International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 05 Issue: 04 | Apr-2018 www.irjet.net p-ISSN: 2395-0072

CLOUD RADAR WAVEFORM GENERATION USING DIGITAL UP CONVERTER

Lenisha Mertle Pinto[1], Shahul Hameed V[2], Dr. Veena Devi Shastrimath V[3]

[1]M.Tech Student, Dept. of Electronics and Communication, NMAMIT, Nitte, Udupi Destrict, Karnataka, India
[2]Scientist/Engineer, Radar Development Area, ISTRAC, ISRO, Bengaluru, Karnataka, India
[3]Professor, Dept. of Electronics and Communication, NMAMIT, Nitte, Udupi Destrict, Karnataka, India

---

Abstract - *This paper proposes the design of Digital Up Converter (DUC) for the cloud radar communication. DUC is used at the transmitter side and it performs the function of translating baseband signal to the Radio Frequency (RF). DUC mainly comprises of interpolation filters, Numerically Controlled Oscillator (NCO) or Direct Digital Synthesizer (DDS) and mixer. Pulse Shaping Filter (PFIR), Compensator Filter (CFIR) and Cascaded Integrator Comb (CIC) is used as interpolation filters. The effective design of DUC has become very essential in order to reduce the cost of design. DUC is efficiently implemented in Field Programmable Gate Array (FPGA) using Kintex 7.*

Key Words: Digital Up Converter (DUC), Radio Frequency (RF), Numerically Controlled Oscillator (NCO), Direct Digital Synthesizer (DDS), Pulse Shaping Filter (PFIR), Compensator Filter (CFIR), Cascaded Integrator Comb (CIC).

1. INTRODUCTION

Radar stands for Radio Detection and Ranging. It is an electromagnetic system for the detection of the object. Main components of radar are transmitter, receiver, transmitting antenna, receiving antenna and the processor. Transmitter transmits the particular type of waveform. The reflected radio wave from the object is received by the receiving antenna and it detects the nature of the echo signal. Radar is designed to detect the object through rain, snow, darkness and haze. It also has an advantage of determining range, angle or velocity of the object. Cloud radar are used to determine cloud characteristics, which aids in understanding of radiant energy passing through the atmosphere. Different cloud radars operate at different wavelengths.

DUC perform the sample rate conversion process in the digital signal processing. DUC has two paths, one is in-phase input and another is quadrature input. Because of this reason DUC is also called as complex DUC. Interpolation filters present are used to increase the sample rate as well as to perform filtering to acquire spectral shaping. Output of interpolation filter and output of NCO is being mixed by the mixer for the purpose of shifting the signal spectrum to the required frequency level [2].

1.1 LITERATURE SURVEY

CHAITHRA M. R., YASHWANTH N [1] has described about the implementation of DUC using PFIR interpolation filter and also stated about the Root Raised Cosine FIR for the multi standard DUC which reduces the power consumption as well as reduces multiplication and addition per input samples. It is implemented on XCS3S400 FPGA.

ARUN RAJ S. R. [2] described about the FPGA implementation of DUC and DDC. The DUC and DDC are complex in nature and extensively used in radio system. The DUC and DDC circuit is developed in Xilinx system generator. DDC and DUC is designed for WCDMA system.

VIPIN GEORGE, C. SENTHIL SINGH [3] describes about DUC which is implemented in FPGA using the interpolation filter such as CIC and CFIR. The FPGA implementation is done in vertex 7.

RITA PATIL, G. S. GAWANDE [4] described about major block of the transmitter part of the communication system such as DUC. Effective implementation of DUC is very important. In this paper the author explained about the design of DUC using Xilinx system generator in order to reduce the design cycle and increase the design productivity.

2. METHODOLOGY

The baseband signal that has to be up sampled and filtered using the interpolation filters and converted to pass band signal. The sample rate of input signal is less. But for the transmission of the signal, higher sample rate is required. For this reason the input signal has to be up sampled. This overall process takes place in DUC.

2.1 DUC DESIGN USING PFIR, CFIR AND CIC INTERPOLATION FILTERS

The block diagram of DUC design using PFIR, CFIR and CIC is shown in Fig 1. DUC mainly consists of PFIR interpolation filter, CFIR interpolation filter, CIC interpolation filter, DDS and mixer. The pulse shaping filters are FIR filters rather than IIR filters. In order to shape and filter the input waveform pulse shaping filter is required in DUC. It is also used as a filter for eliminating the spectral content caused by constellation mapping quantisation [3]. CFIR filter is also a type of FIR filter. It can be used to compensate for pass band droop caused by the CIC filter and it gives inverse sinc-like response. The power of inverse sinc function is matched to the total number of stages present in CIC. CFIR also increases

the sample rate and provides passband filtering. Advantage of CFIR filter is spectral mask rejection.

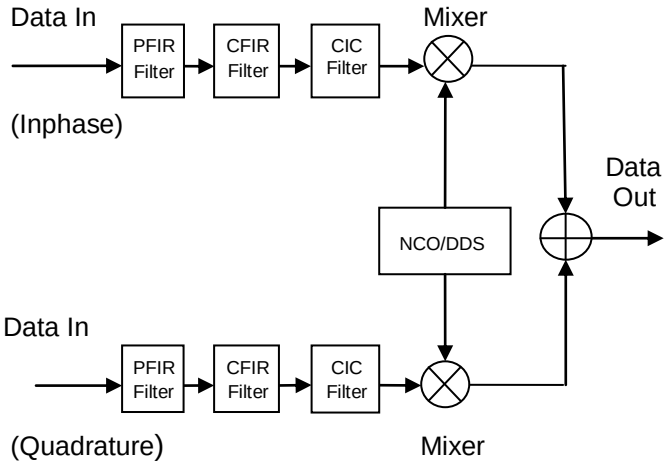

Fig -1: Block Diagram of DUC with PFIR, CFIR and CIC filters

In this paper FIR filters has been replaced by CIC filter. The advantage of CIC filter compared to FIR filter is that, it eliminates multiplication operations as CIC filter interpolation filter constitutes delays and adders as shown in Fig 2. CIC filter can either perform decimation or interpolation operations. If CIC filter is used for decimation, the unit includes the cascade of integration units followed by down sampling stage and finally cascade of comb filters. For CIC interpolation the unit contains cascade of comb filters followed by up sampler and finally cascade of integrator units. Stop band attenuation is one of the important parameter of CIC. It can be increased by some of the parameters like differential delay of comb filter and number of stages of CIC. By increasing the differential delay of the comb filter, stop band attenuation can be increased, But it results in considerable passband droop. The second parameter is number of stages of CIC filter. The desired stop band attenuation can be acquired by increasing the number of stages of CIC filter.

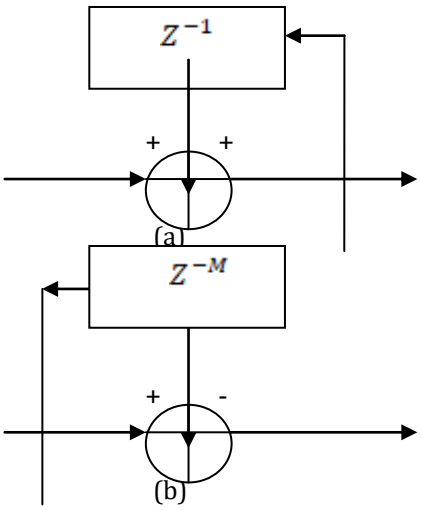

Fig -2: The CIC building block (a) Integrator (b) Comb Filter [5]

The digital version of NCO, i.e DDS which generates carrier signal and synthesizes discrete representation of sinusoidal waveform. Under the influence of digital processor corresponding amplitude, phase and output frequency of DDS can be varied. The carrier signal generated from DDS is multiplied with the output of CIC interpolation filter [4].
Input signal with low sample rate is passed through the three interpolation filter for UP sampling and filtering process. The output from the third interpolation filter which is CIC filter is mixed with carrier signal generated from DDS in the mixer. Output from the adder will be the combination of In-phase and Quadrature-phase signal.

3. RESULT AND ANALYSIS

3.1 OUTPUT OF DUC WITH PFIR, CFIR AND CIC FILTERS

The baseband signals received by DUC are given to the interpolation filters. DUC with interpolation filters such as PFIR, CFIR and CIC is designed using MATLAB. The baseband signal frequency used is of 10MHz with sampling frequency of 10.1MHz and interpolation factor of PFIR is 2, CFIR is 2 and CIC is 2. Total interpolation factor is 8. NCO output obtained is 64MHZ is shown in the Fig 3. Fig 4 shows the DUC output at 80 MHz.

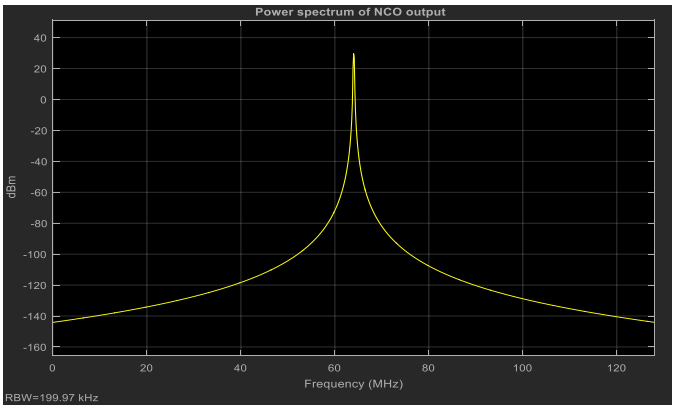

Fig -3: NCO output of DUC

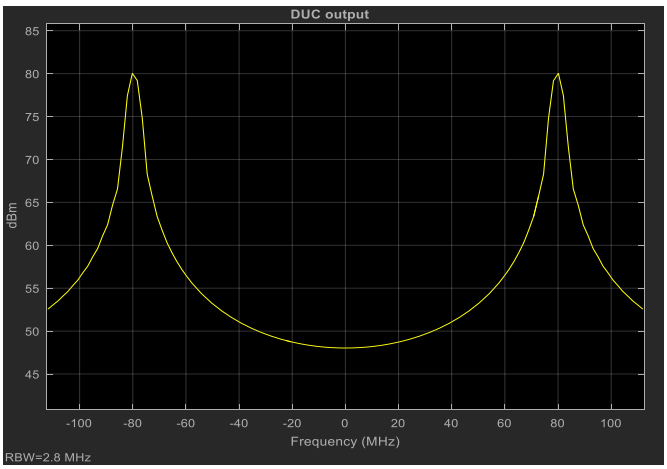

Fig -4: DUC output

3.2 HARDWARE OUTPUT

VHDL code for DUC is written using Xilinx ISE Design Suite 14.3. Constraint file is created based on kintex7 FPGA board. RTL schematic can be implemented and then generating programmable bit file. This bit file is used to dump the program into hardware. Xilinx FPGA Kintex-7 is connected to the host computer and VHDL code is dumped into the hardware using ISE iMPACT. The output obtained is 79.95 MHz which is similar to that of Matlab output as shown in the Fig 5.

Fig -5: DUC output using Kintex 7

4. CONCLUSION

The Matlab coding for the DUC with PFIR, CFIR and CIC filters is done. The CIC filters introduce passband droop in its frequency response. In order to eliminate the droop CFIR filters are used. The proposed work is implemented in FPGA using Kintex 7 through VHDL programming. The resource consumption is less compared to FIR filter implementation.

ACKNOWLEDGEMENT

The authors would like to thank ISTRAC, RDA, Bengaluru for support and providing pleasant environment to carry out the project work.

REFERENCES

[1] Chaithra M. R. and Yashwanth N, "FIR Interpolation Filter for Multi-Standard Digital Up Converter Using FPGA," International Journal of Science and Research, vol.4, May 2015, pp. 3033-3036.

[2] Arun Raj S. R., "High Speed and High Frequency based Digital Up/Down Converter for WCDMA Systems," International Journal of Innovations in Engineering and Technology, vol. 4, Dec. 2014, pp. 1058-2319.

[3] Vipin George, C. Senthil Singh, "Novel FPGA Design and Implementation of Digital Up Converter," International Journal of Research in Engineering and Technology, vol. 3, Mar. 2014, pp. 124-127.

[4] Rita Patil and G.S. Gawande, "Efficient Design of Digital Up Converter using Xilinx System Generator," International Jounal of Engineering Research and Technology, vol. 3, May 2014, pp. 2284-2286.

[5] Kumar Vijay Mishra, "Frequency Diversity Wideband Digital Receiver and Signal Processor for Solid-State Dual-Polarimetric Weather Radars," Degree of Master of Science thesis, Colorado State University Fort Collins, Colorado, 2012.