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# Design of Low Power Dissipation of Pacemaker based on Duty Cycle Generation using Boost Converter of Fixed Pulse Width

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**ABSTRACT:** In the field of medicine, the bio-medical implants play a vital role in improving the patient's quality of life. Improvements in the technology used in these implants will serve as a more efficient and reliable remedy for the patients. Pacemaker is a medical implant, which is a small electrical device that helps to regulate abnormal heart rhythms in case of arrhythmias. The main problem of pacemaker was its battery's lifetime which was rectified by using thermal energy harvesting. In this work, the source of the thermal energy to be completely depended on the human body temperature and by doing this, the area of the pacemaker is reduced compared to the early pacemakers. In this paper, the designed power supply includes an internal startup and does not need any external reference voltage. It is done by using the component named as peltier, which senses both heat and cold temperatures of a body and converts it into required electrical energy for the operation of pacemakers. The effectiveness of the proposed system has been proved by using modelsim in the simulation result.

**KEYWORDS:** Energy Harvesting, Boost Converter, Pulse Width Modulation, Peltier, Body Temperature, Thermo Electric Generator.

## I.INTRODUCTION

There are three million people worldwide with pacemakers, and every year over 600000 pacemakers are implanted. Although most people who receive pacemakers are aged 60 years or older, people of any age, even children, may need pacemakers. Most often, a pacemaker is implanted to treat slow heart beating, which is called bradycardia. If the heart beats too slowly, the brain and the body do not get enough blood flow and a variety of symptoms may result.

A pacemaker is a small device, about the size of a half dollar piece, implanted just below the collarbone. Although it weighs just about an ounce, a pacemaker contains a powerful battery, electronic circuits, and computer memory that together generate electronic signals. The signals, or pacing pulses, are carried along thin insulated wires, or leads, to the heart muscle. The signals cause the heart muscle to begin the contractions that cause a heartbeat.

One of the main problems about pacemakers is their batteries. As the capacity of the batteries is limited, they limit the lifetime of pacemakers. After a period of five years, one should undergo a surgical procedure to replace the battery of the pacemaker. Replacing these batteries is cumbersome since it requires surgical procedures. In addition, 60% of the volume of a pacemaker is taken up by its batteries. Eliminating these batteries effectively reduces the dimensions of the pacemaker.

One of the alternative methods to power up an implantable pacemaker is harvesting thermal energy. Harvesting ambient thermal energy using thermoelectric generators (TEGs) is a convenient means of supplying power to implantable sensors, especially pacemakers. Micro-TEG is scalable and reliable and does not require any moving parts like vibration energy transducers. As a consequence, it is very appealing in micro scale energy harvesting systems, such as human body-powered biomedical devices.

Recently, on-chip TE modules have been used to harvest electrical energy from waste heat. TEGs (also called Seebeck generators) are devices that convert heat (temperature differences) directly into electrical energy, using a phenomenon called the Seebeck effect (a form of TE effect). A voltage source in series with an internal resistance is a representative of TEGs. The open-circuit output voltage of the TEG is proportional to the temperature gradient. When implanting a TEG, the best place should be as close as possible to the superficial skin, where a maximum temperature difference between the two junctions of the TEG could be established. This would guarantee a good output of the TEG.

Using TEGs for implantable applications limits the output voltage to 50 mV for temperature differences of 1–2 K usually found between the body and ambience. This output voltage is very low. A kind of high-efficiency voltage multiplier circuit is then needed to successfully increase the output voltage to the desired value.

Voltage multiplier circuit with an internal start up is introduced that successfully converts a minimum of 40-mV input voltage provided from a TEG into a 2.5 V output voltage needed for a pacemaker to operate normally. Typically, pacemakers consume an average of 50 $\mu$w at 100% pacing. As a result, the circuit should be able to provide this power. The voltage multiplier circuit is a boost converter based on a constant charge time (CCT) structure as introduced. Up to now, different approaches have been proposed for starting up a boost converter from low input voltages. Carlson *et al.* have used on-time pre charge of the load capacitor to start up the converter. The drawback of this method is that if the storage element is discharged, the boost converter operation fails. It can be overcome by the proposed system.

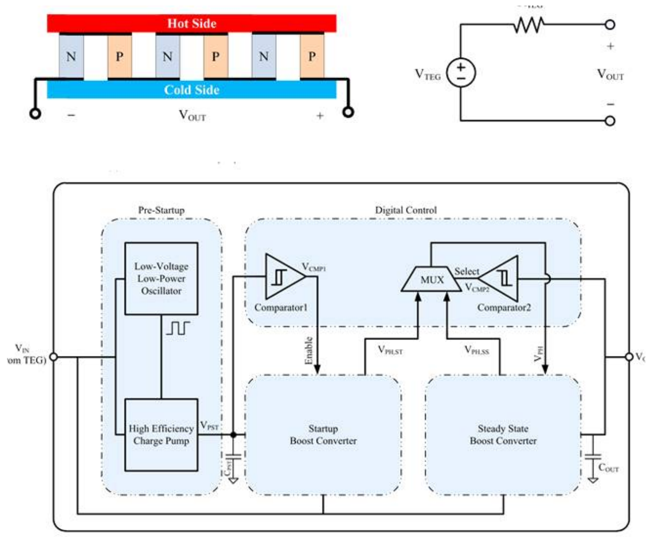


Fig.1. Thermo Electric Generator

## II.RELATED WORK

Effect of thermal cycling on commercial thermoelectric modules has been already discussed in [1]. In that work, the large temperature gradients experienced by thermoelectric modules induce significant thermal stresses which eventually lead to device failure. The impact of thermal cycling on a commercial thermoelectric module is investigated through characterization of the electrical properties. In this work, we measure the evolution of the thermoelectric and electrical properties with thermal cycling. One side of the thermoelectric module is cycled between 30oC and 160°C every 3 minutes while the other side is held at ~20°C. The thermoelectric figure of merit, *Z*!"*T*, and electrical resistivity are measured after every 1000 cycles. The measured *Z*!"*T*value is compared using both a modified Harman method and an electrical measurement technique analysed with an electrical circuit model. In addition, the change in output power and resistivity with cycling are reported. This study provides insight into characterization methods for thermoelectric modules and quantifies reliability characteristics of thermoelectric modules.

The Switched-Inductor DC–DC Converters designed for Harvesting Kinetic Energy [3], deals with the potential application space for miniaturized systems like wireless micro sensors is expansive, from reconnaissance mission work and remote sensors to biomedical implants and disposable consumer products. Conforming to micro scale dimensions, however, constrains energy and power to such an extent that sustaining critical power-hungry functions like wireless communication is next to impossible. Harvesting ambient energy offers an appealing alternative, except the act of transferring energy requires power that could easily exceed what the transducer generates in the first place.

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High-efficiency multiple-output dc–dc conversion is already developed for low-voltage systems [5]. In this, versatile power converter controller provides dual outputs at a fixed switching frequency and can regulate either output voltage or target system delay (using an external L-C filter). In the voltage regulation mode, the output voltage is monitored with an analog to digital (A/D) converter, and the feedback compensation network is implemented digitally. The generation of the pulse width modulation (PWM) signal is done with a hybrid delay line/counter approach, which saves power and area relative to previous implementations. Power devices are included on chip to create the two independently regulated output PWM signals.

## III.PROPOSED SYSTEM

In order to overcome the limitations of the existing system that are discussed in literature survey, peltier and temperature sensors are used to detect and utilize the heat energy within the human body and surroundings. A PWM is used to generate pulse which is similar to the human heart pulse and a peltier is used to detect the surrounding temperature and it converts the heat into corresponding voltage using thermo-electric effect. A Boost Convertor is used to boost up the voltage generated from the peltier. Pic-Microcontroller is used to measure high voltage.

In the proposed design a Digital to analog converter using DPWM and Boost converter. The Proposed system consists of Digital controlled oscillators, a synchronous counter, a combinational reset and a combinational comparison logic. We are replacing VCO through DCO to design Digital pulse width modulator. DCO designed by flip flop. DCO act as the register. DCO tunable strength is high comparing VCO. It stored the input word. Digital to analog converter designed by the digital pulse width modulator and low pass filter.

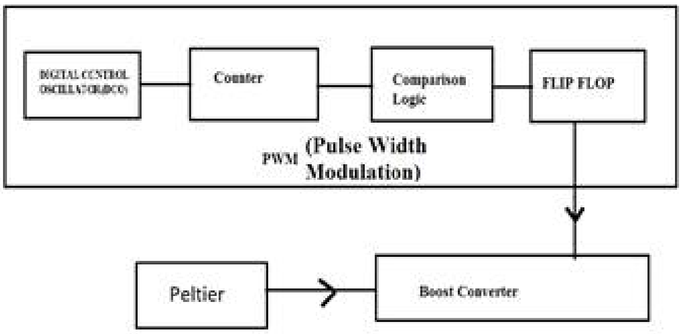


Fig.2. Block diagram of proposed system

### A. *Digital Controlled Oscillator (DCO):*

One of the main component upgraded in the proposed system is the oscillator. Voltage Controlled Oscillator is upgraded to Digital Controlled Oscillator. DCO is designed using flip flop. DCO acts as a register. DCO's tunable strength is high compared to VCO. It stores the input word. Each bit has one flip flop.

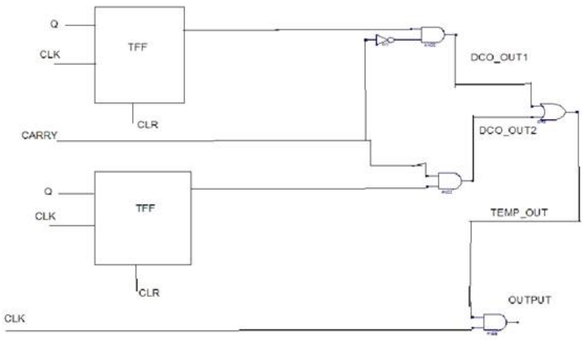


Fig.3. Digital Controlled Oscillator

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B. *Counter:*

A counter circuit is usually constructed of a number of flip-flops connected in cascade. Counters are a very widely used component in digital circuits, and are manufactured as separate integrated circuits and also incorporated as parts of larger integrated circuits.

A digital counter is a device that generates binary numbers in a specified count sequence. The counter progresses through the specified sequence of numbers when triggered by an incoming clock waveform, and it advances from one number to the next only on a clock pulse. The counter cycles through the same sequence of numbers continuously so long as there is an incoming clock pulse.

The binary number sequence generated by the digital counter can be used in logic systems to count up or down, to generate truth table input variable sequences for logic circuits, to cycle through addresses of memories in microprocessor applications, to generate waveforms of specific patterns and frequencies, and to activate other logic circuits in a complex process.

C. *Combinational comparison logic:*

Combinational Logic Circuits are made up from basic logic 5NAND, 6NOR or 4NOT gates that are "combined" or connected together to produce more complicated switching circuits. These logic gates are the building blocks of combinational logic circuits.

An example of a combinational circuit is a decoder, which converts the binary code data present at its input into a number of different output lines, one at a time producing an equivalent decimal code at its output.

Combinational logic circuits can be very simple or very complicated and any combinational circuit can be implemented with only NAND and NOR gates as these are classed as "universal" gates.

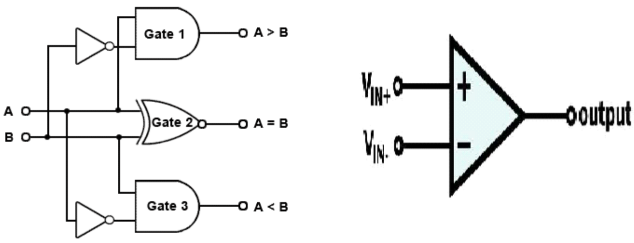


Fig.4. Combinational Logic Circuits

Combinational Logic Circuits consist of inputs, two or more basic logic gates and outputs. The logic gates are combined in such a way that the output state depends entirely on the input states. Combinational logic circuits have "no memory", "timing" or "feedback loops", there operation is instantaneous. A combinational logic circuit performs an operation assigned logically by a Boolean expression or truth table.

*D. Flip flop*

Flip-flops and latches are used as data storage elements. A flip-flop stores a single *bit* (binary digit) of data; one of its two states represents a "one" and the other represents a "zero". Such data storage can be used for storage of *state*, and such a circuit is described as sequential logic. When used in a finite-state machine, the output and next state depend not only on its current input, but also on its current state (and hence, previous inputs). It can also be used for counting of pulses, and for synchronizing variably-timed input signals to some reference timing signal.

Flip-flops can be either simple (transparent or opaque) or clocked (synchronous or edge-triggered). The state of circuit changes only when the control signal goes from high to low or low to high (i.e. sensitive to signal change only).

E. *Pulse Width Modulation (PWM):*

We integrate the Digital controlled oscillators, a synchronous counter, a combinational reset and a combinational comparison logic. It generates duty cycle in various percentage and same frequency.

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Pulse Width Modulation (PWM) uses digital signals to control power applications, as well as being fairly easy to convert back to analog with a minimum of hardware.

Analog systems, such as linear power supplies, tend to generate a lot of heat since they are basically variable resistors carrying a lot of current. Digital systems don't generally generate as much heat.

Almost all the heat generated by a switching device is during the transition (which is done quickly), while the device is neither on nor off, but in between. This is because power follows the following formula,

P = E I, or Watts = Voltage X Current

If either voltage or current is near zero then power will be near zero. PWM takes full advantage of this fact.

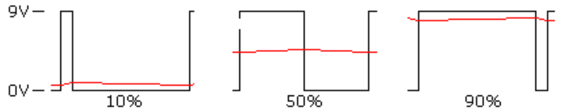


Fig.5. Example of PWM waveforms

The term duty cycle describes the proportion of 'on' time to the regular interval or 'period' of time; a low duty cycle corresponds to low power, because the power is off for most of the time. Duty cycle is expressed in percent, 100% being fully on.

The main advantage of PWM is that power loss in the switching devices is very low. When a switch is off there is practically no current, and when it is on and power is being transferred to the load, there is almost no voltage drop across the switch. Power loss, being the product of voltage and current, is thus in both cases close to zero. PWM also works well with digital controls, which, because of their on/off nature, can easily set the needed duty cycle.

F. *Peltier:*

A new component named as peltier used in this system. It is used to convert thermal energy into electrical energy. This component also minimize the power dissipation from the circuit.

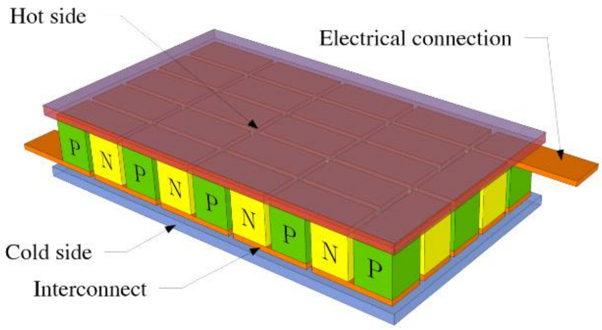


Fig.6. Petlier schematic diagram

The petlier device has two sides, and when a DC electric current flows through the device, it brings heat from one side to the other, so that one side gets cooler while the other gets hotter. The "hot" side is attached to a heat sink so that it remains at ambient temperature, while the cool side goes below room temperature. In some applications, multiple coolers can be cascaded together for lower temperature.

The Peltier effect is a temperature difference created by applying a voltage between two electrodes connected to a sample of semiconductor material. This phenomenon can be useful when it is necessary to transfer heat from one medium to another on a small scale. The Peltier effect is one of three types of thermoelectric effect; the other two are the Seebeck effect and the Thomson effect.

*F. Boost converter*

A Boost converter is a switch mode DC to DC converter in which the output voltage is greater than the input voltage. It is also called as step up converter. The name step up converter comes from the fact that analogous to step up

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transformer the input voltage is stepped up to a level greater than the input voltage. By law of conservation of energy the input power has to be equal to output power (assuming no losses in the circuit).

Input power ($P_{in}$) = output power ($P_{out}$)

Since $V_{in}<V_{out}$ in a boost converter, it follows then that the output current is less than the input current.

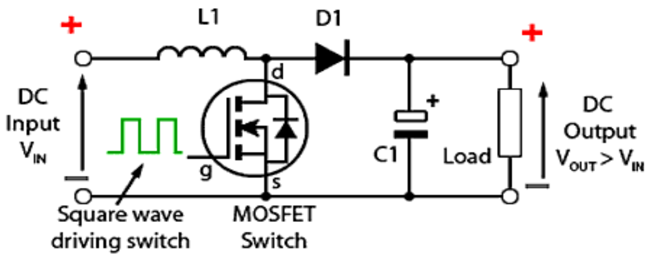


Fig.7. Circuit diagram of Boost Converter

The main working principle of boost converter is that the inductor in the input circuit resists sudden variations in input current. When switch is OFF the inductor stores energy in the form of magnetic energy and discharges it when switch is closed. The capacitor in the output circuit is assumed large enough that the time constant of RC circuit in the output stage is high. The large time constant compared to switching period ensures a constant output voltage $V_o(t) = V_o$(constant). We designed the boost converter, using Digital Pulse Width Modulator, Boost converter is used to boost up the electrical energy received from the peltier component.

## IV.SIMULATION RESULTS

The simulation results are done by using modelsim tool. In the graph shown in below, the average output voltage is proportional to the duty cycle on time.

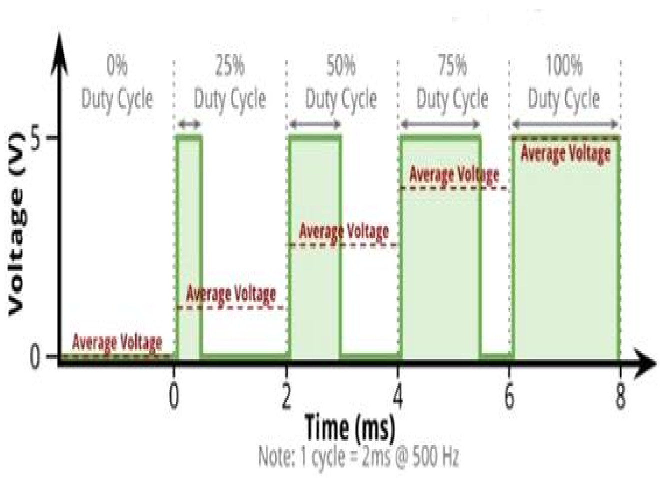


Fig.8. Average output voltage with Duty cycle

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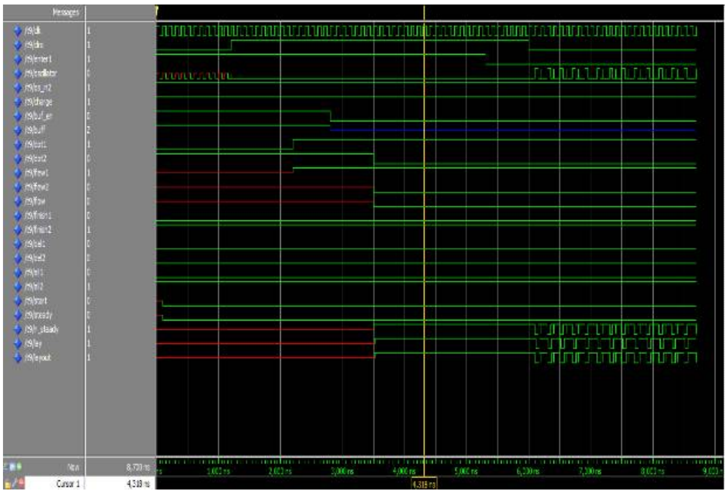

Fig.9. Reference pulse

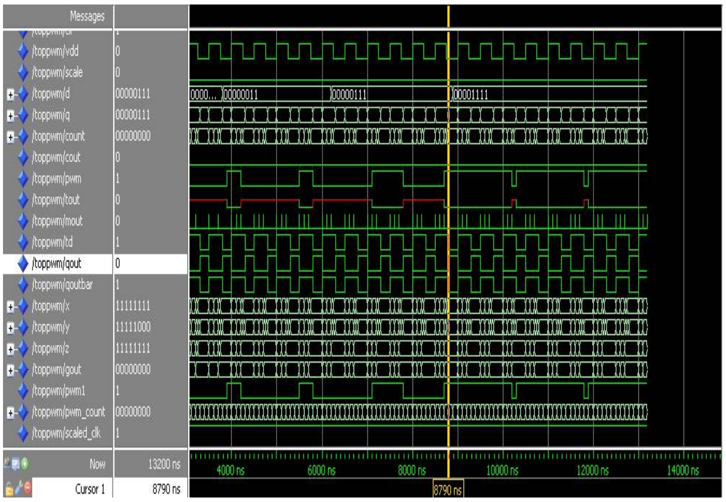


Fig.10. Pulse Width Modulation pulse

This simulation outputs shows the PWM pulse generation, which is used as human heart beat. By comparing the reference pulse with PWM pulse, the human heart beat is generated. This Pulse is given to the boost Converter, which also receives the electrical energy from the peltier and boosts up the voltage required for the circuit to function. This pulse shows the duty cycle generation needed for the pacemaker's function.

## V.CONCLUSION

Thus, the designed pace making circuit is wholly depended on the patient's body temperature for its start up. Hence the seasonal changes do not interrupt the pace makers function and the area of the pacemaker is also reduced compared to the existing system. Simulation results prove the effectiveness of the proposed system. The use of the peltier component makes a way for the future development.

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