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Remote Monitoring of Heart Patient with Auto Defibrillator

Ms. M. Lakshmi[1], Sai Sri Gaddala[2], Sandhya Rani Konda[3], Sahithi Gaja[4], Spoorthi Begari[5]

[1]Assistant professor, G.Narayanamma Institute of Technology and Science, India.
[2,3,4,5]G. Narayanamma Institute of Technology and Science, India.
[1]lakshmimithra@gnits.ac.in, [2]gaddalasaisri1919@gmail.com, [3]ksandhyarani5200@gmail.com, [4]sahithigaja69@gmail.com, [5]spoorthibegari77@gmail.com
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ABSTRACT—

An adaptable biomedical device has been created to support heart patients in intensive care units. This gadget provides continuous body temperature and heart rate monitoring, wirelessly sending data to medical personnel for in-the-moment evaluation. An automatic defibrillator component in the device helps restore rhythm by giving a modest electric shock when the heart rate falls below 40 beats per minute. The prototype incorporates an IC3524-based defibrillator circuit, an Arduino Uno board, and heart rate sensors all inside a wireless communication framework. The functionality of the system is improved with a second remote monitoring device. Despite being mostly intended for demonstration, the device shows promise for cutting-edge cardiac treatment within a hospital setting.

This cutting-edge biomedical device combines an automated defibrillator mechanism with continuous monitoring of body temperature and heart rate. The device uses an Arduino Uno board and heart rate sensors to track a patient's vital indicators in real time. The gadget allows for the wireless transmission of data to medical staff, facilitating timely response. If the heart rate drops below 40 beats per minute, the defibrillator feature, which uses an IC3524 circuit, stimulates the heart with a safe electric pulse. The device, while intended for demonstration purposes, is a prime example of how critical care for patients with heart failure in a hospital setting might be improved.

I. Introduction

Heart patients admitted in ICU or critical care unit are supposed to be monitored continuously. Since the ICU accommodates many patients and where as the medical team contains limited members, it is difficult to monitor each and every patient continuously. In this regard it is essential to monitor critically sick patient remotely who is suffering from heart disease and therefore this system is designed which sent data continuously to the care taking nurse who is present within the premises. In addition during emergency, the system itself energizes the defibrillator automatically when the heart pulse rate reduces.

Defibrillation is a kind of bio-medical instrument which is used to treat heart patients those who are suffering from cardiac arrhythmias. A heart arrhythmia or irregular heart beat is known as heart rhythm problems and this disease is called cardiac arrhythmias. Irregular heart beat problems occur when the electrical signals that coordinate the heart’s beats don’t work properly. The faulty signaling causes the heart to beat too fast (tachycardia), too slow (bradycardia) or irregularly. A defibrillator delivers a dose of electric current known as counter shock to the heart. By applying a counter shock to the heart muscles, the process of depolarization activity will be applied to the muscles. In physiology, to cause a muscle or nerve cell to undergo depolarization in order to establish or applying electric current by discharging a capacitor can depolarize entire heart and it was tested as a cardiac defibrillator. But the system designed here is intended to detect the week heart in advance and treat accordingly using this defibrillator.

There are many reasons to slow down the heart rate, one main cause is week heart and other cause is low BP. These are common risk factors for heart disease, hence monitoring Heart rate during above reasons is important and accordingly taking suitable medical care is also important. The heart rate monitor (HRM) designed here is very useful instrument, it is a kind of bio-medical instrument and is a personal monitoring device that allows one to measure and display the heart rate in real time. The heart rate monitor designed here is intended to measure the blood flow cycles through our finger tips, for this purpose IR sensors are used to detect the blood flow through finger tips. These sensors wired with LM358 can generate digital pulses according to the blood flow.

II. Methodology

The following steps are commonly included in an Remote Monitoring of Heart Patients using Auto defibrillators methodology:

Planning and Objective Setting: The work goal is to provide a remote monitoring system with integrated defibrillator capabilities for heart patients in the intensive care unit. This system will guarantee ongoing monitoring and prompt action in the event of an emergency.

Circuit Design: Based on the chosen components, separate circuits for the defibrillator, alarm system, and heart rate monitor will be created. Making sure the circuits work together and integrate well will be emphasised.

Programming: To handle functions like data reading, heart rate processing, alarm control, and defibrillator interface, code will be written for the microcontroller (such as the Arduino Uno). Well-commented code will make it easier to understand and maintain.

Construction of the Prototype: Circuits will be constructed on PCBs in accordance with component placement recommendations and circuit schematics. To be tested, a prototype system comprising the microcontroller, sensors, display, and alarm will be put together.

Testing and Validation: To ensure accuracy and operation, every part and circuit will go through a rigorous testing process. Integration testing will confirm that the entire system functions properly in a variety of scenarios, confirming its capacity to identify irregular heart rhythms and initiate the necessary actions.

Calibration and Optimisation: To guarantee accurate measurement and dependable performance, sensors and componentry will be calibrated. To ensure efficient functioning, system settings including defibrillator activation criteria and alert levels will be optimised.

Deployment and Training: After the system is complete, it will be installed in intensive care units or intensive care units in accordance with safety regulations. Training on system operation, emergency protocols, and maintenance duties will be provided to medical professionals.

Support and Maintenance: To guarantee the sustained dependability and efficiency of deployed systems, ongoing technical support and maintenance services will be offered.

III. Hardware description

Arduino UNO Processor: At the heart of the Arduino Uno is an ATmega328P microcontroller. This 8-bit microcontroller, which is a member of Atmel's AVR family, has a RISC CPU core and a modified Harvard architecture that run at 16 MHz clock speed. With 2KB of SRAM, 1KB of EEPROM, and 32KB of flash memory for programme storage, the ATmega328P has enough power to support a wide range of embedded application development. A UART serial communication interface for interacting with other devices, an analog-to-digital converter for reading analogue inputs, and pulse width modulation for exact control over output signals are some of its integrated capabilities. Additionally, the microcontroller has 20 digital I/O pins, of which 6 can be used as analogue inputs and 6 as PWM outputs, providing a variety of options for attaching external actuators and sensors. The Arduino Uno board, which offers extra parts like voltage regulators and USB ports, when combined with the ATmega328P microcontroller, creates a flexible and popular platform that may be used for hobbyist, educational, and prototyping applications.

Figure-1 Arduino UNO Processor

LCD Interfacing: These LCD screens are excellent for communicating with users and displaying information. There are several formats available for LCD displays. The most popular format is 2 x 16, which consists of two lines and 16 alphabetic characters. Compared to LED displays, which are confined to displaying numbers using seven-segment displays, LCD displays are more common since they can display alphabets, numbers, and special symbols. LCD displays are commonly offered in 2x16, 3x16, 2x40, and 3x40 configurations, which indicate two lines with sixteen alphanumeric characters each. Due to LCDs' adaptability in displaying several types of information, such as numbers, characters, and images, they have gradually displaced LEDs in recent years. They can transmit more information because of their portability and simplicity of programming, which make it possible to show text and graphics effectively. LCD modules typically have an 8-bit interface, where Port 0 is used for data buses and Port 2 is used for control lines. It is possible to communicate with the LCD module using just four of the data lines, even though the normal data transfer is eight bits. The R/W line is also frequently grounded, which prevents the processor from reading status data but allows it to send data to the LCD.

Figure-2 LCD display

Voltage Regulator: A voltage regulators play a crucial role by maintaining a constant output voltage regardless of fluctuations in input voltage, load current, or temperature. They lower noise for circuit dependability, match power supply output to device requirements, and stabilise voltage to protect delicate electronic components. There are two primary varieties of voltage regulators: switching and linear. Although linear voltage regulator integrated circuits (ICs) such as the 78XX and 79XX series are easy to use and have minimal output noise, they are wasteful and not recommended for big voltage differentials. Conversely, switching regulators provide great efficiency and flexibility to different input voltages by quickly turning current on and off to ensure stability. Even though they are more complicated, they are widely used in situations where efficiency is a top priority, such battery-operated gadgets. Depending on the needs of a given circuit, considerations such as input/output voltage, load current, efficiency, and cost must be made while deciding between switching and linear regulators.

Figure-3 Voltage Regulator

Relay: A Relays function as electrically controlled switches, and they are often used in conjunction with electromagnets to control circuits through independent low-power signals. It finds use in situations when a single signal must control several circuits or where high power handling is necessary, as in the case of contactors used in motor control. Solid-state relays use semiconductor devices for switching instead of moving parts. Specific polarity changes are necessary for the operation of magnetic latching relays, which provide specialised functionality. They are useful in situations when smooth power changes are necessary. A coil creates a magnetic field that activates an armature in a simple electromagnetic relay, causing moveable contacts to connect or disconnect from fixed contacts. In order to minimise noise and arcing and ensure effective functioning in a range of voltage applications, a spring or gravity returns the armature, rapidly opening or closing contacts.

Figure-4 Relay

Buzzer: An auditory signalling device, such as a buzzer or beeper, can be piezoelectric or electromechanical. Joseph Henry created the first electromechanical buzzer in 1831, and it was widely used in doorbells until the 1930s, when melodic chimes gained popularity. Conversely, piezoelectric buzzers were developed in the 1970s and 1980s as a result of joint efforts amongst Japanese businesses. The Barium Titanate Application Research Committee was established in 1951 to aid the development of piezoelectric buzzers. Through collaborative innovation, companies were able to achieve substantial improvements in piezoelectric technology. These buzzers were widely used in many different goods, including timers, alarms, and processing units for user input confirmation.

Figure-5 Buzzer

89C51/52 Microcontroller Chip: The AT89C52 microcontroller is a multipurpose CMOS 8-bit microcomputer that has 256 bytes of RAM and 8K bytes of Flash memory. It uses the industry-standard 80C51 and 80C52 instruction set and pinout and is compatible with Atmel's high-density nonvolatile memory technology. The AT89C52 has a wide range of standard capabilities, including 32 I/O lines, three 16-bit timer/counters, a six-vector two-level interrupt architecture, and a full-duplex serial interface. It also features two software-selectable power-saving modes, Idle Mode and Power Down Mode, and static logic for operating down to zero frequency. Various I/O ports (Port0, Port1, Port2, Port 3), reset input (RST), address latch enable/program pulse input (ALE/PROG), programme store enable (PSEN), external access enable (EA/VPP), and reset input are among the pin configurations of the microcontroller. With inputs from oscillators (XTAL1, XTAL2). The AT89C52 also has a baud rate generator that configures transmit and receive baud rates by using Timer 2. The AT89C52 offers a very flexible and affordable embedded control solution thanks to its flexible architecture and plethora of capabilities.

Figure-6 89C51/52 Microcontroller Chip

IC LM358: The dual operational amplifiers in the LM358 series include a true differential input stage, single-supply operation from 3.0 V to 32 V, and are intended for low-power applications. These amplifiers have a common mode input range that extends to the negative supply, internally compensated circuitry, and low input bias currents compared to normal types. They have ESD clamps and outputs protected against short circuits for added durability. Two two-stage operational amplifiers with internal compensation are part of the circuit design. The first stage of the amplifiers handles gain, level shifting, and transconductance reduction tasks. A typical current source load amplifier stage biassed by an internal voltage regulator with appropriate temperature characteristics and power supply rejection makes up the second stage. These products are acceptable, devoid of lead, halogens and BFRs, and comply with RoHS. and equipped with PPAP capabilities and AEC-Q100 qualification, making it appropriate for use in automotive and other applications with specific site and control change needs.

Figure-7 IC LM358

LM35 Temperature Sensor: Precision integrated-circuit temperature sensors, like those in the LM35 series, eliminate the need for constant voltage subtraction for simple scaling by providing a linear output voltage proportional to Celsius temperature. The LM35 does not require external calibration or trimming, and it offers typical accuracy levels of ±1⁄4˚C at ambient temperature and ±3⁄4˚C over a broad temperature range of -55 to +150˚C. It may run on a single or two power supply and has a low output impedance, linear output, and built-in calibration that make integrating it with reading or control circuitry simple. Its 60 µA power consumption indicates that it has very little self-heating. The LM35 is appropriate for a range of temperature sensing applications and is offered in multiple packaging configurations, such as surface mount, TO-46, and TO-92 packages. Applying it is simple and only requires glueing or cementing. It can be applied with simplicity by simply glueing or cementing to a surface, and its temperature nearly resembles that of the surface. To reduce inconsistencies brought on by changes in air temperature, care should be made to guarantee that the wiring exiting the device stays at the same temperature as the surface of interest.

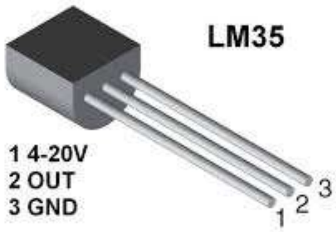


Figure-8 LM35 Temperature Sensor

IC3524: For high-power-output applications, the SG2524 and SG3524 integrated circuits make it easier to build switching regulators, inverters, or regulating power supplies on a single chip. These devices include a comparator, on-chip regulator, error amplifier, programmable oscillator, pass transistors, pulse-steering flip-flop, and circuitry for current limitation and shutdown. By generating a linear voltage ramp and comparing it to the output voltage, these fixed-frequency pulse-width-modulation (PWM) voltage-regulator control circuits allow for exact control of the output pulse duration. For flexible use, the outputs can be set up for push-pull or single-ended applications. They also provide choices for voltage reference and synchronous operation. The error amplifier can be customised for certain applications by offering dc gain control and ac phase compensation. The compensation is given by the COMP pin. Their functionality and flexibility in different circuit designs are further enhanced by characteristics like blanking and synchronous operation.

Figure-9 IC3524

Z44 MOSFET: The Z44 MOSFET, a fifth-generation HEXFET from International Rectifier, has a low on-resistance per silicon area thanks to sophisticated manufacturing methods that guarantee great efficiency. Its ruggedized construction and quick switching speed make it adaptable to a wide range of applications. Die sizes up to HEX-4 are supported by the SMD-220 surface mount power package, which offers high power capabilities and low on-resistance. The Z44's low internal connection resistance makes it appropriate for high current applications, and it can dissipate up to 2.0W in common surface mount applications. When choosing the right MOSFET for a given circuit, key characteristics including N-channel or P-channel types, voltage and current ratings, threshold voltage, on-resistance, gate charge, switching speed, temperature rating, and packaging type are crucial.

Figure-10 Z44 MOSFET

IV. Software Description

Arduino: Programming the 89C51/52 microcontroller involves a series of steps integrating both software and hardware tools. Firstly, the microcontroller code is written in a programming language such as assembler or C using a standard ASCII text editor and saved as a text file. Assembler involves learning the microcontroller's specific instruction set, resulting in compact and fast code, while C offers portability at the cost of larger code size.

Next, the source code is translated into machine-readable instructions known as op codes or hex codes, which represent the microcontroller's instruction set. This translation is typically represented in hexadecimal format and stored in a file known as a hex file.

Debugging the code involves using a debugger software running on a PC, tightly integrated with the emulator used to validate the code. Emulator manufacturers often provide debugger software with their tools, while compiler manufacturers may include debuggers in their development suites.

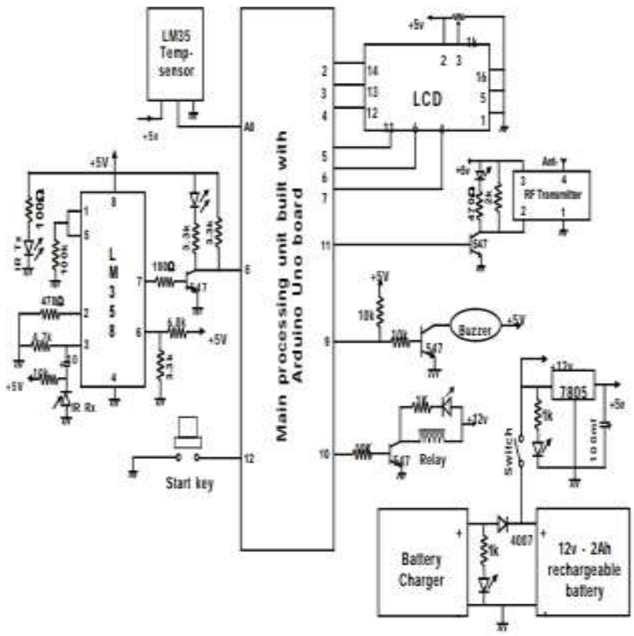
Advantages of embedded systems include decreased power consumption and space, with microcontroller-based systems offering low power consumption, I/O, COM port, and ROM on a single chip.

The chip burning process depends on the compiler kit used. For instance, the CA51 Compiler Kit for the 8051 microcontroller family supports various derivatives. The kit includes the C51 'C' Compiler, A51 Macro Assembler, µVision3 IDE, OH51 Object-HEX Converter, and KEIL Compiler.

To work with the Keil Compiler, the basic steps involve opening Keil, creating a new project, selecting the target device, writing the program in assembly or C, adding the program file to the project, compiling the program, debugging it using the debugger, and running it step-by-step using the available tools. This step-by-step process ensures the efficient development and testing of microcontroller programs.

The Arduino IDE is a platform for creating software that lets you control and program Arduino microcontrollers. Writing the required code for the Arduino board can be done using the Arduino IDE in the context of tracking the sun using an LDR (Light Dependent Resistor), a solar panel, and a servo motor. The Arduino analyzes the data from the LDR, which measures light intensity, and uses it to instruct the servo motor to move the solar panel in the direction of the sun to maximize exposure and energy production.

V. BLOCK DIAGRAM



Remote monitoring of heart patient with auto defibrillator - Part – 1

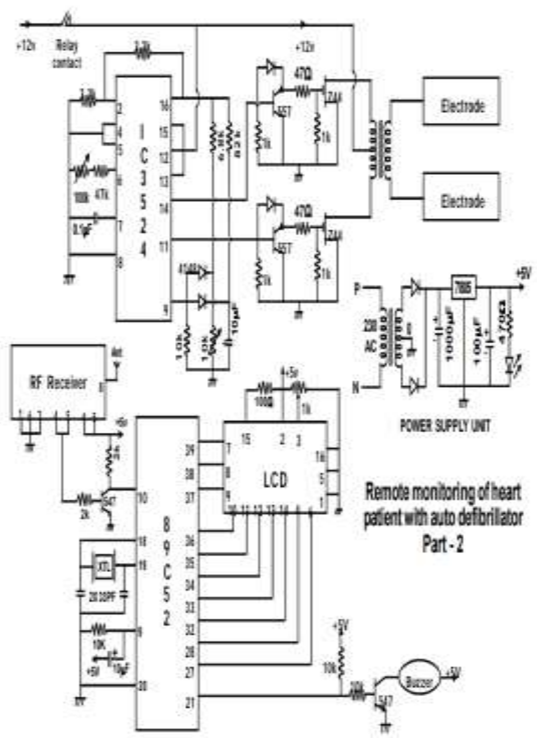


Figure-11 Block Diagram

VI. RESULTS

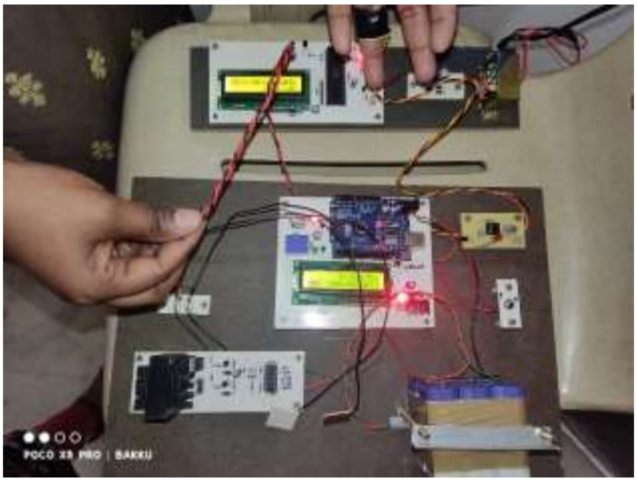


Figure-9 Hardware Connection

The above shown Figure 9 is the hardware connection of the Remote Monitoring of Heart Patient with Auto Defibrillator using all the hardware components.

Figure-10 Output when Temperature and pulse rate is displayed

Figure-11 Readings on Receiver Side

VII. CONCLUSION

In conclusion, The use of auto defibrillators in cardiac care represents a major advancement. This strategy significantly improves patient safety by ongoing monitoring, early problem discovery, and timely response. Furthermore, the smooth exchange of information between patients and healthcare professionals promotes better results while providing unmatched convenience.

Future developments in remote monitoring have enormous potential to significantly improve and personalise the management of cardiac health. This creative approach gives people the ability to actively participate in their own health care while also streamlining healthcare procedures. Remote monitoring with auto defibrillators, which makes use of cutting-edge technology, represents a synergistic fusion of innovation and healthcare, offering more effective, efficient, and patient-centered cardiac treatment.

VIII. FUTURE SCOPE

The future scope for remote monitoring of heart patients with auto defibrillators is quite promising! Here are a few possibilities:

1. Improved Connectivity: As technology develops, auto defibrillators and medical professionals should be able to connect even more easily. This could involve quicker reaction times, better algorithms for identifying anomalies, and real-time data transfer.
2. Integration of Artificial Intelligence: AI has the potential to be very important for remote monitoring. Large volumes of patient data can be analysed by machine learning algorithms, which can then be used to spot trends, anticipate possible problems, and offer individualised treatment recommendations. Improved care plans and more precise diagnoses may result from this.
3. Wearable Technology: As wearable technology gains traction, auto defibrillators may be incorporated into more compact and comfortable wearables. As a result, patients may find remote monitoring even more convenient, feeling free to carry out their regular activities.
4. Telemedicine Expansion: Patients can have virtual consultations with their healthcare providers by combining telemedicine services with remote monitoring.This could reduce the need for frequent in-person visits, particularly for basic checkups, and increase patient access to healthcare for those living in remote locations.
5. Data Security and Privacy: It will be essential to protect patient data security and privacy as remote monitoring becomes more common. Tighter laws and developments in encryption technology will be required to safeguard private data and preserve patient privacy.
6. Integration with Smart Home Systems: By integrating auto defibrillators with smart home systems, seamless monitoring and emergency response are made possible. For instance, the gadget might immediately contact nearby family members or emergency personnel if it notices an irregular heartbeat.

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