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Object Tracker Using Fmcw System And Image Acquisition

C.Abhishek[1] K.Mourya[2] E.Vishnu[2]
[1.] *B.Tech (ECE) Student. SCSVMV University Kanchipuram-India*
[2.] *B.Tech (ECE) Student. SCSVMV University Kanchipuram-India*
[2.] *B.Tech (ECE) Student. SCSVMV University Kanchipuram-India*

***Abstract:* -** This paper discusses the design and implementation of FMCW systems and tracking an object by using the data given by these systems followed by image acquisition. It concludes with an overview of the effects of oscillator phase noise and reflected power on the performance of these systems.

***Keywords:* -** *frequency modulated continuous wave, radar, range resolution, phase noise, image acquisition.*

I. INTRODUCTION

Frequency Modulated Continuous Wave (FMCW) systems operate using the homodyne principle, i.e., a CW in which the oscillator serves as both the transmitter and local oscillator. The CW signal is modulated in frequency to produce a linear chirp which is radiated toward a target through an antenna. The echo received (T_b) seconds later is mixed with a portion of the transmitted signal to produce a beat signal at a frequency (f_b), this is proportional to the round-trip time Tp.

II. METHODOLOGY

FMCW (Frequency Modulated Continuous Wave) should be generated and transmitted using a transmitter. When an obstacle is present in the path of the transmitted signal, the wave hits the obstacle and retraces back with some phase difference, the reflected signal is received using a receiver and phase shift of the received wave is calculated. These waves are recorded in (.wav) and are further processed. MATLAB reads these .wav files and sort out triggered pulses, group of pulses to process in three modes of operation Doppler vs. time, range vs. time, SAR imaging.

1. **Determining the Beat Frequency:**

For an analytical explanation the change in frequency (W_b) with time can be described as

$W_b = A_b.t.$

Substituting into standard equation for FM and simplifying we obtain

$V_f\,(t) = Ac \cos [Wc\ t + A_b/2\ t^2].$

A portion of the transmitted signal is mixed with the returned echo by which time the transmit signal frequency will be shifted from that of the received signal because of the round trip time T_p. The first cosine term describes a linearly increasing FM signal (chirp) at about twice the carrier frequency with a phase shift that is proportional to the delay time Tp. This term is generally filtered out either actively or more usually in radar systems because it is beyond the cut-off frequency of the mixer and subsequent receiver components. The second cosine term describes a beat signal at a fixed frequency which can be obtained by differentiating the instantaneous phase term.

For a chirp duration of Tb seconds, the spectrum of the beat signal will be resolvable to an accuracy of 2/Tb Hz assuming that $T_b >> T_p$. It is common practice to define the resolution bandwidth of a signal $\delta\ f_b$ between its 3dB points, which in this case fall within the $1/T_b$ region centered on f_b.

The rate of change of frequency (chirp slope) in the linear case is constant and equal to the total frequency excursion Δf divided by the time Tb. The beat frequency is then given by

$F_b = 0.636\ A_b\ T_p = \Delta f\ T_p / T_b$

The round trip time T_p to the target and back can be written in terms of the range as

$T_p = 2R/C$
Substituting the value of T_p we get
$F_b = \Delta f\, 2R / T_b\, C$

III. RANGE RESOLUTION

The range resolution, δR, can be obtained by substituting the frequency resolution δf_b, as follows
$R = T_d\, C\, f_b / 2\Delta f$
$\delta R = T_d\, C\ \ \delta fb / 2\Delta f$
As $\delta f_b \approx 1/T_d$
$\delta R = C/ 2\Delta f$

For closed-loop linearization where an almost perfectly linear chirp is generated, it is no longer practical to try to optimize the bandwidth. In this case the resolution degrades with range in a predictable way, with the resolution determined by the chirp bandwidth at close range, and by the linearity thereafter.

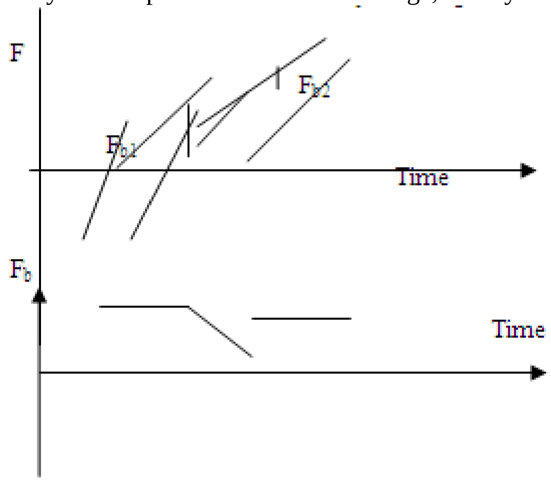

Fig.1,Graph showing Frequency difference

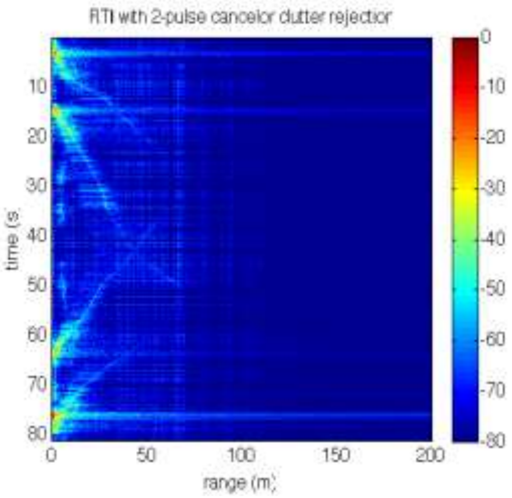

Fig.2 RTI with 2-pulse cancelor clutter rejector

IV. IMPROVING RANGE RESOLUTION

To improve the range resolution a number of practical methods of linearising the chirp signal have been considered. A common method uses the programmed correction stored in a lookup table which is then clocked through a digital to analog converter (DAC). The VCO temperature must either be held constant or different lookup tables must be used to accommodate variations in the oscillator characteristic. It uses an analog multiplier to produce a quadratic voltage that is added to the linear ramp to perform the correction.

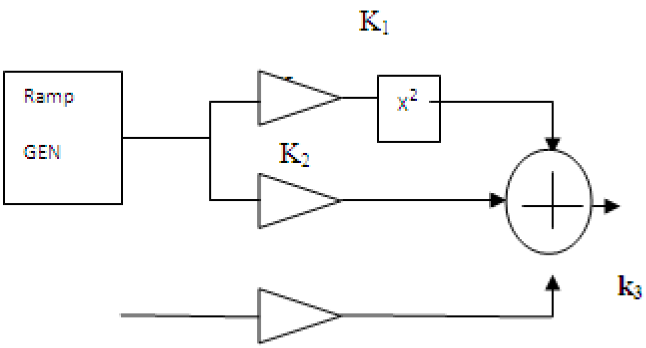

Fig.3. Quadratic ramp generator

In essence all a FMCW does is mix a portion of the transmitted signal with the received signal to produce a beat signal, the frequency of which is proportional to the range. A delay-line discriminator performs the same function using an electrical delay-line rather than the genuine round-trip delay to a target and back.

Block diagram:

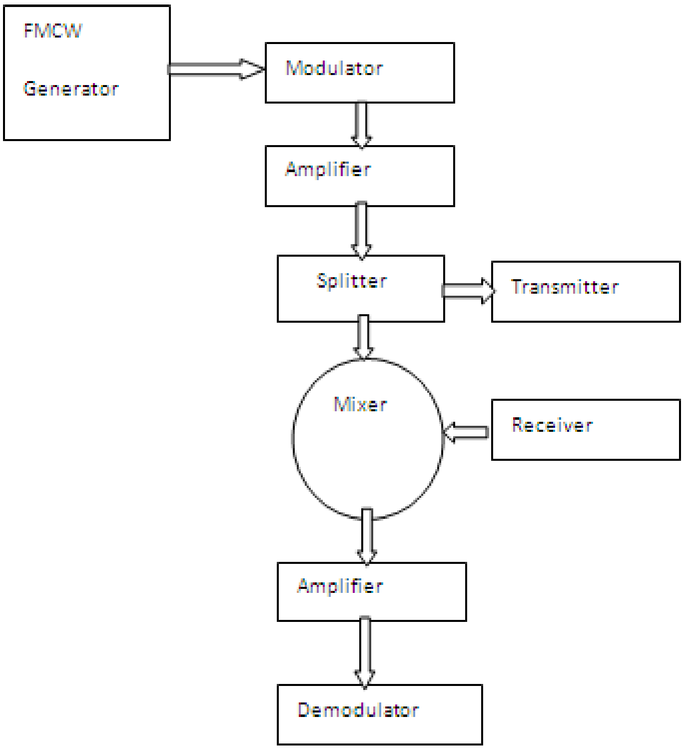

Fig.4 Quadratic frequency chirp correction circuit using an analog multiplier chip

Phase Noise around the Target:

Phase Noise around the Target Phase noise fringes also appear around any received target, and if the target is large they leak into the adjacent range bins. This results in a blurring of edges in image and can even result in smaller targets being completely swamped. Noise must be removed from the image.


Fig.5. Noise around the target

Features of the system:
1. Coherent FMCW architecture
2. Records files in .wav format
3. Bandwidth of 2.4GHz.
4. Three modes of operation Doppler vs time , range vs time , SAR imaging.

V. CONCLUSION

This paper shows that FMCW principle is straight forward and can be used for tracking purpose. Careful implementation of this system is very beneficial and accurate results can be obtained. This type of systems will be very useful to track the objects in remote areas.

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C.Abhishek is pursuing his under graduation in Scsvmv university .He has completed his research project in DRDO on inertial navigation system. He presented papers in international conferences .His area of interests are satellite communication, wireless systems .Currently he is doing his research on micro Doppler radar in NARL.