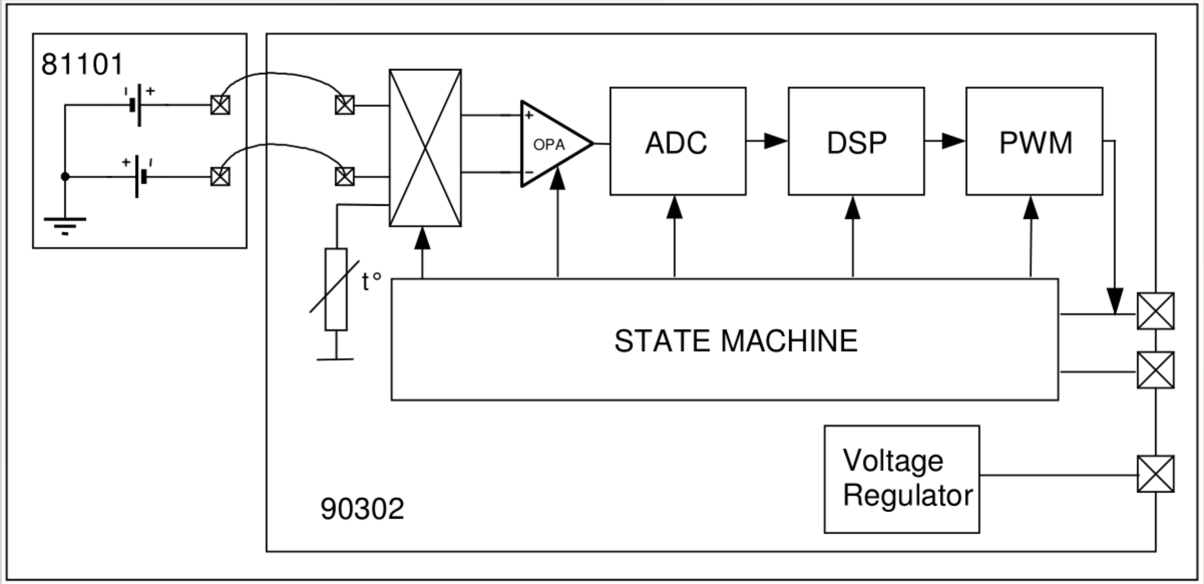
SENSORS

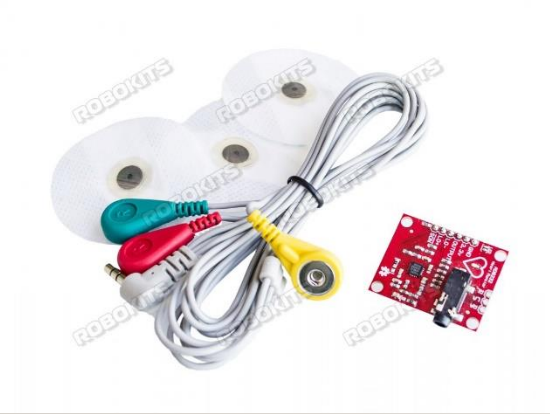
MLX90614 TEMPERATURE SENSOR

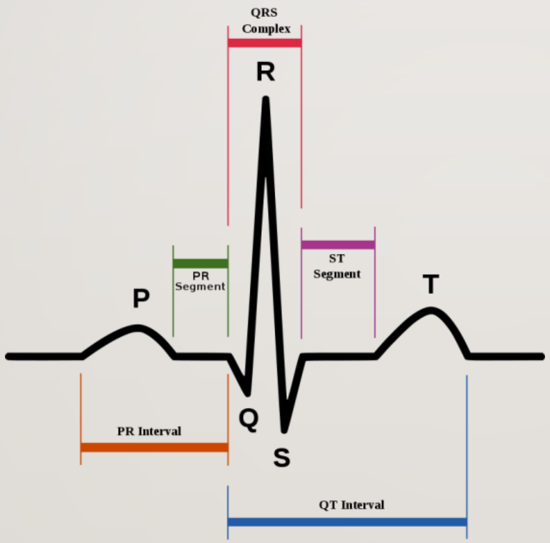


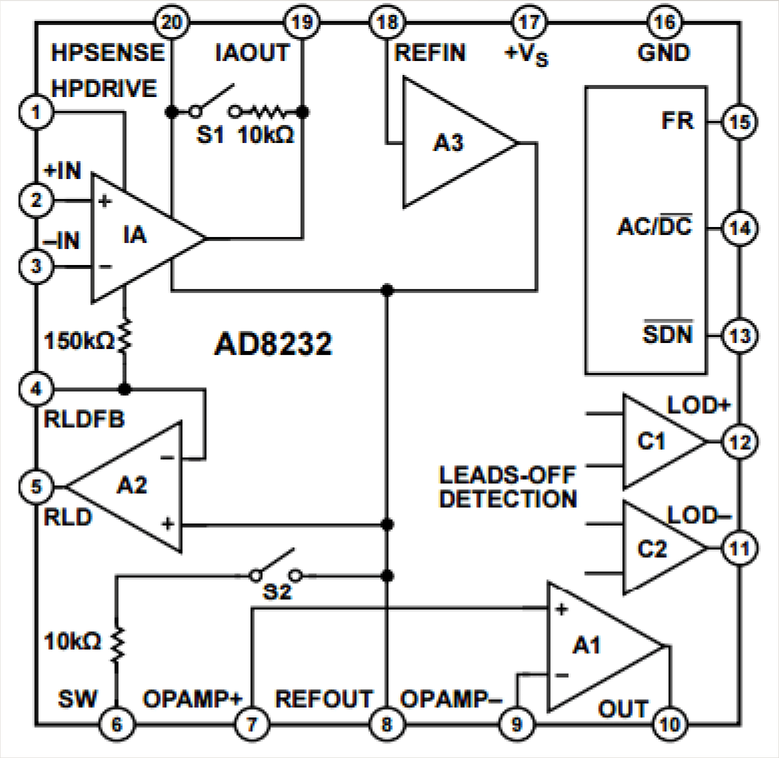
- The MLX90614 consists of two devices embedded as a single sensor, one device acts as a sensing unit and the other device acts as a processing unit. The sensing unit an **Infrared Thermopile Detector** called **MLX81101** which senses the temperature and the processing unit is a **Single Conditioning ASSP** called MLX90302 which converts the signal from the sensor to digital value and communicates using I2C protocol. The MLX90302 has a low noise amplifier, 17-bit ADC and a powerful DSP which helps the sensor to have high accuracy and resolution.
- The IR sensor work in IR wavelengths of 0.4 microns to 5.8microns(as most of the objects IR radiation lie between these range).
- The IR sensor consists of serial connected thermo-couples with cold junctions placed at thick chip substrate and hot junctions, placed over thin membrane. The IR radiation absorbed from the membrane heats (or cools) it.
- The change in voltage difference is taken and sent to the amplifiers through filters.

- The FIR (Finite Impulse Response) filter is provided primarily as a noise control. The IIR (Infinite Impulse Response) filter is useful to control the effect of fast temperature measurement changes. The settling time is a result of both filters working one after the other on the same signal path. Thus the overall settling time is dependent on both filters.
- The IIR filter can be used to “smooth” the measurement. Decreasing the signal step allowed to pass the signal-processing path limits the magnitude of spikes. For example, if an object passes through the MLX90614 Field of View (FOV), and measuring that object is not desired, the IIR filter can be limit the disturbance.
- Then comes the processing unit ASSP which reads the output voltage and coverts it into digital value. It contains an DSP and analog to digital converter.
- The sensor can communicate using the I2c or pwm however the i2c has precision of 0.02 C where as the pwm with 0.14 `C.
- The device contains two measurements one ambient and object temperature .(-25 to 125 for ambient and -70 to360 for object)
- The sensors EEPROM & RAM can be accessed using the i2c protocol.
- Medical accuracy .

ECG SENSOR (AD8232)







Electrocardiography is the process of producing an electrocardiogram (ECG or EKG). It is a graph voltage versus time of the electrical activity of the heart using electrodes placed on the skin. These electrodes detect the small electrical changes that are a consequence of cardiac muscle depolarization followed by repolarization during each cardiac cycle (heartbeat). Changes in the normal ECG pattern occur in numerous cardiac abnormalities, including cardiac rhythm disturbances (such as atrial fibrillation and ventricular tachycardia), inadequate coronary artery blood flow (such as myocardial ischemia and myocardial infarction), and electrolyte disturbances (such as hypokalemia and hyperkalemia).

Electrodes are placed on the surface of the chest. The overall magnitude of the heart's electrical potential is then measured from different angles ("leads") and is recorded over a period of time (usually ten seconds). In this way, the overall magnitude and direction of the heart's electrical depolarization is captured at each moment throughout the cardiac cycle .

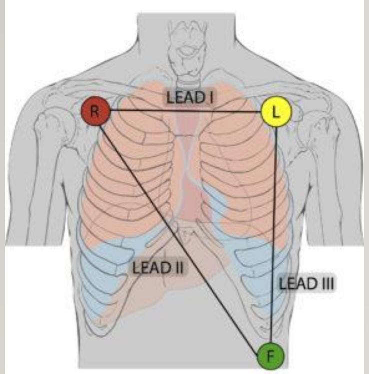
There are three main components to an ECG: the P wave, which represents the depolarization of the atria; the QRS complex, which represents the depolarization of the ventricles and the T wave, which represents the repolarization of the ventricles.

An ECG conveys a large amount of information about the structure of the heart and the function of its electrical conduction system.[7] Among other things, an ECG can be used to measure the rate and rhythm of heartbeats, the size and position of the heart chambers, the presence of any damage to the heart's muscle cells or conduction system, the effects of heart drugs, and the function of implanted pacemakers.

How we produce ECG?

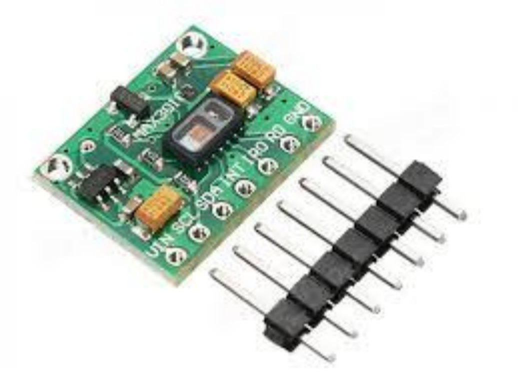
We make use of a 3 electrode probe to measure the electrical signals which is then processed by a highly efficient and reliable analog signal processing module AD8232.

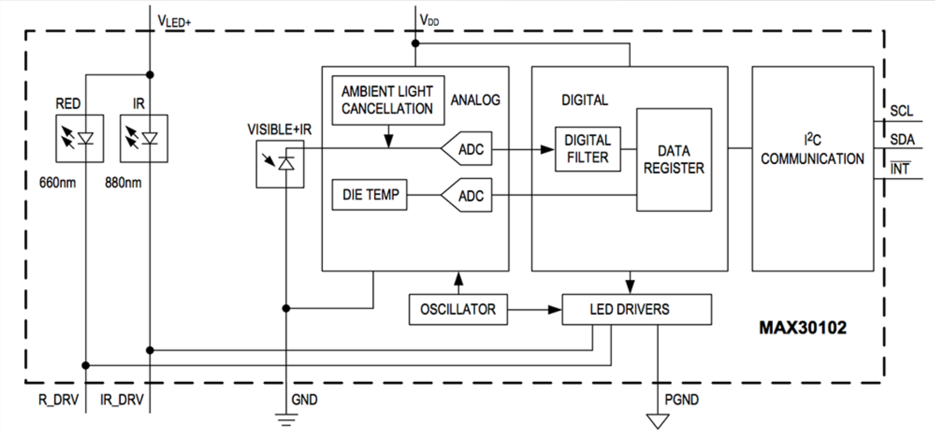
Electrodes are the actual conductive pads attached to the body surface. Any pair of electrodes can measure the selectrical potential difference between the two corresponding locations of attachment. Such a pair forms a lead.

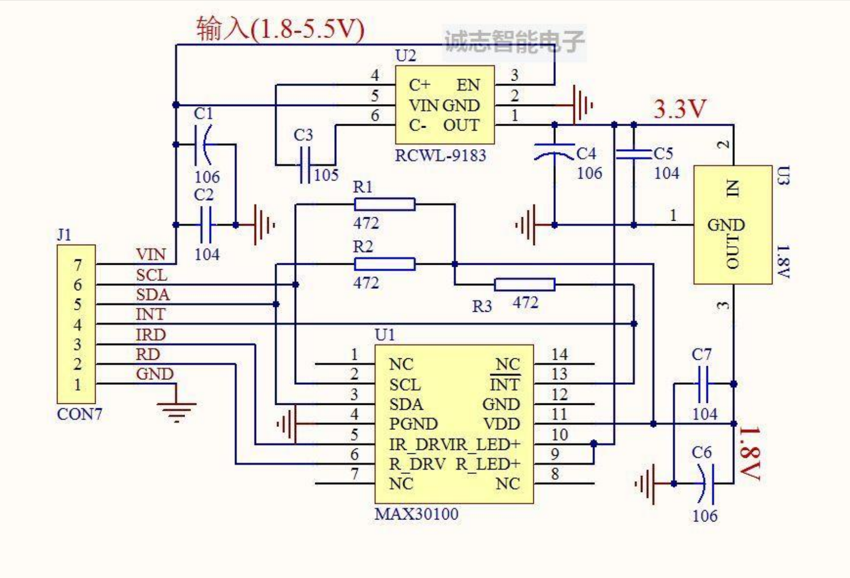


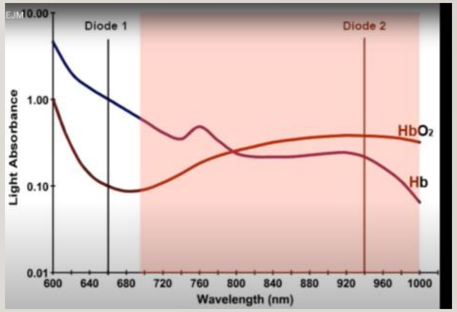
The AD8232 produces an analog output which is the picked up by the microcontroller.

OXIMETER MAX30102 (MAX86141)









- The MAX30102 is a complete pulse oximetry and heart-rate sensor system solution module designed for the demanding requirements of wearable devices.
- The SpO2 subsystem of the MAX30102 contains ambient light cancellation (ALC), a continuous-time sigma-delta ADC, and a proprietary discrete time filter. The ALC has an internal Track/Hold circuit to cancel ambient light and increase the effective dynamic range. The SpO2 ADC has programmable full-scale ranges from 2μA to 16μA. The ALC can cancel up to 200μA of ambient current.
- The ADC output data rate can be programmed from 50sps (samples per second) to 3200sps.
- The device consists of a photo diode and two light emitting diodes.
- One led emits light at 660nm(deoxy hemoglobin)and another is for 880nm(oxyhemoglobin). One helps to measure the oxyhemoglobin concentration another for deoxyhemoglobin, the percentage of oxyhemoglobin is calculated by oxyhemoglobin concentration/total concentration.
- The sensor includes ambient light cancelation for more accuracy.

- The pulse beat of heart can be calculated with the help of this sensor . For this purpose only the IR sensor is used.
- When the heart pumps their will be increase in oxygenated blood and when it relaxes their will be decrease in amount of oxygenated blood .
- The pulse rate is the time difference between increase and decrease of oxygenated blood.
- The sensor uses i2c protocol for transfer of data.
- The data is stored in the registers of the sensor which can be accessed and also several other specifications can be changed

BLOOD PRESSURE SENSOR

MPX53DP

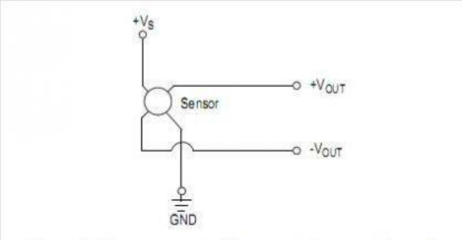
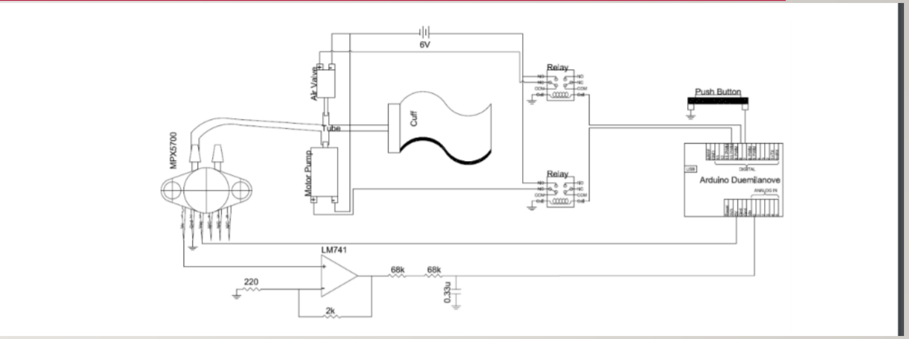
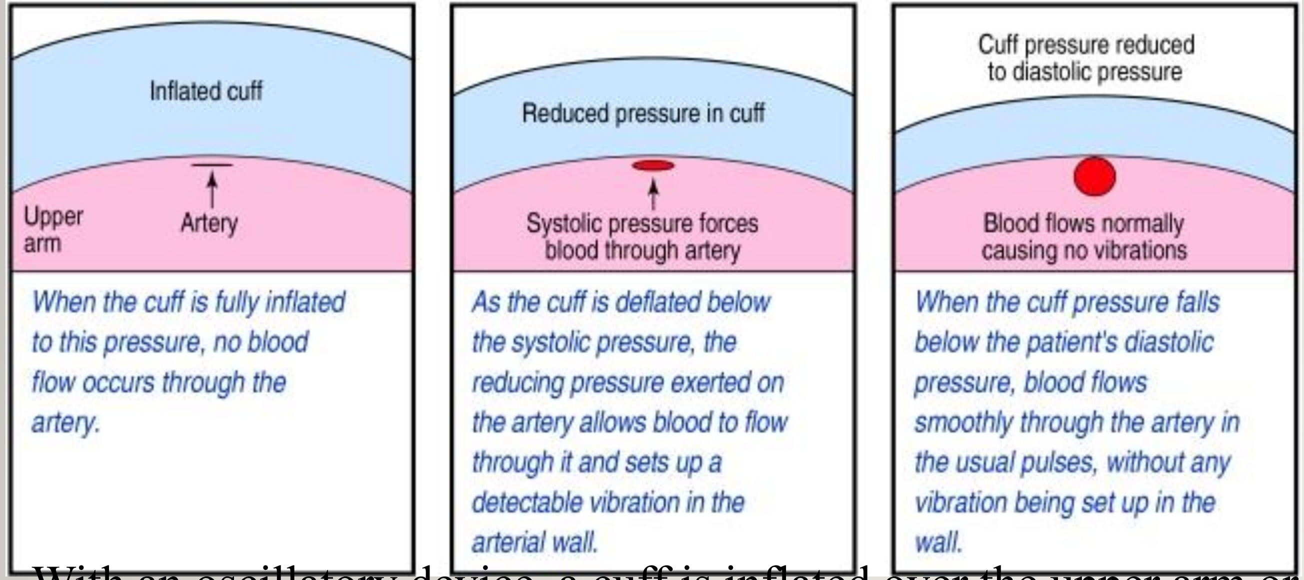


Figure 1. Uncompensated Pressure Sensor Schematic



- The blood pressure is of 2 types one is systolic(generated during heart contraction) and another is diastolic pressure(during heart relaxation)
- The systolic measures generally about 100-120 mm of hg and diastolic pressure measure of 60-80 mm of hg.
- The device which measures Bp electronically are based on principle of oscillometer method.
- The auscultatory method has been the standard method of determining BP for over 100 years and relies on the observer to detect the audible sounds (Korotkoff sounds) that occur during constricted blood flow.
- The oscillometer method, employed by most clinical-grade automated BP devices, analyzes pulse waves collected from the cuff during constricted blood flow. In this case, the cuff is the sensor.
- The auscultatory and oscillometer methods are two very different approaches to determining the same vital sign.



- With an oscillatory device, a cuff is inflated over the upper arm or wrist. The new models use "fuzzy logic" to decide how much the cuff should be inflated to reach a pressure about 20 mm Hg above systolic pressure for any individual
- When the cuff is fully inflated to this pressure, no blood flow occurs through the artery. As the cuff is deflated below the systolic pressure, the reducing pressure exerted on the artery allows blood to flow through it and sets up a detectable vibration in the arterial wall.
- When the cuff pressure falls below the patient's diastolic pressure, blood flows smoothly through the artery in the usual pulses, without any vibration being set up in the wall
- Vibrations occur at any point where the cuff pressure is sufficiently high that the blood has to push the arterial wall open in order to flow through the artery.
- The vibrations are transferred from the arterial wall, through the air inside the cuff, into a transducer in the monitor that converts the measurements into electrical signals.
- These digital devices deflate at about 4 mm Hg per second, making them sometimes seem slower to use than auscultatory aneroid devices, but they are more accurate.

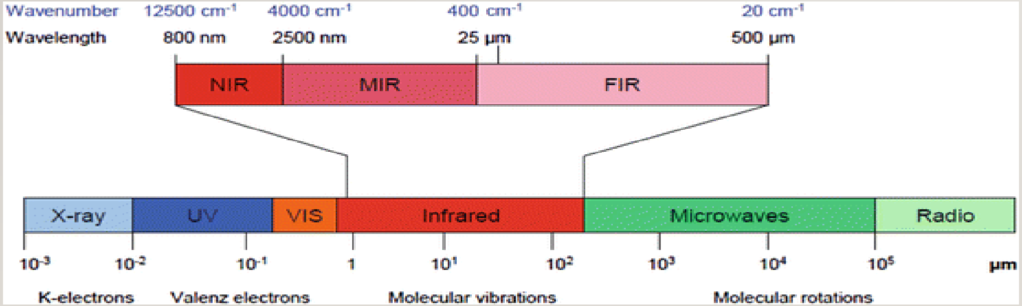
GLUCOMETER

Non Invasive Glucometer

- Optical methods are considered to be one of the painfree and the promising methods which can be used for non-invasive blood glucose measuring. In which the Near-infrared (NIR) is considered to be the most widely used optical techniques because of its high penetration in the skin. These techniques are applied in various regions of the body such as earlobe, finger, forearm, and palm. On comparing with other methods, the NIR method finds a good advantage in sensitivity, complexity, power consumption, cost, and accuracy.

OVERVIEW OF NIR SPECTROSCOPY:

- The Infrared wave is classified as Near-infrared, Mid-infrared, and Far-infrared.



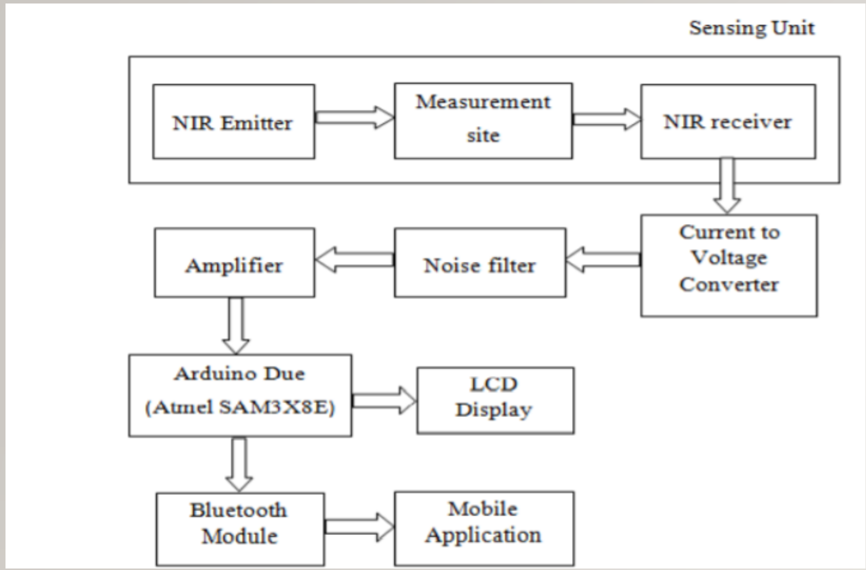
The NIR light lies in the wavelength range of 750nm – 2500nm. The infrared (NIR) rays can penetrate through the skin at the wavelength range of 650-1350nm. Some of the regions considered for examination are Earlobe, Forearm, Fingertip, and Palm. On comparing the considered regions, the accuracy of glucose detection is better at the earlobe, due to its boneless tissue and small thickness. Near-infrared was passed on one side of the earlobe while the opposite end is the receiver side which receives the attenuated light. Normally, photodiodes are used for light detection at the receiver side. The variations of glucose concentration in the blood attenuate the light transmitted, which results in variation of photodiode voltage.

PRINCIPLE OF BLOOD GLUCOSE MEASUREMENT:

When a light ray passes through biological tissues, it is both absorbed and scattered by the tissues. Light scattering occurs in biological tissues due to the mismatch between the refraction index of extracellular fluid and the membranes of the cells. Variation in glucose level in blood affects the intensity of light scattered from the tissue. Beer-Lambert Law plays a major role in absorbance measurement which states that absorbance of light through any solution is in proportion with the concentration of the solution and the length path travelled by the light ray.

WORKING:

The proposed work is based on NIR optical technique. NIR light source of 940 nm wavelength is chosen because it is suitable for measuring blood glucose concentration. The sensing unit consists of NIR emitter and NIR receiver (photodetector) positioned on either side of the measurement site (fingertip) as shown in figure1.When the NIR light is propagated through the fingertip in which it interacts with the glucose molecule, a part of NIR light gets absorbed depending on the glucose concentration of blood and remaining part is passed through the finger tip. The amount of NIR light passing through the fingertip depends on the amount of blood glucose concentration.



The transmitted signal is detected by the photodetector. The output current of the photo detector is converted into voltage signal and then it is filtered and amplified. This amplified signal is fed into microcontroller.

The inbuilt ADC block is used for converting the received analog signal to digital form.

This digital signal is processed by using second order regression analysis to predict the blood glucose value and the blood glucose value is displayed on the LCD display.

SENSORS USED:

The sensor used here is the NIR sensor. NIR sensor is chosen amongst others is that it does not harm the human skin.

To measure the blood glucose non-invasively the NIR LED and the photodiode is used.

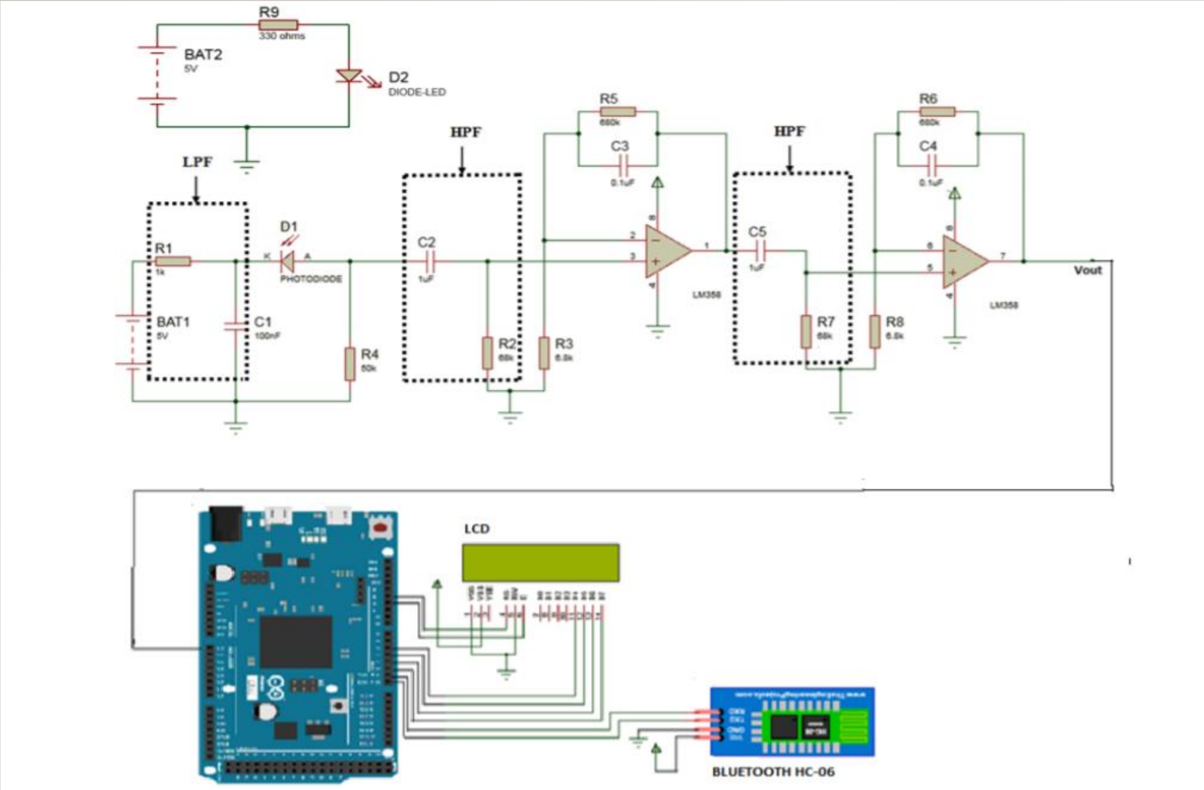
One side of the sensor clip is attached with the NIR LED (TSAL5300) as Transmitter and the opposite side we have photodiode (BPW34) to measure the attenuated light received after the penetration of NIR waves through our earlobe.

SYSTEM DESIGN:

The circuit diagram of the designed system consists of filtering stage and amplification stage as shown in figure 3. The electrical current obtained from the photo detector is converted into the voltage by placing the load resistance R4= 50kΩ at the anode side of photodiode. The cut-off frequency of high pass filter and low pass filter are designed as 2.34 Hz and 1.59 kHz respectively.

Cut off frequency of LPF = 1/ (2πR1C1) = 1/ [2π (1*103) (100*10-9)] = 1.59 kHz
Cut off frequency of HPF = 1/ (2πR2C2) = 1/ [2π (68*103) (1*10-6)] = 2.34Hz
Voltage gain = 1 + (Rf / Rin) = 1 + [(680*103)/ (6.8*103)] = 101

The amplified output voltage is connected to analog pin of Arduino microcontroller for converting the analog signal into digital values. This digital value corresponds to the glucose level. From this digital value, the actual glucose level is determined using polynomial regression equation. This equation is formed from the glucose levels obtained from the laboratory using invasive measurement. A mobile app is created for displaying and storing the predicted glucose value. Bluetooth module (HC-05) is connected to Arduino microcontroller in order to communicate with the mobile app via Bluetooth.



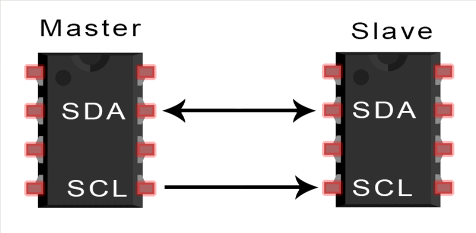
R9
330 ohms
BAT2
5V
D2
DIODE-LED
LPF
HPF
HPF
R5
680k
C3
0.1uF
R6
680k
C4
0.1uF
D1
R1
1k
PHOTODIODE
C2
1uF
C5
1uF
BAT1
5V
C1
100nF
R4
50k
R2
68k
R3
6.8k
R7
68k
R8
6.8k
LM358
LM358
Vout
LCD
BLUETOOTH HC-06

I2C COMMUNICATION .

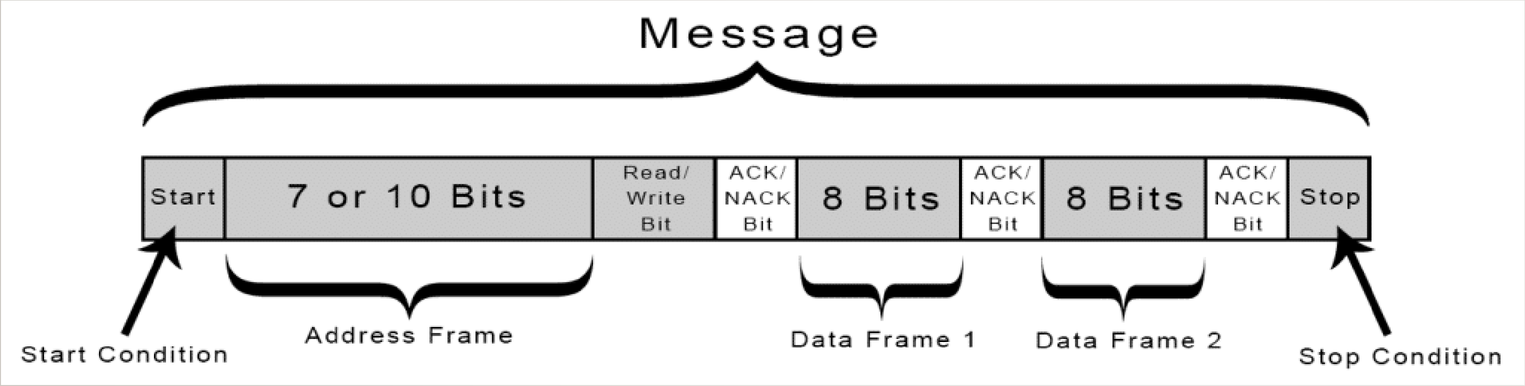
INTRODUCTION TO I2C COMMUNICATION

- I2C combines the best features of SPI and UARTs. With I2C, you can connect multiple slaves to a single master (like SPI) and you can have multiple masters controlling single, or multiple slaves. This is really useful when you want to have more than one microcontroller logging data to a single memory card or displaying text to a single LCD.
- Like UART communication, I2C only uses two wires to transmit data between devices:

SDA (Serial Data) – The line for the master and slave to send and receive data.
SCL (Serial Clock) – The line that carries the clock signal.



Wires Used	2
Maximum Speed	Standard mode= 100 kbps
	Fast mode= 400 kbps
	High speed mode= 3.4 Mbps
	Ultra fast mode= 5 Mbps
Synchronous or Asynchronous?	Synchronous
Serial or Parallel?	Serial
Max # of Masters	Unlimited
Max # of Slaves	1008



Start Condition: The SDA line switches from a high voltage level to a low voltage level *before* the SCL line switches from high to low.

Stop Condition: The SDA line switches from a low voltage level to a high voltage level *after* the SCL line switches from low to high.

Address Frame: A 7 or 10 bit sequence unique to each slave that identifies the slave when the master wants to talk to it.

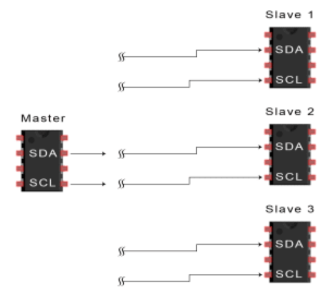
Read/Write Bit: A single bit specifying whether the master is sending data to the slave (low voltage level) or requesting data from it (high voltage level).

ACK/NACK Bit: Each frame in a message is followed by an acknowledge/no-acknowledge bit. If an address frame or data frame was successfully received, an ACK bit is returned to the sender from the receiving device.

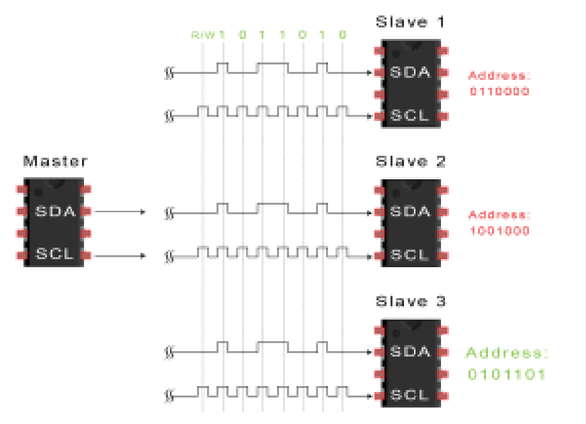
ADDRESSING
I2C doesn't have slave select lines like SPI, so it needs another way to let the slave know that data is being sent to it, and not another slave. It does this by *addressing*. The address frame is always the first frame after the start bit in a new message.
The master sends the address of the slave it wants to communicate with to every slave connected to it. Each slave then compares the address sent from the master to its own address. If the address matches, it sends a low voltage ACK bit back to the master. If the address doesn't match, the slave does nothing and the SDA line remains high.
READ/WRITE BIT
The address frame includes a single bit at the end that informs the slave whether the master wants to write data to it or receive data from it. If the master wants to send data to the slave, the read/write bit is a low voltage level. If the master is requesting data from the slave, the bit is a high voltage level.
THE DATA FRAME
After the master detects the ACK bit from the slave, the first data frame is ready to be sent.
The data frame is always 8 bits long, and sent with the most significant bit first. Each data frame is immediately followed by an ACK/NACK bit to verify that the frame has been received successfully. The ACK bit must be received by either the master or the slave (depending on who is sending the data) before the next data frame can be sent.
After all of the data frames have been sent, the master can send a stop condition to the slave to halt the transmission. The stop condition is a voltage transition from low to high on the SDA line after a low to high transition on the SCL line, with the SCL line remaining high.

STEPS OF I2C DATA TRANSMISSION

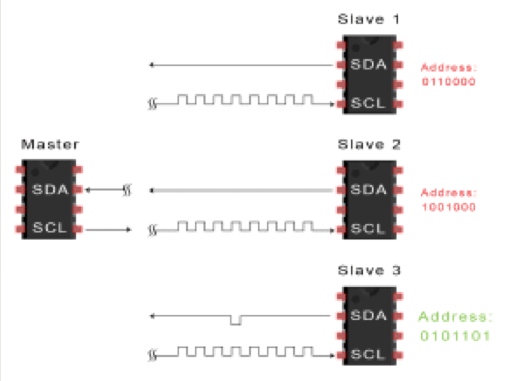
1. The master sends the start condition to every connected slave by switching the SDA line from a high voltage level to a low voltage level *before* switching the SCL line from high to low:



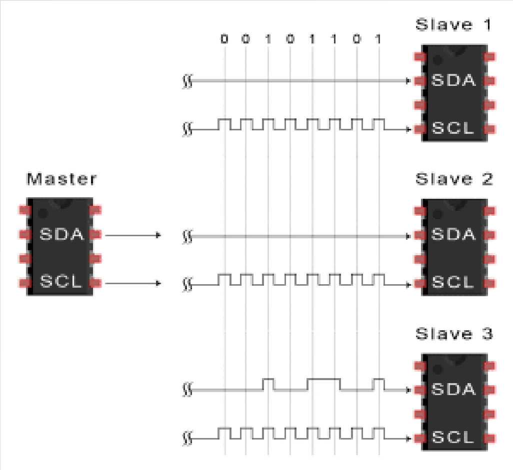
2. The master sends each slave the 7 or 10 bit address of the slave it wants to communicate with, along with the read/write bit:



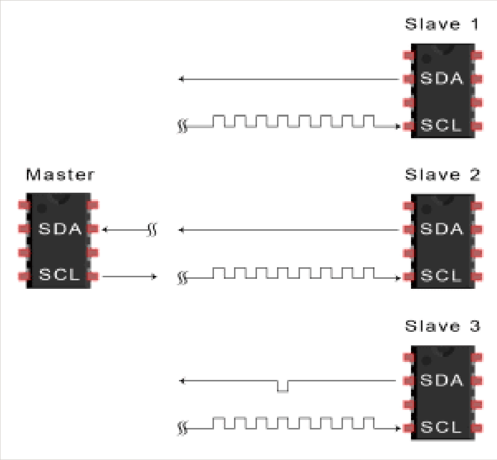
3. Each slave compares the address sent from the master to its own address. If the address matches, the slave returns an ACK bit by pulling the SDA line low for one bit.
If the address from the master does not match the slave’s own address, the slave leaves the SDA line high.



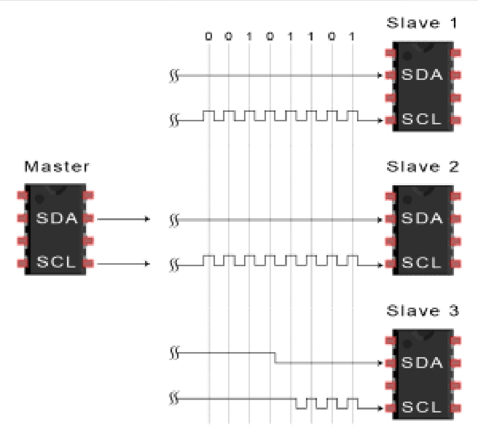
4. The master sends or receives the data frame:



5. After each data frame has been transferred, the receiving device returns another ACK bit to the sender to acknowledge successful receipt of the frame:



6. To stop the data transmission, the master sends a stop condition to the slave by switching SCL high before switching SDA high:



ADVANTAGES

- Only uses two wires
- Supports multiple masters and multiple slaves
- ACK/NACK bit gives confirmation that each frame is transferred successfully
- Hardware is less complicated than with UARTs
- Well known and widely used protocol

DISADVANTAGES

- Slower data transfer rate than SPI
- The size of the data frame is limited to 8 bits
- More complicated hardware needed to implement than SPI