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Design and Development of an Embedded System for Surveillance of Health Status of a Patient

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Abstract: In most of the cases, patients are being admitted to hospitals for longer time for frequent surveillance of patients round-the-clock. Nowadays admission to hospital has become very expensive and also there exists a worry of quality status of patient healthcare and resource distribution problem. So to overcome this problem, a working model of project is undertaken which includes sensing devices to measure factors like Body Temperature, Heart Rate to keep tracking health status of patients time to time. This system also performs Fluid Dispensing task electronically replacing manual control of medicinal fluid flow by caretaker and this system also performs Medicine Reminding task to remind patient to consume right medication at right time and Functional Electric Stimulation operation for helping patients suffering from spinal cord injury or numbness due to paralysis in any part of body. ARM Micro-controller is used for examining the patient's responses and any abnormality felt by the patient causes the monitoring system to give an alarm and send results to remote doctors mobile via GSM so that the patient's health state can be examined by doctors residing anywhere in the hospital. Further this system uses Zigbee technology for wireless transmission. Thus, it reduces the doctor's workload and also gives accurate results.

Keywords : Zigbee; GSM; ARM; Spinal cord injury, Functional Electric Stimulation

1. INTRODUCTION

1.1 Heart Rate and Temperature Monitoring System

Nowadays due to spreading of coronary artery disorder, the valuable asset of our nation i.e its young population is under serious health issue. Coronary arteries carry blood and oxygen to the heart; therefore any disease which affects the coronary arteries withdraws the heart of oxygen which results in heart attack. Therefore Heart rate is a very vital health parameter that needs to be monitored regularly. So this project describes a technique of measuring the heart rate of patient. When the heart is beating, it actually means blood is pumped throughout the body that results in variation of the blood volume inside the finger artery also. This variation of blood flow can be detected through an optical sensing mechanism placed around the fingertip of patient and temperature of patient is accurately measured using a calibrated sensor called LM35 which initially senses temperature and which is then converted into a suitable number in Celsius scale using Analog to Digital Converter (ADC) [1].

1.2 Medicine Reminder System

There may be varied reasons for, why people forget or don't take medications. Prescribed medication not taken at time may lead to serious health penalties. It could be that the doctor did not explain the patient/caretaker properly about timely consumption of medication. Maybe Patients feel better and consider they don't require the medicine anymore. Maybe they just forgot. Anyone who cares for someone with a prolonged illness will soon realize need for organizing the medications. This project helps to remind patient about medication in everyday life [3] [8]. It is the system that can help several caretakers get adjusted to schedule without requiring too much detail. Caretakers group out medications and place it in the different slots available one week ahead, at the suitable time, the patient/caretaker can tell which medicine is to be consumed.

1.3 Fluid Dispensing System:

In Most of hospitals, caretaker has to manually set flow of fluid in fluid dispenser which is a difficult task.in order to solve the problem a system called Fluid Dispensing System is introduced where a Rack and Pinion assembly is used to dispense fluid electronically with help of a DC motor and arm controller. The Amount of fluid to be dispensed is set by user and time at which caretaker need to be alerted is also set. As soon as time is reached, appropriate quantity of fluid starts dispending.

1.4 Functional Electrical Stimulation (FES)

FES is a technique of using electrical currents to activate nerves affected by paralysis which mostly occurs due to the spinal cord injury, head injury or stroke FES is primarily used to repair function of different parts of body in people with disabilities. It is sometimes referred to as neuromuscular electrical stimulation.

2. PROBLEM DEFINITION

2.1 Problems in the Existing System

Currently there are number of healthcare systems available for the Intensive Care Unit (ICU) patients. This system is wired everywhere. The patient is monitored in ICU and the data transferred to the Personal Computer (PC) is wired. Such systems become difficult where the distance between the system and PC is more. The available

systems are huge in size. Regular monitoring of patient is difficult once patient is discharged from hospital. The other problem with these systems is that it is not capable of transmitting data continuously also there is an issue of range limitations of different wireless technologies used in the systems.

3. IMPLEMENTED SYSTEM

3.1 Block Diagram of Implemented System

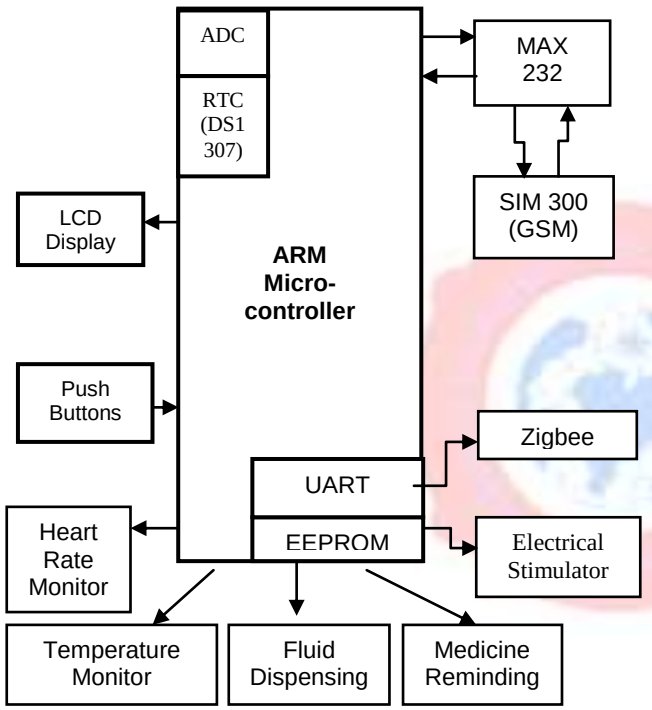


Figure1 Block Diagram of Implemented System

Figure1 shows Block diagram of system implemented. The pushbuttons used to set different desired values on display for performing different tasks. MAX232 is a dual driver/receiver that contain RS232 level converters that reduce different voltage levels in circuit to a std 5V .SIM300 is a GSM device used for communication purpose via SMS. Zigbee is ued for wireless data transmission A UART (Universal Asynchronous Receiver/Transmitter) that controls a computer's interface to its attached serial devices such as RS232 so that it can exchange data with modems and other serial devices.EEPROM (Electrically Erasable Programmable Read Only Memory) is a type of non-volatile memory that can be programmed and erased in circuits. RTC keeps track of the current time.ARM microcontroller is 32 bit microcontroller based on RISC(Reduced instruction Set Computers) architecture.

3.2 Patient Heart Rate Monitoring system

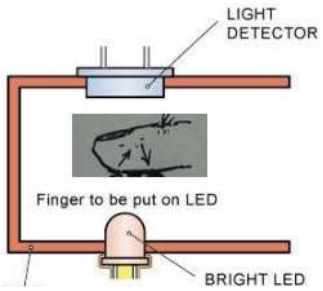


Figure 2 Illustration of heart rate monitoring

Figure 2 illustrates heart rate monitoring sensor used in the system. This subsystem describes the simple design of a cost-effective microcontroller based heart rate measuring and monitoring system with LCD output [1] [5]. Heart rate of the subject is measured from the index finger using Infra-Red Device sensors (IR transmitter and Receiver). The sensor unit comprises of an infrared light-emitting diode (IR Transmitter) and a photo diode (IR Receiver). IR Transmitter transmits infrared rays in the range of 760 nm wavelength. Such LEDs are usually made of gallium arsenide or aluminum gallium arsenide. Since the human eye cannot see the infrared radiations, it is not possible for a person to identify whether the IR LED is working or not. To overcome this problem, the camera on a cellphone can be used show the IR rays being originated from the IR LED in a circuit**.** The fingertip is placed between the sensor assemblies. The IR LED transmits an infrared light into the fingertip, a part of which is reflected back from the blood inside the finger arteries. The IR receiver detects the portion of the light reflected back. The light intensity depends upon the quantity of blood flowing inside the fingertip. So when heart beats, the brightness of reflected light changes, which can be detected by the photo diode. this little variation in the amplitude of the reflected light can be converted into a pulse with a high gain amplifier and then Heart rate is averaged and displayed on text based Liquid Crystal Display. The desired threshold values (both high and low) are set by caretaker using push buttons on microcontroller board. The system gives buzzer sound when the heart rate crosses the preset threshold value. This information is then wirelessly conveyed to the doctor who is at distant location from the patient through GSM technique.

3.3 Patient Temperature Monitoring system

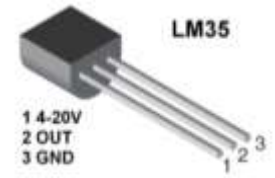


Figure 3 Temperature Sensor (LM35)

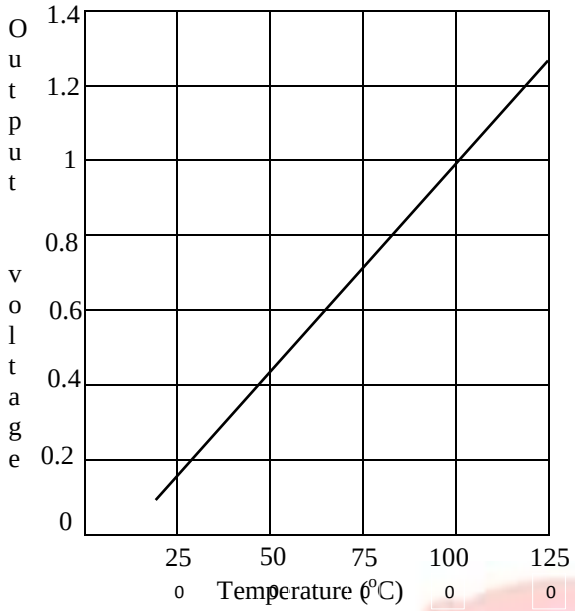


Figure 4 Output Voltage Vs. Temperature Graph

Figure 3 shows Temperature Sensor Named LM35 and Figure 4 shows Output Voltage Vs. Temperature Graph. The temperature sensor used in the project is LM35 [2]. These sensors use a solid-state technique to determine the temperature. They use the fact as temperature increases, the voltage across a diode increases at a known rate which is actually the voltage drop between the base and emitter (V_{BE}) of a transistor. The LM 35 IC generates a 10mV variation to its output voltage for every degree Celsius change in temperature. The Output of the temperature sensor is analog in nature so an analog to digital converter used for converting the analog input to its equivalent binary output. The binary output of ADC is fed to the microcontroller .The microcontroller reads the input through ADC and displays the corresponding decimal value on LCD and also the desired threshold value is set by caretaker using push buttons on microcontroller board. The system gives buzzer sound when the temperature crosses the preset threshold value. This information is then wirelessly conveyed to the doctor who is at distant location from the patient through GSM technique [8] [5].

3.4 Precision Fluid Dispensing System

Figure 5 shows working model of a Precision Fluid Dispensing System. In Fluid Dispensing System one end of the Rack and Pinion assembly is fixed to a DC motor which is connected to microcontroller and other end is connected to fluid dispenser. Number of rotation of motor ie amount of fluid to be dispensed is set by user and time at which caretaker need to be alerted is set. As soon as time is reached, appropriate quantity of fluid starts dispending and it stops when task is done.

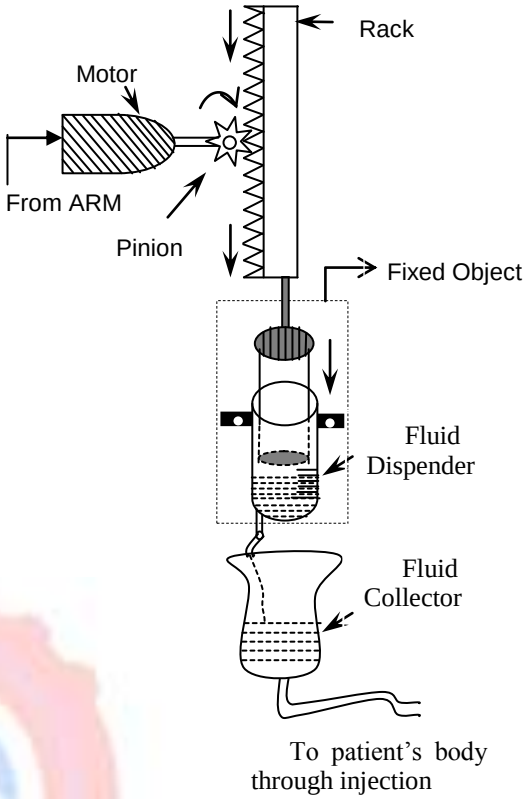


Figure 5 Working Model of a Precision Fluid Dispensing System

3.5 Patient Medicine Reminder system

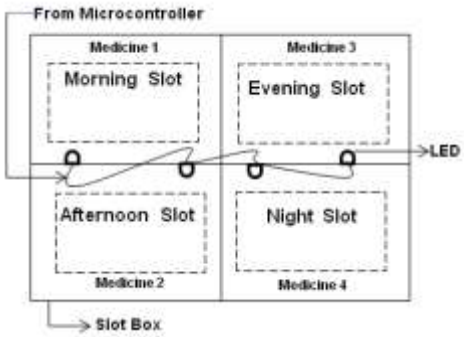


Figure 6 Working Model of Medicine Reminder System.

Figure 6 shows Working Model of Medicine Reminder System. Most of the patients fail to recall instruction given by physician to consume medication at the appropriate time, which leads to problematic situation as it upsets the dosage required for the patient resulting in not obtaining expected recovery outcome. It is difficult for doctors/attenders to monitor patients round the clock. In order to avoid these problems, the patient medicine reminder system is implemented [6] [3]. The system allows the user to enter the prescribed timings, at which the patient has to take the medication present in particular slot of medicinal slot box marked with different times of the day

(morning, afternoon, evening and night). There will be four medicinal slots in proposed working model of slot box designed for one day, since physician's prescription for particular patient will be similar for rest of the days. In the implemented system, the caretaker presets the time for reminding patient about medicine by pressing push buttons on microcontroller board. This data will be stored in the Electrically Erasable Programmable Read Only Memory (EEPROM) by the microcontroller. The microcontroller continuously reads the time from the real time clock (RTC) .When the timings read from the RTC equals the timings stored in the EEPROM; the system alerts the patient with a buzzer sound followed by glowing of Light Emitting Diode (LED) of slot in medicinal slot box for few seconds. Process repeats for remaining slots in sequence.

3.6 Functional Electrical Stimulation

Figure 7 Illustrations of Functional Electric Stimulator

Figure 7 illustrates the Functional Electric Stimulator of patients. Functional Electrical Stimulation (FES) is a process of restoring the functionality of part of human body affected by paralysis due to Spinal Cord Injury (SCI) with the help of electrical stimulator [7]. The electrical stimulator uses symmetric biphasic pulses that suppress skin breakdown and itching.it is also a post-exercise recovery tool for athletes. The electric impulses are produced by a stimulator which is delivered through electrodes .The electrodes are placed on the skin in vicinity to the muscles to be stimulated. The impulses mimic the action potential coming from the central nervous system, causing the muscles to contract.

4. HARDWARE DESCRIPTION

4.1 ARM 7 Microcontroller

ARM 7 based microcontroller from NXP-Philips i.e. LPC2138 will be used in this project. Due to their tiny size and low power consumption, the LPC2138 microcontrollers are best choice for applications where miniaturization is the required. ARM stands for 32 bit Advanced Reduced Instruction Set Computer (RISC) Machines. Due to its RISC based approach, ARM processors require fewer transistors than other processors that are found in a traditional computer. The benefits of RISC based approach are reduced costs, heat and power usage compared to other complex chip designs which are desirable for light, portable, battery-powered devices such as smart phones and tablet computers.

4.2 Temperature sensor

LM35 in general, converts temperature value into electrical signals. Data processing is more easy with linear LM35 (approximately -40 to 100°C) output than Pt100 (approximately -200 to +850°C) to get the exact temperature. LM35 is cost effective and its usage is highly effective. LM35 series sensors are precision integrated-circuit temperature sensors whose output voltage is linearly proportional to the Celsius temperature. The LM35 requires no external calibration

4.3 Heart Beat Sensor

Heart beat sensor is designed to give digital output of heart beat when a finger is placed on it. When the heart beat detector is working, the beat LED blinks for each heartbeat. This digital output can be connected to microcontroller directly to measure the Beats per Minute (BPM) rate. It works on the principle of light modulation by flow of blood through fingertip at each pulse.

4.4 Zigbee

Zigbee is a low-cost, low-power, wireless mesh networking standard. The low cost allows the technology to be widely deployed in wireless control and monitoring applications. It is an IEEE 802.15.4 standard for data communications. It is designed to consume less power allowing batteries to essentially last for longer time.

4.5 SIM300 GSM/GPRS Module

The SIM300 is a complete Quad-band GSM/GPRS solution in a SMT module which can be embedded in the customer applications featuring an industry-standard interface. The SIM300 delivers GSM/GPRS 850/900/1800/1900MHz performance for voice, SMS, Data, and Fax in a small form factor and with low power consumption. With a tiny configuration of 24mm x 24mm x 3 mm, SIM900 can fit almost all the space requirements, especially for slim and compact demand of design.

4.6 Rack and Pinion

Rack and Pinion is a type of linear actuator that comprises a pair of gears which converts rotational motion into linear motion. A circular gear called The Pinion engages teeth on a linear gear bar called rack. Rotational Motion applied to pinion causes rack to move thereby translating rotational motion of Pinion into linear motion of rack.

5. FLOWCHARTS OF IMPLEMENTED SYSTEM

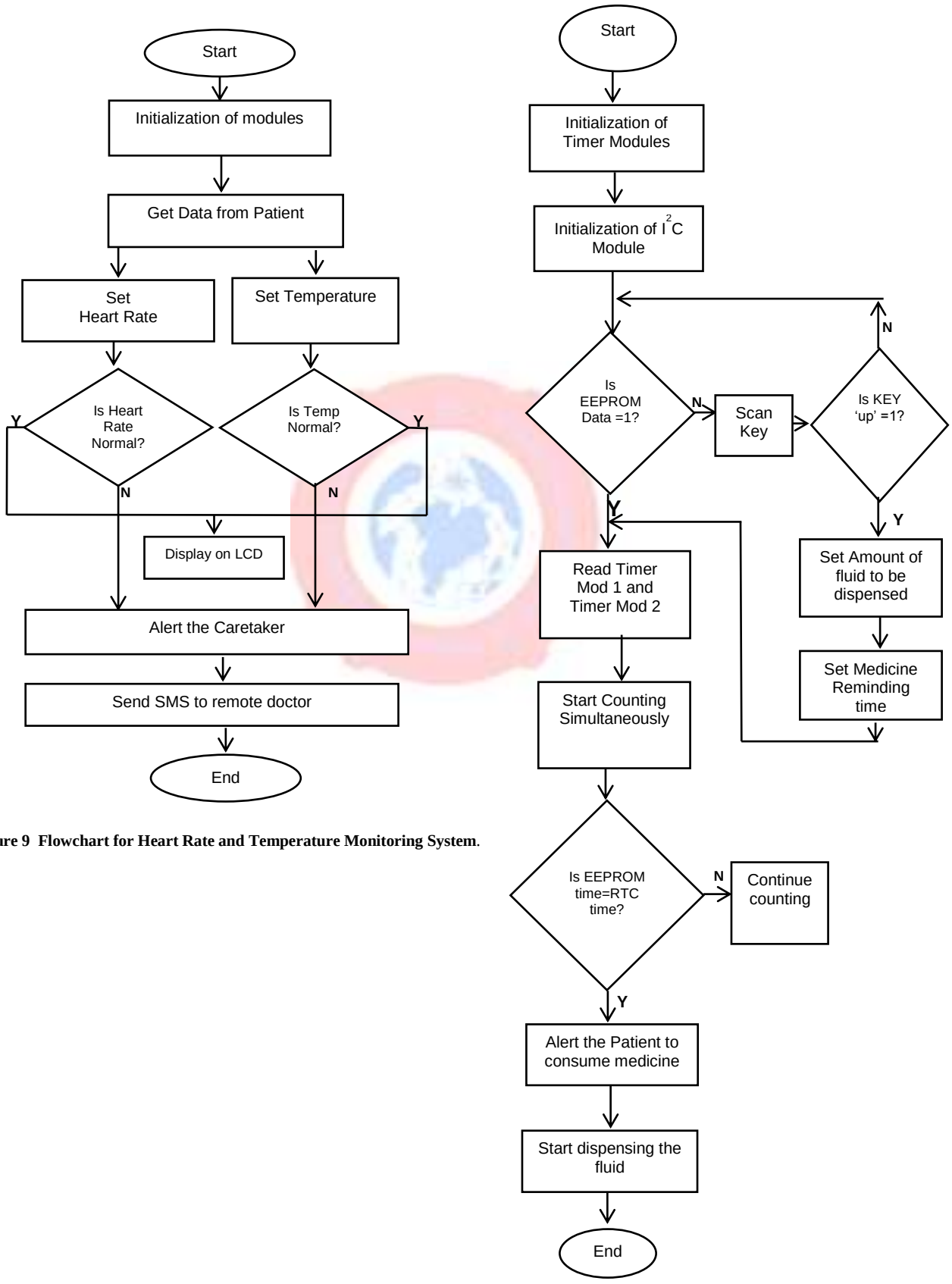


Figure 9 Flowchart for Heart Rate and Temperature Monitoring System.

Figure 10 Flowchart for Medicine Reminder and Fluid Dispensing System.

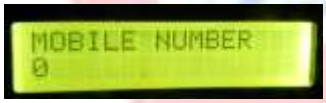
6. RESULTS

Snapshots of the implemented system were taken. During the execution of the system snapshots of the LCD display have been captured. The A few test results of the system are put down below, which show successful implementation of the system.

- Initial display

- Sample Values set when asked for upper and lower limit of Heart Rate

- Sample Value of temperature set when asked for upper limit of Temperature and mobile number is asked to set, to send SMS



- Suppose measured Heart Rate or Temperature values of patient is exceeding threshold values set by user.

- A sample reading of Temperature and heart rate of patient onto the LCD attached to the module on the patient's side.

- Sample values for Number of Motor Rotation and time duration after which motor has to rotate for fluid dispensing is set

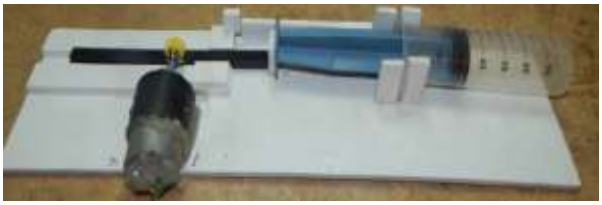
- Sample value 2min is set of for medicine reminding operation. This means after every 2 minutes led starts blinking in sequence followed by buzzer sound.

- Now timers for completing both tasks starts counting time simultaneously

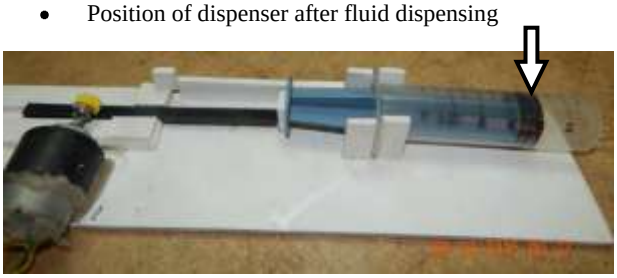
- For medicine reminding task, LED start blinking in sequence after a preset time starting from morning slot followed by buzzer sound.

- After a preset time DC motor starts rotating for fixed number of rotation which in turn dispenses required quantity of the medicinal fluid.

- Initial position of dispenser before fluid dispensing



- Position of dispenser after fluid dispensing



7. CONCLUSION

The System being a complete hardware design, the system's prototype is successfully implemented and can be demonstrated. This work not only provides real-time update of the patient's health to the caretaker but also reduces work of patient caretaker or nurse to dispense fluid at appropriate time and help caretaker to be alert to provide medicine to patient as instructed by physician. GSM technology makes the system to communicate for longer distances. Thereby reducing frequent doctors visit to each patient's bed.

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