EXPERIMENT NO. 6

AIM: To Study principal and operation of RADAR.

THEORY:

- Principle of RADAR Operation:

Radar is an acronym for Radio Detection and Ranging. The term "radio" refers to the use of electromagnetic waves with wavelengths in the so-called radio wave portion of the spectrum, which covers a wide range from 10^4 km to 1cm. Radar systems typically use wavelengths on the order of 10 cm, corresponding to frequencies of about 3 GHz. The detection and ranging part of the acronym is accomplished by timing the delay between transmission of a pulse of radio energy and its subsequent return. If the time delay is Δt, then the range may be determined by the simple formula:

$R = c^*\Delta t/2.$

Where $c = 3 \times 10^8$ m/s, the speed of light at which all electromagnetic waves propagate. The factor of two in the formula comes from the observation that the radar pulse must travel to the target and back before detection, or twice the range. A radar pulse train is a type of amplitude modulation of the radar frequency carrier wave, similar to how carrier waves are modulated in communication systems. In this case, the information signal is quite simple: A single pulse repeated at regular intervals. The common radar carrier modulation, known as the pulse train is shown below. The common parameters of radar are defined by referring to Figure 1

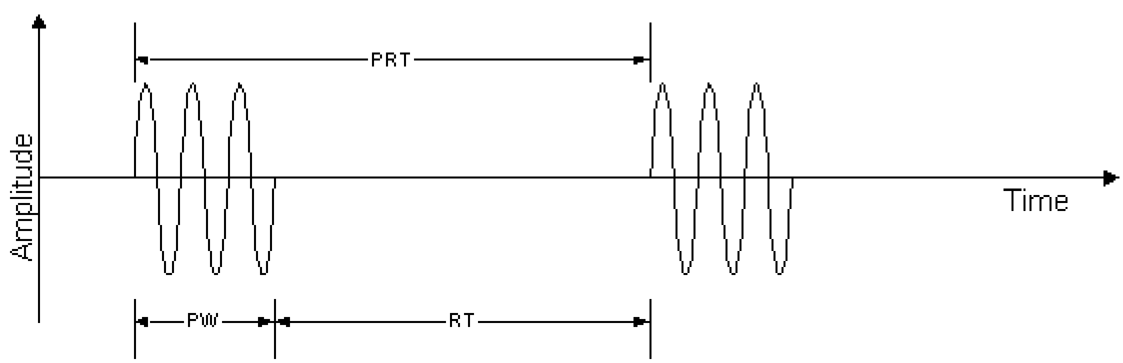


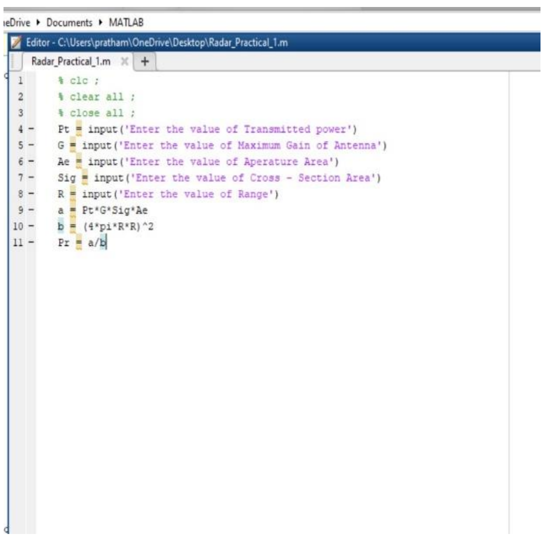
Figure 1

EXPERIMENT 1

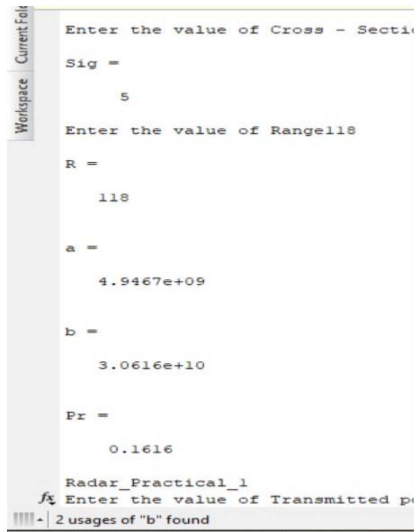
AIM: Write a program for computing Doppler frequency.

INPUT & OUTPUT:

INPUT



OUTPUT



Conclusion: Doppler frequency has been computed using theprogram.

EXPERIMENT 2

AIM: Write a program for computing minimum detectable power forRadar.

INPUT:

Radar_Practical1.m | Radar_Practical_2.m | Radar_Practical_1.m

```
clc;
close all;
clear all;

Vr = input('Enter the value of Relative Frequency')
L = input('Enter the value of Wavelength')

fd = 2*Vr/L
```

OUTPUT: **1) PART 1** **2) PART 2**

C: ▸ Users ▸ pratham ▸ OneDrive ▸ Documents ▸

```
Enter the value of Transmitted power279000

Pt =

      279000

Enter the value of Maximum Gain of Antenna3940

G =

        3940

Enter the value of Aperature Area0.9

Ae =

    0.9000

Enter the value of Cross - Section Area5

Sig =

     5

Enter the value of Range118
```

```
    0.9000

Enter the value of Cross - Section Area5

Sig =

     5

Enter the value of Range118

R =

   118

a =

   4.9467e+09

b =

   3.0616e+10

Pr =

    0.1616
```

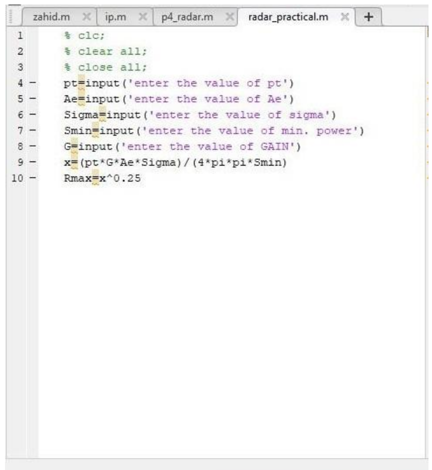
CONCLUSION:

Minimum detectable power for Radar has been computed with the help of the program.

EXPERIMENT 3

AIM: Write a program for computing radar range including noise.

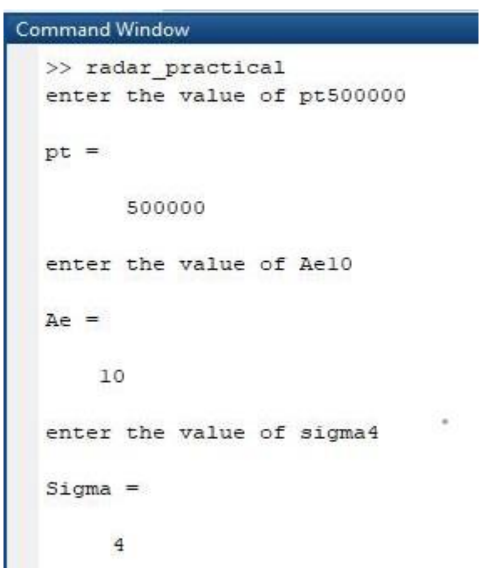
INPUT:



```
% clc;
% clear all;
% close all;
pt=input('enter the value of pt')
Ae=input('enter the value of Ae')
Sigma=input('enter the value of sigma')
Smin=input('enter the value of min. power')
G=input('enter the value of GAIN')
x=(pt*G*Ae*Sigma)/(4*pi*pi*Smin)
Rmax=x^0.25
```

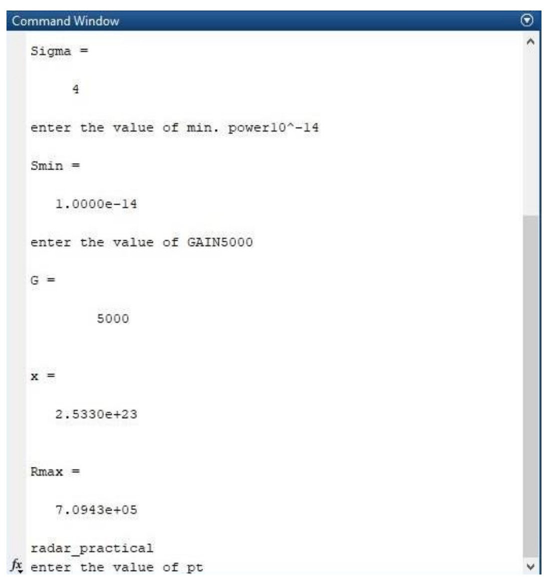
OUTPUT:

PART 1



```
Command Window
>> radar_practical
enter the value of pt500000

pt =

      500000

enter the value of Ae10

Ae =

    10

enter the value of sigma4

Sigma =

     4
```

PART 2



```
Command Window
Sigma =

     4

enter the value of min. power10^-14

Smin =

   1.0000e-14

enter the value of GAIN5000

G =

        5000


x =

   2.5330e+23


Rmax =

   7.0943e+05

radar_practical
enter the value of pt
```

CONCLUSION:

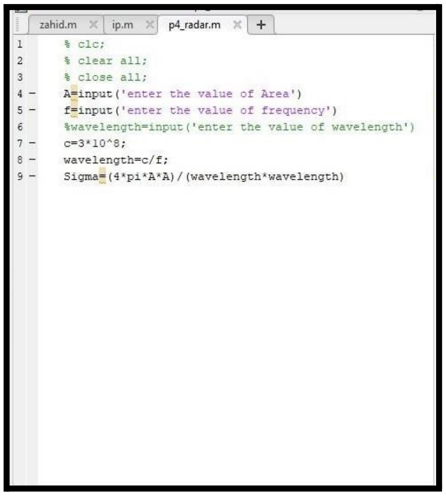
RADAR Range including noise has been computedusing the *program.*

EXPERIMENT 4

AIM: Write a program for radar cross-section.

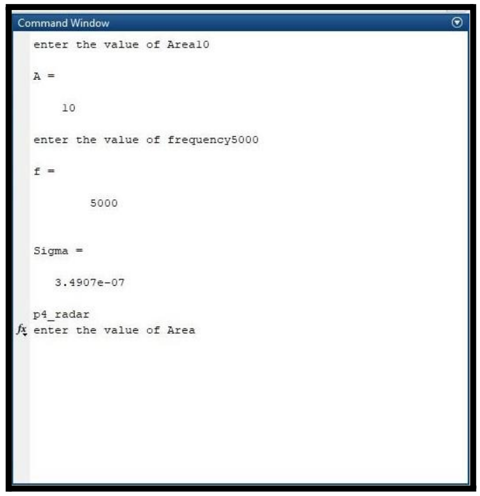
INPUT & OUTPUT:

INPUT



```
zahid.m   ip.m   p4_radar.m
% clc;
% clear all;
% close all;
A=input('enter the value of Area')
f=input('enter the value of frequency')
%wavelength=input('enter the value of wavelength')
c=3*10^8;
wavelength=c/f;
Sigma=(4*pi*A*A)/(wavelength*wavelength)
```

OUTPUT



```
Command Window
enter the value of Area10

A =

    10

enter the value of frequency5000

f =

        5000


Sigma =

   3.4907e-07

p4_radar
enter the value of Area
```

CONCLUSION:

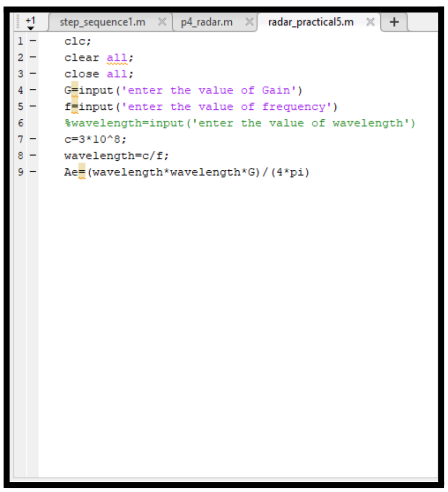
Radar cross-section has been computed using the program.

EXPERIMENT 5

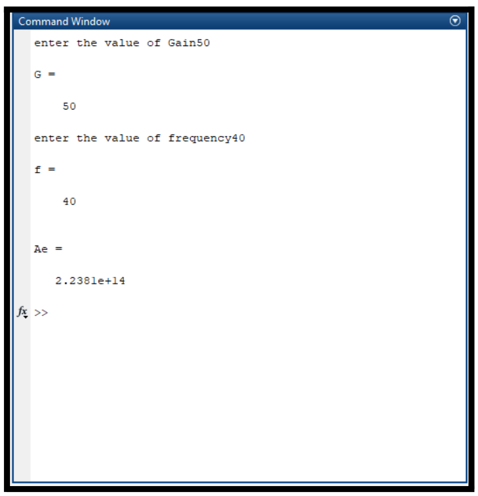
AIM: Write a program to compute the effective aperture of RADAR.

INPUT & OUTPUT:

INPUT



OUTPUT



CONCLUSION:

The effective Aperture of RADAR has been computed using the program.

Where PW = pulse width. PW has units of time and is commonly expressed in □s. PW is the duration of the pulse. RT = rest time. RT is the interval between pulses. It is measured in ms. PRT = pulse repetition time. PRT has units of time and is commonly expressed in ms. PRT is the interval between the start of one pulse and the start of another. PRT is also equal to the sum, PRT = PW+RT. PRF = pulse repetition frequency. PRF has units of time^{-1} and is commonly expressed in Hz (1 Hz = 1/s) or as pulses per second (pps). PRF is the number of pulses transmitted per second and is equal to the inverse of PRT. RF = radio frequency. RF has units of time^{-1} or Hz and is commonly expressed in GHz or MHz. RF is the frequency of the carrier wave which is being modulated to form the pulse train.

- Block Diagram of RADAR:

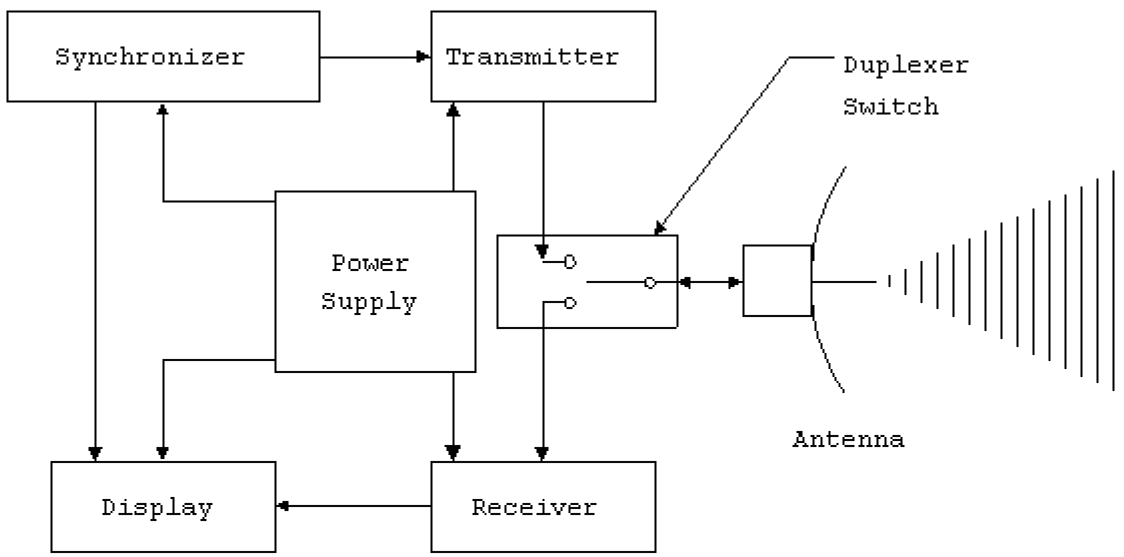


Figure 2

- The SYNCHRONIZER (also referred to as the TIMER or KEYER) supplies the synchronizing signals that time the transmitted pulses, the indicator, and other associated circuits.
- The TRANSMITTER generates electromagnetic energy in the form of short, powerful pulses.
- The DUPLEXER allows the same antenna to be used for transmitting and receiving.

The ANTENNA SYSTEM routes the electromagnetic energy from the transmitter, radiates it in a highly directional beam, receives any returning echoes, and routes those echoes to the receiver.

- The RECEIVER amplifies the weak, electromagnetic pulses returned from the reflecting object and reproduces them as video pulses that are sent to the indicator.
- The DISPLAY produces a visual indication of the echo pulses in a manner that, at a minimum, furnishes range and bearing information.
- While the physical configurations of radar systems differ, any radar system can be represented by the functional block diagram in the figure above. An actual radar set may have several of these functional components within one physical unit, or a single one of these functions may require several physical units. However, the functional block diagram of a basic radar set may be used to analyze the operation of almost any radar set.

  - ***Synchronizer (Timer):***

    The synchronizer ensures that all circuits connected with the radar system operate in a definite timed relationship. It also times the interval between transmitted pulses to ensure that the interval is of the proper length. Timing pulses are used to ensure synchronous circuit operation and are related to the PRF. The PRF can be set by any stable oscillator, such as a sine-wave oscillator, multi vibrator, or a blocking oscillator. That output is then applied to pulse-shaping circuits to produce timing pulses. Associated components can be timed by the output of the synchronizer or by a timing signal from the transmitter as it is turned on.

  - ***Transmitter:***

    The transmitter generates powerful pulses of electromagnetic energy at precise intervals. The required power is obtained by using a high-power microwave oscillator, such as a magnetron, or a microwave amplifier, such as a klystron, that is supplied by a low-power RF source. (The construction and operation of microwave components can be reviewed in NEETS, Module 11 and Microwave Principles.)

The high-power generator, whether an oscillator or amplifier, requires operating power in the form of a properly-timed, high-amplitude, rectangular pulse. This pulse is supplied by a transmitter unit called the MODULATOR. When a high-power oscillator is used, the modulator high-voltage pulse switches the oscillator on and off to supply high-power electromagnetic energy. When a microwave power amplifier is used, the modulator pulse activates the amplifier just before the arrival of an electromagnetic pulse from a preceding stage or a frequency-generation source.

Normally, because of the extremely high voltage involved, the modulator pulse is supplied to the cathode of the power tube and the plate is at ground potential to shield personnel from shock hazards. The modulator pulse may be more than 100,000 volts in high-power radar transmitters. In any case, radar transmitters produce voltages, currents, and radiation hazards that are extremely dangerous to personnel. Safety precautions must always be strictly observed when working in or around a radar transmitter.

- ***Duplexer:***

A duplexer is essentially an electronic switch that permits a radar system to use a single antenna to both transmit and receive. The duplexer must connect the antenna to the transmitter and disconnect the antenna from the receiver for the duration of the transmitted pulse. The receiver must be completely isolated from the transmitted pulse to avoid damage to the extremely sensitive receiver input circuitry.

After the transmitter pulse has ended, the duplexer must rapidly disconnect the transmitter and connect the receiver to the antenna. As previously mentioned, the switching time is called receiver recovery time, and must be very fast if close-in targets are to be detected. Additionally, the duplexer should absorb very little power during either phase of operation. Low-loss characteristics are particularly important during the receive period of duplexer operation. This is because the received signals are of extremely low amplitude.

Antenna System:

The antenna system routes the pulse from the transmitter, radiates it in a directional beam, picks up the returning echo, and passes it to the receiver with a minimum of loss. The antenna system includes the antenna, transmission lines and waveguide from the transmitter to the antenna, and the transmission line and waveguide from the antenna to the receiver. In some publications the duplexer is included as a component of the antenna system.

- ***Receiver:***

The receiver accepts the weak echo signals from the antenna system,
amplifies them, detects the pulse envelope, amplifies the pulses, and then routes them to the indicator. One of the primary functions of the radar receiver is to convert the frequency of the received echo signal to a lower frequency that is easier to amplify. This is because radar frequencies are very high and difficult to amplify. This lower frequency is called the INTERMEDIATE FREQUENCY (IF).

The type of receiver that uses this frequency conversion technique is the SUPER HETERODYNE RECEIVER. Super heterodyne receivers used in radar systems must have good stability and extreme sensitivity. Stability is ensured by careful design and the overall sensitivity is greatly increased by the use of many IF stages.

- ***Display:***

The display uses the received signals routed from the radar receiver to
produce a visual indication of target information. The cathode-ray oscilloscope is an ideal instrument for the presentation of radar data. This is because it not only shows a variation of a single quantity, such as voltage, but also gives an indication of the relative values of two or more quantities. The sweep frequency of the radar indicator is determined by the pulse-repetition frequency of the radar system. Sweep duration is determined by the setting of the range-selector switch. Since the indicator is so similar to an oscilloscope, the term RADAR SCOPE is commonly used when referring to radar indicators.

EXPERIMENT NO.:7

AIM: To Study Applications Of Different Types Of Radar And Also Write Down Advantages and Disadvantages Of Radar.

APPLICATION OF RADAR:

Radar has been employed to detect target on the ground, on the sea, in the air, in space, and even below ground. The major areas of radar application are briefly described below.

Military: Radar is an important part of air-defense system as well as the operation of offensive missiles and other weapons. In air defense it performs the functions of surveillance and weapon control. Surveillance includes target detection, target recognition, target tracking, and designation to a weapon system. Weapon-control radar track targets, direct the weapon to an intercept, and assess the effectiveness of the engagement. A missile system might employ radar methods for guidance and futzing of the weapon. High-resolution imaging radars, such as synthetic aperture radar, have been used for reconnaissance purposes and for detecting fixed and moving targets on the battlefield. Many of the civilian applications of radar are also used by the military.

Remote sensing: All radars are remote sensors; however, this term is used to imply the sensing of the environment. Four important examples of radar remote sensing are (1) weather observation, which is a regular part of TV weather reporting as well as a major input to national weather prediction; (2) planetary observation, such as the mapping of Venus beneath its visually opaque clouds; (3) short–range below-ground probing; and (4) mapping of sea ice to route shipping in an efficient manner.

Air traffic control (ATC): Radar have been employed around the world to safely control air traffic in the vicinity of airports and en route from one airport to another as well as ground vehicular traffic and taxiing aircraft on the ground. The ASR also maps regions of the rain so thataircraft can be directed around them. There are also radars specifically dedicated to observing weather in the vicinity of airports, which are called Terminal Doppler Weather Radar, or TDWR.The Air Traffic Control Radar Beacon System widely used for the control of air traffic, although not radar, originated from military If and uses radar-like technology.

Law Enforcement and Highway Safety: The radar speed meter, familiar to many, is used by police for enforcing speed limits. Radar has been considered for making vehicles safer by warning of pending collision, actuating the air bag, or warning of obstructions or people behind avehicle or in the side blind zone. It is also employed for the detection of intruders.

Aircraft Safety and Navigation: The airborne weather-avoidance radar outlines regions of precipitation and dangerous wind shear to allow the pilot to avoid hazardous conditions. Low- flying military aircraft rely on terrain avoidance and terrain following radars to avoid colliding with obstructions or high terrain. Military aircraft employed ground-mapping radars to image a scene. The radio altimeter is also radar used to indicate the height of an aircraft above the terrain and as a part of self-contained guidance system over land.
Ship Safety: Radar is found on ship and boats for collision avoidance and to observe and to observe navigation buoys, especially when the visibility is poor. Similar shore-based radars are used for surveillance of harbors and river traffic.
Space: Vehicles of space have used radar for rendezvous and docking, and for landing on the moon. Large ground-based radars are used for the detection and tracking of satellites and other space objects. The field of radar astronomy using Earth-based systems helped in understanding the nature of meteors.

ADVANTAGES OF RADAR

It provides superior penetration capability through any type of weather condition and can be used in the day or night time.
Radar uses electromagnetic wave that does not require a medium like sonar so can be used in space and air.
Radar can be long range and the wave propagates at the speed of light rather than sound.
It is less susceptible to weather conditions compared with lasers. And be used at night unlike passive cameras.
It does not require target cooperation to emit any signals or emission.
Radar communication is faster and has less attenuation (loss of signals).

DISADVANTAGES OF RADAR

Radar can take up to 2 seconds to lock on.
Radar has wide beam spread (50 ft diameter over 200 ft range).
Large targets close to radar can saturate receiver.
Hand held modulation can falsify readings.
More interference sources.
The transceiver emits radiation that can be harmful to nearby organisms (including radar).
The Doppler radar emits microwave radiation. Scientists noticed that people who live or work in an environment that has devices that emit microwave radiation have morechances to die from a sickness.

EXPERIMENT NO.: 8

AIM: To Study The Different Types Of Antenna Used For Radar And Navigation.

INTRODUCTION:

An antenna used normally for radar applications different form the antenna used in communication system. Radar antenna with the shaped directive pattern can be scanned either mechanically or electronically.
In general an antenna is a transmission device, or transmission device .or transducer, between a guided wave and a free space wave or vice versa. The basic parameter of an antenna will be discussed in the brief in the following section.
The radar antenna acts as a transducer, which converts electrical pulses from the transmitter to the free space in the form of EM wave and receives the reflected EM signals from the target in free space and converts it in to electrical signals.

DIFFERENT TYPES OF RADAR ANTENNA.

Half wave antenna
Parabolic antenna
Yagi antenna
Antenna with cosecant squared pattern
Cassegrain antenna
Phase array antenna

HALF-WAVE ANTENNA:

Most radiatoremit (radiate) stronges radiation in one direction then in another. Sometimesit is used also as a reference antenna, as the isotropic radiator.
A half wave antenna a consist of two length of wire rod, or tubing, each ¼ wave length long at a certain frequency. It is the basic unit from which many complex antenna are constructed. For a dipole, the current is minimum at the center and minimum at the center and maximum at the ends.
Energy may also be fed to the half-wave antenna by dividing the antenna it its center and connecting the transmission line from the final transmitter output stage to the two center ends of the halved antenna. Since the antenna is now being fed at the center, this type of feed is known as the “center feed” or “current feed ” method.

YAGI ANTENNA:

The antenna used for however also in radar units. It employs parasitic elements to improve directivity and gain. A reflector behind the dipole and a director in front of dipole could be employed for achiving extra gain about 5.5 db. This arrangement is known as yagi aerial.

The director and the reflector in yagi antenna are usually welded to a conducting rod tube at their center.
The yagi antenna is shown in fig. has three directors. In general, the greater number of parasitic element used, the greater the gain. However, a greater number of such element cause the array to have a element cause the array to have a narrow ever frequency response as well as anarrower beam width. Therefore, proper adjustment of antenna is critical. The gain does not increase directly with the number of elements used. The spacing between the element are uniform. It is usually between 0.15 to 0.25

PARABOLIC ANTENNA:

The parabolic antenna is the form, which is most frequently used as the radar antenna. A feed horn as a radiation source is place at the focal point F is known as feed.
The parabolic antenna pattern has a conical form because of in accuracies in production more. This main lobe may vary in angular width form one or two degrees some radar and it up to15 to 20 degree in other radars.
The radiation pattern of parabolic antenna contains a major lobe, which is directed along the axis of propagation, and several small minor lobes. Very narrow beams are possible with these types of reflector. The main application has been for tracking-radar antenna.

ANTENNA WITH COSECANT SQUARED PATTEN:

Antennas with cosecant-squared pattern are special designed for air-surveillance radar units. These permit an a dapped distribution of the radiation the beam and causing a more ideal space scanning.
The lobe of the radiator is weaker to the margin to, therefore the margins of the reflector are hitted weaker as the center by the fact that the rays tumed up do not have a large power density. The maximum range in their higher elevation is limited with that.
The cosecant squared pattern is not restricted to parabolic reflectors. This can be realized also with other kind of antenna. An an antenna array with yagi antenna the pattern is achived by inter ference of direct wave with this at earth’s surface reflected quartos.

PHASED ARRAY ANTENNA:

A phase array antenna is composed of lots of radiating elements composed of lots of radiating elements each with a phase shifter. Beams are formed by shifter the phase of the signal emitted from each radiating element, to provide constructive/destructive interference so as to steer the beams is in the desired direction. In fig. both radiating elements are fed with the same phase. The signal is amplified by construction interference in main direction.

APPLICATION OF PHASE ARRAY ANTENNA:

Phase array antenna are used in surveillance radar because large antenna aperture are necessary for high performance long range radar, the array is move practical at lower frequencies than at higher frequencies.
They are frequently used in tracking radar.
They are also being used in satellite.
They are used in defuse radar.

CASSERGAIN ANTENNA:

The cassergain principal is the adaptive to the microwave region of an optical technique, which is widely used in telescope design to obtain high magnification with a physically short telescope. Its application the microwave reflector antenna allows the reduction in the aerial dimensions' of the antenna. It's also allow reducing the length of the transmission lines and flexibility in the design of feed system.
In fig. shows the arrangements of cassergain antenna. In this the primary feed radiator is positioned around an opening near the vertex of the parabolic instead of at focuser and a sub reflector is locoed in front of the parabola between the vertex and focus. The hyperbolic reflectorimages the feed so that it appears as a virtual image at the focal point of the parabola.

EXPERIMENT NO.: 9

AIM: To study Continuous wave and Frequency Modulated radar.

THEORY:

CW radar:

CW radar works on the principle of Doppler frequency shift due to motion of thetarget. In CW radar transmitter radiates the EM energy continuously unlike a pulse radar transmitter which transmits in pulse. A simple working of radar is explained below:

TRANSMITTER:
In CW radar transmitter radiates a continuous energy in the form of unmodulatedsinusoidal oscillation at freq ft. A common antenna issued in the block diagram which will transmit the energy as well as reflected energy.
According to the movement of the target the reflected energy frequency will vary. Ifthe target is closing at the received energy will have freq (ft+fd) and if the target is moving awaythen the received energy freq will have (ft-fd) in other words we can say that

DETECTOR:
The purpose of detector a mixer is to multiply the received signal (ft+fd) (ft-fd)frequency with the reference freq ft which is taken from the transmitter directly.

DOPPLER FILTER:
Detector will produce the difference in freq and further pass it onto the Doppler filterwhich is a low pass filter. It will stop the low freq from the transmitter. The upper freq cut off level is decided by the maximum accepted radial velocity of the target.
The o/p from the Doppler filter is further amplify up to that level, so that we canindicate over to the freq meter or some audio form.

APPLICATION:

CW radar is used as a speed measurement.
<u>FREQUENCY MODULATED CW RADAR:</u>
The transmitter in a CW radar is not modulated. therefore it can neither provide rangeof the target nor sense which particular cycle of oscillation is being received at an instant. This major drawback can be eliminated freq modulating the transmitted signal even if increase the bandwidth.

OPERATION:
A widely used technique to broden the spectrum of CW radar is to freq modulated carrier. The timing mark is the changing freq. the transit time is proportional to the difference infreq between the echo signal and the transmitted signal. By measuring freq of written signal thetime delay between Tx and Rx can be measure and therefore range can be determined.
The FMCW system measured the instantaneous difference between the Tx and Rx signal freq ft. these difference is directly proportional to the time delay which is takes the radar signal to reach the target and return from this the range can be found using the usual formula.
R=C*del t/2…(1)
The time delay can be found as follows.
Del t=T*del f/(f2-f1) (2)

Where,f2=max freq
F1=min freq
T=period of sweep from f1 to f2
Del f=the difference between Tx and Rx signalCombining eq (1) and (2) we get,
R=2CTdelf/(f2-f1)

FMCW radar generally used for radar altimeters in the aircraft. If it is considered that the relative velocity of the earth and the aircraft is not equal to zero than there will be Doppler freqshift and this freq shift provides a measure of relative velocity. The rate of change of freq id given by,

(df/dt)=2delf/(T/2)Where, delf=the range of freq
T=modulation period
he beat freq fb is corresponding to the range may be given by
(df/dt)(2R/c)=(2delf/(T/2)) (2R/c)Fb=8R*4delf/fm
Where, fm=min beat freq
Rmin=(c/8delf)
A portion of Tx signal acts as a reference signal required to produce the beat freq is amplified and limited to remove any amplitude fluctuation. The frequency of amplitude limited beat note isusually measured with a cycle counting frequency meter calibrated in distance.

APPLICATION:
One of the major application of the FMCW radar principle has been as an altimeter on boardaircraft to measure height above the ground.

EXPERIMENT NO.: 10

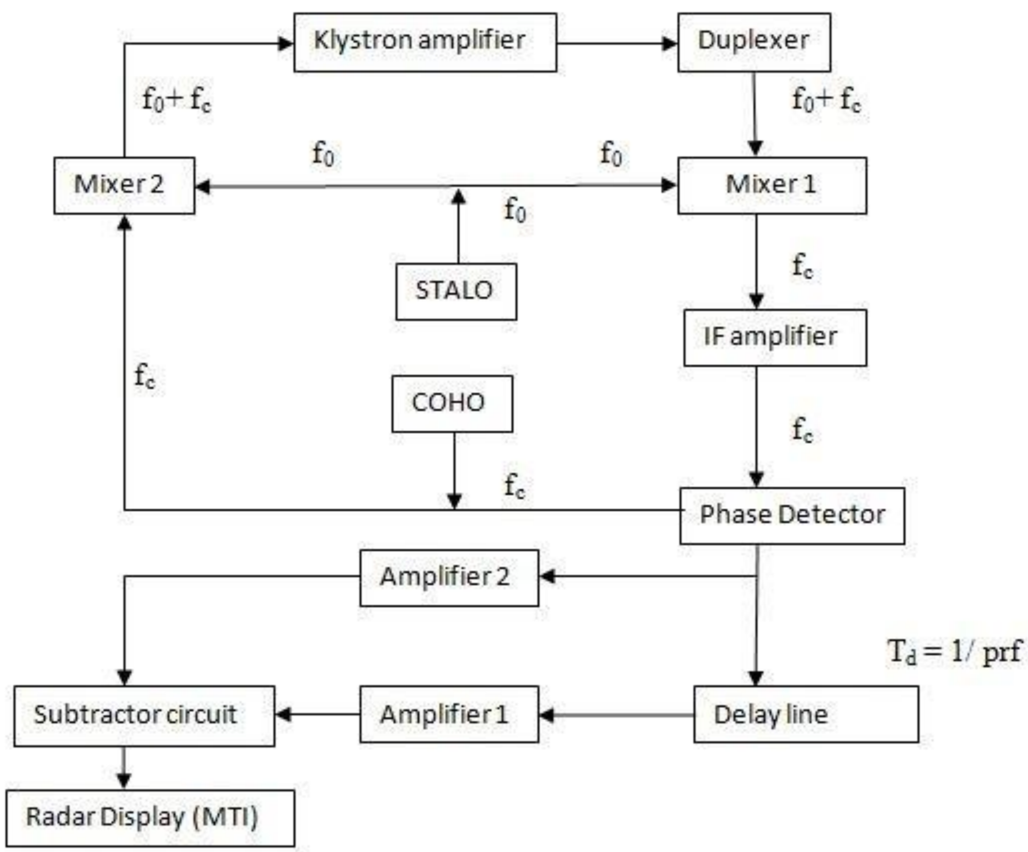
AIM: To Study MTI Radar.

THEORY:

This type of radar uses the principle of Doppler effect for its operation and it is using pulse radar system along with delay line techniques to measure target velocity and to distinguish moving targets from stationary targets.

Hence it is necessary to separate stationary object from moving target and it is achieved by moving target indicator radar operation principle.

Block Diagram of MTI Radar :



Block Diagram of MTI Radar

The receiver section includes mixer 1, IF amplifier, phase sensitive detector, delay line, two power amplifiers, substrator and the display device. The transmitted frequency is producedin mixer-2 which is the sum of the frequency generated by 'stalo', the stable local oscillator and'fc‘ generated by ‘coho’. The coherent oscillator. Both the mixer l &2 are identical and use same'stalo'. Because of this the phase relations existing in their inputs are preserved. The preservedphase relations makes it possible to detect the phase change due to only the Doppler shift, beingdetected by the phase sensitive detector. The ‘Coho’ generates the RF signal and also thereference signal for the phase detector. Because of this the transmitted and reference signals arelocked in phase and so, said to be coherent signals from ‘Coho’. The mixer 2 produces the signal with frequency fo + fc, which is modulated by the pulses generated by modulator and finally the pulse -modulated microwave signal, amplified by klystron tube is transmitted by antenna. If there is presence of any moving target,then the received signal frequency will be shifted by Doppler shift as explained in the principles, ofDoppler frequency. The shift be i fd, when the first pulse of transmission has taken place.Because the moving target continuously changes the position, the corresponding frequency shiftdue to each successive pulse, will be different. But for steady targets the reception correspondingto any of the transmitted pulse will be same in frequency & so in phase. So the best option todifferentiate the moving targets from steady targets is to compare the received signals, due tosuccessive pulses. If the difference between them is not zero the conclusion can be the presenceof moving target and the difference from subs tractor will be zero if the target is a steady target. '

The only problem with this simple concept is to make possible the subtraction between two successive receptions available at different times. Practically the second reception is after time delay of T = 1/ PRF, where PRF is the frequency of the signals. For comparison ‘between, say Is‘ and 2nd reception, the ls‘ received signal must reach the sub tractor block after delay of T
= l/PRF, then only the sub tractor gets two inputs’ one due to l st reception and other due to 2nd reception, at same time to compare them. So the delay line block is used. The amplifiers will amplify the signals before applying to sub tractor. The phase detector outputs for three consecutive pulses and the corresponding Subtract.

The basic principle of MTI radar is to compare a set of received echoes during previous sweep. For stationary target, there is no change in phase of the echo’s, and those are cancelled out, while moving target will give change of phase and are not cancelled.

Thus echo’s due to stationary target are removed from the display and moving targets aredetected very easily.

ADVANTAGES :

1. The small echoes coming from far distance target are detected in radar.
2. Time required for the analysis of moving target is greatly reduced due to removal ofstationary target echo.
3. Pilotless plane/slow moving target cannot mask the faster ones in the display.

CONCLUSION : Thus with the help of MTI radar it is possible to distinguish moving targetfrom stationary target.

EXPERIMENT NO.: 11

AIM: To Study of Hyperbolic Navigation.

THEORY:

Most recently used navigator systems are:

1. Loran(Long Range Navigation)   2. Decca Navigation

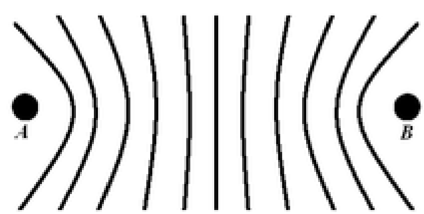
SystemLet's study each of them in detail.

1) LORAN:

LORAN (Long Range Navigation) is a terrestrial radio navigation system using low frequency radio transmitters in multiple deployment (multilateration) to determine the location and speed of the receiver. The most recent version of LORAN in use is LORAN-C, which operates in the low frequency portion of the electromagnetic spectrum from 90 to 110 Kilohertz.

LORAN use has been in steep decline, with the satellite based Global Positioning System (GPS) being the primary replacement. However, there have been attempts to enhance and re- popularize LORAN, mainly to serve as a backup and land-based alternative to GPS and other satellite navigation systems.

- **Principle**



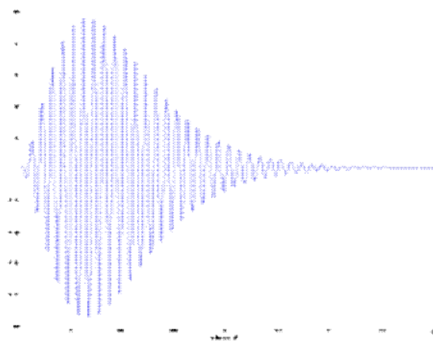
A crude diagram of the LORAN principle

The difference between the time of reception of synchronized signals from radio stations A and B is constant along each hyperbolic curve; when demarcated on a map, such curves are known as "TD lines". The navigational method provided by LORAN is based on measuring the time difference between the receipt of signals from a pair of radio transmitters. A given constant time difference between the signals from the two stations can be represented by a hyperbolic line of position (LOP).If the positions of the two synchronized stations are known, then the position of the receiver can be determined as being somewhere on a particular hyperbolic curve where the time difference between the received signals is constant. In ideal conditions, this is proportionally equivalent to the difference of the distances from the receiver to each of the two stations.

So a LORAN receiver which only receives two LORAN stations cannot fully fix its position - it only narrows it down to being somewhere on a curved line. Therefore the receiver must receive and calculate the time difference between a second pair of stations. This allows to be calculated a second hyperbolic line on which the receiver is located. Where these two lines cross is the location of the receiver.

In practice, one of the stations in the second pair also may be — and frequently is — in the first pair. This means signals must be received from at least three LORAN transmitters to pinpoint the receiver's location. By determining the intersection of the two hyperbolic curves identified by this method, a geographic fix can be determined.

- **LORAN method**



LORAN pulse

In the case of LORAN, one station remains constant in each application of the principle, the master, being paired up separately with two other slave, or secondary, stations. Given two secondary stations, the time difference (TD) between the master and first secondary identifies one curve, and the time difference between the master and second secondary identifies another curve, the intersections of which will determine a geographic point in relation to the position of the three stations. These curves are referred to as TD lines.

In practice, LORAN is implemented in integrated regional arrays, or chains, consisting of one master station and at least two (but often more) secondary (or slave) stations, with a uniform group repetition interval (GRI) defined in microseconds. The master station transmits a series of pulses, then pauses for that amount of time before transmitting the next set of pulses. The secondary stations receive this pulse signal from the master, then wait a preset amount of milliseconds, known as the secondary coding delay, to transmit a response signal. In a given chain, each secondary's coding delay is different, allowing for separate identification of each secondary's signal.

LORAN chains (GRIs): Every LORAN chain in the world uses a unique Group Repetition Interval, the number of which, when multiplied by ten, gives how many microseconds pass between pulses from a given station in the chain. (In practice, the delays in many, but not all, chains are multiples of 100 microseconds.) LORAN chains are often referred to by this designation (e.g., GRI 9960, thedesignation for the LORAN chain serving the Northeast United States)

Due to the nature of hyperbolic curves, a particular combination of a master and two slave stations can possibly result in a "grid" where the grid lines intersect at shallow angles. For ideal positional accuracy, it is desirable to operate on a navigational grid where the grid lines are closer to right angles (orthogonal) to each other. As the receiver travels through a chain, a certainselection of secondary's whose TD lines initially formed a near-orthogonal grid can become a grid that is significantly skewed. As a result, the selection of one or both secondary's should be changed so that the TD lines of the new combination are closer to right angles. To allow this, nearly all chains provide at least three, and as many as five, secondary's.

- **Timing and synchronization**

Each LORAN station is equipped with a suite of specialized equipment to generate the precisely timed signals used to modulate / drive the transmitting equipment. Up to three commercial cesium atomic clocks are used to generate 5 MHz and pulse per second (or 1 Hz) signals that are used by timing equipment to generate the various GRI-dependent drive signalsfor the transmitting equipment.

- **Transmitters and antennas**

LORAN-C transmitters operate at peak powers of 100 kilowatts to four megawatts, comparable to long wave broadcasting stations. Most LORAN-C transmitters use mast radiators insulated from ground with heights between 190 and 220 meters. The masts are inductively lengthened and fed by a loading coil. A well known-example of a station using such an antennais LORAN-C transmitter Rantum. Free-standing tower radiators in this height range are also used. LORAN-C transmitter Carolina Beach uses a free-standing antenna tower. Some LORAN- C transmitters with output powers of 1000 kW and higher used super tall mast radiators of around 412 meters in height (see below). Other high power LORAN-C stations, like LORAN-C transmitter George, used four T-antennas mounted on four guyed masts arranged in a square.

All LORAN-C antennas radiate an omni directional pattern. Unlike long wave broadcasting stations, LORAN-C stations cannot use backup antennas. The slightly different physical location of a backup antenna would produce Lines of Position different from those of the primary antenna.

Limitations

LORAN suffers from electronic effects of weather and the ionosphere effects of sunrise and sunset. The most accurate signal is the ground wave that follows the Earth's surface, ideally over seawater. At night the indirect sky wave, bent back to the surface by the ionosphere, is a problem as multiple signals may arrive via different paths (multipath interference). The ionosphere's reaction to sunrise and sunset accounts for the particular disturbance during those periods. Magnetic storms have serious effects as with any radio based system.

LORAN uses ground based transmitters that only cover certain regions. Coverage is quite good in North America, Europe, and the Pacific Rim.

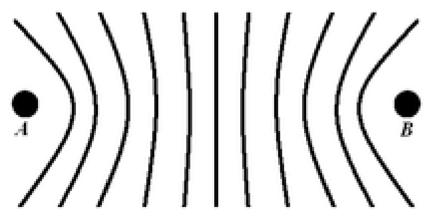
The absolute accuracy of LORAN-C varies from 0.10–0.25-nautical-mile (185–463 m).

Repeatable accuracy is much greater, typically from 60–300-foot (18–91 m).

2) Decca Navigator System

The Decca Navigator System was a low frequency hyperbolic navigation system (also known as multilateration) that was first deployed during World War II when the Allied forces needed a system which could be used to achieve accurate landings.

- **Principles of Operation**



The phase difference between the signals received from stations A (Master) and B (Slave) is constant along each hyperbolic curve. The foci of the hyperbola are at the transmitting stations, A and B. The Decca Navigator System consisted of a number of land-based stations organised into chains. Each chain consisted of a Master station and three (occasionally two) Slave stations, termed Red, Green and Purple. Ideally, the Slaves would be positioned at the vertices of an equilateral triangle with the Master at the centre. The baseline length, that is, the Master-Slave distance, was typically 60~120 nautical miles. Each station transmitted a continuous wave signal that, by comparing the phase difference of the signals from the Master and one of the Slaves, resulted in a set of hyperbolic lines of position called a pattern. As there were three Slaves there were three patterns, termed Red, Green and Purple. The patterns were drawn on nautical charts as a set of hyperbolic lines in the appropriate colour. Receivers identified which hyperbola they were on and a position could be plotted at the intersection of the hyperbola from different patterns, usually by using the pair with the angle of cut closest to orthogonal as possible.

When two stations transmit at the same phase-locked frequency, the difference in phase between the two signals is constant along a hyperbolic path. Of course, if two stations transmit on the same frequency, it is practically impossible for the receiver to separate them; so instead of all stations transmitting at the same frequency, each chain was allocated a nominal frequency, 1f, and each station in the chain transmitted at a harmonic of this base frequency, as follows:

Station	Harmonic	Frequency (kHz)
Master	6f	85.000
Purple Slave	5f	70.833
Red Slave	8f	113.333
Green Slave	9f	127.500

The frequencies given are those for Chain 5B, known as the English Chain, but all chainsused similar frequencies between 70 kHz and 129 kHz.

Decca receivers multiplied the signals received from the Master and each Slave by different values to arrive at a common frequency (least common multiple, LCM) for each Master/Slave pair, as follows:

Pattern	Slave Harmonic	Slave Multiplier	Master Harmonic	Master Multiplier	Common Frequency
Purple	5f	×6	6f	×5	30f
Red	8f	×3	6f	×4	24f
Green	9f	×2	6f	×3	18f

It was phase comparison at this common frequency that resulted in the hyperbolic lines ofposition. The interval between two adjacent hyperbolas on which the signals are in phase was called a lane. Since the wavelength of the common frequency was small compared with the distance between the Master and Slave stations there were many possible lines of position for a given phase difference, and so a unique position could not be arrived at by this method.

- **Lanes and Zones**

Early Decca receivers were fitted with three rotating Decometers that indicated the phase difference for each pattern. Each Decometer drove a second indicator that counted the number oflanes traversed – each 360 degrees of phase difference was one lane traversed. In this way, assuming the point of departure was known, a more or less distinct location could be identified.

The lanes were grouped into zones, with 18 green, 24 red, or 30 purple lanes in each zone. This meant that on the baseline (the straight line between the Master and its Slave) the zone width was the same for all three patterns of a given chain. Typical lane and zone widths on the baseline are shown in the table below (for chain 5B):

Lane or Zone	Width on Baseline
Purple lane	352.1 m
Red lane	440.1 m
Green lane	586.8 m
Zones (all patterns)	10563 m

The lanes were numbered 0 to 23 for red, 30 to 47 for green and 50 to 79 for purple. The zones were labelled A to J, repeating after J. A Decca position coordinate could thus be written: Red I 16.30; Green D 35.80. Later receivers incorporated a microprocessor and displayed a position in latitude and longitude.

- **Multipulse**

Multipulse provided an automatic method of lane and zone identification by using the same phase comparison techniques described above on lower frequency signals. The nominally continuous wave transmissions were in fact divided into a 20 second cycle, with each station in turn simultaneously transmitting all four Decca frequencies (5f, 6f, 8f and 9f) in a phase-coherent relationship for a brief period of 0.45 seconds each cycle. This transmission, known as Multipulse, allowed the receiver to extract the 1f frequency and so to identify which lane the receiver was in (to a resolution of a zone).

As well as transmitting the Decca frequencies of 5f, 6f, 8f and 9f, an 8.2f signal, known as Orange, was also transmitted. The beat frequency between the 8.0f (Red) and 8.2f (Orange) signals allowed a 0.2f signal to be derived and so resulted in a hyperbolic pattern in which one cycle (360°) of phase difference equates to 5 zones. Assuming that one's position was known to this accuracy, this gave an effectively unique position.

- **Range and Accuracy**

During daylight ranges of around 400 nautical miles (740 km) could be obtained, reducing at night to 200 to 250 nautical miles (460 km), depending on propagation conditions.

The accuracy depended on:

- Width of the lanes
- Angle of cut of the hyperbolic lines of position
- Instrumental errors
- Propagation errors (for example, Sky wave)

By day these errors could range from a few meters on the baseline up to a nautical mile at the edge of coverage. At night, sky wave errors were greater and on receivers without multipulse capabilities it was not unusual for the position to jump a lane, sometimes without the navigator knowing.

Although in the days of differential GPS this range and accuracy may appear poor, in its day the Decca system was one of the few, if not the only, position fixing system available to many mariners. Since the need for an accurate position is less when the vessel is further from land, the reduced accuracy at long ranges was not a great problem.