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Advancement of Low-cost Medicare System for the Measurement of Physiological Parameters of Human Body

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Abstract: ***This paper represents a design and implementation of a reliable, cheap, low powered non-intrusive and accurate system that can measure many parameters of human body and keep the records of each patient. It gives an idea to make a database of each patient so that whenever the patient comes to the doctor he doesn't have to keep his record with him manually. Such a device can be handled by non technical personnel also and can be used both in small clinics and big hospitals. This paper is presented with a motto of saving time of both the doctor and patients. As the device can measure the vital signs in a very less time it can save time of doctor and no. of patients can be observed. This paper specifically deals with the signal conditioning and data acquisition of three vital signs: heart rate, body temperature, and weight. The vital signs that have been taken are temperature, heart rate and oxygen in blood,blood pressure and body mass index. The heart rate is measured by Heart beat sensor which works on the principle of light modulation by blood flow through finger at each pulse.To measure the oxygen amount in blood we use pulse oximeter. The pulse oximeter measures the ratio of red to infrared pulsating absorption, which is directly proportional to the oxygen saturation. The temperature is measured by using LM34 which measures the temperature directly in Fahrenheit and does not need external calibrations. And the weight is measured by load cell. Here a simple circuit is designed by using AT89S52 microcontroller as heart of the circuit. The three sensors are connected with microcontroller via signal conditioning equipments. The data is also easily accessible by both the doctor and patient as complete record of output can be generated by using VB as programming language.***

Keywords- physiological parameter, vital signs of human body, blood Pressure, heart rate, obesity, BMI, oximeter.

I. INTRODUCTION

There has been exponential increase in health care cost in the last decade. Patients have to make frequent visit to the doctors to get their vital signs measured[1]. And every time they visit they have to keep their previous records with themselves. Now a day every age group has to go for a routine checkup and keep the records with themselves. So there is a need of device that can keep the record of every patient. Also the device should be low cost and portable. Most of the devices available in the market are huge, bulky and wireless systems that can continuously measure the body parameter and give alarm in emergency[10]. However this proposed device is basically designed for the rural areas where networks are not available and the people are not technically very sound. This proposed device is designed for doctor, the nurses and patients all so that anybody can measure the records and keep the records in pc and device itself. There are many portable devices in market that can measure the single body parameter and keep the records like thermometer, glucometer etc. but there is lack of device that can measure all the body parameters together and keep records however there are also such devices but they are continuously monitoring systems with complex designs such as St John's Life link [22] and ADT's Neva Alone[23].

The proposed device has sensors incorporated together to monitor vital signs of human body such as:

- Heart rate
- Oxygen level
- Temperature
- Blood pressure
- Body weight for BMI.

The human vital signs which are in analog forms are sent to ADC and then to microcontroller. The LCD connected with the microcontroller displays the output of different sensors and simultaneously the output is stored in memory connected with microcontroller or directly to the PC. Also a frontend is also available to display the output in PC and printout can be taken or keep it as a digital diary. The front end can be made by using visual basic.

Although the aim of this project was to incorporate all this parameters but due to time constraints it was decided to incorporate heart rate, temperature and body mass index. The main focus is to incorporate all these sensors with a single microcontroller. Here the system block diagram(fig. 1) is represented where all the sensors are connected with microcontroller either directly or via ADC. The digital output data is then displayed in LCD or PC.

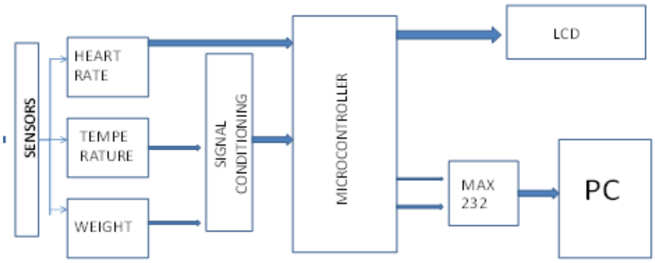

Fig. 1

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II. OVERVIEW OF SENSORS

(A) Temperature Sensor:

The LM34 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Fahrenheit temperature. The LM34 thus has an advantage over linear temperature sensors calibrated in degrees Kelvin, as the user is not required to subtract a large constant voltage from its output to obtain convenient Fahrenheit scaling.

The LM34(Fig. 2) does not require any external calibration or trimming to provide typical accuracies of ±1⁄2°F at room temperature and ±11⁄2°F over a full −50 to +300°F temperature range. Low cost is assured by trimming and calibration at the wafer level.

The LM34's low output impedance, linear output, and precise inherent calibration make interfacing to readout or control circuitry especially easy. The LM34 is rated to operate over a −50° to +300°F temperature range, while the LM34C is rated for a −40° to +230°F range (0°F with improve accuracy).

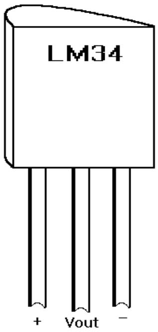

Fig.2

(B) Heart Rate Sensor:

Heart beat sensor (Fig. 3)is designed to give digital output of heat beat when a finger is placed on it. When the heart beat detector is working, the beat LED flashes in unison with each heart beat. 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 blood flow through finger at each pulse.The sensor (Fig.4) consists of a super bright red LED and light detector. The LED needs to be super bright as the maximum light must pass spread in finger and detected by detector. 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 by a LED which blinks on each heart beat.

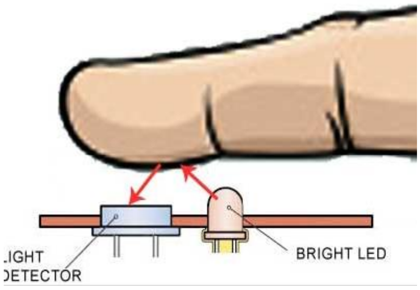

Fig. 3

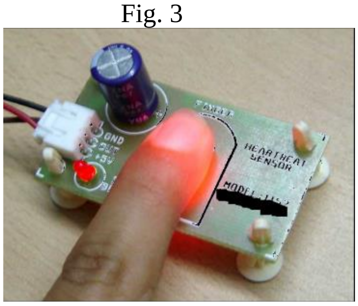

Fig.4

(C) Pulse Oximeter

Arterial blood hemoglobin oxygen saturation (SpO_2) is a measurement of the amount of oxygen attached to the hemoglobin cell in the circulatory system. SpO_2 is given as a percentage; normal reading is around 96%. The "S"stands for saturation. SpO_2 and the pulse frequency are measured non-invasively using a pulse oximeter. Theblood volume changes during the systole and diastole, which has an effect on the light absorption. The light sources for this measurement are a red and an infrared LED, and a photodiode acts as detector. The pulse oximeter measures the ratio of red to infrared pulsating absorption, which is directly proportional to the oxygen saturation. In addition, the time interval between pulsations is converted into the pulse frequency.

Fig. 5

(D) Load Cell

For the measurement of weight we are using load cell rated 5-60 kg as rated load. Single Point Load Cells are usually designed for processing applications which require weight control platforms, usually on the small scale type. They are given their name because they can be used for these platform applications supporting off center loading by utilizing only one sensor. The advantage of this particular load cell design over others is that it is low profile, has high precision, and can be adjusted for off center loading.

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This particular load cell type is generally easy to mount. Other products for similar applications such as load buttons are not as easy to mount. This load cell is also designed for high volume OEM applications and offered in a wide range of capacities from Gram ranges to 500 lbs in the same form fit function. Also due to its compact size, high precision and long Mean Time Between Failure (MTBF of very well over 100 million cycles) it has been an ideal choice for many medical applications such as automated blood management system, dialysis and bag hanging applications for drug delivery application. by using this load cell we can measure the caliberated load of 2 to 3kgs.the out put of load cell is in current form so an I to V converter is used for converting it into voltage form. Then the prescision rectifier is used.

Fig.6

III. HARDWARE AND SOFTWARE

The sensor unit consists of heart rate sensor, temperature sensor and a load cell connected to the microcontroller board as shown in fig 1.there is a signal processing board. The signal processing unit (Fig.7) contains the amplification, signal separation and filtering of received signal which are then sent to the microcontroller for conversion into digital signals and then calculate the values. As in the block diagram we have already seen important components which have been connected to the microcontroller. The sensors cannot be connected directly to the microcontroller so the ADC 0809 is interfaced with microcontroller. For the startup conversion and SOC pin 6 and 22 of ADC are connected to p3.4(pin 14) of microcontroller. Channel selector A is connected to P3.6 of microcontroller. The data pin of ADC (D0 to D7) are connected with P1 of microcontroller. The first sensor i.e. the temperature sensor LM34 is connected input 0 (pin26) of ADC. The advantage of using LM34 is that it does not need any calibration. The second sensor i.e. the Heart Rate Sensor is connected to the input 1 (pin27) of ADC and last but not the least the third sensor the load cell is connected to pin input 2 (pin 28) of ADC. And in this way more 5 different sensors can be added to the circuit in future. Before adding load cell to ADC one I to V converter and prescision rectifier is connected between them. Now a decade counter is added to the circuit for generating the clock pulse for ADC in mod10 mode. For display of output LCD is connected with port 1 of microcontroller. The RS and enable pin of LCD is connected to pin2.0 and 2.1 respectively. For serial transmission of data to the PC MAX232 and RS232 are used. For the display of output an LCD is connected. The front end of the pc is designed by using VB.

IV RESULT

In order to verify the circuit we tested this system for some people and got the satisfactory result. This was a very simple process where the attachments are made to the different body part of person such as to put finger on the heart rate sensor, for temperature the sensor is attached with ear and for weight he has to stand on the platform designed. The circuit worked accordingly to the plan. As per literature review, objective of the proposed work has been set and based on problem identification, methodology is opted to achieve set goal. The final circuit would look like as follows:

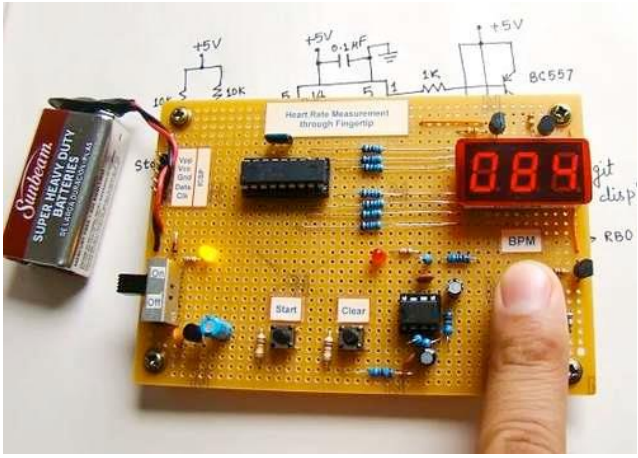

Fig.7

to test whether we achieved our goal or not we have taken a sample test[Fig.8]. Which is as follow

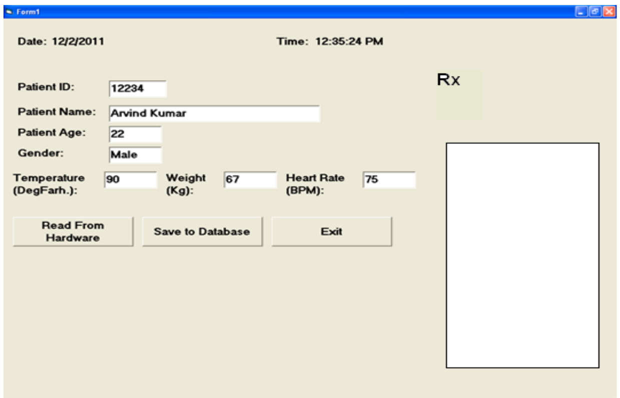

Fig.8

V. CONCLUSION

The objective of this project was to build a low power, low cost, reliable, non-intrusive, and non-invasive monitoring system that would accurately measure the vital signs. The resulting system was also low in power and cost, noninvasive, and provided real time monitoring. It is also easy to use and provides accurate measurements. For medical purpose the accuracy is always before cost of the device but for the countries like India there is huge scope of experiments and work on the medical devices to make them cheaper still equally reliable. Given the scope of this project, the heart rate and weight measurement circuits accurately measure the heart rate signal and body weight. However the temperature measurement is limited because of the 8 bit microcontroller but still the accuracy of temperature is good enough.

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As we discussed earlier according to the different age groups there would be changes in the vital signs values. Especially for the infants and adults who are above 70 it is a must to make the device more precise in terms of heart rate and blood pressure.

This work is dedicated to the medical field with many advantages such as:

It can measure many parameters and can display them together.

The output is accurate and does not need calibration. The sensors used are cheaper still reliable such as LM34.although as the LM34 has resolution of 1^0F it cannot measure the fractional values of temperature. Instead if this LM34 we can use LM92 which can measure the fraction values also. But we have chosen LM34 because of using microcontroller AT89S52 which is an 8 bit microcontroller even if the sensor has resolution less than 1 the microcontroller cannot show that. But as the other parameters are well defined and accurate we have chosen microcontroller of 8 bit.

This gadget gives the facility to work stand alone without PC and can also be interfaced with PC. For making this gadget stand alone we have used LCD for the display of output data.

For making database of different patients we need to use the PC as storage device and program of visual basic already programmed in the PC.

There is no need of any specially trained personnel to handle this gadget a simple demo is required to understand the working of whole process and gadget. There are numerous opportunities to modify and improve this project.

First of all we can add more sensors to the device according to the requirement. The next most important vital sign could be oxygen level in blood. So for that we easily add the following circuit:

1. Oximeter - Selection of LEDs and Photodiode

To build a pulse oximeter, selection of appropriate LEDs and photodiodes are essential to obtaining a good signal. A Red LED and an Infrared LED are normally used in a pulse oximeter [Fig.9] to measure the blood volume changes that are used to determine the content of oxygenated and deoxygenated hemoglobin in the blood. For this project, the transmission technique is used on the finger to obtain the signal. Instead of using two LEDs, only one Red LED is used to measure the volume changes in blood. The photodiode captures the characteristics of the light transmitted through the finger and produces a current. The Red LED chosen for this project is 5mm, 2800 MCD, SSL-LX5093SRC/E that generates light with wavelengths of 660 nm. A light-to-voltage optical sensor, TSL250RLF is chosen to measure the light transmitted through the finger. This sensor combines a photodiode and a transimpedance amplifier, producing a voltage output. It has peak spectral responsivity at 750 nm; however, it also produces 100% responsivity at 660 nm.

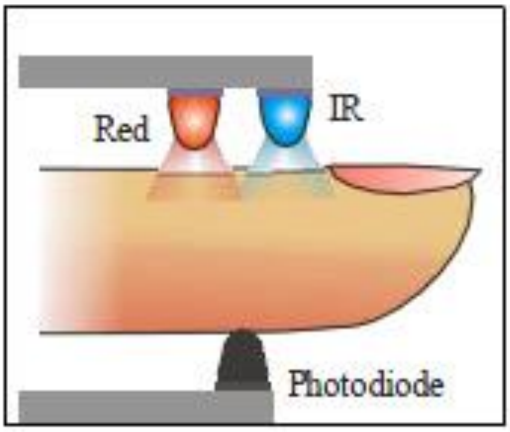

Fig. 9

Signal Conditioning Circuit

The amplitude of the light transmitted varies in the range of micro volts. The frequencies of interest lie within the range of 0.1 Hz to 10 Hz.

The basic block diagram of the PPG signal conditioning circuit is shown in the figure 10 below. All components use 5 V at their positive terminals and the reference voltage andthe voltage at negative terminals is set to 0 V (grounded).

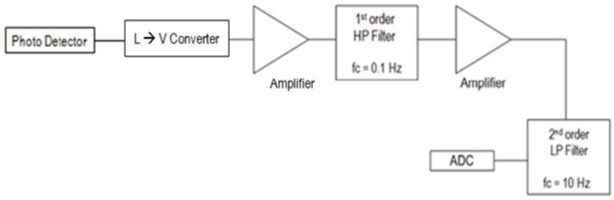

Fig. 10

Through some research, a paper was found where similar analysis of blood pressure was performed and they determined a linear regression that estimated the blood pressure using PWTT. Their final equation was SBP = −0.6881× PWTT + 228.591, where the PWTT is in milliseconds (ms) and SBP is in millimetres of mercury (mmHg). Due to time and resource limitations, the scope of this project did not involve determining this equation. Therefore, for the purposes of this project, this equation is accepted to be a reasonable.

The database that has been made in PC can be linked up with internet so the user can access the data anywhere.

Some recommendations on future work would be to add the fourth vital sign monitor to this system, which is measuring the oxygen level in the blood. This can be achieved through PPG. Adding this last sensing component would make this system a complete vital signs monitor.

In conclusion, with refinements to the design, the Mobile On-Call System .measuring ECG, blood pressure, and body temperature would make a great competitor against other products that currently exist in the market.

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