

SMART INFANT INCUBATOR USING IOT

Submitted in partial fulfilment of the requirements for the award of

Bachelor of Technology Degree in

Biomedical Engineering

by

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**DEPARTMENT OF BIOMEDICAL ENGINEERING SCHOOL OF BIO AND
CHEMICAL ENGINEERING**

SATHYABAMA

INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)

Accredited with Grade "A" by NAAC

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MARCH 2021



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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **SNEHA BHATTACHARYYA (37240069), SONALI DAS (37240070)** who carried out the project entitled **"SMART INFANT INCUBATOR USING IOT"** under our supervision from **October 2020 to March 2021.**

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Submitted for Viva voce Examination held on 23RD MARCH 2021

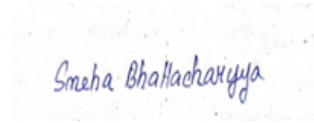
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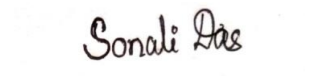
DECLARATION

We, **SNEHA BHATTACHARYYA (37240069), SONALI DAS (37240070)** hereby declare that the Project Report entitled “**SMART INFANT INCUBATOR USING IOT**” done by us under the guidance of **Mrs.Sindu Dinakaran, Department of Biomedical Engineering** is submitted in partial fulfilment of there quirements for the award of **Bachelor of Technology** Degree in **Biomedical Engineering**.

1.



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DATE: 23RD MAR 2021

PLACE: CHENNAI

SIGNATURE OF THE CANDIDATES

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ABSTRACT

There occur almost 20 million premature and low birth weight infants every year in developing countries, among which, nearly 4 million die. These deaths occur mostly due to unavailability of incubators or unreliable traditional incubators available. Moreover, although Telemedicine has emerged in rural areas, there's a shortage of healthcare providers, which make it inaccessible to basic healthcare. Thereby, traditional incubators and therapeutic techniques lack Telemedicine communication and feedback. Therefore, we develop an advanced portable and wireless-base incubator. The parameters we aim to concern in the project are the heart rate, baby position, baby's crying, and temperature. Results showed the advanced design building blocks. We use our technique to monitor the baby inside the incubator from remote location. If any abnormality rise of the baby or the incubator as well, an automatic message is sent to the authorised person.

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LIST OF ABBREVIATIONS

GSM-Global System for Mobile Communication

IOT- Internet of things

LED-Light emitting diode

LCD- Liquid crystal display

Node MCU-Node Micro Controller Unit

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CHAPTER 1

INTRODUCTION

1.1 OUTLINE OF THE PROJECT

During the first weeks of their life, preterm newborns, i.e. newborns born before a gestational age of 37 weeks, are hospitalized in neonatology service and require a particular attention. Indeed, prematurity implies a high risk of mortality, mostly due to late-onset sepsis and respiratory failure. The diagnosis of late-onset sepsis is currently relying on the observation of vital physiological signals and blood culture, which might be a slow process. So, the development of a monitoring system which could automatically give information to the healthcare workers is of great interest. This is an active field of research at the interface between medicine and computer science. The existing works on automatic sepsis detection are based on the analysis of physiological signals. Video-based motion analysis has already been used in several clinical contexts involving newborns. But to the best of our knowledge, there is no work on video-based automatic sepsis detection. This approach would have the advantage to be fully non-invasive and contact-less, which limits the sepsis risk and enable long-term monitoring. However, video-based automatic estimation of newborn motion faces several challenges related to real-life acquisition conditions encountered when considering recordings of several days or weeks. During the stay of the preterm newborn in the neonatology unit, it happens many times that nurses handle the newborn inside the incubator. During these periods, adults are present in the framing, which leads to irrelevant motion with regards to our final aim. Moreover, the newborn is regularly taken out of the incubator in order to change the bedding or to have a skin-to-skin contact with the parents, which leads to irrelevant absence of motion. These periods when adults are present or when the preterm newborn is absent must not be included in the motion analysis. In the context of long-term monitoring, it is of primary importance to be able to automatically detect the periods of interest. This work is part of the Digi-NewB project, whose aim is to develop a monitoring system of preterm newborns, with a focus on late-onset sepsis detection. In this paper, we propose a video-based method to detect automatically the periods when the newborn is solely present in the incubator. We use transfer learning from a deep neural

network in order to label images with three classes: “adult present”, “newborn absent” and “newborn present”. Bottleneck features are extracted from a pre-trained deep neural network and are used to train a classifier. Then we propose a strategy of decision intervals fusion in order to take advantage of temporal consistency. So, the objective of this paper is to find the most appropriate neural network for transfer learning and decision intervals fusion.

CHAPTER 2

LITERATURE REVIEW

Ashish.B, IEEE(2017) reported that “TEMPERATURE MONITORED IoT BASED SMART INCUBATOR”. Baby neonatal Incubator is a closed apparatus for providing a controlled environment in all the possible ways for the immense care of premature babies. Majority of premature babies are born between 32 to 37 weeks of gestation period and die due to lack of simple essential care such as warmth. Until recently, most of the developing countries turned a blind eye to premature babies leading to their demise. This research work provides a cost-worthy design of an embedded device for real time monitoring of newborn babies in the incubator. It permits early detection of potential life-threatening events and maintains a safe environment for the infant. Many of the existing medical technological companies (such as small and medium) may not adopt the best existing technologies as its maintenance might not be cost effective. On the other hand, the bigger medical firms which have adopted them are cost effective and common man cannot afford the same. So, the main objective of this research is to overcome the drawbacks and provide eco-friendly service to all the common people.

Sri Purwiyanti, et al (2018) IEEE reported that “MULTISENSORS SYSTEM FOR REAL TIME DETECTION OF LENGTH, WEIGHT, AND HEARTBEAT OF PREMATURE BABY IN THE INCUBATOR”.Premature babies inserted into the incubator will always be monitored progressively, especially the heart rate, body

length, and body weight. The aims of this research are to design and to create an incubator that can detect the abnormalities of baby's heartbeat through the baby's fingers in continuous and real time by using pulse sensor. The incubator also able to measured baby's length and weight automatically by using ultrasonic sensor and load-cell sensor, respectively. The output of all sensors will be processed and calibrated by Arduino Microcontroller, then the results will be displayed on the liquid crystal display (LCD).The systems also able to allow some notifications if any abnormalities have been occur. As a result, the heartbeat detector has a precision of $\pm 95\%$ when compared to a reference heartbeat detector. The system also can measure the length and weight of the infant with the measurement results are closer to the reference instrument, which the average error is not more than 5%. The results are most likely is a good preliminary result in order to build a smart incubator.

MeghaKoli (2018) IEEE reported that "INTELLIGENT BABY INCUBATOR". In today's world where temperature is an important part of our environment. Any variations in the temperature can affect all the living organism and also some semiconductor materials. Our project is to provide a control on the changes in temperature for certain applications such as baby incubator. Worldwide incubator is used for the infants to improve the survival of babies by providing them warm environment and reducing the heat loss from the baby's body. Basically, incubator is the standard method used worldwide. In this we are using Arduino, temperature sensor for monitoring or controlling the temperature of the baby's body. The constant temperature of 36.5-37.2° C is required by the baby as it is required by the baby as in mother's womb. The programming code of Arduino is used to control the temperature. Buzzer is used for the indication of change in temperature in a neonatal nursing home where a number of incubators are kept. IOT web designing is used for monitoring the changes in temperature anywhere at all time.

M. Shaib(2017) IEEE reported that "ADVANCED PORTABLE PRET INCUBATOR". Nearly 20 million premature and Low Birth Weight infants are born

each year in developing countries, 4 million die within their first month. These deaths occur due to the unavailability or unreliability of traditional incubators. Moreover, although Telemedicine is helpful in rural areas, the shortage of healthcare providers has made it inaccessible in both basic healthcare. Thereby, traditional preterm baby and low-birthweight incubators and therapeutic techniques lack Telemedicine communication and feedback. The aim of our project is to develop an advanced portable and wireless-based incubator. We intend to provide an affordable, feasible, patient friendly and reliable premature baby incubator especially in low-income countries. The project focuses on the premature babies in the third trimester of pregnancy. The design is based on Wi-Fi and infrared technologies that measure the essential parameters that must be controlled for preemies. These parameters include the heart rate, oxygen level in the blood and temperature. Results showed the advanced design building blocks. The response of the generated power-voltage proves that the power can be regulated by the voltage. The thermal isolation can decrease the thermal loss and increase the time needed to drop temperature 6 times. In the room temperature of premature infant, 20°C and 45°C, the resistance decreases from 12.69 kilo Ohms to 4.82 kilo Ohms. The voltage and the temperature were inversely proportional. The heaters were efficient when tested on water. One of the major advantages of the device is that it surpasses existing techniques. As a future prospect more electronic components need to be tested and features need to be extracted.

Gamze Tilbeşen et al (2018) IEEE reported that “DESIGN AND TEST OF AN INCUBATOR ANALYZER”. Incubators are cabins that provide the environment with necessary conditions for premature or newborn babies, and they are designed to allow monitoring and care of the baby. The incubator analyzer is the analyzer that shows the performance of the incubator. Knowing how close the values of a medical device are to the actual values is very important in the treatment process. To ensure the accuracy of medical devices, tests and controls are required. As a result of periodic tests and controls, it is possible to reduce the risks by preventing incorrect measurements. If the temperature, humidity and oxygen sensors of the incubators are measured incorrectly, the baby's life would be threatened. This study aims to determine the design requirements of a single incubator analyzer that

measures heat, oxygen and humidity in the incubator and to design an analyzer. The general design of the incubator analyzer consists of a battery circuit, a microcontroller, a liquid crystal display (LCD) screen, five temperature sensors, a humidity sensor and an oxygen sensor. Incubator standards of our country and EU has been reviewed according to the design. In addition, within the scope of the project, the sensors in accordance with the standards have been researched and determined, but due to their high cost, alternative sensors are preferred. By that the design of the analyzer can be a model for the actual device. Proper firmware is programmed for temperature, oxygen and humidity sensors and data from those sensors are processed and displayed on an LCD screen. Also, a suitable case is designed by computer aided programs. The analyzer is tested in incubators and functioned properly. With this project, it is determined that a cost effective incubator analyzer can be designed and with more sensitive sensors proper standards can be achieved. This project can be a model for incubator analyzer design.

Tanveer Hussain et al (2019) reported that Intelligent Baby Behavior Monitoring using Embedded Vision in IoT for Smart Healthcare Centers. Journal of Artificial Intelligence and Systems

CHAPTER 3

AIM AND SCOPE

3.1 AIM

The aim of our project is to develop an advanced portable and wireless-base incubator. The project focuses on the premature babies in the third trimester of pregnancy these parameters include the heart rate, and temperature. Results showed the advanced design building blocks. Using our technic, we monitor the premature baby and maintain the temperature level of the incubator. At any abnormal of the baby or incubator it automatically sends message to the authorized person.

3.2 SCOPE

The baby incubator can be more effective and better if the number of sensors is increased. This will provide more information to the doctor about the neonate.

One more probe can be attached to the incubator to sense temperature of the room.

A signal transmission can be attached to the baby incubator which can transmit all the essential parameters to the main server of the hospital.

A wireless system which measures real time heart rate can be developed by using Bluetooth module and data can be visualized, recorded and stored in an android application.

We can use this WIFI technique if parents want to have a look at their babies from work. It can be easily achieved by creating android based app which will be showing real time data of their baby .

CHAPTER 4

MATERIALS AND METHOD

4.1 BLOCK DIAGRAM

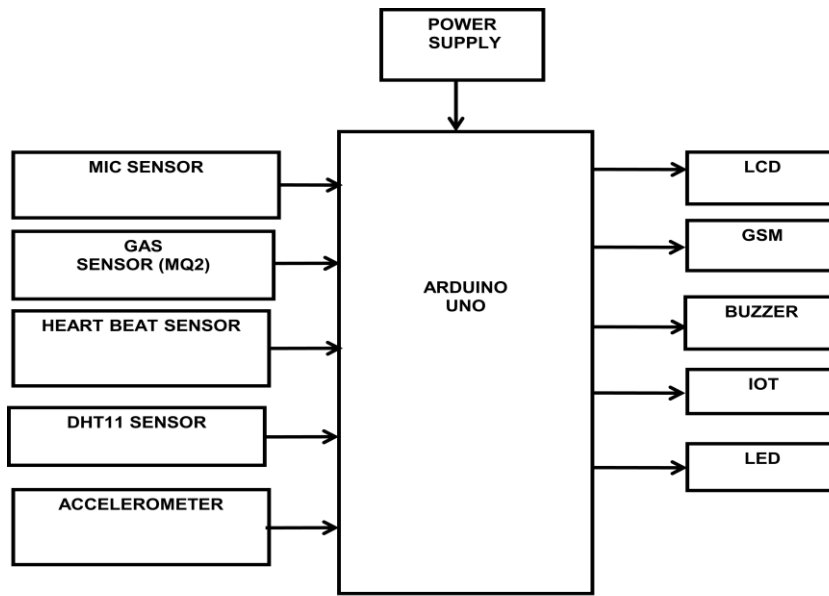


Fig 4.1 BLOCK DIAGRAM

4.1.1 EXPLANATION OF BLOCK DIAGRAM

This system is mainly used to monitor the health condition automatically. In this Proposed system Arduino microcontroller is used as heart of the system, we use the heartbeat sensor to monitor the heart beat or pulse rate of the baby, DHT11 Sensor is used to monitor the temperature inside the incubator. It automatically maintains the incubator temperature using light. Gas sensor is used to detect the any harmful gas that may damage the baby health. MIC sensor used to check the baby crying status. Accelerometer sensor is used to check the baby body position (axis). Any Abnormal Condition and any values that are being monitored went beyond threshold, automatically alarm will be issued using buzzer, sending

Message through GSM to Parents, and doctors. All the information is sent to IOT webpage.

4.2 ARDUINO MICRO-CONTROLLER

4.2.1 INTRODUCTION TO ARDUINO:

Arduino is an open-source electronics platform based on easy-to-use hardware and software. Arduino boards are able to read inputs - light on a sensor, a finger on a button, or a Twitter message - and turn it into an output - activating a motor, turning on an LED, publishing something online. You can tell your board what to do by sending a set of instructions to the microcontroller on the board.

Over the years Arduino has been the brain of thousands of projects, from everyday objects to complex scientific instruments. A worldwide community of makers - students, hobbyists, artists, programmers, and professionals - has gathered around this open-source platform, their contributions have added up to an incredible amount of accessible knowledge that can be of great help to novices and experts alike.

Arduino was born at the Ivrea Interaction Design Institute as an easy tool for fast prototyping, aimed at students without a background in electronics and programming. As soon as it reached a wider community, the Arduino board started changing to adapt to new needs and challenges, differentiating its offer from simple 8-bit boards to products for IoT applications, wearable, 3D printing, and embedded environments. All Arduino boards are completely open-source, empowering users to build them independently and eventually adapt them to their particular needs. The software, too, is open-source, and it is growing through the contributions of users worldwide.

4.2.2 ARDUINO UNO:

The UNO is the best board to get started with electronics and coding. If this is your first experience tinkering with the platform, the UNO is the most robust board you can start playing with. The UNO is the most used and documented board of the whole Arduino family.



Fig 4.2 ARDUINO UNO MICROCONTROLLER

Arduino Uno is a microcontroller board based on the ATmega328P (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. You can tinker with your UNO without worrying too much about doing something wrong, worst case scenario you can replace the chip for a few dollars and start over again.

"Uno" means one in Italian and was chosen to mark the release of Arduino Software (IDE) 1.0. The Uno board and version 1.0 of Arduino Software (IDE) were the reference versions of Arduino, now evolved to newer releases. The Uno board is the first in a series of USB Arduino boards, and

the reference model for the Arduino platform; for an extensive list of current, past or outdated boards see the Arduino index of boards.

Table 4.2.1 TECHNICAL SPECIFICATIONS:

Microcontroller	ATmega328P
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limit)	6-20V
Digital I/O Pins	14 (of which 6 provide PWM output)
PWM Digital I/O Pins	6
Analog Input Pins	6
DC Current per I/O Pin	20 Ma
DC Current for 3.3V Pin	50 Ma
Flash Memory	32 KB (ATmega328P) of which 0.5 KB used by bootloader
SRAM	2 KB (ATmega328P)
EEPROM	1 KB (ATmega328P)
Clock Speed	16 MHz
LED_BUILTIN	13
Length	68.6 mm
Width	53.4 mm
Weight	25 g

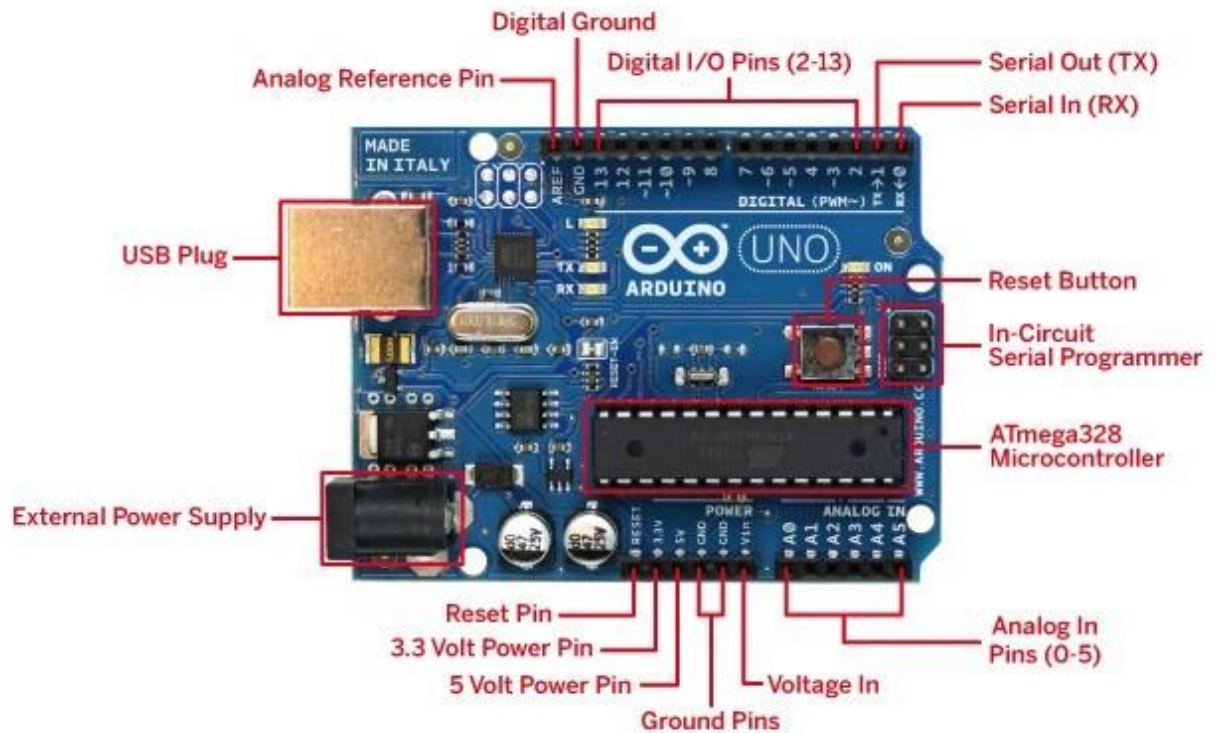
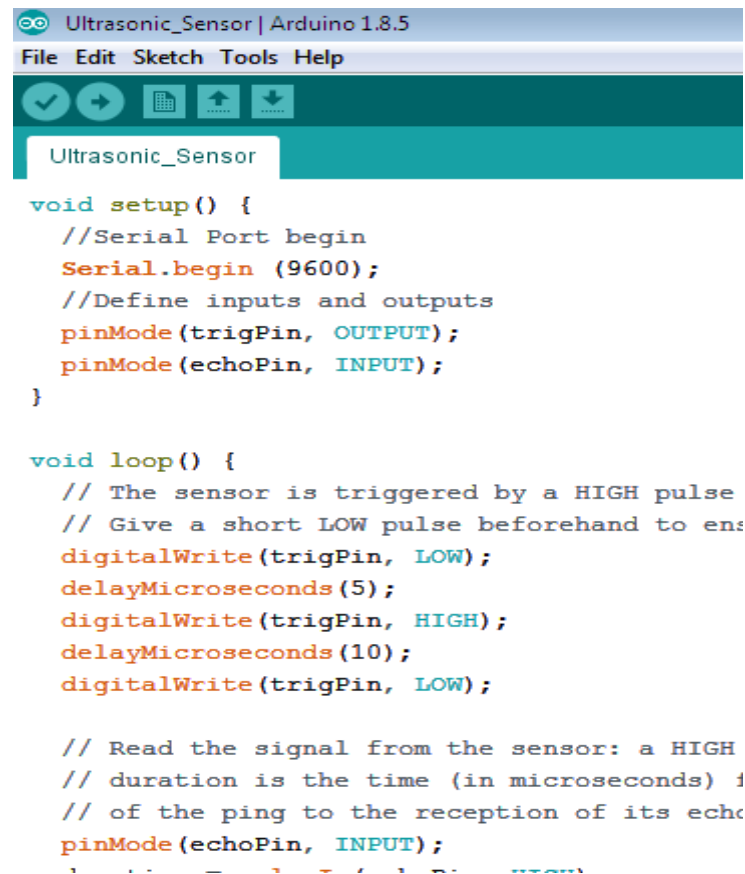


Fig 4.3 ARDUINO BOARD

4.2.3PROGRAMMING:

The Arduino Uno can be programmed with the (Arduino Software (IDE)). Select "Arduino/Genuino Uno from the Tools > Board menu (according to the microcontroller on your board). For details, see the reference and tutorials.

The ATmega328 on the Arduino Uno comes preprogrammed with a bootloader that allows you to upload new code to it without the use of an external hardware programmer. It communicates using the original STK500 protocol (reference, C header files).

The image shows a screenshot of the Arduino IDE interface. At the top, the title bar reads 'Ultrasonic_Sensor | Arduino 1.8.5'. Below it is a menu bar with 'File', 'Edit', 'Sketch', 'Tools', and 'Help'. A toolbar with icons for saving, running, and other functions is visible. The main text area contains the following C++ code:

```
void setup() {  
  //Serial Port begin  
  Serial.begin (9600);  
  //Define inputs and outputs  
  pinMode(trigPin, OUTPUT);  
  pinMode(echoPin, INPUT);  
}  
  
void loop() {  
  // The sensor is triggered by a HIGH pulse  
  // Give a short LOW pulse beforehand to ensure a clean HIGH pulse  
  digitalWrite(trigPin, LOW);  
  delayMicroseconds(5);  
  digitalWrite(trigPin, HIGH);  
  delayMicroseconds(10);  
  digitalWrite(trigPin, LOW);  
  
  // Read the signal from the sensor: a HIGH pulse  
  // duration is the time (in microseconds) from the sending of the ping  
  // of the ping to the reception of its echo  
  pinMode(echoPin, INPUT);  
  long duration = pulseIn(echoPin, HIGH);  
  // Convert the time to a distance  
  float distance = duration * 0.0343 / 2;  
  Serial.print("Distance: ");  
  Serial.println(distance);  
  delay(1000);  
}
```

4.2.4 INPUT AND OUTPUT:

See the mapping between Arduino pins and ATmega328P ports. The mapping for the Atmega8, 168, and 328 is identical.

Note that this chart is for the DIP-package chip. The Arduino Mini is based upon a smaller physical IC package that includes two extra ADC pins, which are not available in the DIP-package Arduino implementations.

Atmega168 Pin Mapping

Arduino function				Arduino function
reset	(PCINT14/RESET) PC6	1	28	PC5 (ADC5/SCL/PCINT13) analog input 5
digital pin 0 (RX)	(PCINT16/RXD) PD0	2	27	PC4 (ADC4/SDA/PCINT12) analog input 4
digital pin 1 (TX)	(PCINT17/TXD) PD1	3	26	PC3 (ADC3/PCINT11) analog input 3
digital pin 2	(PCINT18/INT0) PD2	4	25	PC2 (ADC2/PCINT10) analog input 2
digital pin 3 (PWM)	(PCINT19/OC2B/INT1) PD3	5	24	PC1 (ADC1/PCINT9) analog input 1
digital pin 4	(PCINT20/XCK/T0) PD4	6	23	PC0 (ADC0/PCINT8) analog input 0
VCC	VCC	7	22	GND GND
GND	GND	8	21	AREF analog reference
crystal	(PCINT6/XTAL1/TOSC1) PB6	9	20	AVCC VCC
crystal	(PCINT7/XTAL2/TOSC2) PB7	10	19	PB5 (SCK/PCINT5) digital pin 13
digital pin 5 (PWM)	(PCINT21/OC0B/T1) PD5	11	18	PB4 (MISO/PCINT4) digital pin 12
digital pin 6 (PWM)	(PCINT22/OC0A/AIN0) PD6	12	17	PB3 (MOSI/OC2A/PCINT3) digital pin 11(PWM)
digital pin 7	(PCINT23/AIN1) PD7	13	16	PB2 (SS/OC1B/PCINT2) digital pin 10 (PWM)
digital pin 8	(PCINT0/CLKO/ICP1) PB0	14	15	PB1 (OC1A/PCINT1) digital pin 9 (PWM)

Digital Pins 11, 12 & 13 are used by the ICSP header for MOSI, MISO, SCK connections (Atmega168 pins 17, 18 & 19). Avoid low-impedance loads on these pins when using the ICSP header.

Fig 4.4 ARDUINO PINS CONFIGURATION

4.3 INTERNET OF THINGS

The **internet of things (IoT)** is the network of physical devices, vehicles, buildings and other items embedded with electronics, software, sensors, actuators, and network connectivity that enable these objects to collect and exchange data. In 2013 the Global Standards Initiative on Internet of Things (IoT-GSI) defined the IoT as "the infrastructure of the information society. The IoT allows objects to be sensed and controlled remotely across existing network infrastructure, creating opportunities for more direct integration of the physical world into computer-based systems, and resulting in improved efficiency, accuracy and economic benefit. When IoT is augmented with sensors and actuators, the technology becomes an instance of the more general class of cyber-physical systems, which also encompasses technologies such as smart grids, smart homes, intelligent transportation and smart cities. Each thing is uniquely identifiable through its embedded computing system but is able to interoperate within the existing

Internet infrastructure. Experts estimate that the IoT will consist of almost 50 billion objects by 2020.

4.3.1 ESP-12E BASED NODEMCU

The ESP8266 is the name of a micro controller designed by Espressif Systems. The ESP8266 itself is a self-contained Wi-Fi networking solution offering as a bridge from existing micro controller to Wi-Fi and is also capable of running self-contained applications. This module comes with a built in USB connector and a rich assortment of pin-outs. With a micro USB cable, you can connect NodeMCUdevkit to your laptop and flash it without any trouble, just like Arduino. It is also immediately breadboard friendly.

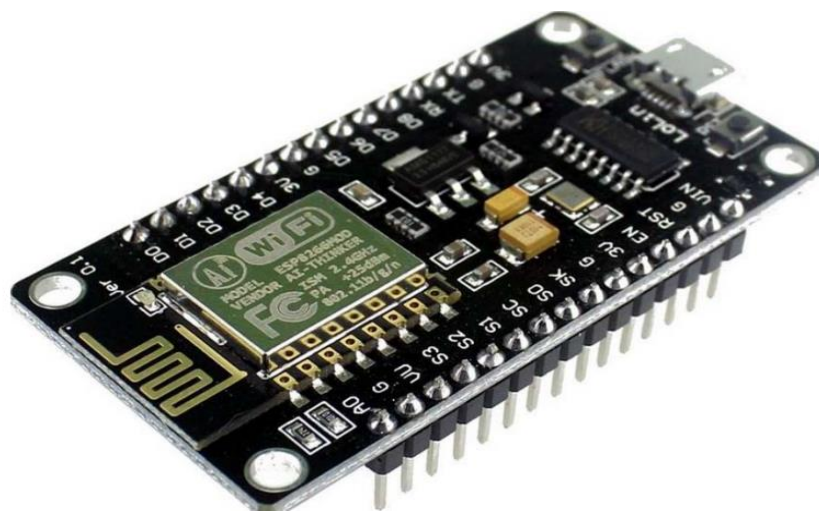


Fig 4.5 ESP-12E BASED NODEMCU

ESP-12E Wi-Fi module is developed by Ai-thinker Team. core processor ESP8266 in smaller sizes of the module encapsulates Tensilica L106 integrates industry-leading ultra-low power 32-bit MCU micro, with the 16-bit short mode, Clock speed support 80 MHz, 160 MHz, supports the RTOS, integrated Wi-Fi MAC/BB/RF/PA/LNA, on-board antenna. The module supports standard IEEE802.11 b/g/n agreement, complete TCP/IP protocol stack. Users can use the add modules to an existing device networking, or building a separate network controller. ESP8266 is high integration wireless SOCs, designed for space and power constrained mobile platform designers. It provides unsurpassed ability to embed Wi-Fi capabilities within other systems, or to function as a standalone application, with the lowest cost, and minimal space requirement.

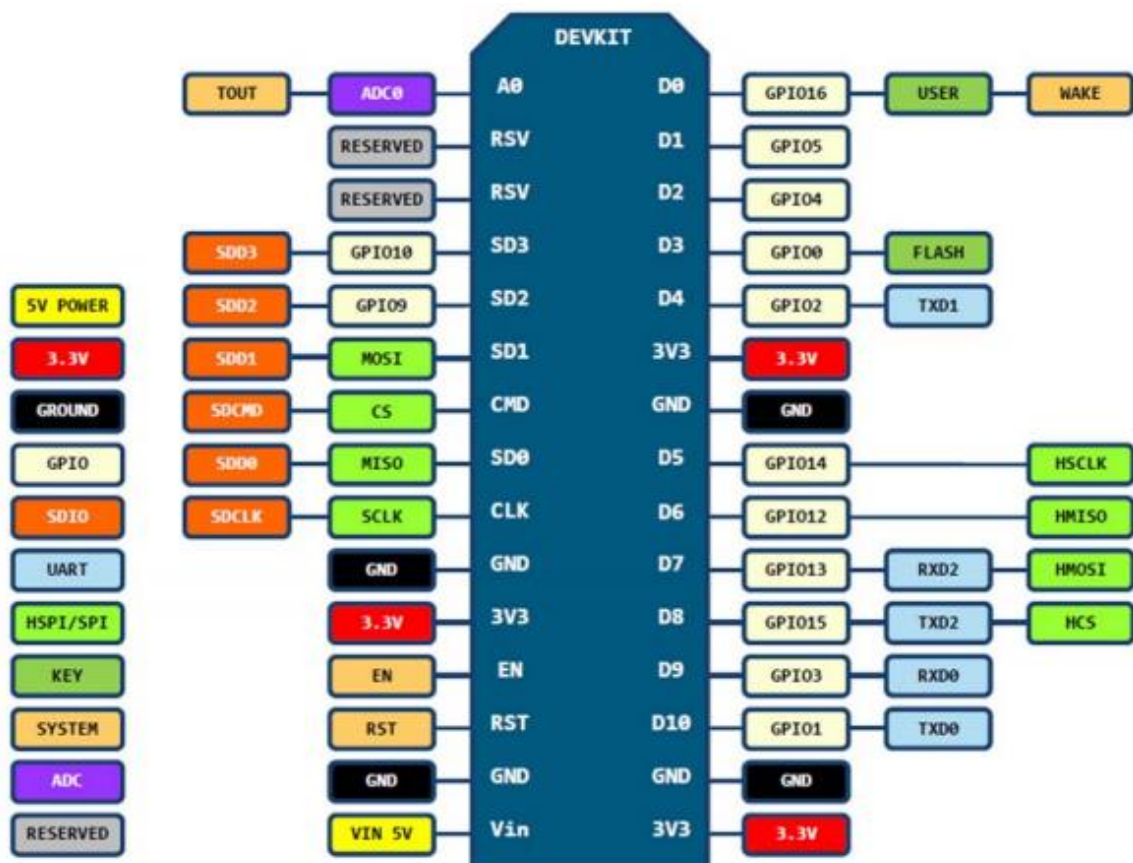


Fig 4.6 NODEMCU PIN CONFIGURATION

ESP8266EX offers a complete and self-contained Wi-Fi networking solution; it can be used to host the application or to offload Wi-Fi networking functions from another application processor. When ESP8266EX hosts the application, it boots up directly from an external flash. It has integrated cache to improve the performance of the system in such applications. Alternately, serving as a Wi-Fi adapter, wireless internet access can be added to any micro controller-based design with simple connectivity (SPI/SDIO or I2C/UART interface). ESP8266EX is among the most integrated Wi-Fi chip in the industry; it integrates the antenna switches, RF balun, power amplifier, low noise receive amplifier, filters, power management modules, it requires minimal external circuitry, and the entire solution, including front-end module, is designed to occupy minimal PCB area.

Table 4.2.2 ESP-12E PIN DESCRIPTION

NO.	Pin Name	Function
1	RST	Reset the module
2	ADC	A/D Conversion result. Input voltage range 0-1v, scope: 0-1024
3	EN	Chip enable pin. Active high
4	IO16	GPIO16; can be used to wake up the chipset from deep sleep mode.
5	IO14	GPIO14; HSPI_CLK
6	IO12	GPIO12; HSPI_MISO
7	IO13	GPIO13; HSPI_MOSI; UART0_CTS
8	VCC	3.3V power supply (VDD)
9	CS0	Chip selection
10	MISO	Salve output Main input

11	IO9	GPIO9
12	IO10	GPIO10
13	MOSI	Main output slave input
14	SCLK	Clock
15	GND	GND
16	IO15	GPIO15; MTDO; HSPI_CS; UART0_RTS
17	IO2	GPIO2; UART1_TXD
18	IO0	GPIO0
19	IO4	GPIO4
20	IO5	GPIO5
21	RXD	UART0_RXD; GPIO3
22	TXD	UART0_TXD; GPIO1

4.4 MQ2- GAS SENSOR FOR AIR QUALITY

Sensitive material of MQ-2 gas sensor is SnO_2 , which with lower conductivity in clean air. When the target combustible gas exist, The sensor's conductivity is more higher along with the gas concentration rising. Please use simple electrocircuit, Convert change of conductivity to correspond output signal of gas concentration. MQ-2 gas sensor has high sensitivity to LPG, Propane and Hydrogen, also could be used to Methane and other combustible steam, it is with low cost and suitable for different application. Sensor is sensitive to flammable gas and smoke. Smoke sensor is given 5 volt to power it. Smoke sensor indicate smoke by the voltage that it outputs .More smoke more output. A potentiometer is provided to adjust the sensitivity. But when smoke exist sensor provides an analog resistive output based on concentration of smoke. The circuit has a heater. Power is given to heater by VCC and GND from power supply. The circuit has a variable resistor. The resistance across the pin depends on the smoke in air in the sensor. The resistance will be lowered if the content is more. And voltage is increased between the sensor and load resistor.

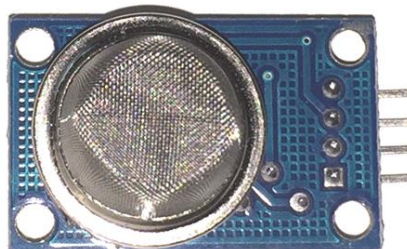


Fig 4.7 GAS SENSOR

The MQ2 has an electrochemical sensor, which changes its resistance for different concentrations of varied gasses. The sensor is connected in series with a variable resistor to form a voltage divider circuit (figure shown below), and the variable resistor is used to change sensitivity. When one of the above gaseous elements comes in contact with the sensor after heating, the sensor's resistance change. The change in the resistance changes the voltage across the sensor, and this voltage can be read by a microcontroller. The voltage value can be used to

find the resistance of the sensor by knowing the reference voltage and the other resistor's resistance. The sensor has different sensitivity for different types of gasses.

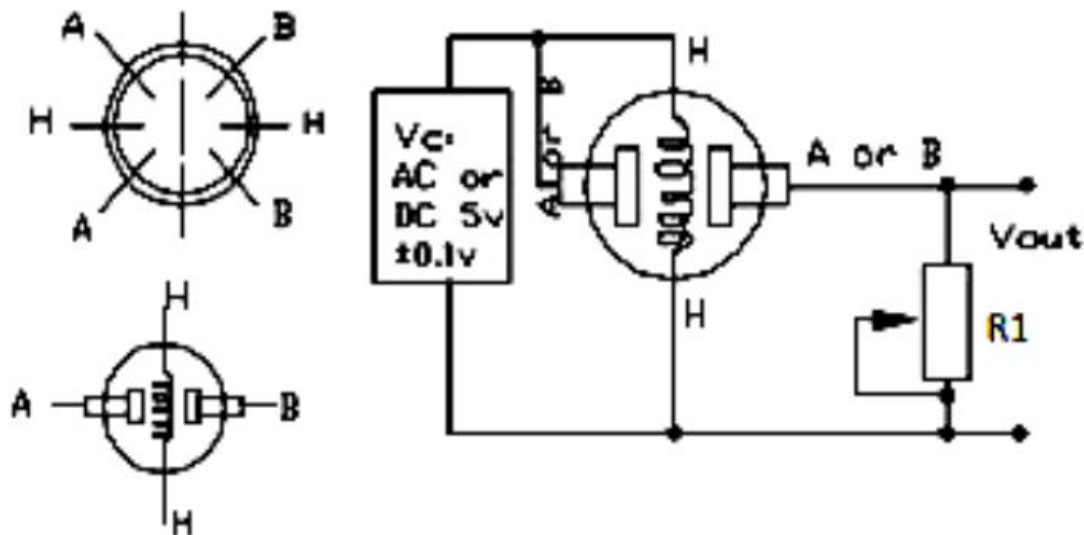


Fig 4.8 GAS SENSOR BLOCK DIAGRAM

Table 4.2.3 PIN CONFIGURATION:

Pin No:	Pin Name:	Description
For Module		
1	Vcc	Used to power the sensor, Generally the operating voltage is +5V.
2	Ground	Used to connect the module to system ground.

3	Digital Out	You can also use this sensor to get digital output from this pin, by setting a threshold value using the potentiometer.
4	Analog Out	This pin outputs 0-5V analog voltage based on the intensity of the gas.
For Sensor		
1	H -Pins	Out of the two H pins, one pin is connected to supply and the other to ground
2	A-Pins	The A pins and B pins are interchangeable. These pins will be tied to the Supply voltage.
3	B-Pins	20. A pins and B pins are interchangeable. One pin will act as output while the other will be pulled to ground.

When it comes to measuring or detecting a particular Gas the MQ series Gas sensors are the most inexpensive and commonly used ones. **MQ135** is available as a module or as just the sensor alone. If you are trying to only detect (not measuring PPM) the presence of a gas then you can buy it as a module since it comes with an op-amp comparator and a digital output pin. But if you planning to measure the PPM of a gas it is recommend buying the sensor alone without module.

4.5 ACELEROMETER

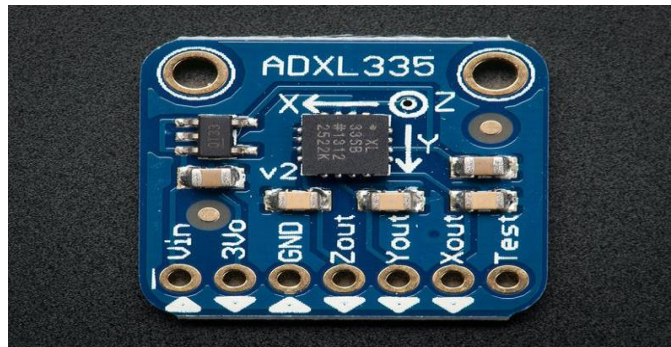


Fig 4.9 ACELEROMETER SENSOR

The ADXL335 is a small, thin, low power, complete 3-axis accelerometer with signal conditioned voltage outputs. The product measures acceleration with a minimum full-scale range of $\pm 3\text{ g}$. It can measure the static acceleration of gravity in tilt sensing applications, as well as dynamic acceleration resulting from motion, shock, or vibration. The user selects the bandwidth of the accelerometer using the CX, CY, and CZ capacitors at the XOUT, YOUT, and ZOUT pins. Bandwidths can be selected to suit the application, with a range of 0.5 Hz to 1600 Hz for X and Y axes, and a range of 0.5 Hz to 550 Hz for the Z axis. The ADXL335 is available in a small, low profile, 4 mm $\times$ 4 mm $\times$ 1.45 mm, 16-lead, plastic lead frame chip scale package(LFCSP_LQ).

4.6 HUMIDITY SENSOR:

This DHT11 Temperature & Humidity Sensor features a temperature & humidity sensor complex with a calibrated digital signal output. By using the exclusive digital-signal-acquisition technique and temperature & humidity sensing technology, it ensures high reliability and excellent long-term stability. This sensor includes a resistive-type humidity measurement component and an NTC temperature measurement component, and connects to a high-performance 8-bit microcontroller, offering excellent quality, fast response, anti-interference ability and cost-effectiveness. Each DHT11 element is strictly calibrated in the laboratory that is extremely accurate on humidity calibration. The single-wire serial interface makes system integration quick and easy.

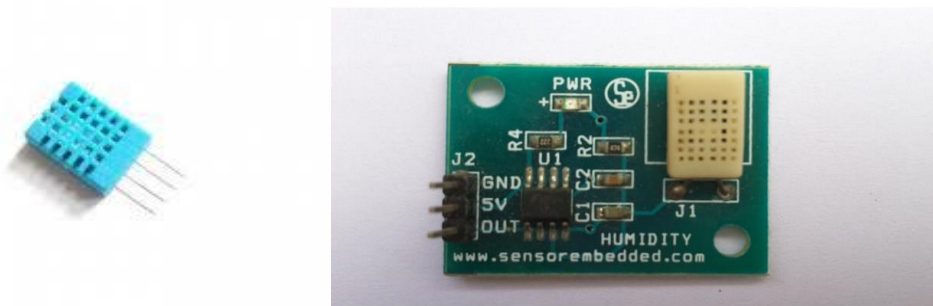


Fig 4.10 HUMIDITY SENSOR

4.7 TEMPERATURE SENSOR

The DS18B20 digital thermometer provides 9-bit to 12-bit Celsius temperature measurements and has an alarm function with non-volatile userprogrammableupper and lower trigger points. The DS18B20 communicates over a 1-Wire bus that by definition requires only one data line for communication with a central microprocessor. It can derive power directly from the data line, eliminating the need for an external power supply.

4.7.1 DESCRIPTION

DS18B20 sensor is a pre-wired and waterproofed. While the sensor is good up to 125°C, the cable is jacketed in PVC, so we suggest keeping it under 100°C. Because they are digital, you don't get any signal degradation even over long distances. These 1-wire digital temperature sensors are fairly precise ($\pm 0.5^\circ\text{C}$ over much of the range) and can give up to 12 bits of precision from the onboard digital-to-analog converter. They work great with any microcontroller using a single digital pin, and you can even connect multiple ones to the same pin, each one has a unique 64-bit ID burned in at the factory to differentiate them. When using with microcontroller put a 4.7k resistor to sensing pin, which is required as a pull-up from the DATA to VCC line.

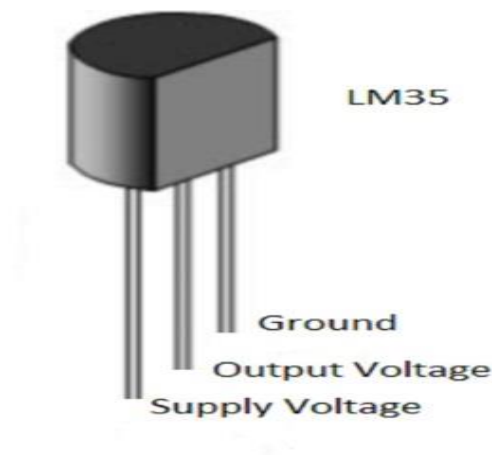


Fig 4.11 LM35

4.8 HEART BEAT SENSOR

This project uses bright infrared (IR) LED and a phototransistor to detect the pulse of the finger, a red LED flashes with each pulse. Pulse monitor works as follows: The LED is the light side of the finger, and phototransistor on the other side of the finger, phototransistor used to obtain the flux emitted, when the blood pressure pulse by the finger when the resistance of the photo transistor will be slightly changed. The project's schematic circuit as shown, We chose a very high

resistance resistor R1, because most of the light through the finger is absorbed, it is desirable that the phototransistor is sensitive enough. Resistance can be selected by experiment to get the best results. The most important is to keep the shield stray light into the phototransistor. For home lighting that is particularly important because the lights at home mostly based 50HZ or 60HZ fluctuate, so faint heartbeat will add considerable noise.



Fig 4.12 HEARTBEAT SENSOR

4.9 SOUND SENSOR

The sound sensor module provides an easy way to detect sound and is generally used for detecting sound intensity. This module can be used for security, switch, and monitoring applications. Its accuracy can be easily adjusted for the convenience of usage.

It uses a microphone which supplies the input to an amplifier, peak detector and buffer. When the sensor detects a sound, it processes an output signal voltage which is sent to a microcontroller then performs necessary processing.

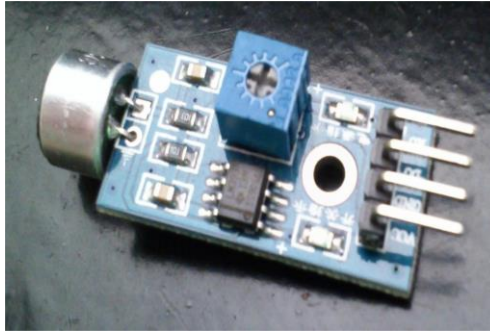


Fig 4.13 SOUND SENSOR

4.10 LIQUID CRYSTAL DISPLAY:

LCD screen is an electronic display module and find a wide range of applications. A 16x2 LCD display is very basic module and is very commonly used in various devices and circuits. These modules are preferred over seven segments and other multi segment LEDs. The reasons being: LCDs are economical; easily programmable; have no limitation of displaying special & even custom characters (unlike in seven segments), animations and so on.

A 16x2 LCD means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in 5x7 pixel matrix. This LCD has two registers, namely, Command and Data. The command register stores the command instructions given to the LCD. A command is an instruction given to LCD to do a predefined task like initializing it, clearing its screen, setting the cursor position, controlling display etc. The data register stores the data to be displayed on the LCD. The data is the ASCII value of the character to be displayed on the LCD. Click to learn more about internal structure of a LCD.

We come across LCD displays everywhere around us. Computers, calculators, television sets, mobile phones, digital watches use some kind of display to display the time. An LCD is an electronic display module which uses liquid crystal to produce a visible image. The 16x2 LCD display is a very basic module commonly used in projects. The 16x2 translates to a display 16 characters per line in 2 such lines. In this LCD each character is displayed in a 5x7 pixel matrix.

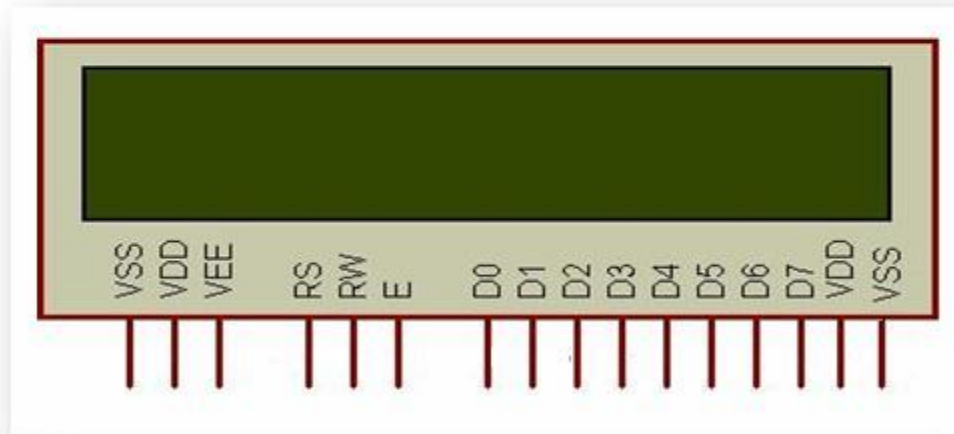


Fig 4.14 16X2 LCD PINOUT DIAGRAM

Table 4.2.4 LCD PIN DESCRIPTION

PIN NO.	FUNCTION	NAME
1	Ground (0V)	Ground
2	Supply voltage; 5V (4.7V – 5.3V)	VCC
3	Contrast adjustment; the best way is to use a variable resistor such as a potentiometer. The output of the potentiometer is connected to this pin. Rotate the potentiometer knob forward and backwards to adjust the LCD contrast.	Vo / VEE
4	Selects command register when low, and data register when	RS (Register

	high	Select)
5	Low to write to the register; High to read from the register	Read/write
6	Sends data to data pins when a high to low pulse is given; Extra voltage push is required to execute the instruction and EN(enable) signal is used for this purpose. Usually, we make it en=0 and when we want to execute the instruction we make it high en=1 for some milliseconds. After this we again make it ground that is, en=0.	Enable
7	8-bit data pins	DB0
8		DB1
9		DB2
10		DB3
11		DB4
12		DB5
13		DB6
14		DB7
15	Backlight VCC (5V)	Led+
16	Backlight Ground (0V)	Led-

4.11 BUZZER:

A buzzer or beeper is an audio signaling device, which may be mechanical, electromechanical, or piezoelectric (piezo for short). Typical uses of buzzers and beepers include alarm devices, timers, and confirmation of user input such as a mouse click or keystroke.



Fig 4.15 BUZZER

4.12 LIGHT EMITTING DIODE:

The Light emitting diode is a two-lead semiconductor light source. In 1962, Nick Holonyak has come up with an idea of light emitting diode, and he was working for the general electric company. The LED is a special type of diode and they have similar electrical characteristics of a PN junction diode. Hence the LED allows the flow of current in the forward direction and blocks the current in the reverse direction. The LED occupies the small area which is less than the **1 mm²**. The applications of LEDs used to make various electrical and electronic projects. In this article, we will discuss the working principle of the LED and its applications.

4.12.1 WORKING PRINCIPLE OF LED:

The working principle of the Light emitting diode is based on the quantum theory. The quantum theory says that when the electron comes down from the higher energy level to the lower energy level then, the energy emits from the photon. The

photon energy is equal to the energy gap between these two energy levels. If the PN-junction diode is in the forward biased, then the current flows through the diode.

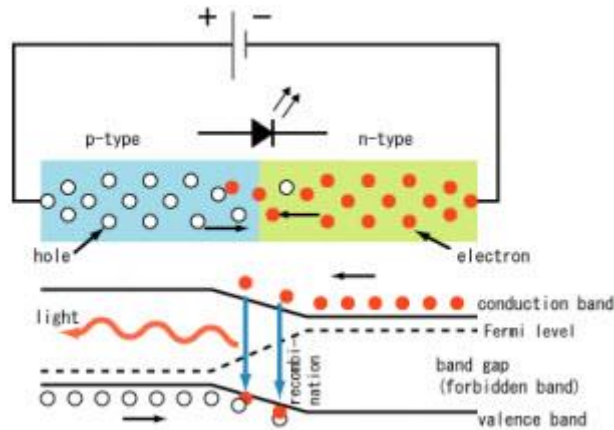


Fig 4.16 LED

The flow of current in the semiconductors is caused by the both flow of holes in the opposite direction of current and flow of electrons in the direction of the current. Hence there will be recombination due to the flow of these charge carriers.

The recombination indicates that the electrons in the conduction band jump down to the valence band. When the electrons jump from one band to another band the electrons will emit the electromagnetic energy in the form of photons and the photon energy is equal to the forbidden energy gap.

For an example, let us consider the quantum theory, the energy of the photon is the product of both Planck constant and frequency of electromagnetic radiation. The mathematical equation is shown

$$E_p = hf$$

Where h is known as a Planck constant, and the velocity of electromagnetic radiation is equal to the speed of light i.e c . The frequency radiation is related to the velocity of light as $f = c / \lambda$. λ is denoted as a wavelength of an electromagnetic radiation and the above equation will become as

$$E_g = h c / \lambda$$

From the above equation, we can say that the wavelength of electromagnetic radiation is inversely proportional to the forbidden gap. In general silicon, germanium semiconductors this forbidden energy gap is between the conduction and valence bands are such that the total radiation of electromagnetic wave during recombination is in the form of the infrared radiation. We can't see the wavelength of infrared because they are out of our visible range.

The infrared radiation is said to be as a heat because the silicon and the germanium semiconductors are not direct gap semiconductors rather these are indirect gap semiconductors. But in the direct gap semiconductors, the maximum energy level of the valence band and minimum energy level of conduction band does not occur at the same moment of electrons. Therefore, during the recombination of electrons and holes are a migration of electrons from the conduction band to valence band the momentum of electron band will be changed.

4.13 GLOBAL SYSTEM FOR MOBILE COMMUNICATION (GSM)

Global system for mobile communication (GSM) is a globally accepted standard for digital cellular communication. GSM is the name of a standardization group established in 1982 to create a common European mobile telephone standard that would formulate specifications for a pan-European mobile cellular radio system operating at 900 MHz. It is estimated that many countries outside of Europe will join the GSM partnership.

4.13.1 THE EVOLUTION OF MOBILE TELEPHONE SYSTEMS:

Cellular is one of the fastest growing and most demanding telecommunications applications. Today, it represents a continuously increasing percentage of all new telephone subscriptions around the world. Currently there are more than 45 million cellular subscribers worldwide, and nearly 50 percent of those subscribers are located in the United States. It is forecasted that cellular systems using a digital technology will become the universal method of telecommunications. By the year 2005, forecasters predict that there will be more than 100 million cellular subscribers worldwide. It has even been estimated that some countries may have more mobile phones than fixed phones by the year 2000.



Fig 4.17 SIM 900 GSM/GPRS MODULE

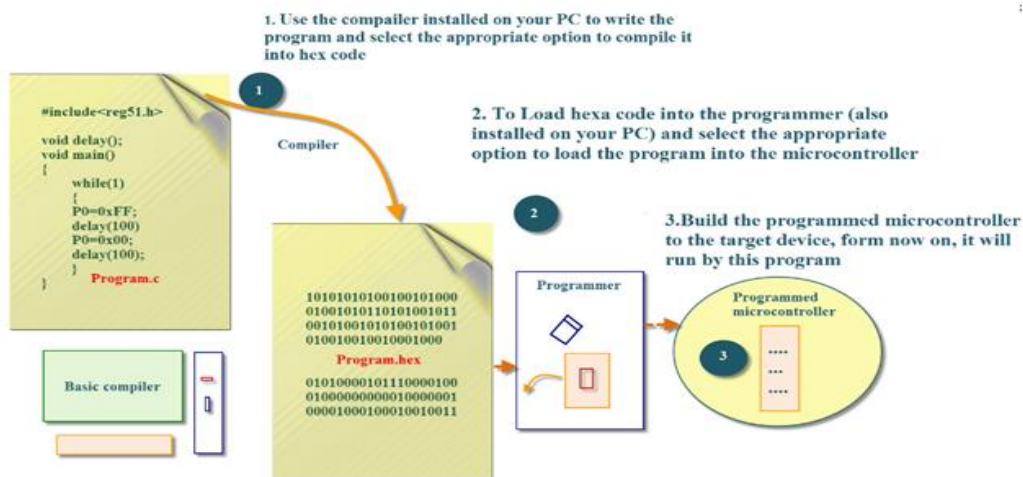
GSM/GPRS Modem-RS232 is built with Dual Band GSM/GPRS engine- SIM900, works on frequencies 900/ 1800 MHz. The Modem is coming with RS232 interface, which allows you connect PC as well as microcontroller with RS232 Chip (MAX232). The baud rate is configurable from 9600-115200 through AT command. The GSM/GPRS Modem is having internal TCP/IP stack to enable you to connect with internet via GPRS. It is suitable for SMS, Voice as well as DATA transfer application in M2M interface. The onboard Regulated Power supply allows you to connect wide range unregulated power supply. Using this modem, you can make audio calls, SMS, Read SMS, attend the incoming calls and internet through simple AT commands.

4.14 EMBEDDED C:

Embedded C is most popular programming language in software field for developing electronic gadgets. Each processor used in electronic system is associated with embedded software.

Embedded C programming plays a key role in performing specific function by the processor. In day-to-day life we used many electronic devices such as mobile phone, washing machine, digital camera, etc. These all device working is based on microcontroller that are programmed by embedded C.

Let's see the block diagram representation of embedded system programming:



The Embedded C code written in above block diagram is used for blinking the LED connected with Port0 of microcontroller.

In embedded system programming C code is preferred over other language. Due to the following reasons:

- Easy to understand
- High Reliability
- Portability
- Scalability

4.14.1 EMBEDDED SYSTEMS:

Embedded System is a system composed of hardware, application software and real time operating system. It can be small independent system or large combinational system.

Our Embedded System tutorial includes all topics of Embedded System such as characteristics, designing, processors, microcontrollers, tools, addressing modes, assembly language, interrupts, embedded c programming, led blinking, serial communication, lcd programming, keyboard programming, project implementation etc.

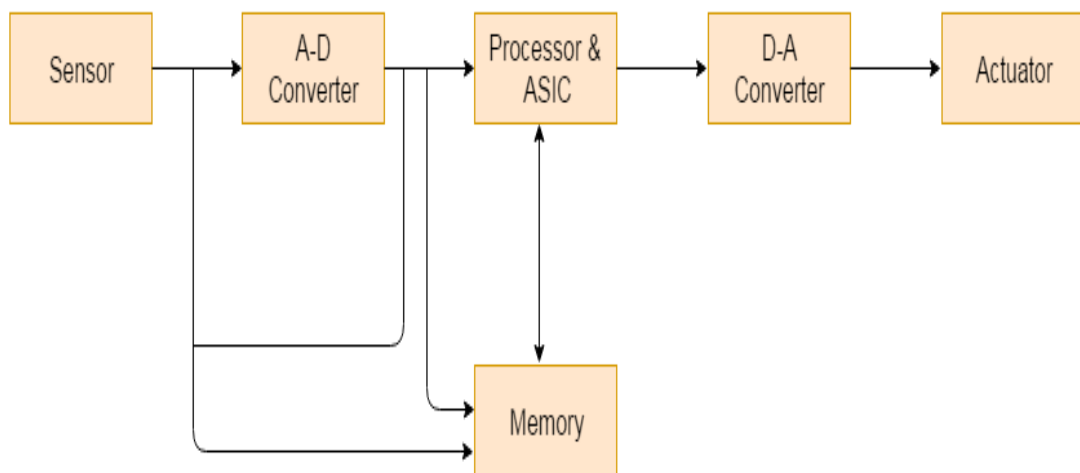


Fig 4.18 BASIC STRUCTURE OF AN EMBEDDED SYSTEM

4.15 ARDUINO SOFTWARE (IDE):

The Arduino Integrated Development Environment - or Arduino Software (IDE) - contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions and a series of menus. It connects to the Arduino and Genuino hardware to upload programs and communicate with them.

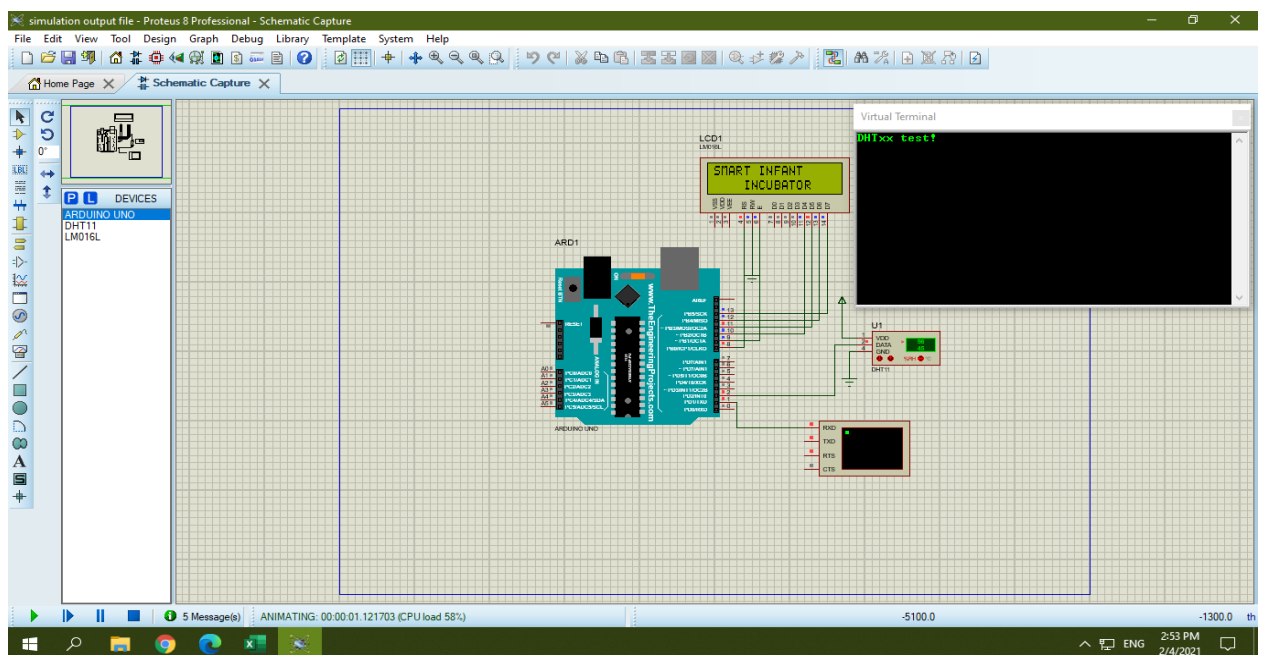
CHAPTER 5

RESULTS AND DISCUSSION

5.1 RESULTS

The sensor response was monitored by changes in ambient humidity and temperature. During measurements, the sensor has taken a measurement per second. In order to ensure that the values shown on the display do not change too much, the average values of each of the ten readings of the sensor are taken and printed on the LCD. The sensor accuracy was also checked using the humidity cabinet and the air conditioning cabinet (Fig.10). Moisture is increased by increasing the humidity inside the cabinet. Humidity was reduced by using a vacuum motor at 30-minute intervals. A total of 3 values were compared and the levels of acceptability were compared to standards, as a result the values were found to be appropriate.

5.1.1 OUTPUT OF DHT11 SENSOR



5.2 DISCUSSION

It will discuss the results of tests that have been obtained and examined about the measurement of heart rate by pulse sensor, body length with ultrasonic sensors and weight with load-cell sensors. The purpose of this test is to know the level of precision and resistance of the system. However, in this research, it was unable to conduct a premature baby's heartbeat because the system is still in the preliminary studies so may be not secure yet for premature babies which is very sensitive to external interactions of physical as well as non-physical. In order to obtain the validation of data, every measurement has been repeated ten times in the same condition.

The developed Advanced incubator promotes the existing infant incubators. In addition to the main function of the Advanced incubator such as warming, the incubator adds the mobility feature which makes the handling of the infant more easily, allows for breastfeeding and conserves the infantmother bond. The warming system consists of 3 main parts batteries, heaters, and insulation. Batteries are the sources of energy which give the system its mobility feature, it can store enough energy to power the system. The stored energy is converted by a heater which acts as simple resistor that converts electrical energy into thermal energy. The last part is the isolation, it provides the use of the temperature that expands the batterie's life span. To conclude, advanced incubator provides the warming feature of incubator, also it provides other features such as continuous monitoring and temporary treatment to get the healthcare necessary to the infant survive.

CHAPTER 6

SUMMARY AND CONCLUSION

6.1 SUMMARY

The proposed system involves the **use** of Node MCU integrated to various sensor units such as pulse, gas, light, temperature, and humidity sensors. The readings of the sensor are continuously monitored with help of IoT and can be controlled, thereby providing efficient and safe working of an **incubator**. This paper deals with the cost-worthy design of an embedded device for real time monitoring of newborn babies in the incubator. In smart incubator a child's medical data can be checked through mobile phones or computers by the doctors or nurses from the place where they are accessing by the cloud storage through the internet. The smart Incubator is a one which monitors the newborn baby continuously and which sends the medical data directly to the cloud storage and the data's are stored. The medical data can be viewed from mobile phones and computer systems from the place where they are and from they can take actions. The change in health parameters can be closely monitored using this method. The accurate values are displayed so that the doctors can check the baby's health easily and they can avoid babies having health problems.

6.2 CONCLUSION

With this project, it is determined that an incubator calibrator can be designed. By using more sensitive sensors it can also satisfies the requirements of the standards. As a literature search, the incubator has been used in the field of medicine, the incubator calibration procedure, the investigation of the calibration standards, temperature, humidity and oxygen sensor research were conducted. Detailed investigation of the sensors was made and the technical characteristics of the sensors were examined. Standards for incubator calibration were reviewed. In order to comply with the standards, the number of sensors of the incubator analyzer was determined to be 5 points. Within the scope of design, Microprocessor-LCD communication and microprocessor temperature-humidity sensor communication and Microprocessor - Oxygen sensor communication are provided by necessary firmware. The overall circuit of the project has been designed, in addition the battery circuit and the outer box design has been

completed. Accuracy of the preboxing sensor was checked in the humidity and air conditioning cabinet, and the acceptability of the obtained values was evaluated. Printed circuit design was realized by computer aided design, and the sensor, microcontroller, LCD, rechargeable battery circuit, power switch, and charge input connections are combined on the printed circuit. The obtained test results are shown that with more accurate sensors this analyzer can be used as an incubator analyzer.

REFERENCES

1. Al- Saffar, Ahmad J , Abbas, Esam , Fardoun .A, Ismail.H ,Mustafa A , Sabzali and, (2008) 'wireless transmission of health parameters in baby incubator, IEEE Transactions on modern technology Vol. 23,Issue 5, pp. 115-121.
2. ChaninBunlaksananusorn,Vuthchhay Eng,and UnnatPinsopon 'Start up incubators and the role of social capital', IEEE Transactions on Biomedical Engineering, Vol.3, Issue 2, pp. 265-271.
- 3..Jaiganesh, R. "Smart Grid System for Water Pumping and Domestic Application using Arduino Controller." International Journal of Engineering Research & Technology (IJERT) 5.13 (2017): 583 588 (2017)
- 4..Jaiganesh, R. Grocery Theft and Monitoring Using IoT for Stack Management application" International Journal of Engineering Research & Technology (IJERT) 4.08 (2018): 583 588 (2018).
5. George Cajazeiras Silveira, Fernando LessaTofoli, Luiz Daniel SantosBezerra and René Pastor TorricoBascopé (2009) 'Internet of things',IEEE Transactions on Internet of things Vol. 60, Issue 5, pp. 1861– 1871.
6. Khalid,Mohamed.H, Taib, Ibrahim . Band Nordin B. Saad (2013) 'Neonatal intensive care unit', IEEE Conference Vol. 2, Issue 1, pp. 107-112.

7. Mitulkumar, Dave.R, K.C.Dave (2012) 'Cloud computing and storage network', IEEE International Journal of Engineering Trends and Technology- Vol. 3 Issue2, pp. 118-123.
8. Marian K. Kazimierczuk and Antonio Massarini (1997) 'sensors with Internet of things', IEEE Vol. 44, Issue 2, pp. 1215-1221.
9. Hittu Mittal, LiniMatthew, Ashish Gupta, "Design and development of an infant incubator for controlling multiple parameters", International Journal of emerging trends in electrical and electronics.
10. N.A.A Hadi, M.H. C Hasan, NMZ Hashim, N.R. Mohmmad, A.S. Rahimi, K.A. Annvar, "Temperature monitoring system for infant incubator using arduino", International Journal for Advance Research in engineering & technology.
- 11.Sahib.M, Rashid.M, Hmawy.L, Arnout.M, El.Majzoub and A.J. Zaylaa, "Advanced portable preterm baby incubator", 2017 Fourth Internatinal Conference on Advances in Biomedical Engineering.
- 12.Slti Farhani, Mohd Amin (2015) "Temperature monitoring system for infant incubator using Arduino Project Report Utem", School of electronics and Computer science at university of Southampton.
- 13..Suruthi.M Suma.S "Microcontroller Based Baby Incubator Using Sensors",International Journal of Innovative Research in Science, Engineering and Technology. IJIRSET,Vol. 4, Issue 12, December 2015,
- 14.OnurKircioölu, Murat Unlu and SabriÇamur (2009) 'Advanced portable preterm baby incubator ' IEEE Transactions on Advances in Biomedical Engineering issue 4, pp. 158-162.
- 15.Riscila Facco de elo et al oger ules, Eduardo F elixRibeiroRomaneli, and Rafael ChristianoAnnunziato (2010) 'Temperature monitored lot based smart incubator', IEEE Transactions on Technology & Engineering Management, Vol. 25, Issue 2, pp.188-193.

APPENDICES

```
#include<LiquidCrystal.h>

#include<SoftwareSerial.h>

#include<DHT.h>

#define DHTPIN 7

#define DHTTYPE DHT11

LiquidCrystallcd (8, 9, 10, 11, 12, 13);

SoftwareSerialgsm(2, 3); //(rx,tx)


#define x_axis A5

#define heart_beat A0

#define led A1

#define buzzer A2

#define mic A3

#define gas A4

DHT dht(DHTPIN, DHTTYPE);


Voidiot(String stringdata);

int message(String phno, String message);


void setup()

{
```

```

    // put your setup code here, to run once:

    Serial.begin(9600); //iot

    gsm.begin(9600);    //message

    lcd.begin(16, 2);

    dht.begin();

    pin Mode(gas, INPUT);

    pin Mode(mic, INPUT);

    pin Mode(x_axis, INPUT);

    pin Mode(heart_beat, INPUT);

    pinMode(buzzer, OUTPUT);

    pinMode(led, OUTPUT);

    digitalWrite(led, LOW);

    digitalWrite(buzzer, LOW);

    lcd.clear();

    lcd.setCursor(0,0);

    lcd.print("BABY INCUBATOR");

    delay(1000);

}

void loop()

{

    // put your main code here, to run repeatedly:

    lcd.clear();

```

```

int heartbeat = heart();

int h_gas = digitalRead(gas);

int voice = digitalRead(mic);

int axis = analogRead(x_axis);

float t = dht.readTemperature();

//Serial.println(axis);


if (heartbeat > 60 && heartbeat < 120)
{
  lcd.clear();

  lcd.setCursor(0, 0);

  lcd.print("HEART NORMAL");

}

else

{

  lcd.clear();

  lcd.setCursor(0, 0);

  lcd.print("HEART ABNORMAL");

  digitalWrite(buzzer, HIGH);

  digitalWrite(led, HIGH);

  message("8917604022", "HEART ABNORMAL");

  digitalWrite(buzzer, LOW);

  digitalWrite(led, LOW);

```

```

iot("*HEART ABNORMAL#");

}

if (h_gas == 0)

{

lcd.clear();

lcd.setCursor(0, 0);

lcd.print("TOXIC GAS");

lcd.setCursor(0, 1);

lcd.print("DETECTED");

digitalWrite(buzzer, HIGH);

digitalWrite(led, HIGH);

message("9943853330", "TOXIC GAS DETECTED");

digitalWrite(buzzer, LOW);

digitalWrite(led, LOW);

iot("*TOXIC GAS DETECTED#");

}

if (voice == 0)

{

lcd.clear();

lcd.setCursor(0, 0);

lcd.print("BABY CRYING");

```

```

digitalWrite(buzzer, HIGH);

digitalWrite(led, HIGH);

message("9943853330", "BABY CRYING");

digitalWrite(buzzer, LOW);

digitalWrite(led, LOW);

iot("*BABY CRYING#");

}

if (t > 33)

{

lcd.clear();

lcd.setCursor(0, 0);

lcd.print("TEMPERATURE");

lcd.setCursor(0, 1);

lcd.print("IS HIGH");

digitalWrite(buzzer, HIGH);

digitalWrite(led, HIGH);

message("9943853330", "TEMPERATURE IS HIGH");

digitalWrite(buzzer, LOW);

digitalWrite(led, LOW);

iot("*TEMPERATURE IS HIGH#");

}

```

```

    if (axis < 400)

    {

    lcd.clear();

    lcd.setCursor(0, 0);

    lcd.print("BABY BODY");

    lcd.setCursor(0, 1);

    lcd.print("POSITION CHANGE");

    digitalWrite(buzzer, HIGH);

    digitalWrite(led, HIGH);

    message("9943853330", "BABY BODY POSITION CHANGE");

    digitalWrite(buzzer, LOW);

    digitalWrite(led, LOW);

    iot("*BABY BODY POSITION CHANGE#");

    }

    delay(1000);

}

```

```

int heart()

{

    int j = 120;

    int i = 0;

    while (j > 0)

    {

```

```

        if (digitalRead(heart_beat) == LOW)

i++;

        j--;

delay(14);

    }

    return i;

}


int message(String phno, String message)

{

gsm.println("AT");

delay(100);

gsm.println("AT+CMGF=1");

delay(100);

gsm.println("AT+CMGS=\"+91\" + phno + \"\\r\");

delay(100);

gsm.println(message);

delay(100);

gsm.println((char)26);

delay(1200);

}

```

```
void iot(String stringdata)    //iot function
{
    for (int i = 0; i<stringdata.length(); i++)
    {
        Serial.write(stringdata[i]);
    }
    delay(4000);
}
```