Intelligent Toco-tonometry with Real Time Respiration Monitoring

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Abstract— Aiming at the enhancement of monitoring system for pregnant patients, an appropriate device is needed to monitor the maternal health during labour. A new method for non-invasive monitoring of respiration and uterine contraction activity of pregnant woman is described in this paper. A prolonged inspiration or shortness of breath occurs during initiation of labour associated with elevated uterine contraction is used as an objective for this project. The system is light weight, portable and smaller in size. It can be used safely by the pregnant women to monitor the foetus condition, abnormal uterine contraction activity and its associated respiration when she is not in hospital. When the uterine contraction (UC) monitors and respiration monitor detects any abnormal activities, it can activate the appropriate alarm to alert the pregnant woman to go to hospital as soon as possible. The output from both the monitors has been given to PIC16F877A microcontroller and then it is interfaced with LABVIEW software. The corresponding output has been viewed and recorded using VI LABVIEW INTERFACE. This device can also be used in small hospitals and government hospitals because of its cost effectiveness.

Index Terms— Toco-tonometry, Abnormal Respiration detector, Uterine contraction monitor, Real time monitoring, Labview interface, labor monitoring, portable labor monitor.

1 INTRODUCTION

Each and every day, around 800 women die from preventable causes related to childbirth and pregnancy.

Almost 99% of all maternal deaths occur in developing countries only. Women living in rural areas and in poorer countries has high maternal mortality rate. During pregnancy young adolescents face a high risk of complications and death when compared to older women. Skilled care is needed before, during and after childbirth can save the lives of new born babies and women.

Maternal mortality around worldwide has been dropped by almost 50% between 1990 and 2010. All of these deaths occuring in low-resource settings, and most of them could have been prevented. Maternal mortality ratio is considerably very high in India. Even in the yeay of 2010, India has maternal mortality rate of 200/100,000 live birth. Eventhough the average life span of people has increased greatly in recent years, the rate of decrease of maternal mortality rate is still challenging.

The need for respiration monitoring device can be seen in many different situations. But here, the uterine contraction (UC) monitoring is done with the help of abnormal respiration monitoring system. Nowadays, it is a necessary to develop a portable and cost-effective device for pregnant women outside the hospital. The system may help them to stay as long as possible in their own environment with an increased independence and a reduction of social cost by the use of home monitor with alarm. It will alarm them to go hospital when the monitor detects abnormal respiration or shortness of breath. Ther are some multifunctional systems which have been designed to monitor the uterine contraction signals in the hospitals. These systems could not monitor the pregnant women in their own environment, because these systems are large, heavy and also expensive. But this proposed system will meet all the requirements of monitorring the pregnant women at home and also in hospitals.

2 METHODOLOGY

The entire system consists of three modules which are represented as block diagram in Fig.1. It consists of an abnormal respiration detector module, uterine contraction (UC) monitoring module and blood flow detector module.

2.1 An Abnormal Respiration Detector

An abnormal respiration detector module consists of sensor unit, audio amplifier part and 555 timer. A mask with nasal airflow tube is fixed onto the face of the pregnant woman. The sensor unit consists of condenser microphone affixed to the nasal airflow tube of the mask which is used to fetch the biosignal particularly the breath of the patient.

The transistor (BC549C) amplifies the signal received from the condenser microphone. When the transistor conducts, a short negative ulse triggers the 555 timer. The 555 timer is used as a monostable multivibrator. Then output of timer goes from low to high. The high output from the 555 timer is used to operate a double contact relay.

One end pair of the relay is connected to 555 timer and buzzer and the other end pair of the relay is connected to voltage supply of the uterine contraction (UC) monitor. The alarm is automatically generated whenever there is an abnormal respiration or shortness of breath. Hence, it will alert the pregnant woman and the surroundings whenever she feels shortness of breath which indicates the onset of labour. This module is powered by single 9V battery. The monostable mode 555 timer produces square wave pulses whenever the timer produces an output. The design equation for monostable multivibrator is given by

$$\text{ON time, } T = 1.1 * R * C \quad (1)$$

Where, R & C are the resistor and capacitor connected to the pin 6 and 7 of an IC741.

2.2 Uterine Contraction Monitoring Module

The sensor part includes the strain gauge sensor in a full-bridge configuration of the wheatstone bridge. The strain gauge sensor has to be placed near the uterine fundus to detect changes resulting from uterine contractions in the anterio-posterior diameter of the abdomen.

The strain gauge amplification circuit is powered by dual power supply and the voltage controlled oscillator circuir is powered by a single 9V battery. Whenever there is any contraction takes place in the abdomen, the strain gauge gets strained and it produces output voltage in milli volts.

An operational amplifier (Ic741) is used to amplify these milli volts into volts. The overall gain of the op-amp is given by the formula

$$\text{Gain (AV)} = -R_f/R_1 \qquad (2)$$

Where, R_f is the feedback resistor, R_1 is the input resistor.

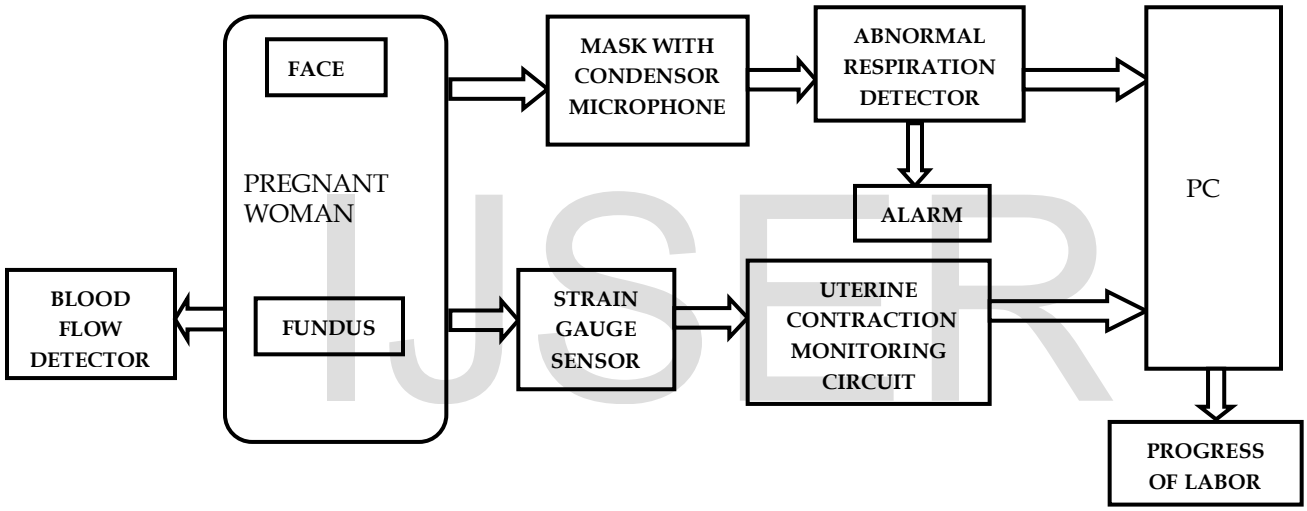

Fig.1 Block diagram of an entire system

The output voltage of the op-am is given by

$$Vo = -R_f / R_1 (V_a - V_b) \qquad (3)$$

Where, V_a & V_b are the two input voltages given to op-amp from strain gauge bridge circuit. Vo is the output voltage of an op-amp.

The amplified output voltage is then given to the voltage controlled oscillator circuit at pin 5 (control voltage) of the 555 timer. Here, timer is used as An astable mode multivibrator.

The timing or duration of the cycle is given by

$$T = 0.693 (R_A + 2R_B)C \qquad (4)$$

Where R_A & R_B are the resistors across the pin 6 and 7 of an IC741(VCO). Cis the capacitor connected between pin 2 and ground.

The frequency of oscillations of an astable mode oscillator is

$$F = 1/T = 1.44/(R_A + 2R_B) C \qquad (5)$$

It produces output with frequency of about 1.2 KHz and the frequency value changes according to the amplified strain gauge output. The changes in output frequency with respect to changes in uterine contractions can be identified easily with the help of loud speaker.

2.3 Blood Flow Detector Module

For determining foetal condition, a blood flow detector module (Ultrasonic Micro Dop system, Impel) is used which is available in the market itself. Blood flow detector module helps to check the foetal alive condition by ourself using above mentioned model.

2.4 Labview Interface and DAQ

The output waveforms obtained from both uterine contraction monitoring module and abnormal respiration detector has been viewed and monitored using PIC 16F877A microcontroller and Labview software. The entire block diagram for PIC microcontroller is shown in the Fig. 2. PIC has been interfaced with LABVIEW using serial port interfacing by RS232. The final output waveform has been displayed in LABVIEW.

3 Results

The waveform of the respiration detector and uterine contraction monitor is shown in the Fig.3

The output waveform is recorded for non-regnant woman and it gives continuous square wave pulses for abnormal respiration. It shows that it will produce output and alert the surroundings during shortness of breath. The shortness of breath is also associated with changes in uterine contractions (UC) of the pregnant woman. It also diplays the output voltage of the uterine contraction monitor. The Corresponding uterine contractions waveform also been displayed in labview.

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4 DISCUSSIONS

The respiratory monitoring is necessary in many clinical situations. Respiration monitoring of pregnant patients for monitorring the progress of labor will give very useful informationn for predicting the stages of labor. By using the method of condenser microphone as a sensor, it is possible to detect the abnormal respiration. Here, the inspiratory period is considered especially because during prolonged inspiration, there is an elevated uterine contractions takes place. Whenever there is an abnormal respiration, the respiration monitor produces an alarm and it is indicated by running LED. The waveforms are generated during the buzzer sound. The waveforms were generated during the buzzer sound. These waveforms indicate that the amplitude and frequency are maximum during prolonged inspiration period which should be matched to the time delay of the timer. During exhalation there is no buzzer sound because its time period doesnot matches with timer time delay.

5 FUTURE WORK

The uterine contraction moitoring output will be send to the physician from the remote areas through bio-telemetry system. The waveforms obtained from these modules will provide sufficient data to predict the iniation of labor.

6 CONCLUSION

The diagnosis of a patient in time is very for avoiding life loss in medical field. But many crucial variables in the living system are inaccessible because the roper measurand system interface cannot be built easily. Respiration unit is sensitive to shortness of breath and can be detected easily. Monitoring respiration rate is an important taskwhen evaluating a subject health articularly in pregnant patients with or without asthma and other breathing problems. This device detected the abnormal breathing especially during inhalation. This device will generate alarm along with LED glowing in case of abnormal or shortness of breath and alerts the surrounding. On the other hand, toco-tonometry module skillfully monitors the uterine wall contractions. The care takers can find out only the hysical disturbances appearing on the face of the patient or from body language. But ains are false indicators and may tend to mislead many times. It would be of great help if the shortness of breath and uterine contraction of such patients can be monitored in real time, so that any sign of irregularity can be immediately witnessed.

The features of the Intelligent Toco-tonometry with respiration monitor includes smaller in size, low cost, low power and light weight. The other ortable fetal and maternal monitorrs are not small enough and are powered by power lines, so their applications are restricted to some special places. But this device is easily portable and powered by commercial 9V battery. Hence it can monitor the pregnant woman outside the hospital also.

A medical device proves to be a success if and only if it is free of any kind of adverse side effects or damage and more essentially does not impart any mental strain on the patient. The sensor part of toco-tonometry unit is placed externally and it is absolutely free of internal complications.

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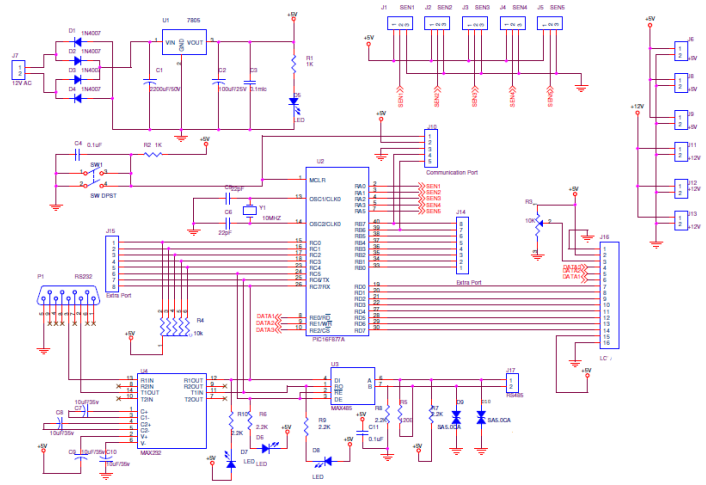

Fig.2 Block Diagram for PIC16F877A Microcontroller

Fig.3 Output waveform for entire module in Labview