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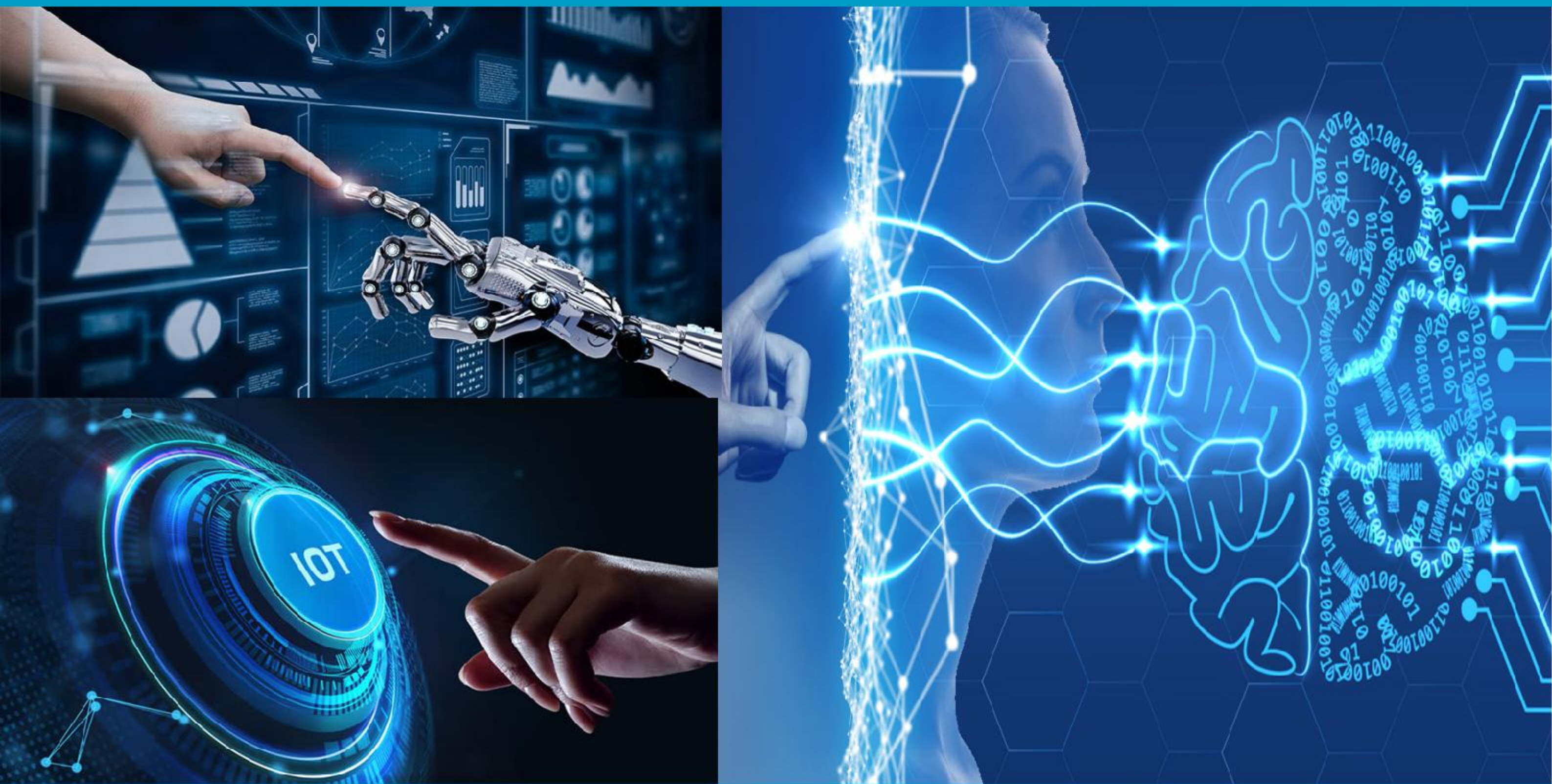


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# Target Detection by Radar Using Linear Frequency Modulation

**Kartik, Kirandeep**

M.Tech, Department of Electronics and Communication Engineering, S K I T M, Bahadurgarh, India

Assistant Professor, Department of Electronics and Communication Engineering, S K I T M, Bahadurgarh, India

**ABSTRACT**

The greatest distance that a target can identify another target is known as range detection. The ability of the radar to tell between two objects that are close together is known as range resolution. Using short duration pulses helps improve range resolution. However, employing brief pulses reduces range detection. Techniques for pulse compression are utilised to address these problems. For pulse compression, we employ a Linear Frequency Modulated (LFM) Wave since it has a large working bandwidth. Stretch processing and matching filter processing are two different correlation procedures that are used. For wide-band signals, Stretch Processor is employed, whereas Matched Filter is used. Also investigated in this thesis are changes in Doppler Frequency, changes in Time-Bandwidth Product and the influence of different kinds of windows on LFM waves. A masking effect is noticed on the echo of a distant target due to the echo of a close target. The many strategies for removing the masking effect are reviewed in this article.

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## I.INTRODUCTION

The term "radar" stands for "Radio Detection and Ranging." It is an electromagnetic system that transmits and receives signals from things within its range in order to detect and locate them. The received echoes are analyzed to determine the target's range, angular location, velocity, and other parameters. The reflected energy that is returned to the radar not only signals the presence of a target, but it can also be used to extract information about the target by comparing the received echo signal to the transmitted signal.

The basic principle of radar is shown is Figure 1.1. A transmitter generates a signal (a short pulse or sine wave) that is radiated into the space through a antenna. A part of the transmitted signal is intercepted by the target object and is reflected back in many directions. The reflected signal is collected by the antenna of the radar which inputs it to a receiver. Processing occurs to detect the presence of the target and to determine its location. A single antenna is generally used on a time-shared basis for both transmitting and receiving where the radar signal is a continuous series of pulses. Range can be measured by calculating the time the signal takes to travel to the target and return back.

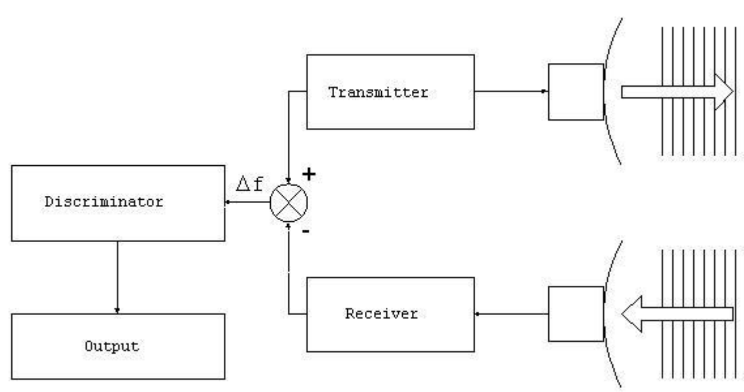


***Fig 1.1***- *Basic Principle of Radar*

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The range to a target is determined by the time it takes for a radar signal to travel to the target and back. Suppose TR is the time taken by the signal to travel to a target situated at a distance R and back. Thus the total time taken is given by

$$TR=2R/c$$

*Where c is the speed of light, c=3 x* $10^8$*m/s.*

Thus the range to the target is

$$R=cTR/2$$

## II. LITERATURE REVIEW

Radar is introduced at this point. Equations are provided for range and the largest unambiguous range. There are a number of things to keep in mind while building an antenna, and it is described what kind of pulse is needed in each situation. After taking into account all the variables, the requirement for pulse compression is shown. There is also discussion of the thesis' goalPulse compression through various correlation operators and their response to wide-band and narrow-band signals Analyzing the LFM signal considering the time bandwidth product, Doppler Effect and effect of windows.

## III. TARGET'S DISTANCES

Time it takes a radar signal to reach and return from a target determines its distance. Assume TR is the signal's to-and-from travel time for R miles. So, time is given by

$$TR=2R/c$$

*Where c is the speed of light, c=3 x* $10^8$*m/s.*

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Thus the range to the target is

$$R=cTR/2$$

## IV.UNAMBIGUOUS MAXIMUM RANGE

Before the next pulse is delivered, there must be enough time after a signal has been sent into space for all echoes to return. If the gap between signals is too small, a long-range object's echo signal might be detected after the next pulse has been sent. Such an echo might be deceptive. Maximum unambiguous range is given by

$$R_{un}=cT_p/2$$

*Where $T_p$ is the pulse repetition period*

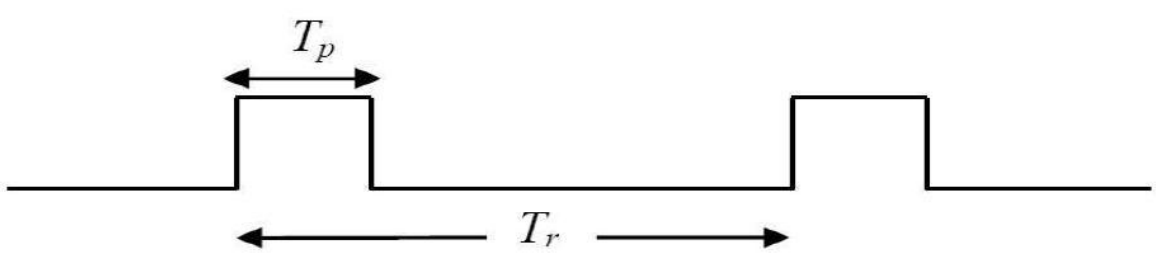


***Fig 1.2***-*A Radar Pulse*

## V.MAKING THE TRANSMITTER'S DESIGN

For a very brief pulse to have enough energy for long distance transmission, the peak power must be high. However, the radar apparatus becomes heavier and the antenna sensors start to burn since it must handle a strong peak power pulse. For a successful range detection, a pulse at the transmitter must have a low peak strength and a longer duration. Better range resolution requires a concentrated echo with a high peak intensity at the receiver end. [4].Therefore, pulse compression is performed.

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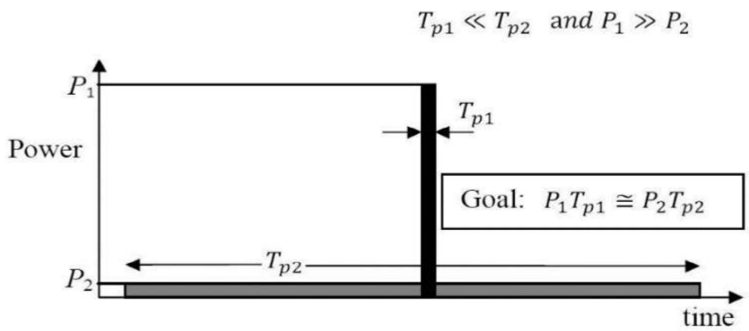


***Fig 1.3****-Receiver and Transmitter Signals*

## VI.PULSE CONSTRICTION

In radar, sonar, and echography, the pulse compression method is often employed to improve range resolution, range detection, and signal-to-noise ratio (SNR). To achieve this, modulate the pulse that is delivered, and compare the returned pulse to the signal that was sent.[1].

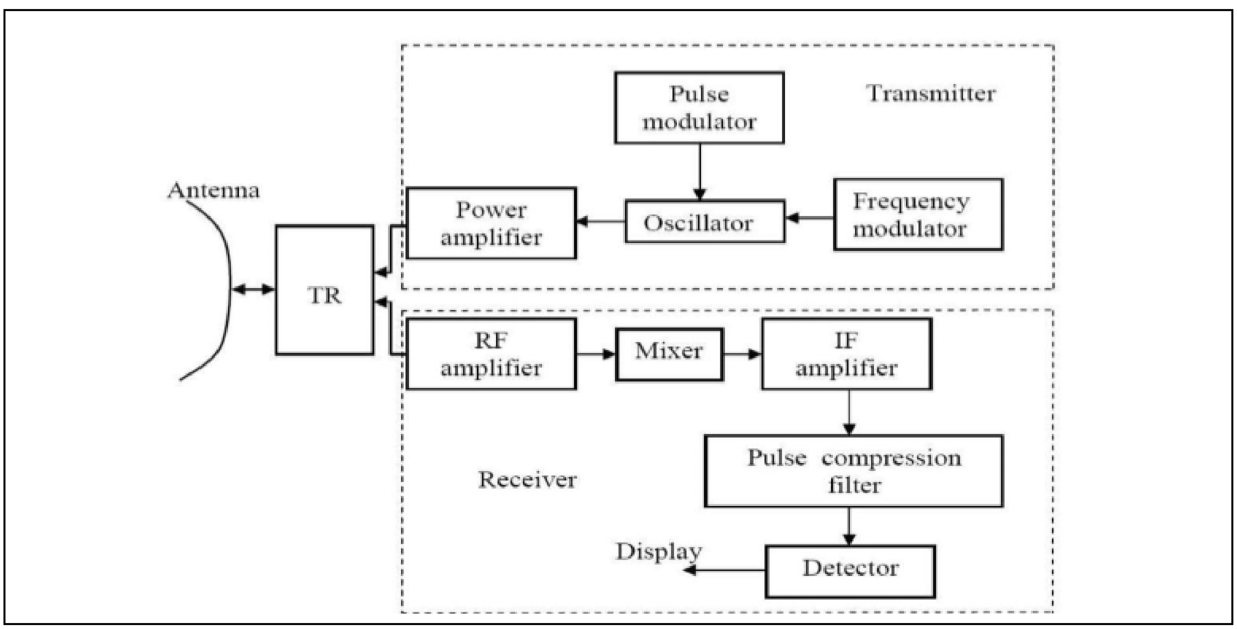


***Fig 2.1****-Antenna block schematic for a radar*

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# VII.MODULATION OF LINEAR FREQUENCY

In order to attain broad operating bandwidths, linear frequency modulation is widely utilised in radar systems. In this scenario, the transmitted wave's frequency either rises (up-chirp) or falls (down-chirp) over time.

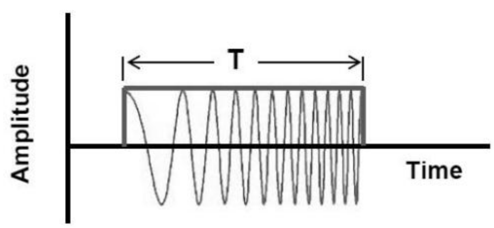


***Fig 2.2*** *-Increasing Intensity(Upchirp)*

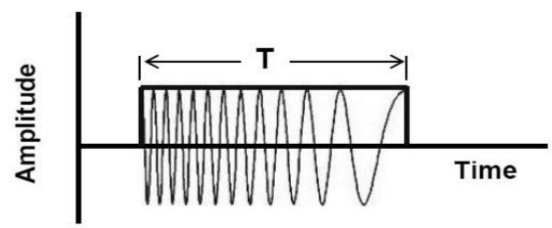


***Fig2.3****-Decreasing Frequency(Downchirp)*

The chirp signal's instantaneous phase is written as:

$$Ø(t) = 2\pi(f_1 t + kt^2)$$

$$K =$$

The formula for instantaneous frequency is

$$f(t) = \qquad = f_1 + kt$$

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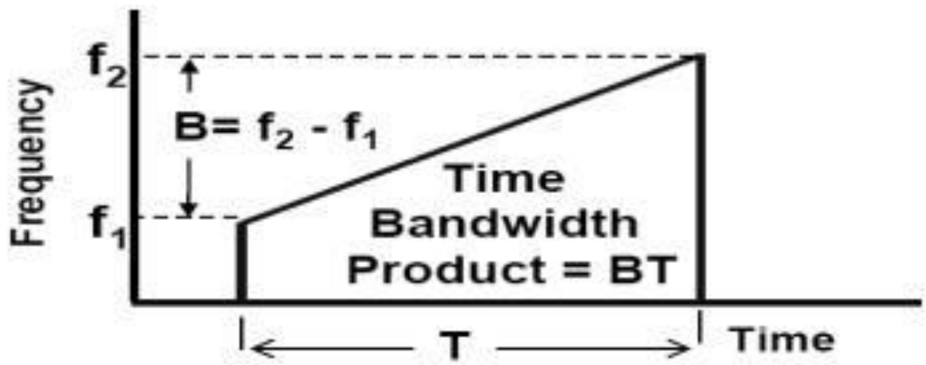


***Fig 2.4***-*Time and frequency relationships in LFM waves*

Linear frequency modulation is the name given to frequency modulation that grows linearly over time. Below is a comparison of an LFM pulse and an unmodulated pulse's responses.

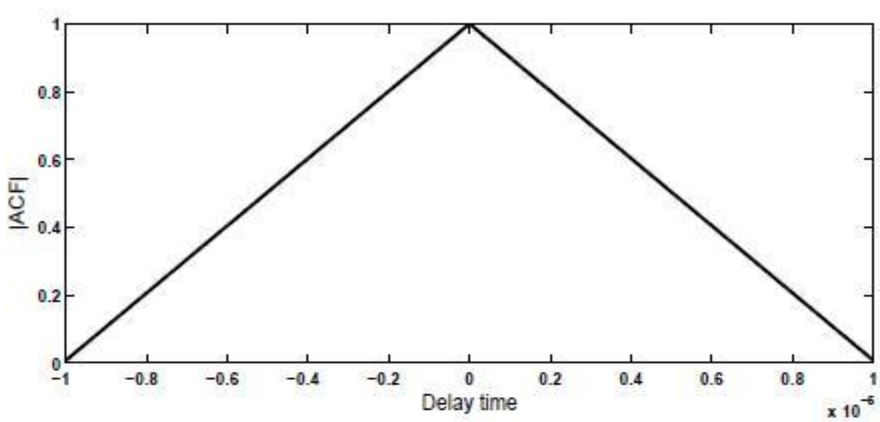


***Fig 2.5***-*Response to an unmodulated pulse-matched filter*

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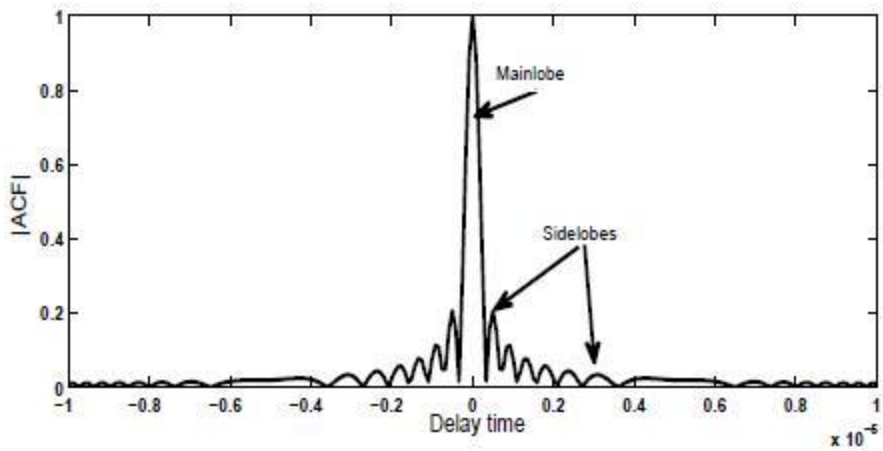


*Fig 2.6*-*Matching filter pulse with frequency modulation*

## VIII.AMBIGUITY FUNCTION

### Response of a Matched Filter to Narrow Band-Pass Signals

The output of the matched filter is obtained as

$$s_0(t) = Re\left\{u_0(t)e^{j2\pi f_0 t}\right\}$$

The narrow band-pass signal's matched filter output contains the complex envelope u0(t), which is formed by passing the complex envelope u(t) through its own matched filter.

## IX.SIMULATIONS

Time Bandwidth Product – 5

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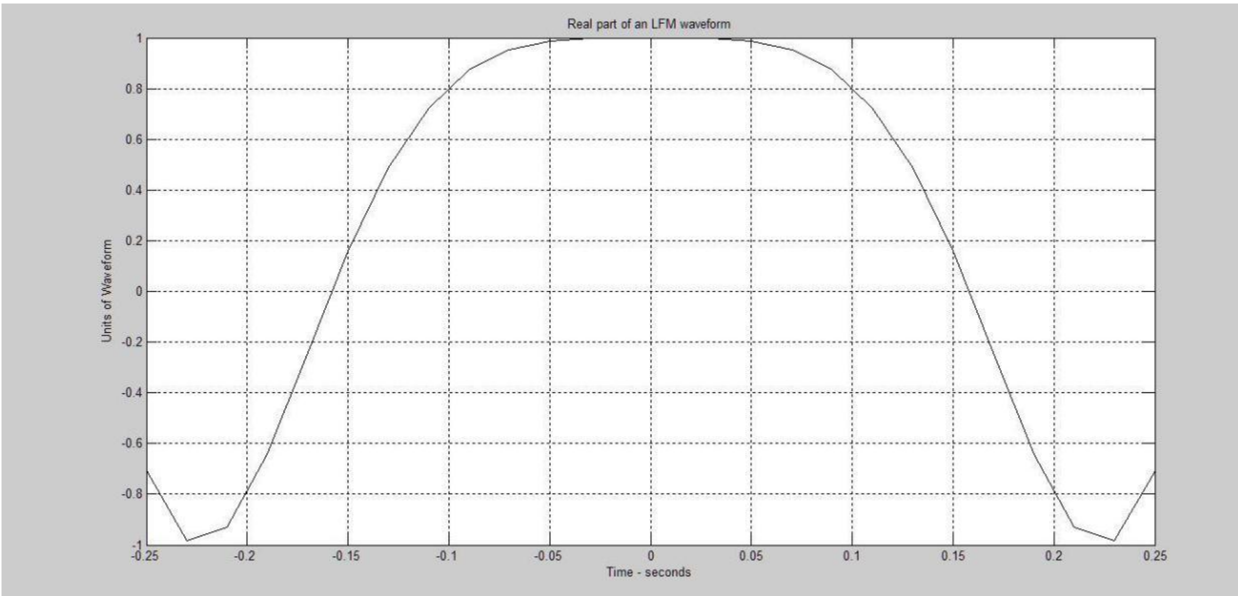


***Fig 2.8****-Real LFM waveform component*

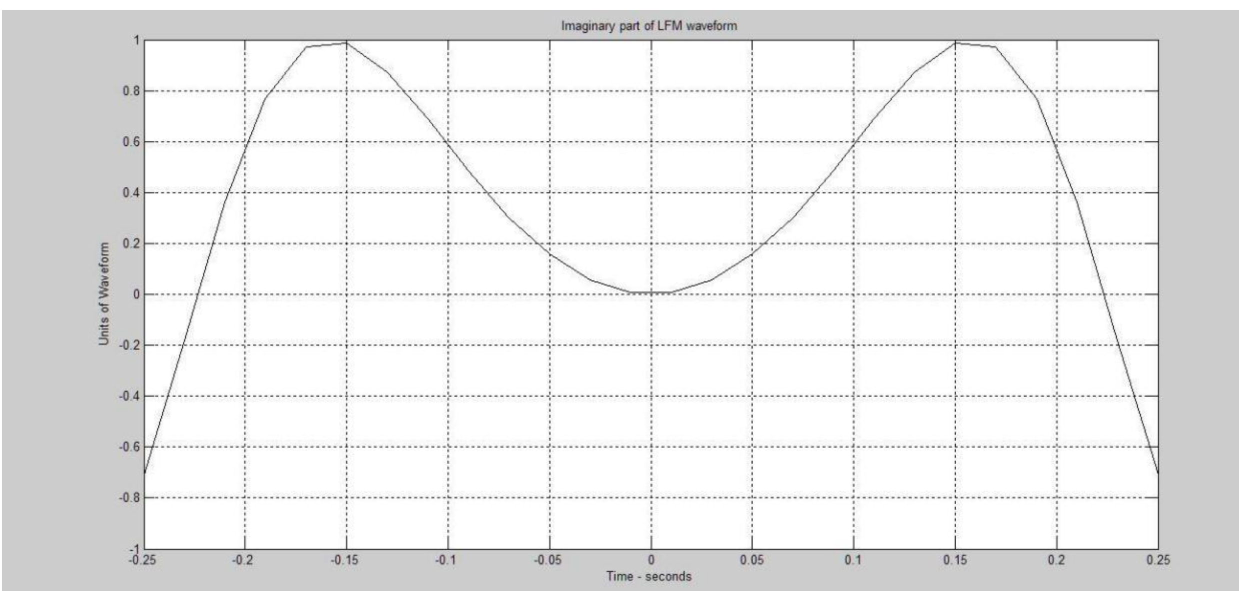


***Fig 2.9****-Imagined LFM waveform component*

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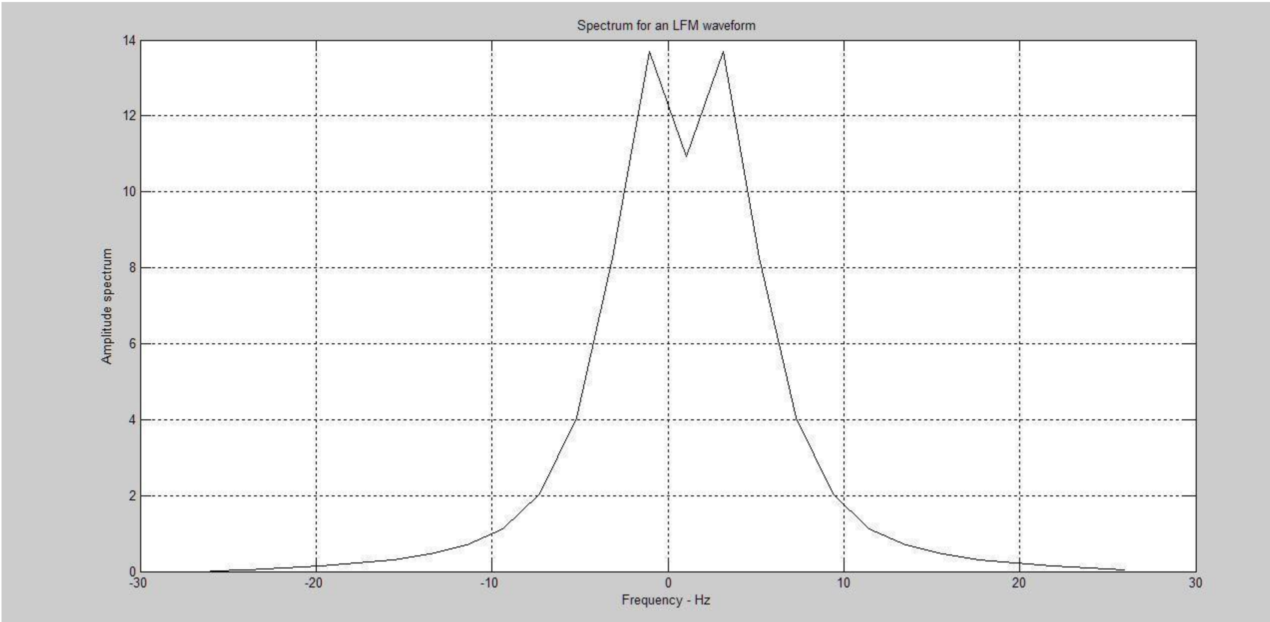


***Fig 2.10****-Spectral Frequency of the LFM waveform*

# X.DETECTION OF TARGET

## Simulation Results

Three targets were identified using the LFM signal, and three windows were opened to let in the received echo.

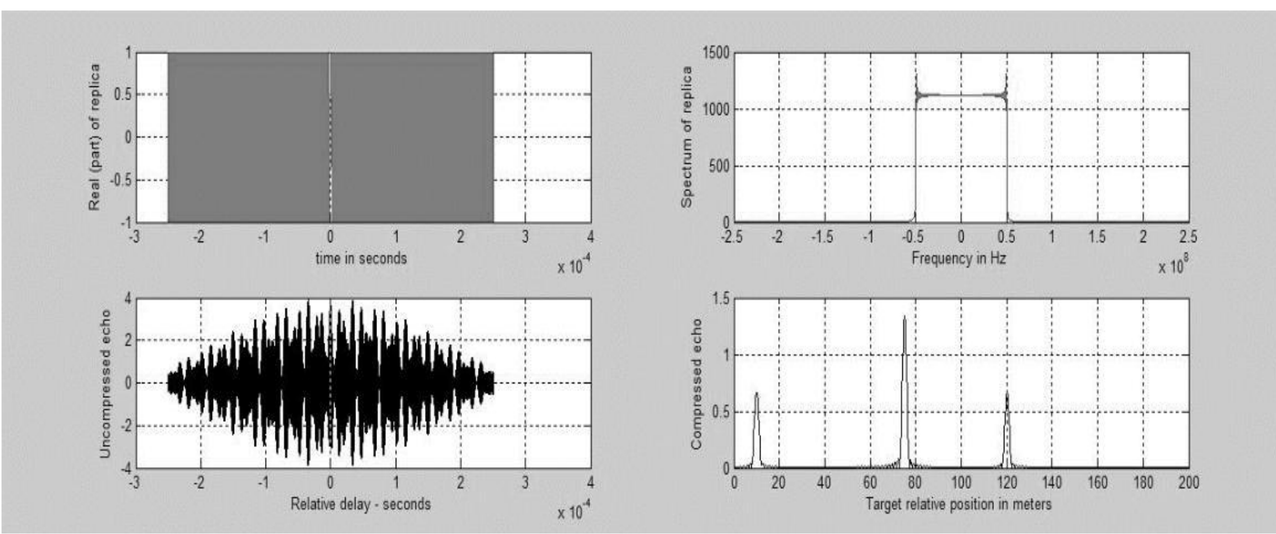


***Fig 2.19****- 3 targets are found using an LFM wave.*

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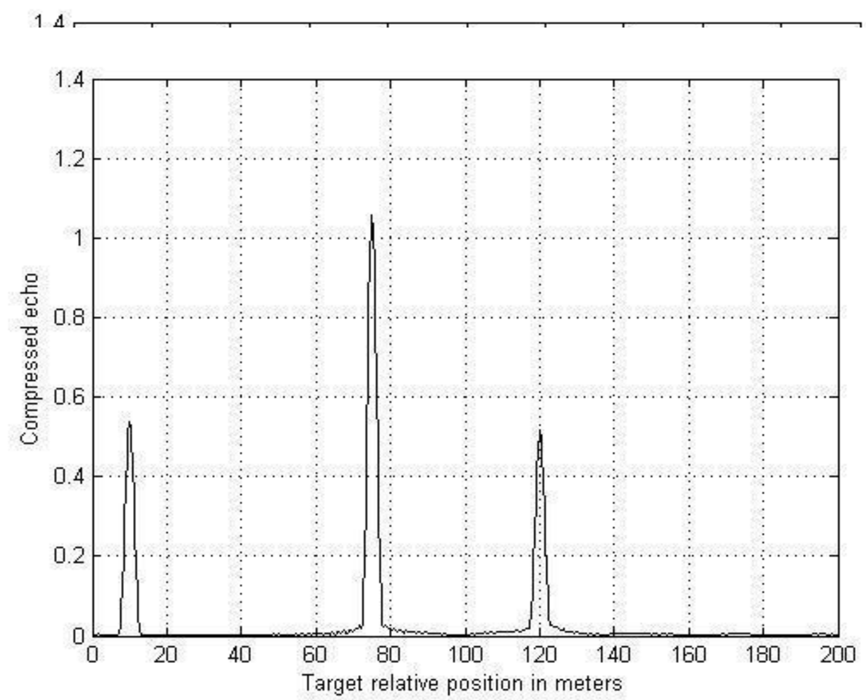


***Fig 2.21-*** *employing an LFM wave that was sent via a Hamming window to detect three targets*

## XI.CONCLUSION

We learned from the thesis that there are two ways to accomplish pulse compression: using a matched filter or by employing stretch processing. The correlation between the received signal and the duplicate of the broadcast signal is performed by the matched filter. Stretch Processing changed the frequency of the signals' time delays. Because stretch processing improves range resolution, it is favoured. In comparison to matched filter processing, it also offers improved side-lobe reduction.

Additionally, the impact of windows on LFM signals was investigated. The LFM wave was traversed. 5 windows

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- Hanning Window
- Hamming Window
- Blackmanharris Window.
- Rectangular Window
- Kaiser Window

We also observed that the Blackman-Harris window provided the best side-lobe reduction.

The masking effect was looked at. Strong echoes from a local target may conceal weaker echoes from distant targets, a phenomenon known as the "Masking Effect." The many techniques for removing the masking effect were explored, and the stretch processing technique was used.

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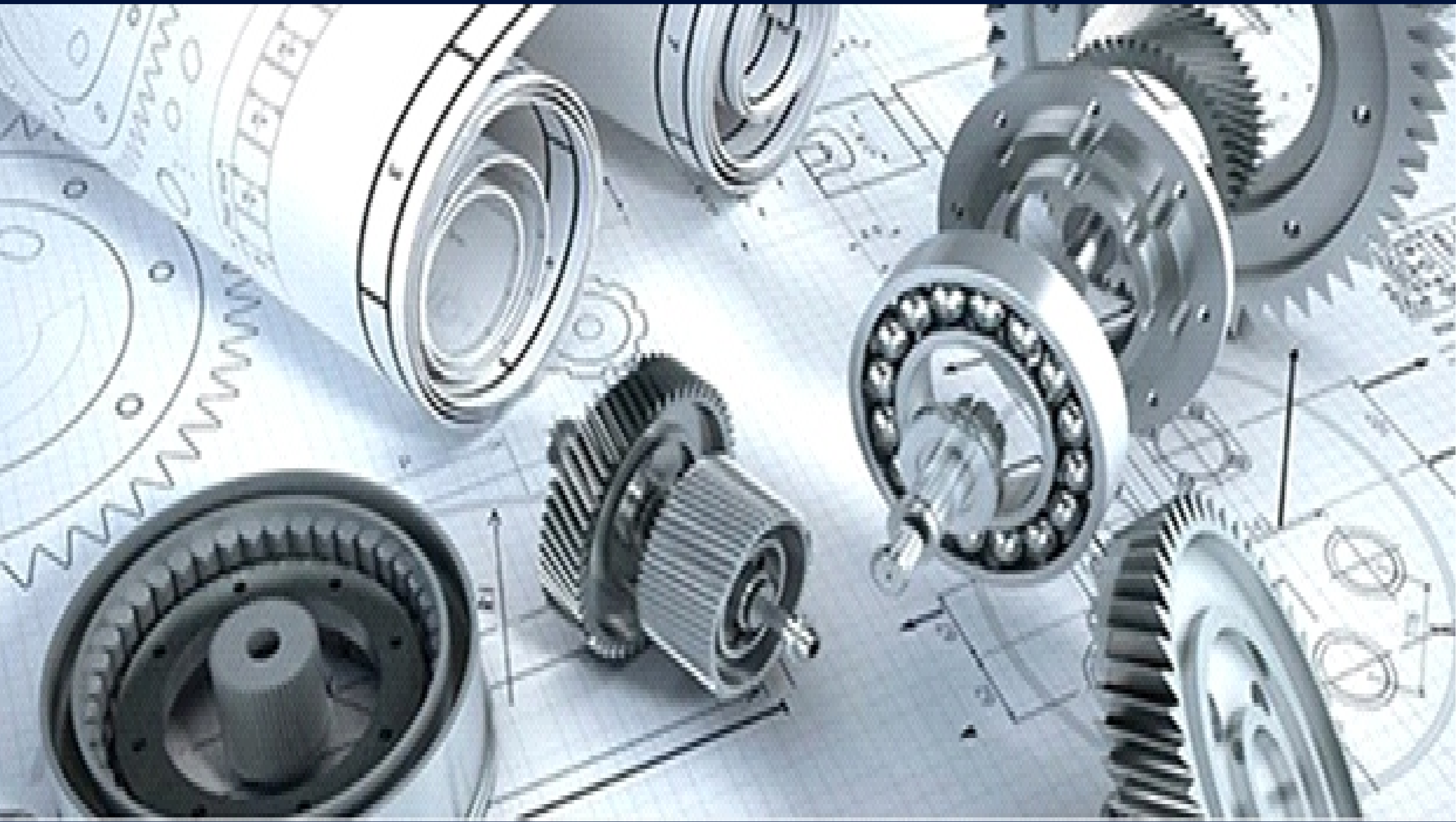

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