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A Review of Significant Role of Electrocardiogram Signal and Field Programmable Gate Arrays

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***Abstract** – This paper presented the review of electrocardiogram and FPGA of digital filtrations .Electrocardiogram (ECG) signals are frequently distorted by electrical and mechanical noise including power line interference, electrode movement, motion artifacts, and so on. Doctors need a clear ECG signal to make an accurate diagnosis. Filtering techniques to remove ECG signal noise using IIR & FIR digital filters have significant advantages over the former. Furthermore, a general-purpose multiplier takes up a lot of space on FPGAs, and its full flexibility isn't always needed. Silicon devices could be programmed in the field to become almost any type of digital circuit or system. Faster time-to-market and lower cost are two advantages of FPGAs over ASICs, which typically require a significant amount of money and time to produce the first device.*

Keyword: - ECG, Field Programmable Gate Arrays, IIR, FIR, digital filters.

I - INTRODUCTION

An electrocardiogram (ECG) is a bioelectric signal that measures the heart's electrical activity over time. Heart disease research relies heavily on this technique. Heart disease is a major factor in the rising death toll in the human population. The unexpected death of a cardiac patient can be prevented if the condition is diagnosed and treated early enough. Heart illness can be diagnosed with the aid of an ECG. The electrical activity of the heart is recorded by placing electrodes on the skin. In most cases, the ECG signal's amplitude is in the 0.1 mV to 3 mV range [Seema et al, 2011]. ECG signals have a frequency range of 0.05 to 100 Hz. The P wave, QRS complex, & T wave combine to generate an ECG signal, as depicted in figure 1.1. In 59 to 70 percent of EGCs, a faint U wave can be seen. Left & right atria activation can be seen on the P wave. The depolarization of the left & right ventricles is represented by the QRS complex. Repolarization of the ventricles is depicted by the T wave complex.

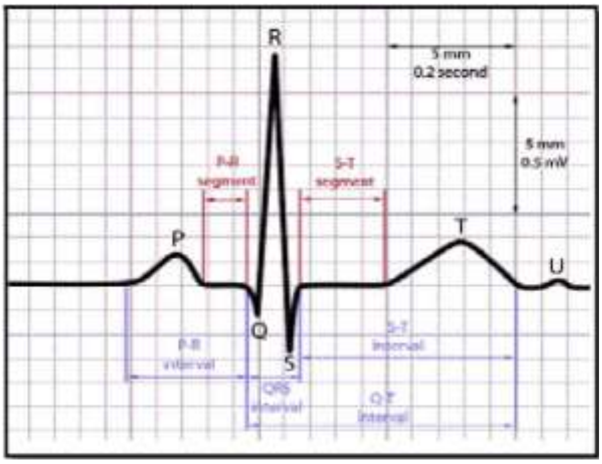

Fig 1- Normal ECG Signal

The varying values of these markers point to a heart condition. Arrhythmia is an abnormal heartbeat, and some arrhythmias can be exceedingly dangerous for patients.. AC interferences, loose electrode connections, the malfunction of the machine, and the patient's motions, such as respiration, can cause the ECG signal to be corrupted. Medical monitoring devices provide a thorough comprehension of the biomedical signal recording & demand more exact data for the diagnostic. When a patient is being diagnosed, it is difficult to achieve an accurate ECG signal recording result [Aleen 1994]. Any surrounding machinery's electromagnetic field has the potential to contaminate the ECG signal.

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Any surrounding machinery's electromagnetic field has the potential to contaminate the ECG signal [Wei2003]. The output of an ECG signal could damage when a patient is being diagnosed in a hospital or someplace else by this 50-60 Hz noise. Because of interference noise from the power source or the environment, it is impossible to get an exact reading from an ECG signal recording. There are groups of sodium (Na+) & potassium (k+) ions in the blood that form an electrical ECG signal. A recording bandwidth of 0.1 to 120 Hz is required for the ECG signal, which is normally in the 2 mV range. Electrodes attached to the surface of the human body can capture the ECG signal, which is created by the heart's rhythmic contractions. Signals gathered at each electrode and subsequently recorded. There are 12 different leads I, II, III, AVR, AVL, & AVH, while the chest leads are V1, V2, V3, V4, V5, and V6. Pictured in figure 1.2 is the original ECG signal downloaded from the MIT-BIH database (Massachusetts Institute of Technology-Beth Israel Hospital)

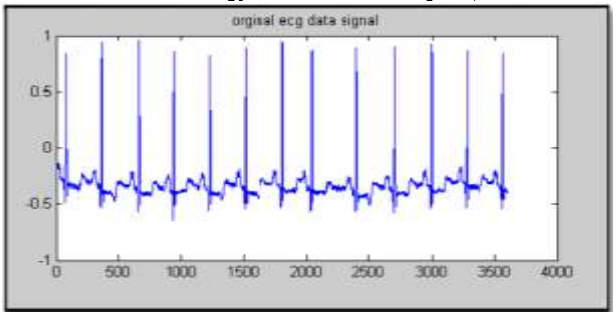

Fig 2- ECG data signal for record No. 222 MITBIH database

RLS algorithm, LMS & NLMS algorithm and SSRLS algorithm of adaptive filtering are some of the strategies being used by researchers to remove noises. Chebyshev filters, IIR filters and Zero phase filtering are also being used to remove noise. In this study, nine window approaches of the FIR (Finite Impulse Response) filter were utilized to reduce the noise of distinct ECG data signals. Neural networks trained for window-based FIR filters aren't mentioned anywhere in the survey.

II -ANALYSIS

DIGITAL FILTERS

Digital filters play a critical role in signal processing, removing unwanted signals like noise or extracting the important parts of signals that fall within a certain frequency range. To reduce noise in the ECG signal, a variety of techniques are available, including the Infinite Impulse Response (IIR) & FIR filters, each with their own set of pros & cons. The best solution for noise reduction is a digital filter, which is best suited for ECG analysis because it improves the ECG signal's quality. Thus, the design cycle of digital filters have to reduced. At each intermediate step in the transformation process, they perform noiseless mathematical functions without causing any interference. Filter coefficient quantization error is less of an issue with FIR filters because they are simple to design and easy to achieve linear phase performance.

This makes FIR filters a popular choice for digital signal processing applications such as digital audio & image processing and data transmission. Various filter types, such as low-pass, high-pass, band-pass, and band-stop filters, are employed in the solution of various design challenges. Direct, cascade, polyphase, lattice, or other major forms of FIR filter structure can all be considered basic structures. An IIR filter is a type of recursive filter in which the current output is dependent on both previous outputs and the inputs it received. Many times, they can be a lot better than a FIR filter when it comes to efficiency in terms of order. Because of their lower latency & closer resemblance to analogue circuits, IIR filters produce better magnitude responses with fewer coefficients. It is difficult to implement IIR filters in a pipelined design due to the fact that feedback could incorporate instability, limit cycles, non-linear phase response, and other drawbacks. The following Eqn1.1. could be used to depict the operation of a FIR filter. Hkare are the filter coefficients, or the length of M is the filter length. The Eqn. is the simplest form of IIR operation. 1.2 Where M is the maximum input delay, hkare the numerator coefficients; N is the maximum output delay, and ak are the denominator coefficients. From Eqn. 1.1 and 1.2, computation of y[n] involves calculation of y[n-1], y[n-2],.....y[n-N] and x[n], x[n-1], x[n-2],......x[n-M] hence there is a requirement of basic elements like delay or storage, multipliers and adders (subtract is measured as addition). As a result, different structures for discrete-time LTI systems could be realized by arranging y[n] computations in various ways to obtain the same difference equation.

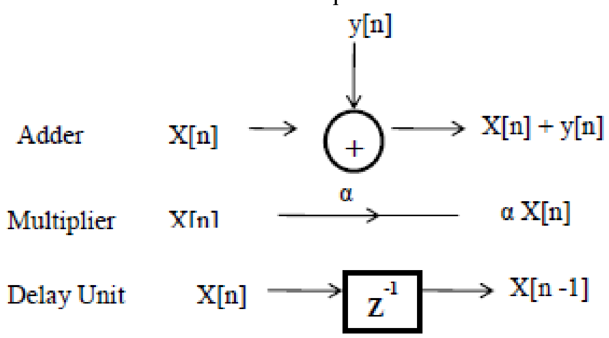

Fig 3- Basic operations in block diagram

A signal flow graph or a block diagram can be utilized to represent an implementation. Figure 1.3 depicts the lock diagram operations required to make digital filters. There are many ways to reduce the number of multipliers in a system, but one of the most common is to use an adder to handle multiple sequences. Digital implementation of the Delay Unit could be achieved by provide a storage register for each delay unit. The Direct Form-I, II, Cascade Form, & Parallel Form are structures used in IIR filters, whereas the Direct Form-I & II are structures used in FIR filters. There are a variety of digital filter structures that has to utilize to remove various types of noise.

A parallel-pipelined architecture is utilized to execute filters based on FPGAs & ASICs, which improves performance. Because of the higher sampling rates and lower costs offered by VLSI implementations of digital filters, they can be used in FPGAs or other VLSI. Because digital filters can achieve a better signal-to-noise ratio than analogue filters and because analogue filters introduce more noise into the signal at each stage, digital filters are broadly utilized in the electronics industry. Filters that remove noise, shape the spectrum, & minimise inter-symbol interference in communication systems have emerged as a viable option. Design engineers can achieve performance levels that are difficult to achieve using an analogue filter because these filters can be precisely reproduced. As opposed to IIR filters, FIR filters are more commonly found in digital signal processing (DSP).

For long-term health monitoring, patients cannot use traditional ECG diagnostic products from various companies because they are cumbersome & inconvenient. Portable biomedical applications require a lot of power to run efficiently. In order to create a flexible electrocardiogram system with an improved filtering technique, the emphasis is on designing systems with embedded circuits & available technologies. ECG currently lacks flexibility & neither compatible with PC and communications standards nor can they be easily upgraded. As if that wasn't bad enough, owning one for personal utilize at home is prohibitively expensive. A medical professional or patient-friendly ECG monitoring system will have these features: integrated designs, portability and flexibility; wireless communications; comfort & ease of use.

Some ECG monitoring systems use microcontrollers, while others use DSPs and medical development kits that include electrocardiograms and oximeters are common. Innovative devices such as FPGAs combine the advantages of software and hardware by limiting their clock rate. Comparatively speaking, FPGAs are low-cost devices that combine high performance with flexibility, reconfigurability & programmability as well as high reliability and high logic density. Many times, an FPGA based system can be reconfigured, as computations are pre-programmed but not permanently frozen at a time of manufacturing.

III- DESIGN

The input design is the link between the information system and the user. It comprises the developing specification and procedures for data preparation and those steps are necessary to put transaction data in to a usable form for processing can be achieved by inspecting the computer to read data from a written or printed document or it can occur by having people keying the data directly into the system. The design of input focuses on controlling the amount of input required, controlling the errors, avoiding delay, avoiding extra steps and keeping the process simple. The input is designed in such a way so that it provides security and ease of use with retaining the privacy. Input Design considered the following things:

- What data should be given as input?
- How the data should be arranged or coded?
- The dialog to guide the operating personnel in providing input.
- Methods for preparing input validations and steps to follow when error occur.

A quality output is one, which meets the requirements of the end user and presents the information clearly. In any system results of processing are communicated to the users and to other system through outputs. In output design it is determined how the information is to be displaced for immediate need and also the hard copy output. It is the most important and direct source information to the user. Efficient and intelligent output design improves the system's relationship to help user decision-making.

IV- CONCLUSION

The ECG is a piece of medical equipment that measures the electrical behavior of heartbeats by sending a pulse wave from the heart to the muscles that squeeze & pump blood into the organ. The ECG is recorded by the ECG machine. Doctors base their decisions on the characteristics of the ECG signal. Electronics systems of the future must be able to operate at high speeds & respond quickly. The use of FPGA design technology for evaluate & implement signal processing algorithms has grown in popularity. However, the FPGA implementation has its own set of issues, including cost, power, area &

speed. Thus, the design cycle of digital filters could reduce. At each intermediate step in the transformation process, they perform noiseless mathematical operations without causing any interference. Numerous digital signal processing fields, including communications, digital audio, image processing, data transmission, biomedicine, and other fields, rely on FIR filters for their signal processing needs.

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