Smart Incubator

Final Year Project Submitted to the Department of Biomedical Engineering in Partial Fulfillment of the Requirements for the Award of Bachelor of Science Degree in Biomedical Engineering

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July 2023

Dedication

We dedicate this project:

God Almighty our creator, strong pillar, source of inspiration, Wisdom, knowledge and understanding Who has been the source of our strength throughout this Program and on His wings only have we soared.

Our great teacher and messenger, Mohammed (May Allah bless and grant him), who taught us the purpose of life.

Our homeland Yemen, the warmest womb

Emirates International University; our second magnificent home

Our great parents, who never stop giving of themselves in countless ways,

Our beloved brothers and sisters to all our family, the symbol of love and giving

Our friends who encourage and support us

All the people in our life who touch our heart, we dedicate this research.

Dedication

We, Abdurahman Nasser, Mohammad Zakaria, Tariq Emran, Moneer Khosurof, Alaa al fadhli, Bilal Mahoosh, declare that this graduation project titled "**Smart Incubator**" submitted to fulfillment of the requirements for the degree of Bachelor, in **Biomedical Engineering**, *Emirates International University*, is wholly my own work unless otherwise referenced or acknowledged. This document has not been submitted for qualifications at any other academic institution.

Students' team

July 2023

Acknowledgment

First and foremost, all thankfulness to Allah, the Beneficent, the Merciful, the One, on who all depend, and none is like Him. Allah, who helps and guides me to overcome the challenges during my study and my life,

Sincere gratitude and many thanks must be expressed to:

- Our supervisor Dr. Mohammed Alolfe who is a tremendous mentor for me, for his constructive criticism, experienced guidance, hours of discussions and patience with which he checked and corrected many technical errors during the preparation of this work.

- We also direct our love and thanks to all who helped and contributed to the success of this project.

Abstract

Newly born babies are very sensitive to rough environments. The dust and temperature issues here can be life threatening. Due to these issues, a baby incubator is made that can provide the same temperature and environmental conditions as a mother's womb does, as well as it monitors the baby's medical conditions such as heart beat, blood pressure, Respiratory rate, skin temperature, internal temperature, etc. Being physically present with the patients has become a huge problem for doctors. In such cases, implementing IOT with hospital equipment such as a Baby Incubator, has become one of the main goals for us. Providing an app that can track the baby's condition remotely will prove to be very fruitful. Our main goal is to make a smart baby incubator that can detect baby's condition and in case anything goes wrong, the system can trip itself so that the conditions can return to a normal state. We will integrate it with IOT and a mobile app so that doctors can check the baby's condition remotely.

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Chapter 1: Introduction

1.1 Overview

The incubator is an isolated area environment with no dust, bacteria, and has the ability to control temperature, humidity, and oxygen to remain them in acceptable levels. Incubator is designed to keep baby warm, to monitor many of their vital body functions like heart rate, blood pressure, oxygen saturation and to support their breathing if necessary.

Regarding the temperature and humidity control, incubators should minimize heat loss from the neonate and eddies around him/her. The main physical variables affecting the incubator environment are temperature, humidity, oxygen saturation and light.

1.2 Problem Statement

The care of new born babies are the most important and sensitive part of bio-medical domain.

Some new born babies have a higher risk of mortality due to their gestational age or their birth weight.

Most of the premature babies born on 32-37 weeks of gestation and are deceased due to their unmet need for warmth.

The neonatal incubator is a device used to nourish the premature babies by providing a controlled and closed environment.

This incubator provides the babies with optimum temperature, relative humidity, optimum light and appropriate level of oxygen which are same as that in the womb.

1.2 Objective:

After we visited the hospitals and made statistics about the problems they face, they told us that they have a problem in the nursery of infants, that the infant needs vital monitoring, so the nurse or health caretaker in charge of the child measures the pressure every hour and monitors the heartbeat and the temperature of the child, and there are some children Those who suffer from breathing difficulty, the nurse needs to monitor the breathing rate of the child, and each of these works may require more time and effort, and from here we came up with the idea of making a smart nursery to provide the infant with a suitable environment and complete comfort. And help The nurse or health responsible for the child monitors the vital signs of the child and also makes an application that helps the nurse monitor more than one child at the same time because we found that the intensive care unit for infants has Two nurses and they are responsible for all children in care.

Chapter 2: Medical and Engineering Background

2.1 Medical Background

infants who born before 37 weeks of the gestation period are known as preterm or premature babies. Preterm baby requires surrounding exactly similar as in the womb to cope with the external environment.

In fact mammals have the advantage of being homoeothermic, i.e. they have a nearly uniform body temperature, regulated independent of the environmental temperature.

vital organs or enzymes of premature babies grow to the very lesser extent and thus requires special attention to copewith external physical condition like temperature, humidity, light and oxygen level.

The infant has several disadvantages in terms of thermal regulation.

An infant has a relatively large surface area, poor thermal insulation, and a small amount of mass to act as a heat sink.

The newborn has little ability to conserve heat by changing posture and no ability to adjust their own clothing in a response to thermal stress.

To provide the similar environment as in the womb infants have to be kept in a device known as incubator.

An infant incubator is a device consisting of a rigid box-like enclosure in which.

2.2 Medical background of Critical Physiological Parameters

Generally, human health situation is defined by variety of physiological parameters, which usually are self-interdependent. Besides, not all of those parameters could be easily and precisely controlled, since measurement of them requires special conditions [1].

Critical Physiological Parameters are the most important signs that indicate the status of the body‘s vital (life-sustaining) functions.

Here, the most important specification considered was that they should be safe to use and accurate.

This is because the physiological information being detected determines the severity of a critical life-threatening situation.

2.2.1 Electrocardiography (ECG)

Electrocardiography (ECG) has been established as one of the most useful diagnostic tests in emergency medicine. ECG signal is one of the best-recognized biomedical signals.

Its high diagnostic capabilities have been demonstrated.

The heart is one of the most critical organs in the human body, thus the development of methods for monitoring its functionality is crucial.

Electrocardiography is considered to be one of the most powerful diagnostic tools in medicine that is routinely used for the assessment of the functionality of the heart.

ECG signals are reflective of electric activities of a heart muscle.

They are related to a variety of intertwined and complex chemical, electrical, and mechanical processes present in heart [1].

They convey a great deal to valuable diagnostic information not only describing functioning of heart but also other systems such as circulation or nervous systems [2].

The ECG signal is some kind of an electric provocation spread in the heart muscle cells.

Under the influence of this provocation, the heart muscle cells shrink, which as a result, causes a mechanical effect in the form of cyclic shrinking of heart atria and ventricles.

As an effect of heart muscle shrinking, the blood circulates in the human organs.

The propagation electric provocation in the heart muscle forms a depolarization wave of the bioelectric potentials of the neighboring heart cells.

The propagation of the depolarization wave, see Figure 2.1, is caused due to a quick movement of positive ions of sodium (Na+).

After moving of the depolarization wave, the heart muscle cells return to their rest state recovering before starting resting negative potential.

This state is called a repolarization phase.

The movement of ions causes the depolarization and repolarization phenomena of the heart muscle cells.

This is the essence of the heart electric activity.

Movement of ions in the heart muscle cells is the electric current, which generates the electromagnetic field around the heart.

There is possibility to measure the electric potential at each point of the electromagnetic field.

The potential difference recorded at the two points of the electromagnetic field reflects the ECG signal.

The shape of the ECG signal and a cyclic repetition of its characteristic parts including P-QRS-T complex, constitute essential information about operation of the electrical conduction system of the heart.

By analyzing, the ECG signals recorded simultaneously at different points of the human body. We can obtain essential diagnostic information related to heart functioning [3].

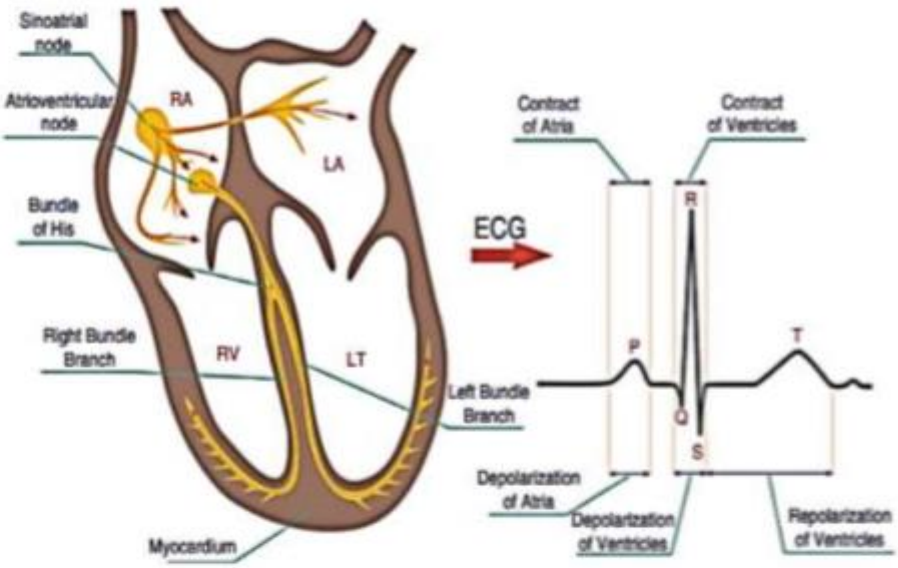


figure 2 1 Propagation of the depolarization wave in the heart muscle

2.2.2 Heart rate

Heart rate variability (HRV) is a reliable reflection of the many physiological factors modulating the normal rhythm of the heart.

In fact, they provide a powerful means of observing the interplay between the sympathetic and parasympathetic nervous systems .

It shows that the structure generating the signal is not only simply linear, but also nvolves nonlinear contributions.

Heart rate (HR) is a nonstationary signal; it is the speed of the heartbeat measured by the number of contractions of the heart per minute (BPM) [4].

Heart rate is a useful indicator of physiological adaptation and intensity of effort.

Therefore, heart rate monitoring is an important component of cardiovascular fitness assessment and training programmes.

It is usually equal or close to the pulse measured at any peripheral point. Several studies [4] [5] [6], as well as expert consensus, indicate that the normal resting adult human heart rate is probably a range between 50 and 90 bpm, though the American Heart Association states the normal resting adult human heart rate is 60–100 bpm.

The actual number of beats may even be higher or lower, as the body is activities that can provoke change include physical exercise, sleep, anxiety, stress, illness, and ingestion of drugs [5].

Table 2.1 represents the range of average heart beat rate with the change of age of person [6].

Table 2 1 Average Heart Beat Rate

AGE OF PERSON	RANGE OF HEART RATE	AVERAGE RATE
0-1 Month	100-180	140
2-3 Month	110-180	145
4-12 Month	80-180	130
1-3 Years	80-160	120
4-5 Years	80-120	100
6-8 Years	70-115	92.5
9-11 Years	60-110	85
12-16 Years	60-110	85
Above 16 Years	60-100	80

Tachycardia is a fast heart rate, defined as above 100 bpm at rest.

Bradycardia is a slow heart rate, defined as below 60 bpm at rest.

During sleep a slow heartbeat with rates around 40–50 bpm is common and is considered normal.

When the heart is not beating in a regular pattern, this is referred to as an arrhythmia. Abnormalities of heart rate sometimes indicate disease [7].

2.2.3 Blood oxygen saturation SpO2

The body need for certain oxygen.

Its availability at a tissue level is sometimes in doubt.

Blood gas measurements provide critical information regarding oxygenation, ventilation, and acid-base status.

However, these measurements only provide a snapshot of the patient's condition taken at the time that the blood sample was drawn.

Is well known that oxygenation can change very quickly.

In the absence of continuous oxygenation monitoring, these changes may go undetected ntil it is too late [8].

Pulse oximeters measure blood oxygen saturation noninvasively and continuously.

In order to obtain measurements, pulse oximeters require that patients have reasonable cardiovascular function and haemoglobin concentrations.

Normal physiologic SpO2 values range between 90 and 100% [9] .

Values in this range indicate that the patient's ventilation and circulation are adequate.

During anaesthesia, the oxygen saturation should always be 95 - 100%.

If the oxygen saturation is 94% or lower, the patient is hypoxic and needs to be treat quickly. A saturation of less than 90% is a clinical emergency [10].

2.2.4 Body temperature

Body temperature is one of the main vital signs.

This section provides the basic guidelines for taking and recording temperature.

Temperature is defined as "the balance between heat lost and heat produced by the body," Heat is lost through perspiration, respiration, and excretion (urine and feces) [11].

Heat is produced by the metabolism of food, and by muscle and gland activity.

A constant state of fluid balance, known as homeostasis, is the ideal health state in the human body.

The rates of chemical reactions in the body are regulated by body temperature.

Therefore, if body temperature is too high or too low, the body's fluid balance is affected.

Temperature can be measured in the mouth (oral), rectum (rectal), armpit (axillary), ear (aural), or by the temporal artery in the forehead (temporal).

A low or high reading can indicate disease.

Most temperatures are measured in degrees on a thermometer that has a Fahrenheit scale.

However, some health care facilities are now measuring temperature in degrees on a Celsius (centigrade) scale [12] [13].

Normal body temperature in health remains constant around 36.8°C, although this can range in adults between 36.5 and 37.5°C.

The ability to sense and regulate body temperature is a key feature of human survival.

A deviation of ± 3.5°C from the resting temperature of 37°C can result in physiological impairments and fatality.

An understanding of thermoregulation during physical exertion is important in protecting athletes from heat injury and in managing physical performance under hot conditions.

Advances in the related field of body temperature measurement have played an important role in human thermoregulation research, by allowing researchers to quantify and —see‖ body temperature.

Although a variety of methods is available to measure body temperature, there are still challenges in measuring body temperature accurately, especially during exercise and sport participation [1] [11].

2.2.5 Blood Pressure

Blood pressure (BP) is one of the most significant fundamental parameters of cardiac and vascular conditions of human body.

The requirements for health conditions measurement and monitoring are increasing with the gradual rise of the world population.

Worldwide hypertension is one of the major diseases that may lead to death and disability.

This disease is a continual high blood pressure (BP) which stresses on the heart, increases heart rate (HR) and thus causes vascular weaknesses and hence may rupture the blood vessels.

Uncontrolled, unnoticed as well as untreated high BP or hypertension increases the risk of the various types of diseases like heart attack, stroke, damages in the coronary arteries, kidney disease, eye damage, pre-eclampsia etc.

Most of these diseases prevail in the developing countries. It also impacts on the country's overall economy.

Blood pressure is measured by getting systole and diastole, both of which represent the heart when beating and resting.

systole is a sign when the heart beats and is measured by detecting the first beat when measuring blood pressure while diastole is a sign when the heart is stationary and is measured by detecting the last beat when measuring blood pressure.

Blood pressure readings are made up of two values:

Systolic blood pressure is the pressure when the heart beats – while the heart muscle is contracting (squeezing) and pumping oxygen-rich blood into the blood vessels.

Diastolic blood pressure is the pressure on the blood vessels when the heart muscle relaxes. The diastolic pressure is always lower than the systolic pressure.

The normal rang values for a resting, healthy adult human are 120 mmHg systolic and 80 mmHg diastolic (written as 120/80 mmHg).

Table 2 2 Normal of systolic and diastolic rang of blood pressure for different year:

Age	Systolic Range mm Hg	Diastolic Range mm Hg
14–18 years	80-120	50-80
19–40 years	95-135	60-80
41-60 years	110-145	60-90
60 and older	95-45	70-90

Table 2 3 Classification of blood pressure

Category	systolic, mmHg	diastolic, mmHg
Hypotension	< 90	< 60
Normal	90 – 120	60-80
Prehypertension	121-139	81-89
Stage 1 hypertension	140-159	90-99
Stage 2 hypertension	≥ 160	≥ 100≥ 100

2.3 Engineering Background

2.3.1 Physiological Parameters Monitoring

2.3.1.1 ECG signal measurement

The movement of charged particles generates an electrical current. In electrocardiology the charged particles are represented by intra- and extracellular ions (Na, K, Ca). These ions flow across cell membranes (so that

the cell can de- and repolarize) and between cells via gap junctions (so that the depolarization can spread between the cells). Electrical potential difference arises as the electrical impulse travels through the heart. Electric potential difference is defined as a difference in electric potential between two measurement points.
In electrocardiology these measurement points are the skin electrodes. Thus, the electrical potential difference is the difference in the electrical potential detected by two (or more) electrodes.

- **Willem Einthoven's original leads**

Leads I, II and III compare electrical potential differences between two electrodes.

Lead I compare the electrode on the left arm with the electrode on the right arm, of which the former is the exploring electrode. It is said that lead I observes the heart "from the left" because its exploring electrode is placed on the left (at an angle of 0°, see Figure 2.2).

Lead II compares the left leg with the right arm, with the leg electrode being the exploring electrode. Therefore, start learning ECG Start now lead II observes the heart from an angle of 60°.

Lead III compares the left leg with the left arm, with the leg electrode being the exploring one. Lead III observes the heart from an angle of 120°

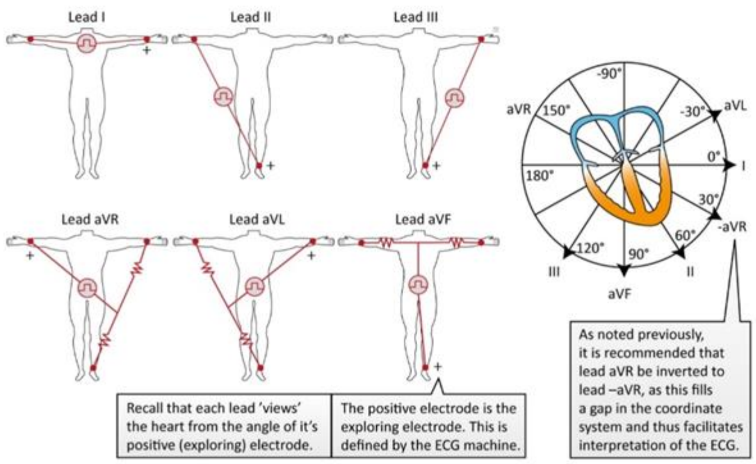


figure 2 2 The limb leads and their view of the heart's electrical activity

Leads I, II and III are the original leads constructed by Wilhelm Einthoven. The spatial organization of these leads forms a triangle in the chest (Einthoven's triangle) which is presented in Figure 2.3 panel B.

According to Kirchhoff's law, the sum of all currents in a closed circuit must be zero. Since Einthoven's triangle can be viewed as a circuit, the same rule should apply to it. Thus, emerges Einthoven's law:

Lead I + lead III=lead II

This law implies that the sum of the potentials in lead I and lead III equals the potentials in lead II.

In clinical electrocardiography this means that the amplitude of, for example, the R-wave in lead II is equal to the sum of the R-wave amplitudes in lead I and III. It follows that we need only know the information in two leads in order to calculate the exact appearance of the remaining lead. Hence, these three leads actually carry two pieces of information, observed from three angles.

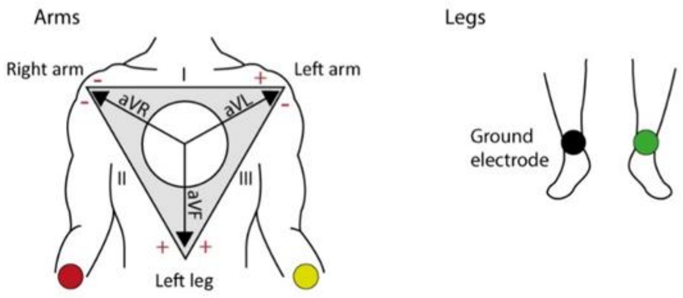


figure 2 3 Einthoven's Triangle

2.3.1.2 Heart Rate calculated method

A. Electrocardiographs method

Pulse, as heart work rhythm characterizing parameter, can be easily calculated from ECG. This might be done by measuring distance between the biggest peaks (usually named R peaks). After a few cycles of heartbeat recorded, the duration of R-R step is measured and pulse is calculated in Equation 2.1 [3] [4].

$$HR = \frac{60}{T R - R} [\min{}^\wedge - 1] \qquad [2.1]$$

B. Photoplethysmography method

Photoplethysmography is of two types of transmission and reflection based on the place from which the light sensed. In this implementation, an IR LED is excited by a modulated signal to avoid low frequency interference and the received light from finger or ear lobe is sensed by a photodiode that is filtered using a band pass filter with synchronous demodulator which is in sync with the modulator.

This is digitize by an ADC and passed through software filters to shape the pulse [4].

The heart rate is determined using a software peak detector as shown in Figure 2.4.

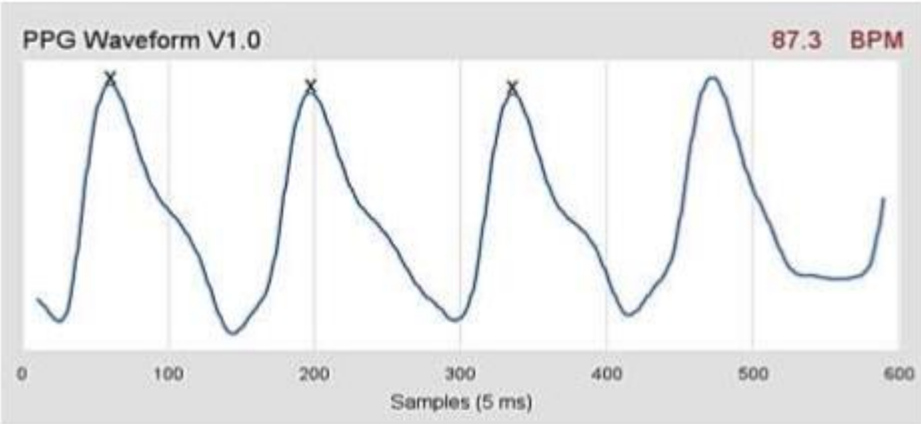


figure 2 4 Detect heart rate using Photoplethysmography method

C. Pressure sensing method

The rhythmic contraction and relaxation of the heart exerts a change in blood pressure along the walls of the blood vessels.

As a result, the blood vessels pulsate in rhythm to the beat of the heart.

This pulsation of blood vessels can be sensed by pressure or piezo circiuts placed at appropriate places on the human body like the wrist.

This variation in pressure is used in a blood pressure monitor to measure the heart rate. Figure 2.5 shows

the pulsation of blood vessels in an arm using pressure circuit with filtering and amplification. These pulses are called oscillometric pulses and are measured in automatic blood pressure monitors [7].

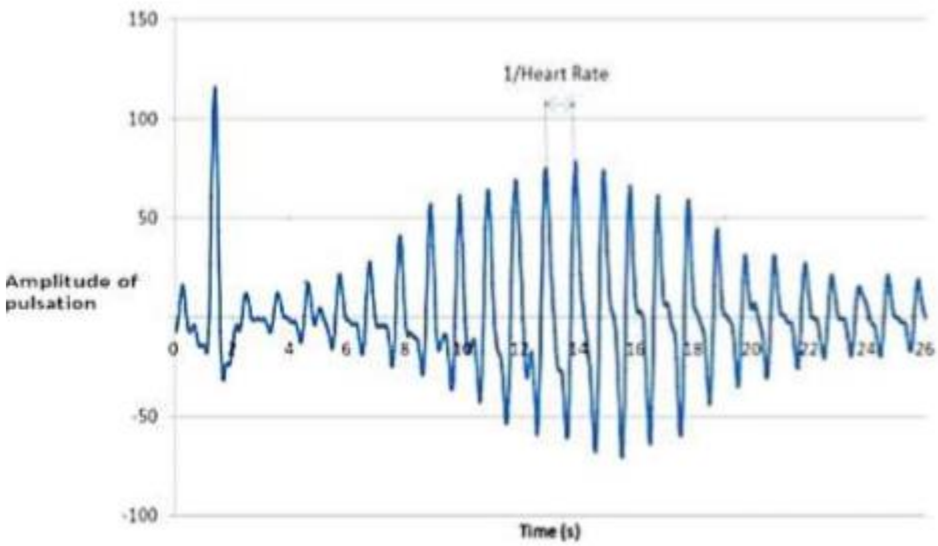


figure 2 5 Detect heart rate using Pressure sensing method

2.3.1.3 SPO2 acquisition method

Methods for measurement of SPO2 can be categorized according to their invasiveness:

- Measurement methods that is non-invasive.
- Invasive methods for SPO2 measurement.

A. Invasive Method

1. Clark PO2 electrode

The Clark electrode is an electrical cell composed of a platinum cathode and a silver anode.

As in, any resistive circuit as the voltage is increased the current will also increase.

This cell is covered with a membrane which is freely permeable to oxygen.

Clark's polarographic oxygen electrode has been used for over 30 years to measure oxygen partial pressure in gases and liquids in both medicine and industry.

The primary problem in continuous invasive PaO2 monitoring is miniaturization of the Clark electrode to permit insertion through an arterial cannula.

There are two approaches to this problem.

One is to insert only the platinum cathode in the arterial cannula and place the reference anode on the skin surface.

The platinum cathode is surround by a thin layer of electrolyte and covered with an oxygen permeable membrane.

‘ The second approach involves miniaturization of the entire anode-cathode electrode for intra-arterial insertion [17].

2. Laboratory oximeters

Laboratory oximeters use this principle to determine hemoglobin concentration by measuring the intensity of light transmitted through a hemoglobin dispersion produced from lysed red blood cells.

For each wavelength of light used an independent Lambert Beer equation can be written (Equation 2.2).

If the number of equations is equal to the number of solutes (i.e. hemoglobin species) then we can solve for the concentration of each use.

Therefore, to determine the concentrations of four species of hemoglobin we require at least four wavelengths of light.

For the Lambert-Beer to be valid, both the solvent and cuvette must be transparent at the light wavelengths used, the light path length must be known exactly, and no other absorbers can be present in the solution.

It is difficult to fulfill all of these requirements in clinical devices.

Consequently, although these devices are theoretically based on the Lambert-Beer law, they also require empirical corrections to improve their accuracy [17].

$$T = \frac{\Phi_{et}}{\Phi_{ei}} = \mathbf{e}^{-\mathrm{T}} = \mathbf{10}^{-\mathbf{A}} \qquad [2.2]$$

Where:

- T is transmitted light
- A is absorbance light
- Φ et is the radiant flux transmitted by that material sample;
- Φ ei is the radiant flux received by that material sample.

B. Non- Invasive Method

1. Transcutaneous PO2

Transcutaneous PO2 is the oxygen tension of heated skin. To obtain a measurable PO2 at the skin surface with a fast response time, the skin temperature must be heated to more than 43°C. This heating causes several changes in the various layers of the skin.

The stratum corneum, composed of lipid in a protein matrix, is normally a very efficient barrier to gas transport.

When heated above 41°C the structural characteristics of this layer change, allowing oxygen to diffuse through it readily [16].

In the epidermis, heating causes vasodilatation of the dermal capillaries that is said to 'arterialize' this capillary blood.

The perfusion of this hyperemic epidermal capillary bed is also dependent upon adequate blood flow to the dermal vasculature.

Consequently, if the cardiac output decreases we would anticipate a decrease in skin blood flow and hence in oxygen delivery to the transcutaneous circuit.

During the shock state, Po2, decreased with decreasing cardiac output [16].

2. Pulse Oximetry

Pulse oximetry was a Technical development by Glen Millikan who in the 1940s developed a lightweight device for noninvasively monitoring hemoglobin saturation coined the term oximeter.

This device estimated hemoglobin saturation by trans illuminating the ear with light of two wavelengths, one in the red and one in the infrared range.

An SPO2 measurement system involves two different wavelength LEDs, Red and near IR light emitting diodes (LEDs) to measure the light that scatters through blood perfused tissue.

Oxygen transported in the blood by hemoglobin, and, depending on whether hemoglobin is bound to oxygen, it absorbs light at different wavelengths [16].

The graphs of hemoglobin light absorption when it saturated with oxygen and when it is not are shown in Figure 2.6.

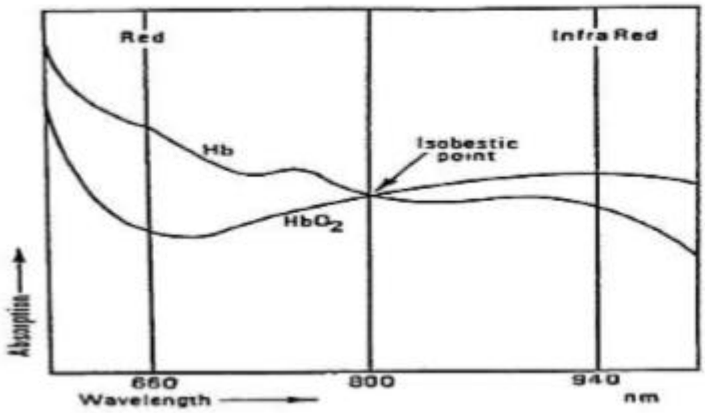


figure 2 6 The graphs of hemoglobin light absorption

This effect is taking an advantage of in oximetry by using two LEDs with different wavelengths and shining them through the tissue.

The ratio of absorption at the two wavelengths used to determine the fraction of saturated hemoglobin.

Previous research had indicated that oxy and deoxy hemoglobin has different optical attenuation characteristics.

For best result, the wavelengths are to be selected such that at one wavelength, the attenuation by Hb and HbO are such that at one wavelength, the attenuation by Hb and HbO are different as possible and at the second wavelength, they are nearly the same.

The available pulse oximeters uses the light at 660nm (R) and 940nm (IR.).

Based upon the ratio of changing absorbance of the red and infrared light caused by the difference in color between oxygen-bound (bright red) and oxygen unbound (dark red or blue, in severe cases) blood hemoglobin, a measure of oxygenation (the per cent of hemoglobin molecules bound with oxygen molecules) can be made as in Equation 2.3 [17].

$$SpO_2 = \frac{HbO_2}{HbO_2 + Hb} * 100 \qquad [2.3]$$

The transmitted light was measured with a photodetector.

This Beer‘s law device (Equation 2.2) effectively used the earlobe as a cuvette containing hemoglobin as stated in [17] [16] [18].

2.3.1.4 Body Temperature acquisition method

A. Non-Invasive Methods

Non-invasive measurement techniques such as axillary, oral or ear temperatures are much easier to use and are less invasive but are also inaccurate and not suited for continuous measurement.

Their use in the clinical setting is therefore limited [12].

B. Minimally Invasive Methods

In the anesthesiological and intensive care settings, core temperature measurement is routinely used during vital parameter monitoring.

If exact, continuous measurement is indicated, invasive methods are used (rectum, oesophagus, and bladder).

These techniques deliver reliable results, but are somewhat arduous and uncomfortable for

patients.

For these reasons, continuous monitoring is often not used, although it is medically indicated [12].

C. Invasive Methods

As a rule, the more invasive methods tend to deliver better accuracy. The gold standards still involve measurements in the pulmonary artery or the cerebrum, but are usually substituted for bladder or oesophageal measurement methods due to their less invasive nature [12].

D. New Technologies Methods

Heat flux or Doppler circuit technology eliminates the need for an active heating element.

Here, the heat flux of an isolated area of skin is measured with the help of two temperature circuits and a defined thermal isolator, allowing the determination of body core temperature.

This principle makes their use comfortable and practical in combination with active warming systems [12].

2.3.1.5 Blood Pressure measurement methods

Blood pressures are usually measured non-invasively (indirectly), without penetrating skin or artery.

Measuring pressure invasively (directly), by penetrating the arterial wall to take the measurement, is much less common, and usually restricted to a hospital setting.

A.1 Invasive method

Invasive (intra-arterial) blood pressure (IBP) monitoring is a commonly used technique in the Intensive Care Unit (ICU) and is also often used in the operating theatre.

This technique involves direct measurement of arterial pressure by inserting a cannula needle in a suitable artery. The cannula must be connected to a sterile, fluid-filled system, which is connected to an electronic patient monitor. The advantage of this system is that a patient's blood pressure is constantly monitored beat-by-beat and a waveform (a graph of pressure against time) can be displayed.

The principle of invasive monitoring is:

- The pressure of the arterial pulse is transmitted along the vessels as a pressure wave.
- This wave can be measured by a pressure transducer.
- The pressure transducer system can be described as a second-order dynamic. system (a harmonic oscillator), in terms of resonance, damping and frequency response

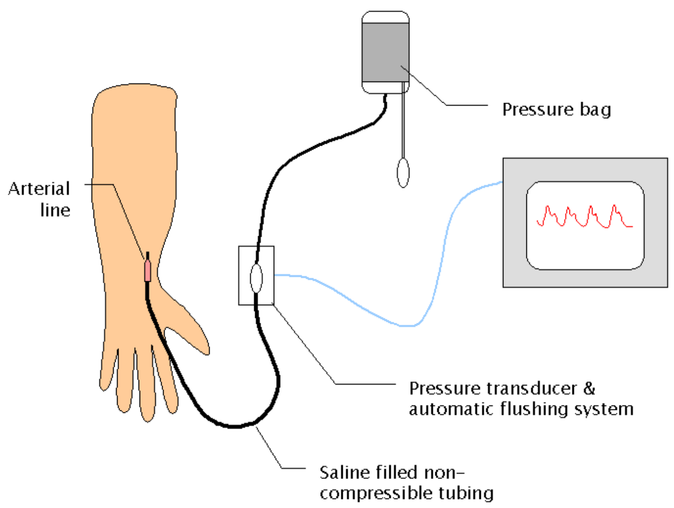


figure 2 7 Represent the invasive technique for BP measurement

A.2 Noninvasive methods

Currently, the most common non-invasive methods for measuring BP rely either on the auscultatory method or on the sociometric approach that require an inflatable cuff which may cause discomfort and only provide intermittent BP readings.

Auscultatory Method

The auscultatory method uses a stethoscope and a sphygmomanometer. This comprises an inflatable cuff placed around the upper arm at roughly the same vertical height as the heart, attached to a mercury or aneroid manometer. The mercury manometer, considered as the gold standard, measures the height of a column of mercury, given an absolute result without need for calibration and, consequently, not subject to the errors and drift of calibration which affect other methods.

The use of mercury manometers is often required in clinical trials and for the clinical measurement of hypertension in high-risk patients.

A cuff of the appropriate size is fitted smoothly and also snugly, then inflated manually by repeatedly squeezing a rubber bulb until the artery is completely occluded. It is important that the cuff size is correct: undersized cuffs record too high a pressure; oversized cuffs may yield too low a pressure. Usually three or four cuff sizes should be available to allow measurement in arms of different size. Listening with the stethoscope to the brachial artery at the antecubital area of the elbow, the examiner slowly releases the pressure in the cuff. When blood just starts to flow in the artery, the turbulent flow creates a "whooshing" or pounding (first Korotkoff sound). The pressure at which this sound is first heard is the systolic blood pressure. The cuff pressure is further released until no sound can be heard (fifth Korotkoff sound), at the diastolic arterial pressure. The auscultatory BP device and the methodology of auscultatory BP measurement are shown in Figure 2.6 important that the cuff size is correct: undersized cuffs record too high a pressure; oversized cuffs may yield too low a pressure. Usually three or four cuff sizes should be available to allow measurement in arms of different size.] Listening with the stethoscope to the brachial artery at the antecubital area of the elbow, the examiner slowly releases the pressure in the cuff. When blood just starts to flow in the artery, the turbulent flow creates a "whooshing" or pounding (first Korotkoff sound). The pressure at which this sound is first heard is the systolic blood pressure. The cuff pressure is further released until no sound can be heard (fifth Korotkoff sound), at the diastolic arterial pressure. The auscultatory BP device and the methodology of auscultatory BP measurement are shown in Figure 2.8

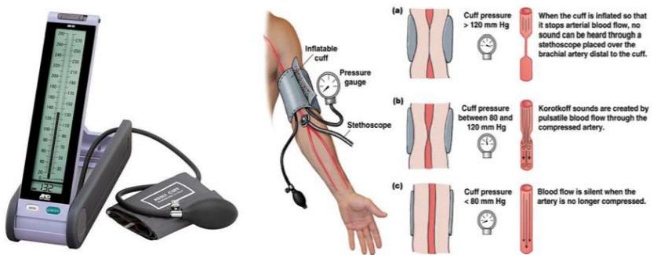


figure 2 8 The auscultatory BP device (left) and the methodology of auscultatory BP measurement (right)

sociometric method

The oscillometer method was first demonstrated in 1876 and involves the observation of oscillations in the sphygmomanometer cuff pressure which are caused by the oscillation of blood flow, i.e., the pulse. The electronic version of this method is sometimes used in long-term measurements and general practice. It uses a sphygmomanometer cuff, an electronic pressure sensor to observe cuff pressure oscillations, electronics to automatically interpret them, and automatic inflation and deflation of the cuff. The pressure should be calibrated periodically to maintain accuracy.

The cuff is inflated to a pressure initially in excess of the systolic arterial pressure and then reduced to below diastolic pressure over a period about 30 seconds. When blood flow is nil (cuff pressure exceeding systolic pressure) or unimpeded (cuff pressure below diastolic pressure), cuff pressure will be essentially constant. When blood flow is present, but restricted, the cuff pressure, which is monitored by the pressure sensor, will vary periodically in synchrony with the cyclic expansion and contraction of the brachial artery.

Over the deflation period, the recorded pressure waveform forms a signal known as the cuff deflation curve. A bandpass filter is utilized to exact the oscillometer pulses from the cuff deflation curve. Over the deflation period, the extracted oscillometer pulses form a signal known as the oscillometer waveform (OMW).

The amplitude of the oscillometic pulses increases to a maximum and then decreases with further deflation. A variety of analysis algorithms can be employed in order to estimate the systolic, diastolic, and mean arterial pressure. The calculation of systolic, diastolic and mean BP using oscillometric method is shown in Fig 2.8 .

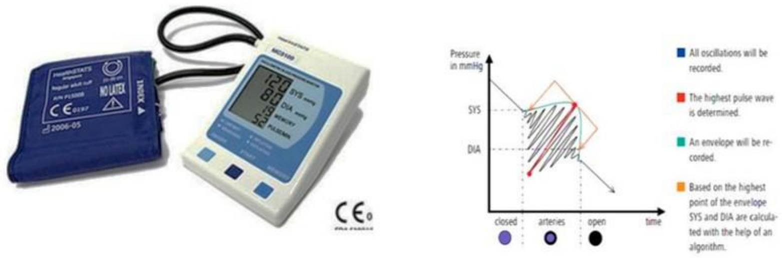


figure 2 9 The oscillometer BP device (left) and the methodology of oscillometric BP measurement

2.3 LITERATURE REVIEW

EARLY DEVELOPMENTS:

In 1985, Infants are nursed in incubators using either air mode control or skin temperature servo control.
Data are collected continuously using a computer linked monitoring system.
In 1998, Water permeability of the infant's skin is an important factor in the maintenance of a controlled water and heat balance.
Radiant warmers and incubators are used to maintain the body temperature of newborn infants.
Incubators provide a heated environment to reduce body heat losses.
The heat production is performed by forced circulation of air warmed by electrical heater, controlled manually.
In this paper an active humidification system is proposed to control ambient humidity in incubator .
In 2000 ,the observation that the relative importance of Picophytoplankton is greatest in warm and nutrient-poor waters was tested here based on a comprehensive review of the data available in the literature from oceanic and coastal estuarine areas.
The results support the increasing importance of Pico-phytoplankton in warm, oligotrophic waters.
The reduced contribution of Pico-phytoplankton in warm productive waters is hypothesized here to be due to increased loss rates, whereas the dominance of Picophytoplankton in warm, oligotrophic waters is attributable to the differential capacity to use nutrients as a function of differences in size and capacity of intrinsic growth of Picophytoplankton and larger phytoplankton cells .
In 2002 ,relative humidity levels of an incubator were measured and Controlled .
An integrated circuit-type humidity sensor was used to measure the humidity level of the incubator environment.
Measurement and control processes were achieved by a PIC microcontroller.
The high-performance and high-speed PIC provided the exibility of the system.
The developed system can be used effectively for the intensive care of newborns and/or premature babies.
In this study, the humidity measurement and control system has been developed to control the humidity level of the incubator environment.
The IC-type humidity sensor is used in the humidity measurement circuit.

Since the linearity of the sensor is better**,** accuracy is higher, the response time is faster than the other humidity sensor, and the RH of the incubator environment is controlled with small actuations around the control values.
Since, measurement and control processes are achieved by the high-performance and high-speed PIC microcontroller, it is possible to provide better performance to control [1-5].

SUBSEQUENT DEVELOPMENTS:

In 2005, the aim is to compare, in a prospective clinical trial, oxygen delivery on intermittent positive pressure with nasal cannulae versus facial mask in primary resuscitation of the newborn with moderate asphyxia.
In a direct comparison of nasal versus oral mask ventilation, however, Segedinet all showed that artificial ventilation in infants can be better performed via the nasal route.
Oxygen delivery on intermittent positive pressure with nasal cannulae in primary resuscitation of the newborn with moderate asphyxia is a less aggressive and potentially advantageous alternative to the traditional oral route.
In 2007; sophisticated electronics are within reach of average users.
Cooperation between wireless sensor networks and existing consumer electronic infrastructures can assist in the areas of health care and patient monitoring.
This will improve the quality of life of patients, provide early detection for certain ailments, and improve doctor-patient efficiency.
The goal of their work is to focus on health-related applications of wireless sensor networks.
In this paper they detail our experiences building several prototypes and discuss the driving force behind home health monitoring and how current and future technologies will enable automated home health monitoring.
They have brought sophisticated electronics within the reach of average users.
These technologies, when complimented with wireless sensor networks, promise to add a truly ambient intelligent component to our daily lives.
Today, these technologies may be integrated into existing consumer electronic and infrastructure already found in the home.
In 2008, the main objectives of this study were to: 1) determine practical field methods to monitor oral temperature (OT), heart rate (HR), and respiration rate (RR) of captured manatees; 2) establish normal OT, HR, RR parameters with correlations to blood chemistry; 3) provide an easy to reference OT, HR, RR monitoring field guide for manatee researchers.
Monitoring of the parameters can help to improve the ability to obtain individual health assessments of manatees in the field.
In 2009 ,In this paper, they propose the application of wireless transmission technology for neonatal monitoring at NICU.
Software is developed for ensure the correct data transmission, detection and display.
The system is designed to be suitable for integration into a non-invasive monitoring platform such as a smart neonatal jacket.
Some interesting aspects related to the wireless transmission at NICU were briefly touched during the later stages of the project, which are highly relevant for future development.

Firstly, for demonstrating the transmission of multi modal data from different sensors, such as ECG and SpO2, the hardware and calibration of sensors as well as signal processing will need to be implemented with the integration of noninvasive sensors.
In 2009, a ZigBee network based wireless heart rate monitoring system for the premature babies who are under the constant monitoring system.
The main focus of this project is to study the existing heart monitoring systems in different physical situations, search the feasibility for wireless heart monitoring systems for premature babies in the hospital.
Then develop an unconstrained monitoring system that can monitor babies' heart rates continuously.
So that it gives the medical staff an early warning in real time if necessary.
In this project, they develop a heart rate monitoring system for the babies who are kept in the incubators in different rooms.
The system will allow hospital personnel to remotely monitor the heart rate from the center monitoring system.
The heart-rate information of babies kept in various incubators and transmit the heart rate information to the central wireless device which is kept in the incubator room through the wireless communication network.
They have proposed a low-cost solution to enhance the remote monitoring capability of existing health care system. They conducted a feasibility study of using ZigBee network based heart rate monitoring system.
It is cheap, secure, robust and low-power consuming.
It can operate on multiple channels so as to avoid interference with other wireless evices or equipments in the hospital [6-11].

LATEST DEVELOPMENTS:

In 2016, in this article, they define and discuss some of the major challenges in the healthcare systems which can be effectively tackled by the recent advancement in ICT technologies.
In particular, they focus on sensing technologies, cloud of computing, internet-of-things and big data analytics systems as emerging technologies which are made possible by the remarkable progress in various aspects including network communication speed, computational capabilities and data storage capacities that provide various advantages and characteristics that can contribute towards improving the efficiency and effectiveness of healthcare services.
In particular, they focused on exploiting the advancements in the areas of sensor technologies, cloud computing, Internet- Of- Things and Big data analytics systems as emerging technologies that can significantly contribute towards improving the efficiency and effectiveness of healthcare services.
Several use cases and application scenarios have been discussed to promote the importance of our proposed framework.
Future work will concentrate on designing the adequate programming .
Abstraction that can equip the analytics process for various healthcare related complex data sources.
In 2016 ,this paper describes a non -pharmacological solution, called Smart, which provides comfort through mediation of a parent’s physiological features to the distressed neonate via an intelligent pillow system embedded with sensing and actuating functions.

An intelligent pillow system was proposed and implemented with embedding sensing and actuating functions for the transfer of maternal heart beat into the pillow and playing the pulsation to the neonate.

For the design of a comfortable monitoring system for prematurely born babies in the Neonatal Intensive Care Unit(NICU), they proposed the concept of diversity measurement and context awareness to improve reliability.

Clinical multi-modal sensor data was collected in the NICU with the Smart Jacket connected to a state –of-the art amplifier.

They found that signals quality varied among sensors and varied over time, and found correlations between ECG signal, acceleration data, and context ,which support the feasibility of the concept.

The Neonatal Intensive Care Unit represents a complex and multi-output context aimed at monitoring and controlling biological signals and parameters in premature newborn.

This paper details some methodological and design options for developing technologies that allow end-user composition and control.

The main goal of ambient or ubiquitous computing applications was to make the technology transparent or invisible to the users .

An intensive care situation provides a highly dynamic environment where a number of heterogeneous actors co-exist .

This ongoing dynamic changing situation provides very specific ,but in the same time ,continuously changing requirements .

Users can construct assemblies of heterogeneous technologies as discussed of heterogeneous technologies s discussed in this paper .

Initial result of the field trails show the possibility to use redundancy inspection scenarios within this domain.

Combining the sampled clinical data with the associated context could provide further insight to the natural cause and progression of the disease.

For instance, with arrhythmic heart disease monitoring, the underlying cause of the altered ECG signals can be attributed to the intrinsic cardiac condition as well as a number of other factors including the physical and mental stress of the patient .

This paper proposes miniaturized sophisticated intelligent wireless sensors networks to provide real time monitoring of parameters like ECG, Blood Pressure, Oximetry, Pulse, and Temperature of the infant/patient and the humidity of the incubator.

The simulation results are encouraging enough to warrant their use as a real time information delivery system that would greatly help Paediatrics consultants and particularly infants and can rely on this extremely potential Intelligent Sensors Network that provides accurate pathological parameters.

Each proposed incubator will have a set of six sensors which will provide the ECG, Blood Pressure, Oximetry, Pulse and Temperature of the infant in the incubator.

Data collected from all the sensors is stored temporarily in the node provided in the Incubator itself and transmits the data to the Base Station over a wireless channel for analysis.

7The proposed Real time incubator monitoring system collects various biometric parameters of the infant in the incubator and sends this over a wireless network to the Base Station.

The proposed system ensures proper monitoring of the infants and helps in case of emergencies as well using enhanced-AODV protocol.

The future work is focused on the implementation of the monitoring system to monitor all the pathological parameters of infants in all the hospitals with common physician/consultant.

This paper aim is todetermine possible correlations of OT, HR, RR with blood chemistry.
Oral temperature will show a time dependent increase in value after capture; heart rate and respiration rate will stabilize over time.
A positive correlation exists between heart rate, potassium, and lactate concentration amongst healthy captured manatees[12-15].

Chapter 3 Block Diagram and Flowchart

3.1 block diagram of patient monitor

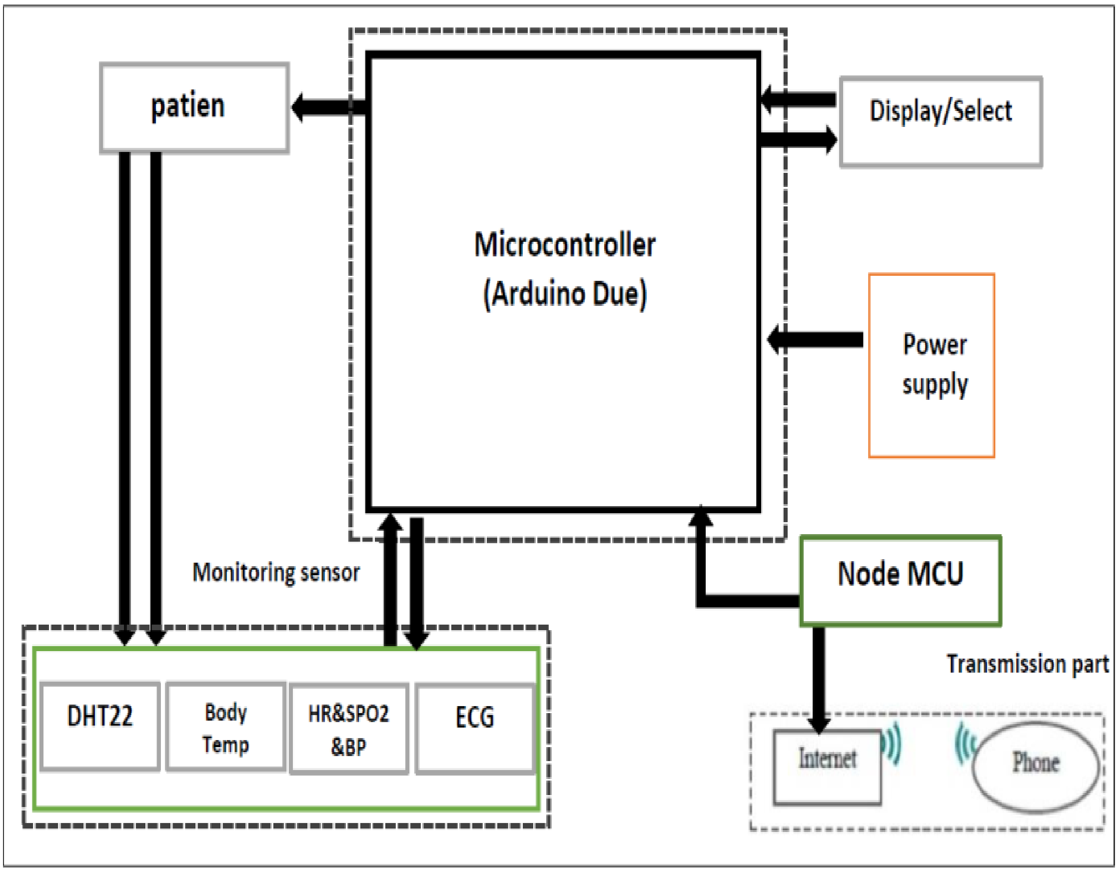


figure 3 1 block diagram of patient monitor

3.1.1 A Main parts of block diagram consist of:

1. Monitoring part
2. Processing and Controller unit part
3. Transmission part

3.1.1.1.Monitoring part

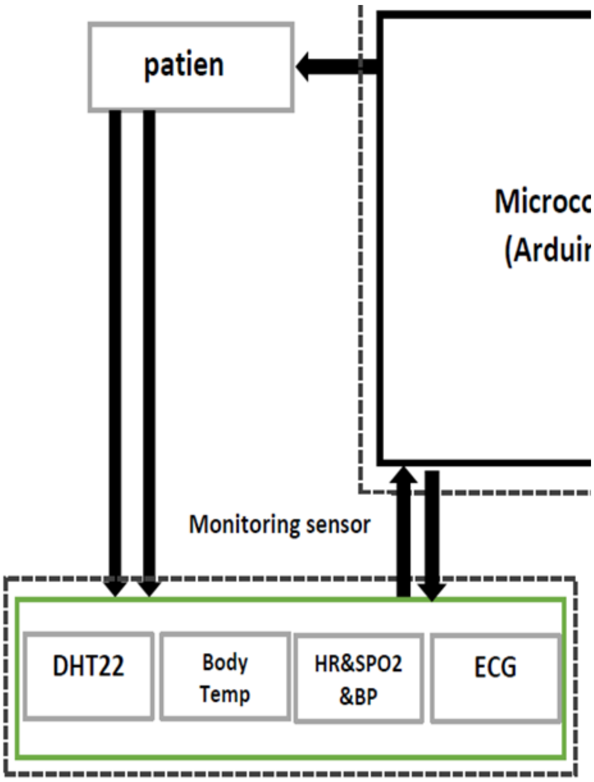


figure 3 2 monitoring part

For monitoring part, we design a system monitoring that contain of the following:

- **ECG Sensor:**

The working principle of the ECG sensor is like an operational amplifier to help in getting a clear signal from the intervals simply.

- **BP, Heart rate& SPO2 Sensor:**

It turns out, oxygenated blood absorbs more infrared light and passes more red light while deoxygenated blood absorbs red light and passes more infrared light and calculated by using Beer-Lambert law: **A = εbc.**

Where **ε** is the molar absorptivity of the absorbing species, **b** is the path length, and **c** is the concentration of the absorbing species.

- ## DHT 22:

It consists of a humidity sensing component, a NTC temperature sensor (or thermistor) and an IC on the back side of the sensor which a thermistor is actually a variable resistor that changes its resistance with change of the temperature.

- ## Body Temperature Sensor:

It works on the principle of direct conversion of temperature into a digital value.

3.1.2 Processing and Controller unit part:

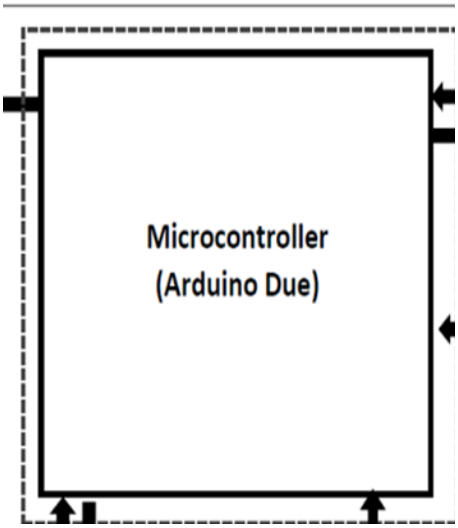


figure 3 3 Processing and Controller unit part

Processing and controller unit part contain Microcontroller (ARDUINO DUE), Display and Node MCU.

Arduino DUE controled by all the sensors, frequencies which need for patient. Then the microcontroller sends the monitoring signal to the display.

3.1.3 Transmission part

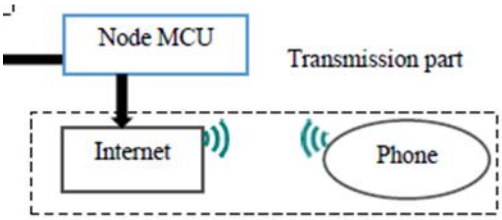


figure 3 4 Transmission part

This part contains of ESP8266 Wi-Fi interface of Node MCU and smart phone. The phone will receive the data which coming from the Node MCU and display the data.

3.2 flow chart of the patient monitor:

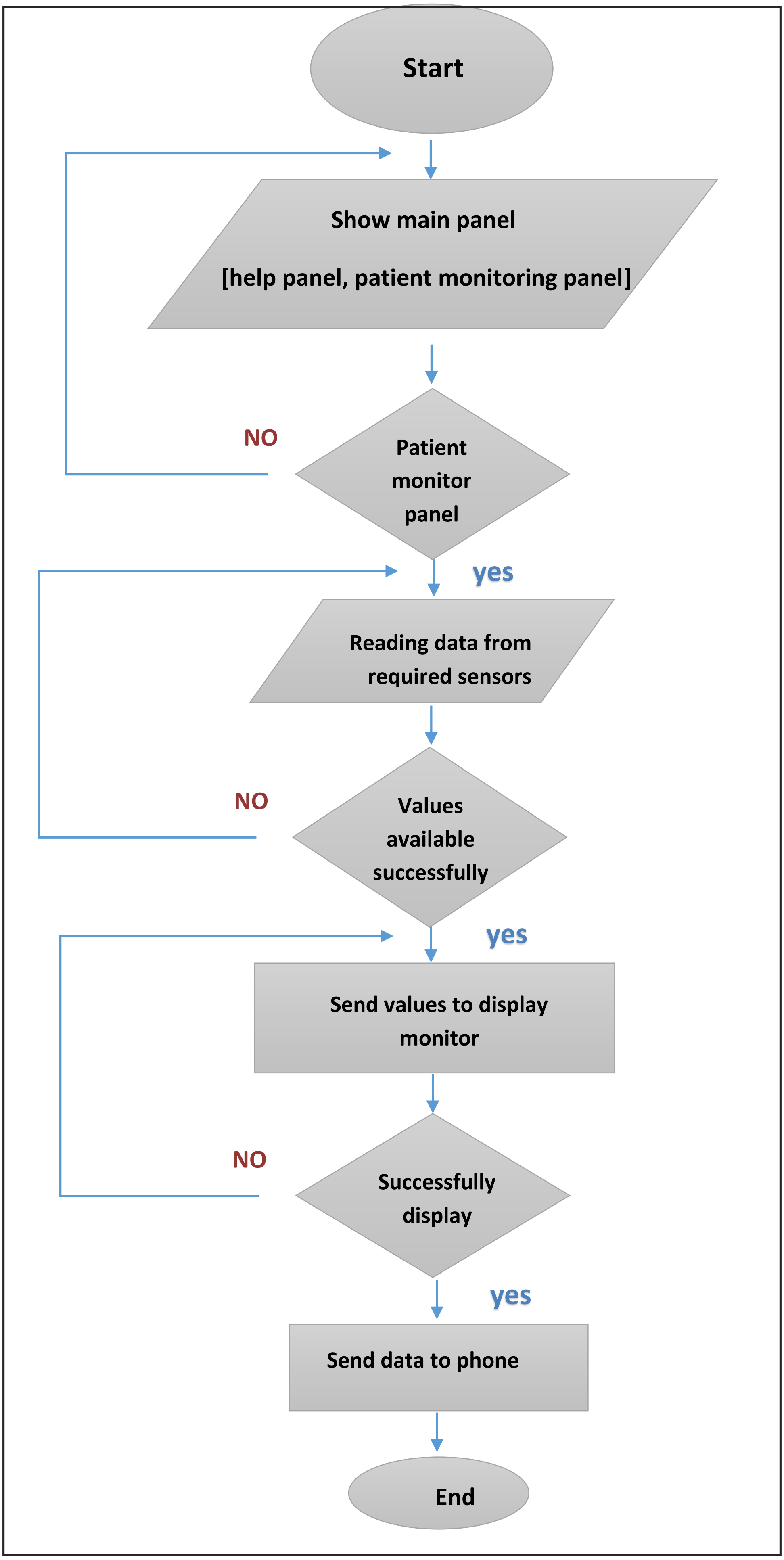


figure 3 5 flow chart of the patient monitor

Chapter 4 Simulation & Implementation:

4.1 Simulation of the circuit:

For this purpose, we use 8.6 version of Proteus design and software program of electronic tools for simulate our project. Proteus Design Suite (designed by LaCenter Electronics Ltd.) is a software tool set, mainly used for creating schematics, simulating Electronics & Embedded Circuits and designing PCB Layouts. Proteus ISIS is used by Engineering students & professionals to create schematics & simulations of different electronic circuits. Also, it’s used for designing/testing programming codes for different Microcontrollers i.e. Arduino, PIC Microcontroller, 8051 etc. In Embedded projects, we need to design a programming code for Microcontrollers and for designing such codes you have to perform a lot of testing, which involves uploading code to Microcontroller.

the patient monitor is subdivided into body temperature ECG, Spo2, heartbeat the blood pressure in the proteus program cannot be simulated that is why they have not been added in this part of the project as shown in Figure 4.1 the final form.

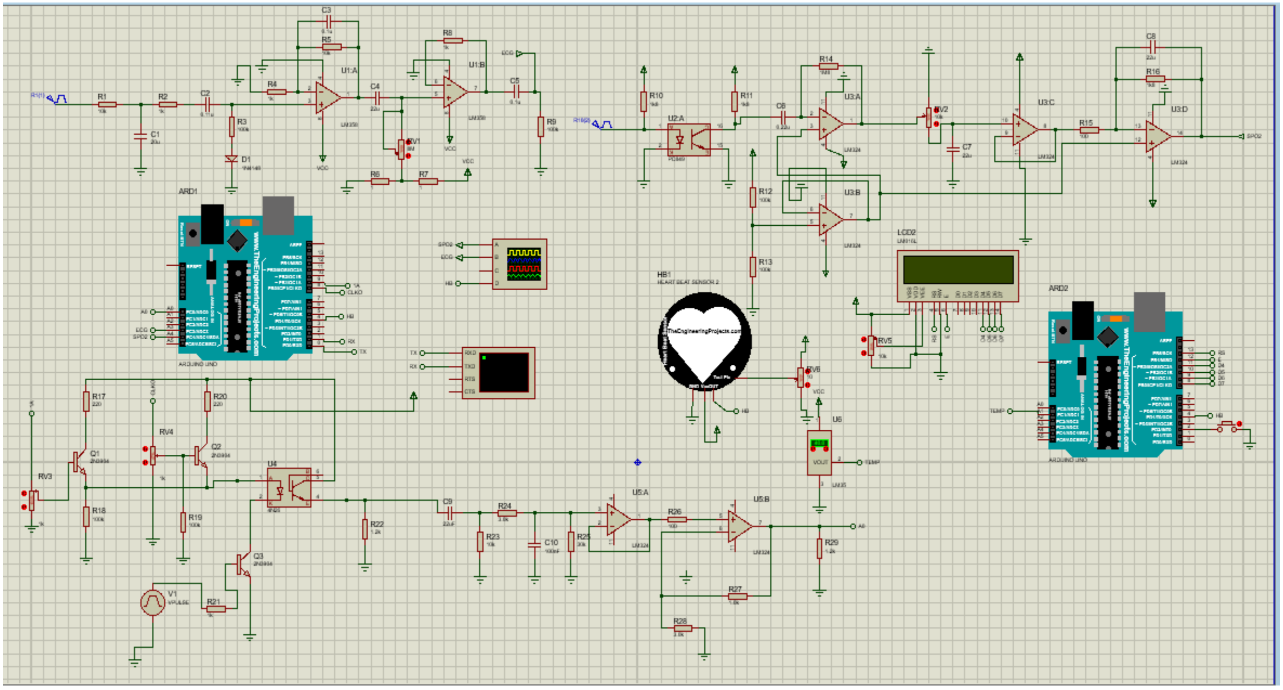


figure 4 1 The final form of the patient monitor

We use two Arduino uno: the first Arduino that show the results of the temperature and the heart beat through LCD 16X2 but the other one it is show the result of ECG, Spo2 and heart beat through the oscilloscope.

4.2 Implementation of project:

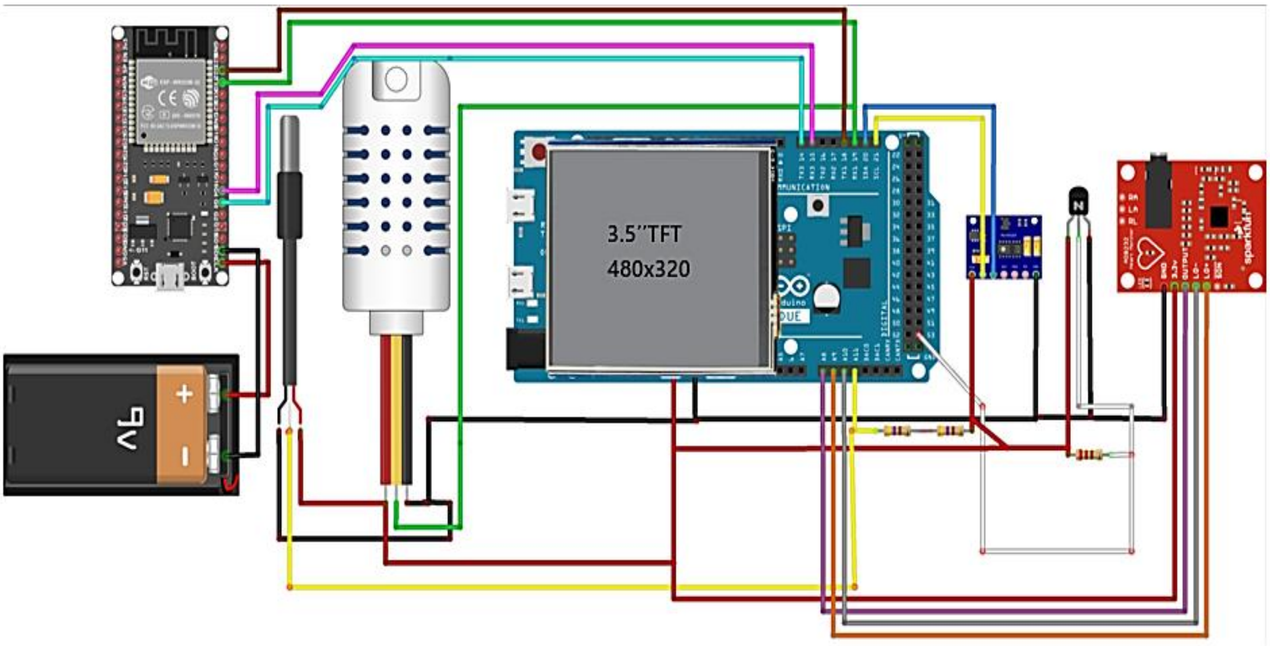


figure 4 2 Electrical circuit

4.2.1 Project description:

The particle circuit contains of two modes, the is monitoring which will measure the ECG signal through the sensor (AD8232), BP,HR,SpO_2 and PPG signal through the sensor (MAX 30100), body temperature through (DS18B20) probe, and air temperature and humidity through (DHT 22) sensor and shows the result on display (3.5 TFT) after data processing data with microcontroller (Arduino DUO) and transmits the result to the phone through (Node MCU ESP32) via (Wi-Fi interface).

4.3 Components of the Project:

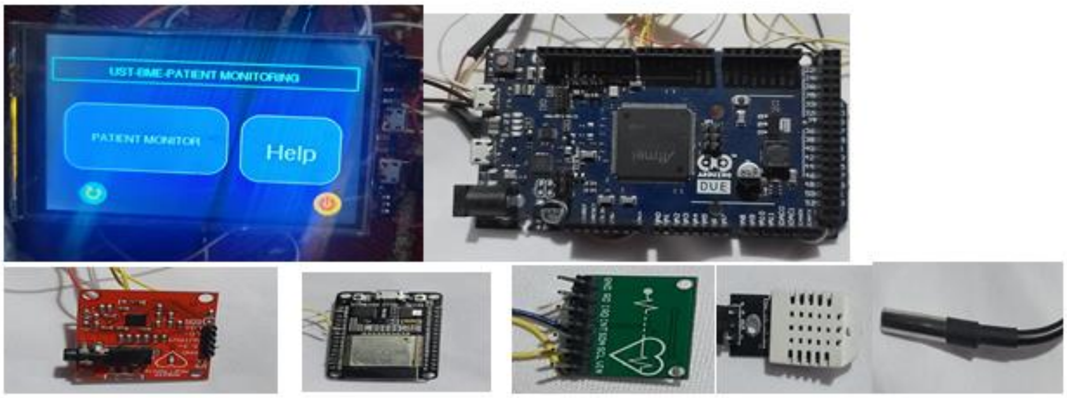


figure 4 3 Components of the Project

4.3.1 AD8232 Sensor :

The AD8232 is an integrated signal conditioning block for ECG and other biopotential measurement applications. It is designed to extract, amplify, and filter small biopotential signals in the presence of noisy conditions, such as those created by motion or remote electrode placement. This design allows for an ultralow power analog-to-digital converter (ADC) or an embedded microcontroller to acquire the output signal easily.

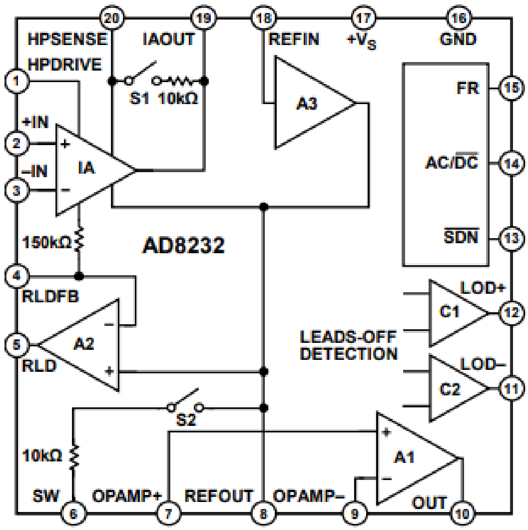


figure 4 4 Block diagram of AD8232 sensor

Features and Benefits

- Two or three electrode configurations.
- Leads-Off Detection: AC or DC options.
- Brand New & High Quality.
- 2-pole adjustable high-pass filter.
- 3-pole adjustable low-pass filter.
- High signal gain (G = 100).
- Operating Voltage: 2 V to 3.5V.
- Low supply current: 170 µA.
- Working Temp Range: -40 C^o to 85 C^o.

4.3.2 MAX30100 Sensor:

The MAX30100 is an integrated pulse oximetry and heart-rate monitor sensor solution. It combines two LEDs, a photodetector, optimized optics, and low-noise analog signal processing to detect pulse oximetry and heart-rate signals and blood pressure.

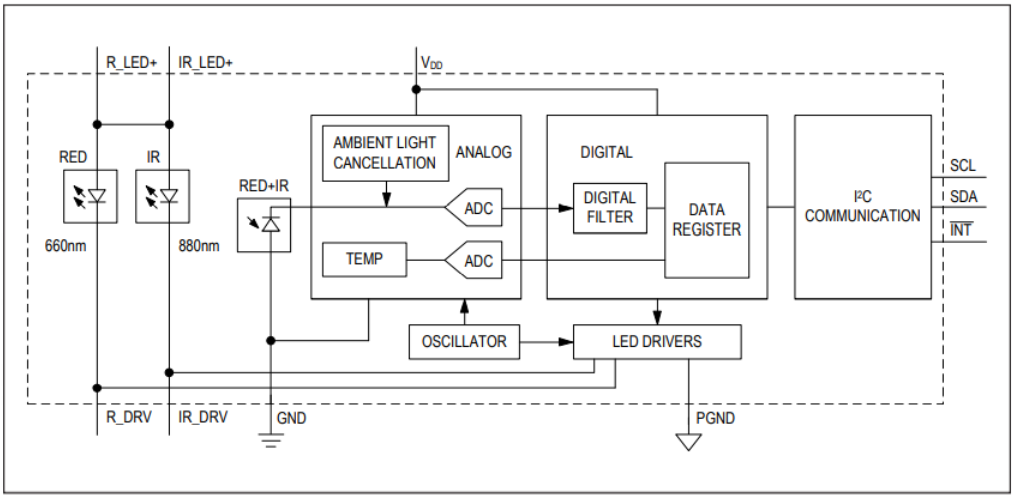


figure 4 5 functional diagram

Benefits and Features

- Complete Pulse Oximeter and Heart-Rate Sensor Solution Simplifies Design

  • Integrated LEDs, Photo Sensor, and High-Performance Analog Front -End.

  • Tiny 5.6mm x 2.8mm x 1.2mm 14-Pin Optically Enhanced System-in-Package.

- Ultra-Low-Power Operation Increases Battery Life for Wearable Devices

  • Programmable Sample Rate and LED Current for Power Savings.

  • Ultra-Low Shutdown Current (0.7µA, typ).

- Advanced Functionality Improves Measurement Performance

  • High SNR Provides Robust Motion Artifact Resilience.

  • Integrated Ambient Light Cancellation • High Sample Rate Capability.

  • Fast Data Output Capability.

4.3.3 DS18B20 Probe:

The DS18B20 digital thermometer provides 9-bit to 12-bit Celsius temperature measurements and has an alarm function with nonvolatile user-programmable upper and lower trigger points. The DS18B20 communicates over a 1-Wire bus that by definition requires only one data line (and ground) for communication with a central microprocessor. In addition, the DS18B20 can derive power directly from the data line ("parasite power"), *eliminating the need for an external power supply*.

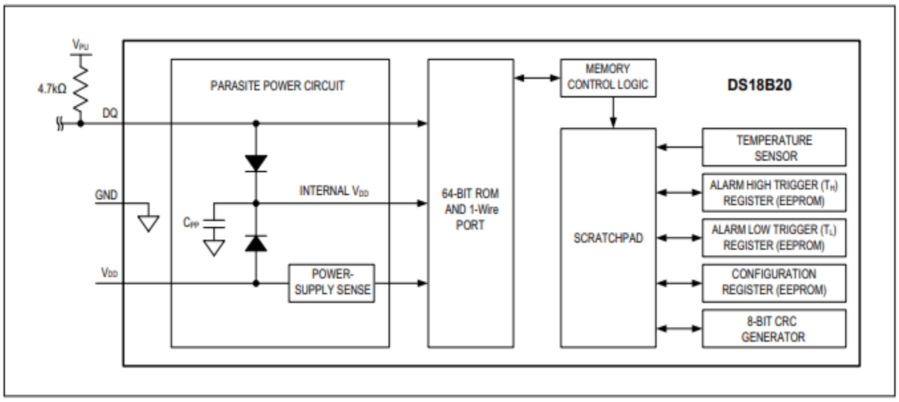


figure 4 6 block diagram

Benefits and Features

- Unique 1-wire interface requires only one port pin for communication.
- Reduce component count with integrated temperature sensor and eeprom.
  - Measures temperatures from -55°c to +125°c (-67°f to +257°f).
  - ±0.5°c accuracy from -10°c to +85°c.
  - Programmable resolution from 9 bits to 12 bits.
  - No external components required.
- Parasitic power mode requires only 2 pins for operation (dq and gnd).
- Simplifies distributed temperature-sensing applications with multidrop capability.
  - Each device has a unique 64-bit serial code stored in on-board rom.
- Flexible user-definable nonvolatile (nv) alarm settings with alarm search command. Identifies devices with temperatures outside programmed limits.
- Available in 8-pin so (150 mils), 8-pin µsop, and 3-pin to-92 packages.

4.3.4 DHT 22 Sensor:

DHT22 output calibrated digital signal. It utilizes exclusive digital-signal-collecting-technique and humidity sensing technology, assuring its reliability and stability. Its sensing elements is connected with 8-bit single-chip computer.

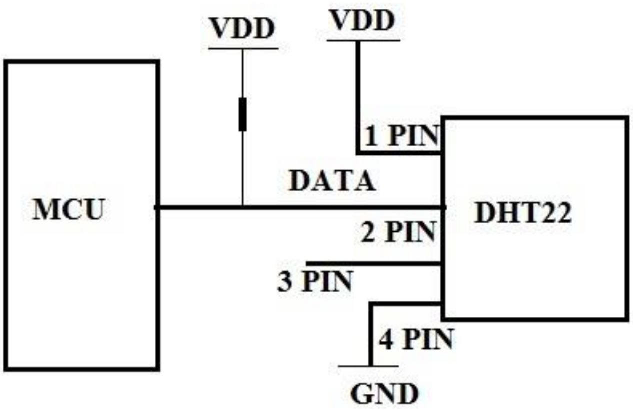


figure 4 7 circuit diagram

Features and benefits

- Full range temperature compensated.
- Relative humidity and temperature measurement.
- Calibrated digital signal.
- Outstanding long-term stability.
- Extra components not needed.
- Long transmission distance.
- Low power consumption.
- 4 pins packaged and fully interchangeable.

4.3.5 Node MCU ESP32:

NodeMCU-32s module integrates traditional Bluetooth, low power Bluetooth and Wi-Fi. Has a wide range of applications: Wi-Fi support for a wide range of communication connections and direct connection to the Internet through routers; Bluetooth allows users to connect Cell phone or broadcast BLE Beacon to facilitate signal detection. Data transfer rates up to 150 Mbps, supported by the module. Antenna output power up to 20 dBm, can achieve maximum range of wireless communication. So, this module has a leading industry in high integration, wireless transmission distance, power consumption and network connectivity performance are excellent.

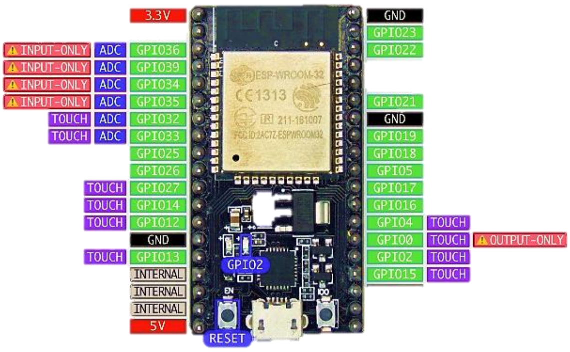


figure 4 8 Node MCU ESP32

Features and benefits

- 802.11b/g/n （802.11n，Speed up to 150Mbps）.
- WIFI frequency range 2400~2483.5MHz.
- Adjusting range of clock frequency for 80 MHz to 240 MHz support RTOS.
- Built-in 2 channels 12-bit high precision ADC, up to 18 channels.
- Support UART/GPIO/ADC/DAC/SDIO/PWM/I2C/I2S interface.
- Support multiple sleep modes, ESP32 chip sleep current less than 5μA.
- Embedded Lwip protocol stack.
- Supporting STA/AP/STA AP operating mode.
- Support for local serial port upgrades and remote firmware upgrades（FOTA）.
- Generic AT instructions can be used quickly.

4.3.6 Microcontroller (Arduino DUE):

The Arduino Due is one of the most powerful boards of the Arduino series. This board is powered by a 32-bit ARM cortex-M3 processor Atmel SAM3X8E.

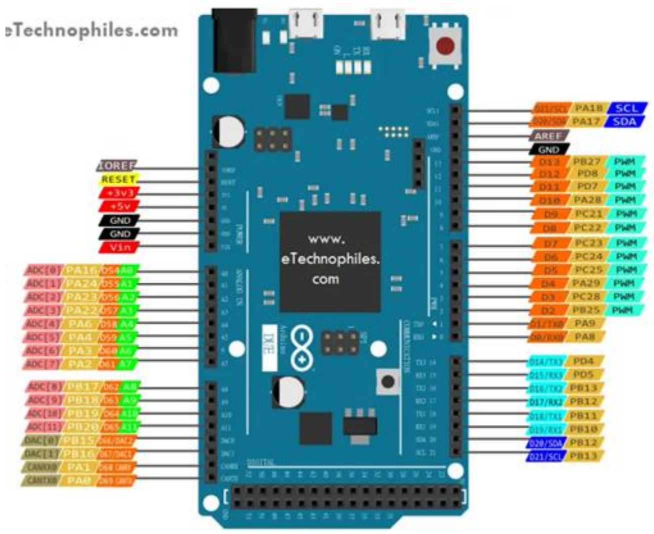


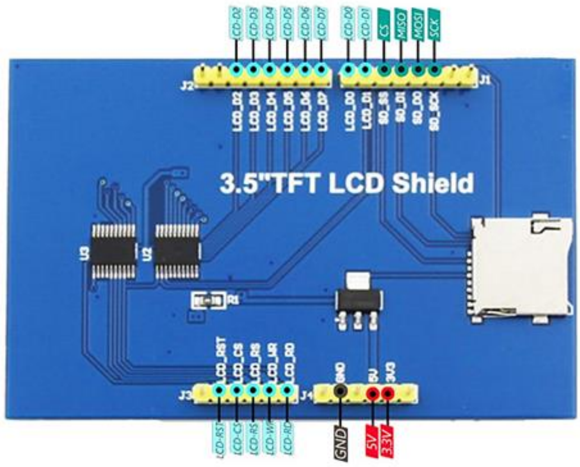
figure 4 9 Arduino due

Technical specifications:

- Microcontroller AT91SAM3X8E
- Operating Voltage 3.3V
- Input Voltage (recommended) 7-12V
- Input Voltage (limits) 6-20V
- Digital I/O Pins 54 (of which 12 provide PWM output)
- Analog Input Pins 12
- Analog Outputs Pins 2 (DAC)
- Total DC Output Current on all I/O lines 130 mA
- DC Current for 3.3V Pin 800 mA
- DC Current for 5V Pin 800 mA
- Flash Memory 512 KB all available for the user applications
- SRAM 96 KB (two banks: 64KB and 32KB)
- Clock Speed 84 MHz

4.3.7 Display (3.5 TFT LCD):

3.5-inch color screen, support 65K color display, display rich colors. 480X320 resolution, optional touch function using the SPI serial bus, it only takes a few IOs to illuminate the display. Easy to expand and experiment with SD card slot.



(a) **(b)**

figure 4 10 front panel, (b)background panel of 3.5 TFT LCD Shield

Technical specifications:

- Display color 262K.
- Viewing Direction 12 O’clock.
- Grey scale inversion 6 O’clock.
- Operating temperature -20~+70 ℃.
- Storage temperature -30~+80 ℃.
- Active Area(W×H) 70.08×52.56 mm.
- Number of Dots 320×RGB×240 dots.
- Controller HX8238D.
- Power Supply Voltage 3.3 V.

- Backlight 6-LEDs (white) pcs.
- Interface RGB 24bit.

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