Palestine Polytechnic University

College of Engineering

Smart Vest to Isolate
Infectious Diseases and Radiation

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الإهـــــــــــــداء

بدأنا بأكثر من يد وقاسينا أكثر من هم وعانينا الكثير من الصعوبات وها نحن اليوم والحمد لله نطوي سهر الليالي وتعب الإيام وخلاصة مشوارنا بين دفتي هذا العمل المتواضع.

إلى منارة العلم والامام المصطفى إلى سيد الخلق إلى رسولنا الكريم سيدنا محمد صلى الله عليه وسلم.

إلى روح غســان كنفانــي الذي قال " إذا أردت شيئـاً فخذه بذراعيك وكفيك وأصابعك ".

إلى الينبوع الذي لا يمل العطاء إلى من حاكت سعادتي بخيوط منسوجة من قلبها إلى أمي العزيزة.

إلى من سعى وشقى لأنعم بالراحة والهناء الذي لم يبخل بشئ من أجل دفعي في طريق النجاح الذي علمني أن أرتقي سلم الحياة بحكمة وصبر إلى والدي العزيز.

إلى من حبهم يجري في عروقي ويلهج بذكراهم فؤادي إلى أخواتي وأخواني .

إلى من سرنا سوياً ونحن نشق الطريق معاً نحو النجاح والإبداع إلى من تكاتفنا يداً بيد ونحن نقطف زهرة وتعلمنا إلى زملائي وزميلاتي.

إلى من علمونا حروفاً من ذهب وكلمات من درر وعبارات من أسمى وأجلى عبارات في العلم إلى من صاغوا لنا علمهم حروفاً ومن فكرهم منارة تنير لنا سيرة العلم والنجاح إلى أساتذتنا الكرام.

إلى أسـرانا البواسـل في سـجون الإحتـلال الذيـن ضحوا بزهـرة أعمارهم من أجـل أن نحيـا وأهلينـا وأبناء شـعبنا بـكل عـزة وكرامة.

إلى مـن قـدموا أرواحهم فداءً لوطننـا الحبيـب إلـى شـهدائنا الأبـرار.

الملخص

أكثر أمراض الجهاز التنفسي انتشارًا في الشرق الأوسط هي مرض النكاف ومتلازمة الشرق الأوسط التنفسية. وليس للمرضين أي لقاح حتى الآن والطريقة الوحيدة للتحكم والحد من انتشار هذه الأمراض هي غرفة العزل والحجر الصحي وغرف العزل ليست فقط للسيطرة على الأمراض المعدية فقط بل تستخدم أيضًا للسيطرة على الإشعاع المنبعثة من المرضى الذين تم تشخيصهم بمضاعفات الغدة الدرقية ومعالجتهم باليود المشع ، يجب على المرضى الذين يخضعون لهذا العلاج تجنب الاتصال بشكل دوري و متواصل مع الأفراد من أجل حماية الآخرين من التعرض للإشعاع الضار الناتج عن العلاج.

يهدف هذا المشروع إلى تقديم بديل أقل في التكلفة والتأثير في نفسية المرضى , طريقة للعزل ، ويتكون من مستشعر للكشف عن الإنسان ومستشعر مسافة، يتم تنفيذه في حزام خاص ، إذا اكتشفت المستشعرات عن وجود انسان ضمن نطاق المسافة المحدد مسبقًا (منطقة الخطر) ، سيتم تفعيل أنظمة الإنذار الصوت والاهتزاز ، يمكن معايرة نطاق المسافة من متر واحد الى مترين تبعا لحالة المريض.

Abstract

The most common respiratory-spread diseases in the Middle East are Mumps disease and the Middle East Respiratory Syndrome (MERS). Both diseases have no vaccine till now, and the only way to control and reduce the spread of these diseases was the isolation room and quarantine. Insulation rooms are not only to control infectious diseases, but also to control radiation emitted from patients who are diagnosed with thyroid complications treated with radioactive iodine (I-131). Patients that undergoing this treatment must avoid excessive contact with individuals in order to protect others from radiation exposure.

The purpose of this project is to offer an alternative, lower in both cost and impact in patients psyche, separation way. It consists of human detection sensor and distance sensor, implemented in a special strap. If the sensors detect human within a predefined range of distance (risk zone), the alarm systems, audio and vibration, will be activated, the distance range can be calibrated from one meter to two meters according to the patient's condition.

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List of Abbreviations

Abbreviations	Full Word
MERS	Middle East Respiratory Syndrome
RAI	Radioactive Iodine Therapy
CoVs	Coronaviruses
DPP4	Dipeptidyl Peptidase 4
MuV	Mumps Virus
RNP	Ribonucleoprotein
TSH	Thyroid-Stimulating Hormone
mSv	Millisievert
IR	Infrared
PIR	Passive Infrared Sensors
EM	EM random access memory
RAM	Random Access Memory

Chapter One

Introduction

1.1 Introduction

1.2 Project Idea Description

1.3 Project Objectives

1.4 Project Importance

1.5 Literature Review

1.6 Time Schedule

1.1 Introduction

Several infectious diseases spread from one person to another, which in some cases need isolation, Two main infectious illnesses are found in the Middle East which are the Middle East Respiratory Syndrome (MERS) and Mumps, both of these contagious diseases need isolation in order to prevent or control infection , Isolation is not only used for infectious diseases it also used for radioactivity control which is results of some treatment like Radioactive Iodine Therapy (RAI), after a patient is treated with therapeutic doses of radioactive iodine (I-131) then the patient is discharged , the radiation from the doses can be potentially harmful to those in close proximity to the patient . The Greatest concern is given to family members, or any individual close to the patient, as well as healthcare professionals and also the environment. Reducing the transmission of communicable diseases and radiation effects are the primary function of public health law, and isolation and quarantine must be the least restrictive means necessary to prevent the spread of a contagious disease to others and may include the homes or other private and public premises. The isolation of health in hospitals and health centers reduces the risk of the spread of these diseases among humans, and the risk of exposure to radiation to other people, but unfortunately isolation has many disadvantages including relatively expensive wages, it costs for people unable to work during quarantine, and the effect in patient's psyche result of the isolation in a room for a long time. Because of isolation and quarantine disadvantages, this project offers another solution which is a smart vest alerts the patient and others around them of their proximity, in order to prevent contagious diseases and control radioactivity.

1.2 Project Idea Description

Design a vest can detect the unsafe distances between the patient and other people and activate an alarm system. An infrared sensor is used to detect the people whereas the ultrasonic sensor is used to detect the distance (Risk zone). This device aids the patients with the two infectious diseases MERS, Mumps, and RAI Patients, to interact with family members and others, regardless of their home, public places even crowded places. If the patient is in isolation period (in a time span) and becomes in the risk zone, the vest detects that and receives an acoustic and optical feedback. The zone and time span will be controlled according to the illnesses type; Close contacts of confirmed or probable cases should be identified and monitored for a different time span and different unsafe distance, in MERS, Mumps and radioactive iodine should monitoring for fourteen days [1], nine days, and five days, respectively .and the unsafe distance of each one is two meter [2], one meter [3], and one meter distance [4], respectively.

1.3 Project Objectives

This project will achieve the following objectives:

1. Design a vest that has the ability to detect the closeness of human to the patient in different distances.
2. Design a medical alarm system that activates when the vest detects human within the risk zone.
3. Calibrate the risk zone depending on the type of disease.

1.4 Project Importance

The importance of the project is concentrated in the following points:

1. Saves people's life from infectious disease and radioactive iodine.
2. Provides more comfort and easy to the patient more than isolation rooms.
3. Reduces the overload on the isolation sections in hospitals, and patient's observation operation.
4. Reduces the hospital medical care expenses.

1.5 Literature Review

Dr. Sarah Hagi from the radiology department at King Abdulaziz University Hospital in collaboration with Professor John Webster have requested a device that alerts the RAI patient and others if the patient is within one meter of a human. Proposed the original design of the Radiation Distance Safety Meter. The proposal calls for the design of one or many devices that aid Radioactive Iodine Therapy especially patients with interactions with family members and others, in their home settings after hospital discharge. The initial idea was a form of headwear that contains both a distance and heat sensor. If a patient is to get within 1 meter of another person, the patient receives an acoustic, vibratory, or optical feedback. The client proposed the use of a pyro-electric infrared sensor for the heat sensor and an ultrasonic time-of-flight sensor for the distance sensor. [5]

1.6 Time Schedule

This table illustrates the activities of the project, and the time of each one.

Table 1.1 Time schedule of the year.

Time schedule of spring 2018 semester

Task \ Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Project Idea	■	■													
Proposal		■	■												
Searching for information		■	■	■	■	■	■	■	■	■					
sorting the information and documentation					■	■	■	■	■	■	■	■	■	■	
Draft Edition														■	
Print the thesis report															■

Time schedule of winter 2019 semester

Task \ Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Electronic chips buying	■	■	■	■	■	■									
Electronic chips testing					■	■	■	■	■						
Preparing circuit schematics							■	■	■						
Connecting circuits							■	■	■	■	■				
Programming									■	■	■				
Testing the system											■	■	■	■	
Preparing the documentation				■	■	■	■	■	■	■	■	■	■		
Submitting project documentation															■

Chapter Two

Infectious Diseases and Radioactive Iodine

2.1 Middle East Respiratory Syndrome (MERS)

2.1.1 Symptoms and Complications

2.1.2 MERS-CoV Origin and Transmissions

2.1.3 Prevention and Treatment

2.2 Mumps

Several infectious diseases spread from one person to another, which in some cases need isolation. Two main infectious illnesses are found in the Middle East which are the Middle East Respiratory Syndrome (MERS) and Mumps, both of these contagious diseases need isolation in order to prevent or control infection. Isolation is not only used for infectious diseases, it also used for radioactivity control, which is the results of some treatment like Radioactive Iodine Therapy (RAI), in this chapter, each case is discussed in further details.

2.1 Middle East Respiratory Syndrome (MERS)

MERS is a viral respiratory disease caused by a novel coronavirus that was first identified in Saudi Arabia, coronaviruses (CoVs) are large, enveloped, positive-sense RNA viruses that infect birds and a wide range of mammals, including humans. These viruses are composed of a few structural proteins that hold a relatively long (around 30 kb) positive- stranded genome as shown in figure (2.1) MERS-CoV genome organization: S, spike protein; M, membrane protein; E, envelope protein; N, nucleocapsid protein. [6]

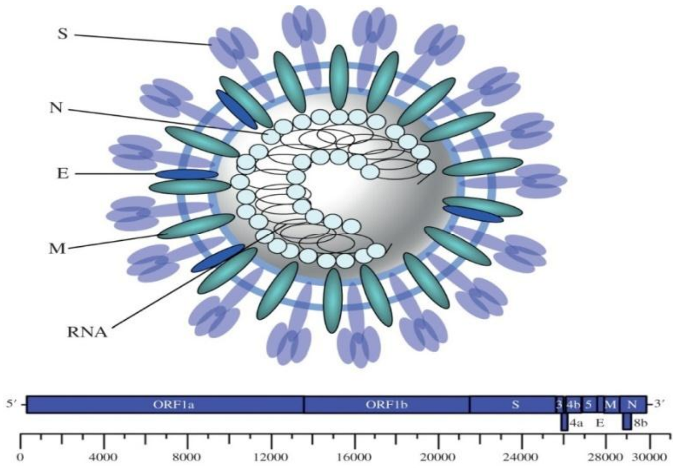

Figure 2.1 Schematic diagram of a MERS-CoV particleand genome organization. [6]

2.1.1 Symptoms and Complications

Most people confirmed to have the MERS-CoV infection have had the severe acute respiratory illness with symptoms of fever, cough and shortness of breath. Some people also had gastrointestinal symptoms including diarrhea and nausea/vomiting. For many people with MERS, more severe complications followed, such as pneumonia and kidney failure. About 3 to 4 out of every 10 people reported with MERS have died. Most of the people who died had an underlying medical condition. Some infected people had mild symptoms (such as cold-like symptoms) or no symptoms at all. Based on what researchers know so far, people with pre-existing medical conditions (also called comorbidities) may be more likely to become infected with MERS-CoV, or have a severe case. Pre-existing conditions from reported cases have included diabetes, cancer, chronic lung, heart, and kidney disease. Individuals with weakened immune systems are also at higher risk for getting MERS or having a severe case. [7]

2.1.2 MERS-CoV Origin and Transmissions

Coronaviruses are thought to originate from animal reservoirs MERS-CoV emerging from bats via masked palm civet cats on Chinese wet-markets and dromedary camels in the Middle East, respectively [8]. Given the fact that MERS-CoV seems to be widely present in dromedary camels in the Middle East and some parts of Africa, zoonotic transmission is likely to have originated from this animal species and is expected to continue for a long period of time in these regions. Through the usage of a common entry receptor, dipeptidyl peptidase 4 (DPP4), the emergence of MERS-CoV in humans from dromedary camels, and potentially earlier in time from bats, is facilitated by the presence of a highly similar viral receptor (DPP4) in humans. Hypothetically, MERS-CoV present in dromedary camels may have emerged from CoVs in bats that also use DPP4 as an entry receptor as shown in figure (2.2). [9]

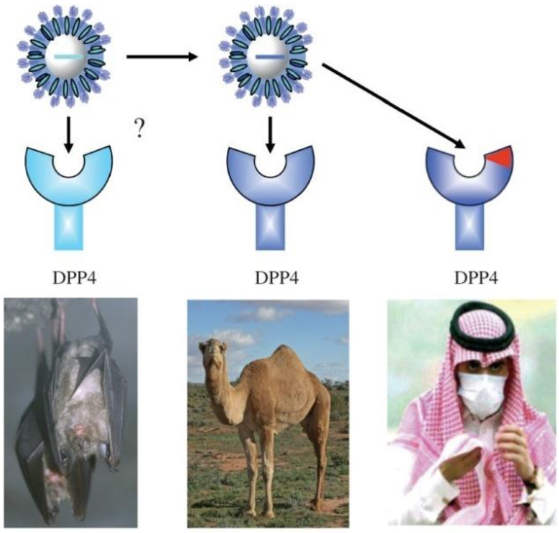

Figure 2.2 Zoonotic transmission of MERS-CoV. [9]

In case of human-to-human transmission the virus does not pass easily from person to person unless there is close contact, such as providing unprotected care to an infected patient. There have been clusters of cases in healthcare facilities, where human-to-human transmission appears to have occurred, especially when infection prevention and control practices are inadequate or inappropriate. Human to human transmission has been limited to date and has been identified among family members, patients, and in-hospital outbreaks are mostly due to person-to-person transmission in hemodialysis units, intensive care units or inpatient units, where patients are infected with MERS-CoV of a single monophyletic clade. An outbreak among healthcare workers in a hospital was due to overcrowding and inadequate infection control measures whereas the transmission through person-to-person contact occurs via large respiratory droplets, due to coughing and sneezing [10]. Between 2012 and 7 July 2015, 1368 laboratory-confirmed cases of human infection with Middle East respiratory syndrome coronavirus have been reported to WHO, including at least 487 deaths as shown in figure (2.3). Overall, 65% of cases where gender has been reported (n=1359) are male and (n=1365) are female. [11]

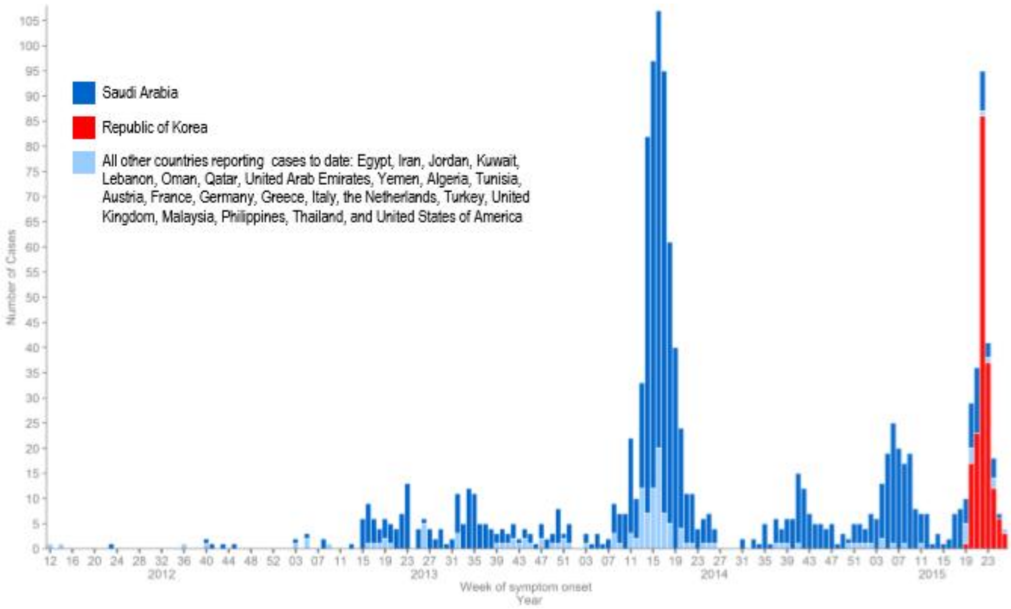

Figure 2.3 Epidemic curve of MERS-CoV (n=1368) cases as of 7 July 2015. [11]

Since 2012, 26 countries have been affected, including countries in the Middle East, Europe, Asia, and in North America. The majority of cases (approximately 75%) have been reported from Saudi Arabia as shown in table (2.1). [10]

Table 2.1 Number of laboratory-confirmed MERS-CoV cases reported by country and by year. [11]

Country of reporting	2012	2013	2014	2015	Total

Algeria	0	0	2	0	2
Iran	0	0	5	1	6
Jordan	2	0	10	0	12
Oman	0	1	1	4	6
Qatar	0	7	2	4	13
Republic of Korea	0	0	0	165	165
Saudi Arabia	5	136	679	210	1030
Thailand	0	0	0	1	1
Tunisia	0	3	0	0	3
Turkey	0	0	1	0	1
United Arab Emirates	0	12	57	5	74
Total	9	168	768	393	1338

2.1.3 Prevention and Treatment

No vaccine or specific treatment is currently available. Treatment is supportive and based on the patient's clinical condition, so to prevent MERS from Transmission the patients undergo Health-care facilities and isolation, that patients with MERS should be isolated for fourteen days after the initiation of symptoms. Infection prevention and control measures are critical to prevent the possible spread of MERS-CoV in health-care facilities. To decrease the risk of transmission of the virus from an infected patient to other patients, health-care workers, or visitors they keep the two-meter distance from the infected patient. Contact Investigation for Imported Case of Middle East Respiratory Syndrome a group of people were assessed all contact persons (contacts) retrospectively and monitored them prospectively, divided contacts into 2 groups. Close-distance contacts had face-to-face contact with the patient (<2 meters from the patient) or direct contact with secretions or body fluids of the patient, irrespective of protective measures worn. All other contacts were classified as less-close-distance contacts. The contact investigation identified 83 contacts.69 of them, (83%) was classified as close-distance contacts and 14 (17%) as less-close-distance contacts. [12]

2.2 Mumps

Mumps is caused by the mumps virus (MuV), a member of the Paramyxoviridae family of enveloped, non-segmented, negative-sense RNA viruses. Mumps is characterized by painful inflammatory symptoms, such as parotitis and orchitis. The virus, a member of the family Paramyxoviridae, is an enveloped particle containing a non-segmented negative-strand RNA molecule of 15,384 nucleotides. The encapsidated genome as shown in figure (2.4) contains seven tandemly linked transcription units, in the order: nuclear (N), V/P/I (V/phospho-/I proteins), matrix (M), fusion (F), small hydrophobic (SH), haemagglutinin-neuraminidase (HN) and large (L) proteins [13]. The template for viral replication and transcription is the ribonucleoprotein (RNP) complex, which is composed of the negative-strand viral RNA encapsidated by N protein. The RNA-dependent RNA polymerase, a complex of the L and P proteins, acts as a replicate to copy the negative sense (−) RNA to a positive sense (+) RNA and as a tr3anscriptase to generate mRNAs from the (−) RNP by entering at a single promoter at the end of the genome. [14]

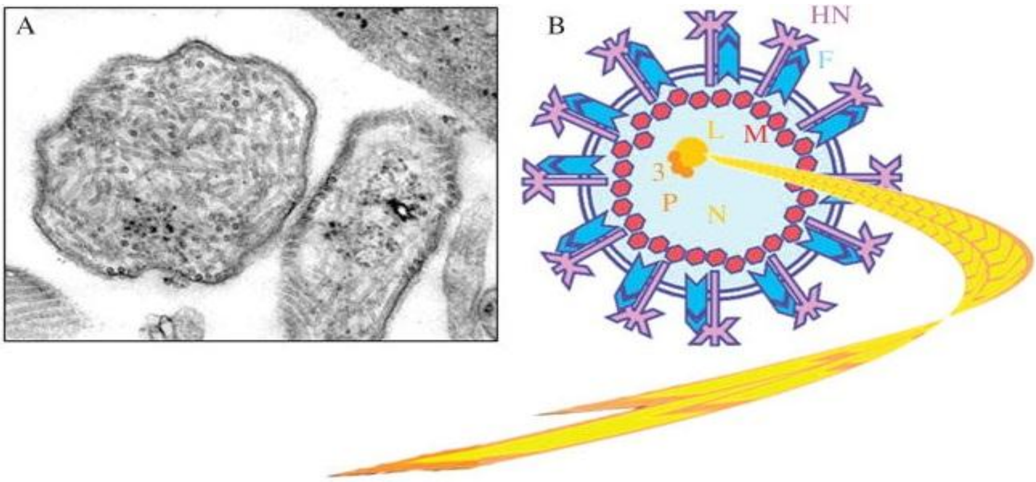

Figure 2.4 MuV virion structure. [14]

Mumps visors virion structure as shown in figure (2.4). (A) Thinly sectioned transmission electron micrograph showing a typical MuV particle alongside (B) a schematic of the particle. The enveloped particles are pleomorphic, in the size range 100–600 nm. Within this structure lies the long, coiled electron-dense ribonucleoprotein (RNP), containing the Mumps genome. Small spikes can be observed on the surface of the particle, corresponding to the viral HN and F glycoproteins. The same general features of the MuV particle are shown in the schematic (B). The envelope (blue lines) is studded with the HN (purple) and F (blue) glycoproteins and encases the viral RNP, made up of the RNA genome (3–5) in complex with N (yellow), P (orange) and L (gold) proteins. The M protein (red) interacts with the envelope, glycoproteins and the RNP. The V, I and SH proteins are expressed in infected cells. [14]

2.2.1 Symptoms and Complications

Approximately one-third of infections are asymptomatic. The prodromal phase is characterized by often mild symptoms, such as low-grade fever, headache and malaise. An early acute phase follows likely representing spread of the virus from the respiratory tract and development of systemic symptoms, typically parotitis, which lasts from a few days to 1 week. During the established acute phase, orchitis, meningitis or encephalitis may appear. Symptoms usually resolve within 2 weeks, coincident with the development of a MuV-specific humoral response. Long-term complications of mumps happen more often among adults than children [15].

2.2.2 Transmission

Mumps only affects humans especially children and is spread by tiny respiratory droplets that are small enough to be carried short distances in the air, so mumps virus is hugely contagious and anyone near a person with mumps is at risk for getting the disease as well. The mumps virus has a single strand of RNA and a viral polymerase enzyme surrounded by a phospholipid bilayer envelope studded with viral proteins hemagglutinin-neuraminidase, or HN protein, and fusion or F protein. The HN protein allows the virus to stick to a potential host cell, and cut itself loose if necessary, and the F-protein which fuses the viral and cell membranes together allowing the mumps virus to enter the cell. Once mumps comes a cell, the single-stranded RNA, which is negative sense, gets transcribed by the viral polymerase enzyme, into a complementary positive sense strand of mRNA, which can then be translated by the host cell ribosome’s into new copies of the envelope proteins and the viral polymerase, which get assembled into new viruses. What also ends up happening with these, though, is that those HN and F-proteins on the cell surface now bind other cells, so they end up bind epithelial cells to one another, which forms a clump of connected cells called a multinucleated giant cell or a syncytium. Mumps enters the body and first infects the epithelial cells of the nasopharynx, where it starts replicating and causing local damage to the tissue**.** [16]

2.2.3 Incubation and Colonization

The incubation period of mumps ranges from 16-18 days as shown in figure 2.5. Fever can last for three to four days, and if parotitis occurs, usually lasts seven to nine days. A person is considered most infectious from one to two days before the symptoms of parotitis. Mumps mostly colonize and replicates along with the upper respiratory tract in the midst of asymptomatic infection. After entering the respiratory system, the virus locally replicates. To target tissues of the salivary glands and central nervous system, viremic dissemination occurs. The virus replicates at target organs leading to a secondary phase of viremia before the immune response occurs. The virus also colonizes via blood transmission into the kidneys and other organs, possibly leading to renal impairment**.** [17]

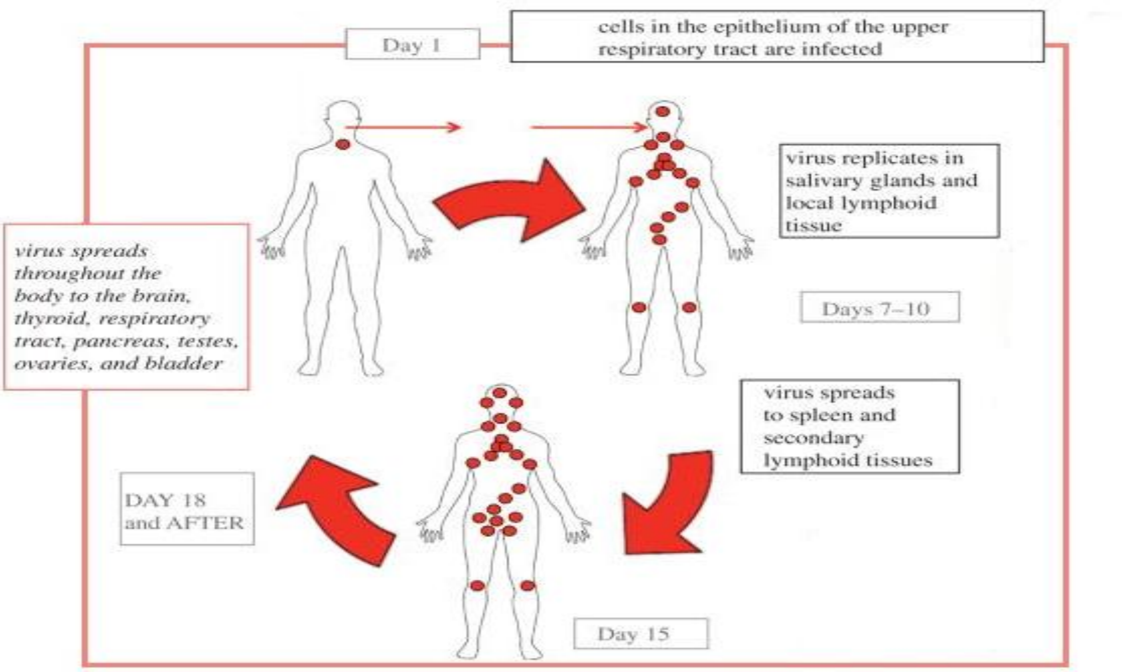

Figure 2.5 The incubation period of Mumps. [17]

2.2.4 Treatment and Prevention

Mumps is a self-limiting disease, therefore it will be resolved if proper medical care is taken in cases without complications. Current research shows that patients with mumps should be isolated for nine days after the initiation of symptoms. If a person has previously been infected with mumps or received the vaccine, they are considered immune. From a study in 2011, it was shown that people who received one dose of the vaccine had a 49-82% success rate of preventing the virus. While those who had received two doses of the vaccine showed a 66-88% success rate of prevention. [18]

2.3 Thyroid gland

The thyroid is a 2-inch-long, butterfly-shaped gland weighing less than 1 ounce. Located in the front of the neck below the larynx, or voice box, it has two lobes, one on each side of the windpipe as shown in figure (2.6). The thyroid is one of the glands that make up the endocrine system. The glands of the endocrine system produce, store, and release hormones into the bloodstream. The hormones then travel through the body and direct the activity of the body's cells. The thyroid gland makes two thyroid hormones, triiodothyronine (T3) and thyroxine (T4). T3 is made from T4 and is the more active hormone, directly affecting the tissues. Thyroid hormones affect metabolism, brain development, breathing, heart and nervous system functions, body temperature, muscle strength, skin dryness, menstrual cycles, weight, and cholesterol levels. Thyroid hormone production is regulated by thyroid-stimulating hormone (TSH) as shown in figure (2.6), which is made by the pituitary gland in the brain. When thyroid hormone levels in the blood are low, the pituitary releases more TSH. When thyroid hormone levels are high, the pituitary responds by decreasing TSH production. [19]

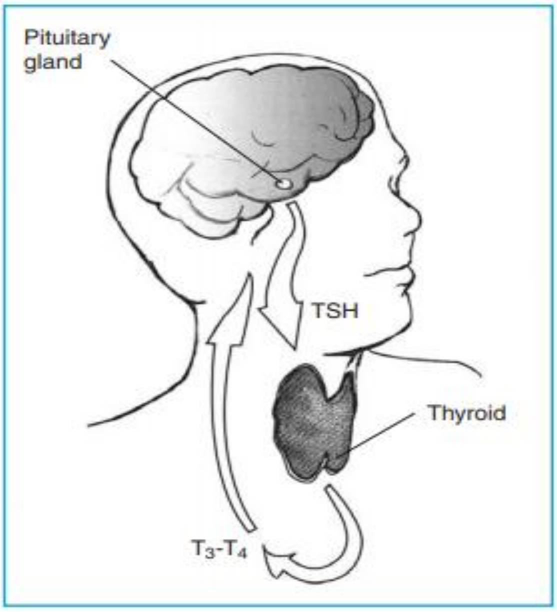

Figure 2.6 The thyroid's production of thyroid hormones T3 and T4. [19]

2.3.1 Hyperthyroidism

Hyperthyroidism is a disorder that occurs when the thyroid gland makes more thyroid hormone than the body needs. It is sometimes called thyrotoxicosis, the technical term for too much thyroid hormone in the blood. Thyroid hormones circulate throughout the body in the bloodstream and act on virtually every tissue and cell in the body. Hyperthyroidism causes many of the body's functions to speed up. Doses of radioactive iodine as a method of systematic radiation therapy have successfully treated hyperthyroidism. [20]

2.3.2 Thyroid Cancer

Thyroid cancer is the presence and/or growth of cancerous cells in the thyroid gland. The most common forms are referred to as well-differentiated thyroid cancer, composed of papillary and follicular, and constitute more than 90 percent of all thyroid carcinomas. These cancerous cells appear as normal thyroid cells, making early detection difficult. The early stages of papillary and follicular thyroid cancer include a tumor in the thyroid gland less than four centimeters. Later stages consist of tumors larger than four centimeters and the expansion of the malignant cells into nearby tissues: lymphoid, pulmonary, skeletal, tracheal, and laryngeal. Many patients do not experience any symptoms in the early stages. As the cancer progresses, swelling of the lymph nodes, appearance of lumps in the neck, difficulty speaking, swallowing, and breathing may occur. The remaining forms of thyroid cancer, medullary and anaplastic, follow similar stages as to those of the differentiated forms; however, these forms grow and spread at a much faster rate but occur much less frequently. Thyroid cancer is more commonly found in women than men, but affects people of all ages. Large amounts of exposure to radiation or even those who have been medically treated with radiation are at larger risk to develop thyroid carcinoma. In some medullary carcinoma cases, an abnormal gene is present in the patient's DNA.Tests are conducted to determine if other family members also inherited the abnormal gene. For those who develop thyroid carcinoma, the outlook is positive; as thyroid cancer is very treat able .The principal treatment for all types of thyroid cancer is surgery. Removal of the entire thyroid gland is general protocol; this procedure is known as a thyroidectomy. In some cases, the cancer will spread beyond the thyroid gland and appear in the lymph nodes of the neck and upper chest, which then must also be removed from the body. Typically, surgery alone cures thyroid cancer, especially if it is small. However, if the cancer has spread or has a high chance of recurrence, radioactive iodine therapy is utilized. [21]

2.3.3 Radioactive Iodine (i-131) Therapy

Patients, who receive radioiodine (iodine-131) treatment for hyperthyroidism, emit radiation and represent a potential hazard to other individuals. Critical groups amongst the public are fellow travelers on the patient's journey home from hospital and members of the patient's family, particularly young children. The dose which members of the public are allowed to receive as a result of a patient's treatment has been reduced following recently revised recommendations. The annual public dose limit is 1 millisievert (mSv), though adult members of the patient's family are allowed to receive higher doses, with the proviso that a limit of 5 mSv should not be exceeded over five years. Unless the doses received during out-patient administration of radioiodine can be demonstrated to comply with these new limits, hospitalization of patients will be necessary. Patients can continue to be treated with radioiodine on an out-patient basis, if given appropriate radiation protection advice .However, particular consideration needs to be given to children aged 3 years or younger. There is no justification for admission to the hospital on the basis of radiation protection. Patients must stay at least 3 feet away (about 1 meter) from everyone except for short periods totaling less than 1 hour each day, for approximately the first 5 days. Stay at least 6 feet away most of the time. Stay this distance from small children or pregnant women for 8 days. [22]

Chapter Three

Theoretical Background

3.4 Microcontroller

This chapter illustrates four main topics; the first one demonstrates the non-contact thermal sensor definition, principle, and the role it contributes in human detection, the second one talks about ultrasound and its own physics, the third one illustrates vibration and the vibration motors , and the fourth the last one talks about microcontroller is used as a controlling unit.

3.1 Thermal Sensor

Temperature is physical quantity describes the flow of heat from one object or region of space to another. The thermal sensor also known as the temperature sensor is a sensor can convert temperature to an electrical signal. It can be classified according to measuring ways as non-contact thermal sensor and contact thermal sensor. All non-contact thermal sensor use infrared (IR) radiation and are referred to as IR temperature sensor to measure a spectrum of the electromagnetic radiation naturally radiated by all objects above absolute zero as Planck's Law state without any direct contact. Non-contact thermal sensors used for detection and tracking both subjects and livings, by exploiting the infrared electromagnetic radiation emitted from a target to track it, one of the most important applications of non-contact thermal sensor is human detection, several types of sensors shown in figure (3.1) are used for human detection; Melexis MLX90614 digital infrared, TMP007 Infrared Thermopile Sensor, Passive Infrared Sensors (PIR), and Omron D6T8L06 MEMS thermal sensor.[23]

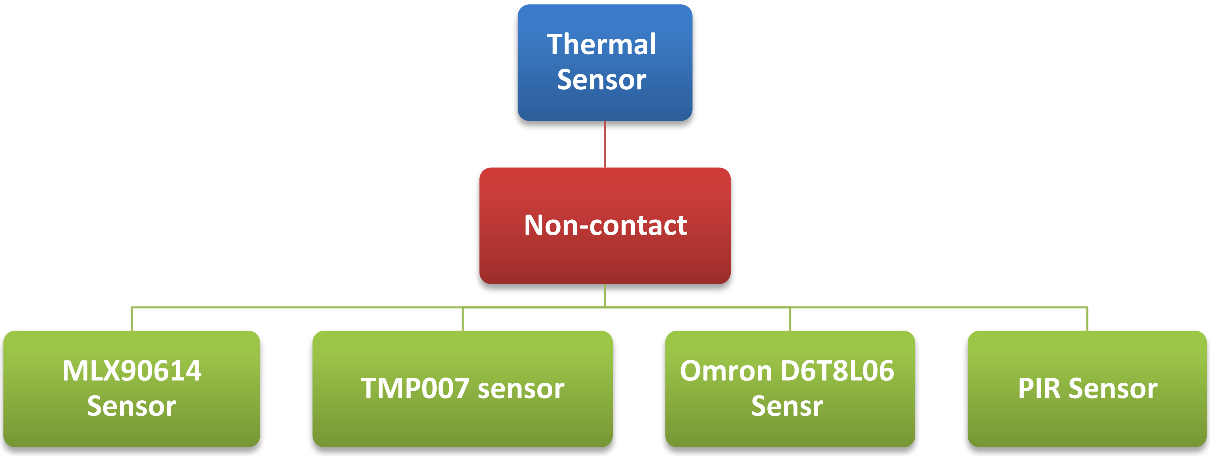

Figure 3.1 Types of non-contact thermal sensors used for human detection.

3.1.1 The Electromagnetic Spectrum

The electromagnetic (EM) spectrum is the range of all types of EM radiation wave, electromagnetic waves are a form of energy waves that have both an electric and magnetic field. Electromagnetic waves are different from mechanical waves in that they can transmit energy and travel through a vacuum. Electromagnetic waves are classified according to their frequency and wavelength as shown in figure (3.2). Electromagnetic spectrum consists of microwaves, infrared light, ultraviolet light, X-rays and gamma-rays. In the electromagnetic spectrum, the infrared portion has a wavelength of 3000 nm to 1 mm. [24]

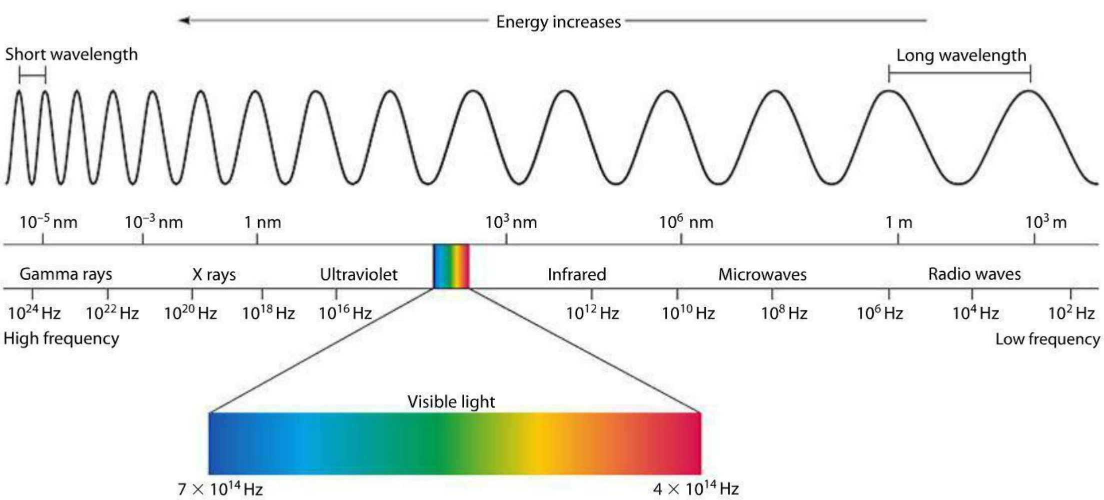

Figure 3.2: The electromagnetic spectrum. [24]

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3.1.2 Blackbody Radiation and Planck's Law

A Blackbody is an idealized physical body that absorbs all incident electromagnetic radiation, regardless of frequency or angle of incidence. A black body emits electromagnetic radiation called black-body radiation. The radiation is emitted according to Planck's law. [25]

Planck's law describes the spectral density of electromagnetic radiation emitted by a black body in thermal equilibrium at a given temperature *T*. The law is named after Max Planck. The spectral radiance of a body, B_v, describes the amount of energy it gives off as radiation of different frequencies. It is measured in terms of the power emitted per unit area of the body, per unit solid angle that the radiation is measured over, per unit frequency. Planck showed that the spectral radiance of a body for frequency *v* at absolute temperature *T* is given by

$$B\nu(\nu, T) = \frac{2h\nu^3}{c^2} \frac{1}{e^{\frac{h\nu}{k_B T}} - 1} \qquad 3.1$$

Where k_B is the Boltzmann constant, *h* is the Planck constant, and *c* is the speed of light in the medium, whether material or vacuum. [25]

The spectral radiance can also be expressed per unit wavelength λ instead of per unit frequency [24]. In this case, it is given by

$$B\lambda(\lambda, T) = \frac{2hc^2}{\lambda^5} \frac{1}{e^{\frac{hc}{k\lambda_B T}} - 1} \qquad 3.2$$

A black-body at room temperature appears black, as most of the energy it radiates is infra-red and cannot be perceived by the human eye. Because the human eye cannot perceive light waves at lower frequencies, a black body, viewed in the dark at the lowest just faintly visible temperature, subjectively appears grey, even though its objective physical spectrum peak is in the infrared range. When it becomes a little hotter, it appears dull red shown in figure (3.3). As its temperature increases further it becomes yellow, white, and ultimately blue-white. [26]

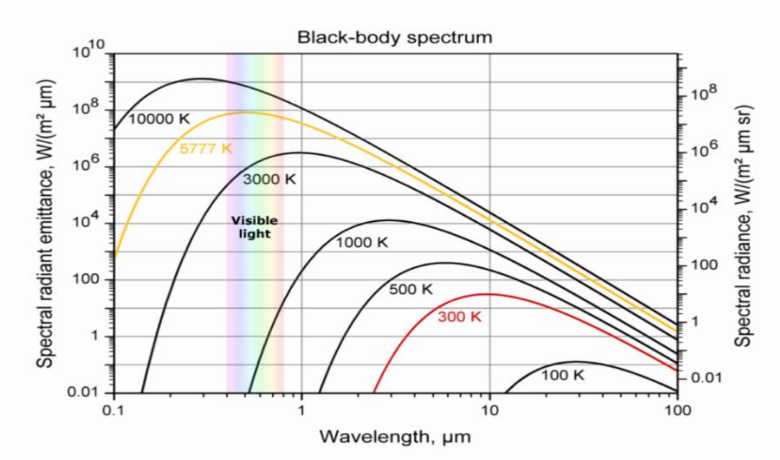


Figure 3.3 Planck's law accurately described black body radiation. [26]

3.1.3 Human Sensing

Human sensing (also called human detection or human presence detection) encompasses a range of technologies for detecting the presence of a human body in an area of space, typically without the intentional participation of the detected person. Modern technologies proposed or deployed for human sensing include non-contact thermal sensors. [27]

All non-contact thermal sensors emit and detect infrared radiation to sense its surrounding. The working principle of any non-contact thermal sensors is governed by Planck's law states that "every object emits radiation at a temperature not equal to 0^0K". non-contact thermal sensors, shown in figure (3.4), emits and detects infrared radiation to sense its surrounding; When the IR transmitter emits radiation, it reaches the object and some of the radiation reflects back to the IR receiver. Based on the intensity of the reception by the IR receiver, the output of the sensor is defined. [28]

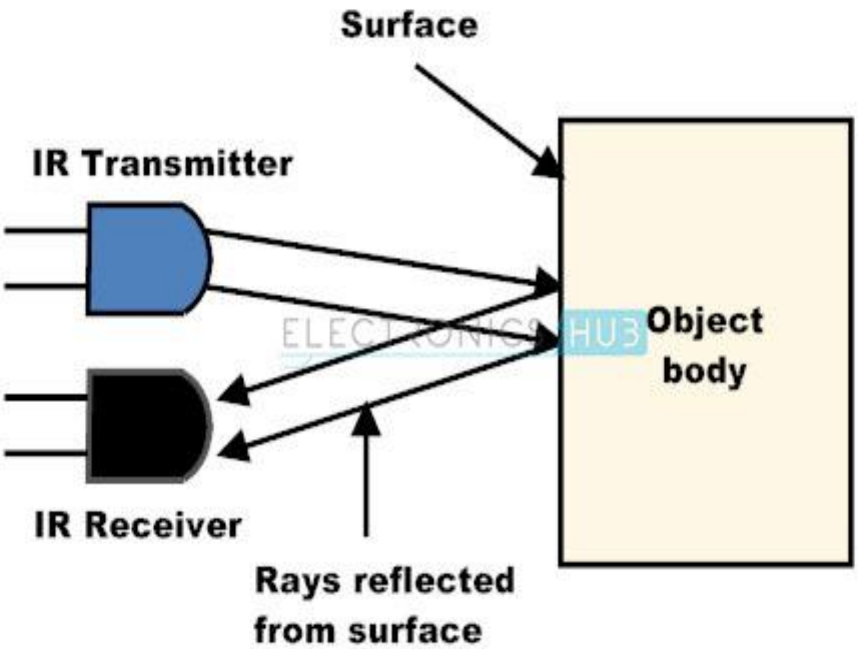


Figure 3.4 Non-Contact Thermal Sensors working principle. [28]

Human body temperature is normally around 37°C (310 K), and electromagnetic radiations emitted by humans of wavelengths between 6 µ and 14 µ, as shown in figure 3.3 the red line is infrared radiation emitted from a human at 310K.[29]

The table (3.1) shows the comparisons between different types of the non-contact thermal sensors used for human detection.

Table 3.1 Comparisons between different types of the non-contact thermal sensors.

Sensor / Features	MLX90614 	TI-TMP007 	4x4 Omron D6T8L06 	PIR 
Field of View	X direction : 90°	X direction : 90°	X direction : 44.2°	X direction : 180°

	Y direction: 90°	Y direction: 90°	Y direction: 45.7°	Y direction: 180°
Temperature range	40°C to125°C	40°C to125°C	5°C to 50°C	36°C to 37°C
Accuracy	+/- 0.5°C	+/- 0.1 °C	+/- 1.5°C, +/- 3°C	Up to 30 ft 110° to 70°
Diminutions	6.5 mm H x 13.8 mm W x 40.4 mm T	1.9 mm H × 1.9 mm W × 0.625 mm T	18 mm H x14 mm W x8.8mm T	36.0 mm H x 36.0 mm W x 20.2 mm T
Detection distance up to	2 ft	25ft	20 ft	30 ft
Rated Voltage	5V Dc	5V Dc	5.5V Dc	6 V Dc
Rated Current	2 mA	2 mA	5 mA	170 mA
Cost	4.28 $	105 $	39.5 $	12.99 $

3.2 Ultrasound

Ultrasonic waves are sound which cannot be heard by humans and are normally, frequencies of above 20kHz.Sound is a physical phenomenon that transfers energy from one point to another. In this respect, it is similar to radiation. It differs from radiation, however, in that sound can pass only through matter and not through a vacuum as radiation can. This is because sound waves are actually vibrations passing through a material. If there is no material, nothing can vibrate and sound cannot exist.

Ultrasound is a form of mechanical sound energy that travels through a conducting medium as a longitudinal wave producing alternating compression (high pressure) and rarefaction (low pressure). Sound propagation can be represented in a sinusoidal waveform as shown in figure (3.5) [30]. The source of sound is a vibrating object, the piezoelectric transducer element. Since the vibrating source is in contact with the tissue, it is caused to vibrate.

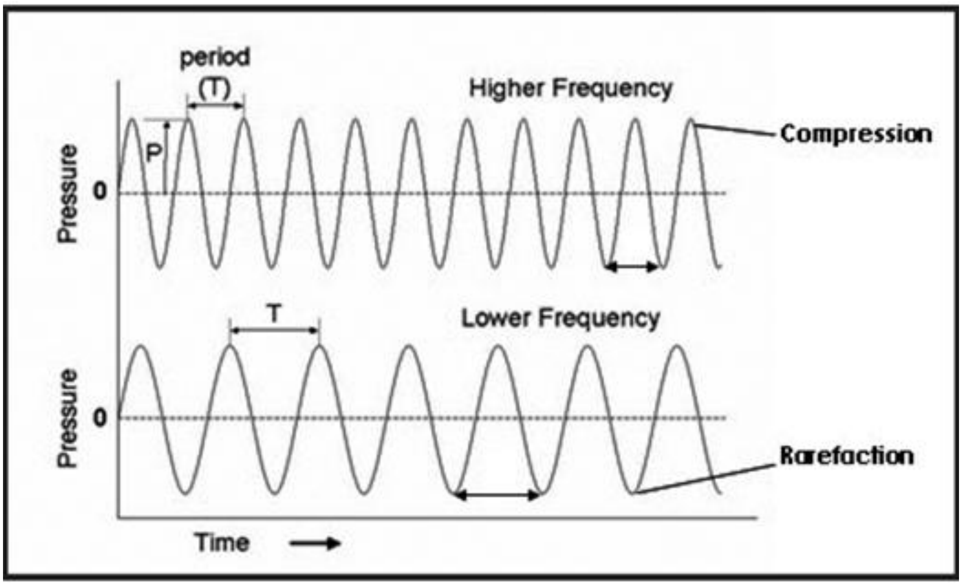


Figure 3.5 Ultrasound physics. [30].

3.2.2 Ultrasonic Characteristics

A zone of compression and an adjacent zone of rarefaction constitute one cycle of an ultrasound wave. A wave cycle can be represented as a graph of local pressure (particle density) in the medium versus distance in the direction of the ultrasound wave as shown in figure (3.6). The distance covered by one cycle is the wavelength of the ultrasound wave. The number of cycles per unit time (cps, or just sec−1) introduced into the medium each second is referred to as the frequency of the wave, expressed in units of hertz, kilohertz, or megahertz. The maximum height of the wave cycle is the amplitude of the ultrasound wave [31]. The wavelength (λ) equal the frequency (f) divided by the velocity of the wave (v).

$$\lambda = \frac{v}{f} \qquad 3.3$$

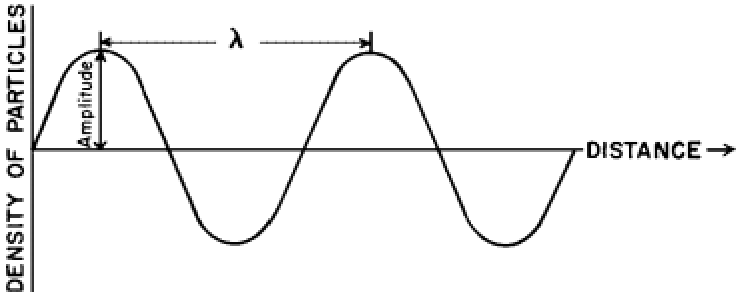


Figure 3.6 Characteristics of an ultrasound wave. [31]

3.2.2.1 Ultrasonic Velocity

The velocity of an ultrasound wave through a medium varies with the physical properties of the medium. In low-density media such as air and other gases, molecules may move over relatively large distances before they influence neighboring molecules. In these media, the velocity of an ultrasound wave is relatively low. In solids, molecules are constrained in their motion, and the velocity of ultrasound is relatively high. Liquids exhibit ultrasound velocities intermediate between those in gases and solids. With the notable exceptions of lung and bone, biologic tissues yield velocities roughly similar to the velocity of ultrasound in liquids. In different media, changes in velocity are reflected in changes in wavelength of the ultrasound waves, with the frequency remaining relatively constant. The velocities of ultrasound in various media are listed in table (3.2).The product of the frequency (f) and the wavelength (λ) is the velocity of the wave (v), which can be written as shown in equation (3.3).

Table 3.2 Approximate Velocities of Ultrasound in Selected Materials. [31]

Material	Velocity (m/sec)
Acetone	1174
Air	331
Aluminum	6420

Brass	4700
Ethanol	1207

The velocity of an ultrasound wave should be distinguished from the velocity of molecules whose displacement into zones of compression and rarefaction constitutes the wave. The molecular velocity describes the velocity of the individual molecules in the medium, whereas the wave velocity describes the velocity of the ultrasound wave through the medium. Properties of ultrasound such as transmission and refraction are characteristic of the wave velocity rather than the molecular velocity. [31]

3.2.2.2 Reflection

The reflection of an ultrasound pulse occurs at the interface, or boundary, between two dissimilar materials, as shown in the figure (3.7). In order to form a reflection interface, the two materials must differ in terms of a physical characteristic known as acoustic impedance Z .Acoustic impedance is a characteristic of a material related to its density and elastic properties. Since the velocity is related to the same material characteristics, a relationship exists between tissue impedance and ultrasound velocity [32]. The relationship is such that the impedance (Z) is the product of the velocity (v) and the material density(Y), which can be written as

$$Z=vY \quad 3.4$$

The percentage of the ultrasound wave reflected can be described by the intensity reflection coefficient (**αR**)

$$\alpha R = \frac{(Z2-Z1)^2}{(Z2+Z1)^2} \qquad 3.5$$

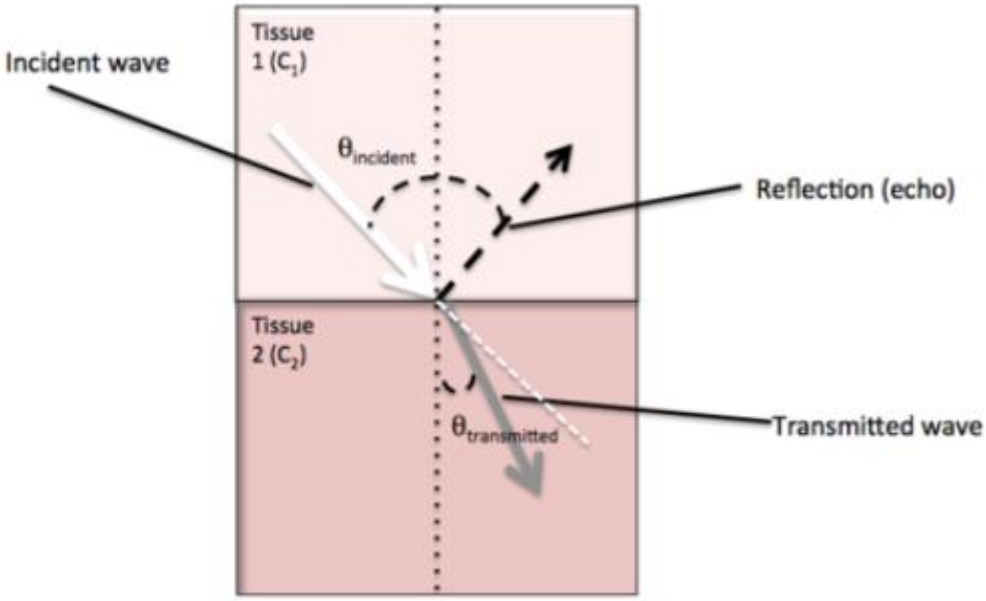


Figure 3.7 Reflection interfaces. [33]

At most interfaces within the body, only a portion of the ultrasound pulse is reflected. The pulse is divided into two pulses, and one pulse, the echo, is reflected back toward the transducer and the other penetrates into the other material, as shown in figure (3.7). The brightness of a structure in an ultrasound image depends on the strength of the reflection, or echo. This in turn depends on how much the two materials differ in terms of acoustic impedance. The amplitude ratio of the reflected to the incident pulse is related to the tissue impedance values by

$$\text{Reflection loss (dB)} = 20 \log \frac{(Z2 - Z1)}{(Z2 + Z1)} \qquad 3.6$$

3.2.2.3 Attenuation

The strength of ultrasonic waves propagated into the air attenuate proportionally with distance. This is caused by diffusion loss on a spherical surface due to diffraction phenomenon and absorption loss, that energy is absorbed by medium. As shown in figure (3.8), the higher the frequency of the ultrasonic wave, the bigger the attenuation rate and the shorter the distance the wave reaches. [34]

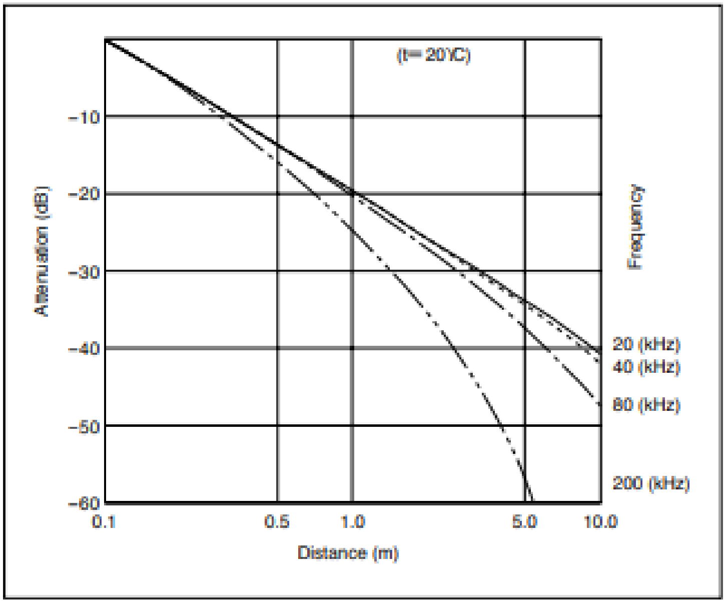


Figure 3.8 Attenuation Characteristics of Sound Pressure by Distance. [34]

3.2.3 Ultrasonic Principles

Ultrasonic sensors emit short, high-frequency sound pulses at regular intervals. These propagate in the air at the velocity of sound. If they strike an object, then they are reflected back as echo signals to the sensor as shown in figure (3.9), which itself computes the distance to the target based on the time-span between emitting the signal and receiving the echo . As the distance to an object is determined by measuring the time of flight (T) and not by the intensity of the sound, Virtually all materials which reflect sound can be detected, regardless of their color. Even transparent materials or thin foils represent no problem. [35]

As the distance to an object is determined by the following equation

$$Distance = Velocity \times (\frac{T}{2}) \qquad 3.7$$

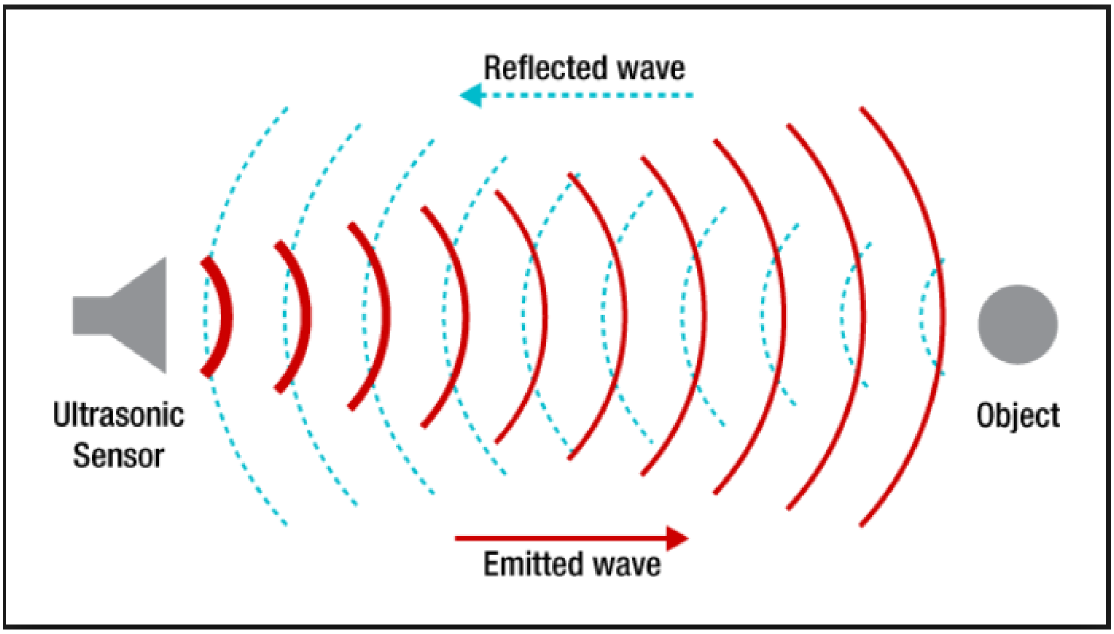


Figure 3.9 Ultrasound waves reflected. [36]

The following table for difference between the most common ultrasonic transducers used depending on digikey website.

Table 3.3 Differences between two common types of ultrasonic transducer.

	HC-SR04	**Maxsonar series**
Brand name		
Power supply	5V Dc	5.5V
Current consumption	15mA	2mA
Range	2-400 cm	15.24 -50 cm
Resolutions	3cm	2.5cm
Price	5$	30$

3.3 Vibration

Any motion that repeats itself after an interval of time is called vibration or oscillation. The swinging of a pendulum and the motion of a plucked string are typical examples of vibration. The theory of vibration deals with the study of oscillatory motions of bodies and the forces associated with them.

A vibratory system, in general, includes a means for storing potential energy (spring or elasticity), a means for storing kinetic energy (mass or inertia), and a means by which energy is gradually lost (damper). The vibration of a system involves the transfer of its potential energy to kinetic energy and of kinetic energy to potential energy, alternately. If the system is damped, some energy is dissipated in each cycle of vibration and must be replaced by an external source if a state of steady vibration is to be maintained. [37]

If the value or magnitude of the excitation (force or motion) acting on a vibratory system is known at any given time, the excitation is called deterministic. The resulting vibration is known as deterministic vibration. Vibration In some cases, the excitation is nondeterministic or random; the value of the excitation at a given time cannot be predicted. In these cases, a large collection of records of the excitation may exhibit some statistical regularity. It is possible to estimate averages such as the mean and mean square values of the excitation. Examples of random excitations are wind velocity, road roughness, and ground motion during earthquakes. If the excitation is random, the resulting vibration is called random vibration. In this case the vibratory response of the system is also random; it can be described only in terms of statistical quantities. Figure (3.10) shows examples of deterministic and random excitations. [37]

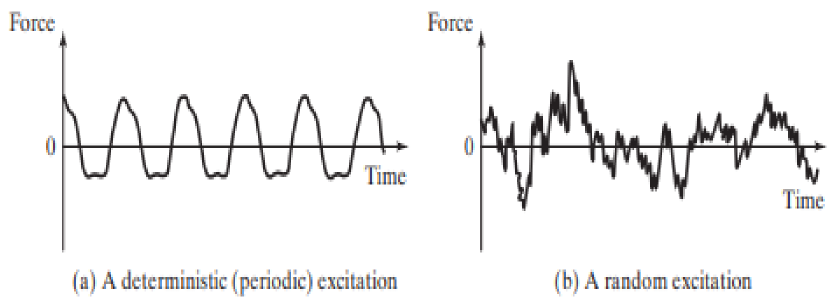


Figure 3.10 Deterministic and random excitations. [37]

3.3.1 Vibration motor

Electric motors can be configured into DC motor and AC motor based on different type of power supplies. Vibration motor is a compact size coreless DC motor used to inform the users of receiving the signal by vibrating, without sound. Vibration motors are widely used in a variety of applications including cell phones, handsets, pagers, and so on. The main features of vibration motor is the magnet coreless DC motor are permanent, which means it will always have its magnetic properties (unlike an electromagnet, which only behaves like a magnet when an electric current runs through it); another main feature is the size of the motor itself is small, and thus light weight. Moreover, the noise and the power consumption that the motor produce while using are low. Based on those features, the performance of the motor is highly reliable. [38]

Selecting a DC motor for a particular application, some factors need to be considered and clarified such as power equal product of speed and torque. The maximum power of a DC motor is produced at the operating point that is defined by operation at half the no-load speed and half the stall torque, the relationship between torque and speed is called a characteristic of the operating system. This DC motor's characteristic varies based on three different magnetization sources: separately excited field, self-excited field or permanent field, which is used selectively to control the motor over the mechanical load's range

Beside these requirements, some restrictions exist as well that limit the motor selection. The major constraint on motor operation is thermal in nature. The heat a motor must dissipate can always be calculated as follows:

$$P_{dis} = I^2 R \qquad 3.8$$

Where

P_{dis} = heat dissipated

I= current through the motor

R = the terminal resistance.

The current through a motor is determined by the torque the motor produces. Current and torque are related by the torque constant of the motor as follows:

$$I = \frac{M_o}{K_M} \tag{3.9}$$

I =current through motor

M_o = torque produced

k_M =the torque constant

3.3.2 Vibration Motor Principle

The need for smaller, thinner designs led to the adaptation of brush motor technology into the coin-type vibration motor. Figure (3.11) depicts an internal construction diagram of the brush coin-type motor. Similar to the bar-type vibration motor, coin-type vibration motor is comprised of a weight, a ring magnet, rotor with commutation points attached in the front and coils assembled on the back, and power supplied brushes attached to the ring magnet. The commutation points, which are the yellow part on the figure (3.11), are in contact with the end of the brushes. It will energize the electrical coils in the rotor. Energizing the coils produce a magnetic field and it is strong enough to interact with the ring magnet integrated into the stator, causing rotation. A force is generated due to the magnetic field. This force causes the weight to displace. The repeated displacement of the weight produces a varying force which is felt as vibration. The commutation points are used in changing the polarity pairs, so that as the rotator moves, the coils are constantly reversing the polarity. [38]

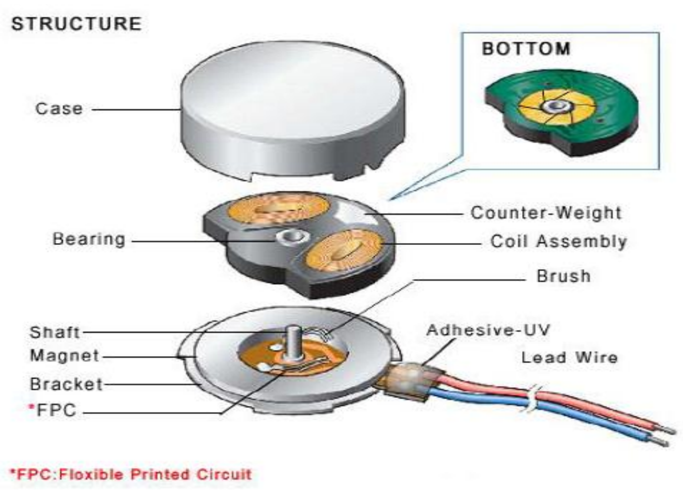


Figure 3.11 Structure of flat vibration motor. [38]

The magnetic field intensity is proportional to the current forced into the motor leads. The magnetic field rotation is automatically obtained commutating the active coil through mechanical switches (brushes). The load angle is almost constant and it is about 90° allowing the maximum efficiency (current vs. torque proportion).The motor is controlled by applying a voltage to the motor leads. The higher the voltage, the higher the speed as shown in figure (3.12). [38]

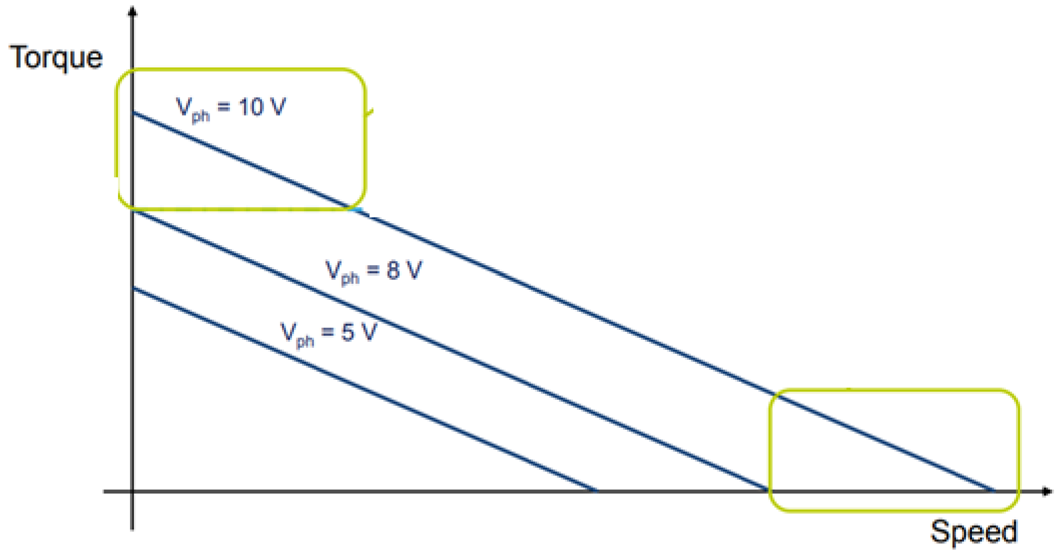


Figure 3.12 Increasing the supply voltage allows reaching higher speed. [39]

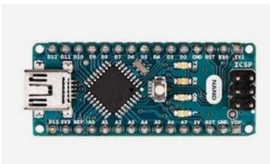
3.4 Microcontroller

A microcontroller is a small computer on a single integrated circuit. In modern terminology, it is similar to, but less sophisticated than, a system on a chip; a chip may include a microcontroller as one of its components. A microcontroller contains one or more CPUs (processor cores) along with memory and programmable input/output peripherals. Program memory in the form of ferroelectric random access memory (RAM). Microcontrollers are designed for embedded applications, in contrast to the microprocessors used in personal computers or other general purpose applications consisting of various discrete chips.

Arduino is a one of a type microcontroller, an open source electronic platform that relies on easy to use hardware and software. Arduino boards are able to read inputs light on a sensor or finger on a button and turn it into an output - activating a motor, turning on an LED, publishing something online. The user can tell your board what to do by sending a set of instructions to the microcontroller on the board. To do so you use the Arduino programming language (based on wiring), and the Arduino software, based on processing.

The Arduino software is easy to use and flexible enough for advanced users. It runs on mac, windows, and linux. Teachers and students use it to build low cost scientific instruments, to prove chemistry and physics principles, or to get started with programming and robotics. Designers and architects build interactive prototypes, musicians and artists use it for installations and to experiment with new musical instrument. There are many other microcontrollers and microcontroller platforms available for physical computing. Parallax Basic Stamp, netmedia's BX-24, phidgets, MIT's handyboard, and many others offer similar functionality. All of these tools take the messy details of microcontroller programming and wrap it up in an easy to use package. Arduino also simplifies the process of working with microcontrollers, but it offers some advantage for teachers, students, and interested amateurs over other systems [40]. Table (3.4) shows differences between three types of Arduino.

Table 3.4 Differences between three types of Arduino.

Arduino name	**Mega** 	**Nano** 	**Uno** 
CPU speed	16MHz	16MHz	16MHz
Analog Pins	16	8	6
Digital Pins / PWM	54/15	14/6	14/6
Input Voltage	7-12 v	7-9v	7-12v
Size	101.52*53.3 mm	43.18*18.54 mm	68.6*53.4 mm
Price	38.5$	22$	22$

Chapter Four

System Design

In this chapter, a general process for designing the system is described. A system consulting of interconnected components is designed to achieve a desired purpose; a general block diagram of an embedded system is shown in figure (4.1).

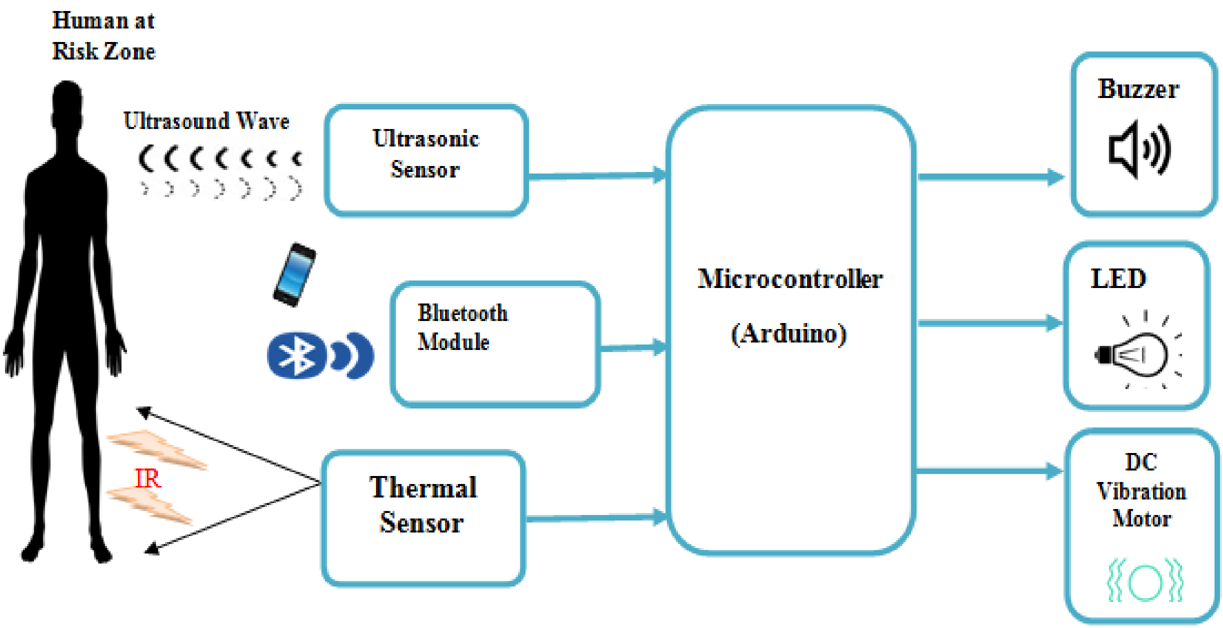


Figure 4.1 General Block Diagram.

4.1 System Block Diagram

The system, shown in Figure 4.1 consists of three main stages the first stage determines the patient condition (illness) via Smartphone Bluetooth module witch activates two input sensors human detection sensor and distance sensor. Thermal Sensor detects IR emitted by the person who entered the risk zone which is determined by the ultrasonic sensor, the output, from the sensors are processed by the second stage is an Arduino microcontroller. The microcontroller sends outgoing signals to the third stage is a three alarm system located on the strap. This three alarm system includes a visual alert via a LED, an auditory alert via buzzer and movement alert via DC vibration motor. The LED, DC vibration motor, and auditory alarm begin to flash, vibrate, and sounds simultaneously when the sensors immediately detect a person within risk zone of the user

4.2 Ultrasonic Sensor

Ultrasonic sensor used to determine the risk zone distance by determining the time of flight for sent signals when strike an object and reflected back as echo signals, and then send it to microcontroller. In this design, a sensor with two meter range and fast time response are required. Depending on studying several types of ultrasonic sensor in chapter three, ultrasonic ranging module (HC-SR04) is the best transducer to use in our project, the ranging accuracy can reach to 3mm. The modules include ultrasonic transmitters, receiver and control circuit. And the principle of the sensor starts with trigger sending for at least 10us high level signal then the module automatically sends eight 40 kHz and detect whether there is a pulse signal back. If the signal back, through high level, time of high output is the time from sending ultrasonic to returning. The following figure shows the connection of ultrasonic sensor with the processing unit.

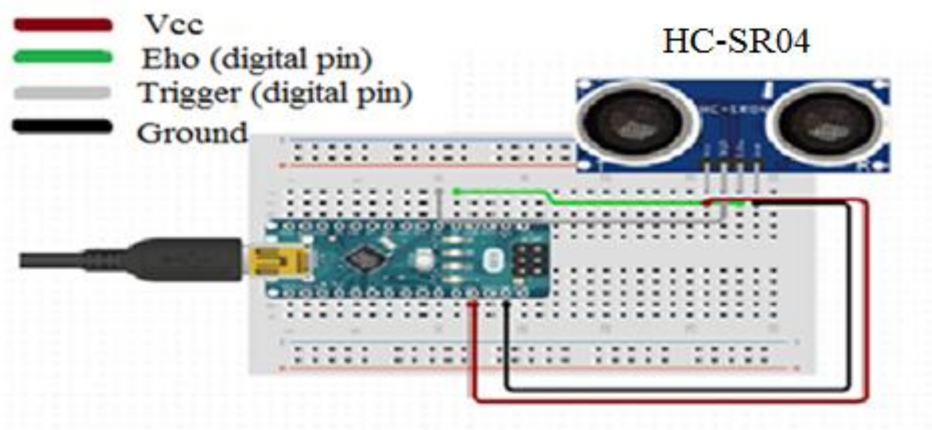


Figure 4.2 HC-SR04 connection with processing unit.

4.3 Thermal Sensor

Thermal sensor can be used to detect wavelength emitted from human and sends the data to microcontroller to be processed, after studying several types of thermal sensors in chapter three, HC-SR501 PIR (Passive Infrared) motion sensor is chosen. The HC-SR501 PIR provides high-accuracy area temperature detection with low cross-talk field of view characteristics, and most importantly the sensor has the greatest field of view angle. Figure 4.3 shows HC-SR501 PIR composed of two main parts, a pyroelectric Sensor and a special lens called Fresnel lens which focuses infrared (IR) radiation emitted by a warm body and directs it onto the pyroelectric sensor, the IR radiation pass through two rectangular slots as shown in Figure 4.4, behind these slots, there are two separate infrared electrodes sensor, one responsible for producing a positive output and the other a negative output. When a warm body like a human or animal passes by, it first intercepts one half of the PIR sensor, which causes a positive differential change between the two halves. When the warm body leaves the sensing area, the reverse happens, whereby the sensor generates a negative differential change. These change pulses are what is detected. [41]

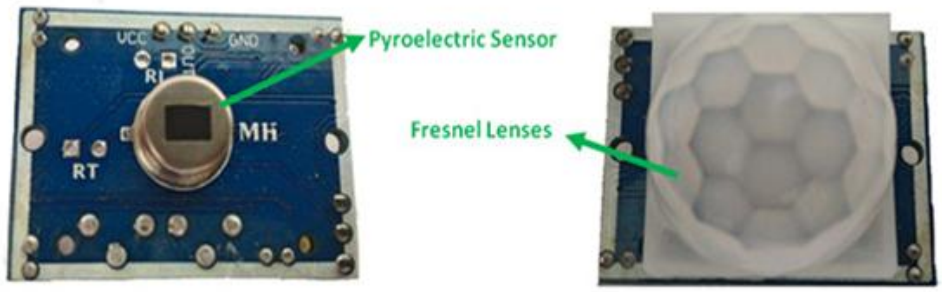


Figure 4.3 HC-SR501 PIR motion sensor. [41]

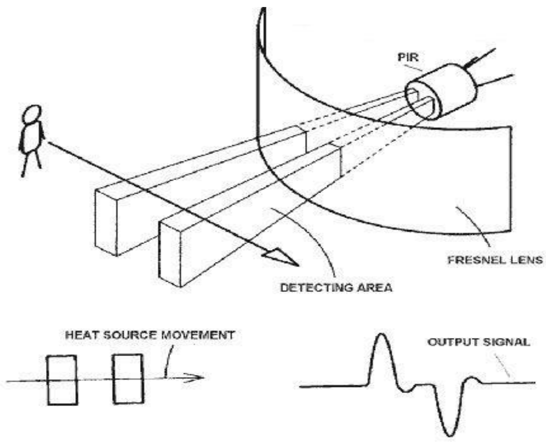


Figure 4.4 HC-SR501 PIR motion sensor working principle.[41]

The following figure shows the connection of the HC-SR501 PIR thermal sensor used it the system with the main processing unit.

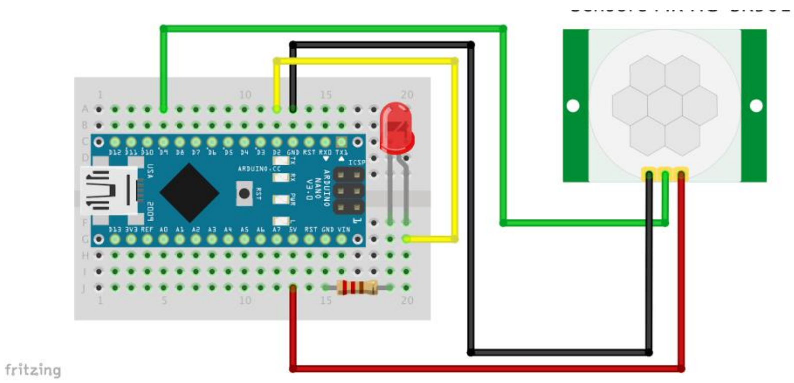


Figure 4.5 HC-SR501 PIR motion sensor connection with processing unit.

4.4 Bluetooth Module HC-05

HC-05 Bluetooth Module is designed for transparent wireless serial connection; its communication is via serial communication which makes an easy way to interface with Microcontroller. HC-05 Bluetooth module receives data from a Smartphone, Smartphone acts as switch for each type of illnesses depending on the study in chapter three, and then sets up the microcontroller reference value depending upon the patient condition.

Figure 4.6 Bluetooth Module HC-05.

The following figure shows the connection of the HC-05 module with the system main processing unit.

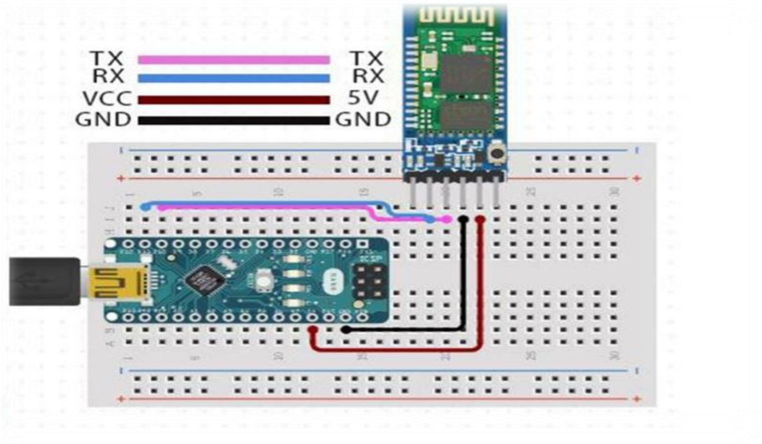


Figure 4.7 HC-05 Module connection with processing unit.

4.5 Microcontroller (Arduino)

Arduino receives signals from the thermal sensors and ultrasonic sensors and then compares the data with a programmed reference value depending upon the patient condition. When a person is detected in the risk zone, Arduino activates the alarm system. Depending on studying several types of Arduino in chapter three, the Arduino nano is the best to use in project, It is the smallest size (43.18*18.54 mm).The Arduino nano, shown in figure (4.6), can be powered via 9V regulated external power supply (pin 27). The power source is automatically selected to the highest voltage source, each of the 14 digital pins on the nano can be used as an input or output. They operate at 5 volts and each pin can provide or receive a maximum of 40 mA.

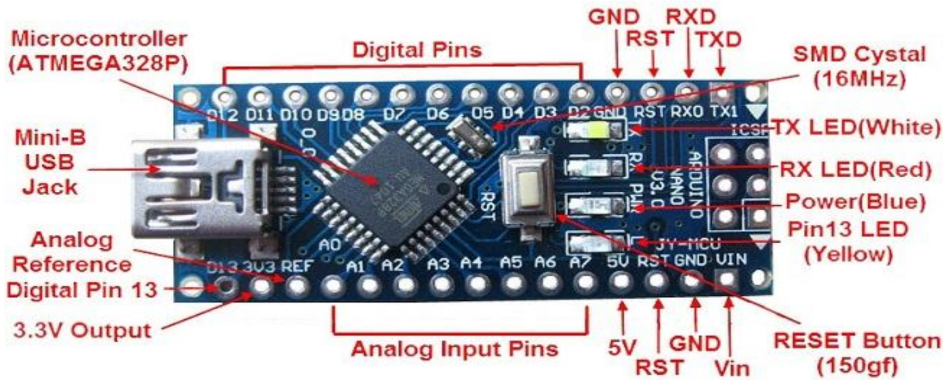


Figure 4.8 Arduino nano.

4.6 Alarm System

Alarms are intended to draw attention when the sensors detect a person within the user risk zone before it becomes harmful. This alarm system includes a visual alert via a LED, an auditory alert via buzzer and movement alert via DC vibration motor. The following figure shows the connection of the alarm system used it the system with the main processing unit.

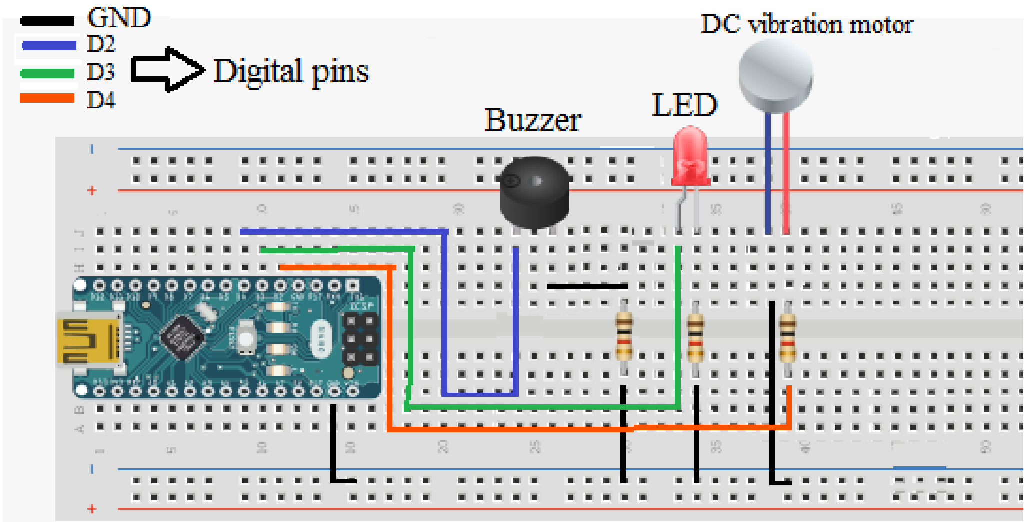


Figure 4.9 Alarm system connections with processing unit.

4.6.1 Vibration Motor

A vibration motor is necessary in this project to provide the user with alarm when sensors immediately detect a person. The following table shows the main features of the used coin vibration motor (ROB-08449).

Table 4.1 Features for ROB-08449.

Vibration Motor ROB-08449 
Rated voltage = 3v
Rated current = 60mA
Diameter 10mm
Price = 3$

4.6.2 Buzzer

A buzzer is necessary in this project to provide the human in the risk zone with alarm ten seconds after sensors detected him. A buzzer or beeper is an audio signaling device, which may be mechanical, electromechanical, or piezoelectric. Buzzer is an integrated structure of electronic transducers, DC power supply, widely used in computers, alarms, timers and other electronic products for sound devices. Buzzer chosen depend on its sound not too high and its voltage trigger suitable for output voltage Arduino, this buzzer working voltage is 3 volt Dc. The following table shows the main features of the used LTE12 which is chosen to be used.

Table 4.2 Features for LTE12.

LTE12 
Rated voltage = 3v
Rated current =30mA
Price = 5$

4.6.3 LEDs

Light Emitting Diode in this project to provide the user with alarm when sensors immediately detect a person. LEDs are a very important metric of the conversion of electrical energy into emitted optical energy. LEDs produce more light per watt than incandescent bulbs; this is useful in battery powered or energy saving devices, LEDs can emit light of an intended color without the use of color filters that traditional lighting methods require. This is more efficient and can lower initial costs. LEDs can have a relatively long useful life. LEDs have a life time of about 50,000 hours, whereas Fluorescent tubes typically are rated at about 30,000 hours, and incandescent light bulbs at 1,000–2,000 hours.

4.7 Power Supply

The project is portable system supply. Hence, a battery has relatively long life, provides needed power, small and not heavy is required. The following table shows the total power consumption in this project.

Table 4.3 Power consumption for each component.

System component	Power consumption	Quantity	Total power consumption (mWatt)
Arduino Nano	19mA * 9 v	1	171
Ultrasonic sensor	15mA * 5v	6	450
Thermal sensor	5mA * 5v	4	100
Bluetooth Module	30mA*3v	1	90
Vibration Motors	60mA * 3v	2	360
Buzzer	30mA * 3v	1	90
LEDs	15mA * 2v	4	120
Total			1381

The system intended to operate using rechargeable (9V) battery to power the Arduino and the other components, then Arduino distributes 5 volts for each components, that’s reduces the hardware component and cost.

4.8 Flow Chart

The Smartphone determines patient's condition then transfers the data via Bluetooth module, which signals the ultrasonic sensor to take a distance measurement, then compares it with risk zone as reference distance according to the patient condition, if the person within risk zone Adriano requests the temperature output value from the thermal sensor. If temperature value around 37ºC, the alarm system turns on. The following flow chart illustrates the steps of running the system.

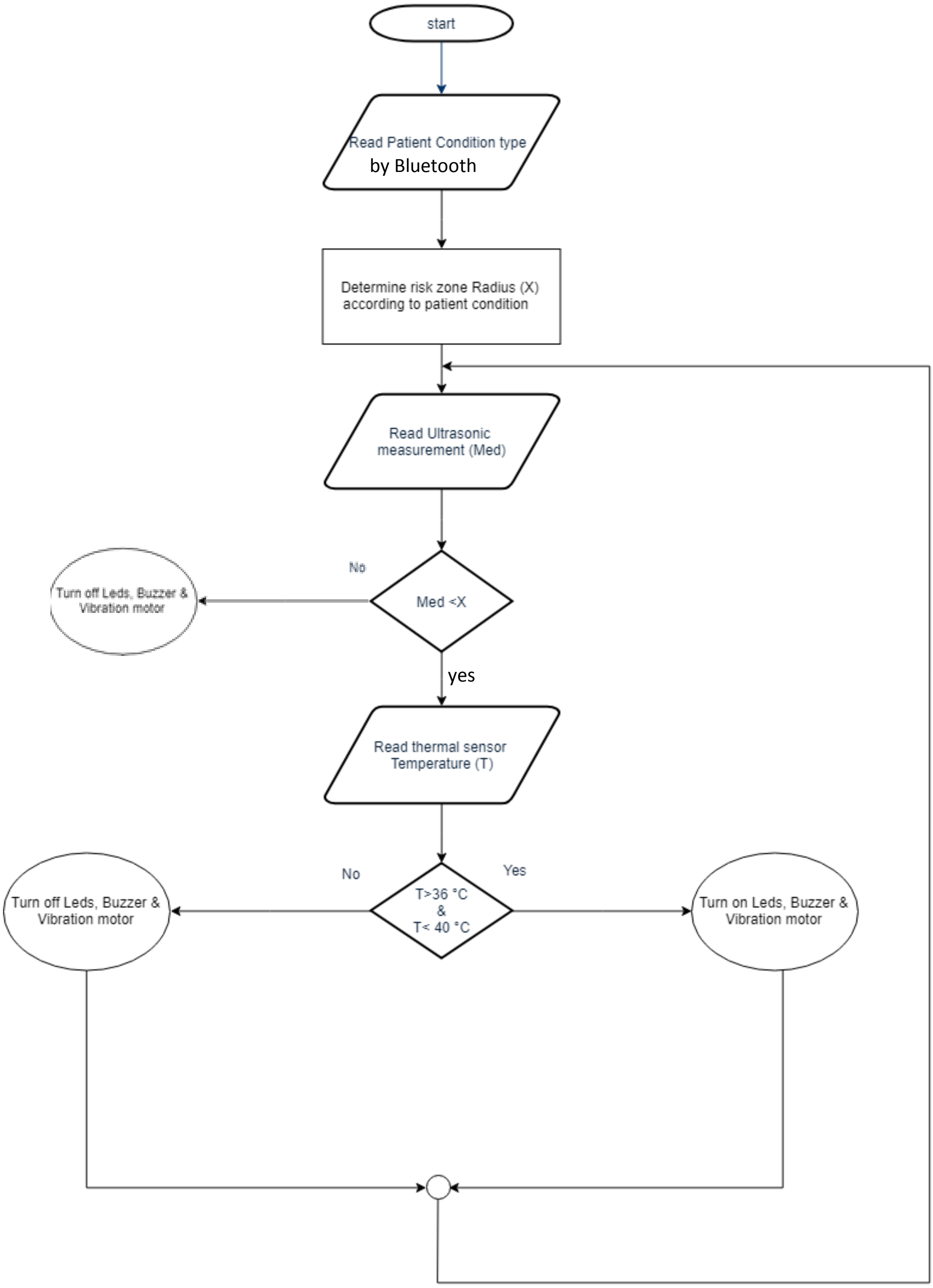


Figure 4.7 Flow Chart.

Chapter Five

Test and Implementation

5.1 Vest

5.1.1 Ultrasonic Sensors (HC-SR04)

5.1.2 Thermal Sensors (HC-SR501 PIR)

5.1.3 LEDs , Vibration motors and buzzer

5.2 Implemented Box

5.2.1 Arduino Nano

5.2.2 Bluetooth Module (HC-05)

The project components have been connected and tested, in this chapter shows the product final design implemented with its main components.

5.1 Vest

Vest with straps over the shoulders and around the trunk, was implemented by comfortable material, and the vest contains a scotch allows to vary different sizes to fit the user, also rubbery fabric at each shoulder to facilitate user movement as to fit different user measurement .Figure 5.1 Shows five ultrasonic sensors are located below, three PIR sensors are located on the front at the each shoulder and one on the back of the vest. Battery pack, buzzer and microcontroller would be mounted on the back of the vest.

Figure 5.1 Implemented vest.

5.1.1 Ultrasonic Sensors (HC-SR04)

The vest contains six ultrasonic sensors, each ultrasonic module have 4 pins as discussed in the previous chapter, each sensor is connected with the Arduino nano. Figure 5.2 shows the connection of trigger and echo which are connected to digital pins.

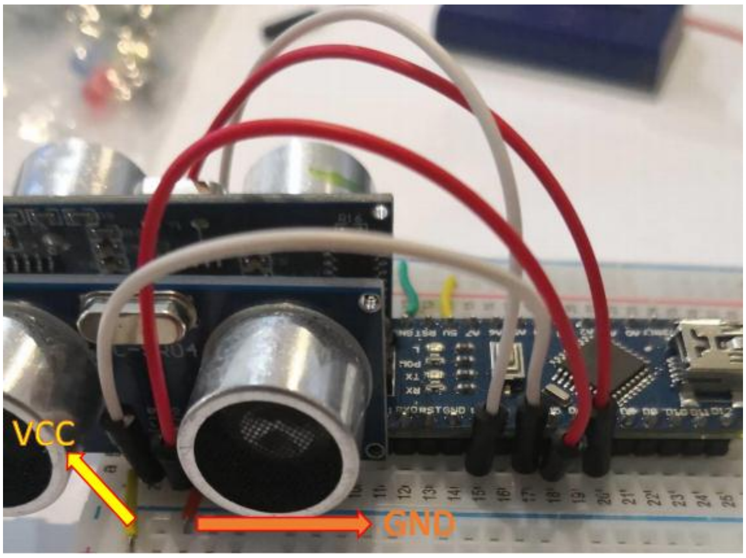


Figure 5.2 HC-SR04 connected to Arduino nano.

Figure 5.3 shows the distance on serial monitor for each sensor that have been calculated by the Arduino after measured the time that has been traveled from transmitter to the object then back to the receiver, these result have been compared with measured distance via measuring tool, and the results were equal and the error percentage was almost nonexistent. The response speed and sensitivity of each sensor were high in detecting a person less than the allowed radius.

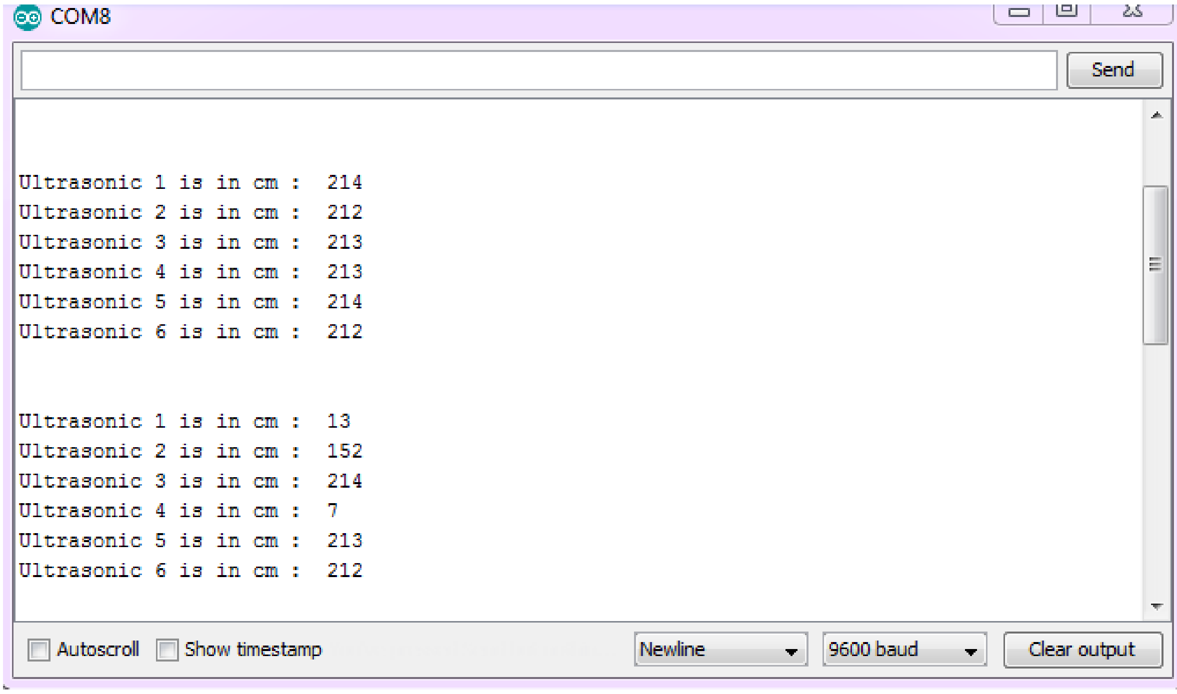


Figure 5.3 Ultrasonic distance measured.

The following figure shows the connections of six ultrasonic sensors in the vest:

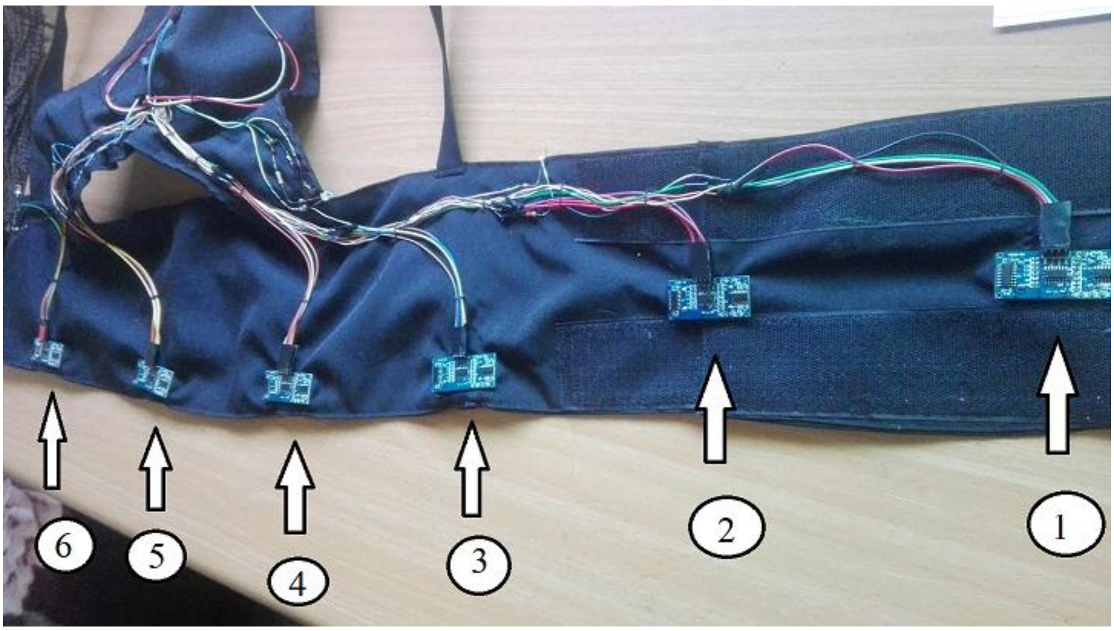


Figure 5.4 Six ultrasonic sensors implementation.

5.1.2 Thermal Sensors (HC-SR501 PIR)

In this project (HC-SR501 PIR) was chosen, three PIR sensors are used each thermal sensor has three pins as discussed in the previous chapter, each sensor is connected with the Arduino nano, the input connected to digital pins, when any sensors detect a person in risk zone a led alarm flashes as demonstrated in figure 5.5.

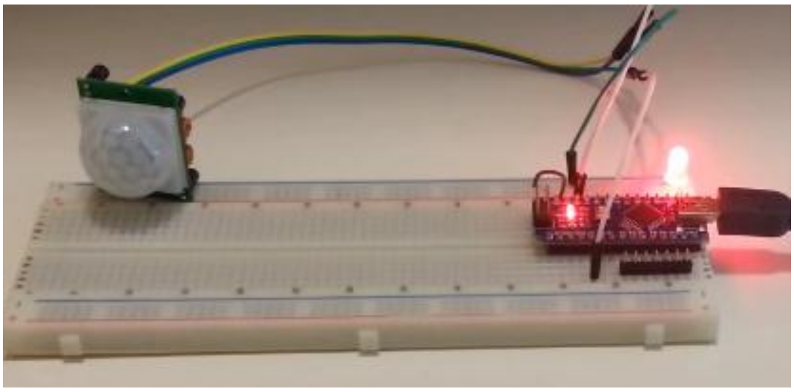


Figure 5.5 HC- SR501 and Arduino nano connection**.**

The following figure shows the work of PIR on serial monitor for three PIR sensors.

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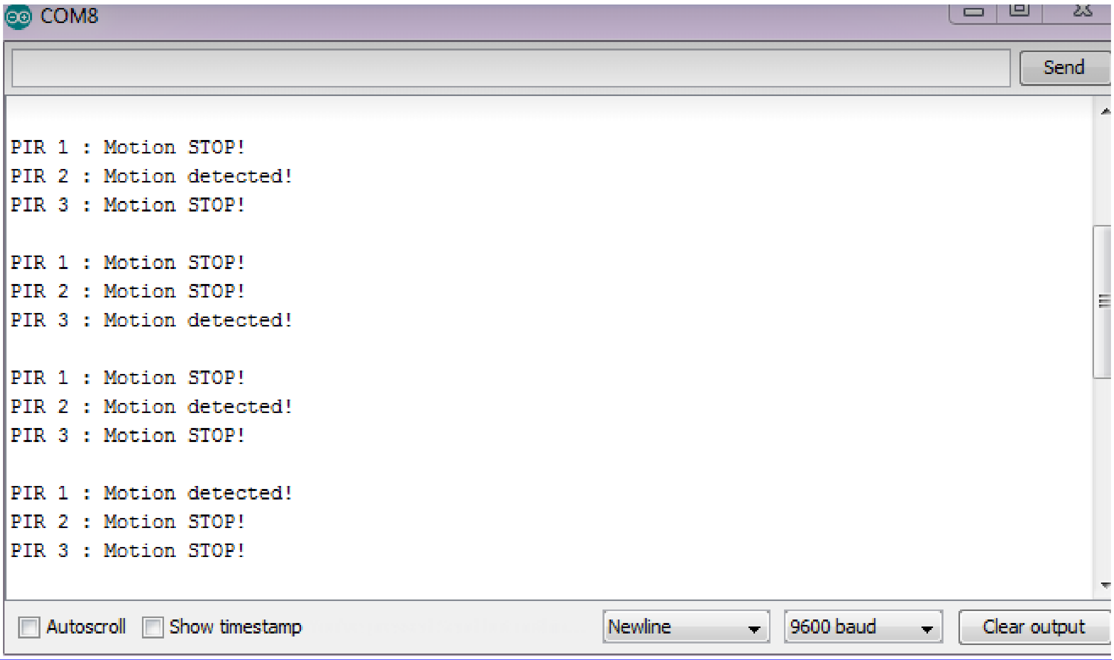

Figure 5.6 Work of PIR on serial monitor.

The following figure shows the connection of three PIR sensors in the vest:

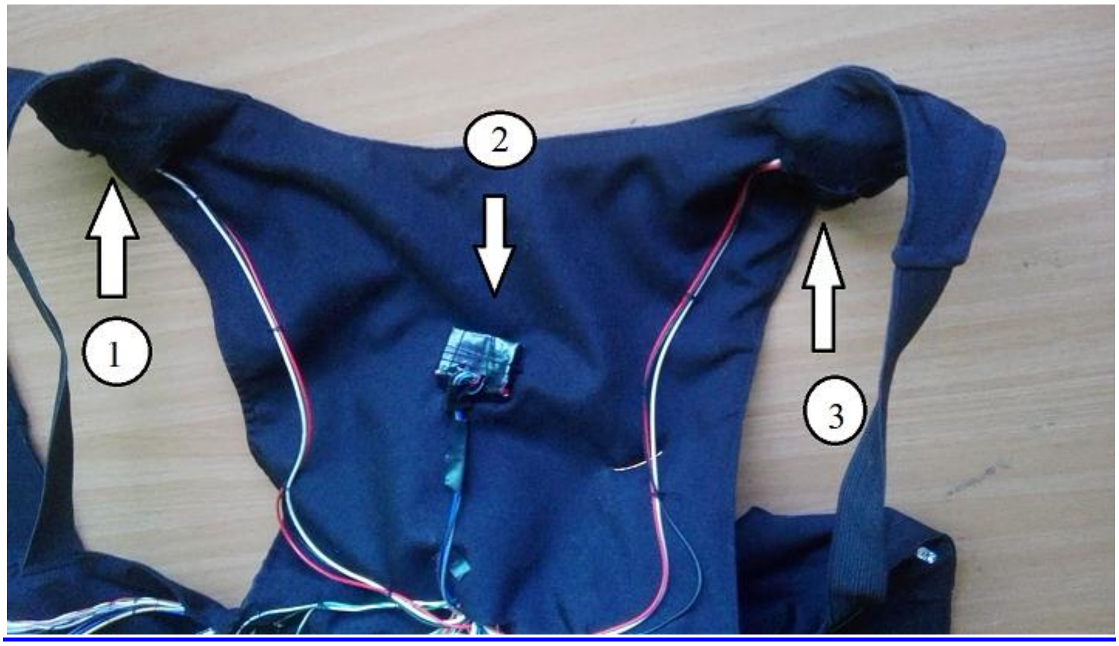

Figure 5.7 Three PIR sensors implementation.

5.1.3 LEDs & Vibration Motors

The alarm system consists of LEDs and vibration motor, Which located on the vest, and buzzer, located in the implemented box. The LEDs are placed on the vest where people can be alerted in all directions. The two vibration motors are placed in vest to alert the patient as shown in the following figure.

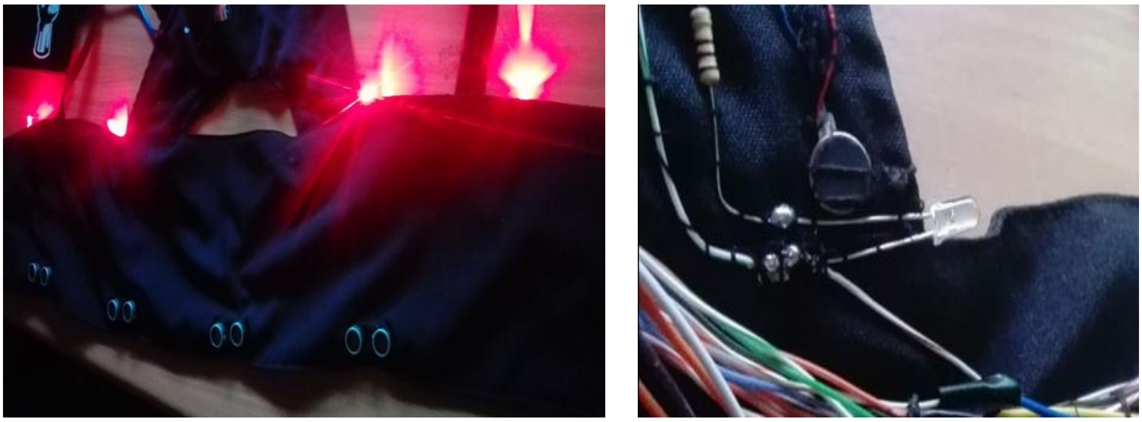

Figure 5.8 LEDs and Vibration motor on the vest.

5.2 Implemented Box

The box located on the back of vest, it contains conditioning circuit which includes Arduino nano, Bluetooth Module and Buzzer as illustrate in the following figure.

Figure 5.9 Implemented box on the vest.

5.2.1 Arduino Nano

For programming code Arduino Nano is used, this microcontroller joins every single sensor with the alarm system to investigate the project objectives.

5.2.2 Bluetooth Module (HC-05)

This design use HC-05 to send selected patient condition from a user's Smartphone to the Arduino nano as shown in figure 5.10.

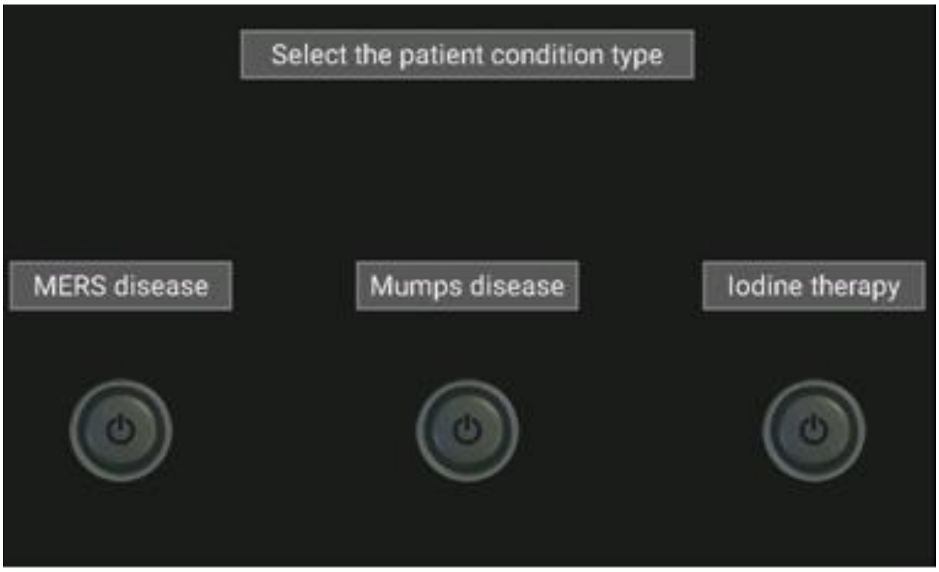

Figure 5.10 Patient condition selection via Smartphone interface.

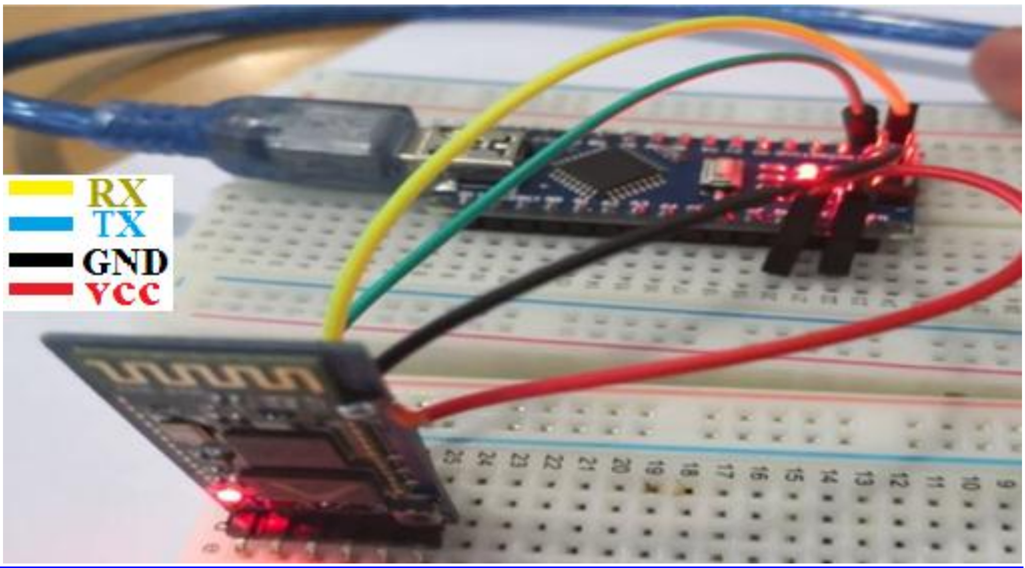

Figure 5.11 HC-05 connected to Arduino nano.

Chapter Six

Result and Recommendations

1. **Project Result**
2. **Conclusion**
3. **Challenges and Solutions**
4. **Recommendations and Future Work**

This chapter contains the result of the project, conclusion, and some recommendations for this project and future work, at the end of this chapter shows the challenges that we had in this semester.

6.1 Project Result

The previous chapter shows the results of each sensor by side, after connecting all sensors with each other as explained in the block diagram chapter four, after selecting the type of condition MERS, Mumps or radioactive iodine effect by Smartphone, the result of detecting a person around patient in risk zone is shown in figure 6.1, and the result when the person leaves the risk zone is shown in figure 6.2. Response time for alarm system needs a few delays "two seconds", this delay accrued because the Arduino needs time to process the data and gives the command to the alarm system.

After detecting person in the risk zone the alarm system will activate in a several types including sound, light and vibration for alerting the person and the patient, on the other hand when a person being out of the risk zone the alarm system will not activate.

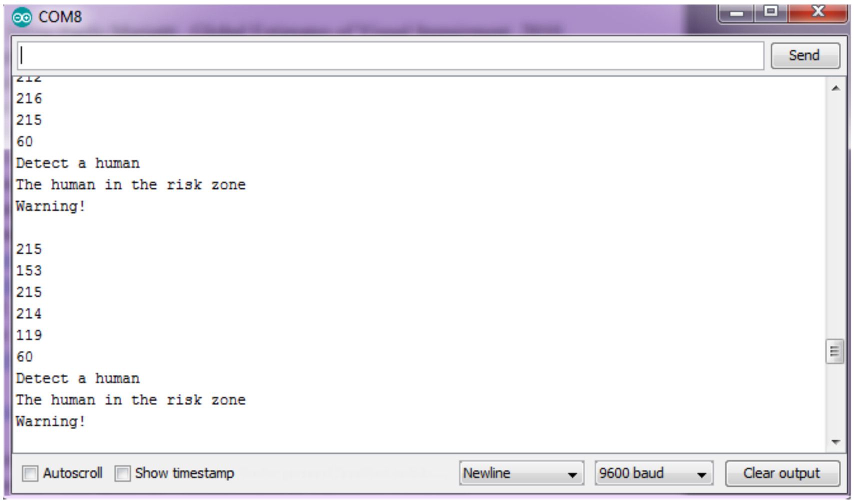

Figure 6.1 Person is detected in risk zone.

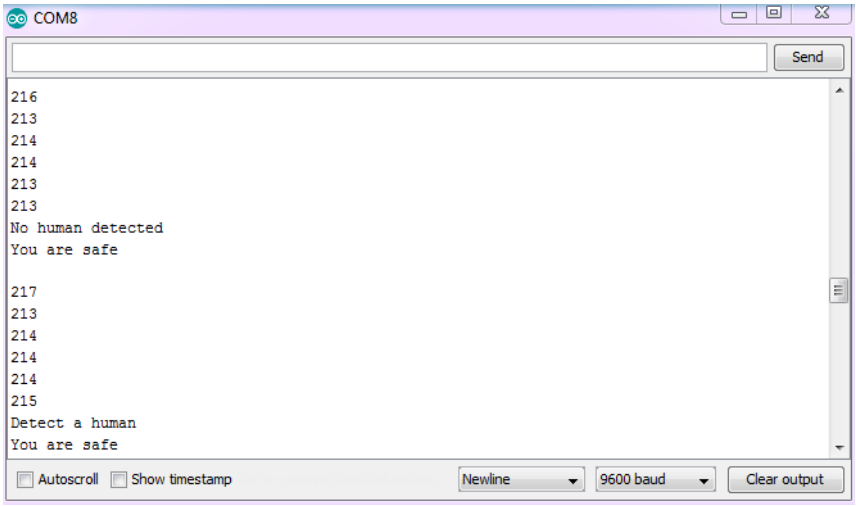

Figure 6.2 No person was detected in risk zone.

6.2 Conclusion

The following points show the conclusion of this project:

1) A vest can detect the unsafe distances between the patient and other people and activate an alarm system.

2) The combination of the thermal and distance sensors was successful in detecting a human within a risk zone radius and alarming the patient.

3) The vest offered a comfort and easy life style to the patient more than isolation rooms.

4) The material used allows the design to be lightweight, comfortable and easy to wear.

5) A vest can be calibrated depending on the type of disease to detect the unsafe distances.

6.3 Challenges and Solutions

In this semester while implementing the project components some challenges accrued that have been solved:

1) Inability to obtain the thermal sensor (4x4 Omron D6T8L06) because of the refusal of the occupation entering it to the country, so we replace it with PIR sensor.

2) Design strap shape is not effective due to change position of PIR sensors, so the design shape was changed to vest that contains all components.

3) PIR sensors detect patient's limps as person, so the PIR sensors were placed two of them on the shoulders and on the top of the back this solved the obstructions caused by the limbs of the patient.

6.4 Recommendations and Future Work

In order to proceed with this project or develop it, we recommend some points:

1) A different feedback mechanism can be implemented to provide more information to the patient. For example, different color lights could be used to indicate the danger level of a person that has been in the field of view for certain amounts of time (green, yellow, red).

2) Several illnesses could be added to the project to save people's life from infectious disease.

3) Encouraging the medical staff of hospitals to benefit from the design, in order to protect them from infectious diseases in their daily practices.

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