IJCTA, 9(9), 2016, pp. 3589-3597

Biomedical Signal Processing Using Memristor Emulator CT FIR Filter

E. Preethi[1], A. Mohamed Abbas[2], S. Prabhu Kumar[3] and P.G. Kuppusamy[4]

ABSTRACT

In this paper we discuss how a memristor emulator based timing storage circuit could be used in biomedical applications. The memristor emulator can replicate many of the features of the real memristor. The memristor emulator can store and reproduce timing information in an analog manner without performing quantization which can be utilized for a wide range of applications. As an example, a 15-tap CT finite impulse response (FIR) Savitzky-Golay (S-G) filter was designed with memristor emulator-based delay blocks. The blood signal which varies infrequently is considered as input for the designed SG_FIR filter. The simulations were carried out using MATLAB and Modelsim.

Keywords: Memristor, Memristor emulator, SG FIR filter, biomedical signal Processing, Verilog test bench.

1. INTRODUCTION

Memristor is a nonvolatile electrical component which regulates the flow of charge and also remember the amount of charge flown through it. The memristors are fabricated at Nano device fabrication, it employs cost and technical issues which makes it unavailable in near future. Thereby a device which replaces the behavior of memristor is required. This could be termed as memristor emulator, in which recent studies have shown that it embraces most of the behavior of memristor like non volatility, bimodal operation, wide range of memristance value. The resultant input memristance range obtainable with the proposed circuit configuration is theoretically from RS to infinity.

SG filter is used to smooth the signal and to increase the Signal to Noise ratio without greatly distorting the signal. It is typically used to smooth out a noisy signal with short term fluctuations and highlight the long term cycles, but they could not reject the noise.

The biomedical signals varies infrequently and has larger number of coefficients, thereby FIR filter is used rather than IIR filter. Since IIR Filter can satisfy only the constraint with signals having less coefficients. Biomedical signals like Electrocardiogram, Electroencephalogram, and blood signals varies with irregular intervals. Then such sporadically varying signals have long tap coefficients, thereby it is necessary to design a filter accepting such long tap delays. The implementation of such delay block is a challenging one. The delay block is designed using timing storage circuit with memristor emulator. As the memristor emulator have wide range of memristance value as the memristor, the inputs could be stored and reproduced.

The simulations are done using MATLAB and ModelSim. The SG FIR filter is designed and processed using MATLAB. And also the input, the image, is converted into text file using MATLAB and the text file is given as input to the designed SG FIR filter and output is obtained. The power and area utilization were analyzed using Xilinx Xpower analyzer.

[1] P.G. Scholar, Department of ECE, Vel Tech Multi Tech, Avadi, Chennai-62

[2, 3] Assistant Professors,

[4] Professor, Department of ECE, Vel Tech Multi Tech, Avadi, Chennai-62, *Email: kuppusamy@veltechmultitech.org*

The section I introduces the design of timing storage circuit using Memristor emulator, follows with section II which describes the design of FIR filter, follows with section III introducing biomedical application work and section IV simulation and its results.

2. DESIGN OF TIMING STORAGE CIRCUIT WITH MEMRISTOR EMULATOR:

First the section starts with design of memristor emulator which replaces the real memristor and its properties. The memristor emulator embrace the properties of memristor like non volatility, wide range of memristance. The power supply used in the design is 3.3 DC_V, and 0.35 technology.

The input voltage is the combination of R_S with current flowing through it i_{in} and the output of the analog multiplier $\alpha V_T V_C$. The sign of α should be positive. By following mathematical derivations the

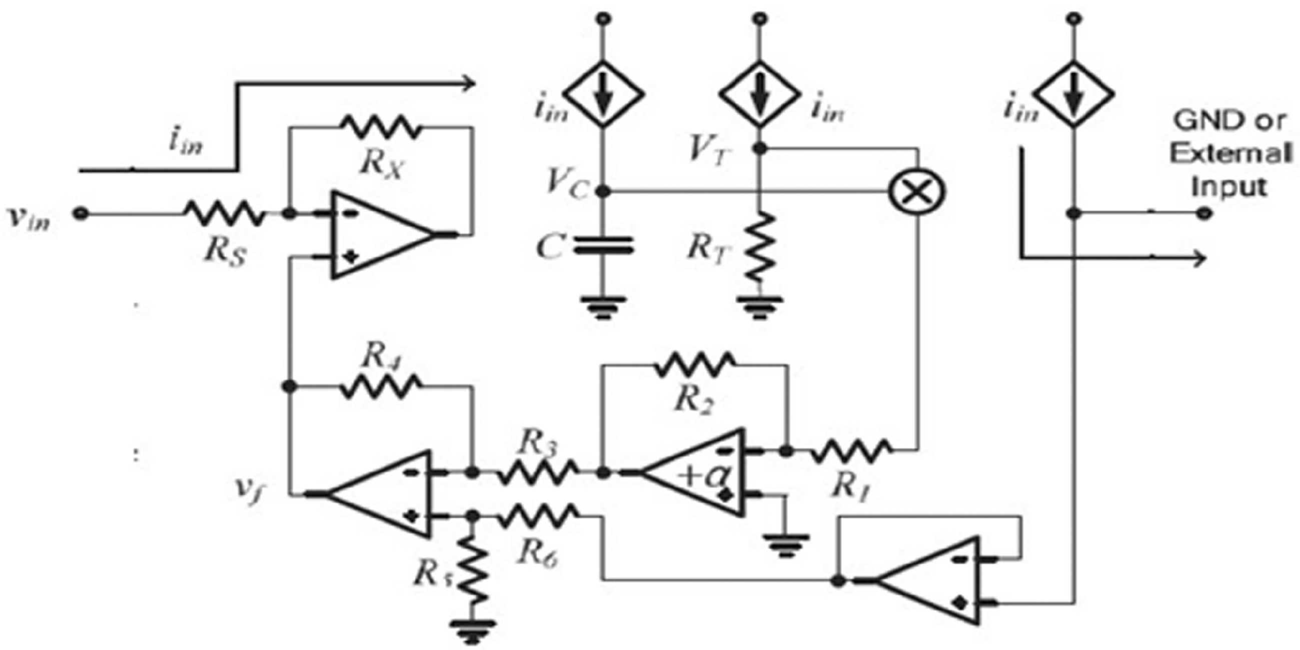

Figure 1: Memristor emulator circuit diagram.

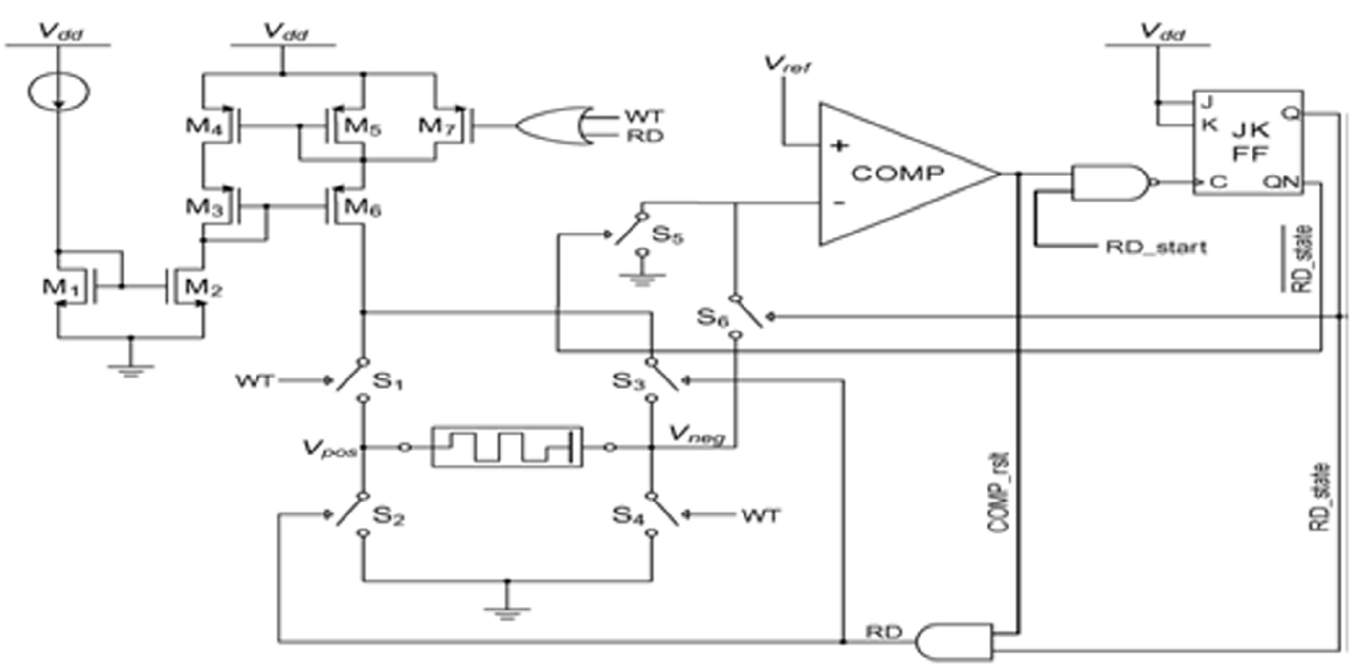

Figure 2: Memristor emulator based timing storage cell.

input memristance range varies from R_s to infinity theoretically. Thereby the memristor emulator has wide range of memristance value.

The four Memristor emulator based timing storage cell is used in each delay blocks. The timing storage cell has basic current mirror, memristor emulator, comparator followed with internal JK flip flop.

In timing storage cell two event occurs. For time T_1, the memristor emulator and current source gets connected in series, thereby the memristance value gets decreases, at time T_2, the current source gets disconnected and memristance value will be constant.

The time interval could be obtained with the difference of events T_1 and T_2. The reproduction of timing information could also be obtained byreconnecting the constant current source in opposite orientation.

3. DESIGN OF SG FIR FILTER

In the design of SG FIR filter 0.35 technology is used, Wilson current mirror is formed using transistors M_1 – M_6 and M_7 transistor act as switch. The inputs of JK flip flop are tied to V_{DD} to configure JK flip flop as T_ flip flop, which is used to start and end the reproduction phase. The T flip flop is set, then the outputs at “RD_State” and “RD-State” will be “0” and “1” respectively.

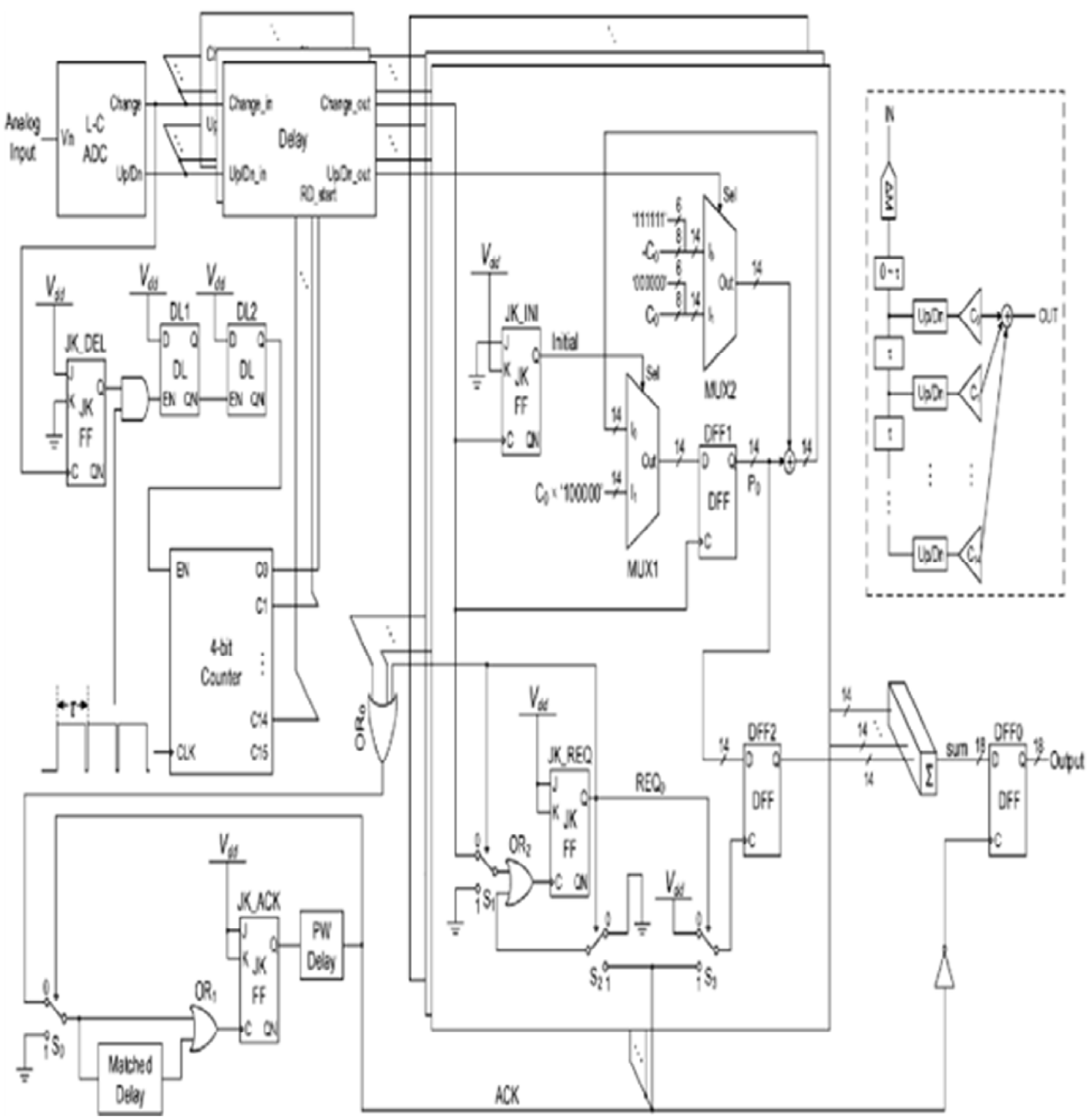

Figure 3: Design of 15-tap CT FIR filter

The comparator block detects the instance of V_{neg} crossing V_{ref}. The delay block which has memristor emulator based timing storage cell records and reproduces the timing information in τ time. The effective power and area utilization could be achieved by sharing the comparators and the current mirrors between the four timing storage cells

A four bit counter is used to generate RD_ Start signal, which in turn starts reproducing phase in delay blocks. The input signals are stored in memristor emulator based timing storage cell. The square wave generated by 4_ bit counter gets stopped when the delay block start to reproduce the inputs stored.

The 15 delay blocks in the designed FIR filter turns "ON" when the ADC block produce its output as "change" pulse thereby inputs to the filter are recorded. An external square wave with a respective period τ is used to control the delay present between consecutive 15 taps of FIR filter. When ADC produce first "change" pulse and if the external square wave is either "1" then "JK_DEL" signal is set and counter is enabled, or if the external square wave is "0" then "JK_DEL" signal is set and also the gate DL_1 and the counter gets ON at the arrival of next rising edge of square wave. The gates DL_1 and DL_2 are added for backup protection to assure metastability state.

To record the input signal only one memristor emulator cell could be selected, whereas the other one has to be selected for reproducing the signal. The memristor emulator cells are selected in circular order using ring counter. For the efficient memristor emulator cell selection, Multiplexed addressing techniques are employed. The number of memristor emulator cells required could be optimized by reusing the memristor emulator cells after each Record and Reproduce phases.

As simultaneous recording and reproducing is not done, the current mirror used could also be reduced to one, for efficient signal storage. A signal dependent variable current source has to be used for storing and reproducing the signal with long tap delays.. But at practical consideration it may have routing limitations along with area constraints.

4. APPLICATION

The biomedical signals vary infrequently with larger coefficients and also with longer intervals. The input signal(blood signal) is obtained from a standard Database and fed to the 15 tap SG FIR filter. Then the simulations were done using MATLAB and ModelSim.

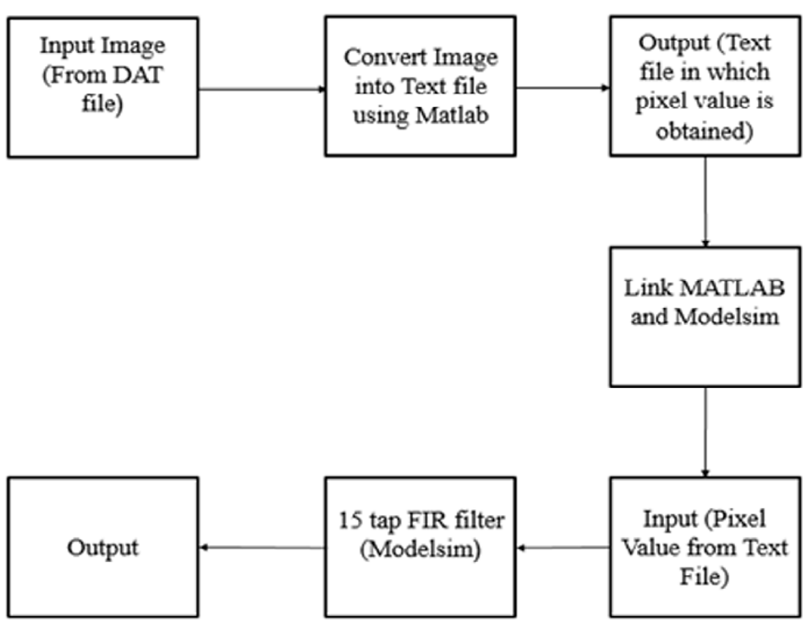

Figure 4: Block diagram for filtering a blood sample image using MATLAB and MODELSIM

First the blood sample image is converted into a text file using MATLAB and the values obtained from text file is fed as input to the SG FIR filter and processed The filtered output is obtained in ModelSim.

5. SIMULATION RESULTS

5.1. Simulations using MATLAB and MODELSIM

First the blood sample image is obtained from Standard Database and the image is converted into a text file using MATLAB

The text values obtained from the blood sample are in decimal form they have to be converted to binary form. And the binary values are given as input to the SG FIR filter and simulations are carried out using ModelSim.

The simulation analysis is observed using Modelsim. The output of Memristor emulator is expressed in Figure 6.1 and Figure 6.2.

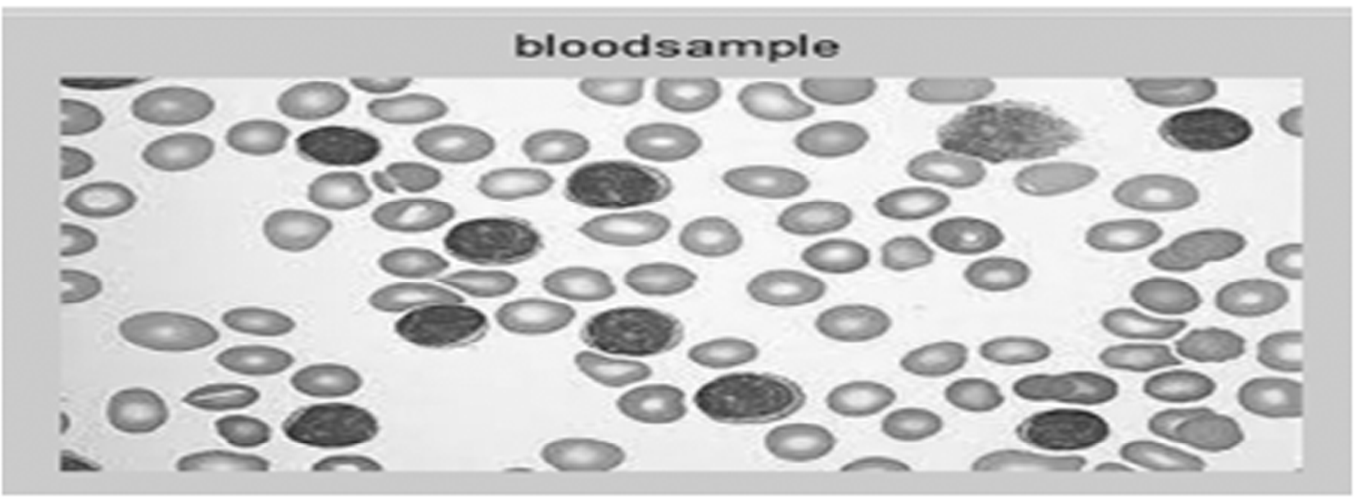

Figure 5: Input blood sample

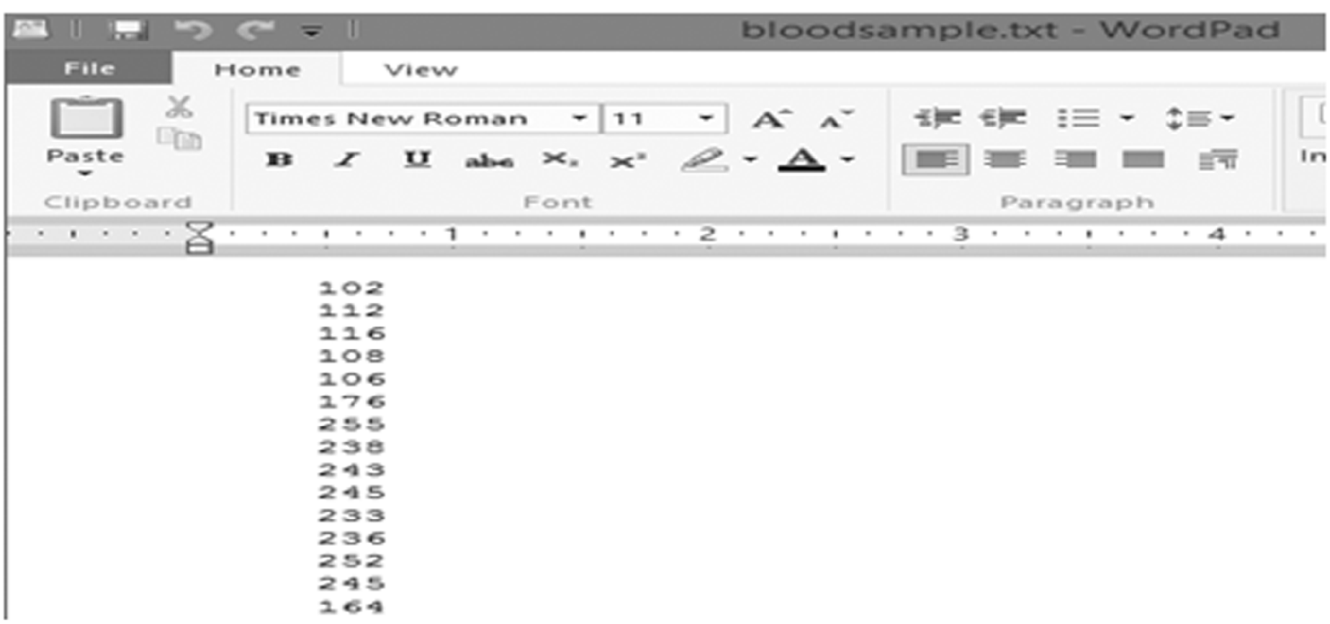

Figure 6: Text document for blood sample

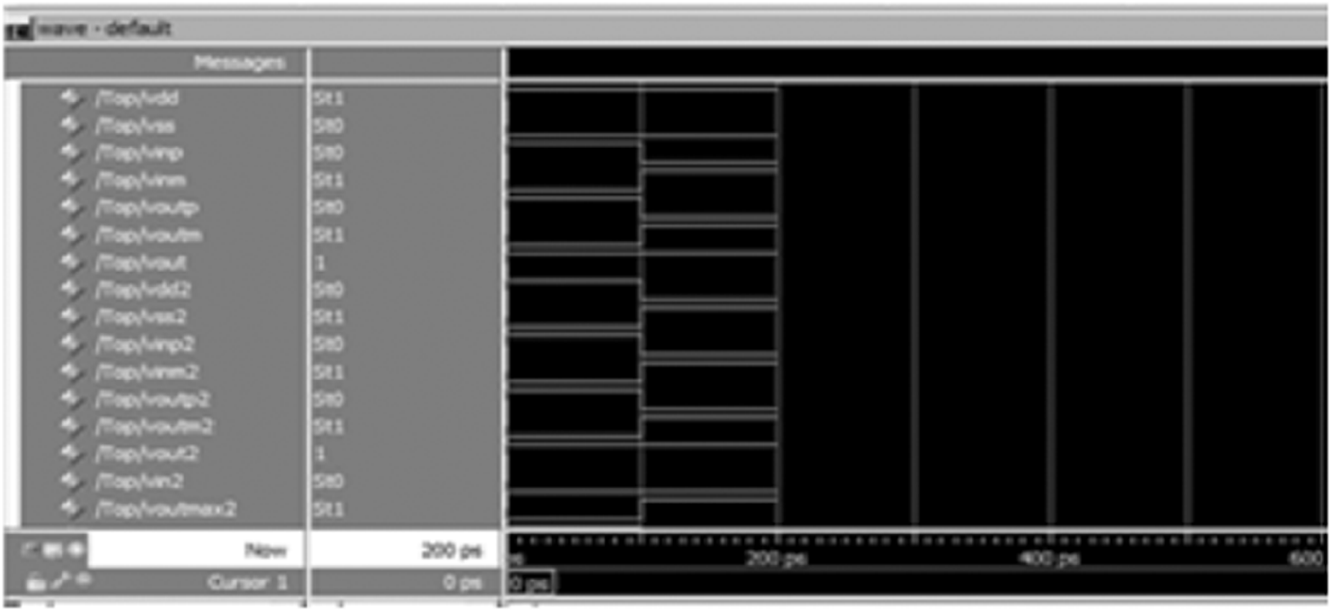

Figure 7(a): Memristor emulator output

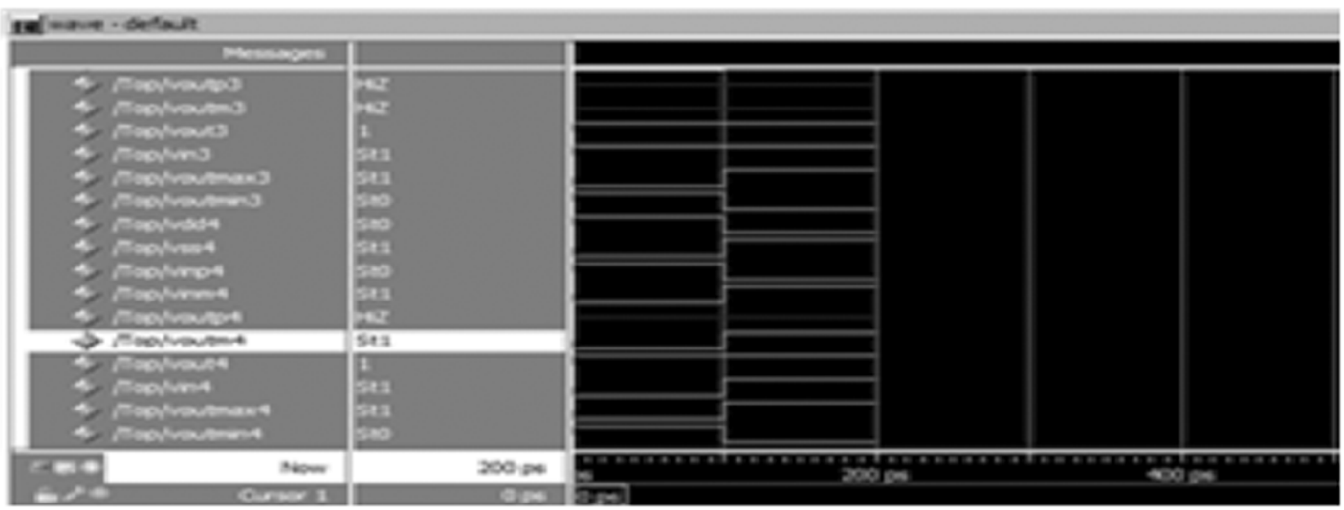

Figure 7(b): Memristor emulator output

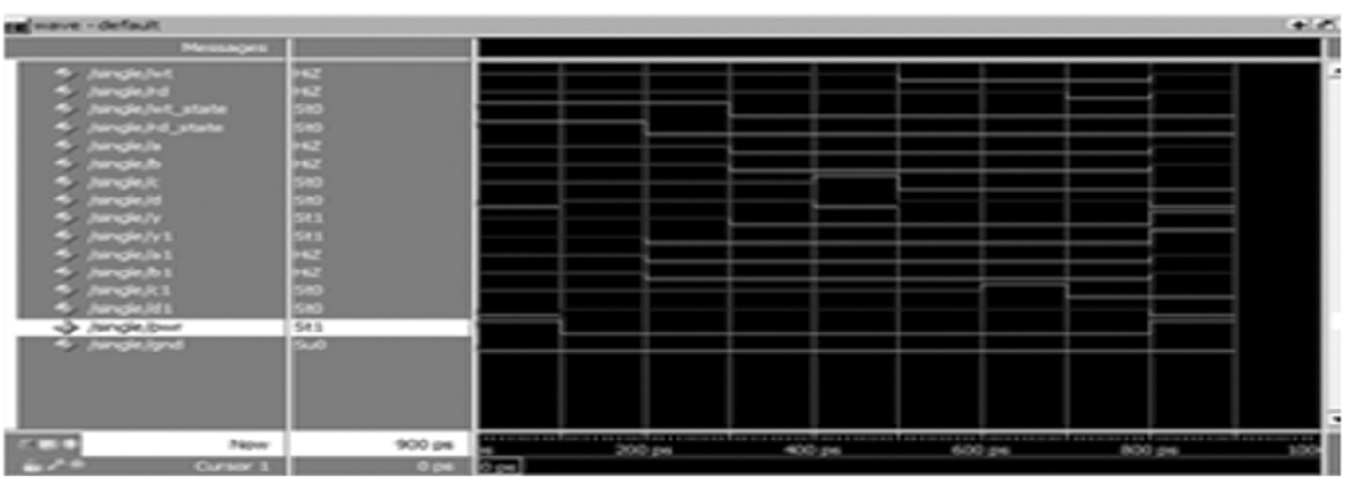

Figure 8 (a): Single timing storage cell using memristor emulator output

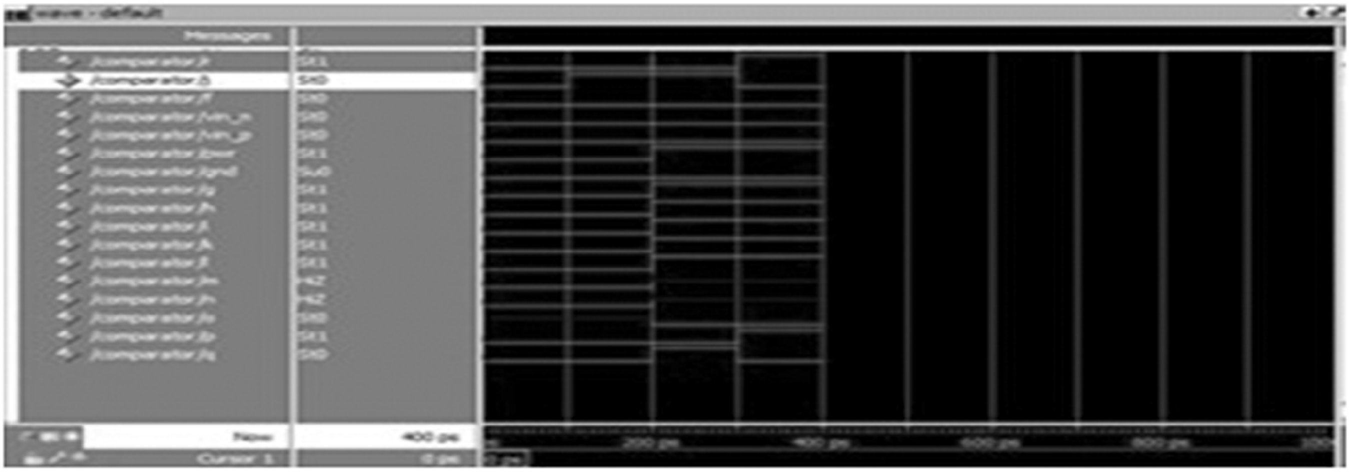

Figure 8 (b): Single timing storage cell using memristor emulator output

5.2. Simulation Using MATLAB

The simulations are done using MATLAB and filtered output is obtained

The input signal is obtained from a standard Database and fed to the SG FIR filter. The high frequency noise present in the input signal could only be reduced but it could not be rejected.

The frequency response for input blood signal is obtained and presented below

The power supply used in both the systems are 3.5 DC V and the technology used was 0.35nm. But in existing system the parameters and transistors are normalized i.e they are optimized, thereby the power

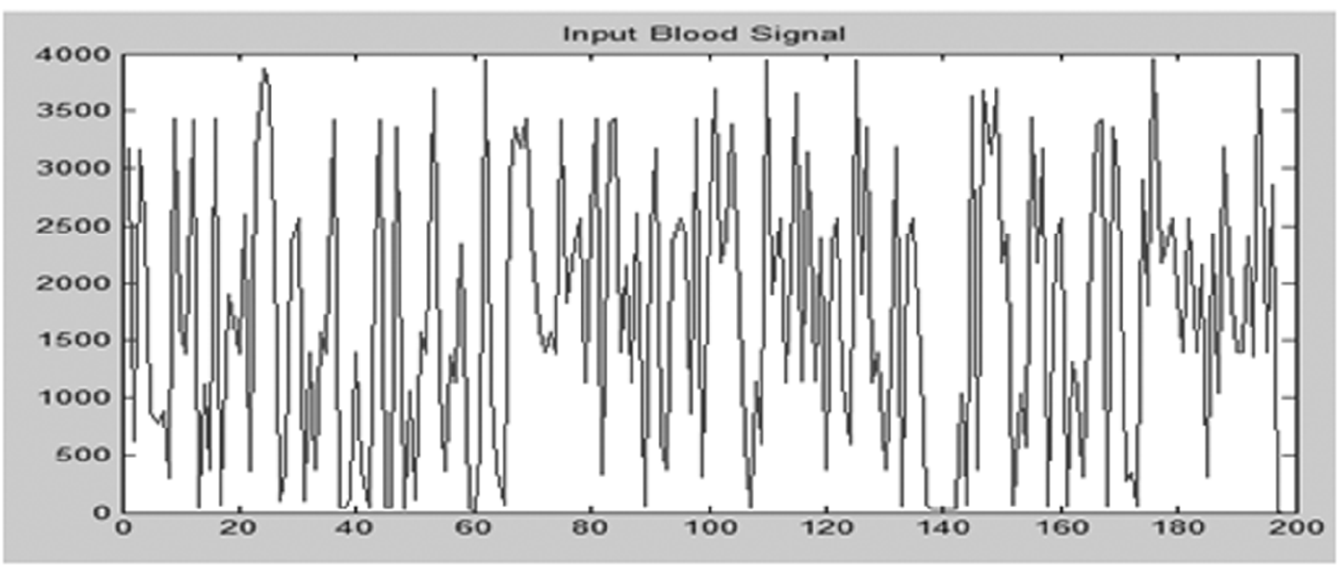

Figure 9: Input Signal for 15-SG FIR filter

Table 1
Performance Metrices

Parameters	*Existing System*	*Proposed System*
V_{DD}	3.5 DC V	3.5 DC V
Technology	0.35 nm	0.35 nm
Power	496 nw (under Normalized condition)	27mw (Without Normalization)

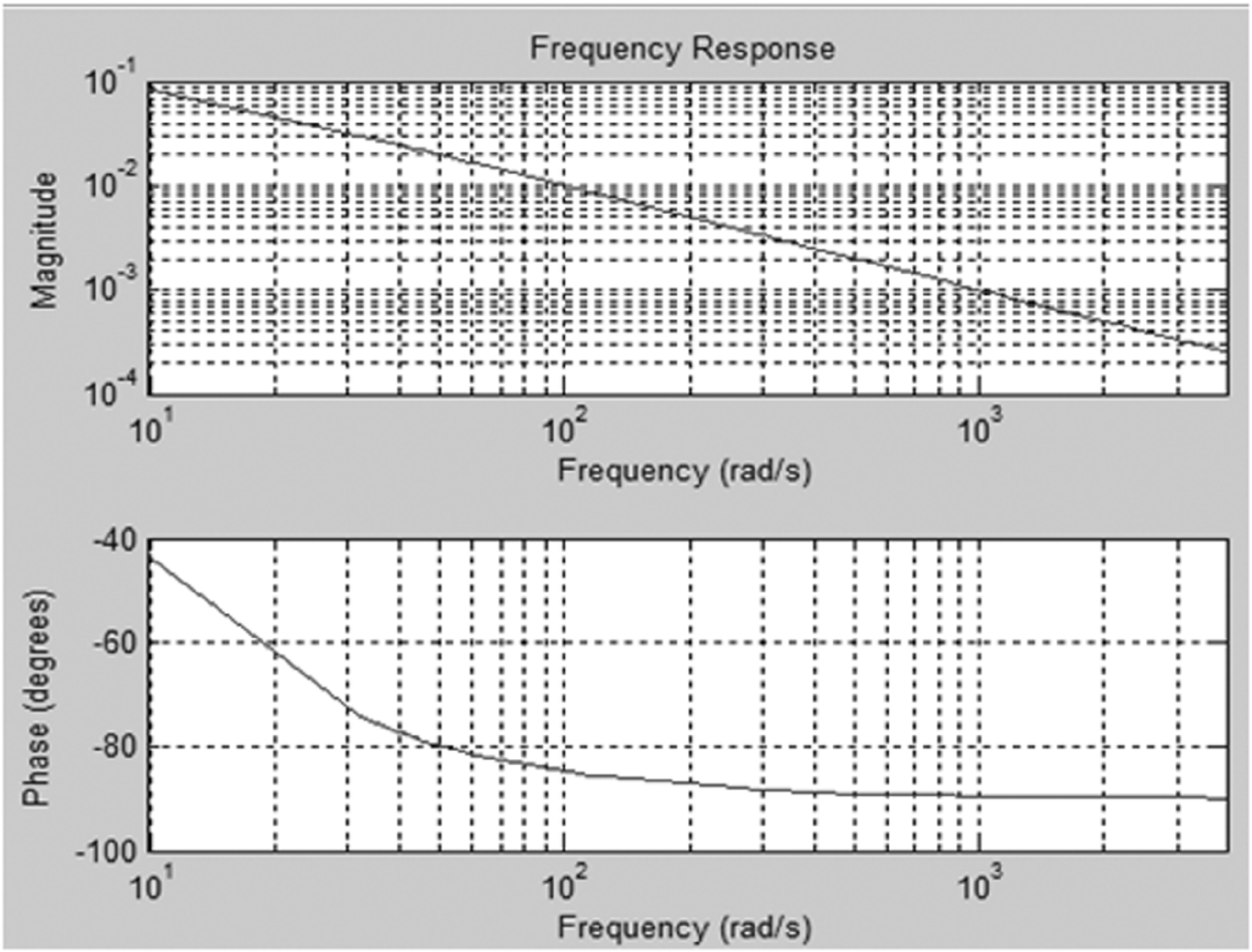

Figure 10: Frequency response of SG FIR filter for the input blood signal

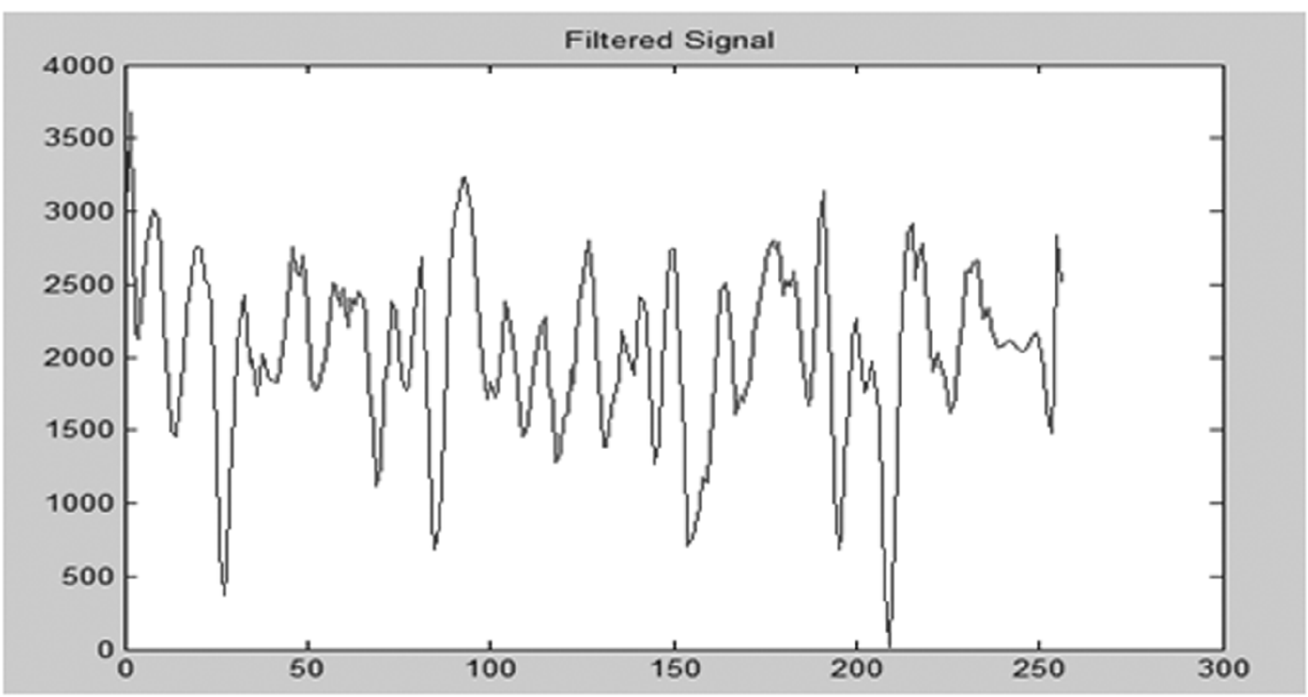

Figure 11: Filtered output of blood signal

utilization was 496 nw. In proposed work parameters and transistors are not normalized thereby the power utilization was 27mw.

6. CONCLUSION AND FUTURE DIRECTION

We have presented that a memristor emulator could be used for biomedical application. As the memristor emulator have wide range of memristance value as the memristor, the inputs could be stored and reproduced. The simulations are done using MATLAB and MODELSIM. The SG FIR filter is designed and processed using MATLAB. And also the input, the image, is converted into text file using MATLAB and the text file is given as input to the designed SG FIR filter and output is obtained. The power and area utilization were analyzed using Xilinx Xpower analyzer.

As the memristor is not available in near future due its cost, fabrication and technical difficulties, the memristor emulator could be replaced in the memristor part. The biomedical applications which requires long tap intervals could be processed using the designed filter. In future the Normalization has to be done for the designed SG FIR filter thereby power and area utilization could be further optimized.

REFERENCES

[1] A Memristor Based Continuous Time Digital FIR Filter For Biomedical Signal Processing Yibin Hong Yong Lian, May 2015, IEEE.

[2] A Memristor Emulator As a Replacement Of a Real Memristor by Changju Yang, Hyuncheol Choi, Semiconductor Science and Technology, 2015 IOP Publishing.

[3] Device Engineering and CMOS Integration of NanoscaleMemristors by Shuang Pi, Peng Lin, Hao Jiang, Can Li, 2014 IEEE.

[4] Design and Simulation of Canny Edge Detection by D Narayana Reddy*, VaijanathV.Yerigeri, Harish Sanu, IJESRT November 2014.

[5] An Event-driven Clockless Level-Crossing ADC With Signal-DependentAdaptive Resolution by Colin Weltin-Wu and Y. Tsividis, Life Fellow, IEEE SEPTEMBER 2013.

[6] Optimization and Implementation of Continuous Time DSP-Systems by using Granularity Reduction by Dieter Brückmann, Tobias Feldengut, BedrichHosticka, Rainer Kokozinski 2011 IEEE.

[7] A Memristor SPICE Model for Designing Memristor Circuits by Mohammad Mahvash Alice C. Parker, 2010 IEEE.

[8] A Continuous-Time ADC/DSP/DAC System with No Clock and With Activity-Dependent Power Dissipation by Bob Schell and Y. Tsividis, Fellow, IEEE 2008.

[9] A Continuous-Time Programmable Digital FIR Filter by Y. W. Li, K. Shepard, and Y. P. Tsividis 2005 IEEE.

[10] Continuous-Time Digital Signal Processors by Y. W. Li, K. L. Shepard, and Y. P. Tsividis 2005 IEEE.

[11] An Analog CMOS High-Speed Continuous-Time FIR Filter by Efram Burlingame and Richard Spencer, Sold State Circuit conf, ESSCIRC 2004.

[12] Memristor-The Missing Circuit Element by Leon 0. Chua, IEEE Transactions On Circuit Theory, Vol. Ct-18, No. 5, September 1971.