

# **Optimization of SNR InSigma-Delta Modulators with Clock Jitter Using Genetic Algorithm**

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**Abstract-** Oversampling Sigma Delta ADC (Analog to Digital) Converters are the key building blocks of wireless transceivers. In sigma delta modulator design, the scaling coefficients determine the peak signal-to-noise ratio. So selecting the optimum value of the coefficient is necessary. And therefore GA (Genetic Algorithm) is used for optimizing the coefficients. The performance of the design is analyzed using clock-jitter effect and considering noise also. The Simulation is done in MATLAB and the corresponding results were observed.

**Keywords-** Analog to Digital Converter (ADC), Genetic Algorithm (GA), Optimization.

## **I. INTRODUCTION**

GA are applied to a wide range of optimization problems. It can be effectively used to optimize the coefficients to get better signal-to-noise ratios. GA search engine is developed for quicker and easier designing of sigma delta modulators. This algorithm is applied to a second order sigma delta modulator while considering noise and clock jitter effects to analyze the SNR values.

## **II. NOTEWORTHY PAPERS**

In 2013, T. K. Bandopadyay, Manish Saxena, Raghav Shrivastava implemented "Sigma Delta Modulator with Improved Performance through Evolutionary Algorithm" In which Sigma-delta modulation is the most prevalent manifestation of analog-to-digital conversion utilized as a part of sound applications. The sigma delta conversion system has been in presence for a long time, however late innovative advances now make the gadgets reasonable and now range of use getting to be extensive. The primary thing of these converters is that they are the main low cost conversion system which gives both high dynamic range and adaptability in changing over low transfer speed data signals. These papers clarify how execution is enhanced utilizing genetic algorithm (GA). Specifically, the proposed converter makes utilization of low-distortion swing suppression SDM design which is exceedingly suitable for low oversampling proportions to accomplish high linearity over a wide transmission capacity. GAbased search tool is a stochastic search strategy which can discover the ideal arrangement inside the given requirement.

In 2013, A.A. Wan and S.C. Neoh implemented GA as optimizing technique for optimizing the design variables of the

3<sup>rd</sup> order low pass filter. This 3<sup>RD</sup> multiple Feedback low pass filter was designed using MATLAB and it was simulated in LTSpiceIV. Through this paper we get a clear view about how successfully a filter can be designed and simulated for gain, cut-off frequency and ripple.

In 2012, J. L. A. de Melo, B. Nowacki, N. Paulino and J. Goes implemented a design methodology for sigma delta modulators based on a genetic algorithm that used simulation and linear equations. The hybrid Cost function observes variations in different parameters like thermal noise, quantization noise, voltage swing variations and stability of the modulators. This paper also determined that as the order of the modulator is increased the performance of the sigma delta modulators improved. This performance was assessed using equations derived from its transfer function. But as these equations are not meant to be accurate therefore a simulation was done for determining the behavior of sigma delta modulators. This paper used 3<sup>rd</sup> order 1.5 Bit Continuous Time sigma Delta modulator but it did not analyze the effect of clock jitters.

In 2008, BaktiDarma Putra and GerhadFettweisanalyzed how clock jitter degrades the performance of discrete time sigma delta modulators and affects the SNR. A Comprehensive model was constructed which combined the effect of the clock jitter and quantization noise. Two orders were implemented to observe the effect of increasing the system's order to analyze the performance. For the 2<sup>nd</sup> order sigma delta ADC, when the sampling frequency is doubled, then the noise power is reduced by 9dB and for the 4<sup>th</sup> order sigma delta ADC, when the sampling rate is increased by factor 2, then the noise power is reduced 15dB. The output as PSD showed the Lorentzian shape spectrum due to clock jitter. This showed that the clock jitter degrades the SNR of the Sigma Delta Modulator.

### III. SIGMA-DELTA MODULATORS

Sigma delta modulator is used to modulate analog signal which gets into a form of digital. Sampling rate used during modulation is much higher than nyquist rate. The noise shaping function of 2<sup>nd</sup> order can be improved by using two integrators. The performance of sigma delta modulator can be optimized by using Genetic Algorithm.

### IV. GENETIC ALGORITHM

Genetic Algorithm raises a couple of important features. First it is a stochastic algorithm; randomness as an essential role in genetic algorithms. Both selection and reproduction needs random procedures. A second very important point is that genetic algorithms always consider a population of solutions. Keeping in memory more than a single solution at each iteration offers a lot of advantages. The algorithm can recombine different solutions to get better ones and so, it can use the benefits of assortment. A population base algorithm is also very amenable for parallelization. The robustness of the algorithm should also be mentioned as something essential for the algorithm success. Robustness refers to the ability to perform consistently well on a broad range of problem types. There is no particular requirement on the problem before using GAs, so it can be applied to resolve any problem. All those features make GA a really powerful optimization tool [5].

The basic four steps used in simple Genetic Algorithm to solve a problem are:

- The representation of the problem.
- The fitness calculation.
- Various variables and parameters involved in controlling the algorithm.

- The representation of result and the way of terminating the algorithm.

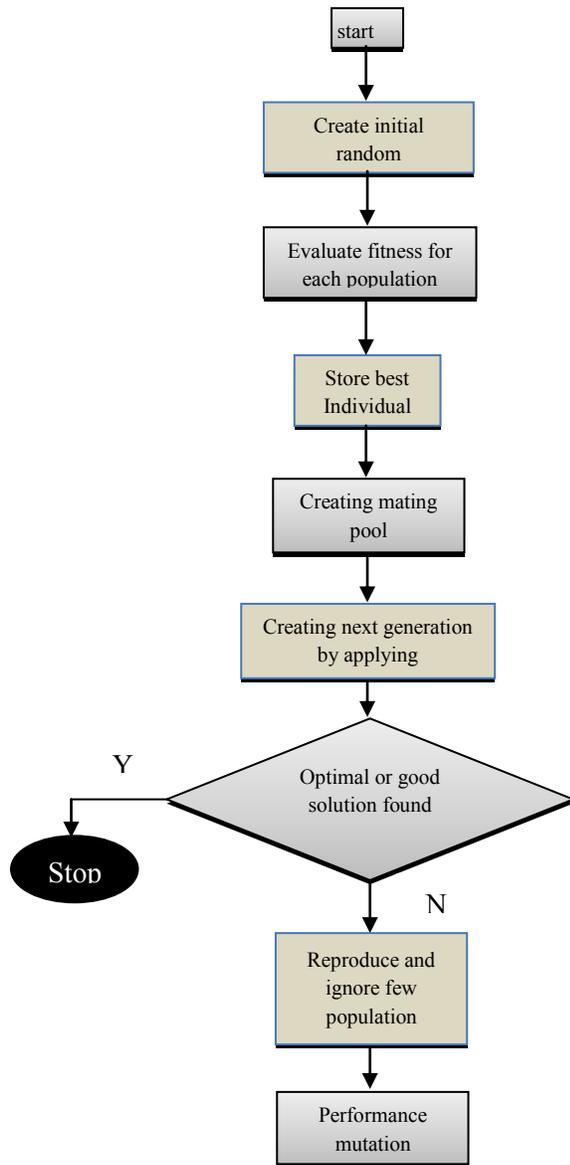


Fig.1: Flow Chart of Genetic Algorithm

## V. EXPERIMENTAL WORK

The simulation of the 3<sup>rd</sup> order sigma delta modulator was implemented on SD toolbox within MATLAB. Non-idealities are included such as thermal noise and clock jitter. GA was implemented with clock jitter and without clock jitter also. Results are obtained for frequency 700KHz.

The following list shows us the SNR improvements.

Frequency-700kHz and with clock jitters

Clock Jitter = 0.100 microSec

SNR (dB) = 45.123

Clock Jitter = 1.000 microSec

SNR (dB) = 30.920

Clock Jitter = 10.000 microSec

SNR (dB) = 10.592

Clock Jitter = 20.000 microSec

SNR (dB) = 4.451

Table1: Iteration Results

Generations	Best f-count	Mean f(x)	Stall f(x)	Generations
1	40	95.55	95.67	0
2	60	95.55	95.64	1
3	80	95.55	95.56	2
4	100	95.55	95.56	3
5	120	95.55	95.59	4
6	140	95.55	95.58	5
7	160	95.55	95.58	6
8	180	95.55	95.57	7
9	200	95.55	95.57	8
10	220	95.55	95.58	9

Frequency-700kHz and without clock jitter.

Enter Signal Bandwidth (Hz) : 700000

Clock Jitter = 0.000 microSecond

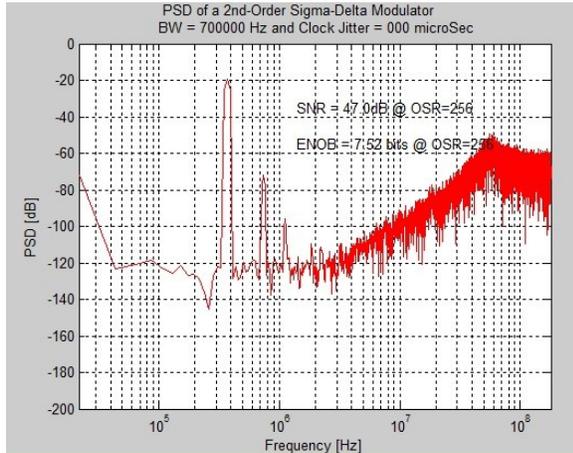
SNR (dB)=47.076

Table2: Iteration Results.

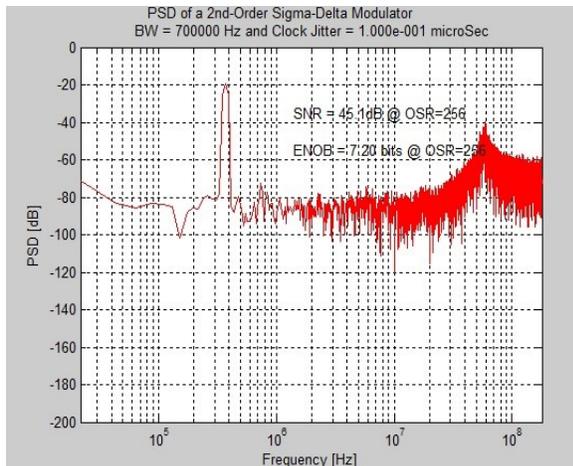
Generations	Best f-count	Mean f(x)	Stall f(x)	Generations
1	40	95.54	95.8	0
2	60	95.54	95.63	1
3	80	95.54	95.61	2
4	100	95.54	95.61	3
5	120	95.54	95.58	4
6	140	95.54	95.58	5
7	160	95.54	95.58	6
8	180	95.54	95.58	7
9	200	95.54	95.58	8
10	220	95.54	95.58	9

## VI. SIMULATION RESULTS

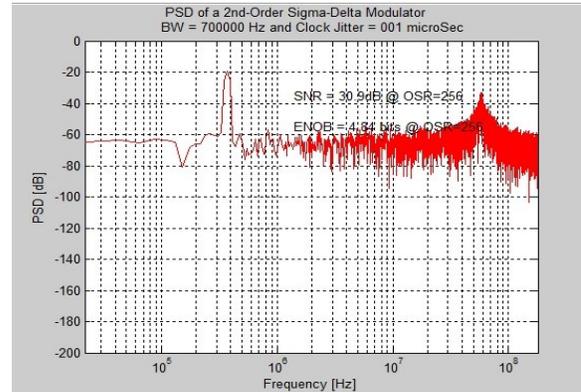
Simulations are done for both with and without clock jitters using GA. Our work population is run for 10 generations to get the optimum value of SNR.



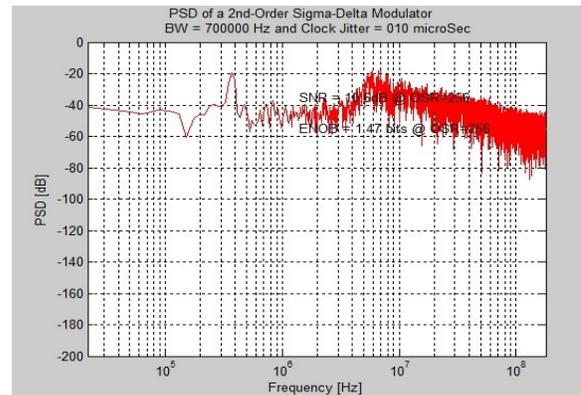
**Fig.2:PSD plot without Clock jitter.**



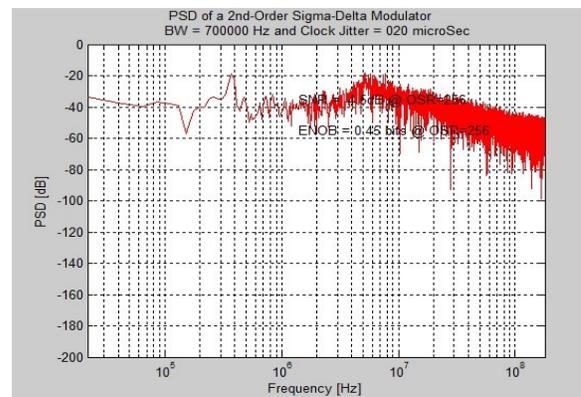
**Fig.3: PSD Plot with Clock Jitter 1microsec.**



**Fig.4: PSD plot with Clock Jitter 001microsec.**



**Fig.5:PSD plot with Clock Jitter 10microsec.**



**Fig.6:PSD plot with Clock Jitter 20Microsec.**

## VII. CONCLUSION

Genetic Algorithm is implemented for clock jitters and thermal noise optimization. We can observe that as the values of clock jitters increase the corresponding values of SNR also decreases.

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