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Radar Problems and Solutions

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Abstract
RADAR can be defined as the electromagnetic system that senses, detects, and locates the objects that are present within the ambience. The word stands for Radio Detection and Ranging. The term was used in for the first time in the year 1940 by the US navy. During that time, the system was designed to transmit electromagnetic wave and detect the reflected signal. The operations attributed to the Radar were specifically for the detection and transmission of electromagnetic wave and reflected signals respectively. However, prior to 1940, the early development of the radar ensured the detection of an existing target and provision of its distance measurement from a specific location. In the Second World War, the Radar was used to give different notifications pertaining to the approach of a hostile aircraft. It also used for routing aircraft weapons to be used for the Second World War. In the modern times, the radar system has a lot of applications and uses. It can be used for the extraction of important information from reflected source. This paper examines a radar system, its problems and solutions. It also gives the outline of the principles used in the radar technology and applications such as air traffic control, climate and disaster monitoring.

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I. Introduction

Radar is a detection system that determines the angle, range, and velocity of objects through the use of radio waves. In most of the cases, it used by peopled to detect terrain, weather formations, ships, aircraft, motor vehicles, and guide missiles. It usually consists of the transmitter, transmitting and receiving antenna. The other component is the processor used for the determination of the properties of the objects. It functions by allowing the transmission of the radio waves from the transmitter to reflect off from the object. Thereafter, the reflected radio waves return to the receiver before giving information pertaining to the object's speed and location. Until now, there is no system in the modern electronic world that has the ability of replacing the radar. This is because the radar has proved to be accurate and reliable in sensing and detecting object (Bhatta & GeethaPriya, 2016).

By observing the atmospheric conditions, RADAR has the ability to utilize its vision in sensing objects. For example, it has the capacity of detecting the environmental conditions which tend to be impervious to the vision of the human beings. In this case, the system is considered as a sensory organ added to the human eye for detecting and locating objects that are beyond the reach the naked eyes. The usefulness of the device is usually observed during the collection of data attributed to rain, smoke, fog, darkness, and fog. To determine the distance of an object or person approaching or going away from the observer, the device can be engaged for the realization of accurate and reliable measurements. In most of scientific applications, RADAR functions by either radiating the radio wave or microwave signals before receiving back the designated reflected signal. Some of the radiated signals pertaining to RADAR include rectangular shaped and narrow train pulses.

In modern times, there are a lot of significances and uses of RADAR. The high-tech RADAR is used in aircraft anti-collision systems to prevent accidents from occurring. It is considered as technique of avoiding the collision of aircrafts. Globally, RADAR has been the most useful system in the world that nations depend on the surveillance results. This has made the system to become more popular than other devices and technologies. The deployment of RADARs is always done on the sea, ground, air, and space for the detection purposes. They are used for safety purposes in air traffic control. In airports, they are used for guiding the airplanes to land. This is mostly in adverse weather conditions. High resolution radar systems are employed for this purpose. With ground control approach systems, they ensure the safe landing of aircrafts. Weather avoidance and ground mapping radar systems enable the aircraft to navigate properly in all weather conditions. In addition, they offer safety against aircraft collision (Lidar, 2019).

Objectives of the Research

The research study on RADAR was conducted for several reasons. The following are some of the objectives attributed to the project:

1. To enable the understanding of how radars works and their concepts
2. To understand the terminologies and equations used in Radar Systems
3. To know how to apply formulas and equations to solve problems attributed to radar systems
4. To identify the Problems and challenges affecting the performance of radar systems

II. Literature Review

(i).Basic Radar Concepts

For a very long time, the general principles of radar systems have been known. However, the presence of electronic discoveries has led to the development of powerful and useful radar systems. For example, the Second World War offered a strong incentive for the development of practical radar. As soon as the war began, early versions of the device were in use. Technology attributed to the radar from that time has been improving. For instance, the modern radar systems are smaller, better, and more efficient than the previous devices.

A radar system operates on the electronic principle similar to that of sound-wave reflection. A person shouting in the direction of a sound reflecting object will hear an echo. The knowledge of the speed of the sound in the air would assist in the estimation of the distance and direction of the reflecting object. The time needed for echo to return can be converted to the required distance between the person and object. The principle behind the reflected echo is similar to that of a radar system (Chapman & Hall, 2000).. The system also uses the electromagnetic energy pulses similar to a person shouting in the direction of a sound reflecting object. A very small percentage of the energy undergoes the reflection process before returning to the radar system. The returned energy is called echo. In this case, a radar system utilizes the echo in determining the direction and distance of the reflecting object.

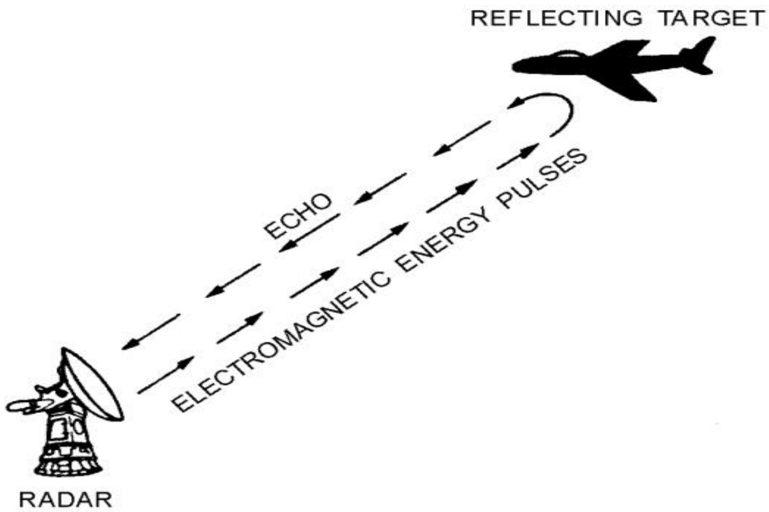


Figure 1 shows the depiction of the echo principle attributed to the radar system

A radar system is also similar to a telescope. Both of them offer a limited field of view. In this case, to define the accurate positions of the objects which have been detected, it will require reference co-ordinate systems. The description made when a telescope is used in locating the position of the object would involve the use of prominent features of the landscape. When a radar system is used, there would be need of a precise reference system. For example, to define the angular measurement of a surface, clockwise direction style would used in reference to the North direction. Two planes namely; horizontal and vertical are used to describe the location of an object from the radar position (Chapman & Hall, 2000). Due to the fact that a radar system operates in manner similar to a sound wave being reflected, it uses electromagnetic energy to detect and locate objects. The operation process is based on the following guidelines:

1. The transmission of electromagnetic waves from the radar is through the antenna in all the directions.
2. Targets also referred as reflecting objects usually intercept the radiated waves before reflecting them back in all directions.
3. The processing and amplification of the received signal is usually performed in digital form. The reception output component of the system decides on how to determine the presence of the reflected signal from the

target. The presence of the target enables the identification of the location and other information attributed to the object.

Elementary System

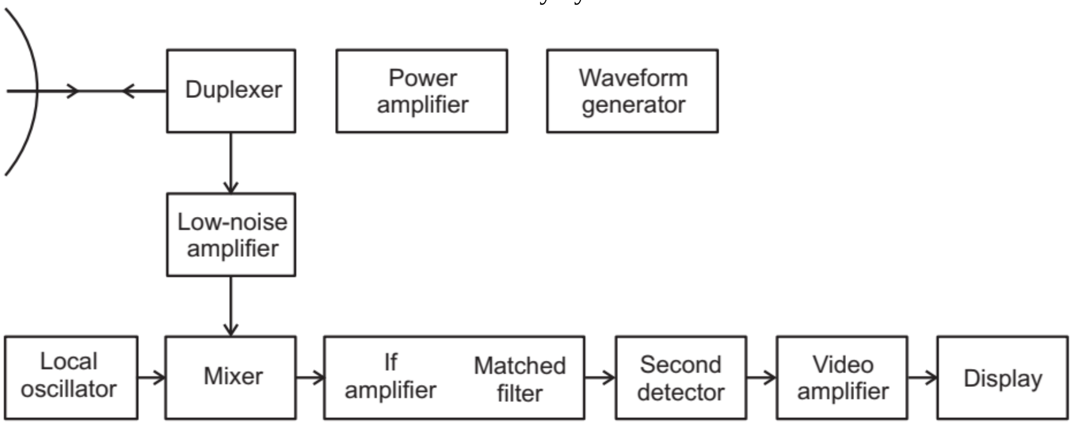


Figure 2 shows the block diagram representation of a radar system

The function of the power amplifier is to act as a transmitter that produces the appropriate signal needed for radiation. It comes in different forms. For instance, it can either be an average or high power amplifier. In most cases, the production of short pulse signal is done by the radar. The presence of the duplexer permits and facilitates the use of a single antenna in transmitting and receiving of signals. It is also used for protecting the receiver from being burn out. The purpose of the antenna is to act as transceiver system for transmitting the electromagnetic radiation in the space. It also performs the function of receiving back the reflected signal. The reason for the selection and use of antenna is attributed to its ability to collect weak echoed signal. It has also the ability of providing angle resolutions because of the spatial filter.

The Radar system consists of a heterodyne receiver system that functions based on the number of steps for processing signals after detecting the target object. The first step can either be low noise amplification or mixing stage. The receiver input that comprises of low noise amplification would be more sensitive to the detection of the signal. For the provision of great dynamic range that is not vulnerable to electronic interferences, the mixer stage or step would have to be deployed as an input (Chapman & Hall, 2000).

The purpose of the receiver would be to amplify the reflected signal to a level where easy analysis can be performed. To remove the clutter from the reflected signals, a receiver input consisting of high dynamic range is used. For the purpose of converting the received RF signal to intermediate frequency signal abbreviated as IF, there would be need to use both the mixer and local oscillator. A radar system used for the surveillance of air usually comprises of bandwidth of 1 MHZ with either the center frequency ranging from 30 MHz and 60 MHz. The design for its amplifier is similar to a matched filter that processes the signal. In this case, it has the ability of separating the desired signed from other signals. In the block diagrammatic representation of the radar system, the function of the second detector is to receive the pulse modulated signal before the video amplifier amplifies it. The display of the signal is performed by the cathode ray tube (CRT).

The most intriguing aspect of system is attributed to the fact that the radar uncovers the range of the target depending on the time taken by the radiated signal to move to the signal and back to the system with great efficiency and accuracy.

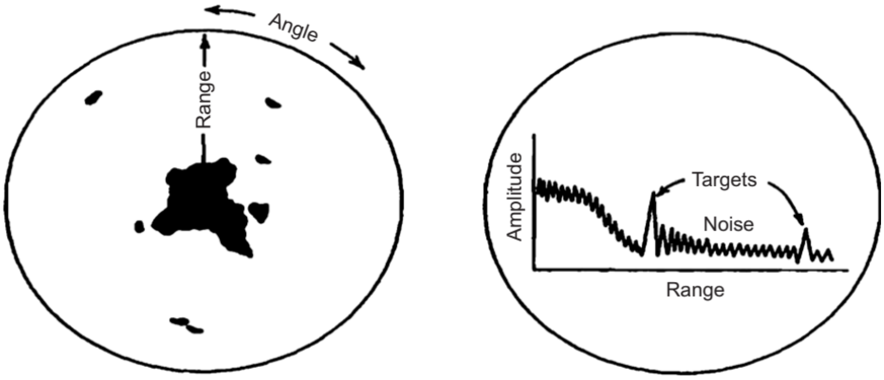


Figure 3 shows the depiction of intensity modulation from the radar system. The second circle illustrates the deflection modulation from the radar system.

The equation for the radar system is climacteric. In this case, it is influenced by factors such as the climate. The equation can be used to describe the features of the provided radar system.

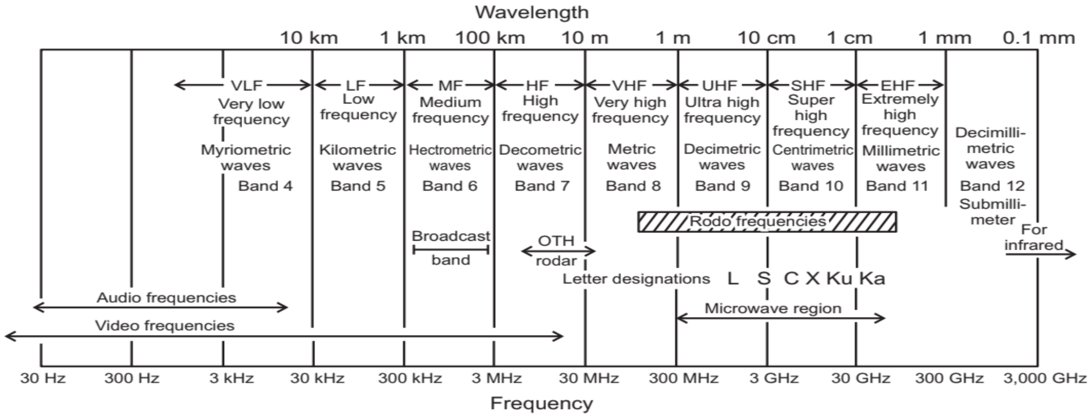


Figure 4 shows the range frequency and electromagnetic spectrum attributed to the radar system.

(ii). Types of Radar System

Primary Radar System

It is also considered as surveillance radar consisting of a transmitter component that radiates signals in all direction. During the process, there is a minimal percentage of the reflected energy signal from the target to the receiver. This type of receiver comes with several benefits. For instance, it can operate independently without the need of using other devices to boost the incoming and outgoing signal. In this case, it can be deployed to be used in various operations such as military purposes for the detection of ships and aircrafts. Primary radar has also some drawbacks. It needs the radiation of high power signal to boost the capability of the signal from returning from the target. Due to the fact that there is minimum percentage of the signal being reflected back to receiver, there are high chances of the occurrence of disruption of the signals. Furthermore, it is difficult for primary radar to provide accurate information concerning the position and distance of the object from it. Figure 1 gives a summary of the information depicted by the primary radar.

Band Designation	*Frequency Range*	*Usage*
HF	3-30 MHz	OTH surveillance
VHF	30-300 MHz	Very-long-range surveillance
UHF	300-1,000 MHz	Very-long-range surveillance
L	1-2 GHz	Long-range surveillance En route traffic control
S	2-4 GHz	Moderate-range surveillance Terminal traffic control Long-range weather
C	4-8 GHz	Long-range Tracking Airborne weather detection
X	8-12 GHz	Short Range tracking Missile guidance Mapping, marine RADAR Airborne Intercept
K_a	12-18 GHz	High Resolution Mapping Satellite altimetry
K	18-24 GHz	Little use (water Vapour)
K_a	27-40 GHz	Very-High-Resolution Mapping Airport surveillance
Millimeter	40-100 + GHz	Experimental

Figure 5 gives a summary of the information depicted by the primary radar.

(ii). Secondary Radar

Secondary radar is also referred as Secondary Surveillance Radar (SSR). It is mostly used for the identification of various targets from unlikely positions. It operates with help of an answering signal system. It is also equipped with a transponder device. The function of the transponder is to receive the signal. The Radar is used to radiate the signal from the transponder. During the process, the target retrieves the signal before sending it in form of code. The obtained information gives the description about the altitude, status, location, and other useful details pertaining to the target or object.

The advantage of secondary over the primary radar is that the signal being received is strong and cannot be attenuated. This enables the base station to get accurate and reliable information about the targeted ships and aircraft. Secondary radar also comes with disadvantages. For instance, aircrafts or ships without the operating transponder make it difficult for the transmission of accurate and reliable information to the radar (Lidar, 2019).

Classification of Radars

Radar are classified in various ways depending on how their features and functions. Some of the classifications are as follows:

(i). General pulse radars.

They operate by radiating the repetitive rectangular pulses. The rectangular pulses are usually in short sizes. They can either be radars with pulse Doppler or with moving target indication. To locate the target, they both use Doppler frequency shift that identifies the received signal.

(ii). Maximum Range Resolution Radars

For the purpose of obtaining high resolution range, angular size, and Doppler velocity, maximum range resolution radar use short pulses. Due to this, they can easily identify and detect the presence of a stationary intruder. They are mostly used by military, air force, and navy.

(iii). Pulse Compression Radar

These radar systems are similar to high range resolution radar systems. They function by use of phase or frequency modulation that has high energy long pulse. The main reason is to get the required resolution. Other types of radars include:

(i). Airport Surveillance Radar

They are capable tracking and detecting aircrafts that are beyond certain altitudes. Examples of such radar systems include ASR-9 that operates unattended. It does not need any maintenance personnel at the site of the radar system.

(ii). Doppler Weather Radar

This type of radar is used for the provision of information attributed to the extent and intensity of the rain and other types of precipitation. The radial velocity of the precipitation being blown by the wind is measured during the process. The measurement of the radial velocity of the wind would assist in identifying the rotating weather patterns of the area.

III. Terminologies Attributed to Radar

Range

The possibility of measuring the distance of the object from the system is influenced by the electromagnetic energy. The measurement is through the use of straight line and speed. However, it ranges due to several factors such as weather and atmospheric conditions. At approximately the speed made by light, the electromagnetic energy makes a travel in the air. The speed of light is 186,00 statute mile/s. The expression for the timing of a radar system is in seconds. For the purpose of relating the radar timing in terms of distance travelled by the energy of the system, am assumption is made that it travels at a speed of 984 feet/ms. With this in mind that a nautical mile is exactly 60809 feet, the time needed for the radar system to make a distance measuring one nautical mile can be obtained from the following calculations:

Time needed for the energy to make a distance of one nautical mile = Distance / Speed

Time $=\frac{6080.0}{984.0\ feet\ per\ Microsecond}$=6.180 microseconds

The same solution could also be obtained when yards are used in place of feet. The following calculation shows how the 6080 foot is converted to get 2027 Yards. In the calculation, the energy speed is also converted to Yards per microsecond from feet.

The time needed for the energy to make a distance of one nautical mile $=\frac{2027\ Yards}{328\ Yards/ms}$ = Approximately 6.2

The transmission range of the systems range from radar to radar. For example, the transmission for pulse-type radar is usually in short bursts of electromagnetic energy. To determine the target range, the elapsed time attributed to when the pulse makes a travel and returns from the target is taken into consideration. Due to the fact that there is the involvement of the two-way travel, the total elapse time between the commencement of the pulse from the antenna to when it returns again back to the same position will be obtained by use of the following formula:

Total elapse time = 6.1 8 * 2 = 12.360 microseconds

The 12.36 microseconds is usually referred as the Radar mile or Nautical Radar Mile.

To determine the range in nautical mile of the object corresponding to the radar, the elapse time would be obtained before dividing the value by the 12.36 according to the depicted equation shown below:

Range $=\frac{Elapsed\ Time}{12.36\ ms/nm}$

For instance, if the elapsed for a given object has been found to be 62 microseconds when the measurement pertaining to the distance is 5 miles, the following formula would be used:

Range =$\frac{Elapsed\ Time}{12.360\ ms/nm}$

By substituting the values, the equation would be as follows:

Range =$\frac{62\ ms}{12.360\ ms/nm}$

Range = 4.9 nm

Minimum Range

To obtain the minimum range between the radar system and object, various concepts need to be applied to enable realization of accurate and reliable results. The radar system uses the microwave switching principle that allows the duplexer to switch the antenna between the receiver and transmitter to enable the use of only one sensor. In microwave system, the switching mechanism is essential for preventing the high pulses being transmitted by the transmitter from damaging the receiver when energy enters the receiver (Richardson, 2012). For the operation of the radar system, the timing of the switching technique is essential. This means that the minimum range capacity of the device system would be influenced by the timing. Therefore, factors such as the recovery time and pulse width need to be taken into considerations (Bhatta & GeethaPriya, 2016).

The timing action for a radar system for the pulse being transmitted should only cater for the connection of the transmitter to the position of the antenna. Once the transmission of the pulse has been facilitated, there should be reconnection of the receiver to the position of the antenna. The alignment of the antenna and transmitter through the duplexer is due to the leading edge of the pulse being transmitted. The process occurs instantaneously. The duplexer is lined up to the antenna with receiver because of the influence of the edge of the trail of the pulse at the end of the pulse being transmitted. Unlike the first action, this second process is not instant. There is an elapse of short duration in terms of seconds at this stage. The measure for the amount of time taken by the receiver becomes limited to account for the pulse being reflected would be equivalent to the width of the pulse being added to the time for recovery.

Another important point to consider during the calculation process is that there would be no detection of the pulses being reflected from close objects or targets that make returns before the connection of the receiver to the position of the antenna. The following formula would be used for the calculation of the minimum range measured in yards.

Minimum Range =$\frac{Pulse\ Width+Recovery\ Time}{2}$ * 328.0 yards

It can also be obtained by use of the following formula

Minimum Range = (Recovery Time + Pulse Width) * 164

To determine the minimum range for a given radar system that has a pulse width that takes a duration of 25 microseconds and recovery time measured in microseconds as 0.1 ms, it would be obtained as follows:

Minimum Range = (0.1 + 25) * 164 Yards = 4116

Maximum Range

Several factors such as peak power section of the pulse being transmitted, pulse repetition rate, pulse repletion frequency, carrier frequency, and the sensitivity of the reciever influence the maximum range of the radar system. The peak power section of the pulse would affect the maximum range that a given a pulse can move to the targeted object and still be able to return as an echo that can be used. This echo would be considered as the signal that has smallest size that can be detected by a receiver of the radar system (Richardson, 2012).

IV. **Factors and Problems Affecting the Performance of Radar System**

To judge the performance of radar systems, the following factors are used:

1. The maximum distance at which the radar sees the target of a specified size
2. The accuracy level of the measurement pertaining to the target. This is in terms of the angle and range
3. The radar's ability to distinguish a target from another one.
4. The ability of the radar system to detect the desired target echo in the presence of large clutter echoes that interfere with signals from other transmitters.
5. The radar's ability to identify and recognize the type of target.
6. The radar's reliability and maintainability.

There are several elements that also influence the efficiency and performance of the radar systems. The following are the basic factors:

(i). The Power of the Transmitter and Size of the Antenna

The power of the transmitter and size of the antenna affect the maximum range of the radar system. The larger the transmission power and antenna size the greater the performance of the radar system. However, there are practical limits to each (Wicks & Braham, 2006).

(ii). The Receiver's Noise

The sensitivity of the receiver to perform according to its specifications is influenced by the unavoidable noise appearing as its input. For example, the frequencies attributed to the microwave radar can go undetected because of the noise being generated by the device itself. To solve this problem, during design and development of an efficient radar system, a transistor amplifier is placed inside the receiver. However, low noise can also be obtained through the use of sophisticated devices. The purpose of having an efficient receiver is to enhance the desired signals and minimize the noise and other unwanted signals that can interfere with the process of detection. The design stage of the radar system should attempt to maximize its ability to detect even weak signals through the incorporation of filters (Bhatta & GeethaPriya, 2016).

(iii). The Target Size

The target's size seen by the radar system sometimes does not correspond to the physical size of the object. The radar's cross section is defined as the size measurement of the target. There is high possibility for two targets with similar physical cross-section areas to have different results after being measured by the system. The difference is usually caused by the surface or terrain of the object. For example, a flat plate will produce a radar size of 1000 square meters while a cone-sphere surface 950 square meters (Wicks & Braham, 2006).

(iv). Clutter

Echoes emanating from the sea, land, birds, and rain become nuisance to the radar systems detecting aircraft, missiles, and ships. The echoes produced by clutter can reduce the performance level of the radar system. Therefore, the design and development phases of the radar system should be devoted in reducing the effects of clutter without necessary minimizing the echoes coming from the desired targets (Bhatta & GeethaPriya, 2016).

To distinguish the moving objects from the clutter being emanated from stationary objects, Doppler frequency is implemented in the design of the radar system. This would reduce problems arising from the detection of the targets during the rainy weather conditions. Also, the implementation of circular polarization would enhance the detection of the target and objects in rain. With the use of the technology in radar system, it will cause the rotation of the electric field at the frequency of the device. The radar system would distinguish the rain from the aircraft due to the fact that there would be reflection of the electromagnetic energy (Lidar, 2019).

V. Solutions to the problems and Recommendations for Radar Efficiency

The rapid recent development in waveform generation and signal processing has resulted to opportunities attributed to the installation of new radar system. Among the identified methods of signal processing, there are various problems that remain unaddressed. For instance, challenges pertaining to the ability of the radar to detect signal and noise (Besson & Scharf, 2016). The main purpose of some of the developed radars is to detect against a background of noise. An example is airborne radar designed and developed for detecting a target that moves on the ground. Figure 1 depicts the block diagram of the problem.

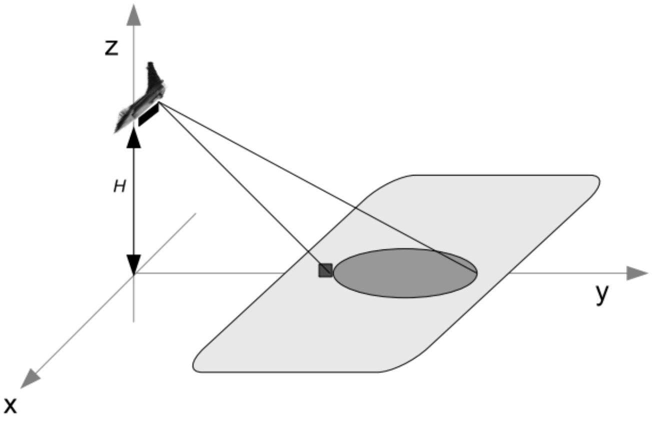


Figure 6 shows the block diagram representation of determining the solution

The radar will function by first sending a series of pulses before receiving the different echoes. The echoes main consist of the noise coming from the target and clutter. Within each pulse, there would be decomposition of the received signal in range cells corresponding to the echoes at the specified distance of the radar system.

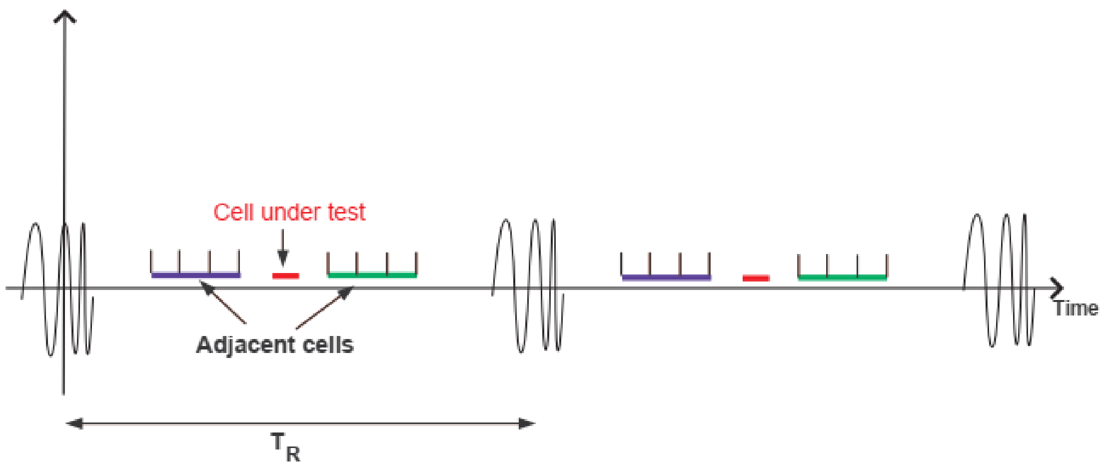


Figure 7 shows the decomposition of the received signal in range cells corresponding to the echoes at the specified distance of the radar system.

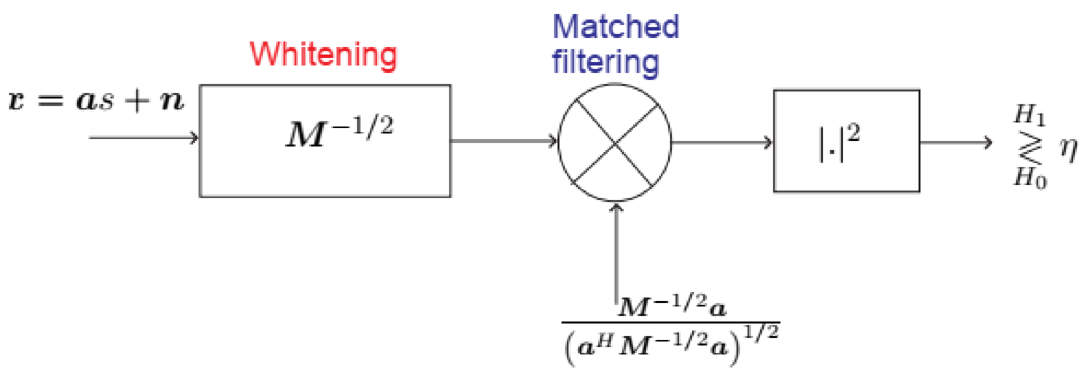
(i). Doppler and Propagation Problems

When the location of the target is at a given direction of the arrival of the signal, the emitted waveform from the target would undergo two effects:

1. Doppler Effect caused by the phase shift between two pulses.
2. Propagation effect caused by a phase shift between two antennas.

The basic problem attributed to the two effects is detection performed in a range cell in the presence of a target of unknown signature where there is noise (Besson & Scharf, 2016).

To solve the problem, there is the need to know the noise con-variance matrix. Thereafter, a formulation for the optimal detection would be depicted as follows by the diagram:



If the value of M is unknown, it would be necessary to infer it from the range of cells adjacent to the system. However, an assumption would need to be made that the noise within adjacent cells has similar statistical properties as the incoming noise from the radar. The Doppler Effect can be used to estimate the velocity of the target. It also influences the performance of the stationary and moving objects. Doppler Effect is also the change in frequency of the signal being received when there is movement between the receiver and transmitter. The reflected signal from the target has different frequency from that of the carrier. The frequency shift could either be positive or negative depending on the direction and location of the target.

(ii). Radar Coverage Problems in Complex Terrains and Coastal Regions

Regions of complex terrain present a problem for radar installed for the observation of the weather patterns of the environment. The two problems attributed to the complex terrain and coastal regions are beam overshoot and beam blockage. When these factors are present, then beam of the scanning radar becomes partially or completely block in various directions depending on its location. To solve or eliminate the problem, there would be need to place the radar at a high elevation or on the top of the mountain. However, this may cause the beam produced by the radar to overshoot lower level. In this case, it would be easy to underestimate the intensity of the precipitation. Also, the precipitation could go undetected.

Complex terrain could also pose observational problems in coastal regions due to the presence of large mass of water that influences the atmospheric conditions. In the same coastal region, any variation of pressure, temperature, and moisture could also affect the propagation of the radar signal. This would derail the radar's ability in detecting and quantifying precipitation. Therefore, the deployment of radar along a coastal would be a compromise between selecting the offshore level coverage and preventing negative influence of the atmospheric conditions that can affect the propagation of the radar signal. Low-level coverage would be essential for radar installed for weather purpose. Therefore, there would be need for the installation of the advanced detection radar.

To characterize the beam of the radar, knowledge about the atmospheric properties such as humidity, pressure, and temperature need to be put in place. An assumption that the propagation of the beam occurs under standard atmospheric conditions would enable the calculation of potential interactions between it and the surrounding terrain. To accomplish, two factors need to taken into consideration; the spreading of the radar's beam as it propagates away from it and the non-uniform distribution of the power of the radar's signal.

The complete blockage of the radar's beam by features on the terrain would usually occur at a given distance and direction. This would prevent the detection of the echoes and signals reflected from the target. Some of these features include mountains and hills.

(iii). Wave Clutter

Wave clutter is considered as a problem that allows the dynamic surfaces to reflect the energy of the radar. When a wave clutter occurs, it creates false targets. It also prevents te detection of the target causing the display of the swamping radar. Whenever there is change in the area being sampled, it produces unreliable and inaccurate results. Figure 6 illustrates a wave clutter.

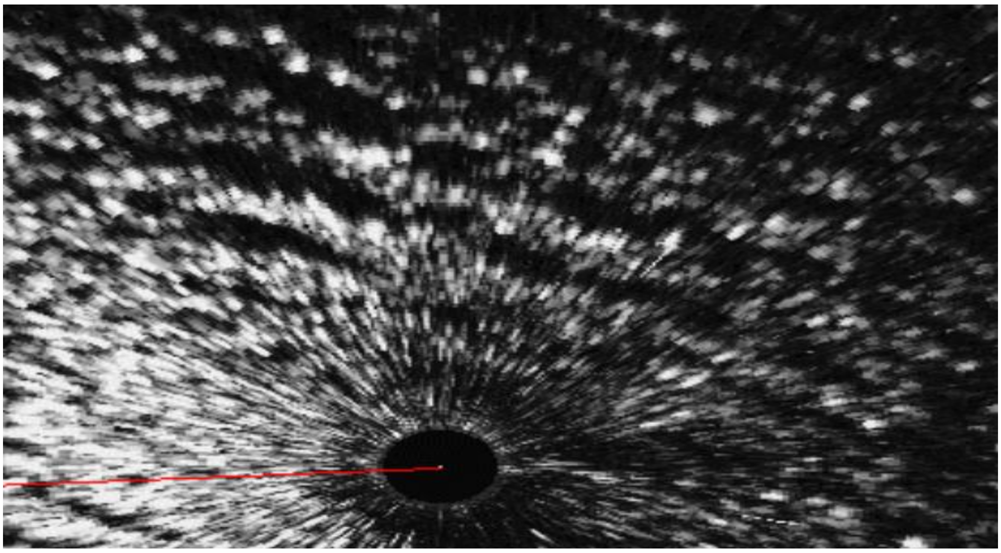


Figure 8 illustrates a wave clutter

There are various ways of solving problems attributed to wave clutter. Firstly, it can be mitigated by reducing the size of the ground area being illuminated by the antenna. Secondly, it can be minimized by reducing the duration of the pulse. In addition, an area affected by the complexity of the terrain, various strategies can be performed. For example, techniques such as Moving Target Indicator (MIT) can be implemented. Apart from this, installation of double cancellers can be used to eliminate the echo problem abbreviated to the clutter signal and wave. This is due to the fact that the signal is equivalent to the shift of the zero Doppler frequency.

The movement of the antenna beam away from the ground produces less clutter power.

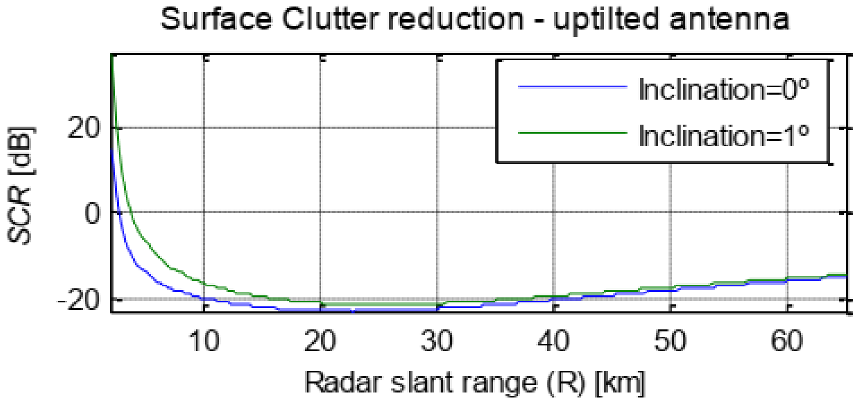


Figure 9 shows the reduction of clutter power when antenna beam is moved away from the ground

The figure shows that when the antenna is up-tilted, it would cause the deviation of the beam from the ground causing a small portion of the area to be illuminated by the radiation from the antenna. Due to the reduction of the area, there would be minimum power coming from the clutter producing high values of SCR. The improvement is critical and essential for small distances. The surface clutter scenario attributed to the wave can be minimized when the bandwidth of the antenna is reduced. When this is done, it also leads to the reduction of the power coming from the wave clutter. This would improve the SCR. This can also be explained by figure 8. Other methods include fencing the radar and use of static clutter maps. Fencing of the radar would assist in absorbing the energy being transmitted through the sections of the beam. It also permit the consistent detection of the objects located in the upper sections of the beam. The material used for fencing the radar can be in form of metal or vegetation. Figure 8 shows an illustration depicting the fencing of the radar to minimize wave clutter.

Figure 10 shows an illustration depicting the fencing of the radar to minimize wave clutter.

(iv). Atmospheric Effects

Types of precipitation and rain can cause the echo signals to affect the performance of a radar system. For instance, the reduction of the atmospheric density of the earth with an increase in altitude can cause the bending of the radar waves through the propagation made through the atmosphere. As a result, it influences the increase in the range of detection at low angles.

The atmosphere has the capacity to lead to the formation of ducts that are capable of trapping and guiding the energy of the radar around the earth's curvature. In addition, it can permit detection of targets beyond the normal horizon.

(v). Interference

Signals emanated from the nearby transmitters and radars could be powerful to gain access to the receiver of the radar before producing spurious results and responses. Interference sometimes becomes a nuisance to the operators. It is difficult for well trained and qualified operators to be deceived by the results attributed to the process affected by interference. In systems that detect and track objects, there are various mechanism used for the removal of interferences pulses that gain access to the radar system.

(vi). Electronic Countermeasures

The presence of electronic countermeasures degrades the quality of the radar system. The electronic countermeasure device could consist of noise jamming signal that gains access to the receiver through the antenna. Thereafter, it increases the noise level before generating a false target that brings confusion. Some of the countermeasures against the effectiveness of radar system include the generation of false target, chaff, and decoys. To curb against electronic countermeasures, there various ways employed by radar engineers to enable the system performs according to its level of ability (Bhatta & GeethaPriya, 2016).

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