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CUFFLESS BP MONITORING SYSTEM USING PULSE TRANSIT TIME

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Abstract : The force your heart needs to circulate blood throughout your body is measured by your blood pressure (BP). It is a critical and dependable estimation for ongoing patient monitoring of the patient's cardiac system and personal health. Blood pressure is measured in millimeters of mercury (mmHg), which is also classified as: systolic pressure, which represents the pressure while your heart pumps blood out, and diastolic pressure, which represents the pressure when your heart is at rest in between beats. Stress is known to be the primary cause of many major illnesses, including cardiac disease. For BP measurement, a continuous approach is necessary to solve this issue. There are several methods for measuring blood pressure, including invasive and non-invasive methods. Due to the discontinuity of both of these methods, a non-invasive methodology based on pulse transit time (PTT) has been developed to monitor the most crucial parameter, such as blood pressure. PTT refers to the lag between the R-wave peak of the electrocardiogram (ECG) signal and the rising edge peak of the photoplethysmogram (PPG) signal. In addition to being used to measure pulse wave velocity (PWV), the PTT time difference is also directly applied to the BP-PWV connection to calculate systolic and diastolic blood pressure (SBP/DBP). This technique was created mostly due to the fact that every individual produces electrical impulses of varying intensities. In this research, we get to the conclusion that the motion artefacts caused by the photoplethysmogram sensor can be minimized by ceramic capacitor and obtain accuracy in final output.

IndexTerms - **Photoplethysmogram sensor, Pulse transit time, Systolic blood pressure, Diastolic blood pressure.**

I. INTRODUCTION

For the ongoing monitoring of a patient's cardiac system andpersonal health care, blood pressure (BP) is an essential factor.Stress is known to be the primary cause of many major illnesses,including cardiac disease. A continuous method for measuringblood pressure is needed to solve this issue. Traditional oscillometer or Korotkoff sound-based cuff technologies do notcontinually record blood pressure. These procedures call for thecuff to be inflated and then deflated, which takes time and inhibits continuous measurement. Additionally, there should bea minimum 2-minute gap between readings to ensure accurate measurements. As a result, variations in BP that occur over thecourse of seconds to minutes cannot be found [2].

Numerous researchers came to the conclusion that regular bloodpressure monitoring is necessary for maintaining good health, and this is crucial for older adults who have heart disease or areat high risk of developing it. Blood pressure fluctuates constantly due to physical activity, medication, emotion, and stress. Traditional noninvasive methods to measure blood pressure include stethoscopes and phonocardiograms, among other oscillometer methods. These cuff-based techniques do, however, have some drawbacks that limit their applicability in specific clinical or domestic settings, particularly during a particular physical activity where the cardiac output increases [5]. Cuff-based techniques cannot measure a continuous BP since there must be a delay of at least 1-2 minutes between twoBP measurements in order to reduce measurement errors. The inflation of the cuff may also disrupt the patient, and this disturbance may result in an abrupt rise in blood pressure.

II. RELATED WORK

In this study, He Xiao chu an, et al. [1] explore a less invasive, suited for continuous measurement method toassess arterial blood pressure. The method is based onmeasuring the interval between the peaks of the fingerphotoplethysmogram (PPG) signal and the R-peak of the electrocardiogram (ECG) signal. The MIMIC database, which provides clinical signal data reflecting genuine measurements, was used to extract actual ECG, PPG, and blood pressure values for the article. The simulations studyfound that there is a strong link between arterial blood pressure and the delay (PTT) between the R-peak of the ECG signal and the peaks of the finger PPG signal, which can be utilised as an indicator of arterial blood pressure.

The purpose of this work, according to B. Surendra Goil etal. [2], was to create a continuous non-invasive blood pressure monitoring system employing pulse transit time. The data for this investigation came from the Polykite-D multiparameter monitor at the beginning. After the data wascollected, it was analysed using a MATLAB method to provide filtered ECG and PPG signals. This was just research that using those parameters BP values calculated and it was not built in any hardware but just was a simulation.

Harinderjit Singh et al. [3] developed a cuffless bloodpressure monitoring system based on pulse transit time in 2015. However, in this case, they were unable to reduce themotion artefacts or noise generated by the most sensible sensor, the PPG sensor. As a result, we included a ceramic capacitor in our proposed system so that noise reduction might lower the error % and the device's accuracy.

III. METHODOLOGY

3.1. HARDWARE DESCRIPTION

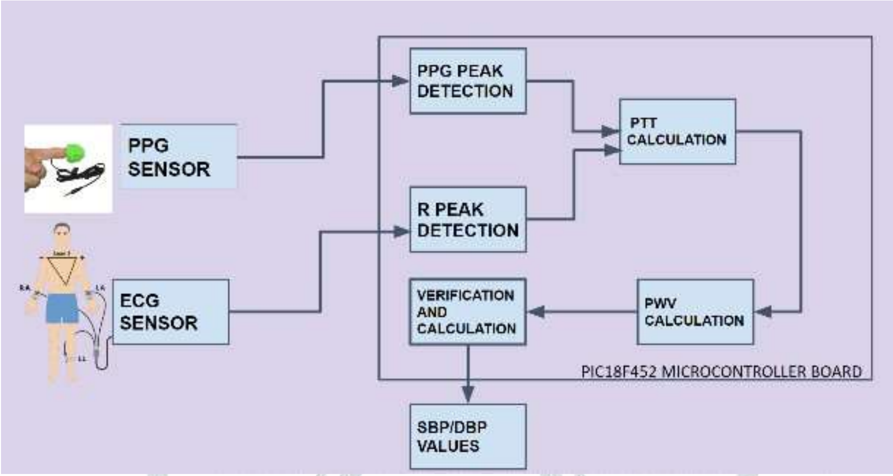

Figure 1: Block diagram of PTT based BP monitoring system

(i) **PIC18F4520 Microcontroller** is an 8-bit, completely static,high-speed microcontroller unit that is low-cost, low-power, and contains 40 pins, of which 36 pins can be used as I/O pins. Additionally, the PIC18F4520 has 4 Interrupts-On-Change (IOC) pins and 3 programmable external interrupts, which are useful capabilities for interrupt-related applications. A 13- channel 10-bit Analog - to - digital converter module is anothercomponent of the system. Its voltage range is 5.5V.

Figure 2: PIC 18F4520 Microcontroller.

(ii) **Echocardiogram Sensor** is the sensor board used to measure the electrical activity of the heart is reasonably priced.An ECG or electrocardiogram can be used to track this electrical activity and produce an analogue reading. Thissensor comeswith 3 lead electrodes such as yellow lead, red lead and green lead these are placed in different position of patient's body such that the heart's electrical activity is then recorded, analysed. The body receives no electrical energy.

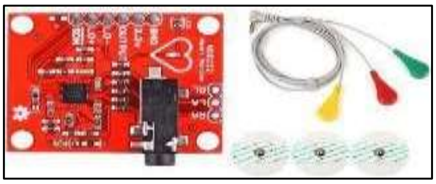

Figure 3: ECG SESOR

(iii) **Photoplethysmogram Sensor** is a sensor which comprisesof a photodiode and the light detector in it such the blood flow from heart to the finger which is placed into the sensor is calculated Figure 4 shown below is PPG sensor, which isinterfaced with the hardware for extracting PPG signal from thefinger of the subject.

Figure 4: Photoplethysmogram Sensor

(iv) **Liquid crystal display (16*2**) A flat-panel display or other electronically manipulated optical device that makes advantageof liquid crystals' light-modulating abilities is known as a liquidcrystal display (LCD).Here in our project we are using LCD to display the BP values such as systolic and diastolic, PTT and even height of the subject.

Figure 5: LCD Display

3.2. SOFTWARE DESCRIPTION

(i) **microC Software** is a compiler which is used as tool for development of PIC Microcontroller. PICKIT 2 is used debugger for PIC programming in our project. This software home page consists a code editor, code explorer, project summery and a error window as shown in the figure 6.

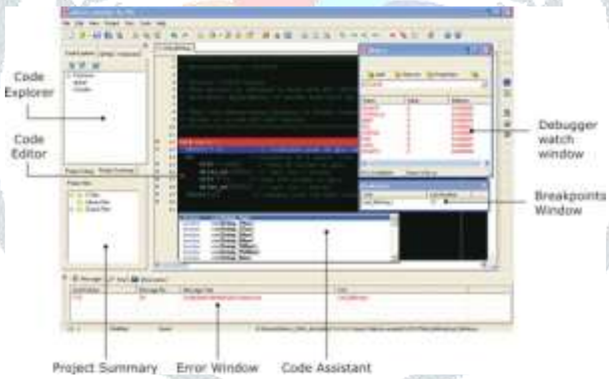

Figure 6: screenshot of home tab from microC application

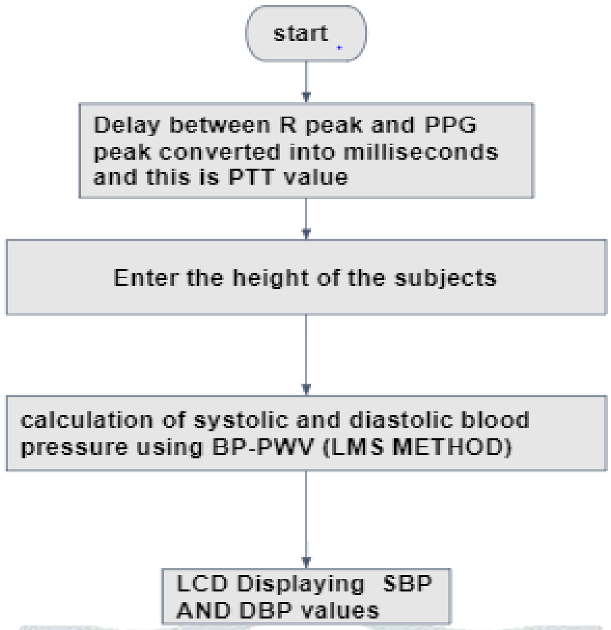

Figure 7: Flow chart of programming part

The flowchart for calculating SBP/DBP, pulse transit time, andpulse wave velocity is shown in Figure 7. The steps in the software programme that calculates blood pressure are as follows:

1) Setting up the equipment after attaching the body's ECGelectrodes.
2) Using a mathematical relationship, this PTT (pulse transittime) is used to determine PWV (pulse wave velocity).
3) Using switches, choose the subject's height.
4) Using BP-PWV to calculate systolic and diastolic bloodpressure (Least Mean Square Method).
5) SBP/DBP and these numbers are shown on the LCD as well.

IV. RESULTS

A. Calculating Pulse Transit Time

The PIC microcontroller's timer is utilised to calculate the PTT between these two peaks. This will wait for the PPG signalonce the timer is ON. When a PPG sensor sends an interrupt signal, the timer stops, and the value is converted to millisecondsso that it may be displayed on the LCD.

B. Equations for calculating Pulse Wave velocity.

$$PWV = \frac{\text{Distance from heart and tip of the finger(D)}}{\text{(Pulse Transit Time (PTT))}} \quad \text{........(1)}$$

Equation 1 highlights the correlation between the PWV and PTT and is used to estimate PWV by applying the direct relationship between velocity and time.

D = Body correlation factor x height of subject (in cm)…...(2)

From many researches it is found the Body correlation factor (BCF) is constant for all adutls i.e.,0.6.

C. Equations for calculating Blood pressure values.

After getting PWV and PTT values and height of each subject we use the following equations (3) and (4) for calculating systolic and diastolic BP values as shown in figure 9.

Systolic Blood Pressure=a (sys) X PWV+ b (sys)…………(3)

Diastolic Blood Pressure = a (dia) X PWV+ b (dia)…..…. (4)

D. Calibration.

In our project we use machine learning algorithm for the calibration purpose since it is a real time monitoring system wedidn't go for any database or datasets for calibration but we tooksome samples of subjects around age 19-22(15 subjects)and35-44(15 subjects) such that we used mean least square algorithmin MATLAB to obtain accuracy in getting the finals values i.e.,SBP and DBP below screenshot shows the calibration done using MATLAB and the table shows the PTT value ,height andPWV values and figure 10 shows final values displaying on LCD.

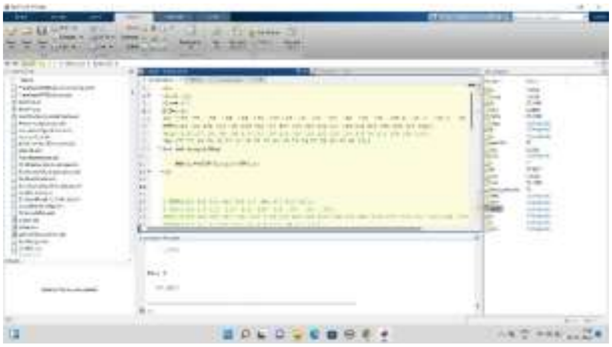

Figure8: screenshot of MATLAB programming

Table 1: samples collected during calibration

SUBJECTS	AGE/GENDER	HEIGHT(cm)	PTT(ms)	PWV(cm/sec)
1	F	158	152	623
2	F	173	143	725
3	M	155	121	768
4	F	164	128	769
5	M	158	180	526
6	F	125	223	336

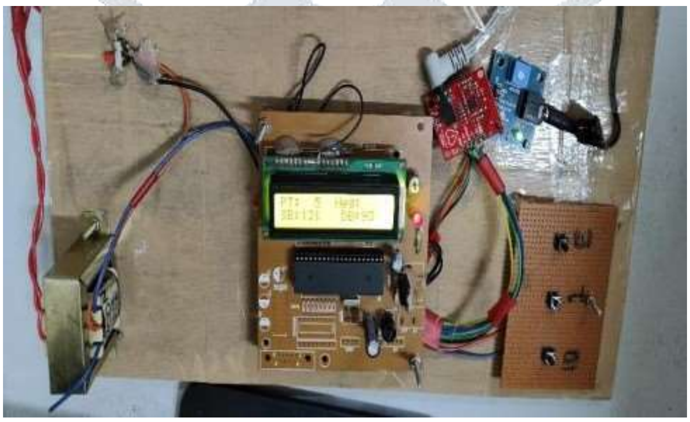

Figure 9 : Shows the top view of the project

Figure 10: LCD displaying final values.

V. Conclusion

The goal of our project is to design and build a pulse transittime-based cuffless blood pressure monitoring system. Although there are numerous methods for monitoring blood pressure, nodevices were developed using such a prototype. Although we have wearable smart devices, their accuracy is lacking. Since blood pressure (BP) is such a sensitive measurement that it changes with position, time, temperature, and many other factorsevery single second.

A recording of data or previous measurements can be madewith this device, which can then be created as a small portable gadget. This data can then be communicated to nearby doctorsfor additional treatment. The potential for this prototype's evolution is limitless because there are so many potential futuredevelopments.

VI. References

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