Zewail City
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Radar Project

Signals and Systems - Spring 2021

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Contents

1 Introduction

RADAR stands for Radio Detection and Ranging System. It is an electromagnetic system used to detect the location and distance of an object from the point where the RADAR is placed. It works by radiating energy into space and monitoring the echo or reflected signal from the objects. It operates in the microwave range with frequencies between 400 MHz to 40 GHz.

Additionally, A radar is an electromagnetic sensor, used to notice, track, locate, and identify different objects which are at certain distances. The mechanism of radar is, it transmits electromagnetic energy in the direction of targets to observe the echoes and returns from them. The targets of the radar may be ships, aircraft, astronomical bodies, automotive vehicles, spacecraft, rain, birds, insects, etc. The radar is able to notice the target's location, velocity, and obtains their shape and size sometimes.

The Radar is basically work as a source and a receiver in the same time. It transmits a specific directed electromagnetic signal using an antenna to detect the surrounding targets and then receive the same signal after hitting the target that locate in its direction using the antenna too. During this operation the radar record the transmitting time and the receiving time and calculate the time taken by the signal to transmit, hit and return, and by knowing the time taken by signal and the speed of the electromagnetic signals $(C = 3 * 10^8)$ the radar can calculate the distance, location, velocity and sometimes shape and size of the target.

2 Results and Discussion

2.1 Task 1:

Figure (1) represents the plotting of the transmitted pulse. The transmitted signal is generated by using the amplitude of the transmitted pulse which is the $\sqrt{TransmittedPeakPower}$. Besides the pulse width is needed which is calculated by dividing the number of the samples "18" by the sampling frequency $"60 * 10^6"$ Hz. Finally, the period is used which is the inverse of the pulse repetition frequency $"0.2 * 10^6"$ Hz. The operating frequency which is 6 GHz is not used as the modulation is not needed to plot the transmitted signal.

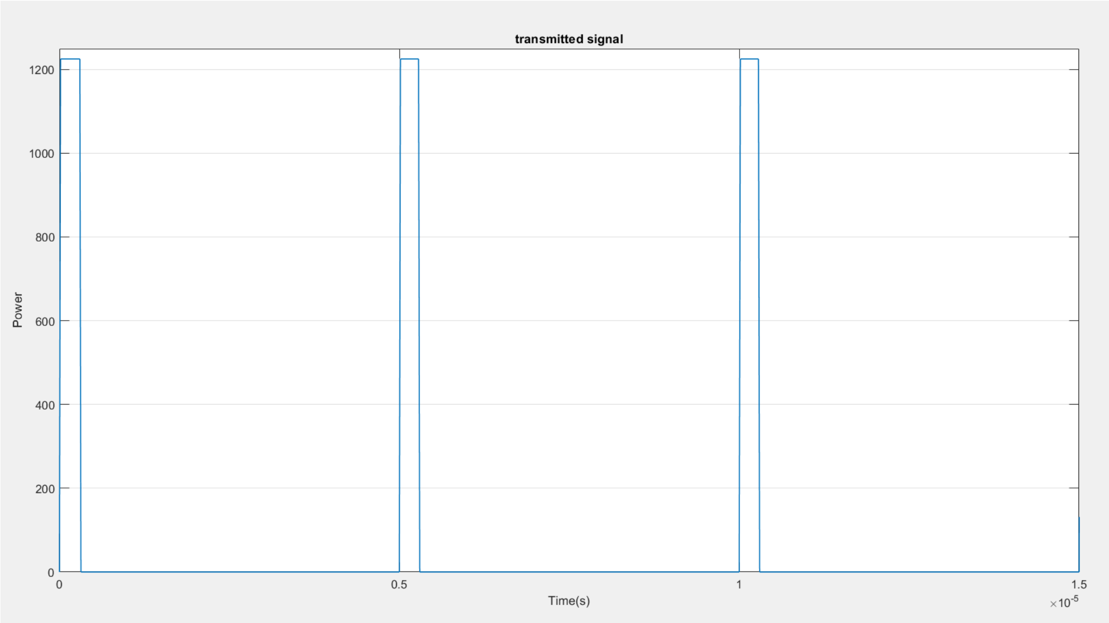

Figure 1: Plot of the Original Transmitted Pulse

2.2 Task 2

The unambiguous range is the maximum range that the transmitted pulse can travel back and forth between consecutive pulses. In other words, The unambiguous range is the maximum distance radar energy can travel round trip between pulses and still produce reliable information.
It is determined by the following equation:

$$R_u = \frac{c}{2f_r} \tag{2.2.1}$$

Where f_r is the pulse repetition frequency which is $0.2 * 10^6$ Hz, and c is the speed of light "$3 * 10^8$" m/s.
*The final result of the unambiguous range is 750 m.

The range resolution is the ability of radar system to distinguish between two or more targets on the same directions but at different ranges. The degree of range resolution depends on the width of the transmitted pulse, the types and sizes of targets, and the efficiency of the receiver and indicator.

The range resolution is determined by the following equation:

$$\Delta R = \frac{c\tau}{2} \tag{2.2.2}$$

Where τ is the pulse width which is $18/(60 * 10^6)$ and c is the speed of light"$3 * 10^8$" m/s.
*The final result of the range resolution is 45 m.

2.3 Task 3

The distance between the radar and the target is calculated by the following equation:

$$d = \sqrt{\frac{\sqrt{\frac{P_t G A_e}{P_r}}}{4\pi}} \tag{2.3.1}$$

Where P_t is the is the transmitted peak power which is $1.5 * 10^6$ Hz.
G is the antenna gain which is 10 dB.
A_e is the radar cross section which is 0.5 m^2.
P_r is the received peak power which is $0.3 * 10^{-3}$ Watt.
*The final result of the distance is nearly 63.0783 m.

The total time taken by the radar to hear back the echo is calculated by the following equation:

$$\Delta t = \frac{2d}{c} \tag{2.3.2}$$

*The final result of the total time is nearly $4.2052 * 10^{-7}$ seconds.

The following figure represents the plotting of the transmitted pulse and the noisy received pulse.

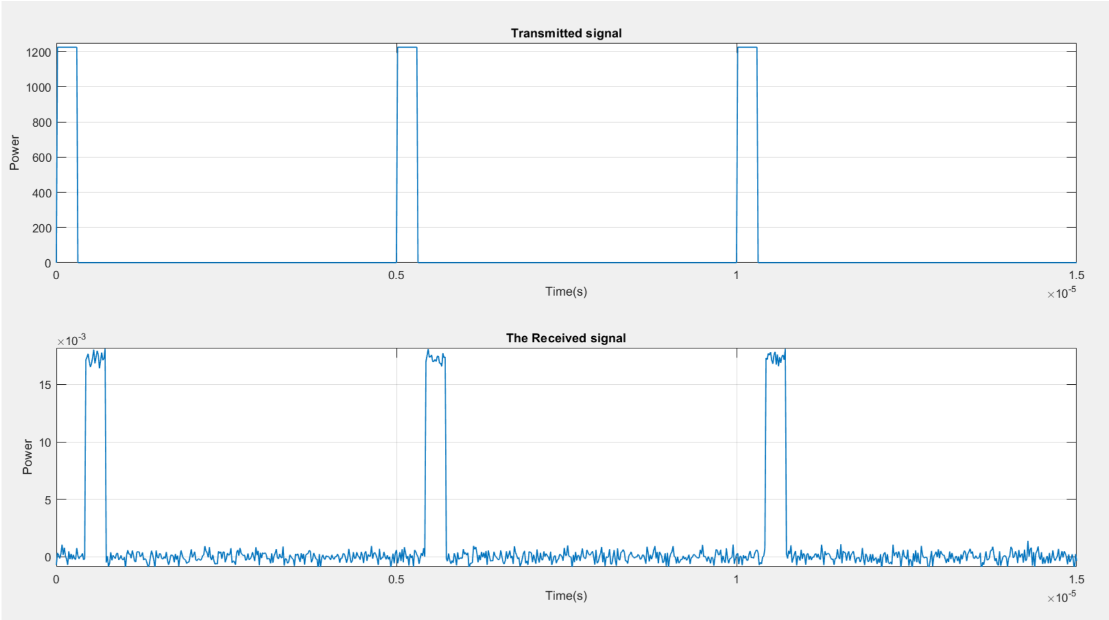

Figure 2: Plotting of the transmitted pulse and received pulse with noise

It is noticed from the previous figure is that the received pulse is delayed by the transmitted pulse by Δt, and the noise appears clearly at the peak of the pulses and at zero.
The noise value is 20 and it is added to the plot by using the function "awgn".

2.4 Task 4

The following figure represents the correlation between the transmitted and received Signals using only one pulse, and hence the result is one triangular pulse with peak value equals to $7.333 * 10^{-7}$, and hence the function used to do the correlation is "conv", then the result is scaled by the pulse width which is $"4 * 10^-7"$ m.
Therefore, the delay will be calculated as follows:
Δt = Peak Value - Pulse Width.
*The final result of the delay is $4.333 * 10^{-7}$ seconds which is consistent with the result of task 3.
It is noticed from the graph is that the correlation increases and then decreases, this happens as a result of the convolution of the transmitted with received signal.
The range is "64.9950 m" which is very close to the range calculated in task 2.

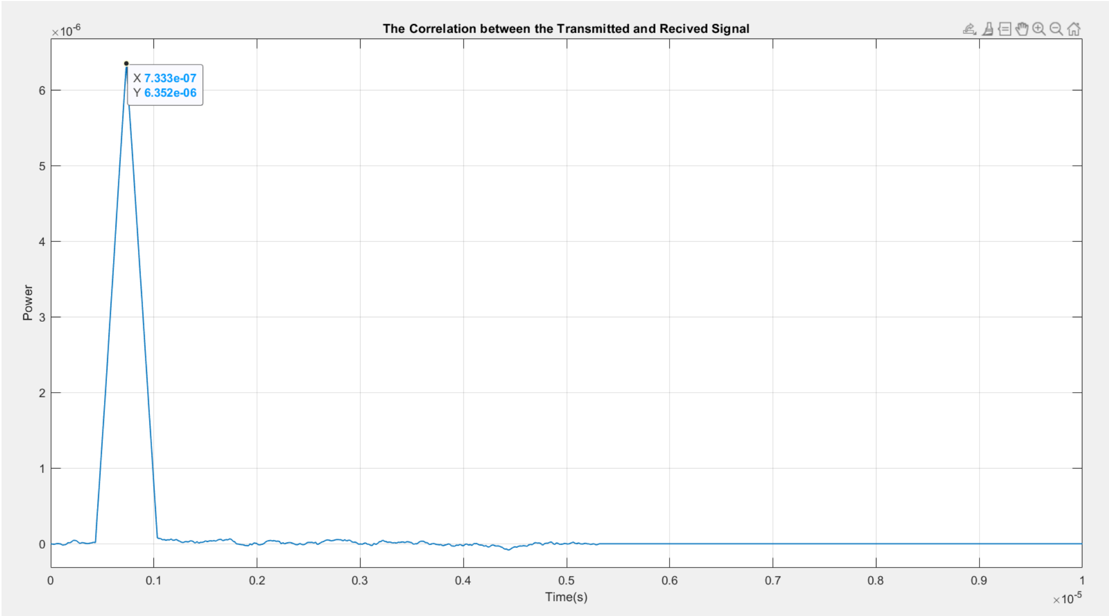

Figure 3: The correlation between the Transmitted and Received Signals

2.5 Task 5

The following figure represents the the correlation between the transmitted and received signals using multiple pulses, therefore the output is multiple triangular pulses with middle peak that has a value "$7.333*10^{-7}$" equal to the value resulting from task 4.
The second figure represents the average of the five peaks resulting from the correlation which is the sum of the peak values divided by their numbers. It is concluded that the value of the peak is the same as the value of the middle pulse and the value resulting from task 4.
As a result of using the "conv" function, the pulse is shifted by the pulse width which is $3*10^{-7}$", Therefore, the delay will be calculated as follows:
Δt = Peak Value - Pulse Width.
*The final result of the delay is $4.333 * 10^{-7}$ seconds which is consistent with the result of task 3.
Additionally, the range is "64.9950 m" which is the same as range of task 4 and very close to the range calculated in task 2.

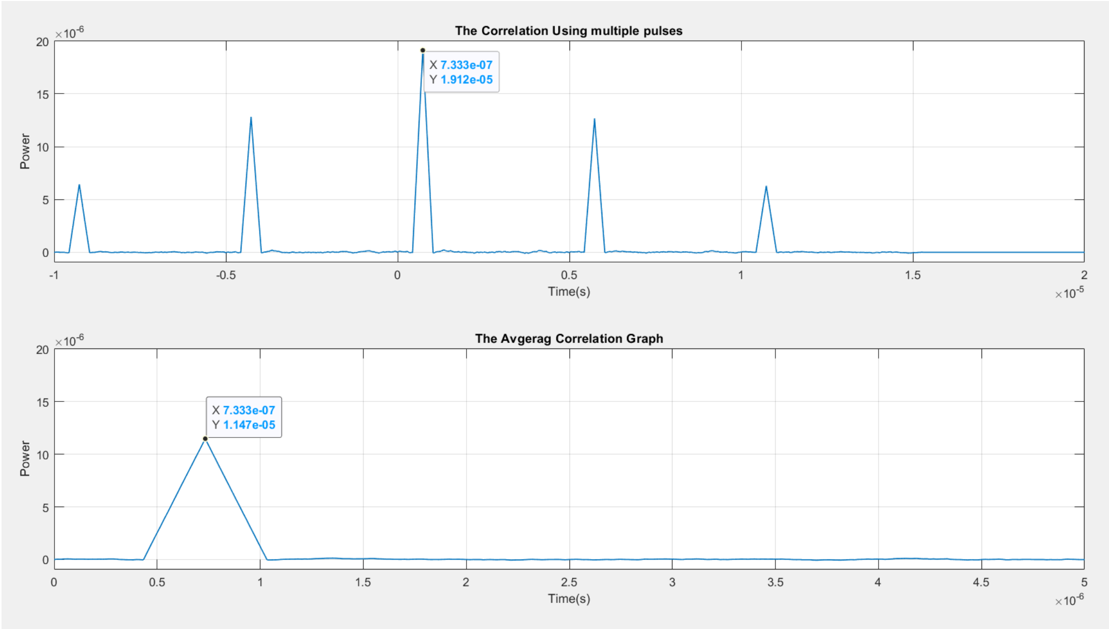

Figure 4: The Correlation between the transmitted and received signal using multiple pulses and plotting the average graph

3 Conclusion

It is concluded that the pulsed radar is very important in signal processing and has many application in most of the life fields. Additionally, the radar is able to locate and notice the target's velocity, location, shape and size. It works by transmitting electromagnetic power as well as examines the energy returned back to the target.

4 References

[1] T. Agarwal. "RADAR - Basics, Types, Working, Range Equation Its Applications." What is a RADAR : Basics, Types Applications. https://www.elprocus.com/radar-basics-types-and-applications

[2] "Advantages of Pulsed Radar — disadvantages of Pulsed Radar." Home of RF and Wireless Vendors and Resources. https://www.rfwireless-world.com/Terminology /Advantages-and-Disadvantages-of-Pulsed-Radar .html