

Design and Implementation of Real Time Embedded Tele-Health Monitoring System

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Abstract

Now a day's healthcare industry is to provide better healthcare to people anytime and anywhere in the world in a more economic and patient friendly manner. In the present paper the physiological parameters such as ECG, Pulse rate and Temperature are obtained, processed using ARM7 LPC 2138 processor and displayed in a MATLAB graphical user interface. If any vital parameter goes out of normal range then alert SMS will be sent to Doctor Mobile. This system is utilizing Teamviewer software and low cost component to transmit ECG data to physicians for monitoring, diagnosis and patients care at a significantly low cost, regardless of patient's location.

Keywords: ECG, pulse Rate, Temperature, ARM, MATLAB

1. Introduction

The electronics technology has entered almost in all aspects of day-to-day life, and the medical field is not exception for that. The need for well-equipped hospitals and diagnostic centers is increasing day by day as the people are becoming more conscious about their health problems. In biomedical fields special units are used, such as intensive care unit or coronary care unit. All of these units are designed to offer the advantage of the low Nurse – Patient ratio and concentration of the equipment and the resources needed; to take care of critically ill or seriously injured units. The medical world today faces two basic problems when it comes to patient monitoring, firstly the need of healthcare providers present bedside the patient and secondly the patient is restricted to bed and wired to large machines. In order to achieve better quality patient care, the above cited problems have to be solved. As the technologies are advancing it has become feasible to design to home based vital sign monitoring system to display, record and transmit signals from human body to any other location. The computer based Signal Acquisition, processing and analysis system using MATLAB to display ECG Waveform and filtering tool for

ECG waveform. This paper discusses the aspects of acquisition of physiological Parameters like ECG Temperature, Pulse rate, pre-processing them and displaying them in a graphical user interface for being

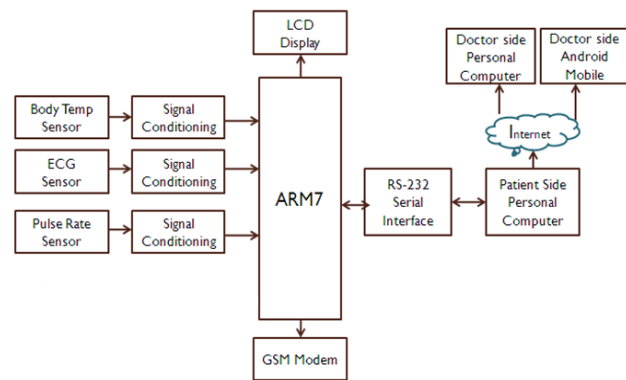


Fig. 1 Block Diagram of System

viewed by the doctor and also observe the clinically useful data, Firstly on Doctors computer and secondly on Android Mobile which contains a Teamviewer application. This system is expected to monitor patient under critical care more conveniently and accurately for diagnosing which can be interfaced with computer to bring it under a network system widely for the doctor to monitor the patient's condition sitting in his own office without being physically present near to the patient's bed. In second section describes system representation, third section describes Hardware description of system, fourth section describes implementation of system algorithm using arm7 LPC2138, fifth section describes simulation of ECG waveform, sixth section describes result and last section describes future scope and conclusion.

2. System Representation

The block diagram of system shown in fig.1. The system contains hardware and software components. The body parameters are processed by ARM processor, it will display to the patient on LCD and Waveforms on Patient side Personal Computer using MATLAB. The same data on computer it can be viewed by physician in two ways. Firstly on Personal Computer using Remote Desktop sharing and secondly on Android mobile having application of Remote desktop sharing. If any parameter goes abnormal then the system will sent an alert SMS to the doctor through GSM modem. Reports indicating that system have been a great concern for physicians with a passion for technology, and barriers still remain for a low cost, comprehensive and integrated use in the daily operations. This system reduces costs by enabling in-home monitoring of patients, eliminating the need for utilization of expensive facilities, and reducing the need for transportation of patients to physicians and medical centers. The system is user friendly and does not require any particular training aside from knowledge of widespread and standard Internet tools. Due to the interactive approach of the system, the physician is also able to make online consultation directly from the software provided on personal computer.

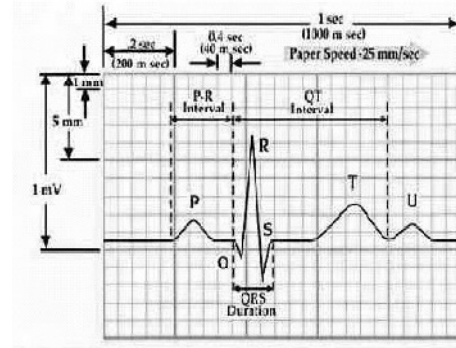


Fig. 3 ECG waveform showing QRS interval

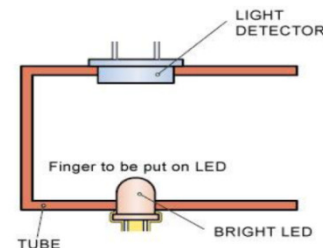


Fig. 4 Sensor Construction

3. Hardware Design of System

The hardware design includes designing of, Temperature, Pulse rate and ECG measurement.

3.1. Temperature Measurement

The temperature sensing is performed by using an IC LM35. The LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. The output from the LM35 is given to the analog to digital converter through LM385. Analog to digital converter is inbuilt part of LPC 2138. general equation used to convert output voltage to temperature is given below

$$T(^{\circ}\text{C}) = V_{out} \times \left(\frac{100^{\circ}\text{C}}{V_{cc}}\right) \quad (1)$$

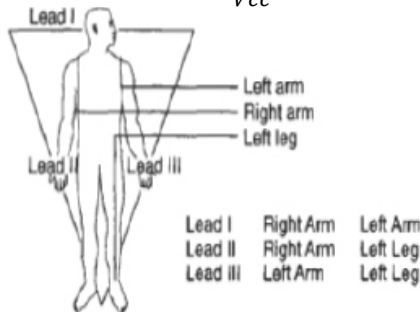


Fig. 2 Lead Placement

3.2. Pulse rate measurement

The sensor shown in fig. 4 consists of a super bright red LED and light detector. The LED needs to be super bright as the light must pass through finger and detected at other end. Now, when the heart pumps a pulse of blood through the blood vessels, the finger becomes slightly more opaque and so less light reached the detector. With each heart pulse the detector signal varies. This variation is converted to electrical pulse. This signal is amplified and triggered through an amplifier which outputs +5V logic level signal. The output signal is also indicated on top by a LED which blinks on each heart beat.

3.3. ECG measurement

Electrodes are placed on human body as shown in fig.2. 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. 5 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.

The parameters are the magnitude & the duration of each wave, and the intervals, such as R-R, PP, Q-T and S-T intervals as shown in fig.3.

3.3.1 Protection Circuit

Diode (D1, D2, D3, D4) are used to protect IC from over 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.

3.3.2 Instrumentation Amplifier

The instrumentation amplifier used is AD620 which has a very high CMRR (90dB) and high gain (1000). The AD620 is a low cost, high accuracy amplifier which requires only one external resistor to set gain of the amplifier.

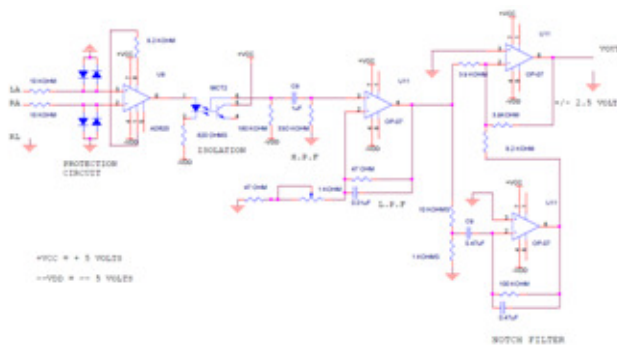


Fig. 5 Circuit Diagram of ECG Measurement

3.3.3 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.

3.3.4 Bandpass Filter (0.5 Hz – 35Hz)

We take the band pass filter the frequency range of 0.5 Hz to 35 Hz. Hence we have cascaded high pass filter and low pass filter. Therefore lower cut-off frequency for HPF is 0.5 Hz.

$$f_c = \frac{1}{2\pi RC}$$

Where C = 1uF, R = 330kohm

Low pass filter allow signal below 35Hz only.

$$f_c = \frac{1}{2\pi RC}$$

Where C = 0.1uF, R = 47kohm

3.3.5 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 resistor gain adjust to 143.

3.3.6 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 freq between 47HZ to 53HZ .Output of notch filter is $\pm 2.5V$. Output of notch filter is $\pm 2.5V$. It connects to input of adder circuit. Adder circuit shifts the signal from $\pm 2.5V$ to 0-5V. And this output gives to ADC of ARM7 LPC 2138.

4. Software Implementation Of System Using ARM7 LPC2138

4.1. Algorithm

To implement the system using microcontroller the flow of the program i.e. algorithm which we are going to implement is as follows:

1. Initialize the microcontroller ARM7.
2. Select the input parameter.
3. Generate the start of conversion (SOC) signal for ADC through the microcontroller.
4. Wait for end of conversion (EOC) signal from the ADC.
5. Read the equivalent digital data of the parameter selected.
6. Display the received data.
7. Send the received data.
8. Select the next parameter.
9. Repeat the process.

5. Simulation of ECG Waveform

5.1 Using MATLAB Simulator

The ECG Simulator is MATLAB based simulator and is able to produce Lead II ECG Waveform. The ECG simulator technique is used for saving time and removes difficulty of taking real time signal. We can simulate any ECG waveform using ECG simulator. ECG Signal is

periodic with fundamental frequency determined by heartbeat. Fourier series can be used to representing ECG signal. The fig.3 shows single period of an ECG signal is a mixture of triangular and sinusoidal wave forms. Each significant feature of ECG signal can be represented by shifted and scaled versions one of these waveforms as shown below.

1. QRS, Q and S portions of ECG signal can be represented by triangular waveforms.
2. P, T and U portions can be represented by triangular waveforms.

The generated output Signal by MATLAB is shown in fig 6. The specifications are default for this signal which can be changed according to the user's requirement while simulating the MATLAB code. We take heartbeat as 72, amplitude of P, R, Q, T waves as 25mV, 1.6mV, 0.025mV, 0.35mV respectively while the duration of P-R interval, S-T interval, P interval, QRS interval as 0.16s, 0.18s, 0.09s, 0.11s respectively.

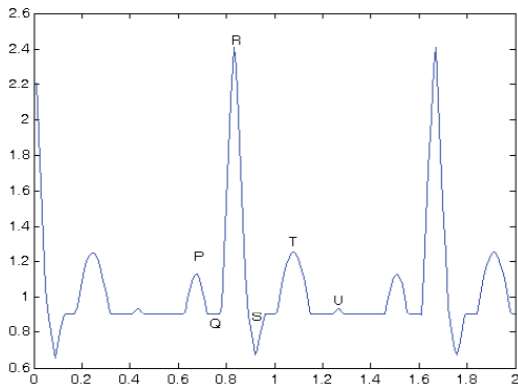


Fig. 6 ECG Waveform simulated by MATLAB

6. Result

Figure 7 shows Detected ECG Signal on DSO after amplification and filtration. For instance, a display format on computer for ECG measurement is shown in Figure 8. The MATLAB GUI program includes name of patient, Patient Report, frequency domain window displays, also display heart rate in beats per minute. The ECG waveform can be sent further through internet for further analysis. This can bring a great change in telemedicine field. ECG Waveforms can be seen by using the MATLAB Software.

6.1 Real time monitoring on Remote side physician Personal Computer

The waveform on remote side physician computer is observed by using Team viewer application present on computer so doctor can take access of patient side

computer desktop sharing and reports can be generated in computer also any one of the vital parameter goes abnormal then alert message will be sent to the doctor.

6.2. Real time monitoring on Remote side physician mobile using android application

The waveform on remote side physician mobile is observed by using Teamviewer application present on mobile so doctor can observe waveform on mobile irrespective of doctor is outside of clinic.



Fig. 7 Detected ECG Signal after amplification and filtration

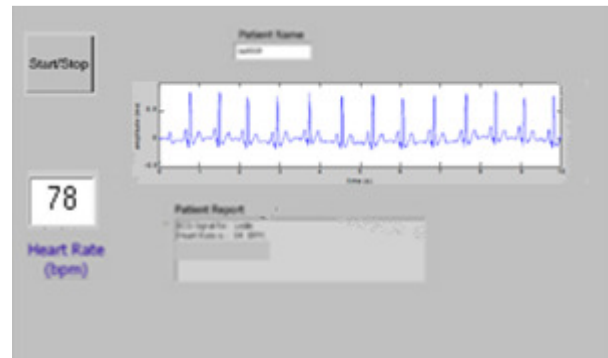


Fig. 8 MATLAB Graphics User Interface (GUI) for ECG measurement and analysis

7. Future Scope

In future work the tele monitoring application is presented which allows doctor to view his patient's vital parameter remotely and dynamically in a Web page in real time and does not need to have any special requirement on his PC; all he needs is an internet access. For the patient side, it is a home based Lab VIEW application embedded in a home PC, during signal acquisition. The alert file is generated in

Lab VIEW it will automatically send mail using Email notification application.

8. Conclusion

This system reduce costs by enabling in-home monitoring of patients, eliminating the need for utilization of expensive facilities, and reducing the need for transportation of patients to physicians and medical centers.

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