CIE 227 - Radar Project

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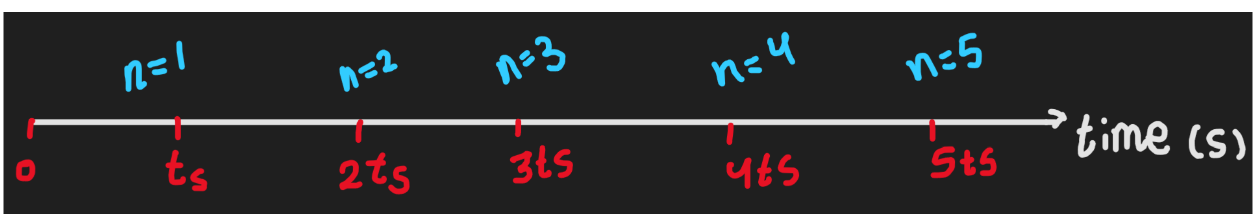
Introduction:

RADAR stands for RAdio Detection And Ranging. Radar device is an electromagnetic based detection system, and its main idea is radiating electromagnetic waves and studying the reflected waves (Echo) reflecting from the objects which provides some information about those objects such as the distance to the target, The angular location of the target, the target is moving or stationary, and a radar can also derive the object track, trajectory, and predict its future location. A radar device has various systems and types depending on the purpose and the used waveform type. Pulsed radar is one of these types that rely on pulses transmission, and it uses one antenna for both, transmitting and receiving.

Results and Discussion:

Note: For plotting, we divided the discrete scale according to the ***ts*** (sample period) not using integers.



Task 1:

In this task, we need to calculate 2 main things:

1. ts = 1/60MHz
2. PRI = 1/0.2MHz

After that, an important part is to calculate the amplitude of the peak.

Amplitude

$$P_{av} = \frac{1}{18} \sum_{n=0}^{17} |x[n]|^2 = \frac{1}{18} \sum_{n=0}^{17} A^2 = \frac{\cancel{18} A^2}{\cancel{18}} = A^2$$

we know that

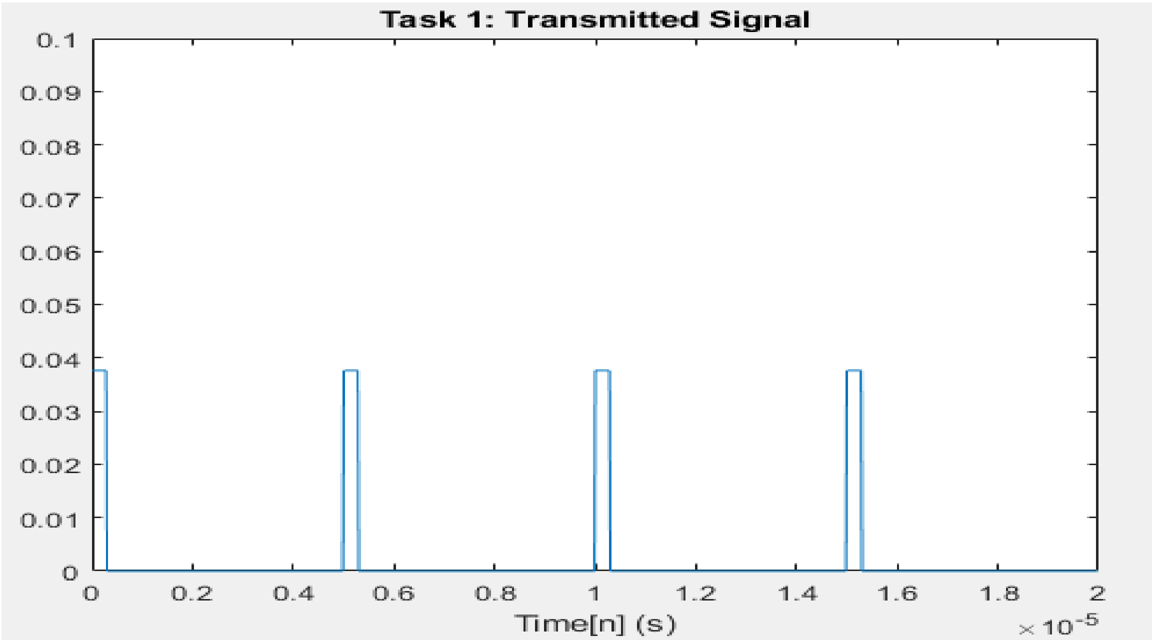
Pulse width

$$P_{av} = P_t \times d_t \quad , \quad d_t = \frac{\tau}{T} \longleftarrow \frac{PRI}{T}$$

$$\therefore \quad A^2 = P_t \times \frac{\tau}{T} \Rightarrow \boxed{A = \sqrt{P_t \times \frac{\tau}{T}}}$$

Now after that, Amplitude = 0.0376

Then plot the results:



Task 2:

Using **pulse_train.m** function (reference Radar Fundamentals Chapter, Listing 1.1)

The delta t used in such function = 1.0e-3 s

Unambiguous Range(m) = 1.0e-3 * c * PRI / 2.0 *1000

= 750 m

Range Resolution(m) = c * tau/ 2.0

= 42.5 m

Where tau = ts * (samplesNumber - 1) is the sample width. And the samplesNumber = 18

Task 3:

To calculate the range d we use the radar equation:

$$P_r = \frac{P_t G \sigma}{(4\pi d^2)^2} A_e$$

$$\therefore 4\pi d^2 = \sqrt{\frac{P_t G \sigma A_e}{P_r}}$$

$$\boxed{\therefore d = \sqrt{\frac{1}{4\pi}\sqrt{\frac{P_t G \sigma A_e}{P_r}}}}$$

Thus, **d=63.0783 m.**

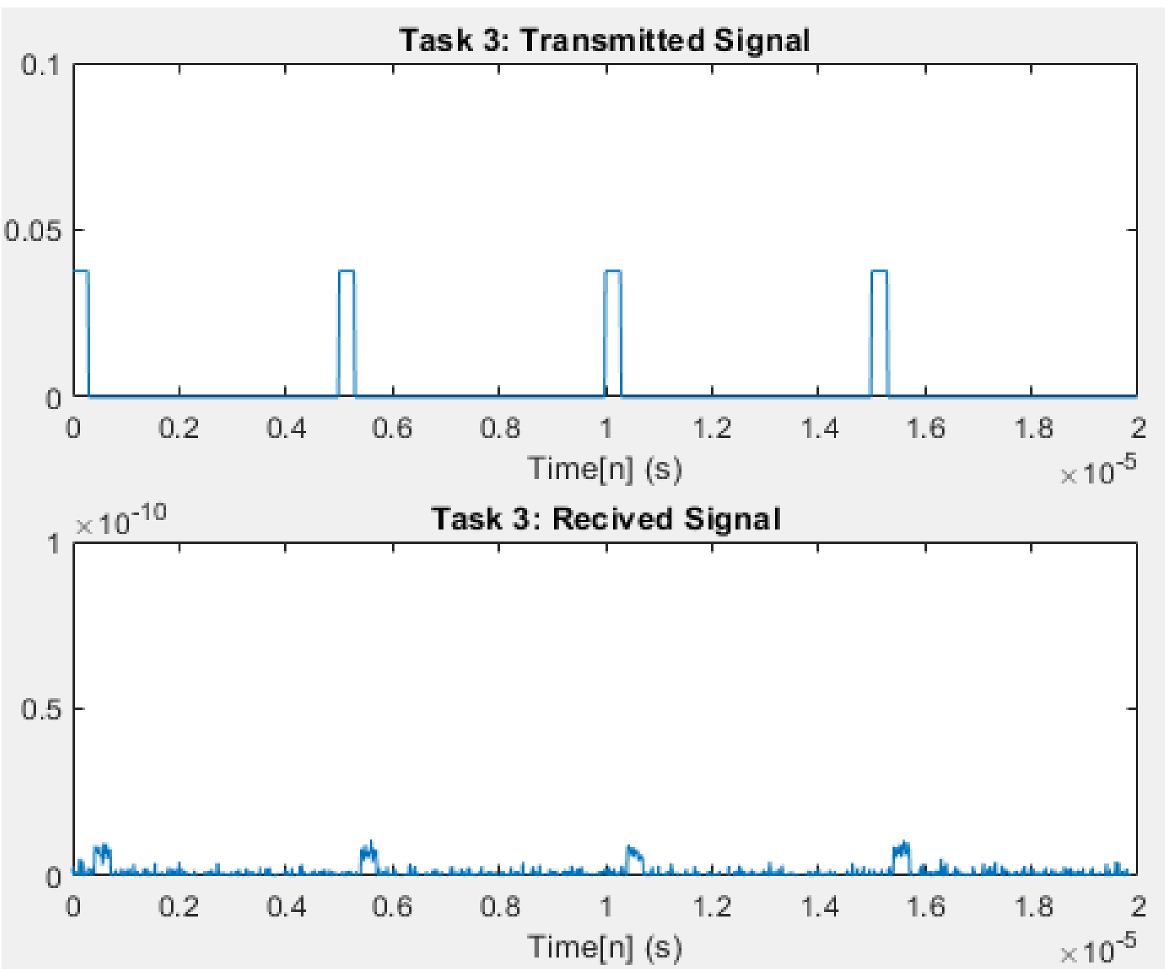
After that we calculate delta t = 2 * d / c

delta t = 4.2052e-07 s

For plotting the echo, the scaled factor will be.

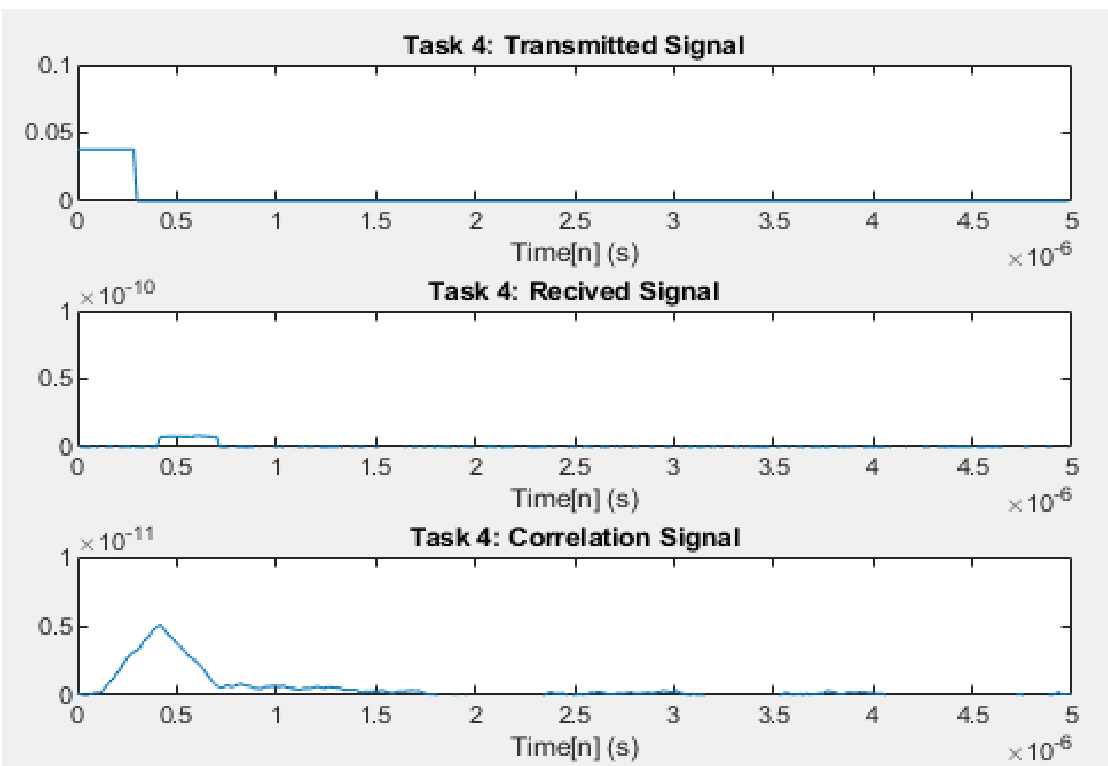
$$\boxed{\text{scale} = \frac{G\sigma}{(4\pi d^2)^2} A_e}$$

thus, plotting the signals:



Task 4:

Using the xcorr matlab function we can get the correlation as follows:



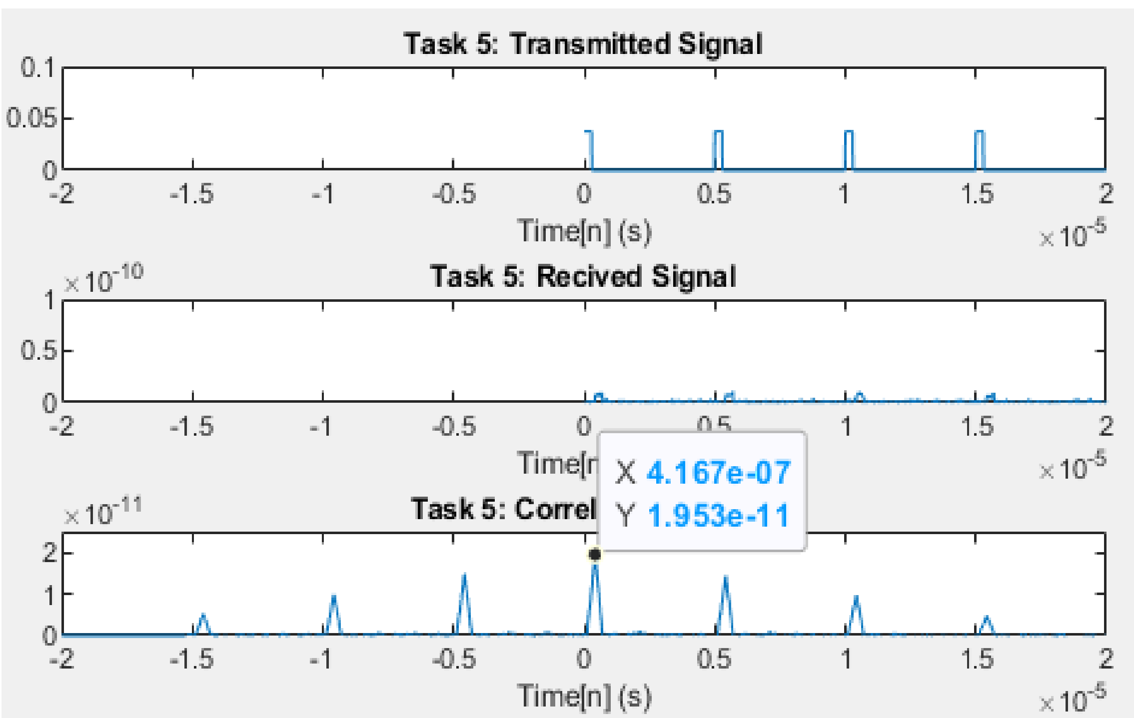
Apparently delta_t in graph 3 = 4.167e-7 s.

Thus, the **range = c * 4.167e-7 /2 = 62.505.**

Error = 100*(63.0783 - 62.505) / 63.0783 = 1.6%

Task 5:

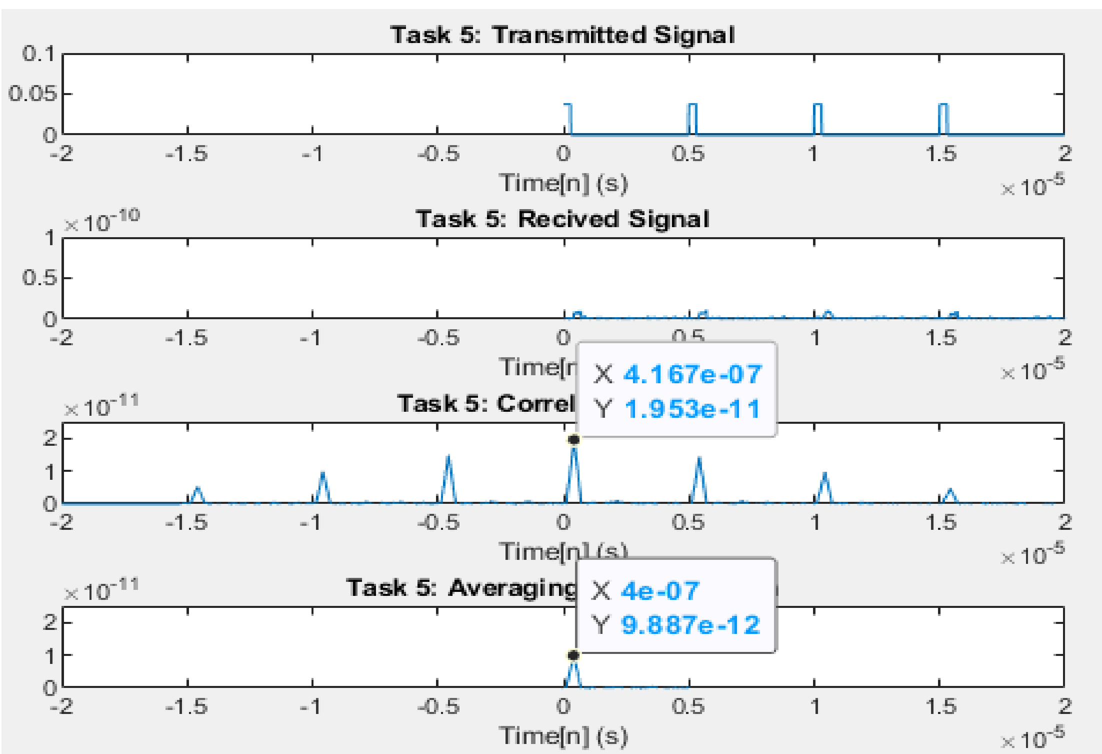
Using same approach for the multi-values we get the following:



- **Attempting to average the graph:**

As requested, if the middle peek was not clear an average should be made.
We took the first 5 segments of the correlation, added them then divided them by 5.

The result was the following:



Apparently delta_t is = 4.0e-7 s.

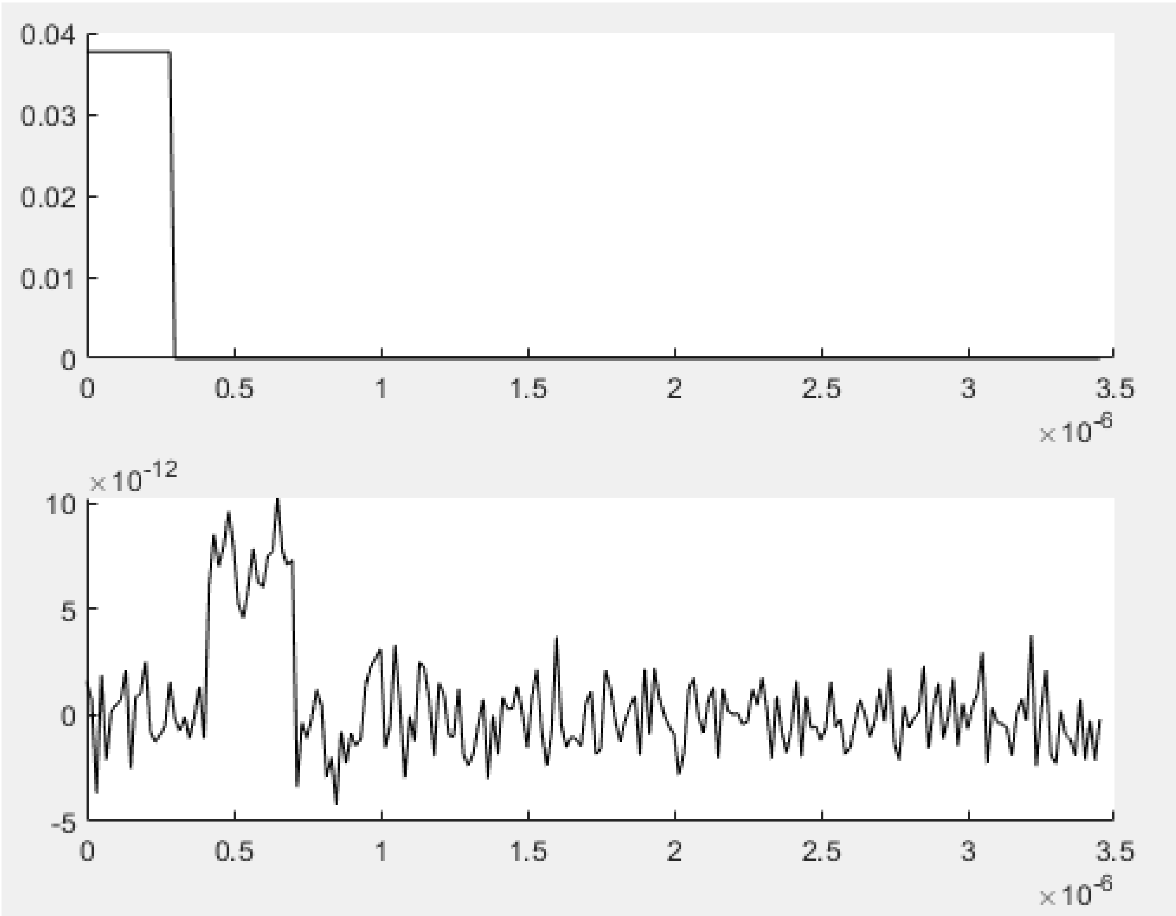
Thus, the **range = c * 4e-7 /2 = 60 m.**

Error = 100*(63.0783 - 60) / 63.0783 = 4.8%

The error is higher due to the noise averaging. In fact, without averaging the peak was more clear and less error. But in some cases, the noise could be high enough so that the peak does not appear. In our example we used a small amount of noise. And that is why the error is higher after averaging.

Task 6 (Bonus):

To animate the process, we used ***animatedline*** MATLAB built-in function. And the process was done easily.



Conclusion:

To sum up, Radar digital analysis can be simulated using tools like MATLAB. Transmitted and received pulses can be generated, analyzed, and correlated to detect precisely the range of the target. The more the power of the transmitted pulses the more accurate the result can be by averaging the correlation of the received waves to be a great application for various fields.

References:

- The reference here is the Radar Fundamentals Chapter attached to Lecture 10. And some MATLAB documentation to use the functions.
- https://www.tutorialspoint.com/radar_systems/radar_systems_pulse_radar.htm
- https://helitavia.com/skolnik/Skolnik_chapter_1.pdf
- Skolnik_chapter_1.pdf (helitavia.com)