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"1st order Sigma Delta modulator for wireless application"

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ABSTRACT - The 1st order single-loop single-bit digital sigma-delta modulator is design in this project.1 bit ADC is use in this project along with Difference Amplifier, integrator and DAC in feedback.2Stage comparator is used as a ADC. Oversampling and Noise shaping technology is use because of this design of anti aliasing filter also reduce. Furthermore, behavioral simulations of the design are verified using Tanner. A top-down system design methodology that can be used to determine the degree of influence of the modulator structure parameters on the performance of the modulator is provided. This approach not only provides important guiding significance on implement of the modulator in an FPGA processor, but also reduces the design complexity and shortens the integrated circuit(IC) design

Keywords: ADC, Sigma-Delta modulator, FPGA, DAC, Oversampling

1. INTRODUCTION

Sigma–delta modulation is the most popular form of analog-to-digital conversion used in audio applications. It is also commonly used in D/A converters, sample-rate converters. Sigma–delta modulation (SDM) is perhapsbest understood by comparison with traditional pulse-code modulation (PCM). A PCM converter typically samples an input signal at the Nyquist frequency and produces an *N*-bit representation of the original signal. This technique, however, requires quantization 2*N* levels. Whether implemented using successive approximation registers, pipelined converters, or other techniques, high resolution is difficult to obtain in PCM conversion due to the need to accurately represent many quantization levels and the subsequent circuit complexity. This is the motivation for sigma–delta modulation. Block diagram Sigma Delta Modulator is as shown in Fig. 1

Sigma–delta modulator is a 1 bit system. In this type of modulator 1 bit ADC is used which convert analog input into 1 bit binary representation. As shown in above fig Block Diagram of Sigma Delta Modulator consist of Difference Amplifier, integrator. In feedback DAC is used which convert 1 bit binary representation into analog signal which will be applied as input to theDifference Amplifier using negative feedback which increases the

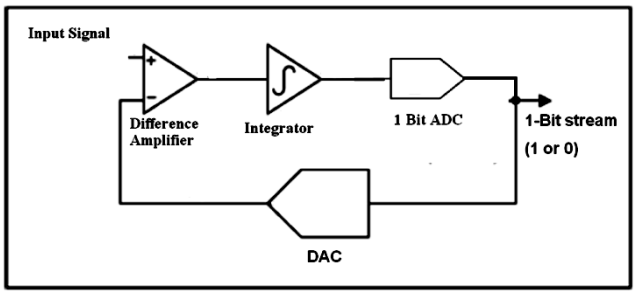

Figure1:- Block Diagram of sigma Delta modulator

stability of the circuit. To achieve high signal-to-noise ratio,Delta Sigma modulation must use oversampling techniques, that is, the analog signal is sampled at a rate several times higher than the Nyquist rate. Digital SDM is not only widely used in oversampling andnoise-shaping DAC but also the most critical component ofthe DAC. It has a direct impact on the performance andstability of the DAC. Oversampling and noise-shaping DACis composed of three parts: digital interpolation filter, digitalSDM and analog filter.
1- bit modulator has excellent linearity, while the multi-bit one has to use digital correction or dynamic matching technology to increase its linearity and to suppress its harmonic distortion, which will increase the complexity of system.

2. METHODOLOGY TO BE EMPLOYED

The Design Methodology of Sigma Delta Modulator given below. It consists of various steps to find the output data. In this, a ADC generate the code depending on the input. It consists of various parts such as Difference Amplifier and Integrator. In feedback DAC is used which convert 1 bit binary representation into analog signal which will be applied as input to the Difference Amplifier using negative feedback which increases the stability of the circuit.

3. Over Sampling and Noise shaping

a) Oversampling

Normally sampling frequency is twice the frequency of input signal for proper sampling and avoiding the aliasing effect and to reconstruct the original signal at the receiver. When we use sampling frequency very high than input signal frequency then that type of sampling is called as "Oversampling".

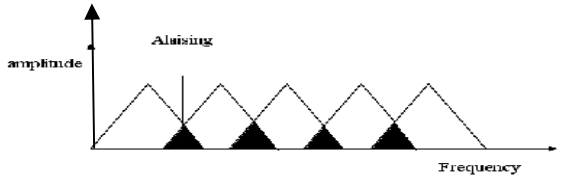

Figure 2:Under sampled Signal

If we oversampled the signal then Aliasing can be removed and quantization noise of the circuit reduces. Over sampling ratio of 128 is used the above circuit.

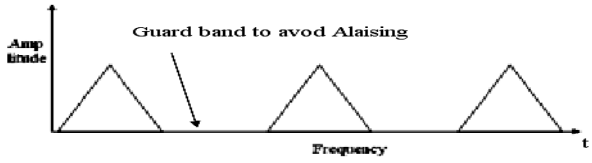

Figure 3: Over Sampled Signal

As signal is oversampled then SNR increase as stated above. The relation between Over sampling rate and modulator performance is shown in table below:-

Over Sampling Rate	SNR	No. of significant bits
16	82	13
32	102	17
64	123	20
128	144	24
256	169	28
512	189	31

Table 1: THE RELATIONSHIP BETWEEN OVER-SAMPLING RATE AND MODULA TOR PERFORMANCE

b)Noise Shaping Technology:-

Noise shaping circuit is to extend the Dynamic range. This result from the application of Feedback. As we apply feedback this modulator acts as a closed loop modulator. A closed loop modulator can be used as a high pass filter for quantization noise and as a low pass filter for the input signal. Noise shaping circuit is also used toreduce the bandwidth of selected signal. As we used Noise shaping technology the quantization noise is moved out of baseband so that SNR (Signal to quantization noise Ratio) increases. As order of modulator increases noise shaping of the circuit becomes improve and SNR also increases.

4. Difference Amplifier:-

Difference Amplifier is a basic Block of Sigma Delta Modulator. 2 Inputs are applied to the Difference Amplifier. Out of these two inputs 1 is main input signal and another input is a output of DAC which is applied as a input to Difference amplifier. Circuit diagram and waveforms of Difference amplifier is as shown below.

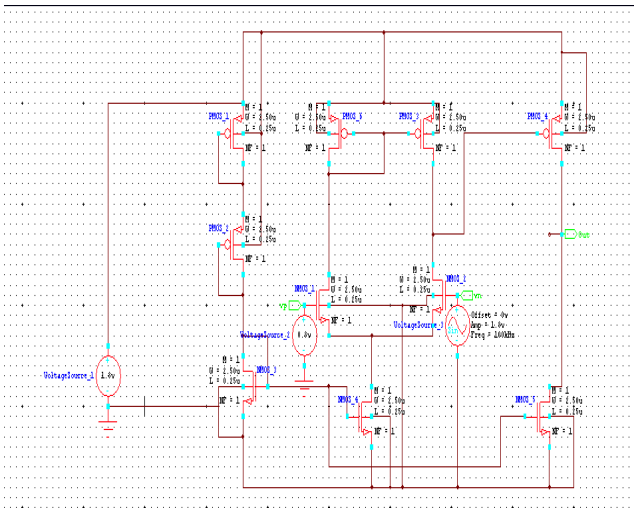

Figure 4:- Structure of Difference amplifier

5. Integrator:-

The integrator consists of an op-amp, a resistor, and afeedback capacitor. The values of the resistor and thecapacitor decide the time constant of the integrator. Thetime constant shouldn't be too big. Otherwise, theintegrator will go into the saturation status. Op-amp is thecore part of the sigma-delta modulator. It provides a largeopen loop gain to implement the negative feedbackconcept as well as let the integrator integrate smoothly. Inaddition, it has large bandwidth to pass through at leastthe first two harmonics of input sine wave. In an affect toachieve better stability, the designed op-amp also haslarge phase margin. Figure 4 shows the structure of theimplemented op-amp

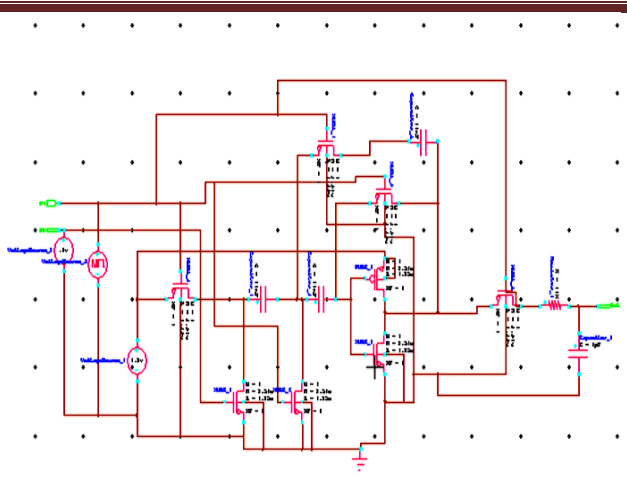

Figure 5: Structure of Op-Amp Based Integrator

6. 1 bit ADC:-

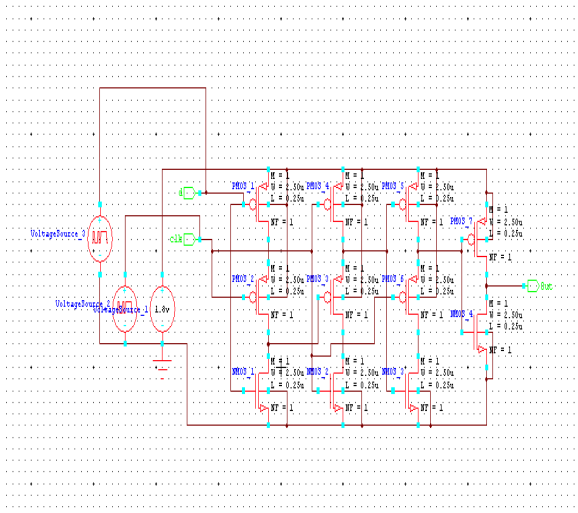

Figure 6:- Structure of 1 bit ADC

The 1-bit ADC is composed of a comparator and a DFF in the first order sigma-delta modulator. To simplify the circuit, the two-stage comparator is used in the project. It is based on the former discussed two-stage op amp circuit. But the comparator does not have to be compensated for close-loop feedback as the stability issue is not a concern. This means that there is no requirement for an internal compensation capacitor. This results in an increased output slew rate. Figure 5 shows the schematic of the two-stage comparator.

N2 and N3 form current mirror to provide stable current for the first stage differential inputs. P0, P1, N0 and N1 are composed of differential amplifier. P2 and N4 form the second stage to amplify the signal from the first stage. Since in sigma-delta modulators the comparator is required to work at a high oversampling frequency but its resolution can be as small as 1 bit, the comparator design thus focuses more on a high-speed operation instead of accuracy. The waveform of comparator is as shown in figure below. Output of ADC is 1 bit so to increase the resolution of the output Decimator can be used. The desired output resolution is given by the equation,

N= (50 log k-12.9) /6.02
Where
N=Required Resolution
K=Over Sampling Ratio

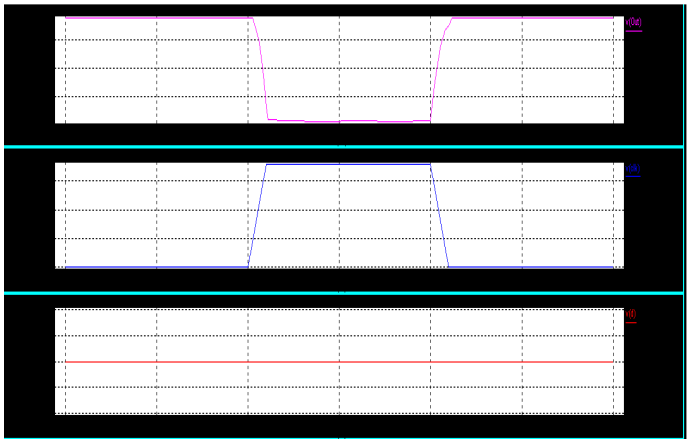

Figure 7:-Output Waveform of 1 bit ADC

7. Digital to Analog Converter

In feedback DAC is used which convert 1 bit binary representation into analog signal which will be applied as input to the Difference Amplifier using negative feedback which increases the stability of the circuit. As oversampling is used the use of anti aliasing reconstruction filter is greatly reduced. If higher order filter is required to reduce this noise,then some advantages of sigma delta DAC architecture are lost.

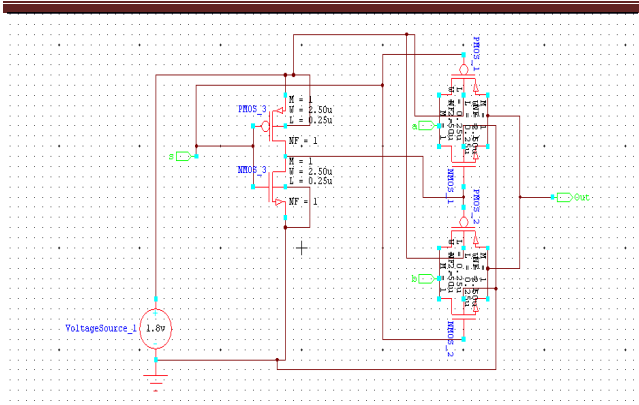

Figure 8:- Structure of DAC

8. Output Waveforms of Sigma DeltaModulator:-

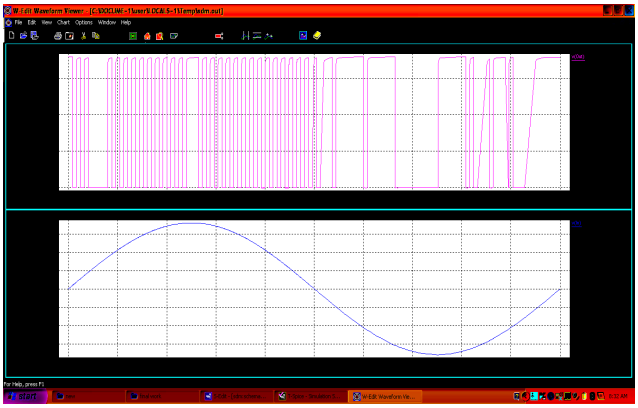

Figure 9:- sInput output waveforms

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