Foetal Health Monitoring System

[1]Sneha M, [1]Sowmya S,
[1]2nd year B.Tech IT,
Sri Krishna College of Technology, Coimbatore

Abstract*-Health monitoring of pregnant women is essential throughout the entire course of pregnancy to ensure proper growth of foetus. In gynecology centers and hospitals some special instruments are used to monitor the health conditions of mother and foetus. In practice, hospital based monitoring system is employed where the pregnant ladies move to the concerned centre to monitor their health. It becomes complex for them to travel and wait for long hours. To overcome this issue an instrument which is used to monitor the important parameters such as ECG (Electro cardio gram), respiration rate, heart rate and rate of dehydration is designed. All the parameters can be monitored on the computer screen which is IoT(Internet of Things) enabled so that the doctor can monitor these parameters as and when the patient uses the instrument kept at her home by fixing an appointment with the doctor. This technology has a desired impact on industrial and hospital automation. The hardware of this project is built on a printed circuit board, constituting PIC micro controller 16F877A. It is a versatile micro controller with in-built features such as 10 bit multi-channel ADC, USART, synchronous serial port, programmable low Voltage detection circuit etc., which is to be interfaced to PC system through RS232C. The software can be easily modified for any alarm setting or record intervals since it is written in Visual Basic.

I. INTRODUCTION

A normal pregnancy lasts nine months. Each three-month period of pregnancy is called a trimester. During each trimester, the foetus grows and develops. There are specific prenatal tests to monitor both the mother's health and foetal health during each trimester. With modern technology, health professionals can

a) Detect birth defects.
b) Identify problems that may affect childbirth.
c) Correct some kinds of foetal problems before the baby is born.

Biophysical tests are conducted using ultrasound. Ultrasound is done every trimester, so it is enough if the patient visits the hospital every trimester that is once in three months. Other than that it is mandatory for the patient to go for a monthly health checkup which includes checking up of respiration rate, heart rate and ECG (Electro Cardio Gram) of both mother and foetus. These tests can be done easily at home by the proposed instrument and the details can either be monitored by doctor through IoT or the logged data can be sent to the doctor. It is mandatory that the patient should not look into the computer while the procedure takes place because the mental variations might affect the results of heart rate and respiration rate. Using IoT also aids this problem because when the doctor is ready to monitor the patient, IoT is enabled and the screen on the patient's side goes blank. The doctor alone will be able to monitor the patient so the tension of getting the accurate result on the patient's side is relieved.

II. BACKGROUND

Foetal monitoring is the procedure used to assess the rate and rhythm of the foetal heart and determine the foetus's health. It is generally recommended during late pregnancy and labour. The average heart rate of the foetus lies between 110 and 160 beats per minute, which can vary up to 5-25 beats per minute. The heart rate may vary as the foetus responds to the uterine conditions, but an abnormal pattern may indicate problems such as the lack of oxygen supplied to the foetus.

The foetal heart can be monitored by two methods:

External monitoring: uses the placement of the device on the mothers' abdomen so that the foetal heartbeat can be heard and recorded. External monitoring can be done to:

a) Track the baby's heart rate during rest and movement
b) Measure the frequency and duration of contractions during labour and delivery
c) Detect premature labour
d) Monitor the baby's health if certain problems are suspected
e) Monitor the placenta (membrane lining the womb and enveloping the foetus) and ensure that the baby gets enough oxygen
f) Monitor for delayed foetal growth, if you have hypertension, diabetes or you have been pregnant for more than 41 weeks

Internal monitoring: Foetal heart rate is monitored by placing an electronic device directly on the scalp of the foetus. Internal monitoring can be done to:

a) Determine if the baby can be harmed due to stress during labour.
b) Measure the duration and strength of labour contractions.

The drawbacks found in existing system are given as follows:

a) Difficulties due to long distance travelling.
b) Mmmmmmn n hours of waiting can occur at times.
c) Chances of miscarriage.
d) Missing up of scheduled dates due to some emergency.

The proposed system to overcome the drawbacks encountered in the existing system is given as follows:

a) To overcome the above issues we would like to propose an instrument which gives perfect ECG of the mother and foetus.

b) Apart from ECG, respiration, heart rate and much more can be monitored on computer screen and same can be transmitted to gynecologist for opinion.

c) The data obtained is sent through IOT.

Advantages of the proposed system are given below:

a) Low cost.
b) Simultaneous monitoring.
c) High speed extraction.
d) Built in simulator for self test.
e) Computer interface.
f) Can be networked.

III SYSTEM DESCRIPTION

Initially the computer is IOT enabled. The pregnant women's parameters are measured and sent to the doctor through IOT. The measured parameters are stored in the patient's computer in a database format. Each patient has an unique IP address which is stored in the doctors database for identification and communication purpose. It is necessary for the pregnant ladies to undergo regular heart rate and respiratory checkup in order to observe the health of the foetus and also that of mother's. Hence, they need to visit hospitals often. This is not easy and safe since they are subjected to a lot of discomforts during travel. Our proposed system is expected to monitor the various parameters of both mother and foetus only by measuring the mother's parameters and segregating the foetus' parameters. This is feasible since this can be done at home itself.

A. RESPIRATION RATE

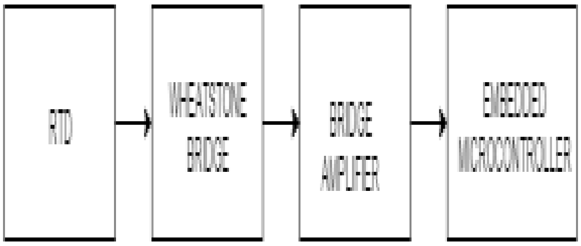


Fig.1 Block diagram for respiration rate module

A mask is placed over the mother's nasal area and the change in temperature while she breathes is given to the RTD. The change in the resistance which is in order of ohms is given as the unknown resistance to the Wheatstone Bridge Network (Kirchhoff's second law). The output of the bridge circuit is given to the bridge amplifier provided with the signal conditioner whose output (0-5) V is given to the embedded microcontroller.

B. ELECTROCARDIOGRAM

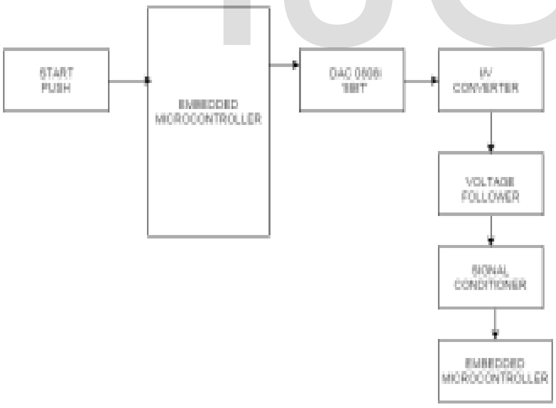


Fig. 2 Block diagram for ECG module

A start push button is used to turn on the simulator which is connected to the embedded microcontroller. The digital format of the normal PQRST curve is fed into the microcontroller. This being a digital signal has to be converted into an analog signal using a DAC 0808.The output of DAC is a current signal and it has to be converted into voltage signal using I to V converter. For impedance matching, a voltage follower is used in the circuit.

C. HEART RATE

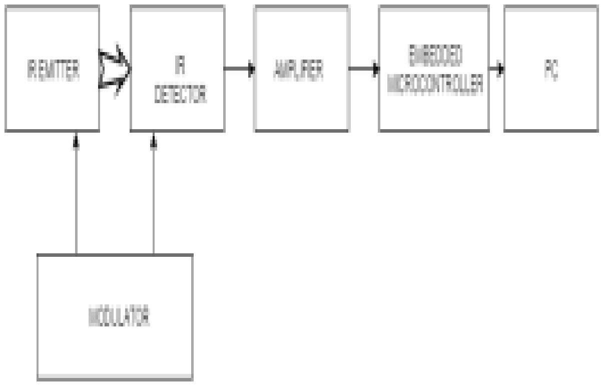


Fig. 3 Block diagram for Heart rate module.

Non–invasive heart rate monitoring is carried out to determine the heart rate. IR sensors and detectors are used. IR sensor is made up of Gallium-Arsenite and IR detector is made up of silicon of wavelength of 680-960nm. Since the wavelength is high penetration increases. The flow of red blood cells and the white blood cells in the fingers are detected by the IR emitters and the signal is absorbed by the IR detector whose output is sent to the amplifier and finally fed into the embedded microcontroller. Emitter and detector are separately energized by the modulators. The pumping speed of heart, its characteristics, blood oxygen, dehydration and HB based characteristics can be studied.

D. DEHYDRATION RATE

The mother is made to walk or stand for a while prior to this test. She has to stand with her hand raised holding the tip of the sensor. The dehydration rate is determined based upon the amplitude of the curve. If the curve touches the bottom level axis then the mother is completely dehydrated. If peaks are seen then the dehydration level is normal. In case of dehydration, Calcium and Zinc supplements are given to the mother as it aids the bone growth of foetus.

IV. DESIGN DETAIL

RTD is used determine the respiration rate of both mother and foetus. Being a passive component a separate excitation source has to be given to the WSB network to which RTD is attached as unknown resistance. The output of the power source is 5V DC signal is given to the WSB arranged in the form of two potential divider.

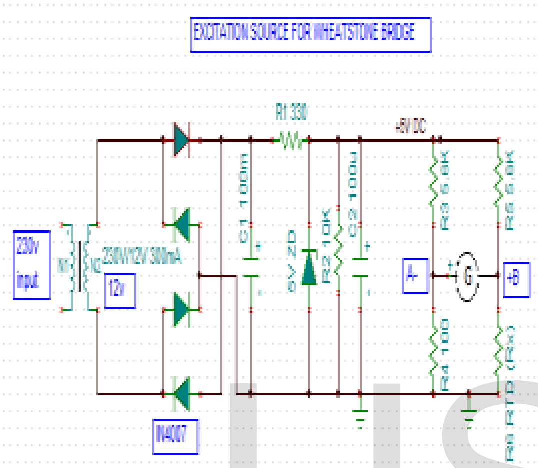


Fig.4 Circuit diagram for Wheatstone bridge with excitation

Resistors R3and R4 form potential divider P1, R5 and R6 form potential divider P2.So, P2-P1=output.

Consider P1, voltage at point A with respect to ground = (V/R3+R4)R4
= (5000mV/5.6K+100Ω)*100Ω
= 87.71mV

Voltage at B with respect to ground at 0^{o}C=87.71mV. At 50^{o}C, Rx changes. For 50^{o}C, resistance=119.4Ω

Voltage at B with respect to ground= (V/R5+R6)Xr6
= (5000mV/5.6k+119.4Ω)*119.4Ω
=104.38mV

For the input voltage of 5V, the output produced from the Wheatstone bridge for the temperature of 50^{o} Celsius is 16 mV. This 16 mV is not sufficient to be given into the EμC, so a signal conditioner has to be designed.

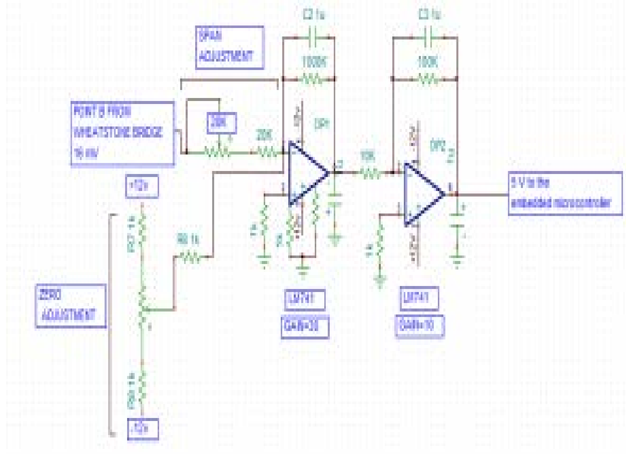


Fig 5 Circuit diagram of signal conditioner

The gain of the bridge amplifier used has to be determined.

GAIN = OUTPUT/INPUT
= 5000mV/16mV ~ 300.

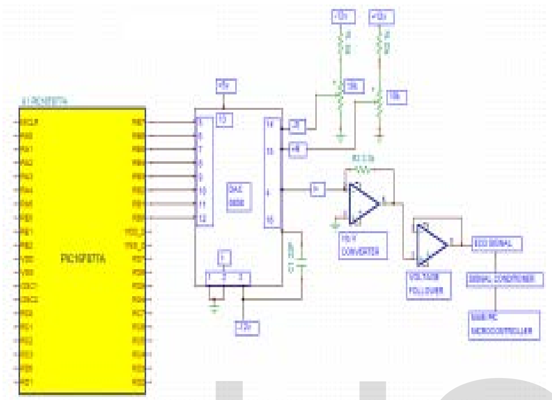
Instead of designing an op-amp of gain 300, two inverting amplifiers of gain 30x10 are designed to reduce the noise and to increase the speed. For a gain of 30 and 10, input and feedback resistance are measured.

Gain of op-amp 1= 30
GAIN= - Rf / Rin
Rf = 1000k
30= - 1000/ Rin
Rin= 33.3k
Gain of op-amp 2= 10
GAIN= - Rf/ Rin
Rf= 100k
10= - 100/ Rin
Rin= 10k

An integrator is introduced by connecting capacitors to reduce the noise. To remove non linearity, low pass filters are attached at the output of the op-amps. The main disadvantage of op-amp is the offset produced. In order to nullify the offset, resistances are added at offset and null pins (1 and 5) of the op-amp. Zero and span adjustments has to be made because the temperature change during respiration is only ±2 degree Celsius from the room temperature.So it is sufficient to get the output in the range of (25°C- 35°C) in order to clearly observe the respiration characteristics of the mother and foetus. The output of signal conditioning circuit (in this case for the input of 16mV) is 5V which is given to the port (Ra-analog signals) of the EμC.

Fig. 6 ECG simulator

ECG simulator is used to produce the PQRST curve of the human heart. ECG



records the electrical activity of the heart over period of time using electrodes placed on a patient's body. Signal obtained from the transducers may not be sufficient for direct computing. It undergoes process like amplification of voltage, amplification of current, protecting input from hazards. This circuit is responsible of zero and span of measurement. A start push button is used to turn on the simulator which is connected to the embedded microcontroller. The digital format of the normal PQRST curve is fed into the microcontroller. This being a digital signal has to be converted into an analog signal using a DAC 0808. The output of DAC is a current signal and it has to be converted into voltage signal using I to V converter and for impedance matching a voltage follower is used. A simulator is used to obtain the ECG of the pregnant women. This signal is in composite form i.e., combination of mother and foetus which has to be segregated. Amplitude of mother's ECG is 20mV and of foetus is 5mV. Port B of PIC microcontroller is used to obtain the ECG curve. This port has 8 pins. So 2^8 = 256 combinations are possible and the corresponding coding of the PQRST curve of a normal human is written and fed into the microcontroller. This being digital has to be converted into analog signal by using DAC 0808(8 BITS, 16 PINS).The port Rb pins(33-40) is connected to the pins 5-12 of the DAC. Positive and negative reference values are given at pins 14 and 15.Frequency compensation is provided to reduce the noise provided. The output is obtained at pin 4 and it is a current signal having a value of 200μA for the corresponding PQRST curve. An I/V converter is used to convert current signal into voltage. The voltage obtained is given to a voltage follower for impedance matching. This analog voltage signal obtained is the actual PQRST curve which is given to the signal conditioner and finally fed to one of the ports of EμC.

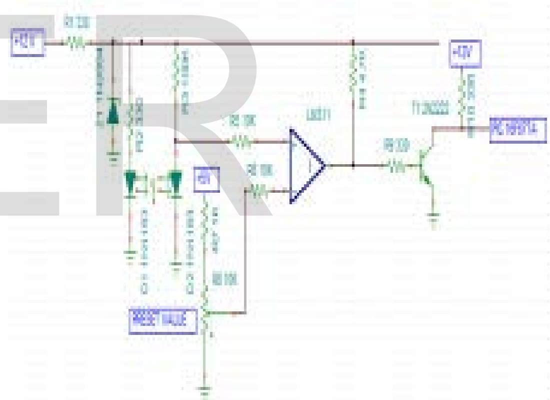


Fig. 7 Circuit diagram for Heart rate module

Non–invasive heart rate monitoring is carried out to determine the heart rate. The principle theory used is Modified Beer Lambert's law. IR sensors and detectors are used. IR sensor is made up of Gallium-Arsenite and IR detector is made up of silicon. The wavelength is of the range 680-960nm. Since the wavelength is high penetration will be more. The red blood cells and the white blood cells in the fingers are detected by the IR emitters and the signal is absorbed by the IR detector whose output is sent to the amplifier and finally fed into the embedded microcontroller. Emitter and detector are separately energized by the modulators. The pumping speed of heart, its characteristics, blood oxygen, dehydration and HB based characteristics can be studied.

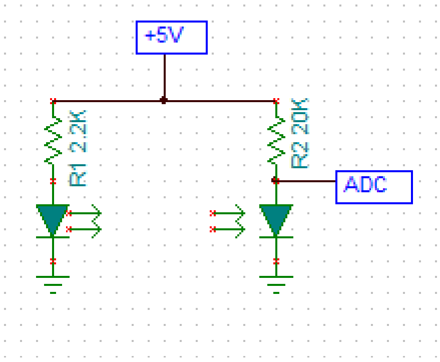


Fig. 8 Circuit diagram for Dehydration module

Pulse oximetry is a non invasive method that enables the measurement of a person's blood oxygen saturation, which is often referred to as SpO2 or "The Fifth Vital Sign".SpO2 is the percentage that reflects the level of oxygen available in blood. SpO2 stands for peripheral capillary oxygen saturation, an estimate of the amount of oxygen in the blood. More specifically, it is the percentage of oxygenated haemoglobin (haemoglobin containing oxygen) compared to the total amount of haemoglobin in the blood (oxygenated and non-oxygenated haemoglobin).SpO2 is an estimate of arterial oxygen saturation, or SaO2, which refers to the amount of oxygenated haemoglobin in the blood. Haemoglobin is a protein that carries oxygen in the blood. It is found inside red blood cells and gives them their red colour. SpO2 can be measured by pulse oximetry, an indirect, non-invasive method (meaning it does not involve the introduction of instruments into the body). It works by emitting and then absorbing a light wave passing through blood vessels (or capillaries) in the fingertip. A variation of the light wave passing through the finger will give the value of the SpO2 measurement because the degree of oxygen saturation causes variations in the blood's colour. This value is represented by a percentage. If your Pulse Ox says 98%, this means that each red blood cell is made up of 98% oxygenated and 2% non-oxygenated haemoglobin. Normal SpO2 values vary between 95 and 100%.Good blood oxygenation is necessary to supply the energy your muscles need in order to function, which increases during a sports activity. If your SpO2 value is below 95%, that could be a sign of poor blood oxygenation, also called hypoxia.

V. CONCLUSION

Our project aims at measuring the ECG, HEART RATE, RESPIRATION RATE and DEHYDRATION ANALYSIS of both the mother and foetus. We make use of Visual Basic 6.0 software. The parameters mentioned above are measured and using IoT the values are sent to the concerned doctor for analysis. In case of any abnormality found by the doctor in the values, immediate actions are taken for the safety of the mother and foetus. The future scope would be using fibre optics and GPRS system to transmit the data to the doctor.

VI. REFERENCES

[1] Chunxiao Li, Anand Raghunath, Niraj K.Jha, "Importance of trustworthiness of medical device software with formal verification methods", *IEEE Embedded systems*, Vol.5, Issue.3, 2013.

[2] "Real-Time Signal Quality-Aware ECG Telemetry System for IoT-Based Health Care Monitoring", Udit Satija; Barathram. Ramkumar; M. Sabarimalai Manikandan, IEEE Internet of Things Journal.

[3] "IoT-based patient information monitoring system by using RFID technologies", Faruk Aktaş; Celal Çeken; Yunus Emre Erdemli, 2016, 20th National Biomedical Engineering Meeting (BIYOMUT), Year: 2016

ISSN 2229-5518

[4] “A Secure IoT-Based Healthcare System With Body Sensor Networks”, Kuo-Hui Yeh, IEEE Access, Year: 2016, Volume: 4.

[5] “BSN-Care: A Secure IoT-Based Modern Healthcare System Using Body Sensor Network”, Prosanta Gope; Tzonelih Hwang, IEEE Sensors Journal, Year: 2016, Volume: 16, Issue: 5, ShaoHua Hu ,2015 International Conference on Logistics, Informatics and Service Sciences (LISS), Year: 2015

[6] “A Health-IoT Platform Based on the Integration of Intelligent Packaging, Unobtrusive Bio-Sensor, and Intelligent Medicine Box”, Geng Yang; Li Xie; Matti Mäntysalo; Xiaolin Zhou; Zhibo Pang; Li Da Xu; Sharon Kao-Walter; Qiang Chen; Li-Rong Zheng, IEEE Transactions on Industrial Informatics, Year: 2014, Volume: 10, Issue: 4.

[7] “Wearable Health Monitoring System and Its Applications”, Tomoya Tanaka; Koji Sonoda; Sayaka Okochi; Alex Chan; Manabu Nii; Kensuke Kanda; Takayuki Fujita; Kohei Higuchi; Kazusuke Maenaka 2011 Fourth International Conference on Emerging Trends in Engineering & Technology, Year: 2011.