# Pulse Radar System

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# Context

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# INTRODUCTION

Pulse radar emits short and powerful pulses and in the silent period receives the echo signals. In contrast to the continuous wave radar, the transmitter is turned off before the measurement is finished.

This method is characterized by radar pulse modulation with very short transmission pulses. The distance of the reflecting objects is determined by runtime measurement (at a fixed radar) or by comparison of the characteristic changes of the Doppler spectrum.

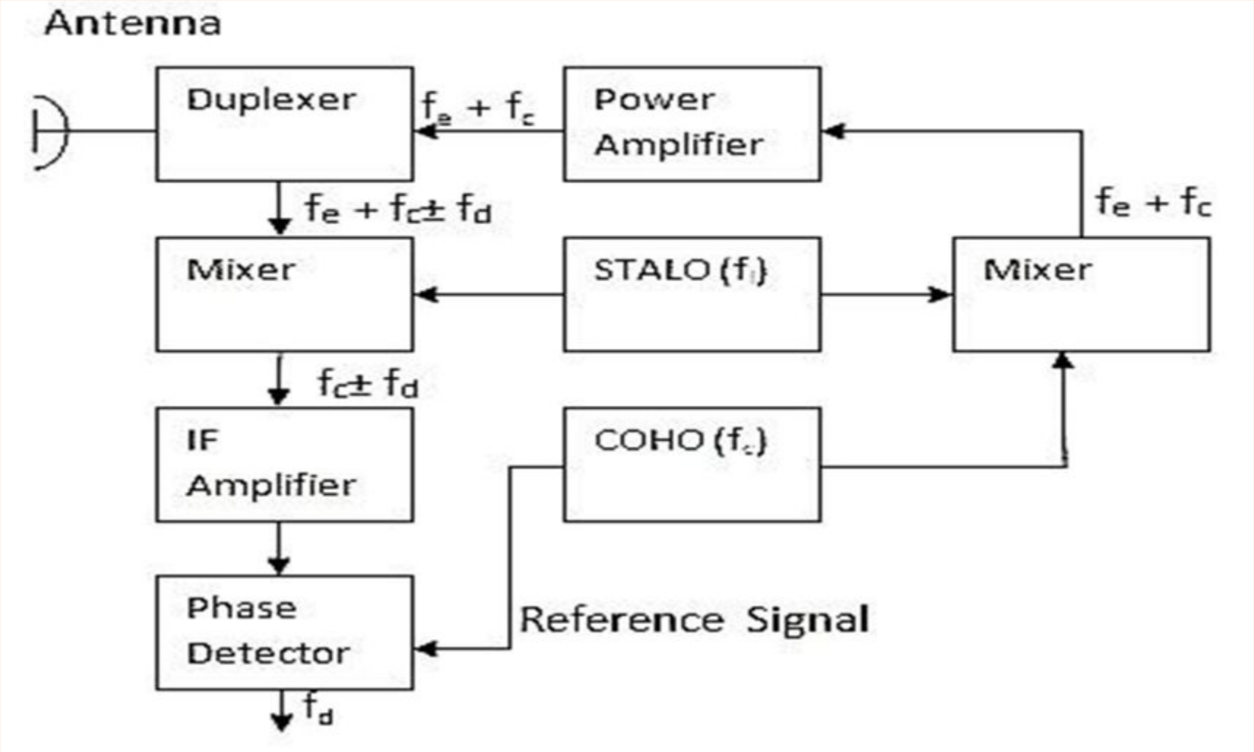
Pulse radars are mostly designed for long distances and transmit a relatively high pulse power.

# MOTIVATION

Important distinguishing feature to other radar method is the necessary time control of all processes inside the pulse radar. In pulse radar, multiple pulses are transmitted to cover search patterns, to track moving targets, to integrate several targets return to improve detection.

Pulse radar also provides greater measurement range as compared to other radar systems. In pulse radar the transmitter is in an “off” state. Although the transmitter is not powered and active so that it is able to detect any signals reflected by radar targets or returned by transmitters.

# BLOCK DIAGRAM



# EXPLANATION

Pulse radar employs a power amplifier as a transmitter. It has high stability and it is capable of transmitting high power.

To employ Doppler if the phase of the local oscillator where to change significantly between pulses and an uncancelled clutter residue can result at the output of the delay line canceller which might be mistaken for a moving target even though only clutter were present.

To recognize the need for high stability, the local oscillator of a pulse radar receiver is called stable local oscillator.

This difference is the Doppler frequency. Coherent oscillator is used to signify the reference signal that has same phase with transmitted signal The coherency is obtained by the sum of coho(Coherent Oscillator) and stalo(stable local oscillator) signals as the input signal to the power amplifier. The transmitter frequency is fc+fl.

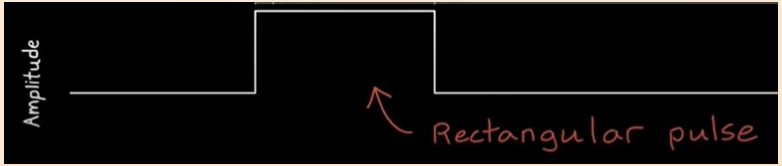
The output of the phase detector is the input to the Delay Line Canceller that acts as High pass filter to separate the Doppler shifted echo signals of moving target from unwanted echoes.

# WORKING PRINCIPLE

Pulse radar systems sends out short pulses of energy waves followed by long periods of silence where the receiver is listening for the reflected signal.

The radar transmits for a certain amount of time called the pulse width, and in our design we are using a pulse width of 2 ms.

In a pulse radar system, the pulse is to radiate out the reflection of an object and return to the radar before the next pulse is sent. This is so that there is no ambiguity as to which pulse the other echo belongs to.



# WORKING PRINCIPLE

In the design, a pulse repetition frequency (PRF) of 0.01 kHz is used. The maximum unambiguous range for this system is :

Max Range = (C/2 )* (100 ms)= 15000 Km

After the pulse is sent, the receiver starts listening, and even before the pulse returns, there is some amount of noise power from environment.

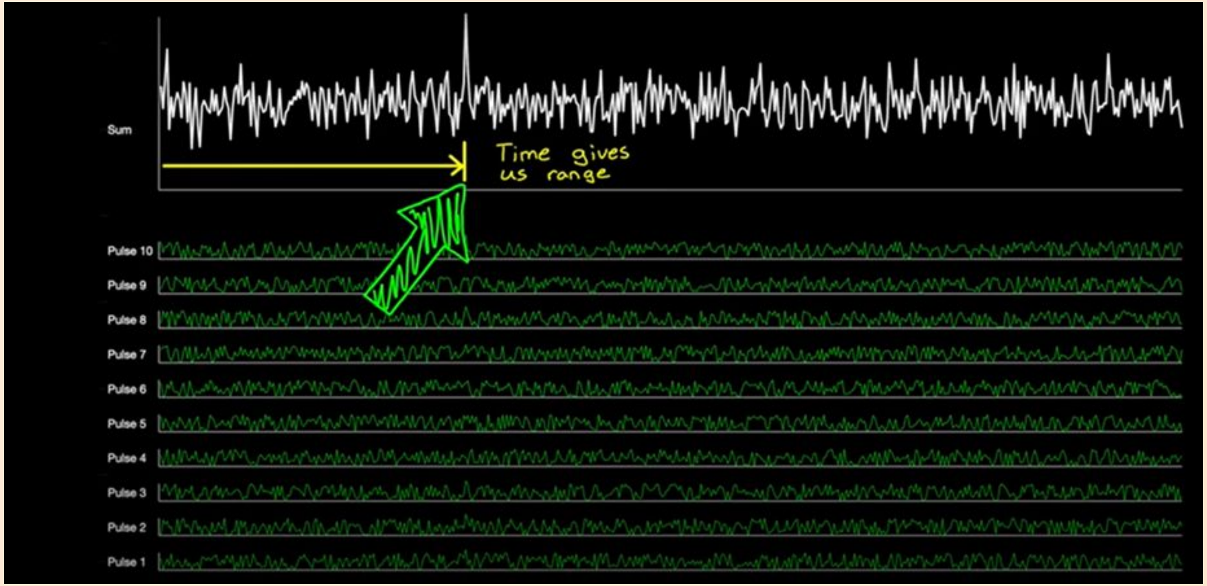
When the reflected signal returns, hopefully it is much greater than the noise, and we can determine the time between when the pulse was sent and when it returned.

So as the object gets further away, it becomes more difficult to pull it out of the noise, which brings us to the second thing that the signal to noise ratio and the threshold at which an object is detectable.

To increase the probability of detection and decrease the probability of false alarm, which can be achieved is with a matched filter.

After passing through a matched filter, this has the effect of amplifying the signal and making the signal more narrow by turning that wide rectangle into a single-peaked triangle. This is called pulse compression.

# WORKING PRINCIPLE

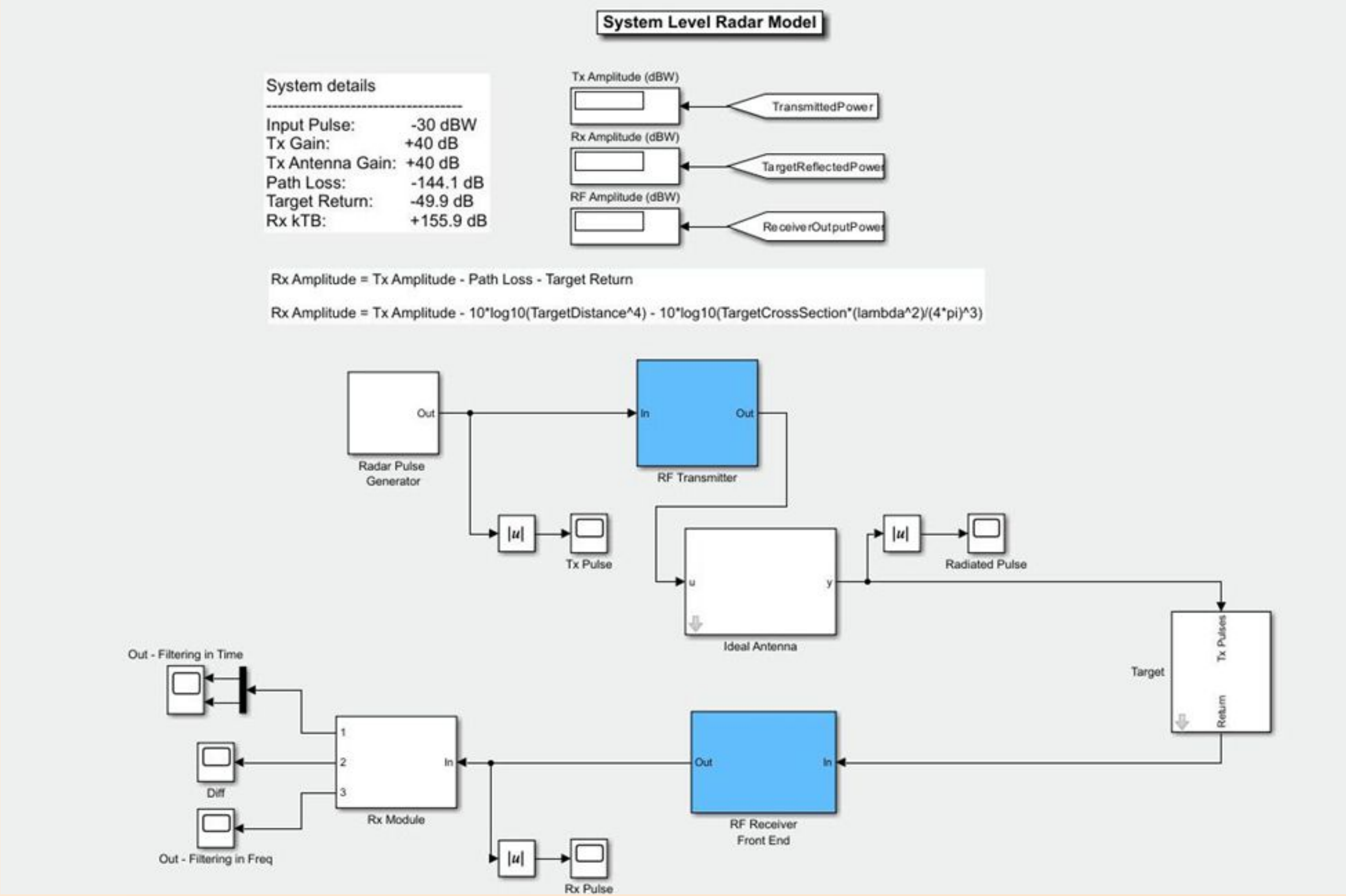



This type of filter amplifies the signal more than the noise since there is a correlation between the pulse and the received signal, whereas there is going to be a lower correlation with random noise. Most importantly, it gives an improved SNR.

# IMPLEMENTATION

The system consists of:

1. A radar pulse generator, which outputs a chirp with a power of 1 mW at a 2% duty cycle (On time = 2 ms, period = 100 ms).
2. An RF transmitter section consisting of a filter and an Amplifier implemented using RF Blockset Circuit Envelope library blocks. Since the filter is a linear device and the amplifier is a non-linear device, they are split into two separate independent subsystems.
3. An ideal antenna element with specified bore sight gain operating at 2.1 GHz.
4. A moving target implementation that reflects the entire incident signal from its cross-sectional surface. The target surface is perpendicular to the incident radar pulse direction of travel.
5. An RF Receiver built using the RF Blockset Circuit Envelope library. The direct conversion structure is implemented in the receiver together with LNA and matching networks.


System Level Radar Model
System details
Input Pulse: -30 dBW
Tx Gain: +40 dB
Tx Antenna Gain: +40 dB
Path Loss: -144.1 dB
Target Return: -49.9 dB
Rx kTB: +155.9 dB
Tx Amplitude (dBW)
TransmittedPower
Rx Amplitude (dBW)
TargetReflectedPower
RF Amplitude (dBW)
ReceiverOutputPower
Rx Amplitude = Tx Amplitude - Path Loss - Target Return
Rx Amplitude = Tx Amplitude - 10*log10(TargetDistance^4) - 10*log10(TargetCrossSection*(lambda^2)/(4*pi)^3)
Out
Radar Pulse Generator
In
Out
RF Transmitter
|u|
Tx Pulse
u
y
Ideal Antenna
|u|
Radiated Pulse
Target
Tx Pulses
Return
Out - Filtering in Time
1
2
3
In
Rx Module
Diff
Out - Filtering in Freq
|u|
Rx Pulse
Out
In
RF Receiver Front End

# OBSERVATION

From time graph the range of the target can be calculated as:

 $\Delta T = 0.1s$

Unambiguous range= (c*  ΔT)/2 = (3*10^8 *0.1)/2=15000km

Path loss=-144.1dB

Noise at Rx KTB=155.9dB

Transmitted power = 48.52dBw

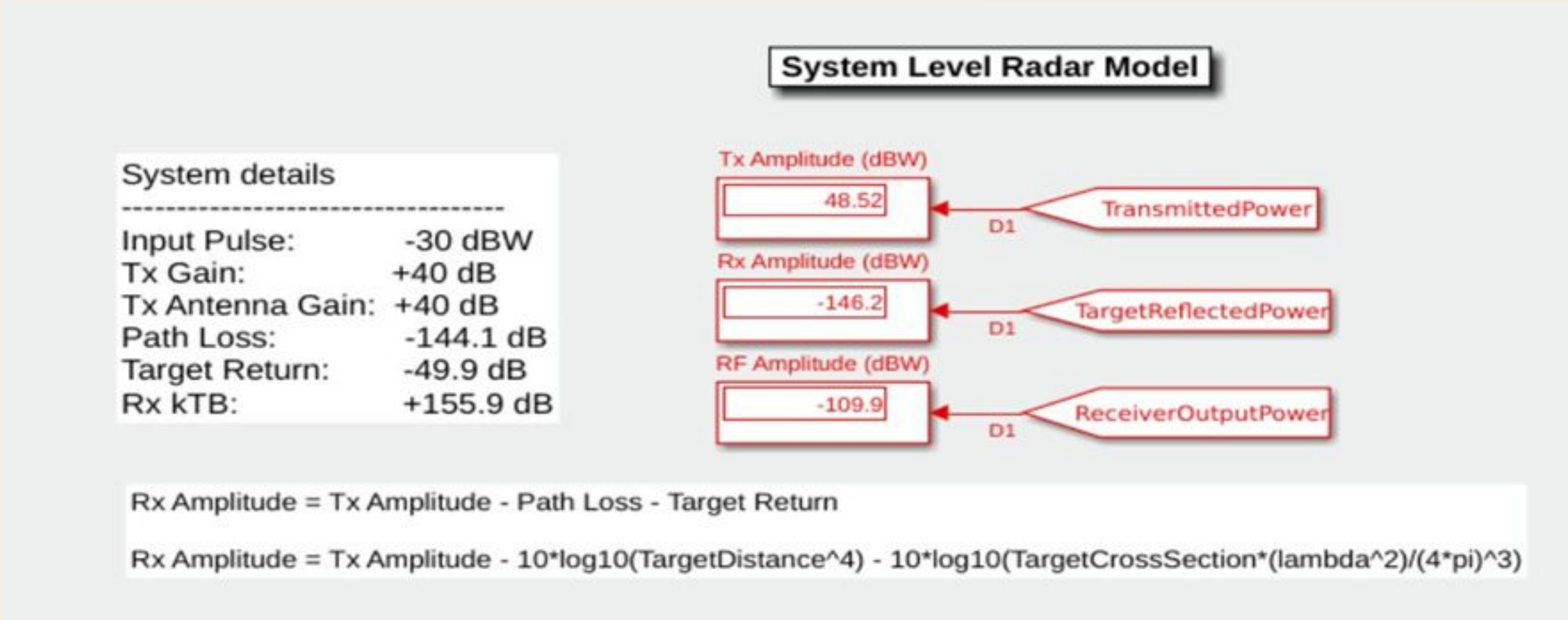
Target reflected power= transmitted power- 10*log(range^4)-10*log(rcs*(lamda)^2/(4*pi)^3)

= -156.48dBw

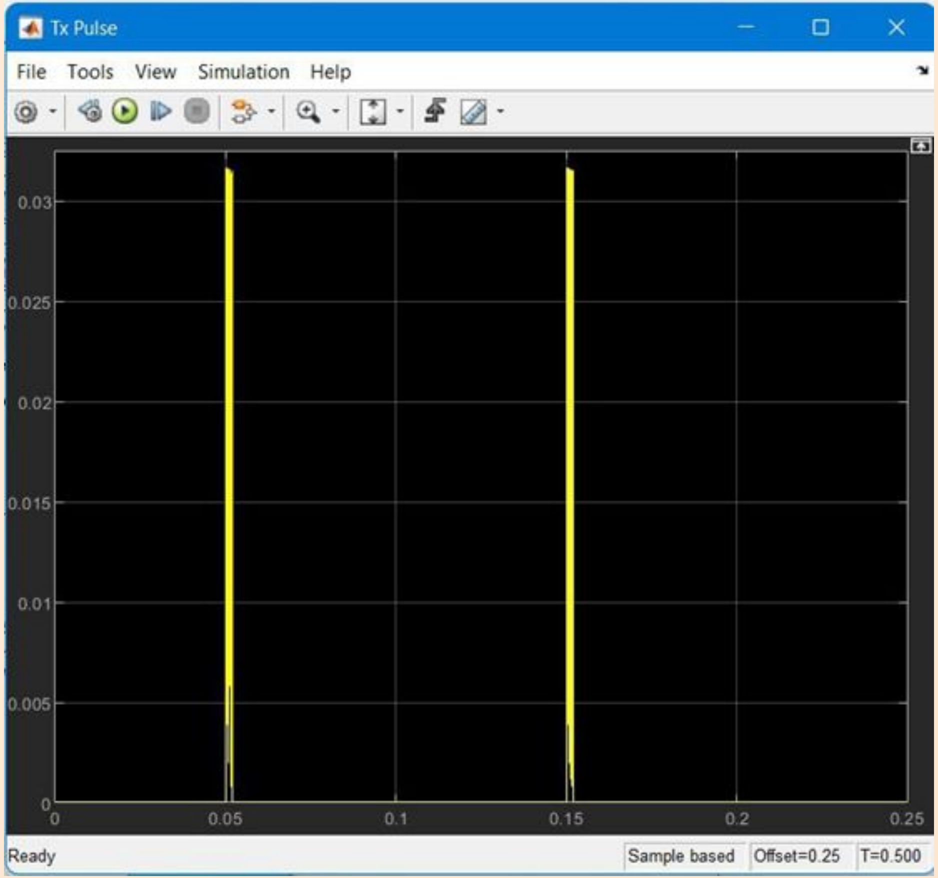
Here, simulated value is -146.1 dBw and calculated value is -156.48 dBw

Error percentage= 6.63%

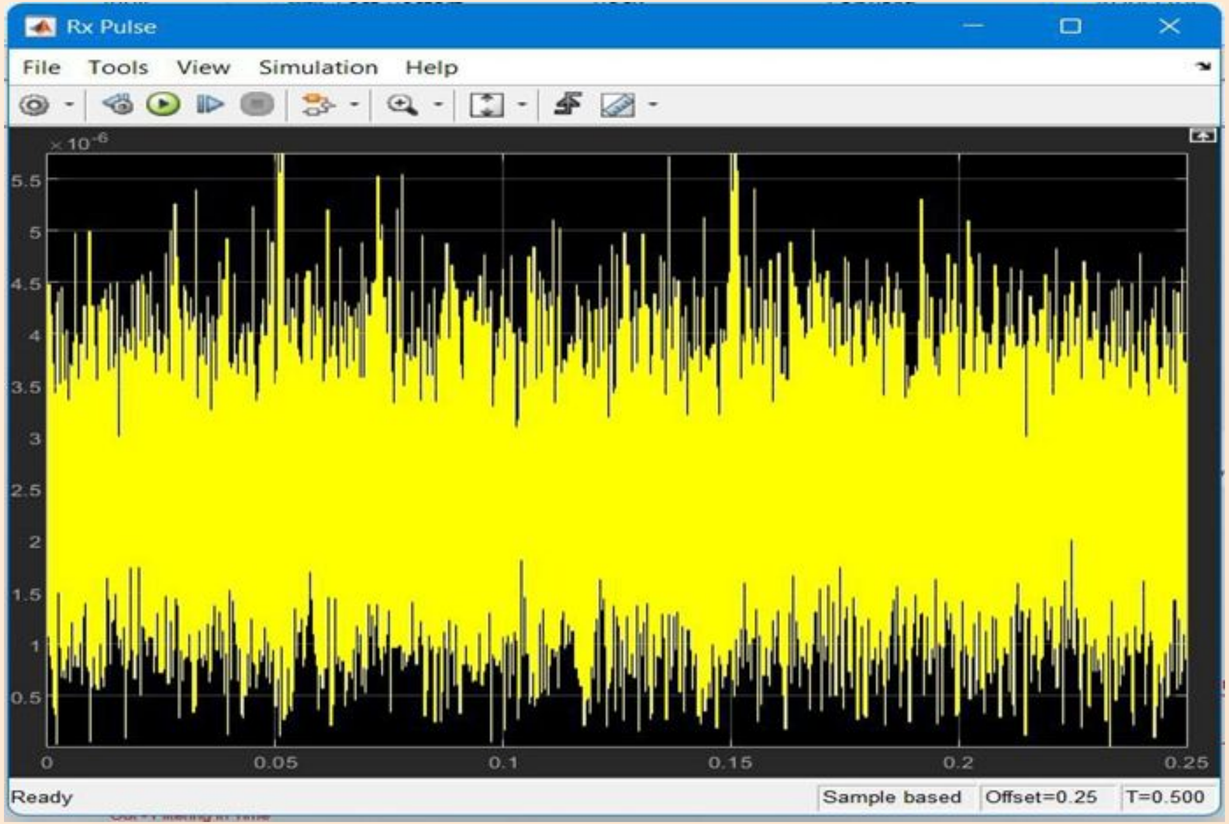
# SIMULATED OUTPUT



Tx Pulse

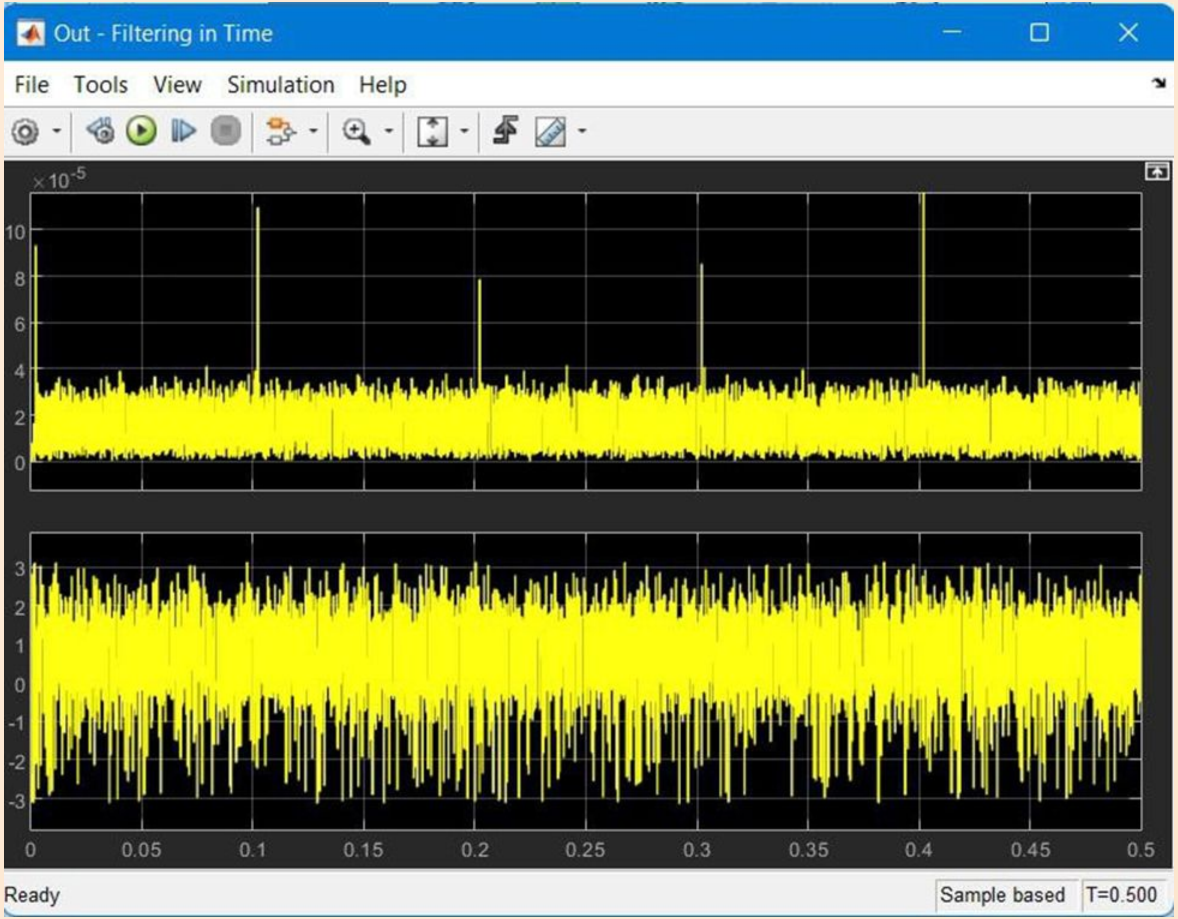

Tx Pulse
File Tools View Simulation Help
0.03
0.025
0.02
0.015
0.01
0.005
0
0
0.05
0.1
0.15
0.2
0.25
Ready
Sample based
Offset=0.25
T=0.500

Rx Pulse



Rx Pulse
File
Tools
View
Simulation
Help
×10^-6
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0.05
0.1
0.15
0.2
0.25
Ready
Sample based
Offset=0.25
T=0.500

Time Graph


Out - Filtering in Time
File
Tools
View
Simulation
Help
×10^-5
10
8
6
4
2
0
3
2
1
0
-1
-2
-3
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5
Ready
Sample based
T=0.500

# CONCLUSION

We have implemented the pulse radar system, simulated it using Simulink. The outputs are displayed and results are calculated. Pulse radars are designed mainly for long distances.

Pulse radar is used for military purposes. Other applications include air traffic control, weather observation (especially precipitation radar) as well as the satellite-based remote sensing of the earth's surface.

Thank You!