the antenna.
* The signal can be of two types based on the oscillations as:
  → Stalo (Static local oscillator)
  → Coho (Coherant oscillator)
* The stalo signal represented as f_l
* The coho signal represented as f_c
* All these signals passes through the mixers and IF amplifiers and then goes to phase detector.
* The final signal contains information about the target and the subsequent related informati of the information gathered between the transmit and receiver.

QUESTION - 3

3 Ans: (a)

Duty Cycle:

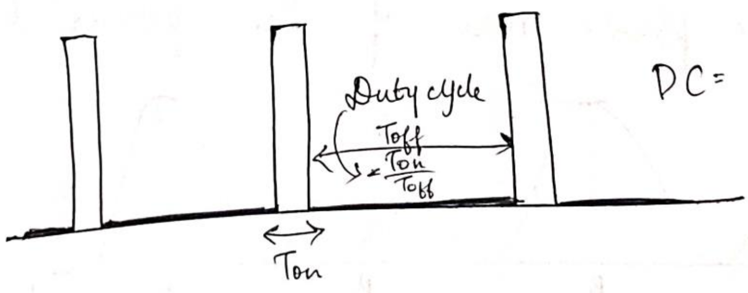
* The term "Duty-cycle" is defined as the total time the radar is radiating energy/signal to to the total time the radar could have radiated.

$$\text{Duty cycle} = \frac{\tau}{T_p} = \tau f_p$$

* Duty cycle can also be represented in terms of power. Its the ratio of avg power to the total power radiated.

$$\text{Duty cycle} = \frac{P_{av}}{P_{total}}$$

* Duty cycle is a dimensionless quantity.

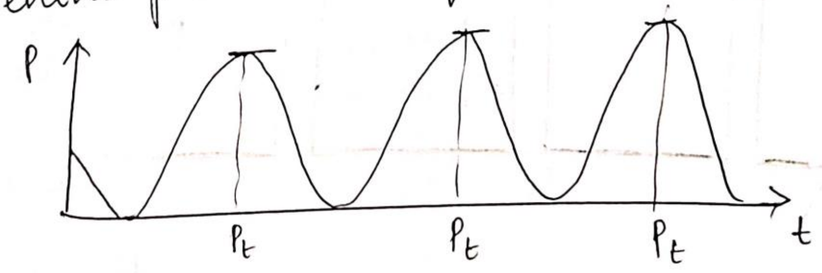


$$DC = \frac{T_{on}}{T_{on}}$$

Ex: A pulse radar waveform, where the pulses turn on only for a shorter duration, whereas off-time is literally high.

b) Peak transmitted power:

* The maximum power that is transmitter from the transmitter to the receiver irrespective of the path-loss or the clutters present is given by Peak transmitted power.
* The transmitted signal power is always considered to be higher than the power that is left at the receiver end, as it may undergo long-distance interference, etc...
* P_t is how we denote the transmitter power
* P_t is given by, $$P_t = \frac{P_t G_t \cdot G_r \lambda^2}{4\pi d^2}$$
* Peak power is designed only once for an entire phase roll of the power transmission



* The points when the signal has maximum amplitude represents the peak power in case of a transmitter or received.

QUESTION- 4

4 Soln:

RADAR Frequencies:

The table below lists the range of frequencies that comes under RADAR:

Band	Frequency range
HF	10-30 MHz
VHF	30 - 300 MHz
UHF	300 - 1000 MHz
L	1-2 GHz
S	2-4 GHz
C	4-8 GHz
X	8-12 GHz
Ku	12-18 GHz
K	18-27 GHz
Ka	27-40 GHz
V	40-75 GHz
W	75-110 GHz
mm	110-300 GHz

Applications of RADAR:

The below mentioned are few of the major applications of RADAR. They are:

1) Military
2) Remote Sensing.
3) Air Traffic Control (ATC)
4) Law Enforcement & Highway safety
5) Air safety and Navigation
6) Ship safety
7) Space and
8) Others

1) Military:

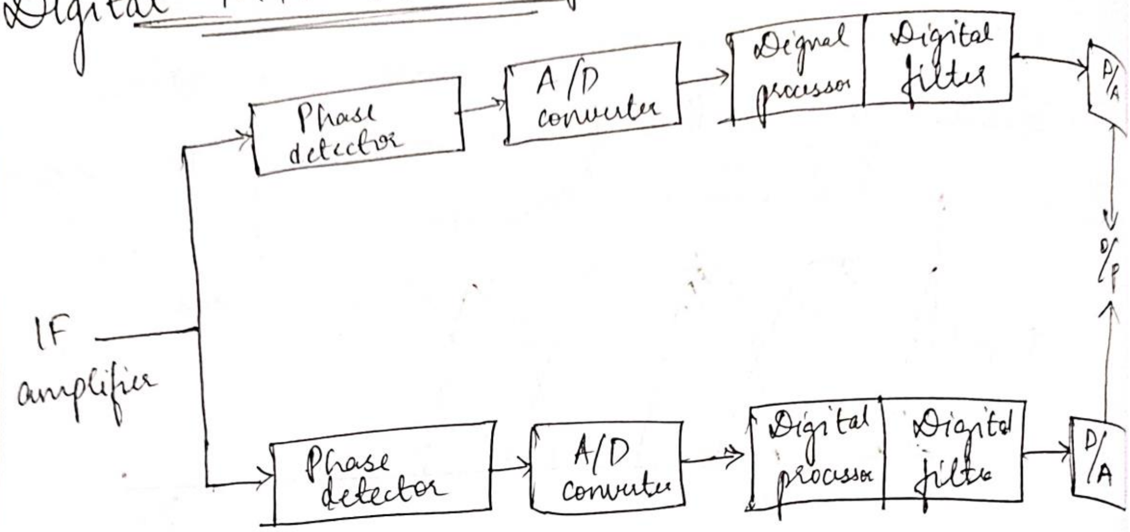
* RADAR is one of technology that is used by armed forces to overcome the spying of the neighbouring rival armed forces entering into our territory.
* This in turn sends some echo signals to the receiver end ~~as~~ a signal of alert.

2) Remote Sensing:

* For Remote sensing or the places where it is unaccessible for manpower / humans RADAR is

QUESTION-5

Digital MTI Processing:



* An IF amplifier acts as an i/p to the MTI processing system
* We have a single system performing operation in two sides at the same time and which enhances the efficiency and performal of digital MTI over the normal MTI radar system.
* The phase detector, detects the signal that is to be processed and detects the phase if the phase of the signal does not coincide with the necessary signal frequency, then it is considered lapse.

* Once phase detection is done, now the next task is of A/D converter
* Converting the signal to the needful pattern before it reaches the processor
* If the signal is in Analog filter, it needs to be converted to digital form
* If the signal is in Digital form, it is directly processed to the Digital processor
* The digitally processed signal then goes to a digital filter
* Finally, the digital signal is converted to the Analog format, when received as output.
* The entire process takes place within the RADAR frequency range & hence seems to be more of conversion of signal to the desired form for the processing to be enhanced.
* This is the brief explanation of Digital MTI Processor.

of great importance.

3) Aircraft Traffic Control (ATC):

* One of the major transport of any country would be Airway, which needs continous montinor of weather or terrain conditions and its clear route for travelling

4) Law Enforcement & Navigation safety:

* The safety while navigating to the region which is priorly unknown is of great importance for tracking any mislead information.

5) Aircraft safety:

It needs to follow the safety precautions needed to maintain aircraft in stability

6) Ship safety:

* Not just for airways we need radar, it is even for ship / water way navigation that RADAR becomes useful.

7) Space:

* RADAR plays an imp role in space related control too.

QUESTION - 6

Given:

$f = 12\ GHz$

$f_d = ?$

$v_r = 200\ KMph$

$\lambda = \frac{c}{f}$

Doppler frequency is given by,

$$f_d = \frac{2 v_r}{\lambda}$$

$$\therefore \lambda = \frac{c}{f}$$

$$= \frac{3 \times 10^8}{12 \times 10^9}$$

$$\boxed{\lambda = 0.025\ m}$$

$$\therefore f_d = \frac{2 \times 200 \times 10^3}{0.025 \times 3600}$$

$$= 4444.44\ Hz$$

$$\boxed{f_d = 4.44\ kHz}$$

Doppler frequency, $f_d = 4.44\ kHz$

QUESTION - 7

7 Soln: Given:-

$P_t = 250$

$P_{rf} = 1500$ pps

$P.W = 0.8$ ms

$G = 2500$

$S_{min} = 10^{-14}$ W

$A_e = 1 cm^2$

$\sigma = 2m^2$

$f = 10 GHz$

$\lambda = \frac{c}{f}$

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

$= \frac{3}{100}$

$= 0.03$ m

(i) $R_{un} = \frac{c T_p}{2} = \frac{c}{2 f_p}$

$= \frac{3 \times 10^8}{2 \times 10 \times 10^9}$

$= \frac{3}{2 \times 100} = 0.015$ m

(ii) $R_{max} = \left(\frac{P_t G^2 \lambda^2 \sigma^2}{(4\pi)^3 S_{min}} \right)^{1/4}$

$= \left(\frac{250 \times (2500)^2 \times (0.03)^2 (2)^2}{(4\pi)^3 \; 10^{-14}} \right)^{1/4}$

$R_{max} = 23074.01$ m $= 23.07$ km

(iii) Duty cycle, $= \frac{P_{av}}{P_t}$

$$= \frac{\frac{1500}{60}}{250}$$

$$= 0.1$$