A Graphical User Interface(GUI) implemented Low-pass continuous time Sigma-delta ADC with improved SNR & ENOB

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Abstract— Sigma Delta ADC is better than Nyquist Rate Converters as they give better Resolution with low signal bandwidth. Sigma-delta ADCs are traditionally used in audio applications ranging up to 20 KHz. ADC based on sigma-delta modulators is attractive for VLSI implementation because they are less dependent to circuit non-idealities like clock Jitter and component mismatch. However, non-idealities become great challenges to the designer, especially at high sampling frequency. This paper presents the GUI representation along with the Simulink model with non-idealities to give better SNR and ENOB

Keywords—ADC, ENOB, Non-idealities, Sigma-delta modulator, SNR.

I. INTRODUCTION

Compared with Nyquist-rate ADCs, oversampling ADCs use more digital signal processing to perform analog-to-digital conversion, with the advantage of significantly relaxed matching requirements for the analog components, while still achieving medium to high resolution. Moreover, due to the oversampling delta-sigma ADCs, they do not need steep roll-off anti-alias filtering, which is usually required in Nyquist-rate ADCs. Power-hungry high-order high linearity anti-alias filters with accurate cut-off frequencies are thus avoided.

Sigma-delta ADC converters are important components in applications requiring the interface between analog and digital domains. There are numerous applications such as digital radio systems, military and medical sensors, and wireless communication systems. Moreover, due to the oversampling delta-sigma ADCs, they do not need steep roll-off anti-alias filtering, which is usually required in Nyquist-rate ADCs. Power-hungry high-order high linearity anti-alias filters with accurate cut-off frequencies are thus avoided. Oversampling ADCs are traditionally used in instrumentation, seismic, voice, and audio applications, with low signal bandwidth and high resolution. ADC based on 2nd order sigma-delta modulators is used for circuit non-idealities and component mismatch. However, issues such as clock jitter and excess loop delay become great challenges to the designer, especially at high sampling frequency. Special design should be applied to overcome these problems.

One of the challenges in these techniques is how to achieve high resolution, high performance and less consuming power with smaller hardware cost. For achieving these challenges continuous time low-pass sigma delta ADCs have been widely used.

Fig.1.1: SNR Versus Oversampling Ratio for First, Second, and Third-Order Loop
II. SYSTEM ARCHITECTURE

As the core of a ΔΣ A/D converter, the analog modulator normally has three primary components which includes loop filter, quantizer and feedback DAC.

**Basic concept in ΣΔ Modulators**

![Diagram of a basic first order sigma delta modulator](image)

**Fig.2.1 Sigma Delta Modulator - Basic Concept**

**LOOP FILTER** – It contains a discrete or continuous time transfer function which has large gain within the signal band while it attenuates out-of-band signals. A loop filter is realized by switched-capacitor integrators in a DT implementation and continuous-time integrators in a CT.

**QUANTIZER** - The quantizer works as an internal A/D converter to convert sampled analog signals and generates the modulator’s output. Its output can be single-bit or multi-bit depending on the system requirements. A single-bit quantizer is realized by a comparator. A multibit quantizer is thus be approximated as an adder, implementation such as active-RC, Gm-C, and passive architectures.

![Diagram of a detailed description of sigma delta modulator](image)

**Fig.2.2 Detailed Description of Sigma Delta Modulator**
III. Description of parameters

FEEDBACK DAC
The DAC feedback converts back the digital output word from the quantizer output to an analog signal or pulse. It is then subtracted from the input signal. Hence, creating a negative feedback loop. This DAC can be implemented with switched-capacitor (SC), current-steering, resistive or other circuit types. Every ΔΣ ADC requires at least one DAC at its input. In ΔΣ A/D modulators, since the quantizer is essentially non-linear, the modulator cannot be considered as a linear feedback system. However, if quantization noise in the quantizer can be modeled as white noise, the nonlinear quantizer

IV. RESULT

The basic design of the GUI is shown below

![Fig 4.1: Basic GUI diagram](image)

The basic GUI performs the following function

1) For giving the inputs – Here in this diagram it is clearly shown that 3 inputs namely Bandwidth, Oversampling Ratio(R) & No. of Samples (N).

![Fig 4.2: Basic Simulink Model](image)

2) For generating the Simulink Model- After applying the inputs the Open Simulink Model Tab will open the simulink model as shown below.The basic design of the simulink model along with the non idealities is shown.

3) For getting the outputs- After the simulink model runs we will get the output in the GUI
The outputs that we got from this model are as follows

![Output as seen in SCOPE of simulator](image1)

![Fig 4.5: PSD of a 2nd order Sigma-Delta Modulator (Detail)](image2)
The output of the command window of MATLAB is given by

![MATLAB Command Window](image)

**Fig 4.7: Output of the command window of MATLAB**

<table>
<thead>
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<th>S. No.</th>
<th>Parameters</th>
<th>Our Work</th>
<th>Previous Work[3]</th>
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<td>1)</td>
<td>Bandwidth (BW in HZ)</td>
<td>20000</td>
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<tr>
<td>2)</td>
<td>Oversampling Ratio (R)</td>
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<td>256</td>
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<tr>
<td>3)</td>
<td>No. of Samples (N)</td>
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<td>$2^{14}$</td>
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<td>4)</td>
<td>Gain (in dB)</td>
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<td>5)</td>
<td>Phase Margin (in degrees)</td>
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<td>6)</td>
<td>SNR (in dB)</td>
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<td>94.7</td>
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<td>7)</td>
<td>ENOB</td>
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Table 4.1: Comparing the value of our work with previous work

**V. CONCLUSION**

In this paper, behavioral model of 2nd order low-pass sigma-delta modulator including the non-idealities (sampling jitter, thermal noise, opamp noise, slew rate and bandwidth) are studied. Special design could be applied to overcome the non-idealities. A GUI based implementation has been made to calculate the SNR and ENOB.
REFERENCES


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