IMPLEMENTATION OF PATIENT MONITORING SYSTEM USING
GSM TECHNOLOGY

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ABSTRACT

In this fast pace of life it is difficult for people to be constantly available for their near ones who might need them while they are suffering from any disease or physical disorder. So also constant monitoring of the patients body parameters such as temperature, pulse rate, sugar level etc. becomes difficult. Also in intensive care units it is necessary to monitor continuously the patient’s health parameters and keep their record. But there is a possibility of human errors. Hence to remove human errors and to lessen excessive burden of continuously monitoring patient’s health from doctor’s head, we are proposing patient monitoring system using GSM. A patient monitoring system which provides continuous monitoring of a patient includes a data acquisition & processing module which receives physiological data from the patient and GSM module to transmit acquired data to doctor’s mobile. This unit may be inserted in a bedside display unit to display the physiological condition of the patient. Patient monitoring systems measure physiological characteristics either continuously or at regular intervals over time.

INTRODUCTION

In this fast pace of life it is difficult for people to be constantly available for their near ones who might need them while they are suffering from any disease or physical disorder. So also constant monitoring of the patients body parameters such as temperature, pulse rate, sugar level etc. becomes difficult [4]. Also in intensive care units it is necessary to monitor continuously the patient’s health parameters and keep their record. But there is a possibility of human errors[6]. Hence to remove human errors and to lessen excessive burden of continuously monitoring patient’s health from doctor’s head, we are proposing patient monitoring system using GSM.

The concept of this paper is builds upon the integration of wireless communications into medical applications to revolutionize personal healthcare. The objective of this project is to build a wireless heart beat monitoring system using GSM Technology, which could potentially be an integral part of a suite of personal healthcare appliances for a large-scale remote patient monitoring system.

As its name implies this is a Patient monitoring system, with a feature of sending SMS to doctor and patients relative in event of emergency, hence the system can be used at hospitals as well as at home. Remote patient monitoring will not only redefine hospital care but also work, home, and recreational activities [4].
The objective of patient monitoring system is to have quantitative assessment of important physiological variables of patients during critical conditions[1-6]. This system is used for measuring continuously automatically the values of the patient's important physiological parameters such as blood pressure, body temperature, pulse rate, respiration rate and other health-related criteria.

The proposed system is portable and can be used at home. In the proposed system microcontroller is used so the cost of the system will very less. For transmission of message GSM technique of messaging can be used, due to that message can be sent any time any were in the network. So the proposed system is very cost effective and the vital parameters are measured and sent accurately to the numbers which are already store i n the system. So the efficiency of hospitals and doctors can be increased by the proposed system. The programming is in assembly language and AT commands of GSM is used for the transmission of message.

**SYSTEM DEVELOPMENT**

Figure 1.1 shows the block diagram of the Patient Monitoring System. Various physiological signals such as body temperature, blood pressure, heart rate are continuously monitored as well as controlled remotely with this system.

Various types of transducers are used to sense these bioelectrical signals [1,2]. To sense the body temperature we used LM35 of national instruments because it is cheap in rate and its size is small enough to fit on patient’s body [11]. Heart rate sensor is non invasive type of sensor based on photo plethesmography principle [1,2]. The heart rate sensor is designed by us only to reduce the overall cost of proposed system. This circuit consists of instrumentation amplifier and ECG electrodes which are not costly. The ECG signal is collected with the help of three electrodes. Out of which one is a reference electrode, one is connected to the left side and other to the right [2]. This collected signal is given to instrumentation amplifier and the remaining circuit, which counts the number of R peaks per minute and gives the accurate Heart rate.

![Figure 1.1: conceptual block diagram of the system](image)

All the signals from transducers are weak signals hence these signals are processed and amplified to desired level with the help of signal conditioner and instrumentation amplifier. The output of instrumentation amplifier is given to analog to digital converter. These converted digital...
signals are then fed to microcontroller 89S52. Microcontroller displays these respective values on LCD display. Microcontroller then compares these values with the hard coded values given to microcontroller by user through keypad. These values are stored in memory of microcontroller. If measured values cross the limit of reference values then microcontroller will activate relay which is connected to alarm circuit. It also send SMS to two mobile numbers stored in memory through GSM modem. Microcontroller continuously displays these variables on the LCD Display. Microcontroller continuously does this work, thus providing a real time monitoring of temperature heart rate and blood pressure.

HEART RATE SENSOR DESIGN

As the sensors which are used in medical field are very costly, to reduce the cost of developed system heart beat measurement sensor is developed using different OAMPS such as LM 358, OPAMP 07 and other IC’s as MCT2E, IC 4538 etc[10]. This sensor is based on the concept of ECG[2]. In the developed system three electrodes are used as ECG leads. Two of them were connected on the body and the third one was used as ground. The circuit diagram of developed heart rate measurement sensor is as shown in figure 1.2

![Figure 1.2: Circuit diagram of heart rate sensor](image)

In the developed system chest sensors are used for sensing ECG signal. Three electrodes are used for sensing signal out of which one electrode is used as a ground and remaining two are connected to body one at left side of chest and other at right side of chest. Range of this ECG signal is in Mv[2] but the input required for ADC is near about 2.5 volts hence the gain of overall system is set to 1000
Output of the ECG sensors is then given to instrumentation amplifier. All the resistors connected to instrumentation amplifier are of 20 kΩ and gain adjust register is of 1 kΩ, hence the gain of instrumentation amplifier is calculated as, IC 620 is used as instrumentation amplifier in the developed system [9].

\[
G_1 = 1 + \frac{R_2}{R_1} = 1 + \frac{2 \times 10^8}{1 \times 10^8} = 21
\]

Output of instrumentation amplifier is given to the opt coupler MCT2 and then it is given to next processing circuit. ECG signal used for diagnostic purpose is in the range of 0.05 Hz to 100 Hz, but the required signal for the system is from 0.5 to 30 Hz, hence design a high pass filter having cut off frequency 0.5 Hz.

\[
F_c = \frac{1}{2\pi R C}
\]
\[
0.5 = \frac{1}{2\pi \times 330 \times 10^3 \times C}
\]
\[
C = 9.64 \times 10^{-7}
\]

Output of this high pass filter is now given to single amplifier whose gain is set to \(\frac{1000}{21} = 47.61\). The gain of this amplifier is adjust to 47.61 so that overall gain of the system is 1000. Gain of this amplifier is given by

\[
G_2 = 1 + \frac{R_f}{R_1}
\]

Select value of \(R_f = 100 \, K\Omega\).

\[
47.61 = 1 + \frac{100k}{R_1}
\]
\[
R_1 = 2.14K \Omega
\]

2.14 kΩ is not standard register value, so fix register of 1.8 kΩ is chosen and pot of 1 kΩ is used to adjust the value of 2.14 kΩ.

The notch filter is used to eliminate the 50 Hz frequency signal. It is narrow band reject filter. Notch out frequency is the frequency at which maximum attenuation occurs.

\[
f_n = \frac{1}{2\pi R C}
\]

In notch filter design \(C \leq 1\mu F\) hence \(C = 0.068 \mu F\)

\[
\therefore R = 46.81K \Omega
\]

Hence taking standard value \(R=47 \, K\Omega\)

The output of notch filter is given to the DC offset null circuit. The DC offset present in the system may vary from 0.2 to 25 mV. This circuit is used to remove this offset present in the system. From data sheets maximum input DC offset for P07 is 25 µV. The gain of system is 1000 hence the maximum DC offset is 25 mV.

The maximum possible output offset voltage \(V_{oo}\) caused by the input offset voltage \(V_{io}\) is.

\[
V_{oo} = V_{io} * Aoo
\]

\[
where \quad Aoo = 1 + \frac{R_f}{Ra + R_{23}}
\]

Where \(R_f = 3.9 \, K\Omega, R_{23} = 8.2 \, K\Omega, Ra = 100K\Omega\)

\[
\therefore Aoo = 1.117
\]

Therefore maximum DC offset that can be removed by this circuit is

\[
V_{oo} = 27.952mV
\]
After removing Dc offset the signal is given to comparator LM324. It compares this signal with the reference signal and gives compared output. For comparator reference voltage is obtained from voltage divider arrangement of 10 KΩ register and 10 KΩ pot at the inverting terminal and input signal is given at non inverting terminal. The signal from comparator is given to the multi vibrator 4538 which gives square pulses according to compared signal these pulses later on given to microcontroller.

**WORKING PRINCIPLE**

In the developed system LM35 is used as temperature sensor. It gives analog output, which changes 10mV per degree Celsius. This sensor output is given to the ADC 808. The ADC808 gives digital count corresponding to the input voltage applied to it. Input Voltage in the range of 0V to 2.5V is given for each sensor. The corresponding digital output will be 0 to 255. In the developed system potentiometer is connected in voltage divider circuit for the simulation of blood pressure sensor. The output of the voltage divider circuit is connected to the ADC808 which converts it to the digital count. In the developed system chest sensors are used and circuit is designed for sensing heart signal.

The outputs of these sensors are given to ADC808. The channel select pins A B C of ADC808 are connected to the port pins P3.2 of micro controller. We can select different channels by changing the status of these pins. The ADC808 is 8 channel ADC having 8-bit resolution. The conversion time of ADC808 is 100 microseconds and its step size is 20 mV. The data lines D0 to D7 of the ADC are connected to the port1 micro controller. When ADC receives pulse on SOC pin (PORT P3.4) from micro controller it starts the analog to digital conversion. After completion of conversion it gives pulse on EOC pin (PORT P3.3).

The output of the ADC is in hex format. The micro controller will convert it into BCD format and then into ASCII format to display different readings of different parameters on LCD. The data lines D0-D7 of LCD are connected to port 0 of micro controller. The control lines RS (Register select), R/W (read/write) and Enable of LCD are connected to port pins P3.5, P3.6, P3.7 of micro controller respectively.

Whenever temperature, heart rate or any parameter exceeds there selecting range at that time message will be sent through GSM port which is connected though MAX 232.
RESULT

The different physiological variables to be monitored & controlled remotely are sensed & converted into analogous form i.e. the digital form. Here microcontroller performs various operations & gives desired output. We have partially implemented the project to monitor temperature heart rate and blood pressure of the patient remotely. For testing system following steps will perform:

1. By using keypad enter mobile no. to which message is to be sent
2. Enter second mobile no. to which message is to be sent
3. Set time after which message is to be sent
4. Set temperature limits using keypad
5. Set heart rate limits using keypad
6. Set blood pressure limits using keypad

Testing results are as shown in table 1.1 through 1.

<table>
<thead>
<tr>
<th>Set Temp</th>
<th>Set Heart rate</th>
<th>Set BP on LCD</th>
<th>Temp on LCD</th>
<th>HR on LCD</th>
<th>BP on LCD</th>
<th>Temp on Therm</th>
<th>Manual HR measure</th>
<th>Msg sent</th>
</tr>
</thead>
<tbody>
<tr>
<td>20-40</td>
<td>60-90</td>
<td>80-90</td>
<td>27</td>
<td>87</td>
<td>85</td>
<td>27</td>
<td>86</td>
<td>Temp-07</td>
</tr>
<tr>
<td>20-40</td>
<td>60-90</td>
<td>80-90</td>
<td>30</td>
<td>83</td>
<td>85</td>
<td>30</td>
<td>83</td>
<td>Temp-00</td>
</tr>
</tbody>
</table>

Table 1.1 test results for normal conditions

<table>
<thead>
<tr>
<th>Set Temp</th>
<th>Set Heart rate</th>
<th>Set BP on LCD</th>
<th>Temp on LCD</th>
<th>HR on LCD</th>
<th>BP on LCD</th>
<th>Temp on Therm</th>
<th>Manual HR measure</th>
<th>Msg sent</th>
</tr>
</thead>
<tbody>
<tr>
<td>10-20</td>
<td>40-90</td>
<td>80-90</td>
<td>21</td>
<td>78</td>
<td>85</td>
<td>21</td>
<td>78</td>
<td>Exceed</td>
</tr>
<tr>
<td>10-50</td>
<td>40-90</td>
<td>80-90</td>
<td>21</td>
<td>79</td>
<td>85</td>
<td>21</td>
<td>78</td>
<td>Exceed</td>
</tr>
<tr>
<td>10-60</td>
<td>80-90</td>
<td>80-90</td>
<td>21</td>
<td>78</td>
<td>85</td>
<td>21</td>
<td>78</td>
<td>Exceed</td>
</tr>
</tbody>
</table>

Table 1.2 test results when temperature exceeds limits

CONCLUSION

After successful completion of this project it can conclude that the microcontroller based system can be effectively used as communication medium in conjunction with GSM. Sensors designed in the developed system give accurate readings so it can be said that the developed system is very cost effective and accurate. The accuracy of the system is up to 99%.
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