LABORATORY WORK BOOK

For Academic Session ______

Semester _____

NAVIGATIONAL AIDS AND RADAR SYSTEMS

(TC-381)
For
TE (TC)

Name: ____

Roll Number: ____

Batch: ____

Department: ____

Year/Semester: _______________________________________

Department of Electronic Engineering
NED University of Engineering & Technology, Karachi

LABORATORY WORK BOOK

For The Course

TC-381 NAVIGATIONAL AIDS AND RADAR SYSTEMS

Prepared By:

Ms. Sundus Ali, (Lecturer)

Reviewed By

Dr. Muhammad Imran Aslam (Associate Professor)

Approved By:

Board of Studies of Department of Electronic Engineering

INTRODUCTION

This work book comprise of practical covering the topics of Radar Systems Theory and Analysis. It has been best tried to relate the learning imparted in the class with what will be learnt in the lab.

Practicals and the objectives are clearly defined. Laboratory sessions are based on MATLAB to give an insight of analysis and simulation in the field of Radar Systems.

The student is required to go through the lab notebook and the suggested reading before coming to the lab. The student should make sure to attempt and bring the assignments and lab tasks, neat and tidy presented and enough explanatory for the marks to be awarded, failing to which will result in deduction of the marks.

The lab reports must have the following:

- Objective
- Clear theoretical concepts & equations used, source code and results of the simulations or plotted data
- Description of the results or data collected and plotted
- Conclusions

The student is supposed to fill in the observation and the result field at the time of the performance of the experiment and submit it then, get it duly signed and marked.

Each lab task is due until the next lab session. After which it will not be graded.

Recommended readings for each laboratory session:

[1] Skolnik, Merill I., *Introduction to RADAR Systems*, McGraw Hill, 3rd Edition, 2001.
[2] Skolnik, Merill I., *RADAR Handbook*, McGraw-Hill.
[3] Mahafza, Bassem R., *RADAR Signal Analysis and Processing*, CRC Press, 2009.

CONTENTS

13		Analyse the dependence of scatter spacing on RCS keeping constant operating frequency		
14		Generate LFM Pulse Compressed signal		

LAB SESSION 01

Objective:

Compute the duty cycle, average transmitted power, pulse energy and pulse repetition frequency of Radar wave

Simulation Tool:

MATLAB

Pre-Lab:

Concepts: ***Introduction to Radar systems, Radar waveform***

1. 1 For a pulsed radar with PRF of 200 *Hz* and 750 Hz; What are the corresponding PRIs?

1. 2 For the same radar in Problem 1.1, assume a duty cycle of 30% and peak power of 5*KW*. Compute the average power and the amount of radiated energy during the first 20*ms*.

1. 3 A certain airborne pulsed radar has peak power P_t = 10KW, and uses two PRFs, f_{r1} = 10 KHz and f_{r2} = 30 KHz. What are the required pulse widths for each PRF so that the average transmitted power is constant and is equal to 1500Watts? Compute the pulse energy in each case.

1. 4 Consider a radar transmitting pulses of duration τ seconds at a "pulse repetition frequency" of *PRF* pulses per second (pps). In terms of *PRF* and/or τ, what is the maximum range at which a target can be located so as to guarantee that the leading edge of the echo from that target on one pulse is received before transmission begins for the next pulse? (This range is called the *maximum unambiguous range* or the *first range ambiguity*.) What is the unambiguous range if *PRF* = 3000 pps (often written, somewhat carelessly, as 3000 Hz) and τ = 10 μs?

1. 5 What information is contained in a Radar signal?

Input Parameters:

Symbol	Description	Units
tau	Pulse width	Seconds
pri	PRI	Seconds
p_power	Peak power	Watts

Output parameters:

Symbol	Description	Units
ep	Pulse Energy	Joules
prf	PRF	Hz

Description:

The most common radar signal or waveform is a series of short duration, somewhat rectangular shaped pulses modulating a sine wave carrier. (This is sometimes called a pulse train).

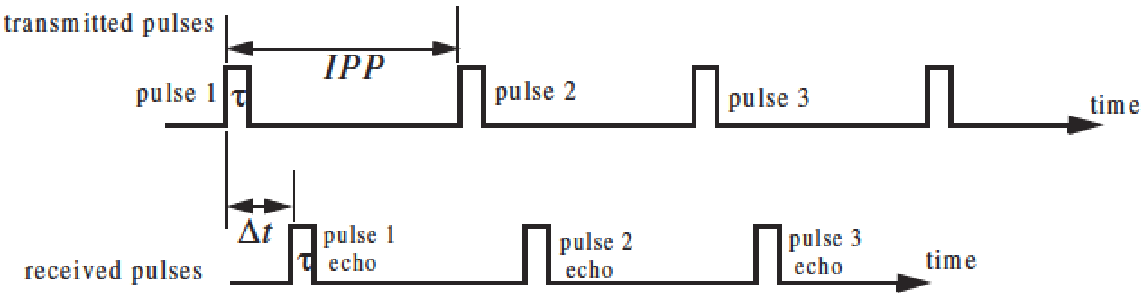

Figure 1.1 Train of transmitted and received pulses

In general, a pulse radar transmits and receives a train of pulses, as illustrated in figure 1.1. The Inter Pulse Period (IPP) is T, and the pulse width is τ. The IPP is often referred to as Pulse Repetition Interval (PRI). The inverse of PRI is PRF, denoted by f_r.

$$\mathbf{f_r=1/PRI=1/T}$$

During each PRI the radar radiates energy only for τ seconds and listens for target returns for the rest of the PRI. The Radar transmitting duty cycle d_t is defined as the ratio $\mathbf{d_t= \tau/T}$. The radar average transmitted power is

$$\mathbf{P_{av}= P_t \times d_t}$$

Where P_t is radar peak power. The pulse energy is

$$\mathbf{E_p=P_t\,\tau = P_{av}\,T= P_{av}/f_r}$$

Task:

Write a MATLAB code that computes the duty cycle, average transmitted power, pulse energy and pulse repetition frequency of Radar wave. Attach the code and result output.

MATLAB Code and Results:

Pre-Lab (Lab Session 02-05)

Concepts: Radar Range Equation, failure of simple form of Radar Equation, Radar Equation in the presence of noise

2. 1 What means of measuring range do you know?

2. 2 Why and how does noise influence the range accuracy?

2. 3 A certain C-band radar with the following parameters: Peak Power P_t = 1.5MW, operating frequency, f0 = 5.6GHz, antenna gain G = 45dB, effective temperature T_e = 290K, pulse width τ= 0.2μsec. The radar threshold is $(SNR)_{min}$ = 20dB. Assume target cross section σ= 0.1m^2. Compute the maximum range.

2. 4 You have a monostatic radar operating at 915 MHz transmitting a 2msec rectangular pulse with a pulse repetition frequency (PRF) of 1000Hz. The system transmits an average power of 100W with 1dB of cable loss, no cable to antenna matching loss, an antenna with a gain of 10,000, an antenna efficiency of 0.45 and a one-way path loss of 3dB. Determine values for the following parameters of the radar: a) Duty cycle b) Peak power c) Maximum unambiguous range d) What is the received power (dBW) for a target with an RCS of 1m^2 at a range of 40km e) What is the maximum detectable range (km) for a target with a RCS of 1m^2 if the minimum detectable power is -100dBm?

2. 5 Use the radar range equation to determine the required transmit power for a radar given P_{rmin} =10-13 Watts, G=2000, λ=0.23m, PRF=524, σ=2.0m^2

2. 6 A short range surveillance radar operates at 3GHz and uses a 1m diameter dish for both transmitting and receiving. If the mean transmitter power is 10KW and the noise level is -140dBw, calculate the maximum range at which a small aircraft of radar cross section 1m^2 could be reliably detected. Assume 5dB losses and a SNR of 13dB

2. 7 For the same radar in 2.5, what is the effect of doubling the size of the dish on the range?

2. 8 Compare the detection ranges of two 3cm radars above for a 10m^2 target using a single pulse. Assume both radars have a mean noise level -131dBW, have losses of -5dB and requires SNR of 13dB for reliable detection. The marine radar has a peak transmit power of 25KW, but the airfield radar is more powerful with a peak power of 55KW.

2. 9 A radar has the following parameters: peak power P_t= 65KW, total losses L= 5dB, operating frequency f=8GHz, PRF f_r=4KHz, duty cycle d=0.3, circular antenna with diameter D=1m, effective aperture is 0.7 of physical aperture, noise figure F= 8dB. a) derive the various parameter needed in the radar equation b) What is the unambiguous range c) Plot the SNR versus range (1Km to the radar unambiguous range) for a 5dBsm target d) If the minimum SNR required for detection is 14dB, what is the detection range for a 6dBsm target? What is the detection range if the SNR threshold requirement is raised to 18dB?

2. 10 Consider a low PRF C-band radar operating at f_0 = 5000MHz. The antenna has a circular aperture with radius 2m. The peak power is P_t=1MW and the pulse width is τ=2 μs. The PRF is f_r = 250Hz, and the effective temperature is T_0 = 600K. Assume radar losses L = 15dB and target RCS σ = 10m^2. (a) Calculate the radar's unambiguous range; (b) calculate the range R_0that corresponds to SNR = 0dB ; (c) calculate the SNR at R = 0.75R_0

LAB SESSION 02

Objective:

Computation of Radar Equation using MATLAB.

Simulation Tool:

MATLAB

Description:

The radar equation is given by:

$$\mathbf{SNR = [Pt.G^2.\lambda^2.\sigma] / [(4\pi^3).k.Te.B.Fn.L.R^4]} \qquad \text{------ (A)}$$

Input Parameters:

Symbol	Description	Units
Pt	Peak Power	Watts
f	Frequency	Hz
G	Gain of the Antenna	dB
Ơ	Target cross section	m^2
Te	Effective noise temperature	Kelvin
B	Bandwidth	Hertz
Fn	Noise figure	dB
K	Boltzmann constant	J/K
L	Radar loss	meters
R	Target range	dB
SNR	Signal to noise ratio	dB

Task:

Simulate the Radar equation (A). The program must consist of a reasonably simple user interface that will enable users to enter the input parameters for the Radar Equation. Attach the code and output result.

MATLAB Code and Results:

LAB SESSION 03

Objective:

Analysis of Radar Signal to Noise Ratio against target detection range for different values of target Radar cross section.

Software Required:

MATLAB

Description:

The radar equation is given by:

$$\mathbf{SNR = [Pt.G^2.\lambda^2.\sigma] / [(4\pi^3).k.Te.B.Fn.L.R^4]} \qquad \text{------ (A)}$$

Here,

Symbol	Description	Units
Pt	Peak Power	Watts
f	Frequency	Hz
G	Gain of the Antenna	dB
Ơ	Target cross section	m^2
Te	Effective noise temperature	Kelvin
B	Bandwidth	Hertz
Fn	Noise figure	dB
K	Boltzmann constant	J/K
L	Radar loss	meters
R	Target range	dB
SNR	Signal to noise ratio	dB

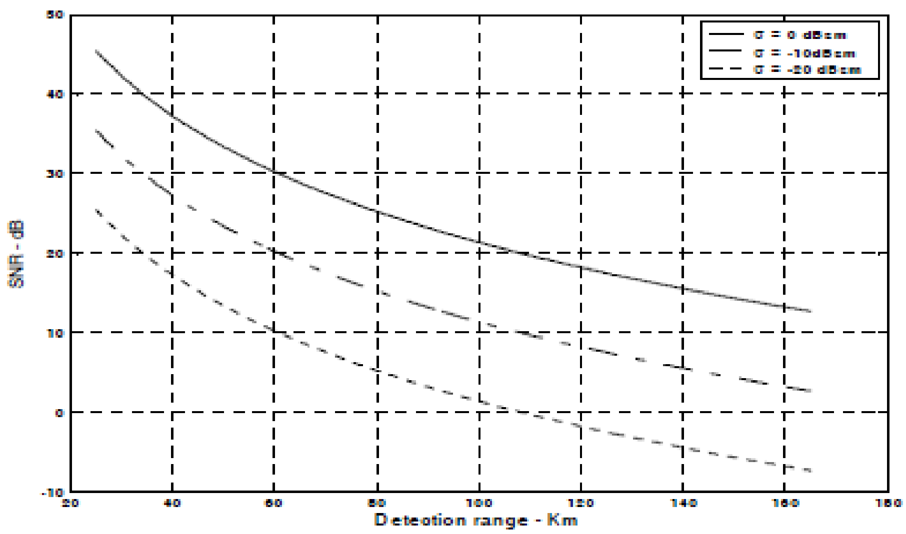

Figure 3.1 SNR versus detection range for three different values of RCS.

Task:

The radar minimum and maximum detection ranges are R_{min} = 25km and R_{max} = 165km. The different target cross section values are Ơ= 0 dB_m, Ơ = -10 dB_m and Ơ = -20 dB_m.

Using simulation tool plot a curve for the SNR versus detection range for given values of target cross section.
Also, attach code and plots along with results.

MATLAB Code and Results:

LAB SESSION 04

Objective:

Analysis of Radar Signal to Noise Ratio (SNR) against target detection range for different values of Radar peak power

Software Required:

MATLAB

Description:

The radar equation is given by:

$$\mathbf{SNR = [Pt.G^2.\lambda^2.\sigma] / [(4\pi^3).k.Te.B.Fn.L.R^4]} \qquad \text{------ (A)}$$

Syntax:

[snr] = radar_eq (Pt, Freq, G, sigma, Te, B, Nf, loss, range)

Here,

Symbol	Description	Units
Pt	Peak Power	Watts
f	Frequency	Hz
G	Gain of the Antenna	dB
Ơ	Target cross section	m^2
Te	Effective noise temperature	Kelvin
B	Bandwidth	Hertz
Fn	Noise figure	dB
K	Boltzmann constant	J/K
L	Radar loss	meters
R	Target range	dB
SNR	Signal to noise ratio	dB

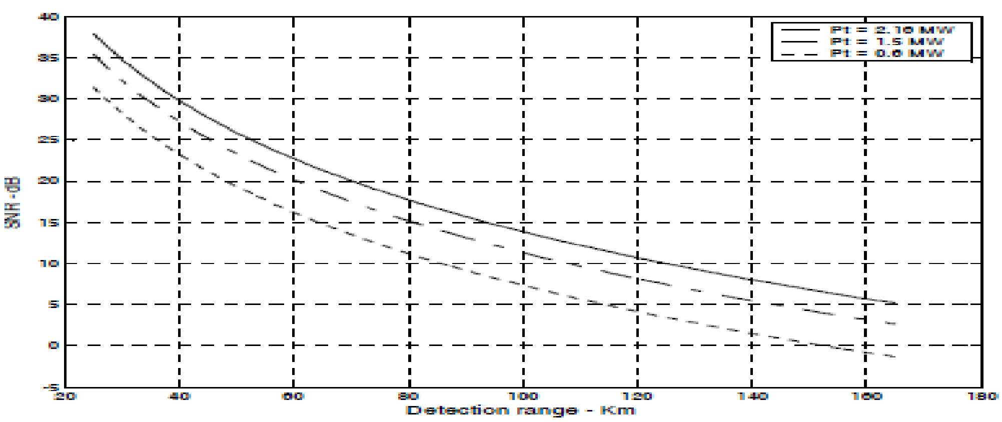

Figure 4.1 SNR versus detection range for three different values of radar peak power

Task:

The radar minimum and maximum detection ranges are R_{min} = 25Km and R_{max} = 165Km. The different target cross section values are P_t = 2.16 MW, P_t = 1.5 MW and P_t = 0.6 MW.

Plot the SNR versus detection range for given values of Radar Peak Power . Also attach the code and result plots.

MATLAB Code and Results:

LAB SESSION 05

Objective:

To compute the pulse-width required to achieve a certain SNR for a given detection range.

Software Required:

MATLAB

Description:

The equation linking the SNR and radar pulse width is given by:

$$\tau = [(4\pi^3).(k).(Te).(B).(Fn).(L).(SNR).(R^4)] / [(P_t).(G^2).(\lambda^2).(\sigma)]$$

Here,

Symbol	Description	Units
Pt	Peak Power	Watts
f	Frequency	Hz
G	Gain of the Antenna	dB
Ơ	Target cross section	m^2
Te	Effective noise temperature	Kelvin
B	Bandwidth	Hertz
Fn	Noise figure	dB
K	Boltzmann constant	J/K
L	Radar loss	Meters
R	Target range	dB
SNR	Signal to noise ratio	dB

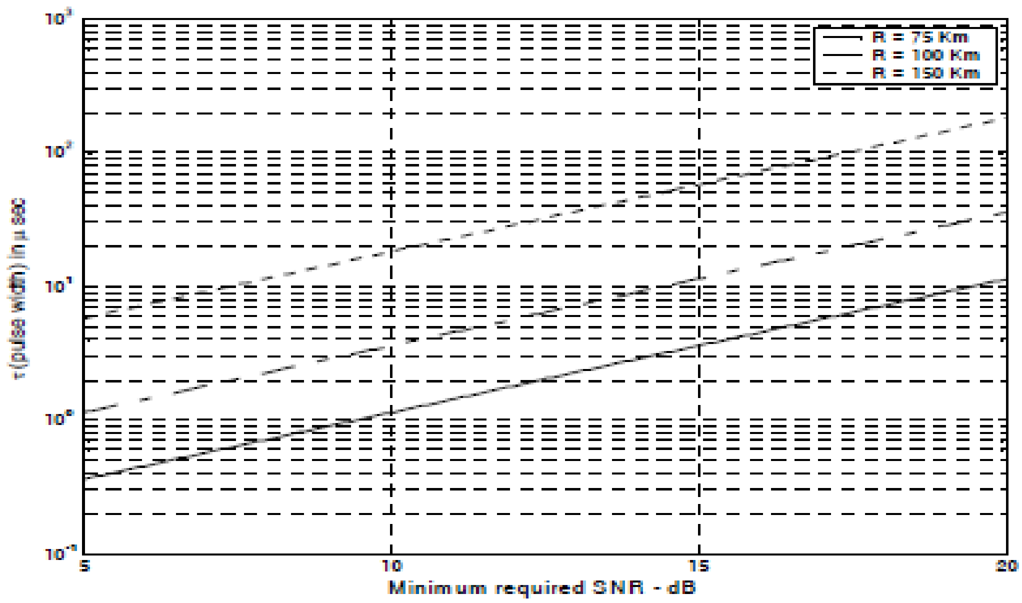

Figure 5.1 Pulse width versus required SNR for three different detection range values

Task:

The three different range values are R_1 = 75 Km, R_2 = 100 Km and R_3 = 150 Km.

Obtain a plot for pulse width versus required SNR for three given range values. Also attach the code along with plot.

MATLAB Code and Results:

Pre-Lab (Lab Session 06-09)

Concepts: Probability of False Alarm, Probability of Detection, Albersheim formula, SNR, DLC and Doppler frequency shift, Swerling Model

6.1 Define probability of False Alarm, probability of detection. Explain the Albersheim formula relating P_{fa}, P_d and SNR.

6.2 Discuss the significance of Blind Speeds. How it is calculated?

6.3 Discuss the importance of using a Delay Line Canceler.

6.4 Why DLC is termed a time-domain filter?

6.5 State the limitations of a Single Delay Line Canceler.

6.6 State the fundamental difference between a single-tap and a double-tap delay canceler.

6.7 What is the highest frequency that radar can be operated on if it is required to have a max. Ambiguity range of 200 nmi and no blind speed less than 600kt?

6.8 A satellite orbiting the earth at an altitude of 5000 nmi has a speed of 2.7 nmi/s.
(a) What is the Doppler frequency shift if the satellite us observed by a UHF radar (450 MHz) lying in the plane of the orbit just as the satellite appears over the horizon? (Radius of earth is 3440 nmi)
(b) What is the Doppler frequency shift when the satellite is observed at the zenith?

6.9 What are the four Swerling models?

LAB SESSION 06

Objective:

Analysis of Albersheim Formula to find the relationship among the probability of false alarm, probability of detection and SNR

Software Required:

MATLAB

Description:

Albersheim Equation:

$$\frac{S}{N} = A + 0.12AB + 1.7B$$

Where, **A= ln(0.62/P_{fa})** **B= ln(P_d / (1-P_d))**

Here,

Symbol	Description
P_d	Probability of Detection
P_{fa}	Probability of False Alarm
SNR	Signal to Noise Ratio

Task:

Generate the curves relating probability of detection to SNR for different values of probability of false alarm as given in figure, by Albersheim formula using a MATLAB program. Attach the graphs and code in results.

MATLAB Code and Results:

LAB SESSION 07

Objective:

Understand and compute the Probability of Detection for Swerling I Targets for varying Probability of false alarm (P_{fa})

Software Required:

MATLAB

Description:

The exact formula for the probability of detection for Swerling I type targets was derived by Swerling. It is

$$P_d = e^{-VT/(1+SNR)} \qquad \text{for} \quad np = 1$$

$$\frac{S}{N} = A + 0.12AB + 1.7B$$

Where, $\quad A = \ln(0.62/P_{fa}) \qquad B = \ln(P_d / (1 - P_d))$

Here,

Symbol	Description
P_d	Probability of Detection
P_{fa}	Probability of False Alarm
SNR	Signal to Noise Ratio
nfa	Marcum’s False Alarm no.
np	No. of integrated pulses
VT	Threshold

Task:

Write a MATLAB code to compute and plot the Probability of Detection for Swerling I targets for varying P_{fa}. Attach plots and code in results.

MATLAB Code and Results:

LAB SESSION 08

Objective:
Understand and analyse the performance of a Delay Line Canceller at different blind speeds.

Software Required:

MATLAB

Description:

Single-Delay Line Canceler frequency response:

The signal from a target at range R_o at the output of phase detector is

$$\mathbf{V_1 = V_o \sin(2\pi f_d t - \Phi_0)}$$

Where, f_d = Doppler frequency shift = $2v_r/\lambda$ or n/T_p
Φ_0 = constant Phase shift = $4\pi R_o/\lambda$ (Range at time = 0)
V_o = Amplitude of the signal

$$\mathbf{V_2 = V_o \sin(2\pi f_{d(}t - T_p) - \Phi_0)}$$

Where, T_p = Pulse Repetition Interval

Delay Line Cancelation: $\mathbf{V=V_1 - V_2}$

The amplitude response hence derived to be: $\mathbf{H(f) = 2 \sin(\pi f_d T_p)}$

Symbol	Description
f_d	Doppler frequency shift
V_o	Amplitude of signal
T_p	Pulse Repetition Period
V	Delay Line Canceler output
H	Amplitude Response

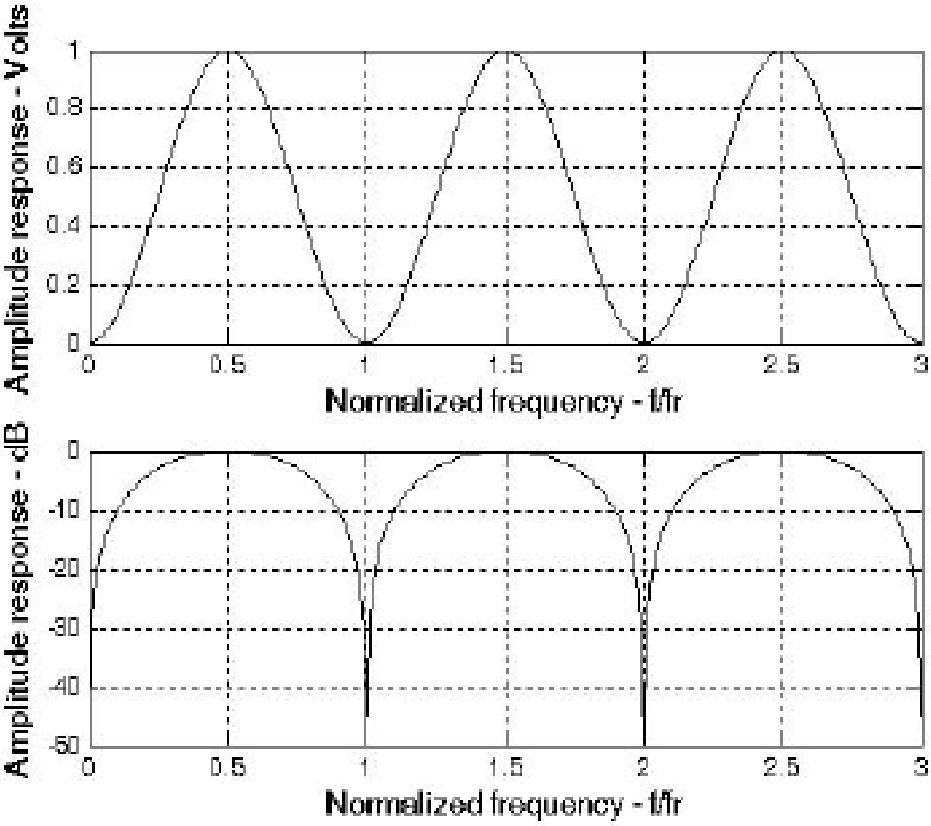

Figure 8.1 Single tap delay canceler frequency response

Task:

Write a MATLAB code to plot the frequency response of a single-tap delay canceler (with normalized frequency). Amplitude is to be shown in Volts and in dB. Attach the code along with plots in results.

MATLAB Code and Results:

LAB SESSION 09

Objective:

Understand and analyse the performance of a Double-Tap Delay Line Canceller at different blind speeds

Software Required:

MATLAB

Description:

Double-Delay Line Canceler frequency response:

The signal from a target at range R_o at the output of phase detector is

$$\mathbf{V_1 = V_o \sin(2\pi f_d t - \Phi_0)}$$

Where, f_d = Doppler frequency shift = $2v_r/\lambda$ or n/T_p

Φ_0 = constant Phase shift = $4\pi R_o/\lambda$ (Range at time = 0)

V_o = Amplitude of the signal

$$\mathbf{V_2 = V_o \sin(2\pi f_{d(}t - T_p) - \Phi_0)}$$

Where, T_p = Pulse Repetition Interval

Delay Line Cancelation: $\mathbf{V=V_1 - V_2}$

The amplitude response of two cascaded delay line canceller hence derived to be: $\mathbf{H(f) = 4 \sin^2(\pi f_d T_p)}$

Here,

Symbol	Description
f_d	Doppler frequency shift
V_o	Amplitude of signal
T_p	Pulse Repetition Period
V	Delay Line Canceler output
H	Amplitude Response

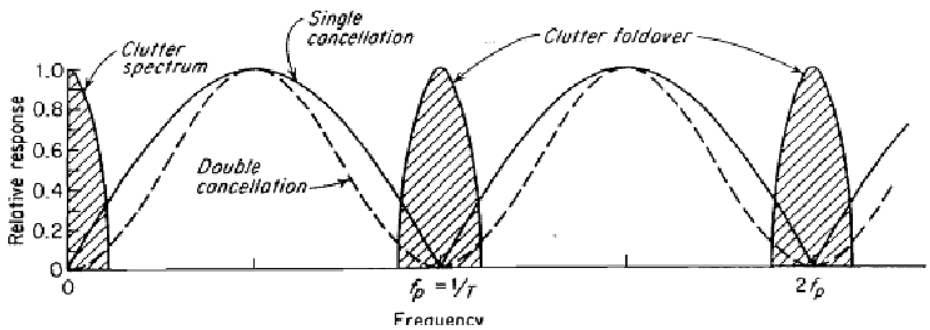

Figure 9.1 Frequency response of a double tap DLC compared with that of single DLC

Task:

Write a MATLAB code to plot the amplitude response of a double-tap delay canceler (with normalized frequency). Amplitude is to be shown in Volts and in dB

Also state the advantage of using a single-tap canceler over a double-tap canceler. Attach code along with plots.

MATLAB Code and Results:

LAB SESSION 10

Objective:

Understand and analyse the performance of a Delay Line Canceller with Feedback (Recursive Filter)

Software Required:

MATLAB

Description:

Delay line cancelers with feedback loops are known as recursive filters. The advantage of a recursive filter is that through a feedback loop we will be able to shape the frequency response of the filter.

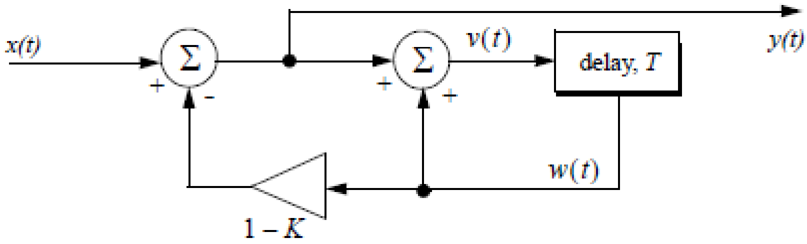

Figure 10.1 MTI Recursive Filter

Frequency Response of Recursive Filter is concluded to be:

$$|H|^2 = \frac{2(1 - \cos 2\pi f T)}{(1 + K^2) - 2K\cos(2\pi f T)}$$

Here,

Symbol	Description
K	Feedback Gain (should be kept <1)
H	Amplitude Response
f	Frequency
T	Delay of Tap

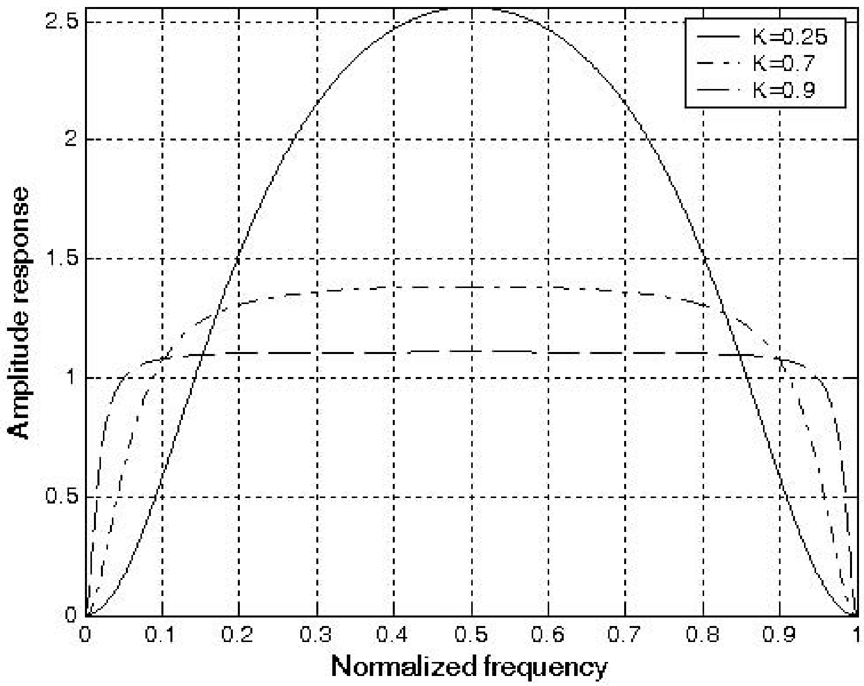

Figure 10.1. Frequency response corresponding to different values of K and normalized frequency

Task:

Write a MATLAB Code to compute the frequency response of the MTI recursive filter having values of K= 0.25, 0.5, 0.75. Also plot the response vs normalized frequency for the values of K. Also attach the code and plots.

MATLAB Code and Results:

Pre-Lab (Lab Session 11-13)

Concepts: RCS, dependence of RCS on Frequency and aspect angle

11.1 What frequency will result in the maximum RCS of a metallic sphere whose diameter is 1 m?

11.2 What is the maximum RCS (sq.meters) of an automobile license plate that is 12 inches wide by 6 inches high, at a frequency of 10.5 GHz ?

11.3 Discuss briefly the behaviour of the RCS of a rain drop and a large aircraft with respect to its dependence on (a) frequency, (b) aspect angle.

11.4 What is isotropic scatterer? Why is it considered?

11.5 Explain with diagrams the concept of Electrical and Scatterer Spacing.

LAB SESSION 11

Objective:
Understand and analyse the effect of aspect angle on Target Radio Cross Section

Software Required:

MATLAB

Description:

The intensity of the *backscattered* energy that has the same polarization as the radar's receiving antenna is used to define the target RCS. When a target is illuminated by RF energy, it acts like an antenna, and will have near and far fields. Radar cross section fluctuates as a function of radar aspect angle and frequency.
For the purpose of illustration, isotropic point scatterers are considered.
The Electrical spacing defined between two scatterers relative angles is:

$$\textbf{Elec\_spacing} = \frac{11.0 \times S \times \cos(\Theta)}{\lambda}$$

$$\textbf{RCS} = \text{Magnitude}\,(1.0 + \cos((11\pi) \times \text{elec\_spacing}) + i * \sin((11\pi) \times \text{elec\_spacing}))$$

$$\textbf{RCS(db)} = 20 \times \log_{10}(\text{RCS})$$

Here,

Symbol	Description
λ	Wavelength
Θ	Aspect Radians
S	Scatter Spacing
F	frequency
RCS	Radar Cross Section
Elec_Spacing	Electrical Spacing

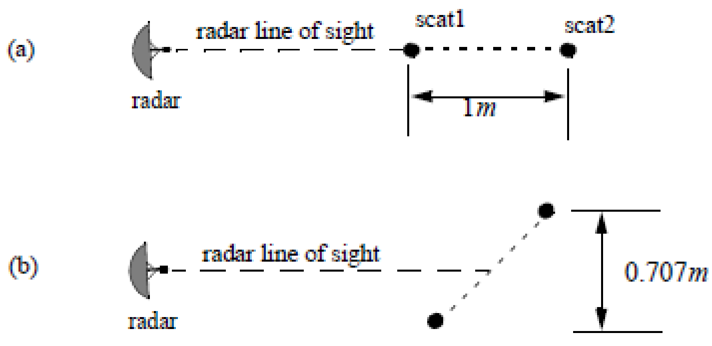

Figure 11.1 Aspect angle and radar line of sight

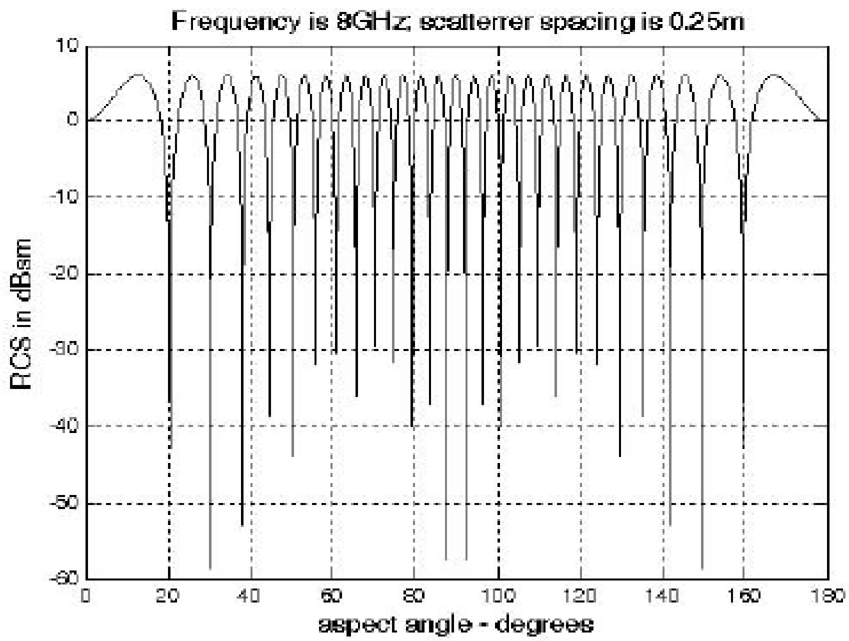

Figure 11.2 Plot of RCS (dB) versus aspect angle

Task:

Write a function code in MATLAB which calculates effect of Aspect angles on RCS. Take operating frequency to be 3 GHz. Also, plot the scatters separated by 0.5 m scatter spacing. Change the aspect angle from 0 to 180 degrees and compute the equivalent RCS. Plot RCS vs. Aspect angle generated. Attach the code and result plots.

MATLAB Code and Results:

LAB SESSION 12

Objective:
Understand and analyse the dependence of operating frequency on Target Radio Cross Section

Software Required:

MATLAB

Description:

The intensity of the *backscattered* energy that has the same polarization as the radar's receiving antenna is used to define the target RCS. When a target is illuminated by RF energy, it acts like an antenna, and will have near and far fields. Radar cross section fluctuates as a function of radar aspect angle and frequency.
For the purpose of illustration, isotropic point scatterers are considered.
The Electrical spacing defined between two scatterers relative angles is:

$$\textbf{elec\_spacing} = \frac{2 \times S}{\lambda}$$

$$\textbf{RCS} = \textbf{Magnitude}\,(1.0 + \cos((11\pi) \times \textbf{elec\_spacing}) + i * \sin((11\pi) \times \textbf{elec\_spacing}))$$

$$\textbf{RCS(db)} = 20 \times \log_{10}(\textbf{RCS})$$

Symbol	Description
λ	Wavelength
Θ	Aspect Degrees
S	Scatter Spacing
F_u	Upper frequency
F_l	Lower Frequency
RCS	Radar Cross Section
elec_Spacing	Electrical Spacing

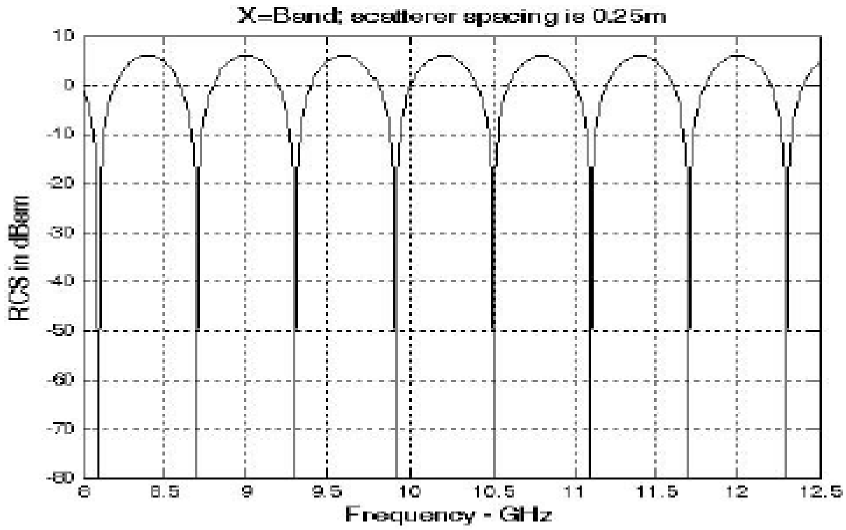

Figure 12.1 Illustration of RCS(dB) dependence on Frequency

Task:

Write a function code in MATLAB which calculates effect of frequency change on RCS. Also, plot the scatters separated by scatter spacing of 0.65m. Plot RCS in dB vs. frequency and attach the code and plots.

MATLAB Code and Results:

LAB SESSION 13

Objective:
Understand and analyse the dependence of scatter spacing on RCS keeping constant operating frequency

Software Required:

MATLAB

Description:

The intensity of the *backscattered* energy that has the same polarization as the radar's receiving antenna is used to define the target RCS. When a target is illuminated by RF energy, it acts like an antenna, and will have near and far fields. Radar cross section fluctuates as a function of radar aspect angle and frequency.
For the purpose of illustration, isotropic point scatterers are considered.
The Electrical spacing defined between two scatterers relative angles is:

$$\textbf{elec\_spacing} = \frac{2 \times S}{\lambda}$$

$$\textbf{RCS} = \textbf{Magnitude}\,(1.0 + \cos((11\pi) \times \textbf{elec\_spacing}) + i * \sin((11\pi) \times \textbf{elec\_spacing}))$$

$$\textbf{RCS(db)} = 20 \times \log_{10} (\textbf{RCS})$$

Symbol	Description
λ	Wavelength
Θ	Aspect Degrees
S	Scatter Spacing
F_u	Upper frequency
F_l	Lower Frequency
RCS	Radar Cross Section
elec_Spacing	Electrical Spacing

Task:

Write a function code in MATLAB which calculates effect of scatter spacing change on RCS. Also, plot the RCS in dB change w.r.t. scatter spacing. Also attach the code and result plots.

MATLAB Code and Results:

Pre-Lab (Lab Session 14)
Concepts: Pulse Compression

14.1 Explain how the Range resolution can be improved by employing pulse compression technique]

14.2 List some pulse compression techniques.

14.3 Discuss LFM Compression technique.

LAB SESSION 14

Objective:
Understand and generate LFM Pulse Compressed signal

Software Required:

MATLAB

Description:

Linear FM pulse compression is accomplished by adding frequency modulation to a long pulse at transmission, and by using a matched filter receiver in order to compress the received signal. Figure 14.1 illustrates the advantage of pulse compression using more realistic LFM waveform. In this example, two targets with RCS $\sigma 1 = 1m^2$ and $\sigma 2 = 0.5m^2$ are detected. The two targets are not separated enough in time to be resolved. After pulse compression the two pulses are completely separated and are resolved as two distinct targets. In fact, when using LFM, returns from neighboring targets are resolved as long as they are separated in time by τ_{n1} , the compressed pulsewidth.

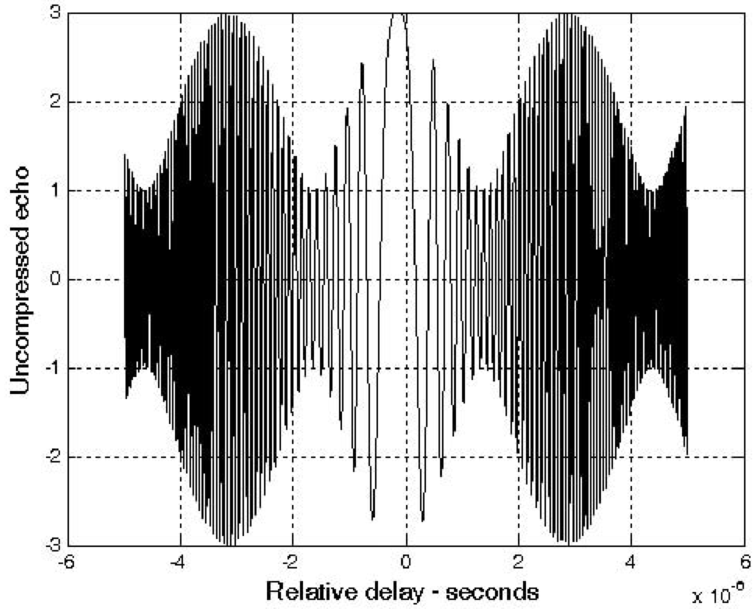

Figure 14.1 Composite echo signals for two unresolved targets

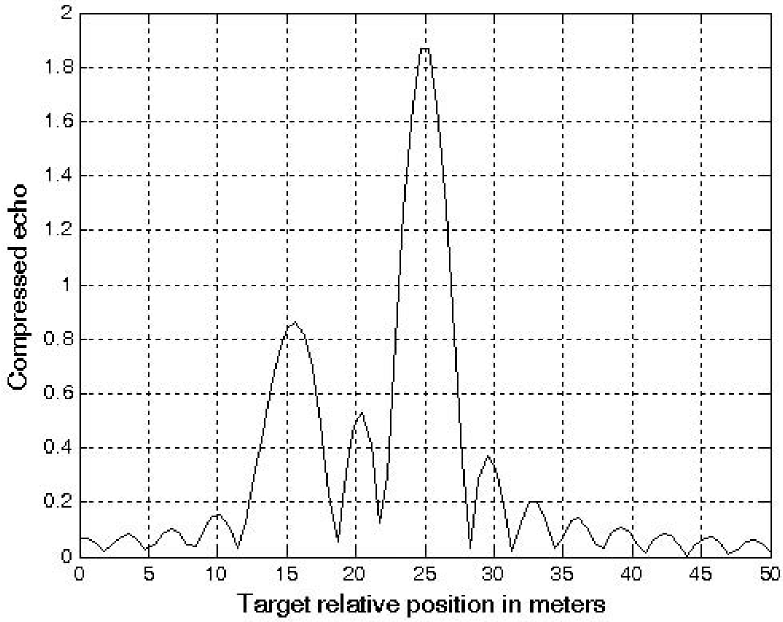

Figure 14.2 Composite echo signals corresponding to Fig. 14.1, after pulse compression

Task:

Write a MATLAB code to generate Linear FM Pulse Compressed signal using Quadrature Channel technique. Also, compute the FFT of the signal and plot I and Q channels. Attach the code and plots.

MATLAB Code and Results: