RESEARCH ARTICLE   OPEN ACCESS

Design and Implementation of Real Time Remote Supervisory System

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Abstract
In today's fast growing communication environment and rapid exchange of data in networking field has triggered us to develop a home based remote supervisory monitoring system. In the present paper the physiological parameters of the patient such as body temperature, ECG, Pulse rate and Oxygen Saturation is displayed in MATLAB graphical user interface which is processed using ARM7 LPC2138. In case any emergency persist and parameters goes abnormal over the optimum level then a buzzer will ring to alert the caretaker. And the vital parameters will be displayed on the patient side computer and an automatic SMS will be sent to the doctor using GSM interface.
Keywords: ECG, Pulse Rate, Temperature, Oxygen Saturation ARM processor, GSM module, MATLAB

I.   INTRODUCTION

As new technologies are emerging everyday in our lives, the improvement in health care industry becomes even more vital. Remote monitoring of the patient is a contemporary approach that has been implemented using the current advancements in technology. Today due to enhancements in the electronics that are now also being implemented in the biomedical and Intensive Critical Care Unit and Intensive Care Unit, people have become more apprehensive towards their health. Real Time Remote Supervisory system is basically used for data acquisition, electronic communication and information technology to allow interaction between the Doctors and the patient.[1]

Emerging augmentation in the networking and communication has forced the Electronics and Telecommunication engineer to develop a home based monitoring system, which will assist the doctor to display and transmit the signal from the human body using the various sensors and display the data on the Personal Computer.

ECG Waveform and filtering tool for ECG waveform has been displayed using MATLAB which is computer based processing, acquisition and analysis system. The acquisition of physiological Parameters are discussed in this paper, like Electronic Cardiogram, Body Temperature, Pulse rate, oxygen saturation. As the signal obtained from the sensor will be in the analog domain, hence a signal conditioning device such as instrumentation amplifier is used. The following figure represents the block diagram of remote supervisory system. [1]

The analog signal can be directly fed in the ARM7 LPC2138 processor as it has inbuilt analog to digital converter. The processor is connected to the patient side computer using a serial interface RS232 cable. It will perform the operations on signal and transfer the data on the patient side computer through a serial port. In this way the system is expected to monitor the patient under critical condition more conveniently and accurately without the physical presence of the doctor near the patient's bed.[1]

The second section describes the system representation, third section describes the hardware design of the system, the fourth section includes the software development tools and graphical user interface in MATLAB, and the last section will be followed by the result, conclusion and reference.

II.   SYSTEM REPRESENTATION

The data obtained from the physiological parameters will be processesed using LPC2138 and displayed on the patient side computer using the MATLAB GUI software, which will display numerical value of the Body Temperature, Pulse Rate, Oxygen Saturation and graphical display of the Electronic Cardiogrma. As the data is converted it is then processed by the microprocessor and it will be displayed on the patients personal side computer using the RS232 data bus. On the patient's personal computer LPC2138 will be interfaced using the Matrix Laboratory Software which will display the

detailed information about the parameters in numerical values and it will display a graphical representation of the Electronic Cardiogram on Graphical User Interface tool of the MATLAB software.
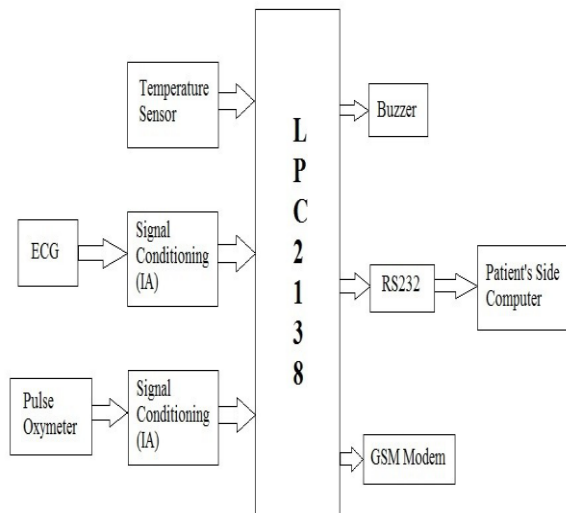

Fig. 1 Block Diagram of Remote Supervisory system

In case if any parameters goes abnormal over the optimum level then a buzzer will ring to alert the caretaker of the patient and an automatic SMS will be sent to the doctor using a GSM interface. These systems did not involve the patient to be admitted in the hospital and the monitoring could be achieved by allowing him/her to remain at home. By far the most key benefits of this system is that it eradicates the high cost obstacle. This system effectively reduces the cost by enabling in-home monitoring of patients, and also eliminate the need for employment of expensive amenities, and reducing the call for hauling of patients to physicians and medical centres. Also using it becomes exceptionally effortless due to user friendly interface and no particular training is essential for the personnel. Due to the interactive nature of the system, it becomes easier for the doctor to monitor the patient and provide with suitable course
of action.

III. HARDWARE DESIGN OF THE SYSTEM

The hardware design includes designing of Temperature, Pulse Oximeter, signal conditioning and ECG measurement.

A. *Temperature sensor*

LM35 is a precision IC temperature sensor with its output proportional to the temperature (in °C). The sensor circuitry is sealed and therefore it is not subjected to oxidation and other processes. With LM35, temperature can be measured more accurately than with a thermistor. It also possess low self heating and does not cause more than 0.1 °C temperature rise in still air. The operating temperature range is from -55°C to 150°C. The output voltage varies by 10mV in response to every °C rise/fall in ambient temperature, i.e., its scale factor is 0.01V/ °C
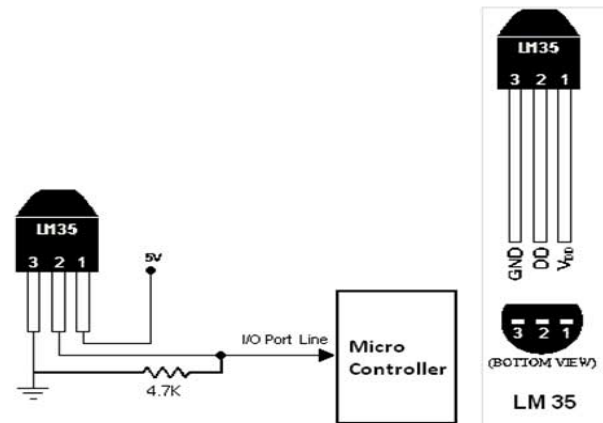

Fig. 2. IC LM35

B. *Pulse Oximeter*

In its most common (transmissive) application mode, a sensor is placed on a thin part of the patient's body, usually a fingertip or earlobe, or in the case of an infant, across a foot. Light of two wavelengths is passed through the patient to a photo detector. The changing absorbance at each of the wavelengths is measured, allowing determination of the absorbance due to the pulsing arterial blood alone, excluding venous blood, skin, bone, muscle, fat, and (in most cases) nail polish.

Reflectance pulse oximetry may be used as an alternative to transmissive pulse oximetery described above. This method does not require a thin section of the patient's body and is therefore well suited to more universal application such as the feet, forehead and chest, but it also has some limitations. Vasodilatation and pooling of venous blood in the head due to compromised venous return to the heart, as occurs with congenital cyanotic heart disease patients, or in patients in the Trendelenburg position, can cause a combination of arterial and venous pulsation in the forehead region and lead to spurious SpO2 (Saturation of peripheral oxygen) results. The sensor itself consists of an infrared emitter and detector mounted side-by-side and pressed closely against the skin. When the heart pumps, blood pressure rises sharply, and so does the amount of infrared light from the emitter that gets reacted back to the detector. The detector passes more current when it receives more light, which in turn causes a voltage drop to enter the amplifier circuitry. This design uses two consecutive operational amplifiers (op-amps) to establish a steady baseline for the signal, emphasize

the peaks, and _lter out noise. Both op-amps are contained in a single integrated circuit (IC or chip), and hooking them up is really just a matter of interconnecting the pins correctly.

C. *Signal conditioning*
1. Protection Circuit
    Diode (D1, D2, D3, D4) are used to protect IC from voltage when input voltage reaches to 0.7V then Diode get clamped and over voltage condition is avoided. Because of this input to instrumentation Amplifier will always be less than 0.7V.[1]

2. Instrumentation Amplifier
    The instrumentation amplifier used is AD8320 which has a very high CMRR (90dB) and high gain (1000). The AD8320 is a low cost, high accuracy amplifier which requires only one external resistor to set gain of the amplifier.[1]
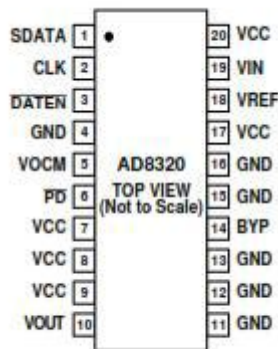

Fig. 3. IC for AD8320

3. Isolation Circuit (IC: MCT2E)
    It is NPN silicon planar phototransistor optically coupled to a gallium arsenide infrared emitting diode. Isolation circuit is used to provide isolation between input and output. It protect patient from shock. For checking the ECG signals on CRO we measure the ECG signals via CRO probes In most of the cases the Patient electrode ground and CRO ground is not the same, for such cases if the CRO ground is not properly earthed then the patient may get a Shock so for this reason we are interfacing a Opto- isolator which provides a optical insulation between the Electrode circuit and the Output circuit. [1].

4. Notch Filter
    Notch filter is used to provide zero output at particular freq. It eliminates power line noise at 50Hz. It contains H.P.F and L.P.F called twin-T network. Signal having frequency between 47HZ to 53HZ .Output of notch filter is +2.5V.Output of notch filter is 2.5V. It connects to input of adder circuit. Adder circuit shifts the signal from 2.5V to 0-

5V. And this output gives to ADC of ARM7 LPC 2138[1].

5. Amplifier OP07
    8 pin DIP package, low input offset voltage and high open loop gain. This non- inverting amplifier is used for signal conditioning purpose, gain provided by amplifier is 143. Total gain required for ECG circuit is 1000.Using variable resister gain adjust to 143.[1]

IV. SOFTWARE DEVELOPMENT IMPLEMENTATION AND TOOLS

A. *ECG measurement*
    Electrodes are placed on human body to capture small electrical voltage produced by contracting muscle due to each heartbeat. The ECG signal obtained by the electrodes is in the range of 1 to 5mV. Due to the weak voltage level, the signal is fed into an instrumentation amplifier to amplify and filter the acquired signal. The fig. shows circuit diagram of ECG measurement. The amplified signal is then fed into the ARM7 LPC 2138 having inbuilt A/D converter. Digital output of the ADC is sent to local terminal (patient's terminal) via an RS232 interface circuit.
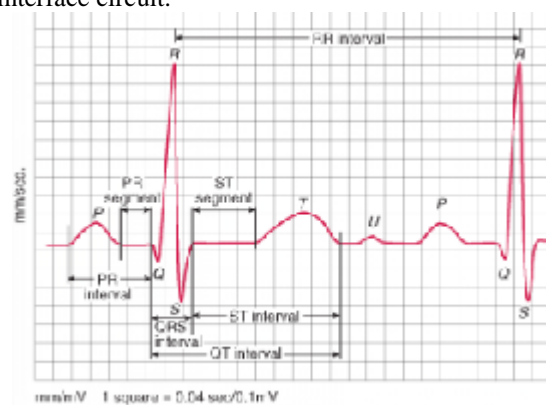

FIG. 4. ECG Waveform

A. *Algorithm*
1. Patient
2. Initialize the LPC2138 (ARM7) Processor.
3. Select the Physiological parameter.
4. Generate the start of conversion (SOC) signal for ADC.
5. Wait for end of conversion (EOC) signal from the ADC.
6. Check the Optimum Limit of Individual Parameter.
7. If satisfied repeat the above steps.
8. If not satisfied with optimum data, then a buzzer will ring and automatic SMS will be sent using GSM modem.
9. Patient monitoring will begin with prescribe treatment from Doctor.
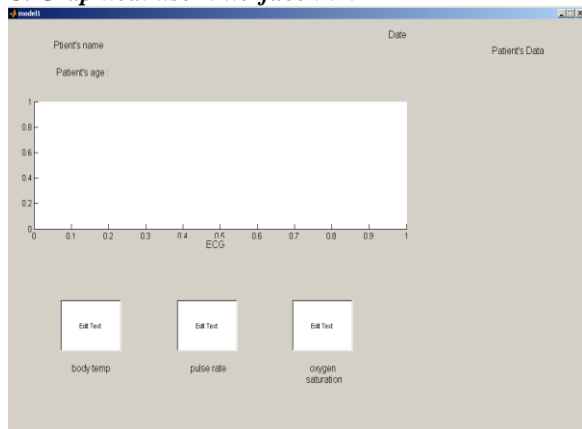
C. Graphical user interface in MATLAB

Fig. 5. Front panel of the GUI

This above figure shows how the front panel of the GUI will look after the implementation of MATLAB code on it , which will graphically display ECG and digitally display the values of Body Temperature, Pulse Rate and Oxygen Saturation.[5]
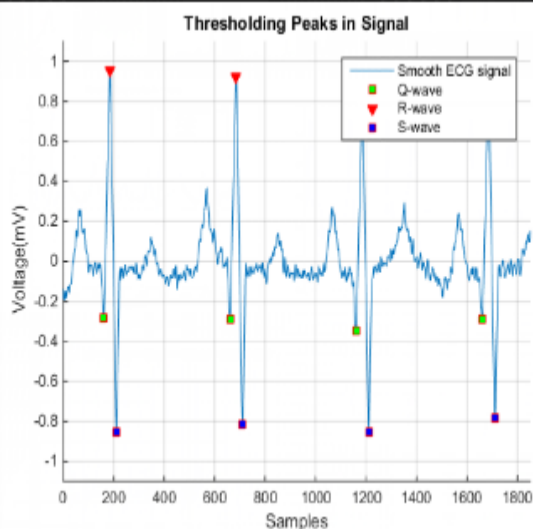
V.   RESULT AND DISCUSSION

Fig. 6. Simulation of ECG Waveform in MATLAB

The above waveform shows the ECG signal and it is periodic with fundamental frequency determined by heartbeat. The fig.4 shows the single period of an ECG signal which is a mixture of sinusoidal wave and triangular wave forms. Each significant feature of ECG signal can be represented by shifted and scaled versions one of these waveforms as shown above. Such an ECG simulator technique is advantageous as it can eliminate the problem of taking a real time signal as well as saves time.

Fig.5 will show the detected ECG signal and other parameters of the patient which are monitored using the processor ARM7 LPC2318. The format will also display the other information of the patient.

The MATLAB GUI program includes the patient's name, age, date, patient report, frequency domain window display will also display heart rate in beats per minutes. The waveform and other parameters are observed on the patient side monitor if any abnormality occurs then the alert will be given using a buzzer and an SMS will be sent to the doctor.

VI.   FUTURE SCOPE

In the future, this monitoring application can be expanded which will allow the doctor to diagnose his patient's vital parameters distantly and progressively in his computer and further in a web page in more real time and does not require to have any special software on his PC. Without any installation of any software, through the internet access the patient can be monitored and diagnosed. Further using a Lab VIEW an alert system can be established on the patient's side monitor, which will automatically send a mail using Email notification application.

VII.   CONCLUSION

This system will be beneficial and has a greater advantage to our society by reducing the cost of travelling of the patient, save huge amount of the hospital bills and conserve the time of the doctors. This home based supervisory system will provide a constant monitoring to the patients condition.

VIII.   ACKNOWLEDGMENT

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