ISSN 2320 - 2599
Volume 6, No. 4, July - August 2017
International Journal of Microwaves Applications
Available Online at http://www.warse.org/IJMA/static/pdf/file/ijma02642017.pdf

Modeling of FMCW Radar for S-band Using SystemVue

Shrikant Sonawane[1], Lata Chouthmol[2]
[1]Late GN Sapkal College of Engineering, India, shrikant8392@gmail.com
[2] Late GN Sapkal College of Engineering, India, Lata_51105@rediffmail.com

ABSTRACT

The FMCW Radar is widely used Radar for detecting the object and its velocity in various applications. Before an actual implementation of the FMCW Radar, it is essential to find out the correct combination of the components in the environment comprising noise and losses. The Radar system is analyzed using a SystemVue Software. Real-world impairments such as channel losses, propagation, and attenuation losses, nonlinearities of the system elements such as phase noise and mixer leakage have been incorporated into the simulation. The simulation helps to predict the results of the system before an actual development and saves development time. The velocity of the target (object) as well as its range is calculated using data flow technique in SystemVue.

Key words: FMCW, FMCW Environment, RADAR, SystemVue, System level analysis.

1. INTRODUCTION

The Frequency Modulated Continuous (FMCW) Radar is the type of continuous wave radar that uses frequency modulation scheme to locate and detect objects. It can also calculate the velocity of the target using Doppler Principle [1]. The FMCW Radar system is very complex to design and analyze. It became very difficult to analyze the system if it is implemented in the form of single chip transceiver.

The Radar systems usually operate in environments with clutter, attenuation, noise, and jamming [4]. Direct analysis of such complex systems are difficult and often fails while designing. To save development time and reduce the cost of any system has to be simulated first before an actual implementation. The simulation ability not only provides a beforehand picture of a Radar system but also provide the ability to create the virtual environment in which Radar has to be implemented considering the propagation and channel losses. This enables rapid prototyping capabilities for any Radar system development. SystemVue provides an effective and efficient environment for Radar Simulation.

In this paper, the S-band FMCW Radar is simulated using SystemVue Software. The paper is organized as follows. Section II explains the principle of operation of FMCW Radar system. Section III shows the characteristics of the simulated FMCW Radar along with its result. Finally, the conclusion summarizes the design of the simulated FMCW Radar.

2. FMCW RADAR SYSTEM

2.1 Principle of Operation

In FMCW Radar, the carrier signal is modulated by linearly ramping it in triangular or saw tooth waveform pattern. The antenna transmits this signal where it suffers the propagation loss and attenuation depending upon the environment. It is reflected by the target and is received by the receiving antenna. The frequency difference (Fr) is proportional to the time difference between the transmitted and received signals, which in turn is proportional to the distance between the transmitter and reflecting target [9].

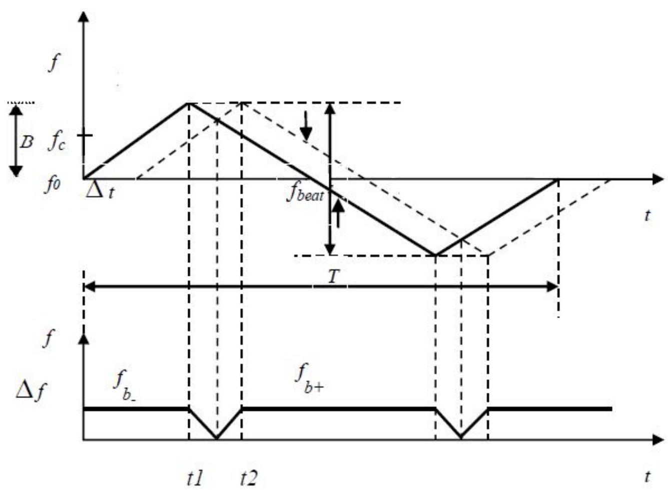

Figure 1: FMCW Triangular Waveform

The transit time (Δt) at FMCW Radar input, the delay can be calculated by:

$$\Delta t = \frac{2R}{c} \quad (1)$$

where R is the distance from the Radar to the target and c is the speed of light.

The range (distance) of the target can be estimated by,

$$R = \frac{f_b T c}{(2\,\Delta f)} \qquad (2)$$

where T is period and Δf, and fb is the frequency difference and beat frequency for the time delay t respectively.

The Δf is transformed using a fast Fourier transform (FFT) into a frequency spectrum, and the range is calculated from the spectrum [9].

2.2 System Parameters

The S-Band comprises of 2-4 GHz. The FMCW Radar system is simulated using the following parameters as shown in Table 1.

Table 1: System Parameters

No	*Parameters*	*Value*
1	Carrier Frequency (fc)	2.45 GHz
2	Sampling Frequency (fs)	600 MHz
3	Bandwidth	300 MHz
4	Period (T)	1 us
5	NFFT	2048
6	Pulse Repetition Frequency	2 MHz
6	Range (R_{max})	50 m
7	Attenuation	1 dB
8	Transmitter and Receiver Gain	1 dB

3. SYSTEMVUE SIMULATION

SystemVue is a focused EDA environment for electronic system-level (ESL) design which provides RF and RADAR simulation capability before actual implementation [4]. The Data flow technique and the *RADAR Parts* library is used for this simulation. The radar system consists of several stages: signal generation and transmission, reception and its procession and estimation of results. The implementation block diagram is shown in Fig 2 below:

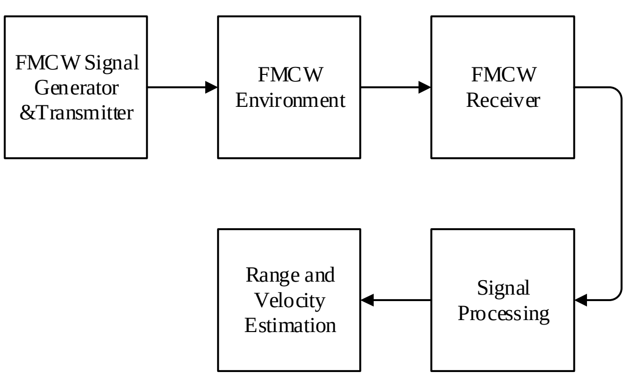

Figure 2: FMCW Radar SystemVue Block Diagram

3.1 Signal Generation and Transmission

The frequency modulated signal is generated using the RADAR_CW block. The Transmitted frequency is varied in time [3]. The triangular linearly modulated waveform with a period T and sampled with sampling frequency fs as shown in Fig 3.

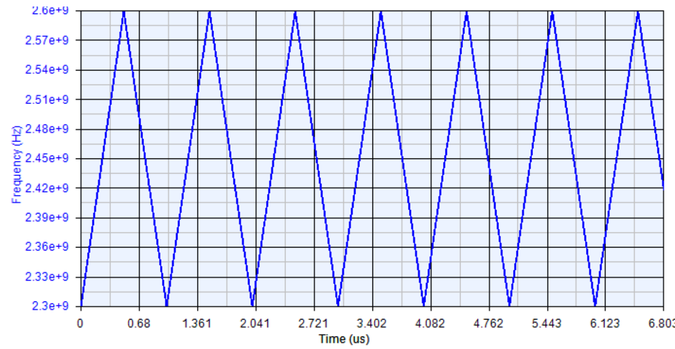

Figure 3: LFM Waveform

The RF signal in SystemVue is defined as an envelope signal, whereas a baseband signal is considered as a complex signal, respectively [3]. The conversion from an envelope to a complex signal is readily available in SystemVue thus the need for a mixer for signal down-conversion is avoided [3]. The Complex to Envelope signal is generated using CxToEnv component. The transmitted Power spectrum is shown in Fig 4.

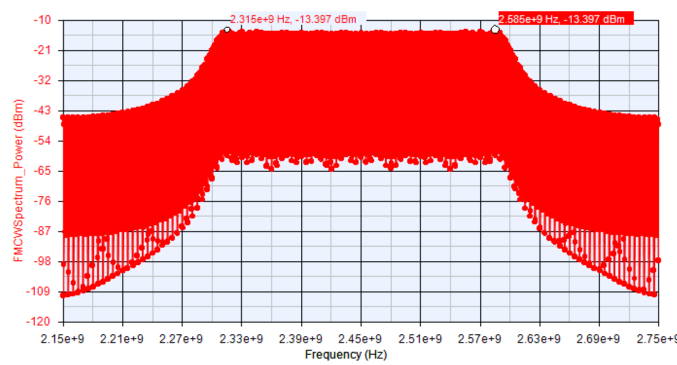

Figure 4: Transmitted Signal Power

3.2 FMCW Environment

FMCW environment includes the transmission channel, which comprises of both transmitting and receiving antenna. The RADAR_Target component is used to simulate the Radar target. The Doppler Effect, attenuation, and delay can be simulated using this component.

3.3 FMCW Receiver

The received signal is down converted using the Passive Mixer component. The IQ Receiver model is adapted here to find the beat frequency (fb).

3.4 Signal Processing

The Radar Signal processing is carried out with the help of FFT_CX block. This block uses mixed radix FFT (Fast Fourier Transform) algorithm to compute the DFT of the input signal. At every execution of this block, samples are read from the input which is zero padded and then processed by a mixed radix FFT algorithm to produce equally spaced samples that are the DFT of the input signal [3].

3.5 Range and Velocity Estimation

The final stage of Radar consists of detecting the frequency difference to resolve range and velocity. This frequency can be obtained by taking discrete Fourier transform. The MATLAB scripted block converts the time signals into frequency bins. However, it is not possible to resolve the velocity and distance from one single frequency measurement simultaneously [3].

3.6 Maximum unambiguous range (R_{un})

The range beyond which targets appear as a second time around echoes is called Maximum unambiguous range (R_{un}) [1]

$$Run = \frac{cT}{2} \tag{3}$$

Substituting the Pulse width in above equation gives the theoretical value of R_{un} = 75 m which is shown in Fig 5

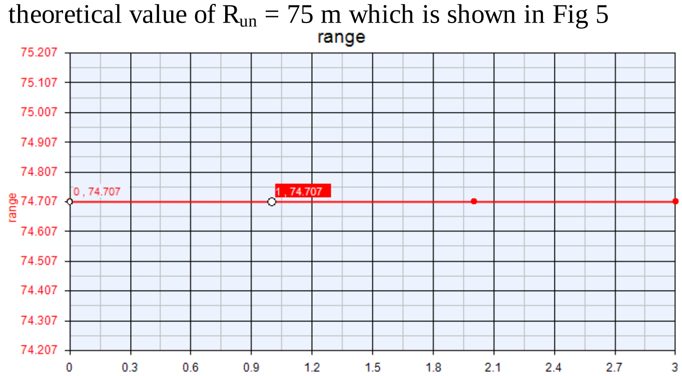

Figure 5: Maximum unambiguous range

3.7 Maximum unambiguous velocity

The Maximum unambiguous velocity depends upon the Pulse Repetition Frequency (PRF) of the Radar.

$$V_{max} = \frac{PRF * \lambda}{4} \tag{4}$$

Substituting the value of Pulse Repetition Frequency (PRF) and lambda, the V_{max} = 61 km/s is obtained and shown in Fig.6

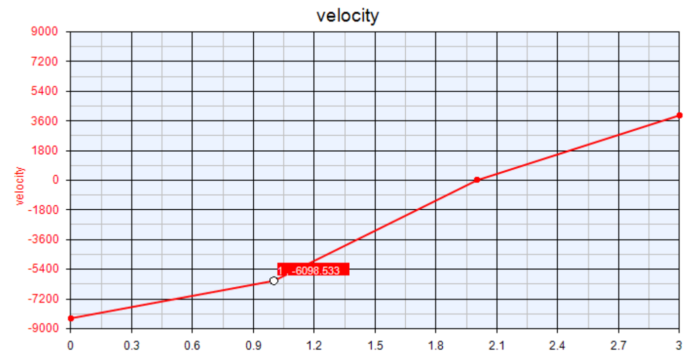

Figure 6: Maximum unambiguous velocity

5. CONCLUSION

An FMCW radar system model has been simulated using an electronic design software, SystemVue. The system model includes a transmitter, receiver along with target model. The system has been evaluated in the FMCW environment including channel noise and attenuation. The simulated results of estimated range and velocity agree with the theoretical results.

.

REFERENCES

1. Merrill I. Skolnik, "**Introduction to RADAR Systems**," McGraw-Hill, 2001
2. Lei Yue, "**FMCW Radar Simulation for Range Estimation**," Keysight Technologies, Nov 2015
3. Héctor J. De Los Santos, Christian Sturm, Juan P, "**Radio Systems Engineering**," Springer 2015
4. "**Keysight Technologies Analysis and Design of RF and Digital Systems Using Keysight SystemVue**", 2015
5. Steinhauer, M., H.O. Ruo, H. Irion and W. Menzel "**Millimeter-Wave Radar Sensor Based in a Transceiver Array for Automotive Applications**,"Microwave Theory and Techniques, Vol.56, pp. 261-269, February 2008
6. Duarte, C., P. Dorta, A. Lopez, A.D. Campo,"**CWLFM Radar for Ship Detection and Identification**," IEEE Aerospace and Electronic Systems Magazine, Vol. 22, pp. 22-26, February 2007
7. Swapnil Vannam, R P Labade, "**Parametric Analysis And Design Of Rectangular Microstrip Patch**", IJMA Vol 3, May-June 2014
8. Antenna for Ultra-wideband ApplicationAhmed M. Eid, Ahmed M. Nahhas, " **System Simulation of RF Front-End Transceiver for Frequency Modulated Continuous Wave Radar**", International Journal of Computer Applications (0975 – 8887) Volume 75–No.2013