International Journal of Global Engineering (IJGE) E- ISSN: 2456-3099

VOL 3 ISSUE 2 (2018) PAGES 120 - 128

Received: 11/10/2018. Published: 25/10/2018

CONVENTIONAL BLOOD PRESSURE MONITORING SYSTEM USING RISC MICROCONTROLLER

1. K.Saravanan, 2. S.Yamini Priya , 3. A.Rajan, 4. J.Kaliappan
Department of Electronics and Communication Engineering
Dhanalakshmi Srinivasan College of Engineering

ABSTRACT

A more efficient newer algorithm of detecting systolic and diastolic pressure of human body along with a complete package of an effective user-friendly embedded programmable blood pressure monitoring system has been proposed in this paper to reduce the overall workload of medical personals as well as to monitor patient's condition more conveniently and accurately. Available devices for measuring blood pressure have some problems and limitations in case of both analog and digital devices. The sphygmomanometer, being analog device, is still being used widely because of its reliability and accuracy over digital ones. But it requires a skilled person to measure the blood pressure and obviously not being automated as well as time consuming. Our proposed system being a microcontroller based embedded system has the advantages of the available digital blood pressure machines along with a much improved form and has higher accuracy at the same time. This system can also be interfaced with computer through serial port/USB to publish the measured blood pressure data on the LAN or internet. The device can be programmed to determine the patient's blood pressure after each certain interval of time in a graphical form. To sense the pressure of human body, a pressure to voltage transducer is used along with a cuff in our system. During the blood pressure measurement cycle, the output voltage of the transducer is taken by the built-in ADC of microcontroller after an amplifier stage. The recorded data are then processed and analyzed using the effective software routine to determine the blood pressure of the person under test. Our proposed system is thus expected to certainly enhance the existing blood pressure monitoring system by providing accuracy, time efficiency, user-friendliness and at last but not the least the 'better way of monitoring patient's blood pressure under critical care' all together at the same time.

Keywords: Blood Pressure, Systolic Pressure, Diastolic Pressure, Cuff Pressure, Pressure Transducer, Embedded System, Amplifier, ADC, Microcontroller.

Blood pressure in human body is essential to maintain the blood supply and function of vital organs properly. Measurement of accurate blood pressure is therefore a key part of the monitoring of patients during anesthesia and critical care. However, in everywhere, measurement of blood pressure is one of the routine procedures of patient examination in clinical practice. In case of Hospitals, it is getting tough day by day to measure Blood Pressure of a huge number of patients within a limited time period and simultaneously keep daily record of it. So with the advancement of science & technology, now-a-days Digital method of measurement and recording of blood pressure is taking place of the traditional one. Although at present, some cuff-based electronic digital blood pressure meters (DBPMs) are available in the market, but these meters care not much reliable as they do not give correct readings always.

The objective of this paper presents that this new technique based embedded device has better accuracy than the available DBPMs, it is programmable for measuring blood pressure periodically by specifying the certain interval of time, it will reduce workload of medical personals and will help to keep flawless & regular data of patient's progress, moreover systole- diastole data can be stored to show graphically for later use. The doctor sitting in his chamber can monitor the patient's blood pressure in a regular interval without going to the patient's bed physically.

SYSTEM DESCRIPTION

The block diagram of an Embedded Programmable Web-Based Blood Pressure Monitoring System is shown in figure 1. The hardware of the Embedded Programmable Blood Pressure Monitoring System has been interfaced with the Microcontroller through Amplifier part. The output voltage of the pressure transducer is not zero at zero pressure input due to some offset voltage and also the output voltage is in the order of mV which can't be used satisfactory while interfacing to the ADC of microcontroller. Thus an instrumentation amplifier stage has been used to produce output voltage from 0 to 5 volt range which also does cancel the offset voltage mentioned due to its internal difference amplifier mode. The software routine run from the microcontroller controls the pressure inside the cuff through control circuit.

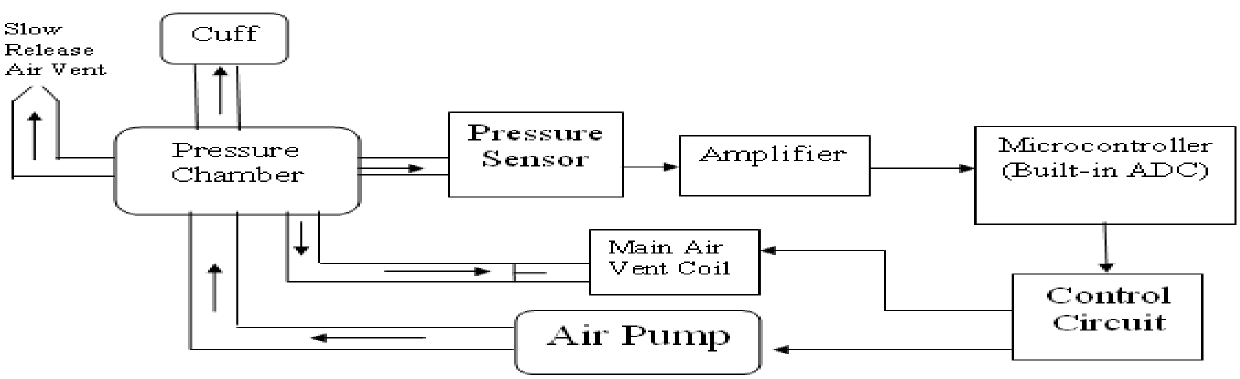


Fig. 1: Block diagram of the whole system

The pressure chamber shown in figure 1 has four outlets and one inlet. One of the outlets is connected to the cuff, one to the pressure to voltage transducer, one to the main air-vent, and another to the slow release air-vent. The slow release air vent is always kept open. The only inlet comes from the air pump to give air pressure to the chamber to ultimately pass to the cuff. The key component of the system is the pressure to voltage transducer or the pressure sensor which is very sensitive to a small change of input biasing voltage. Hence a variable 10-16V high quality (almost ripple free) dc power supply has been used for biasing of the

International Journal of Global Engineering (IJGE) E- ISSN: 2456-3099

VOL 3 ISSUE 2 (2018) PAGES 120 - 128

Received: 11/10/2018. Published: 25/10/2018

pressure to voltage transducer. An instrumentation amplifier stage, with an overall voltage gain of almost 70 is used to collect the data by internal ADC of the microcontroller. The output voltage of the transducer is proportional to the pressure input and is calculated accordingly from the given relationship between voltage and pressure from the datasheet of the transducer.

1.1 ANALYSIS OF COLLECTED DATA

The collected data from pressure sensor's output are plotted in a graph as shown in figure 2, where x-axis contains the sample number and y-axis contains the voltage corresponding to pressure. When the pressure in the cuff is above the systolic blood pressure, this pressure compresses the artery against the underlying bone and shuts off the flow of blood in the vesse*l.* At the beginning of the pressure release, cuff pressure is greater than the arterial blood pressure. As air is gradually released from the cuff, the pressure in the cuff becomes closer to that in blood. At some point, the cuff exhibits the first impulse that corresponds to the first pulsatile flow of blood through the blood vessel as soon as the cuff pressure becomes just lower than the arterial blood pressure, since the obstruction caused by the high cuff pressure is suddenly removed.

The point of systole lies close to that point, where the first pulse appears. Thus, appearance of the first pulse can determine the point of systole. Then as the cuff pressure is further reduced, the peaks of the pulses corresponding to each heartbeat are increased. Ideally, it should go on to show increasing peaks and when the blood flow through the "brachial artery" becomes free, it would show regular heart beat patterns of the same amplitude.

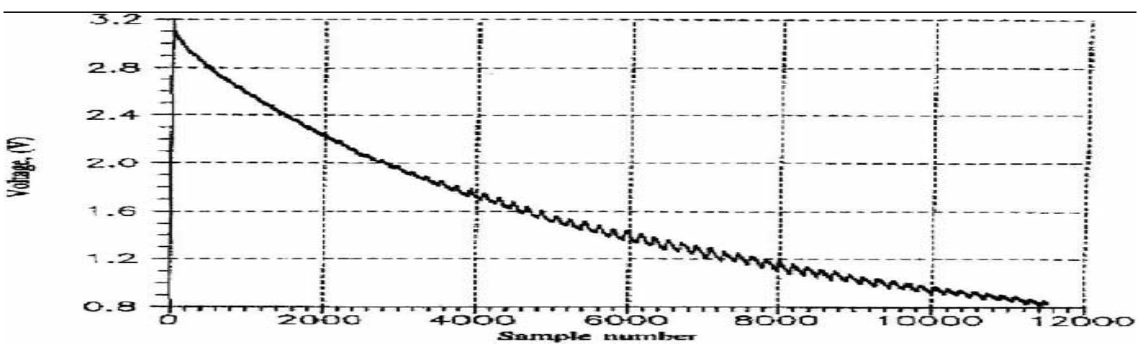


Fig. 2: Output voltage of the pressure to voltage transducer versus sample number However, as the pressure is gradually reduced in the cuff, the impact of the pulse to the air inside the cuff becomes less predominant than it should have been, due to less air-pressure in the cuff and less pressurized contact with the cuff at the arm. Therefore, the pulses are again reduced in amplitude as the pressure gradually falls. Ideally, pulse amplitude should be considered as the difference between the peak of the pulse and the average value of the two minima values at both sides of the peak.

International Journal of Global Engineering (IJGE) E- ISSN: 2456-3099
VOL 3 ISSUE 2 (2018) PAGES 120 - 128
Received: 11/10/2018. Published: 25/10/2018

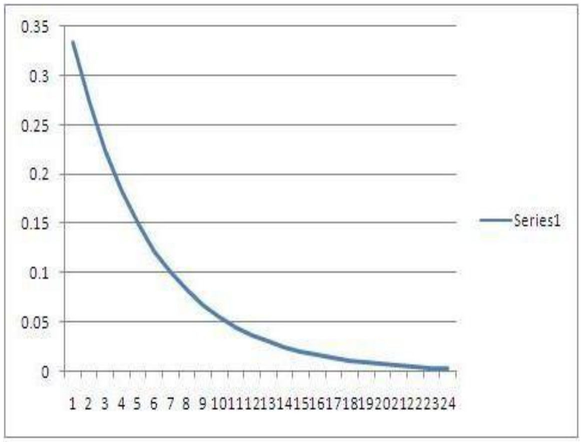


Fig. 3: Release of cuff pressure decays exponentially if there was no blood pressure.

3.1 Technique of detecting systole & diastole

Now if we observe the curve very closely we can see that the pulse shape is distorted which is due to noise. So our challenge is to take out the real shape of the pulse to detect systole, diastole. We can divide above graph into three parts: i) Exponentially decaying curve ii) Pressure curve due to heartbeat iii) Noise

3.1.1 Exponentially decaying curve

Whenever we release the pressure of cuff, the pressure inside the cuff decays exponentially. If there was no effect of anything then it would go to zero without distortion as shown in figure 3.

3.1.2 Pressure curve due to heartbeat

The heartbeat distorts the exponential curve. The heartbeat curve is shown on figure 4

3.1.3 Noise

Noise curve is shown in figure 5.

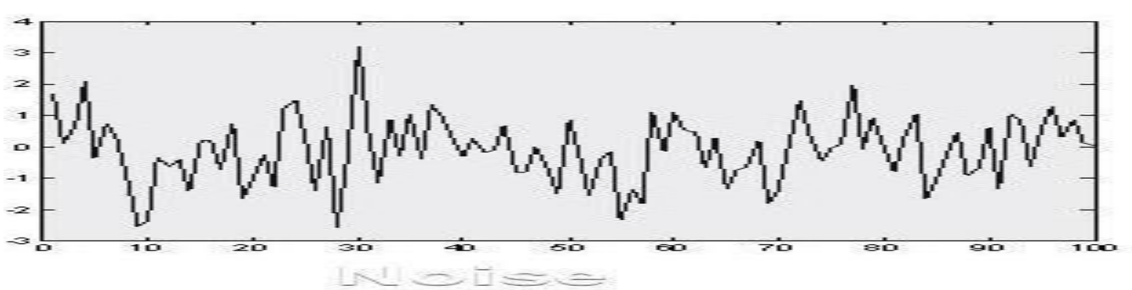


Fig. 5: Noise

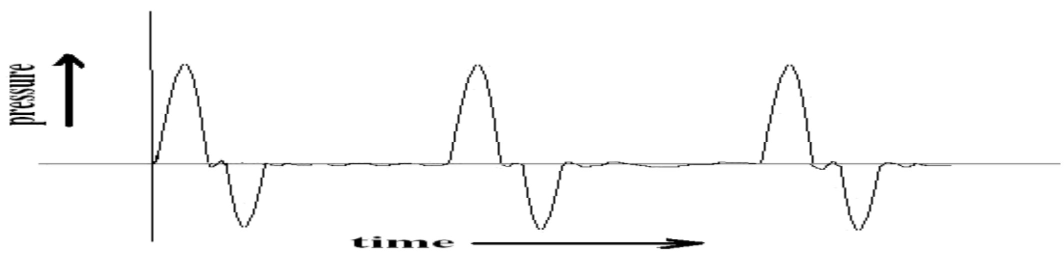
3.2 Detecting systole & diastole points from graph

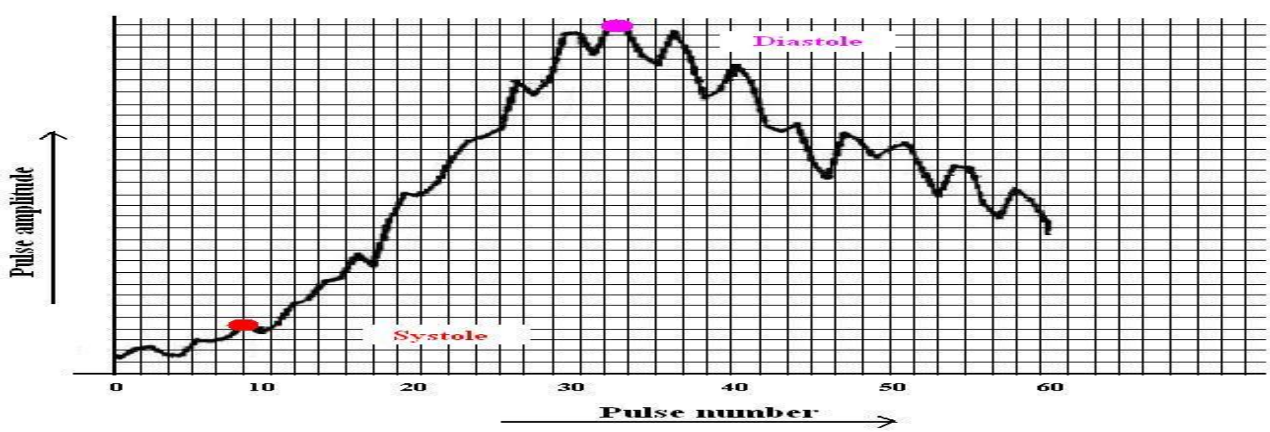
International Journal of Global Engineering (IJGE) E- ISSN: 2456-3099
VOL 3 ISSUE 2 (2018) PAGES 120 - 128
Received: 11/10/2018. Published: 25/10/2018

We have to keep increasing pressure inside the cuff up to the cuff pressure goes above the systole pressure. So then the artery will be closed. No blood will be able to flow. Now we will start to release the pressure. So whenever the pressure of cuff comes just below the systole, there will be a flow in blood. Because at that time the heart gives pressure more than the cuff pressure. So we can say pressure at this point is the maximum pressure the heart can give. That means it is the systolic

pressure. Now as much we will be decreasing the cuff pressure, the pick height will be more. After a certain biggest pick value, it will be decreasing. The point where we will get the biggest peak is the diastole point.

What we have done is just elimination of exponential curve from the main curve. Then we detected the point where the pulse started that means the point where we got the first non-zero value. The pressure at that point is systole. Then we found out the highest value. The pressure at that point is diastole. After elimination the exponential curve becomes look like figure 6:





Read Data from ADC
Find the **Slope** of Pressure Release Curve (*Decreasing Exponential Curve*) Calculate the **Upcoming Expected Value** from the Slope
Compare the Expected Value with the Actual ADC Value
If Actual ADC Value > Expected Value
Then Systolic = Actual ADC value
Send Systolic to PC through **Serial Comm**.

End

(Detecting Diastolic Pressure)

Else Declare a Variable named **'Max'** with Zero Initial Value
Find the **Difference** between Actual & Expected Value & Store it on **'Diff'** Variable

If Max > Diff
Then Keep Max Unchanged (Max = Max)
Else Max = Diff Diastolic = Diff
End

End

HARDWARE DESCRIPTION

The hardware circuits include: ATmega8 microcontroller, Pressure Sensor, Amplifier Stage, PC interfacing by Serial Comm. Port, Motor Interfacing with MC, Program Loader circuit (ISP adapter), Power Supply, etc. and some other related components.

4.1 Microcontroller (ATmega8)

The ATmega8 is a high performance low-power CMOS 8-bit microcontroller based on the AVR RISC architecture. We decided to use ATMega8 as it is one of the simplest low cost mc having maximum features including the 10-bit resolution built-in ADC feature which is needed in our system for converting pressure sensor analog voltage output into digital input data for processing inside the mc.

4.2 Pressure sensor

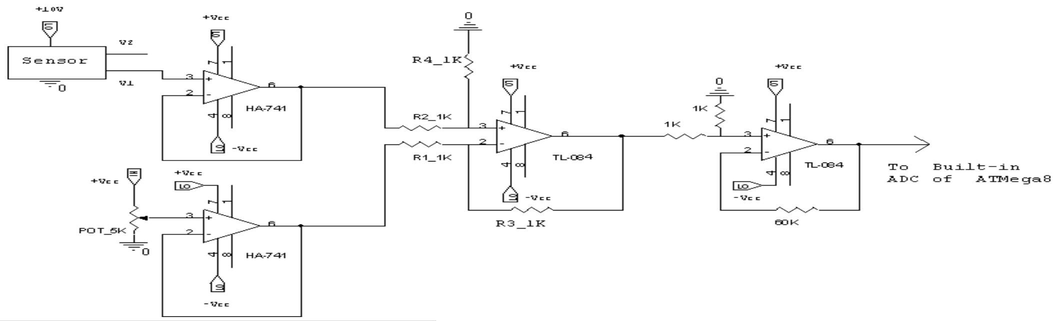
We use 26 pc series pressure sensor. It is a lowest priced sensor with temperature compensation & calibration, having a typical span of 40 mV and supply range from 10 to 16 V dc.

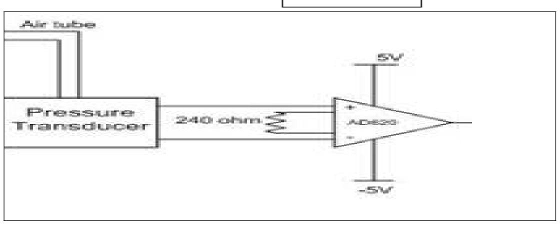
4.3 Amplifier stage

The amplifier stage between sensor and mc is shown in figure 7. The main feature of this stage is that we need to make the output voltage of sensor as zero at zero input pressure. Since there is always an offset at the output of sensor, so we have to compensate that offset by arrangement of op-amps. Again for the analysis of data after ADC conversion significantly, we need to amplify the output voltage of sensor after compensating the offset. If we would not amplify, then difference between different pressure inputs will not be significant to analyze.

International Journal of Global Engineering (IJGE) E- ISSN: 2456-3099
VOL 3 ISSUE 2 (2018) PAGES 120 - 128
Received: 11/10/2018. Published: 25/10/2018

4.4 Serial communication with PC:





We have used max232 to interfaced with PC for make the system web-based. Using Hyper-terminal of windows we get the blood pressure data of different time interval.

Fig. 7: Amplifier interface between sensor & MC

4.5 Motor interfacing:

We use dc motor for pumping to the handcuff which gets command from mc through ULN2003 interfacing circuit.

4.6 Program loader:

We use parallel port to load the program from PC through 74HC125 buffer IC.

4.7 Power supply

We have to use different levels of dc voltages for energizing motor (5V dc), control circuit (5V dc), air-vent solenoid (6V dc), op-amp (+12V, -12V) & pressure sensor (10-16 V dc)biasing. So we made our own power supply in a small PCB board using different types of IC such as LM317, 7805, 7806, 7812.

4.8 4.8 FURTHER IMPROVEMENT OF THE SYSTEM

Due to low offset op-amps and external noise, the output from pressure sensor gets distorted. For the solution of this problem, the choice of high precision op-amp and use of an active low pass filter are needed.

International Journal of Global Engineering (IJGE) E- ISSN: 2456-3099
VOL 3 ISSUE 2 (2018) PAGES 120 - 128
Received: 11/10/2018. Published: 25/10/2018

5.1 Choice of Op-Amp:

We have to use AD620 IC for the instrumentation amplifier part which is high precision, low noise, low offset, low power op-amp. It requires only one external resistor to set a gain of 1-10000 as per required. The application of AD620 as an instrumentation amplifier is shown in figure 8.

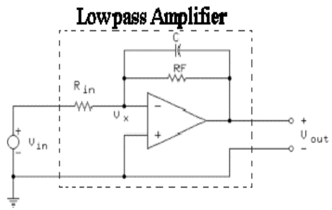


Fig. 8: Application of AD620

5.2 Use of active low pass filter

To eliminate external noise having higher frequency components, we need to use an active low pass filter (figure 9) after the AD620 circuit. For selection of the higher cut-off frequency of this LPF, we analyze the pulse rate of the human body. Since the heart beats 72

Fig. 9: Practical active low pass filter

times per minute on an average (i.e. 1.2 Hz) so we take signal up to its tenth harmonic (i.e. 12 Hz) which is enough to be reconstructed. Then according to Nyquist Sampling Theory, we take almost twice of that frequency,
i.e. 25 Hz as higher cut-off frequency. The corresponding circuit is shown in figure 10. For fH = 25 Hz, if C = 0.1 uF, then RF = 80 K.

CONCLUSION

In this presented work, a new effective technique of detecting the systolic and diastolic pressure point has been proposed with our algorithm. The developed embedded programmable blood pressure monitoring system is low cost since we make it locally. This system certainly add pace in monitoring of patient's blood pressure. The patient in ICU needs to be monitored time by time in a regular interval which can be possible by setting certain interval time as per required by the doctors. Again the doctor can have a look at his PC to check the blood pressure whether it is normal or not as it can be interfaced by LAN network as well. The filtering method used in this system are of both external and software filtering.

The hardware filtering can be improved by providing low noise op-amps. The whole system can be further minimized by replacing the power supply unit with proper dc batteries. We can also use Ethernet chip to make the BP data available in a network system. There is certainly a lot of prospect of this system if it can be manufactured for mass production and make it available in the market. We could have also measured the pulse rate and body temperature of the patient along with his BP by introducing a small change in the algorithm for pulse rate and using a temperature sensor for measuring the body temperature of the patient

REFERENCES

1. M. S. Rahman; R. Parveen; K. H. Kabir, "The technique of detecting systolic and diastolic pressure from the transducer output of a PC-based blood pressure monitoring system" Published on: 24 September 2007
2. B.H. Brown and R.H. Smallwood, Medical Physics and Physiological Measurement, England: Blackwell Scientific Publications, 1981.
3. J.J. Carr and J.M. Brown, Introduction to Biomedical Equipment Technology, New York: John Wiley & Sons Inc., 1981, pp. 6–21, 42–54, 82–109, 129, 282–299, 385–398.
4. P.A. Lynn and W. Fuerst, Introductory Digital Signal Processing with Computer Applications, New York: John Wiley & Sons, 1989, pp. 3–7.
5. R. Parveen, "Development of a PC-based blood pressure and pulse rate monitoring system", M. Sc. Engineering Thesis, Bangladesh University of Engineering and Technology, August 1997.
6. R. Parveen and M.S. Rahman, "Design and implementation of a digital blood pressure meter using the personal computer (PC) interfacing technique", J. Phys. Med., XIII(Supplement 1), pp. 333–338, 1997.
7. M.S. Rahman, "An investigation into spectral analysis using a chirp signal matched filter", PhD Thesis, University of Manchester, 1992, pp. 337–340.
8. J.G. Webstar, Medical Instrumentation Application and Design, 3rd ed., New York: John Wiley & Sons, Inc., 2003, pp. 354–40.