

Design of a New Product Pace Maker with SMS Alerts and Cardiac Signal Plotting using MATLAB

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Abstract

A defibrillator machine is commonly used by cardiologists to cure cardiac arrhythmia. This machine is used in order to shock a human's heart back into usage. The way your heart works is that you have small cells called pacemakers sending electrical pulses to your cardiac muscles that tell your heart when to pump blood. When these electrical pulses stop, your heart stops beating. When this happens, a defibrillator is used to shock the heart muscles and the pacemakers back into action. The way this is achieved is by rubbing the two panels of the defibrillator together to create an adequate electrical current, and then the heart gets back to the normal state. The paper presents design and implementation of a pace maker device which is capable of giving shocks to a human heart which has stopped working suddenly. The system also facilitates by sending alerting messages to the doctors or take care persons when the person suffers from cardiac arrhythmia and also plots the cardiac signal on MATLAB window.

Keywords – pocket defibrillator, GSM modem, LCD, MATLAB.

I. INTRODUCTION

Cardiovascular diseases (CVD's) and heart attacks are one of the several reasons for non-accidental deaths. CVD's are related to improper functioning of heart which is pioneer organ for blood circulation into the

body. CVD's are related to myocardium of heart and blood vessels which is nothing but muscular part of heart. CVD's are one of the leading causes of death in developed countries which is around 31% deaths [1]. Over the years, different types of medical imaging techniques have been developed and used in clinical applications with each have their own abilities and limitations. Types of imaging are x-rays, molecular imaging, magnetic resonance imaging (MRI), ultrasound imaging, and computed tomography (CT).

In a study of CPR and defibrillation for cardiac arrest under ideal conditions, survival with normal neurological function occurred in 38%. Assuming survival without defibrillation to be zero, this is equivalent to saving the life of 2 out of 5 people using defibrillation. Furthermore, when considering only those with a heart rhythm correctable by defibrillation (ventricular fibrillation), survival rate was 59%, equivalent to saving 3 out of 5. Survival rates from cardiac arrest was less, however, in more common circumstances seen outside of the study, including among ill hospitalized persons, people without access to immediate (<4-5 minutes) CPR, and for those whose arrest is not witnessed.

Types of Defibrillator:

1. Manual external defibrillator- The units are used in conjunction with electrocardiogram readers, which the healthcare provider uses to diagnose a cardiac condition. The healthcare provider will then decide what charge (in joules) to use, based on proven

guidelines and experience, and will deliver the shock through paddles or pads on the patient's chest. As they require detailed medical knowledge, these units are generally only found in hospitals and on some ambulances. For instance, every NHS ambulance in the United Kingdom is equipped with a manual defibrillator for use by the attending paramedics and technicians. In the United States, many advanced EMTs and all paramedics are trained to recognize lethal arrhythmias and deliver appropriate electrical therapy with a manual defibrillator when appropriate.

2. Manual internal defibrillator- These are the direct descendants of the work of Beck and Lown. They are virtually identical to the external version, except that the charge is delivered through internal paddles in direct contact with the heart. These are almost exclusively found in operating theatres (rooms), where the chest is likely to be open, or can be opened quickly by a surgeon.

3. Automated external defibrillator (AED)-An AED at a railway station in Japan. The AED box has information on how to use it in Japanese, English, Chinese and Korean, and station staffs are trained to use it.

These simple-to-use units are based on computer technology which is designed to analyze the heart rhythm itself, and then advise the user whether a shock is required. They are designed to be used by lay persons, who require little training to operate them correctly. They are usually limited in their interventions to delivering high joule shocks for VF (ventricular fibrillation) and VT (ventricular tachycardia) rhythms, making them generally of limited use to health professionals, who could diagnose and treat a wider range of problems with a manual or semi-automatic unit.

The automatic units also take time (generally 10–20 seconds) to diagnose the rhythm, where a professional could diagnose and treat the condition far more quickly with a manual unit. These time intervals for analysis,

which require stopping chest compressions, have been shown in a number of studies to have a significant negative effect on shock success. This effect led to the recent change in the AHA defibrillation guideline (calling for two minutes of CPR after each shock without analyzing the cardiac rhythm) and some bodies recommend that AEDs should not be used when manual defibrillators and trained operators are available.

Automated external defibrillators are generally either held by trained personnel who will attend incidents, or are public access units which can be found in places including corporate and government offices, shopping centres, airports, restaurants, casinos, hotels, sports stadiums, schools and universities, community centers, fitness centers and health clubs.

An automated external defibrillator ready for use as Pads are pre-connected. This model is a semi-automatic due to the presence of a shock button. The locating of a public access AED should take into account where large groups of people gather, and the risk category associated with these people, to ascertain whether the risk of a sudden cardiac arrest incident is high. For example, a center for teenage children is a particularly low risk category (as children very rarely enter heart rhythms such as VF (Ventricular Fibrillation) or VT (Ventricular Tachycardia), being generally young and fit, and the most common causes of pediatric cardiac arrest are respiratory arrest and trauma - where the heart is more likely to enter asystole or PEA, (where an AED is of no use). On the other hand, a large office building with a high ratio of males over 50 is a relatively higher risk environment.

In many areas, emergency services vehicles are likely to carry AEDs. EMT-Basics in most areas are not trained in manual defibrillation, and often carry an AED instead. Some ambulances carry an AED in addition to a manual unit. In addition, some police or fire service vehicles carry an AED for use by first responders. Some areas have dedicated community

first responders, who are volunteers tasked with keeping an AED and taking it to any victims in their area. It is also increasingly common to find AEDs on transport such as commercial airlines and cruise ships. The presence of an AED can be a particularly decisive factor in cardiac patient survival in these scenarios, as professional medical assistance may be hours away.

There are 2 types of AEDs: Fully Automated and Semi Automated. Most AEDs are semiautomated. A semi automated AED automatically diagnoses heart rhythms and determines if a shock is necessary. If a shock is advised, the user must then push a button to administer the shock. A fully automated AED automatically diagnoses the heart rhythm and advises the user to stand back while the shock is automatically given. Also, some types of AEDs come with advanced features, such as a manual override or an ECG display.

In order to make them highly visible, public access AEDs often are brightly coloured, and are mounted in protective cases near the entrance of a building. When these protective cases are opened, and the defibrillator removed, some will sound a buzzer to alert nearby staff to their removal but do not necessarily summon emergency services. All trained AED operators should also know to phone for an ambulance when sending for or using an AED, as the patient will be unconscious, which always requires ambulance attendance.

3. Implantable cardioverter-defibrillator-Also known as automatic internal cardiac defibrillator (AICD). These devices are implants, similar to pacemakers (and many can also perform the pacemaking function). They constantly monitor the patient's heart rhythm, and automatically administer shocks for various life-threatening arrhythmias, according to the device's programming. Many modern devices can distinguish between ventricular fibrillation, ventricular tachycardia, and more benign arrhythmias like supraventricular tachycardia and atrial fibrillation. Some devices may attempt overdrive

pacing prior to synchronized cardioversion. When the life-threatening arrhythmia is ventricular fibrillation, the device is programmed to proceed immediately to an unsynchronized shock.

There are cases where the patient's ICD may fire constantly or inappropriately. This is considered a medical emergency, as it depletes the device's battery life, causes significant discomfort and anxiety to the patient, and in some cases may actually trigger life-threatening arrhythmias. Some emergency medical services personnel are now equipped with a ring magnet to place over the device, which effectively disables the shock function of the device while still allowing the pacemaker to function (if the device is so equipped). If the device is shocking frequently, but appropriately, EMS personnel may administer sedation.

4. Wearable cardiac defibrillator- A development of the AICD is a portable external defibrillator that is worn like a vest. The unit monitors the patient 24 hours a day and will automatically deliver a biphasic shock if needed. This device is mainly indicated in patients awaiting an implantable defibrillator. As of February 2011 only one company manufactures these portable external defibrillators and they are of limited availability.

II. METHODOLOGY

In this work significant modifications have been proposed to help cardiologists in performing instantaneous better treatment and more accurate electric stimulator device as pace maker.

The paper proposes a simple pocket defibrillator or pace maker device which is capable of continuously displaying the heartbeat of a person on LCD. When the heart beat suddenly goes at abnormal condition, then the system immediately, sends the live heartbeat data continuously to the doctor in the form of an SMS through GSM Modem.

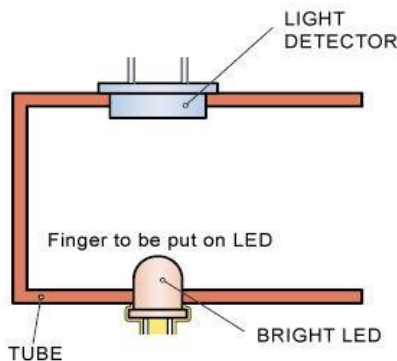


Figure 1: Figure of internal structure of the heart beat sensor

In the proposed idea we have used a flip type Heart beat sensor through which the live heart rate can be transmitted just by inserting the finger to the sensor. The presented device of the Heart beat monitor and display system is a portable and a best replacement for the old model stethoscope which is less efficient. The heart beat rate is calculated manually using stethoscope where the probability of error is high because the heart beat rate lies in the range of 70 to 90 per minute whose occurrence is less than 1 sec, so this device can be considered as a very good alternative instead of a stethoscope.

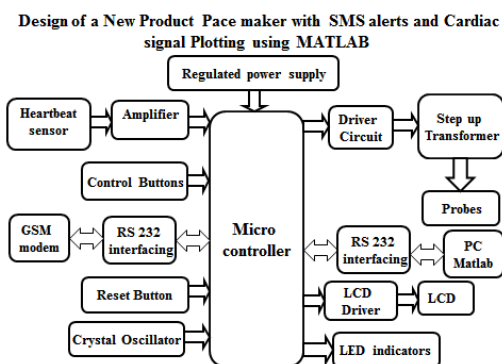


Figure 2:Block diagram of proposed system

A pacemaker is a small device that's placed under the skin of your chest or abdomen to help control abnormal heart rhythms. This device uses electrical pulses to prompt the heart to beat at a normal rate. Pacemakers are used to treat heart rhythms that are too slow, fast, or irregular. These abnormal heart rhythms are called arrhythmias. Pacemakers can relieve some

symptoms related to arrhythmias, such as fatigue or fainting. A pacemaker can help a person who has an abnormal heart rhythm resume a more active lifestyle. "An defibrillator is a small device placed in your chest or abdomen if you have an irregular heartbeat or are at risk for sudden cardiac arrest. It sends electrical pulses or shocks to the heart when it senses any abnormalities in heartbeat. For example, if a patient with an defibrillator has an irregular heartbeat or goes into sudden cardiac arrest, the device will send a shock to the heart to restore normal heart rhythm. Defibrillators can be life-saving, as cardiac arrest can cause death within minutes if not treated.

"The biggest difference between defibrillator and pacemaker is that a defibrillator continually monitors heart rhythm and can send low- or high-energy electrical pulses to correct an abnormal heart rhythm. ICDs will initially send low-energy pulses to restore heart rhythm, but switch to high-energy pulses when the low-energy shocks are ineffective.

"Pacemakers, however, only give low-energy electrical pulses to restore regular heartbeat." "Therefore, defibrillator's are more effective in patients at high-risk for or with a history of sudden cardiac arrest, who may need these more powerful, high-energy electrical pulses to restore their regular heartbeat."



Figure 3: Image of the hardware implementation of the proposed model

The proposed idea facilitates for the doctor to send the data regarding amount of electric shock to give in the form of SMS which can be read by the Microcontroller which in turn gives the input to the defibrillator device for shocking using driver circuit. The system also plots the heart rate onto the PC using matlab.

III. HARDWARE DESIGN FOR PORTABLE DEVICE

The portable pace maker device consists of heart beat sensor, LCD for display purpose, GSM modem for SMS alerts to predefined doctor's number in case of emergencies, PC for plotting cardiac signal plotting using MATLAB software and interfacing controller PIC microcontroller , defibrillator circuit for instant shocks.

a. PIC Microcontroller:

This project makes use of an onboard computer, which is commonly termed as micro controller. It acts as heart of the project. This onboard computer can efficiently communicate with the output and input modules which are being used. The controller is provided with some internal memory to hold the code. This memory is used to dump some set of assembly instructions into the controller. And the functioning of the controller is dependent on these assembly instructions. In the Proposed system we used the microcontroller PIC which stands for Peripheral Interface Controller given by Microchip Technology to identify its single-chip microcontrollers. PIC microcontrollers are very successful in 8-bit microcontrollers. This project makes use of an onboard mini computer, which is usually termed as micro controller. It acts as heart of the project. This onboard computer can efficiently communicate with the output and input modules which are being used. The controller contains some internal memory to store the program code. This memory is also used to dump some set of assembly instructions into the controller and these help for the functioning of the controller. The crystal oscillator speed that can be connected to the

PIC microcontroller ranges from up to 20Mhz. Using the CCS C compiler usually 20Mhz oscillator will be used. The cost of the microcontroller is also very cheaper. The 20 MHz crystal oscillator should be connected with about 22pF capacitor.

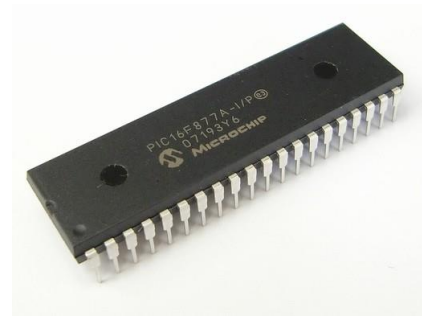


Fig 4. PIC Microcontroller

b. GSM modem

The GSM modem provides the communication mechanism between the user and the microcontroller system by means of SMS messages. It is capable of receiving a set of command instructions in the form of Short message service and performs the necessary actions. We will be using a dedicated modem at the receiver module i.e. and send the commands using SMS service as per the required actions.



Fig 5. GSM modem

c. Heart beat sensor

The functioning of this device is based on the truth that the blood circulates for every one heart beat which can be sensed by using a circuit formed by the combination of an LDR and LED. Depending upon

the rate of circulation of blood per second the heart beat rate per minute is calculated. This device consists of a micro controller which takes the input from the heart beat sensor, temperature sensor, pressure sensor and also calculates the heart rate of the patients.



Fig 6. Heart beat sensor Flip model

d. LCD Display module:

One of the most common devices attached to a micro controller is an LCD display. A liquid crystal display is special thin flat panels that can let light go through it, or can block the light. Some of the most common LCD's connected to the many microcontrollers are 16x2 and 20x2 LCD displays. It means that 16 characters per line by 2 lines were displayed and 20 characters per line by 2 lines were displayed, respectively. Liquid crystal displays are usually abbreviated as LCD's. These displays are often used in battery-powered devices, such as digital watches, since they require very little amount of electricity consumption.

Results:



Figure: values displayed in LCD

Fig.7 LCD module

IV. RELATED SOFTWARE WORK:

MATLAB (matrix laboratory) is a computing numerical environment and fourth generation programming language. Developed by Math works, MATLAB allows matrix manipulations, plotting of functions and data, implementation of algorithms, creation of user interfaces, and interfacing with programs written in other languages, including C, C++, Java, and FORTRAN.

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MATLAB can be used in a wide range of applications, including signal and image processing, communications, control design, test and measurement, financial modeling and analysis, and computational biology. For a million engineers and scientists in industry and academia, MATLAB is the language of technical computing.

SERIAL COMMUNICATION USING MATLAB:

Serial communication is the most common low-level protocol for communicating between two or more devices. Normally, one device is a computer, while the other device can be a modem, a printer, another computer, microcontroller or a scientific instrument such as an oscilloscope or a function generator.

As the name suggests, the serial port sends and receives bytes of information in a serial fashion — one bit at a time. These bytes are transmitted using either a binary (numerical) format or a text format.

The serial port interface for connecting two devices is specified by the TIA/EIA-232C standard published by the Telecommunications Industry Association.

The original serial port interface standard was given by RS-232, which stands for Recommended Standard number 232. The term RS-232 is still in popular use, and is used in this guide when referring to a serial communication port that follows the TIA/EIA-232 standard. RS-232 defines these serial port characteristics:

- The maximum bit transfer rate and cable length
- The names, electrical characteristics, and functions of signals
- The mechanical connections and pin assignments

Primary communication is accomplished using three pins: the Transmit Data pin, the Receive Data pin, and the Ground pin. Other pins are available for data flow control, but are not required.

Other standards such as RS-485 define additional functionality such as higher bit transfer rates, longer cable lengths, and connections to as many as 256 devices.

The MATLAB serial port interface provides direct access to peripheral devices such as modems, printers, and scientific instruments that you connect to your computer's serial port. This interface is established through a serial port object. The serial port object supports functions and properties that allow you to

- Configure serial port communications
- Use serial port control pins
- Write and read data
- Use events and callbacks
- Record information to disk

Instrument Control Toolbox™ software provides additional serial port functionality. In addition to command-line access, this toolbox has a graphical tool called the Test & Measurement Tool, which allows you to communicate with, configure, and transfer data with your serial device without writing code. The Test & Measurement Tool generates MATLAB code for your serial device that you can later reuse to communicate with your device or to develop GUI-based applications. The toolbox includes additional serial I/O utility functions that facilitate object creation and configuration, instrument communication, and so on. With the toolbox you can communicate with GPIB- or VISA-compatible instruments. Using MATLAB we can select COMPORT, BAUDRATE, START BIT, STOP BIT, PARITY BIT and DATA BIT for serial communication.

Create a serial port object:

Obj=serial('port','propertyname',propertyvalue)

Example: s = serial('COM1','BaudRate',9600);

To specify properties during object creation

s = serial

('COM2','BaudRate',9600,'DataBits',8);

Obj = serial('port') creates a serial port object associated with the serial port specified by port. If port does not exist, or if it is in use, you will not be able to connect the serial port object to the device.

Creation of GUI in MATLAB:

A GUI provides the user a simplified experience of running a program. In the Proposed system we used the following steps for ECG graph plotting in MATLAB GUI.

1. MATLAB provides two ways to create a GUI

- Through GUIDE
- Through scratch
- Both allow us to associates functions with components of the GUI.

2. Steps in creating GUI:

- At command prompt type “guide”.
- After laying out GUI in the layout editor define data in Opening Function.
- Edit/Align your components by
 - Tools Menu
 - Align
 - View menu
 - Property Inspector

3. Write the Callbacks

This is the most difficult aspect when creating GUI's

4. Adding serial values to the GUI for plotting:

- Set the relevant serial port used for plotting by using the command
s = serial (“Serial Port”)
- Access the port by using the command
fopen(s);
- Read the values from the port by using the command
fscanf(s, '%f');
- Plot by using the command
plot();

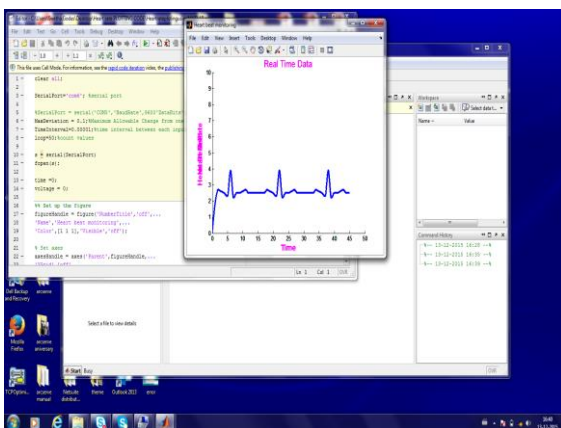


Figure- 8: Heart beat signal plotting on PC using MATLAB

The proposed system uses MATLAB software for ECG signal plotting using GUI. Using serial communication port MATLAB is used for plotting graph of ECG signals along with the hart beat and

temperature monitoring data with location display in the dialogue box.

V. CONCLUSION

The existing system proposes a new product design of pace maker using PIC microcontroller. A good monitoring of heart beat signals is plotted on PC using MATLAB software which is provided if it accompany with a good DSP processor to process raw heart beat waveform using MATLAB GUI tool. When the heart beat becomes abnormal, the heartbeat data of the patient sent automatically to the doctor in the form of an SMS through GSM Modem. The doctor can send the data regarding amount of electric shock to give in the form of SMS which can be read by the Microcontroller which in turn gives the input to the driver circuit. The system presents an Integrating feature of all the hardware components been used and developed in it. The Presence of each and every module has been reasoned out and placed very carefully. Hence the contributing to the best working unit for a tracking of vehicle security system has been designed perfectly. In future we can extend by adding highly advanced IC's like GPS module, GPRS technology with the help of growing technology, the project has been successfully implemented with a unique idea which can send the patient heart rate details along with his/her location in the form of latitude and longitude values. Thus the project has been successfully designed and tested.

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