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MODELLING HIGH RESOLUTION RADAR SYSTEM MODELING WITH MATLAB/SIMULINK

Okhaifoh Joseph, Umayah Erhiega Nana, Akpado Kenneth and James Agajo
[1,,2]Federal University of Petroleum Resources Effurun Delta State
[3]Nnamdi Azikiwe University Awka Anambra State
[4]Dept. of Electrical and Electronics Engineering Federal Polytechnic, Auchi, Edo state Nigeria

Email: agajojul@yahoo.com

ABSTRACT

This project is channelled towards using MATLAB/SIMULINK in modeling a high resolution radar system. Due to its vast importance over the past decade and recent time, this project work did not deny the fact that minimizing the inaccuracy involved during its operation over the past decade is needed. The project also covers the development, which high resolution radar system has undergone and the mode of operation with the factors that have affected its effective performance. At the end this study, it would be appreciated by all that modelling a high resolution radar system using MATLAB/SIMULINK is the only way to reduce the complexity in radar system

design and data analysis.

Keyword: Radar, tracking, antenna, transmitter, receiver, target.

INTRODUCTION

Radar is an acronym formed from radar detection and ranging. Radar system has been used extensively over the past decades for a variety of applications and in a multitude of configurations. One of the relatively more modern implementations, although its origin is traced back to the end of the 1950s is imaging radar, in particular, synthetic aperture radar (SAR). The synthetic aperture radar imaging is used for measurement and modelling the properties of different scattered targets. These imaging radars are also used to obtain visual information about the environment of interest, often with the goal of discerning particular object concealed either intentionally or unintentionally in the background. Besides, these radars can be geared toward certain scenario such as discovery of buried mines and unexploded ordinance for assessment of polar ice cap dynamics, or as surveillance and target tracking tool in renaissance operations. [1] In all scenarios, however radar engineers wishing to improve the resolution of resultant imagery cannot evade the underlying principle of inverse relationship between radar signals bandwidth and a minimum imaged feature dimension in range coordinate. Thus, to properly distinguish between target components of particular size, one needs to select the bandwidth of imaging radar signal accommodating resolution that corresponds to that size. In recent years, the interest of sub-meter resolution has gone. When it is desired to not only detect, but also identify the target as belonging to a certain category. High resolution of obtained radar images is of much significance. Since designing high resolution radar often amounted in building ultra wide band (UWB) radar, several approaches to implementing UWB signals were used. In the somewhat extreme case of using synthetic aperture radar (SAR) to monitor single person targets one cannot avoid implementing ultra wide band (UWB) waveform. Conventionally, ultra wide band (UWB) radars were based on generation and coherent reception; this approach does, indeed, provide for high range resolution if pulse duration is small enough. However, it also has certain disadvantages such as low spectral efficiency and ease of signal repeatability (once the signal has been intercepted by an adversary), which can make these imaging systems susceptible to certain types of electronic counter measures.[2]

Other exciting alternatives to pulse based radars include linear frequency modulation and stepped frequency radars. These types of radar, in particular the linear frequency modulation (LFM)-based, are currently been used and explored for wideband applications, which may include dual use (radar and communication system) and anti-jamming characteristics. More flexibility in spectrum allocation and in handling the instantaneous frequency and phase of radar signal translates into better opportunities for combining electronic counter measures (ECM) and expanding radar functionalities. The main disadvantage of those implementations is increased complexity of resultant systems if ultra wide band (UWB) waveform generation and reception are desired. A class of ultra wide band (UWB) true noise and pseudo-noise radars, which can be pulse based or continuous wave, is being investigated by several researchers, who point out inherent electronic counter measure (ECM) resistance of random waveform as a natural advantage. While these radars exhibit good low probability of intercept and detect characteristics, they are also more difficult to implement for medium and long range applications due to the complexity of building a high power transmitter with sufficiently large dynamic range to accommodate non constant envelop random signals.

Furthermore, the nature of the noise signal allows little control of its parameters by an engineer or operator.[3]

PROBLEM FORMULATION

Due to the vast application of radar system in the world and its increased demand in most communication industries, this research study provides a low cost way to create a proof of concept result model radar architecture through modelling, since the aim of these industries is to maximize profit. The project would also provide a means of minimizing the inaccuracies often encountered in the course of operating a radar system thus, improving the efficiency of the system.[4]

Finally, this work would also provide a means for resolving the difficulties associated in

Implementing the modelling of a high resolution radar system using MATLAB/SIMULINK and would use MATLAB/SIMULINK to estimate the number of targets and direction of target during a high resolution radar system operation.[5]

The transmitted beam width must be very narrow, so that the target angle is precise and a beam width will indicate the angle to a very coarse value and thus requiring antennas that are at least several wavelengths in diameter to provide the sharper beam width. Today’s radar system uses the shorter wavelength frequencies ranging from a multihundred MHz to a multi-GHz, where a sharply focused antenna, that is, many

Wavelength in size is much more practical.

For convenience, a radar mile (200yd or 6000ft) is often used with as little at 1% error being introduced by its measurement adaptation. Statistically, the transmitted signal takes 6.16μs to travel 1radar mile.[6]

Therefore, the round trip for 1mi will be 12.36μs (that is, [2 x 6.16] + 1%error). In eqn 1

$$\text{Range} = \frac{\Delta t \text{ (miles)} \ldots\ldots\ldots\ldots\ldots\ldots}{12.36} \qquad (1)$$

Where t = time pulse from transmitter to receiver in microseconds in eqn 2.

For higher accuracy,

$$\text{Range (yard)} = \frac{328DT}{2} = 164DT \qquad (2)$$

BASIC PRINCIPLE OF HIGH RESOLUTION RADAR SYSTEM

Radar imaging which is one of the more modern implementation of a high resolution radar system provides its own source of electromagnetic energy to illuminate the terrain or target. The energy returned from the target is detected by the system and recorded as imagery. Hence, it is known as active remote sensing system in contradiction to passive system such as the photographic system which depends upon available energy reflected or radiated from the terrain. [7, 8, 9]]

Radar equipment transmits short pulses of energy (at the microwave and radio bands) towards the ground in a narrow beam focused by a directional antenna system. It then records the strength and origin of the backscatter, that is, the echo received from the objects. In other words, the system antenna transmits energy and also collects energy returned (that is, re-radiated) from the terrain. The back scattering effects from different terrain objects contain information on the basis of which terrain images are formed. Timing of the returned energy pulses is very vital because it determines the position of the terrain features on the image. To locate positions on the ground, the travel time is converted to distance by multiplying it by the speed of the electromagnetic radiation (3 x 10^8 ms^{-1}).

The fundamental equation showing the amount of signal received by a high resolution radar system from a particular target is given in equation 3

$$P = \left(\frac{WtGt}{4\pi R^2 \delta}\right)\left(\frac{1}{4\pi}\right)\left(\frac{A^r}{R^2}\right) \qquad \cdots\cdots\cdots 3$$

Where P_r = Received power

W_t = the transmitter power

G_t = The gain of the transmitting antenna

R = The slant distance to the target

A_r = The effective aperture of the receiving antenna

δ = The effective backscattering cross section area of the receiving antenna in square meters.

The equation above expresses the amount of signal received by a high resolution radar system as a function of the transmitted power, the power per unit area of the target and the effective area of the receiving antenna. Form the equation, $(W_tG_t)/(4\pi R^2)$, gives the power per unit area at the target. While (δ) contains the backscattering cross section in square meters. So, combining the two quantities gives the strength of the energy re=radiated by the target coming towards the receiver. This energy spreads out spherically so that the power per unit area arriving at the receiver is given by the product of the three quantities [$(W_tG_t)/(4\pi R^2)$, (δ), $(1/4\pi R^2)$.

Finally, the power actually received = Power per unit area x Effective area of the receiving antenna.

If the effective receiving area is expressed in terms of the antenna gain (G) and the wavelength (λ), we have a more convenient form of the equation shown above. Hence

$$P_r = \frac{W_tG^2\lambda^2\delta}{(4\pi)^3R^4} \qquad (4)$$

Equation (4) is the high resolution radar equation which forms the basis for its operation. Any other form of the equation may be described in terms of variations of this equation. For instance, if the antenna efficiency is taken into consideration, equation

(4) will reduce to the following form:

$$P_r = \frac{W_tG^2\lambda^2 \quad \delta}{(4\pi)^3R^4\,\eta} \qquad (5)$$

where η = efficiency factor of the system antenna.

From the analysis of high resolution radar system equation (5) above, it is observed that the stronger the image forming energy reflected from the terrain to the radar antenna (often referred to as the radar return), the brighter the image. The intensity of the radar return depends upon the high resolution radar system properties and the terrain properties such as its degree of roughness. Surface roughness or irregularity of the terrain influences the strength of radar return and hence radar imagery. Variation of signatures is very apparent in radar imagery.

The unique characteristics of radar imagery provide certain advantages which include:

1) Since the radar beam can illuminate the terrain obliquely, it can produce shadow effects which enhance interpretability. However, in areas of high relief, radar shadows tend to obscure detail.
2) It provides the possibility for acquiring the side looking air borne radar (SLAR) imagery at any time of the day including night time and under almost all weather conditions.
3) Geological structures are more apparent on radar imagery than aerial photographs. The oblique illumination of radar system enhances the detection lineaments.
4) The spatial resolution of the images is relative.
5) Radar imagery has proved valuable for separation wet land and dry land for small scale mapping of drainage patterns in wet tropics because the imagery is highly suitable for providing coverage of cloud-prone tropical forest areas.

6) Side looking air borne radar (SLAR) images have excellent clarity, and coverage can be extensive. Typical radar images can be hundreds of kilometres long and tens of kilometres wide.

3.3 COMPONENTS OF HIGH RESOLUTION RADAR SYSTEM

A practical high resolution radar system requires seven basic components as illustrated below:

TRANSMITTER

The transmitter creates the radio wave to be sent and modulates it to form the pulse train. The transmitter must also amplify the signal to a high power level to provide adequate range.

RECEIVER

The receiver is sensitive to the range of frequencies being transmitted and provides amplification of the returned signals. In order to provide the greatest range, the receiver must be very sensitive without introducing excessive noise.

POWER SUPPLY

The power supply provides the electrical power for all the components. The largest consumer of power is the transmitter which may require several kilowatt of average power. The power supply only needs to be able to provide the average amount of power consumed, not the high power level during actual pulse transmission. Energy can be stored in a capacitor bank, for instance, during the rest time. The stored energy then can be put into the pulse when transmitted, increasing the peak power. The peak power and the average power are related by the quantity called duty cycle, DC. Duty

Cycle is the fraction of each transmission cycle that the radar is actually transmitting.

SYNCHRONIZER

The synchronizer coordinates the timing for range determination. It regulates that rate at which pulses are sent and resets the timing clock for range determination for each pulse. Signals from the synchronizer are sent simultaneously to the transmitter, which sends a new pulse, and to the display, which resets the return sweep.

DUPLEXER

This is a switch which alternately connects the transmitter or receiver to the antenna. Its purpose is to protect the receiver from the high power output of the transmitter. During the transmission of an outgoing pulse, the duplexer will be aligned to the transmitter for the duration of the pulse. After the pulse has been sent, the duplexer will align the antenna to the receiver. When the next pulse is sent, the duplexer will shift back to the transmitter. A duplexer is not required if the transmitted power is low.

ANTENNA

The antenna takes the radar pulse from the transmitters and puts it into the air. Furthermore, the antenna must focus the energy into a well-defined beam which increases the power and permits a determination of the direction of the target. The antenna must keep track of its own orientation which can be accomplished by a synchro-transmitter. There are also antenna systems which do not physically move but are steered electrically. The beam width of an antenna is a measure of the angular extent of the most powerful portion of the radiated energy. For our purposes, the main portion, called the main lobe will be all angles from the perpendicular where the power is not less than $^1/_2$ of the peak power or in decibels. The beam width is the range of angles in the main lobe, so defined. Usually this is resolved into a plane of interest, such as the horizontal or vertical plane. The antenna will have a separate horizontal and vertical beam width. For a radar antenna, the beam width can be predicted from the dimension of the antenna in the plane of interest by

$$\Theta = \lambda/L \quad .... \; (6)$$

where Θ is the beam width in radians, λ is the wavelength of the radar, and L is the dimension of the antenna, in the direction of interest (i.e. width or height).

The directional gain of an antenna is a measure of how well the beam is focused in all angles. In both angles, then, directional gain would be given by:

$G_{directional} = 4\pi/\ \Theta\varnothing$ …………(7)

Where Θ = Horizontal beam width (radians)

$\varnothing$ = Vertical beam width (radians)

Sometimes directional gain is measured in decibels, namely 10log (G_{dir}). Therefore, directional gain

$$\text{Gain (dB)} = 10\log(4\pi/\Theta\varnothing) \quad .... \; (8)$$

PULSE REPETITION FREQUENCY (PRF)

The frequency of pulse transmission affects the maximum, range that can be displayed. Recall that the synchronizer resets the timing clock as each new pulse is transmitted. Returns from distant targets that do not reach the receiver until after the next pulse has been sent will not be displayed correctly. Since the timing clock has been reset, they will be displayed as if the range were less than actual range. If this was possible, then the

range information would be considered ambiguous. An operator would not know whether the range was the actual range or some greater value. When a high resolution radar is scanning, it is necessary to control the scan rate so that sufficient number of pulses will be transmitted in any particular direction in order to guarantee reliable detection. It too few pulses are used, then it will be more difficult to distinguish false targets from actual ones. False targets may be present in one or two pulses but certainly not in ten or twenty in a row, therefore to maintain a low false detection rate; the number of pulses transmitted in each should be kept high, usually above ten. For systems with high pulse repletion rates (frequencies), the radar beam can be repositioned more rapidly and therefore scan more quickly. Conversely, if the PRF is lowered, the scan rate needs to be reduced. For a simple scan, it is easy to quantify the number of pulses that will be returned from any particular target. Let $\boldsymbol{\tau}$ represent the dwell time, which is the duration that the target remains in the radar beam during each scan. The number of pulses, N, which the target will be exposed to during the dwell time is:

$$N = \boldsymbol{\tau}\mathrm{PRF} \qquad (9)$$

We may rearrange this equation to make a requirement on the dwell time for a particular scan as:

$$\boldsymbol{\tau}_{min} = N_{min}/\mathrm{PRF} \qquad (9.1)$$

So it is easy to see that high pulse repetition rate requires smaller dwell times. For a continuous circular scan, for example, the dwell time is related to the rotation rate and the beam width.

$$\tau = \Theta/\Omega \qquad (10)$$

Where q = beamwidth (degrees), W = rotation rate (degrees/sec)which will give the dwell time in seconds. These relationships can be combined, giving the following equation from which the maximum scan rate may be determined for a minimum

number of pulses per scan:

$$\Omega_{max} = \Theta PRF/N \qquad (11)$$

RADAR FREQUENCY

Finally, the frequency of the radio carrier wave will also have some effect on how the radar beam propagates. At the low extremes, radar beams will refract the atmosphere and be caught in “ducts” which results in long ranges. At the high extreme, the radar beam will behave much like visible light and travel in very straight lines. Very high frequency radar beams will suffer high loses and are not suitable for long range systems.

The frequency will also affect the beam width. For the same antenna size, a low frequency radar will have a larger beam width than a high frequency one. In order to keep the beam width constant, a low frequency radar will need a large antenna.

MODELING OF HIGH RESOLUTION RADAR SYSTEM

Modeling radar system is a low cost way to create “proof of concept” results for novel radar architecture, however they are difficult to implement due to a considerable number of variables and conditions to be taken into account. With new advances in modelling software and computer speeds such simulation analyses are becoming more attractive as they allow identifying potential bottlenecks in the entire system, form the overall radar architecture to particular channel models in various conditions.

Different options with respect to choosing a particular simulator exist for which I have chosen MatLab-Simulink platform due to relative simplicity and fast learning curve. As a starting point, users may refer to the demonstration test bench “RF satellite link” built

into MatLab Help (Help → Demos (tab) → Blocksets → Communications → Channels models and impairment → RF satellite link). This demo contains all the major components of an RF communication system—modulator, high power transmitter

amplifier model, free space propagation channel model, thermal noise and phase offset in the receiver, automatic gain control model, demodulator and results displays. The test bench discussed in this research work is aimed at “proof of concept” simulation analysis for the synthetic aperture radar implementation based on orthogonal multicarrier ultra wide band pulses. It assumes the general transceiver architecture similar to the one used for OFDM-based communication systems. The test bench incorporates full transceiver design on a block diagram level, with the potential of adding Radio Frequency (RF) effects and an upgrade channel and target scene model, with free space loss and multi-path delays. The resultant product of the test bench is simulated radar imagery in various noise conductions and target configurations, along with subsequent hardware design and test of the prototype. The partitioning between using Simulink and MatLab appropriate for imaging radar simulations is done the following way:

1) Signal generation
2) Transmission reception of radar systems

The sampling and recording of these into digital arrays are performed in Simulink, while image generation and processing is performed using MatLab scripts. Below is a description of the Simulink based part of the bench.

TRANSMITTER

The transmitter consists mainly of digital blocks—QPSK encoder, IFFT block (to translate sub-carriers from frequency domain representation into time domain 1/Q samples) and auxiliary blocks. All sub-blocks shown in the transmitter model above (that is, Figure 1) are standard Simulink components. A Bernoulli binary generator provides random numbers from which the radar signal is formed.

FREE SPACE LOSS

For the free space loss, Simulink has a pre-made block that implements the general formula for a single frequency signal loss for one-way propagation. For radars, we need to implement the following formula for round trip propagation:

$L_{rmin} = 20 \times \log_{10}(4\pi .\ 2r_{min}/\lambda_{min})$ (13) where r_{min} = the minimum target range from the radar

λ_{min}= the wavelength of the minimum frequency in the signal's spectrum which is achieved by simply doubling the path

distance is Simulink free space path loss block parameter.

TARGET (ERT) MODEL

The simple way to implement a target (ERT) model is to represent it as a collection of point scatterers. Each scatterer therefore will be characterized by a distance from radar (and thus, a path loss associated with that distance) and by the strength of reflection. In my model, designated sixteen (16) point scatterers within a twenty four (24)-meter range swath,of which five scatterers were defined as "strong" and the rest were defined as "clutter" with reflection coefficients around 20dB below those of the "strong" scatterers.

RECEIVER AND SIGNAL-TO-NOISE RATIO (SNR) COMPUTATION MODELS

The receiver consists of an 1/Q detector (it is possible to introduce carrier offset in the target model to simulate non-ideal mixing processes; it is also possible to introduce 1/ Q imbalance by randomly multiplying the output channels by non-unity value), delay sampler (the delay is introduced to align the receive signal with the transmit signal for better visual representation) and FFT bocks (it performs demodulation process for the digitally constructed transmitter multi-carrier signal). The decision blocks map processed signal samples to digital values for further QPSK demodulation. The signal-to-noise ratio (SNR)-computing blocks implement a conventional expression for calculating a ratio of the receive signal's energy to noise energy, averaged over four sample period. These components fully describe the functionality of a multi-carrier ultra wide band radar, yielding radar return samples in digital format, for a given target

function and signal-to-noise ration (SNR). STANDARD Simulink blocks that can be added to the test bench to enhance the simulation process are: realitic power amplifier models, phase noise in the receiver, frequency offset to simulate target's Doppler, receiver noise temperature, complex filter models to simulate transmitter and receiver interconnect (e.g. cables connecting radio frequency (RF) front end to the antenna; non Gaussian noise etc.

Consider the following simple (narrowband) 1-dimensional monostatic, single pulse radar model. Monostatic refers to the set up where the transmitter (TX) and receiver (RX) are collocated. Suppose a target located at range x is traveling with constant velocity V and has reflection coefficient S_{xv}. Figure 4.1 below shows such a radar with one target. After transmitting signal f(t), the receiver observes the reflected signal,

$$r(t) = S_{xv}f(t - T_X)e^{2\pi i w v t} \tag{14}$$

where $T_X = 2x/c$, is the round trip time of flight, c is the speed of light, $w_v \approx -2w_o v/c$, is the Doppler shift, and w_o is the carrier frequency. The basic idea is that the range velocity information (x, v) of the target can be inferred from the observed time delay—Doppler shift (T_X, w_v) of f in equation (4.2) above. Hence, a time frequency shift operator basis is a natural representation for radar systems.

Using a matched filter at the receiver, the reflected signal r is correlated with a time frequency shifted version of the transmitted signal f via the cross ambiguity function which states that:

$$_{fg}(T, w) = \underline{\int f(t + r/2)}g(t - r/2)e^{-2\pi i w t}dt \tag{15}$$

From this, we can see that the time frequency plane consists of the ambiguity surface of fcentered at the target's location (T_X, w_v) and scaled by its reflection coefficient $|S_{xv}|$.

Extending equation (4.4) to include multiple targets is straight forward.

SYSTEM IMPLEMENTATION

The hardware subsystem of a High Resolution Radar system consists of the transmitter, receiver, power supply, synchronizer, duplexer, antenna and the display. A typical schematic representation of this basic hardware subsystem was shown in chapter three. If a target is to be detected using a high resolution radar system, the transmitter components of the radar create the radio wave to be sent and modulate the signal to form the pulse train. The transmitter component can also amplify this signal to a high power level to provide adequate range. This radar equipment records first the time it takes the pulse to reach the grounds and the time to return back to the radar antenna. It also records the strength and the origin of the back scatter. Timing of the returned energy pulses is very important because it determines the position of the terrain features on the image. It should be noted that the stronger the image forming energy reflected from the terrain to the radar antenna, the brighter the image. And the intensity of the radar return depends on the high resolution radar system properties and the terrain properties such as its degree of roughness.[9]

The input interfaces of this system are the power supply and the transmitter. While the receiver is the output interface. The synchronizer, duplexer and the antenna are the major media for control of signals during the system operation.

The partitioning between using Simulink and MatLab appropriate for imaging radar simulation is done in the following way: signal generation, transmission, reception of radar returns, sampling and recording them into digital arrays are performed in Simulink, while image generation and processing is performed using MatLab scripts. The Simulink-based part of the test bench consists of the target model, the transmitter, free space loss and the receiver and signal-to-noise ratio computation models. The transmitter model shown in the Appendix consists of the QPSK encoder, IFFT block

(which is domain representation into time domain I/Q samples) and auxiliary blocks.
All the subblocks shown in this model are standard Simulink components. A Bernoulli binary generator provides random number. The best and simple way to implement a target model is to represent it as a collection of point scatters. Each scatterer is characterized by the distance from the radar and by the strength of reflection. Though for this model, I designated sixteen (16) scatterers within a twenty four meter range swath, of which five scatterers were defined as "strong" and the rest were defined as "clutter" with reflection coefficient around 20dB below those of the strong scatterers.

The target model of this system is shown in the Appendix also. In the free space loss, Simulink has a pre-made block that implements the general formula for a single frequency signal loss for one way propagation. While the receiver consists of an I/Q detector, delay sampler and FFT block. A detailed explanation of the receiver component was discussed in chapter four. The signal-to-noise ratio computing block implements a conventional expression for calculating a ratio of the receive signal's energy to noise energy, averaged over four sample periods. To enhance the simulation process, standard Simulink blocks such as realistic power amplifier models, phase noise in the receiver, frequency offset to simulate target Doppler, receiver noise temperature and complex filter models to simulate transmitter and receiver interconnects are added to the test bench.[10]

PERFORMANCE EVALUATION

A sampler scope capture from the Simulink test bench is shown in the Appendix. Transmit and receive signal spectra are shown in the uppermost graph. Note that MatLab and Simulink operate with discrete numbers only and as such even analog

signals in Simulink have to be represented by digital samples. It is therefore critical to choose the proper simulation step, which is different from sampling interval used in test bench to model ADC/DAC performance. Maximum time step size was chosen to be

20ps for this test bench while the sampling rate in the transceiver itself was 1Gps.

Simulating the performance of a high resolution imaging radar system is achievable using Simulink/MatLab. Simulink contains a large number of pre-made blocks (provided all appropriate tool boxes and block sets are included). For this project, I used communication, RF and signal processing block set in the test bench described, which can be used to model various types of communication and radar systems. Due to the relatively low time and material expenses involved, this type of simulation analysis is deemed promising, particularly for UWB radar with complex architectures that are heavily reliant on digital technology, such as multicarrier system.

RECOMMENDATIONS

Having concluded this research project, I wish to recommend some vital points which future researchers should look into in order to further improve the efficiency of a radar system and reduce the complexity of design.

I wish to humbly admit that there are rooms for modifications and improvements by future researchers based on this project. With the experience gained from the researches made, the following suggestions will be helpful to intending researchers:

i) Future researchers should note that high resolution radar system can also be implemented using other software apart from MATLAB/SIMULINK.

ii) Since one of the aims of engineering researches is to reduce cost and proffer solutions to problems, future researchers should ensure that the software used should be cheap and readily available.

iii)There is also room for improving the accuracy of the systems and reducing the time taken for the system implementation.

Finally, I also suggest that the department should:

i) Give more time to student in order for them to be able to make quality researches.

ii) The students should be provided with research oriented program in course of their study, so as to cultivate research in them.

iii) The department should create a research finding center in the department and ensure every student have an access to this center.

CONCLUSIONS

Radar system is a high-tech engineering equipment that incorporates many fields in engineering such as computer, electrical, electronics and mechanical engineering. It is basically a communication device applying every principle of telecommunication. Despite the vast application of this system, designing a high resolution radar system is complex and difficult to analyze. Thus, this project has discussed how this complexity can be reduced by modeling using MatLab/Simulink. This method used in resolving this difficulty is deemed promising for researchers and the world at large.

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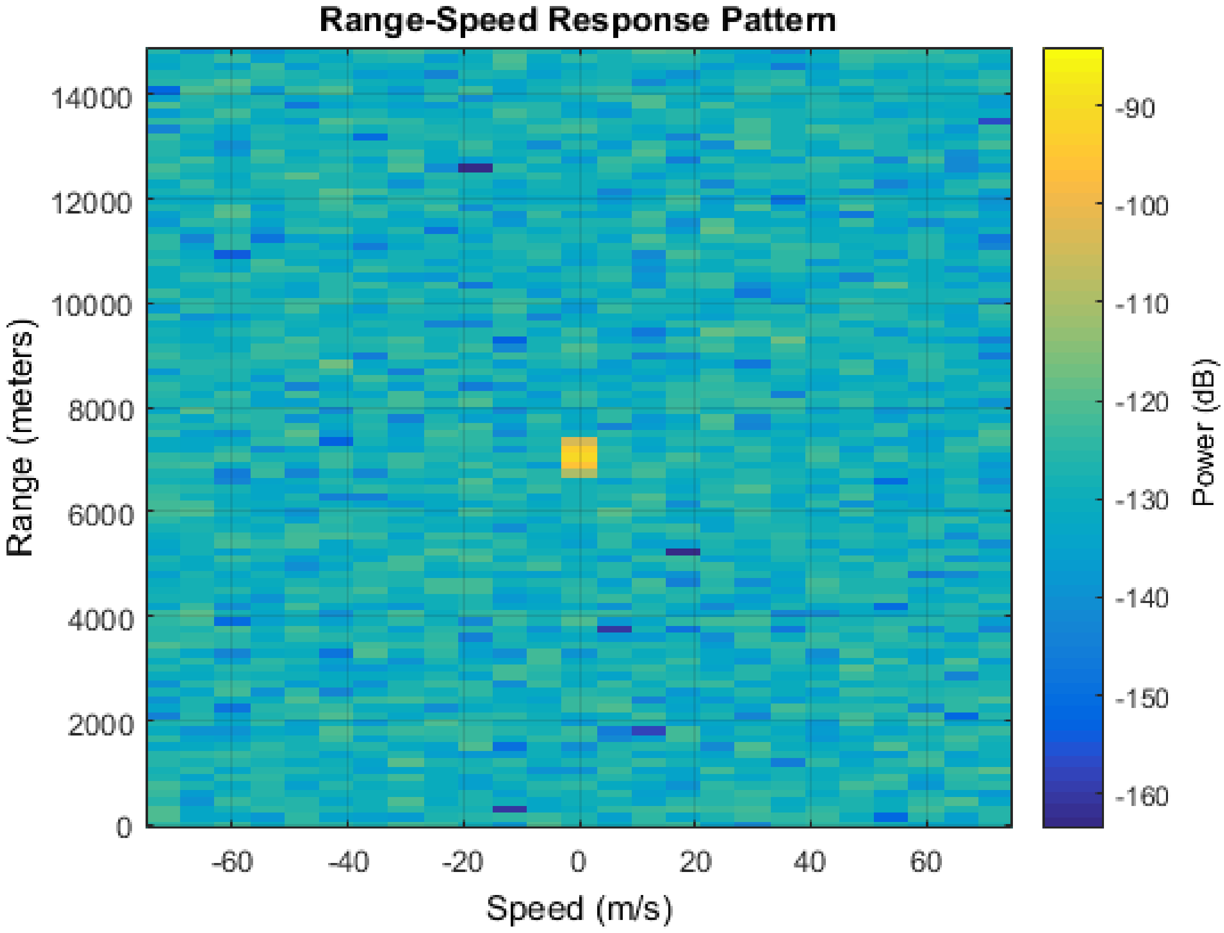
APPENDIX: Doppler Shift and Target range



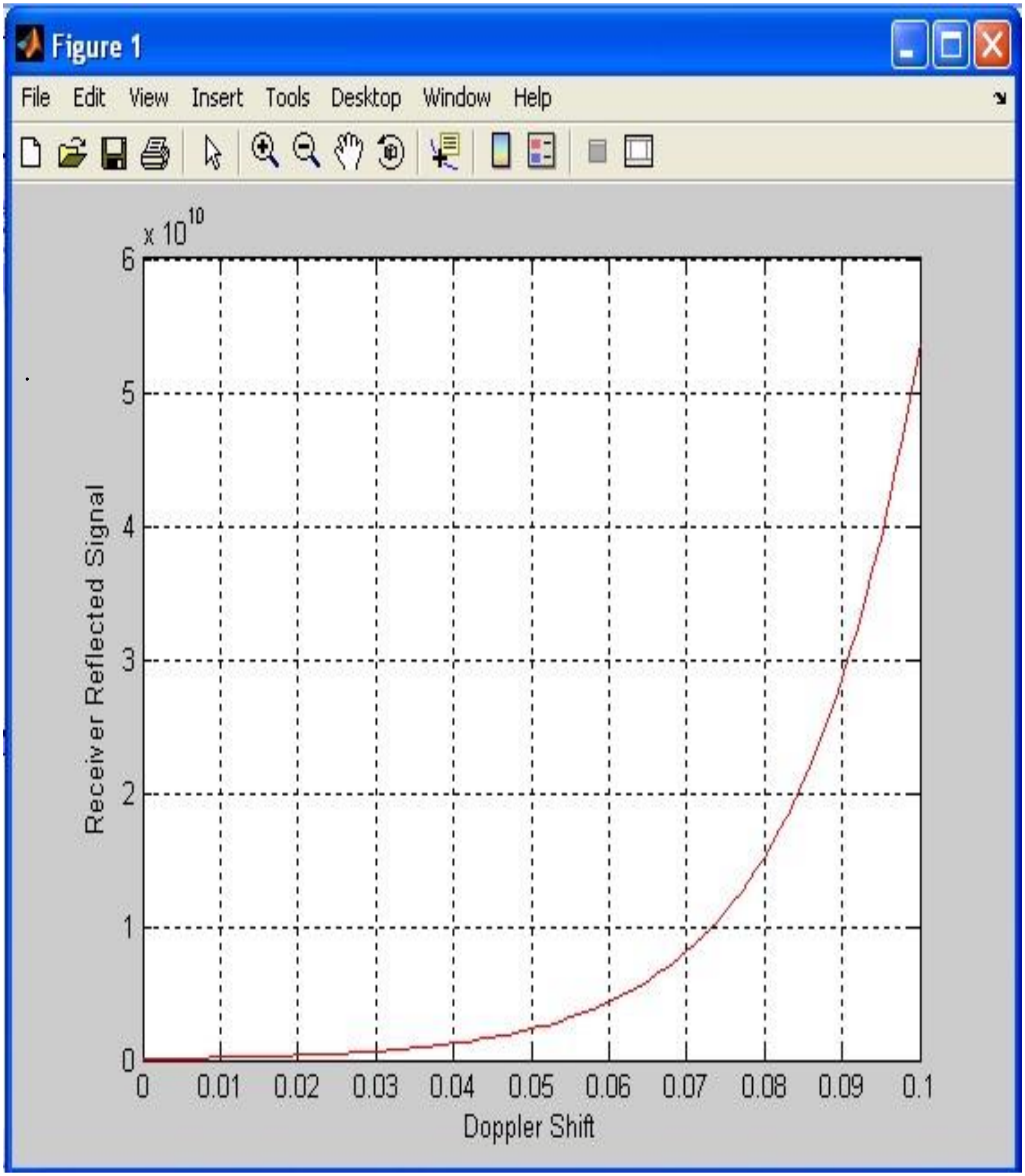


Figure 1
File
Edit
View
Insert
Tools
Desktop
Window
Help
x 10^10
6
5
4
3
2
1
0
Receiver Reflected Signal
0
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.09
0.1
Doppler Shift

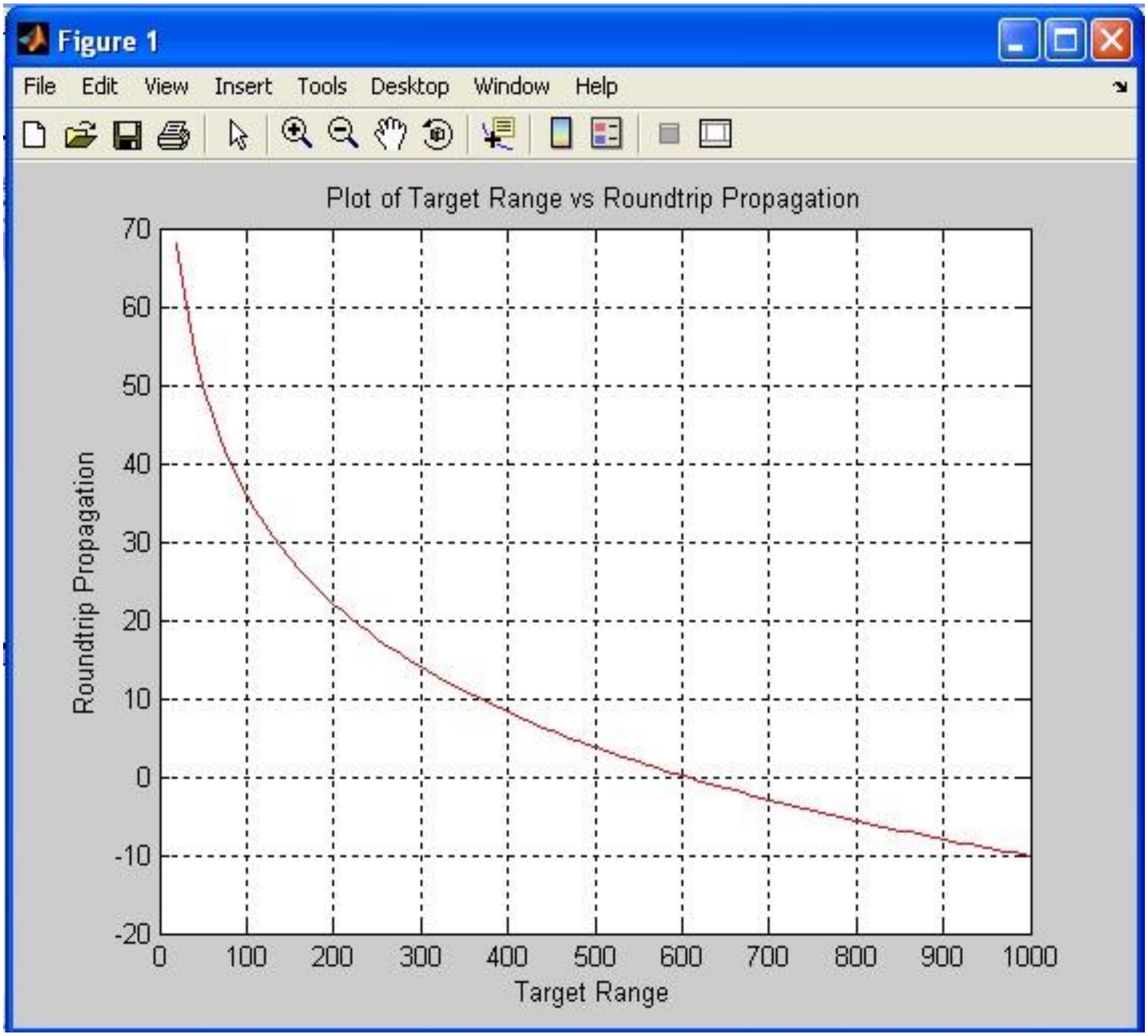


Figure 1
File
Edit
View
Insert
Tools
Desktop
Window
Help
Plot of Target Range vs Roundtrip Propagation
Roundtrip Propagation
Target Range
70
60
50
40
30
20
10
0
-10
-20
0
100
200
300
400
500
600
700
800
900
1000

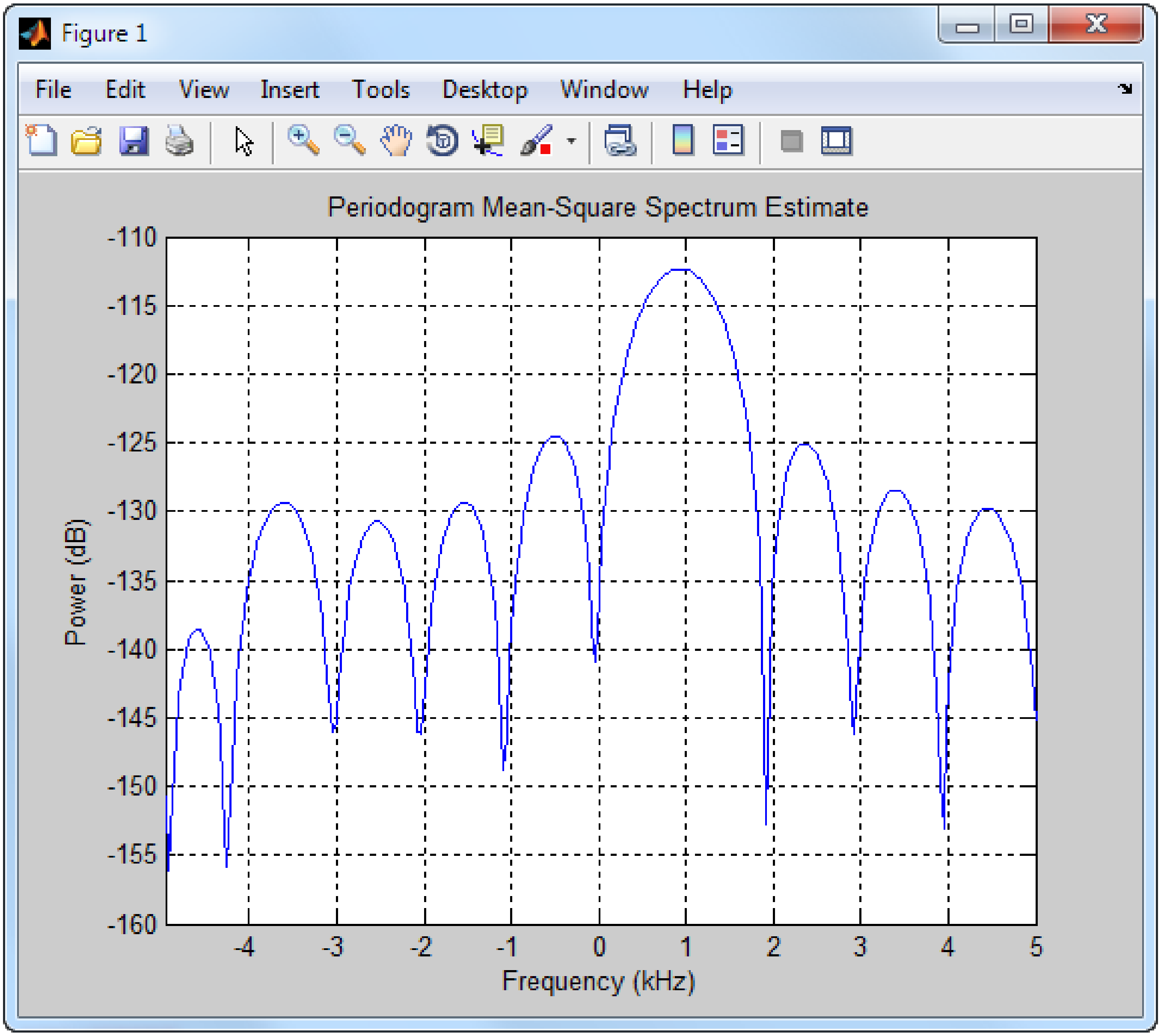


Figure 1
File
Edit
View
Insert
Tools
Desktop
Window
Help
Periodogram Mean-Square Spectrum Estimate
Power (dB)
-110
-115
-120
-125
-130
-135
-140
-145
-150
-155
-160
-4
-3
-2
-1
0
1
2
3
4
5
Frequency (kHz)