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Performance Optimization of 3rd Order Sigma delta Modulator Using GA

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Abstract— In this paper, the case study will be 3rd order sigma delta modulator which will be designed using MATLAB SIMULINK. It will be analyzed by performance and parameter that affect the performance of sigma delta modulator where these parameters will be optimized using GENETIC ALGORITHM. The performance will be evaluated on SNR and ENOB.

Keywords— sigma delta modulator, genetic algorithm, SNR, ENOB

I. INTRODUCTION

An oversampling converter uses noise shaping modulator to reduce in-band quantization noise to achieve high resolution. The oversampling ratio, called OSR, is a ratio of clock frequency to nyquist frequency of input signal. This OSR varies from 8 to 256. Oversampling ADC can be classified as

- Predictive oversampling
- Straight oversampling
- Noise-shaping oversampling

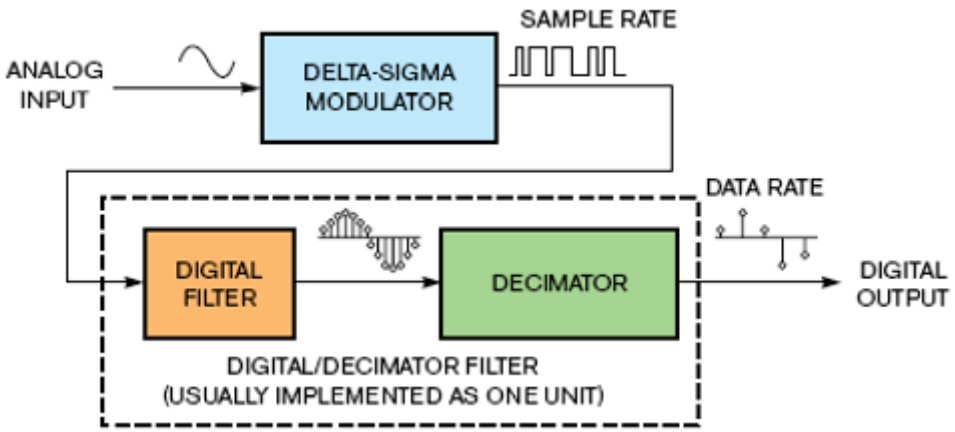

Fig 1: Block diagram of oversampling ADC

II. SIGMA-DELTA MODULATOR

The sigma delta modulator is also called noise shaper. It modulates the analog input signal to a simple digital code, normally a one bit serial stream using a sampling rate much higher than nyquist rate. The sigma delta modulator is a feedback system.

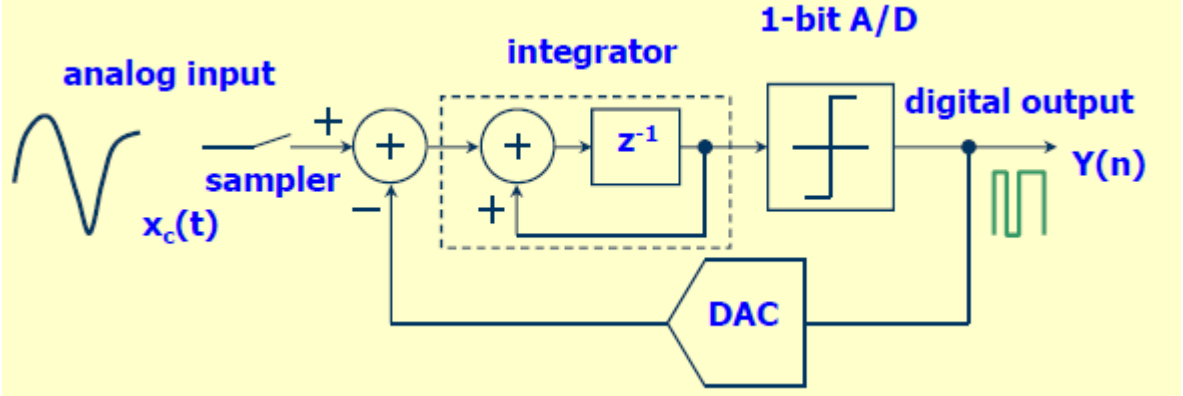

Fig 2: block diagram of 1st order sigma delta modulator

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The noise shaping function of 1st order can be improved by using the two integrators. This configuration is called as 2nd order sigma delta modulator. Similarly by inserting more integrators stages inside the loop a higher order sigma delta modulator can be realized.

Hence we can design 3rd order sigma delta modulator by introducing two integrators in the ideal 1st order sigma delta modulator. However the sigma delta modulator more than order 2 can be unstable due to higher loop gain of the higher order which causes the overload of quantizer. The gain coefficients are introduced to ensure the stability of high order sigma delta modulator. To improve the performance of sigma delta modulator we can optimize gain coefficient using GA explained in (III).

III. GENETIC ALGORITHM.

Genetic Algorithm is a optimization technique based on mechanics of natural selection and genetics. This algorithm is based on the concept of survival of the fittest.

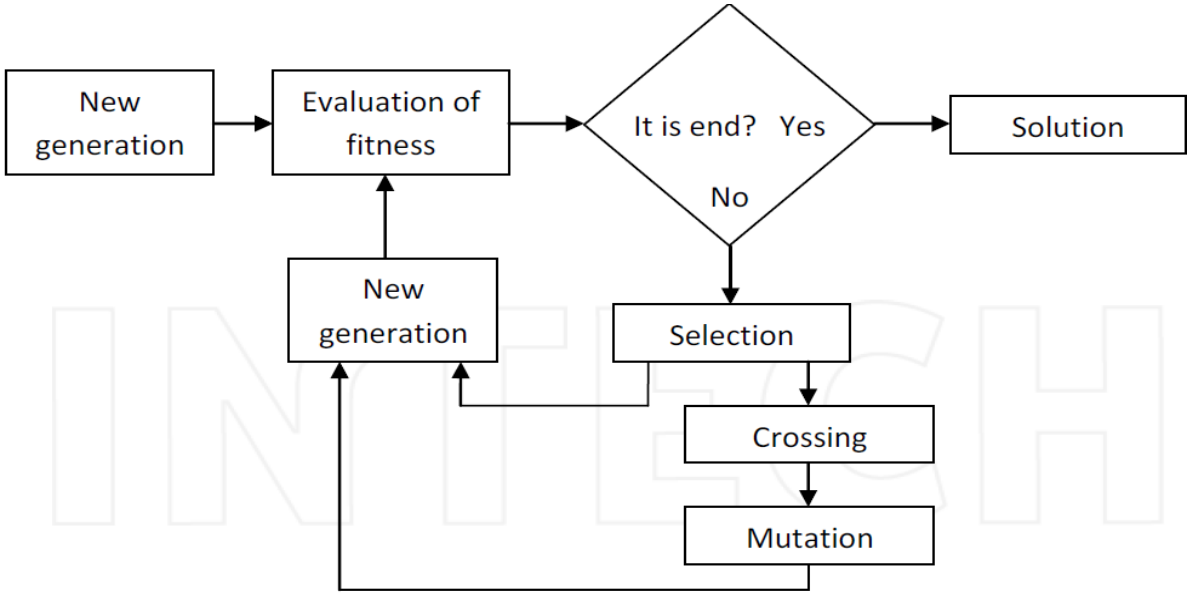

Fig 3 : flow chart of genetic algorithm

The above figure shows the flow chart of the genetic algorithm. Where first we decide the input parameters to be optimized(in this case gain coefficients). Then consideration of initial population which consists of collection chromosomes. The chromosomes which represent best solution are fittest, we find the fitness of the population and chromosomes with best solution are paired to produce offspring. This is done by using Roulette wheel technique. These pairs will be used for reproduction. Reproduction ensures that chromosome with higher fitness will have a higher probability of reproduction than chromosomes with lower fitness. Reproduction is application of crossover, mutation operators over selected chromosomes.

IV. EXPERIMENTAL WORK

The behavioral simulation of 3rd order sigma delta modulator is implemented with SD toolbox. The 3rd order sigma delta modulator has been designed using SD toolbox within MATLAB.

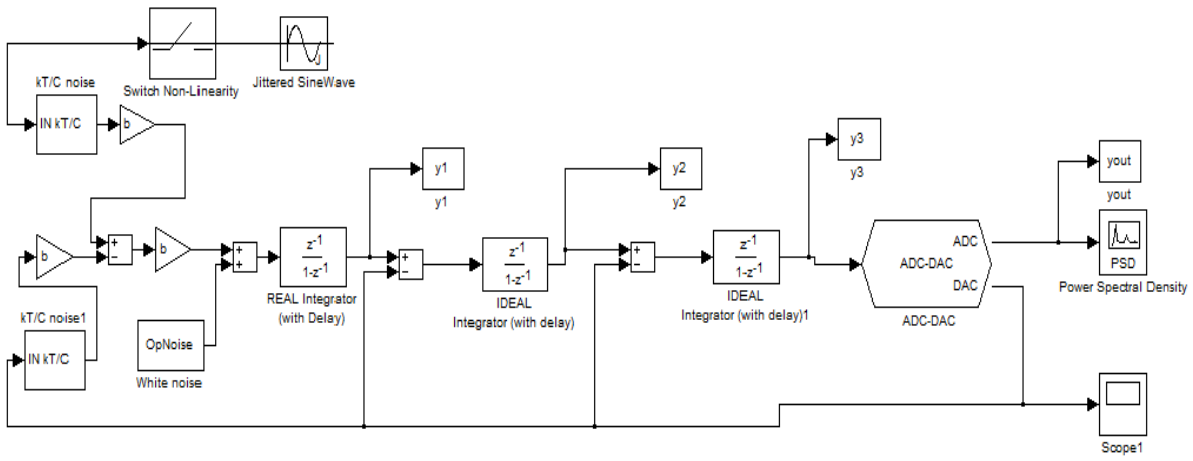

Fig 4: block diagram of 3rd order SDM using SD toolbox within MATLAB SIMULINK environment

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All the important non-idealities are included, such as sampling jitter, kT/c noise, internal adc/dac parameters such as mismatch and non linearity and op-amp parameters. We obtain post processing results SNR and ENOB with the help of SD toolbox. The frequency range is between 100hz to 5khz and OSR is varied between 32 to 256. Sampling frequency depends on OSR and fb. Since OSR is calculated as:

OSR= fs / 2fb.

The performance parameter SNR and ENOB are calculated and improved using GA. The following table shows us that there is improvement in SNR and ENOB after applying GA **.**

Table 1: SNR and ENOB results with and without GA in MATLAB

Fin	Fs	OSR	SNR	ENOB	SNR(ga)	ENOB(ga)
100	6400	32	-82.6	-25.6	-80	-24.54
200	12800	32	-80.8	-24.75	-79	-24.3
300	19200	32	-79.1	-24.32	-81.1	-25
400	51200	64	6.6	6.26	6.8	6.3
500	64k	64	6.8	6.27	7.2	6.41
1k	128k	64	31.1	6.15	32.1	6.35
2k	1280k	128	63.8	11.28	79.8	15.27
5k	1280k	128	69.9	12.81	73.5	13.69
10k	5120k	256	83	16.07	85.23	16.26

V. SIMULATION RESULTS

Simulations are performed for both with and without GA. In this work population is run for 10 generations to get the optimum value of coefficients. Crossover rate is 1 and mutation rate is 0.2 At the end of 10^{th} generation optimum values of coefficients are obtained g1= 0.4074 g2 = 0.5603 and g3 =0.4839

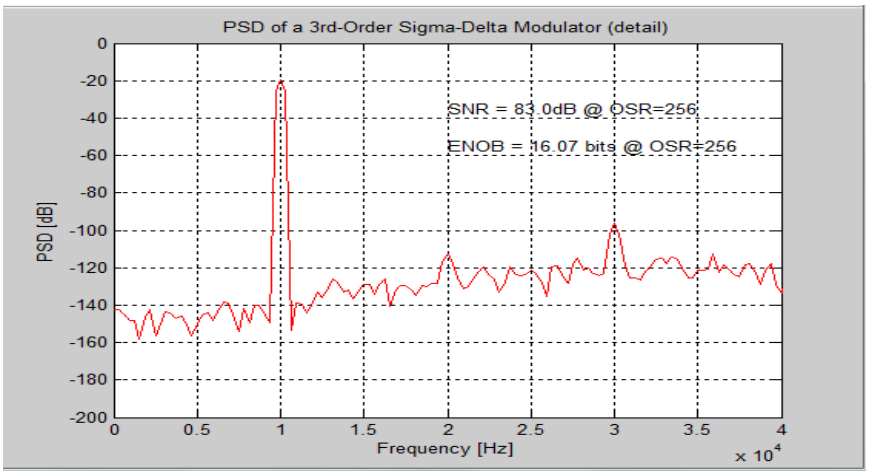

Fig 4 :PSD plot without GA

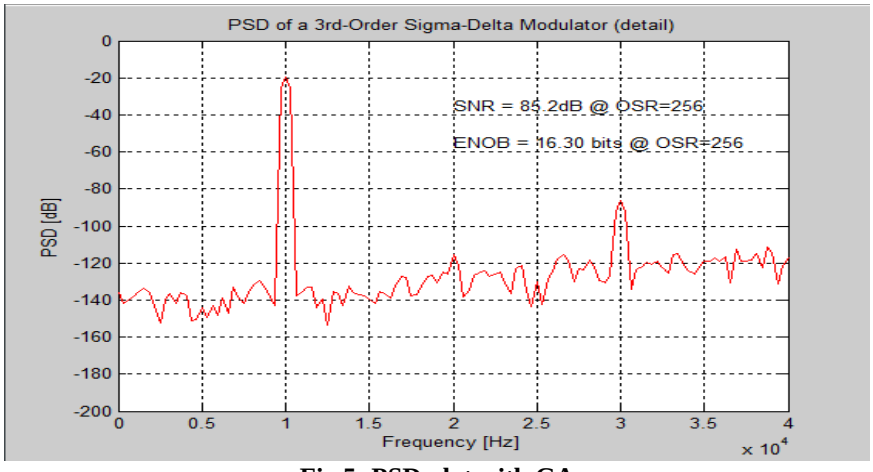

Fig 5 :PSD plot with GA

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Figure 4 and 5 shows the PSD plot of SDM with and without GA respectively where we can see the SNR and ENOB at OSR 256.

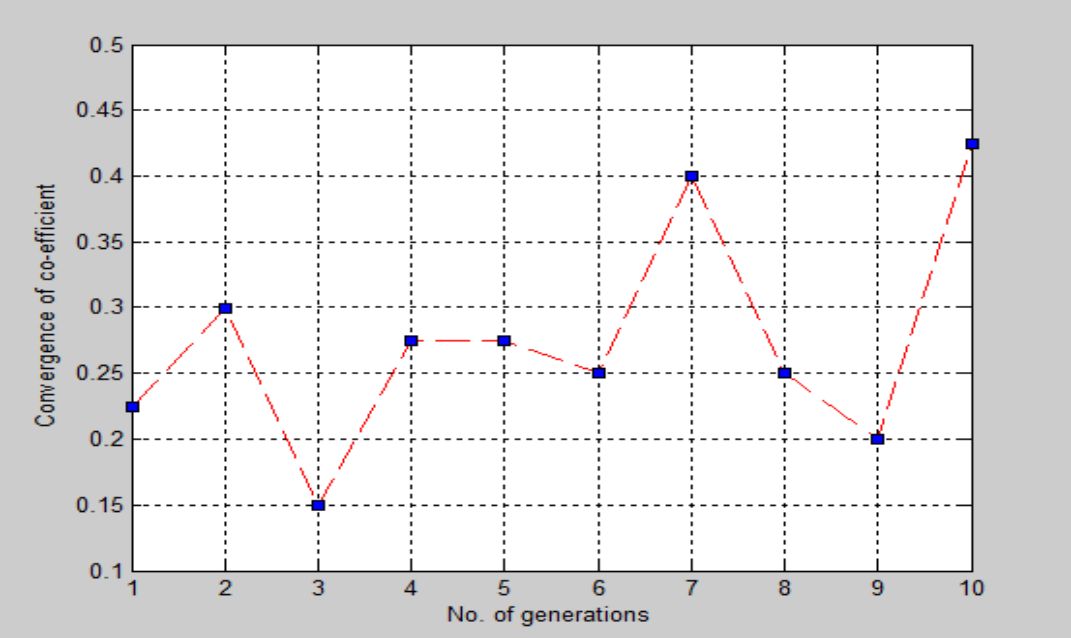

Fig 6: convergence of coefficients with no. of figures;.

Table 2: comparison of gain coefficients with and without GA

	Coefficients	***SNR***	***ENOB***
Without GA	G1= 0.5 , G2= 0.4 , G3= 0.3	83db	16.07
With GA	G1= 0.4074, G2= 0.5603, G3= 0.4839	85.2db	16.30

VI. CONCLUSION

Genetic Algorithm has been successfully used to improve the performance of sigma delta modulator. As seen in the simulation results the performance parameters SNR and ENOB have been improved using GA. Hence this improved SDM can be used in ADC to have better outputs in its application. We have used genetic algorithm successfully.

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