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A Study of High Performance Pulse Analysis System for ASP based Applications

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ABSTRACT: Pulse measurement is an effective way of checking the heart condition of human being. There are different places where the pulse rate of a person can be measured. There are different kind of pulse rate measurement devices are currently in use at different places. These devices consists of different sensors depends on the application, cost and size of the device. Piezoelectric sensor is used to generate charge corresponding to the pressure applied on it. So, placing a sensor against the radial artery can be useful in generating proper signals to detect and measure the pulse rate.

KEYWORDS: Pulse Detection, Piezoelectric Sensor, Pulse rate meter, Pulse Detectors.

I.INTRODUCTION

Pulse detection is a way to check the health condition of a living being because it gives the information about a person's heart whether it is working properly or not. And also it is very easy to learn how to check the pulse.

By checking the pulse one can get the following information:

- How fast the heart is beating. This is measured in beats per minute (bpm).
- The rhythm of the heartbeat.
- The strength of the heartbeat. An uneven rhythm or a weak pulse may be a sign of a problem.

And measuring the pulse rate:

- Gives clues about how well the heart is working, and if it is healthy or not.
- Is used to check the health and fitness level.
- Can tell if a person is exercising too hard or not hard enough.

When heart beats and forces blood through the body, one can feel a throbbing (pulse) at any point where an artery comes close to the surface of the skin. One can measure the pulse at any of these points. Examples include the wrist, neck, temple area, groin, behind the knee, or top of the foot. Most people use the wrist or neck. And the pulse rate can be measured by counting the beats for a set period of time.It is very easy as one just have to place the index and middle finger on the underside of the wrist, below the base of the thumb. Another place to measure the pulse is just to the side of the Adam's apple, in the soft area at the side of the neck [1-3].

With the flat part of the fingers (but not the tips), pressed firmly. It is not necessary to push so hard that one cannot feel the pulse. If a person is taking someone else's pulse, then it is necessary not to use the thumb. Because then the first person will feel his own pulse along with the other person's pulse.Count the number of beats for 30 seconds; then multiply that number by 2 to get the beats per minute. If you are taking your pulse during exercise, you may count the beats for only 10 seconds and multiply by 6 [4].

Electronic pulse meters [4] (heart rate monitors) are designed to measure how fast the heart is beating automatically. They send a signal from the finger, wrist, or chest. They are useful if one is having trouble measuring the pulse or if anyone wants to check the pulse during exercise without stopping.These pulse meters work on the measurement obtained by the pulse sensors such as IR sensors, piezoelectric sensors etc. IR sensors are used to detect the change in

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light passing through the blood flowing through arteries. On the other hand, the piezoelectric sensor is based on the strain produced by the pumping of blood through arteries [5].

II.SENSORS USED FOR PULSE DETECTION

There are different types of sensors are used for detecting the human body pulse. The use of different type of sensors depend on designer as each sensor has its own advantage and disadvantage for pulse detection. Different types of sensors are IR sensor, piezo-resistive sensors and piezoelectric sensors.

IR Sensor:

IR sensor is easy available and cheap that's why it is preferred among the home made projects for pulse detection and measurement. It depends on the flow of the blood through arteries and detects the light passing through the blood when it pumps through the heart. It is used to detect the pulse on the finger tips. It is easy to implement as it doesn't require any kind of amplifier circuit but the circuit formed by the use of IR sensor can be large that's why it is not preferred where the size of the system matters [6].

Piezo-resistive and piezoelectric Sensor:

Besides the above sensor, piezo-resistive and piezoelectric were tried for human pulse detection. While using strain gauge transducer, waveform was noisy and there was dc shift due to the holding pressure and the shift varied as the holding pressure changed. Secondly, the strain gauge requires a power source for its operation. Piezoelectric transducer has good dynamic response, it does not show dc shift because of holding pressure and is an active transducer. Therefore, piezoelectric transducer was used for human pulse detection and the detected human pulse was processed through signal processing circuit.

The pulse signals obtained from the piezoelectric sensor were processed through signal processing circuitry. The signal processing circuit consists of signal amplifier, filters, and noise-reduction circuit. Therefore, the system designed using piezoelectric sensor for pulse detection is expensive than the IR sensor pulse detector system. The piezoelectric sensor based pulse detector can be used on different places of the human body [7-10].

III.PIEZOELECTRIC SENSOR BASED PULSE DETECTORS

Human pulse is detected on the radial artery. Piezoelectric transducer is used for detecting the human pulse. When the pressure is applied on the wrist, two components of pressure are present: Static and Dynamic component. This sensor is required to be placed on the skin against the radial artery which exerts continuous pressure due to pumping of blood. The advantage of this sensor is that it detects the dynamic pulse pressure and rejects the static pulse pressure operating on it. The signals produced due to the pressure of the pulse is in the range of mV therefore it has to be amplified to get the proper output. To obtain this, the signals obtained should pass through a processing circuit. The processing circuit consists of sub-circuits like buffer amplifier, low-pass filter, signal amplifier, and noise-reduction circuit. Position of the sensor on the wrist is to be adjusted to obtain appropriate pulse signal. The output of the system can be observed on the oscilloscope [11].

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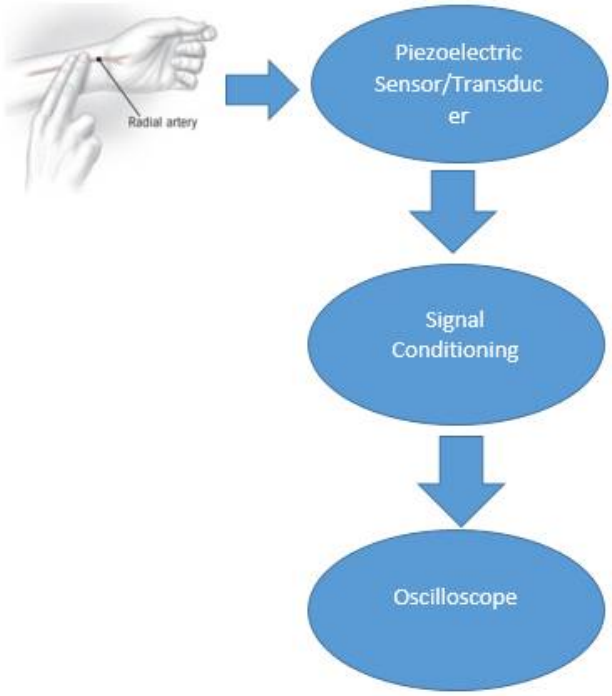

Fig.1. Piezoelectric sensor based pulse detector [12]

IV.COMPONENTS OF PIEZOELECTRIC SENSOR BASED PULSE DETECTOR

Pulse sensor:
A piezoelectric material cannot be identical, or isotropic in all possible directions. If the material is symmetric there would be no electric polarization effect. The figure comprises three different materials. The material used in a) is isotropic and yields no resultant electric polarization when a force is applied. The materials used in b) and c) yield perpendicular and parallel polarization effects respectively for an applied force.

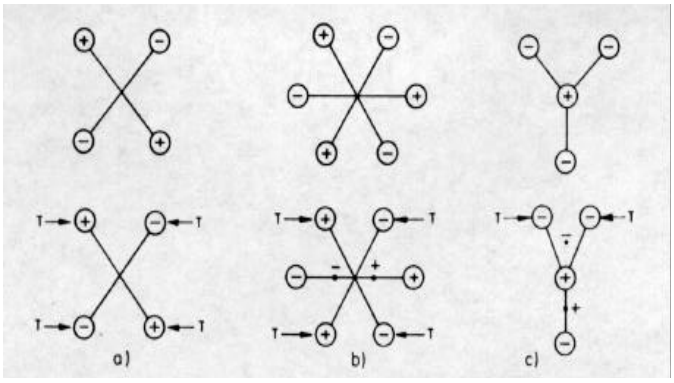

Fig. 2. Material Polariation with stress [14]

If you apply pressure on certain crystals, the crystal molecules will re-align and produce a charge across the crystal. A charge can be treated as a voltage. A piezoelectric crystal is like a capacitor that is pressure-sensitive.

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Therefore: Pressure → Crystal → Voltage

Of the natural piezoelectric materials, the most frequently used are quartz and tourmaline. When pressure (stress) is applied to the piezoelectric material it creates a strain or deformation in the material. This strain creates an electrical potential difference, a voltage. The effect is reversible. When an electric potential is applied across two sides of a piezoelectric material, it strains. Both effects were discovered by Jacques and Pierre Curie in 1880. This sensor produces a high current pulse signal when pressure is applied. The piezoelectric sensor (lead zirconatetitanate) was used for human pulse detection because it has good dynamic response. The piezoelectric elements act in the thickness compression mode and transforms changes in skin contact stress into an electric charge. This voltage signal is in the range of mV.

FET input buffer:
The piezoelectric sensor is used for charge generation. It is necessary to set a cutoff frequency for removing very low frequency signals of pulse. So, a resistance of desired value is connected as load.Piezoelectric sensor has high output impedance therefore it is necessary to connect the output of the sensor by an input buffer as it converts the high output impedance of the sensor into low impedance [15].

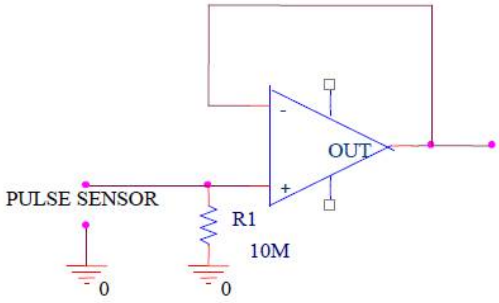

Fig. 3. FET input buffer[16]

Low-pass filter and amplifier:
The output obtained from the buffer consists of some desired as well as some indesired signals. It is required to produce output depend on the signal obtained by the pulse not on the external pressures generated by the movement of the body. So, a low pass filter is connected to the output of the buffer to neglect the high frequency signals of obtained due to body movements. The low-pass filter is designed at the cutoff frequency desired calculated by the following equation and has a gain Rf /R2 which almost equals to 100Hz.

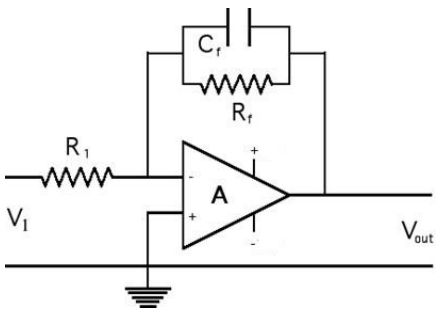

Fig. 4. Low-pass filter and amplifier [16]

Notch filter:
The signals obtained are weak and therefore are susceptible to various noise sources. The information content in the pulse signal is approximately within the 0.1 Hz to 100 Hz frequency band. In this band, the most dominating disturbance is effect of the main ac power supply. The frequency of the ac power supply was 50 Hz (60 Hz within the

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US). Hence, a narrow-band suppress filter was used to suppress the 50 Hz frequency. This could be achieved using an R-C network followed by a 741 buffer.

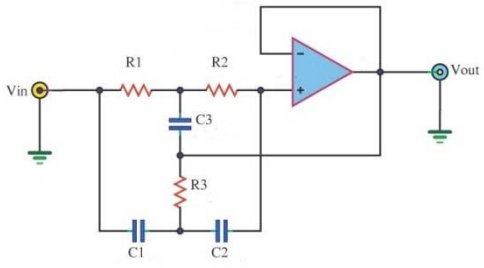

Fig. 5. Notch Filter [16]

V. RESULT AND DISCUSSION

The pulse detection by using the piezoelectric sensor is a difficult task as the signal obtained by the sensor is very weak. So, an additional circuitry is connected to the output of the sensor to create an appropriate result. That's why the circuit of the detector become more complex as well as expensive. But it is an idea to generate the waveform from the pulse pressure. The output of the detector can be observed on an oscilloscope which shows the pulse waveforms. The accuracy of the pulse detected by the piezoelectric sensor based detector can be check by comparing the output waveforms from the standard pulse waveforms.

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