Analysis of VLSI Pacemaker Designs: A review

Amandeep Kaur
University College of engineering
Punjabi University
Patiala, India
E-mail: smagh90@gmail.com

Amandeep Kaur (Astt. Prof.)
University College of engineering
Punjabi University
Patiala, India
E-mail: aman_dhaliwal3333@yahoo.com

***Abstract*—** In this paper, we have reviewed different types of intelligent control systems designs that are used to regulate the heart rate by the use of pacemaker. These system works in a closed loop way and works on the theory that the heart is powered by the pacemaker which is comprised of a cardio vascular system. The optimal control processes are the main consideration in the comparison of the designs. The designs are chosen on the basis of the optimum output which can be achieved by the use different control parameters. Adequate profit margin and the phase make the design of the pacemaker system steady and stable. Finally a study is presented that proposed better method and uses controller optimizations comparative study through conventional approach. For the comparison, the test of observability and controllability of the complete system have been tested and some designs are found fully stable and in fact better than the other.

Keywords- *Intelligent control system, Pacemaker, Cardiovascular systems, Controller*

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I. Introduction

A lot of work has been done since 1960s in the field of cardiovascular systems using various types of physical models in the real system. Cardiovascular systems widely use the mathematical models and Computer analyses for the purpose of simulation. Heart assistance and artificial hearts are planted in the patients to a large extent these days [6]. These are used to main the blood circulation during the heart transplant operation so as to maintain the blood flow. Also after an infarct, artificial hearts are used to replace a weak heart. In order to regulate the heart rate, a medical device called an artificial pacemaker is used. This system uses electrical impulses which are delivered by electrodes for contracting the heart muscles and thus regulate the flow of heart beat. When the native pacemaker of the heart is not fast enough or in case electrical conduction system of the heart is blocked, the artificial pacemaker is used. Its main functions it to maintain a proper and adequate heart rate [3].

Pacemakers who are commonly known as cardiac pacemakers have been used successfully to treat a deadly heart disease known as bradycardia. Blood circulation and heart rate is being monitored by the pacemaker. A pacemaker sends electrical signals or impulses through an electrode to the heart and makes it beat fast [1] whenever the heart rate slows down or the beat is inadequate. It is therefore, of prime focus to improve the performance of the device and extend the operating range of the device. Therefore, it is important to improve these features for improved performance and for extending its operating range. Pacemakers are classified into single chamber pacemakers and double chamber pacemakers. The extension of operating range depends upon the stimulated pacemakers and the also on the number of monitored cameras available. The difference of single chamber pacemaker and dual chamber pacemakers is primarily of technology and ability of double chambered pacemakers to reduce the chances of heart failure, pacemaker syndrome and atrial fibrillation and thus more advantageous over the single chamber pacemakers [4][11].

One of the disadvantage of dual chamber pacemaker is that dual chamber pacemaker consumes more energy of the battery as compared to single chamber pacemakers. Since the pacemaker operate inside the body therefore is not possible to change the battery frequently. Also it is not safe too. Due to this problem, most of the patients have no other option to buy and implant single chamber pacemakers instead of dual chamber one [5].

Therefore an improvement in dual chamber pacemakers is required to make them compete with the single chamber pacemakers on the power consumption side so that patients are able to implant dual chamber pacemakers and have it advantageous[2].

II. REVIEW ON PACEMAKER

A. VVI Pacemaker Engine:

The VVI Pacemaker Engine was broken into a similar structure to the V Refractory block. The only difference is the functionality and that the controller was implemented using the dataflow style with just combinational logic controlling the progression of the state machine. The timer is held in recirculation mode and merely reset on every paced and sensed event by the controller. As shown, this result in a three state state-machine with all unused states automatically transitioning to the reset state [7].

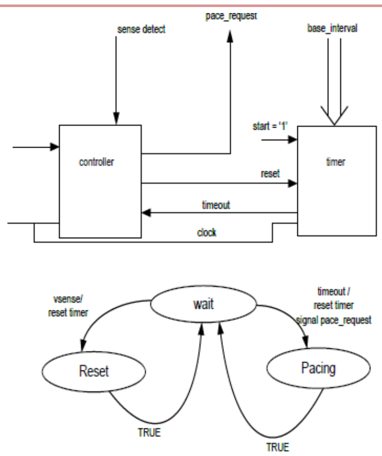
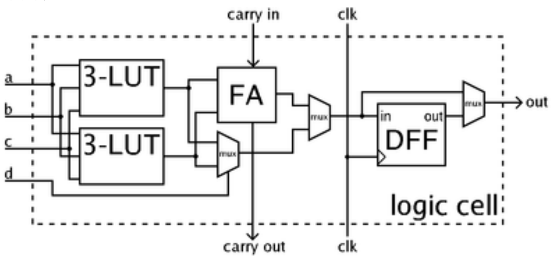


Fig 1. VVIPPacemaker Engine State-machine of the controller

B. SPARTAN-3EFPGA architecture for pacemaker

The Spartan product is a cost reduced high volume FPGA. Most Spartan devices are a close relative to another Xilinx product [14]. The Spartan-3E FPGA family offers the low cost and platform features you're looking for, making it ideal for gate-centric programmable logic designs.Sparatan-3E is the seventh family in the ground-breaking low-cost Spartan Series and the third Xilinx family manufactured with advanced 90nm process technology.Spartan-3E FPGAs deliver up to 1.6 million system gates, up to 376 I/OS, and versatile platform FPGA architecture with the lowest cost per-logic in the industry. This combination of state-of the art low-cost manufacturing and cost-efficient architecture provides unprecedented price points and value. The features and capabilities of the Spartan-3E family are optimized for high-volume and low-cost applications and the Xilinx supply chain is ready to fulfill your production requirements [10].The simulation was achieved with the XC4000E Xilinx family and showed correct results at a rate of 75 ns per output. Since the processing rate is dissociated from the acquisition and the restitution rate, the delay needed for the whole treatment depends on the size of the images to be processed, sent on the video bus.



C. Signal amplification module design for pacemaker

Microcontroller chip adopts C8051F340, which is produced by American Cygnal Company. C8051F340 instruction sets and MCS-51 instruction sets are fully compatible, with highspeed8051-compatiblecore, and you can use the standard803x/805x assembler and compiler for software development [11].

In the course of running system, the MCU module system receives keyboard inputs, according to the input commands; through two I/O port the MCU system products a certain period alternating high and low level [13]. Based on the signal transmitted from MCU system, Pacemaker pulse generation module generates the required high and low pacemaker pulse.

Then the pacemaker pulse signal enters into the signal amplifier module, According to keyboard inputs, signal amplification module amplifies the signal to corresponding amplitude. LCD module will also keep up with pulse frequency, amplitude and other relevant parameters and display them, while in the process of keyboard operation, relevant tip [9].

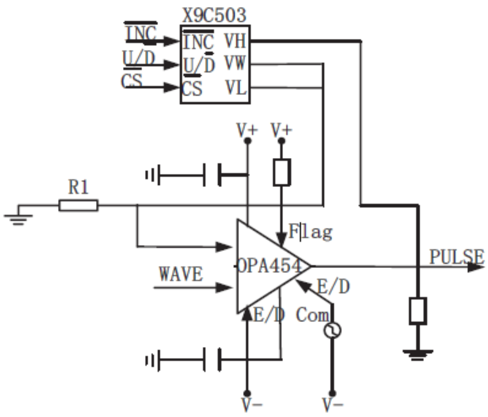


Fig 3. Signal amplification module schematic

D. Basic single chamber pacemaker

The following diagram shows a model of a basic single chamber pacemaker. This paper focuses on the timing engine of the pacemaker which controls when it paces and when it does not according to the patients need. In this case, the pacemaker timing engine is programmed by the physician through the physicians interface block, it receives notification of intrinsic events from the sense detection block, and it tells the pace pulse generation block when to pace [8].

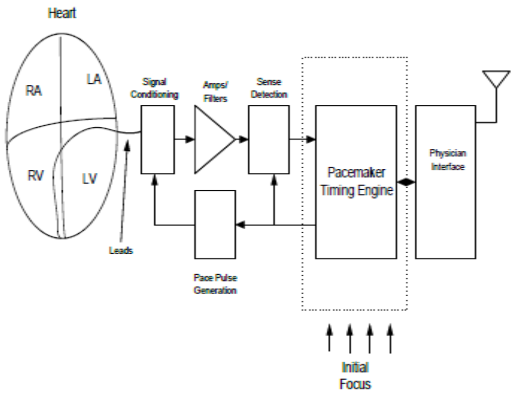


Fig 4. Basic single chamber pacemaker

The Pacemaker Timing Engine operates as follows:

I. If intrinsic contractions are not detected after a programmed interval (e.g. 1000 ms corresponding to 60 beats per minute), the pacemaker stimulates the heart with a pacing pulse [12].

II. If intrinsic events are detected, the pacemaker inhibits (does nothing) for that cardiac cycle and restarts its timer for another programmed interval looking for intrinsic contractions.

III. As a natural human heart has a refractory period where once an intrinsic event occurs, the heart will Most likely not contract again for a certain period (can be around 200 ms), thus this pacemaker will also ignore events that occur within a programmed interval of either a pace or sense.

III. CONCLUSION

As one step toward the design of an automatic pacemaker, the capture control of the electrical heart stimulation could be realized with the help of an efficient design. The investigations have been resulted in the knowledge of an implantable pacemaker which reliably checks the pacing pulses on their effectiveness and reacts on sub threshold stimulation. Beside the application of the to capture recognition, the influence of parameters such as pacing rate and physical load, the design can be recommended for other applications in pacemaker therapy such as physiological rate adaptation.

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