Flexible Telemetry System to Autonomously Monitor Sub-Bandage Pressure and Wound Moisture and temperature

(Flexi-Tele-PMT)

Project team

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Table of Contents

Chapter Three: - Technology Background

ABSTRACT

Wounds are defined as a cut in the skin. The depth of the cut decides how dangerous the wound is. It is known that the leg has one of the main arteries any deep wound there will be considered as fatal if left for bleeding.

The idea of this project is to design and implement a monitoring system that has the ability to measure the moisture of a wound, the pressure inside the wound dressing, and the The system will spray a substance that has the.temperature ability to stop bleeding wounds. The system employs wireless technologies to communicate alerts to LED and smart phones.

The project aims to help patients that has ulcers, diabetic ulcers and chronic wounds in general.

الملخص

تعرف الجروح بانها قطع في الجلد. عمق الجرح يحدد درجة خطورته. من المعروف بان القدم يوجد بها واحد من الشرايين الرئيسية بحيث ان أي جرح في تلك يعتبر جرح قاتل في حال استمرار النزيف.

تنبني فكرة المشروع على تصميم وبناء نظام لديه القدرة على قياس درجة رطوبة الجرح ومقدار الضغط ودرجة الحرارة داخل رباط الجرح، سيقوم النظام برش الجرح بمادة كيميائية من شانها ان توقف النزيف، يوظف المشروع أنظمة لاسلكية لإيصال البيانات الى جهاز لوحي والى نظام بشكل ساعة عليه شاشة تظهر القراءات عليه.

يهدف المشروع لمساعدة المرضى المصابين بجروح مزمنة والمصابين بالتقرحات السكرية.

List of Figures

List of Tables

Chapter 1

Thesis Overview

1.1 Project Idea Description

This report is about a clinical system that will monitor a wound moisture and alarms when bleeding is detected. The system will deliver a medicine that will stop the bleeding by using a pump.

This system will use two sensors; Humidity-Temperature sensor, pressure sensor.

The Humidity sensor will sense the bleeding and the pressure sensor will maintain a certain pressure in two positions: Calf muscle and above the ankle. All sensors are connected via wires. Signals are processed and results are sent to a tablet device and an LCD. When the alarm sounds, the system triggers the pump to spray the medicine over the wound.

The Patient can monitor his state by looking at a watch-like LCD that display the Measurements of the three Parameters.

1.2 Project Motivation

The treatment of chronic wounds such as venous leg and diabetic ulcers has emerged as one of the greatest scientific as well as financial challenges for the global medical community [1]. The average cost per person for a 2-year diabetic foot ulcer treatment in the USA was estimated at $27,987 in 1999 [2].

A current estimate shows the economic cost of wound care activities in the world is distributed as 15%–20% materials, 30%–35% nursing time, and more than 50% as hospitalization time [3].
It was estimated in 1991 that the prevalence of leg ulcers only within the USA was between 0.5% and 1.5% with an annual cost of nearly US$1 billion [4].

In the UK, during 2001, chronic wounds were a major cause of morbidity, affecting more than 1% of population and with treatment cost of at least £1 billion [5].
During 2006–2007, chronic wounds were affecting 3–6 million people in the USA with a total cost of treatment estimated at more than $3 billion annually [6,7].

In 2012, the number of people suffering from chronic wounds was 7 million, and the cost for their treatment was estimated at almost $25 billion annually [8].

Therefore, the system comes in handy in order to reduce the costs of replacing bandage at every medical check on the wound, and by using a 4-layer bandage that two layer of them can be sterilized and washed, and it saves the wasted time for check and replace method.

The system uses two main method in communication one, by using wires to send data from the sensors to the microprocessor and another is to send the data from the microprocessor to two different devices a tablet with android application and to a watch-like LCD by using WIFI technology.

1.3 Project Aims

The project aims to help patient that has ulcers, Diabetic ulcers, Chronic wound in general.

The project provides an easy user interface so that the nursing staff can deal with it needing the minimum training ever, The system is wire free that is all up-to-date methods of communication by using the Wi-Fi technology.

In emergency cases, the system will try to save the patient life by spraying a chemical substance that will stop the bleeding.

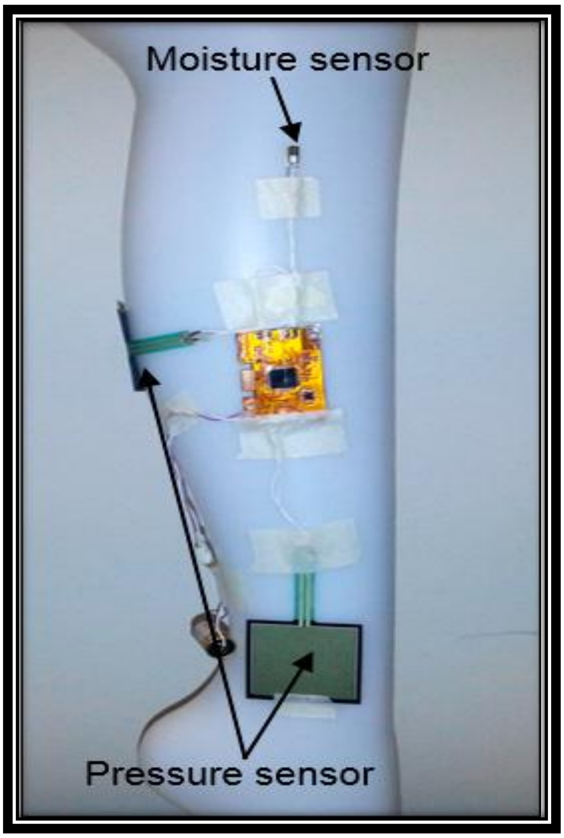
1.4 Related Project.

a similar project that was designed by:

((Nasir Mehmood, Alex Hariz, Sue Templeton and Nicolas H. Voelcker))

Their project monitors the moisture of the wound and the pressure at two points as well, but the sensors were wired-connected and transmit data via ZigBee. Thus, the system only monitors the wound.

A tablet device was used also with USB connected to an RF Receiver to receive ZigBee signals. The system was based on microcontroller to process data.



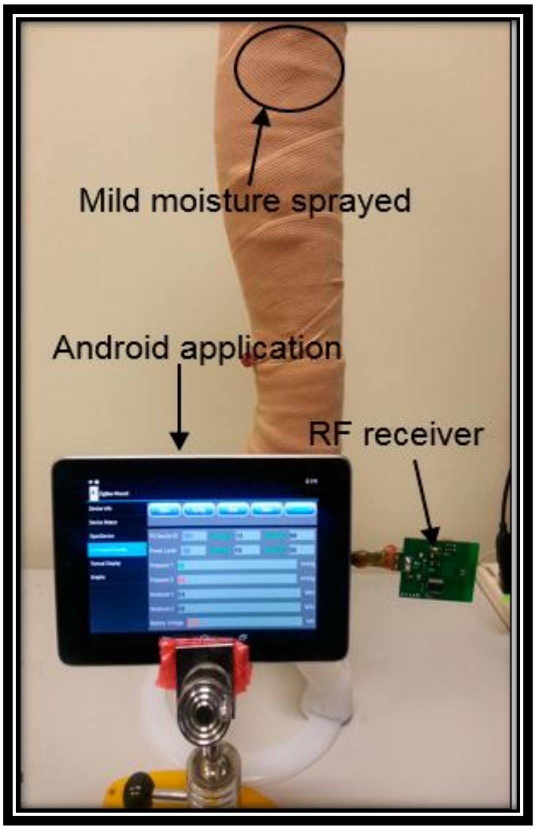


Fig 1.1 Related Project

Table 1.1 Comparison between Systems

No	Comparison Phases	This Project	Related Project
1	Battery Powered	Yes	yes
2	Connection between Sensors	soldering	Soldering
3	Processing Unit	Arduino	Pic
4	Reaction System	Yes	No, just Monitoring

1.5 List of Abbreviation

Table 1.2 list of abbreviation

No	Abbreviation	Full word
1	WIFI	Wireless Internet for Frequent Interface
2	LCD	Liquid Crystal Display
3	OP-AMP	Operational Amplifier
4	IEEE	Institute of Electrical and Electronics Engineers
5	USB	Universal Serial Bus
6	RF	Radio Frequency
7	ADC	Analogue to Digital Converter

1.6 Economical Study

Table 1.3 Economical Study

No	Type	price	quantity
1	Humidity-Temperature Sensor	20 JD	2
2	Pressure Sensor	40 JD	2
3	XBEE	150 JD	2
4	Microprocessor	40 JD	2
7	Battery	35 JD	1
8	DC Pump	50 JD	1
9	Tablet	200 JD	1
10	LCD	20 JD	1
Total		550 JD	

1.7 Schedule Time

Table 1.4 Schedule Time for the First Semester

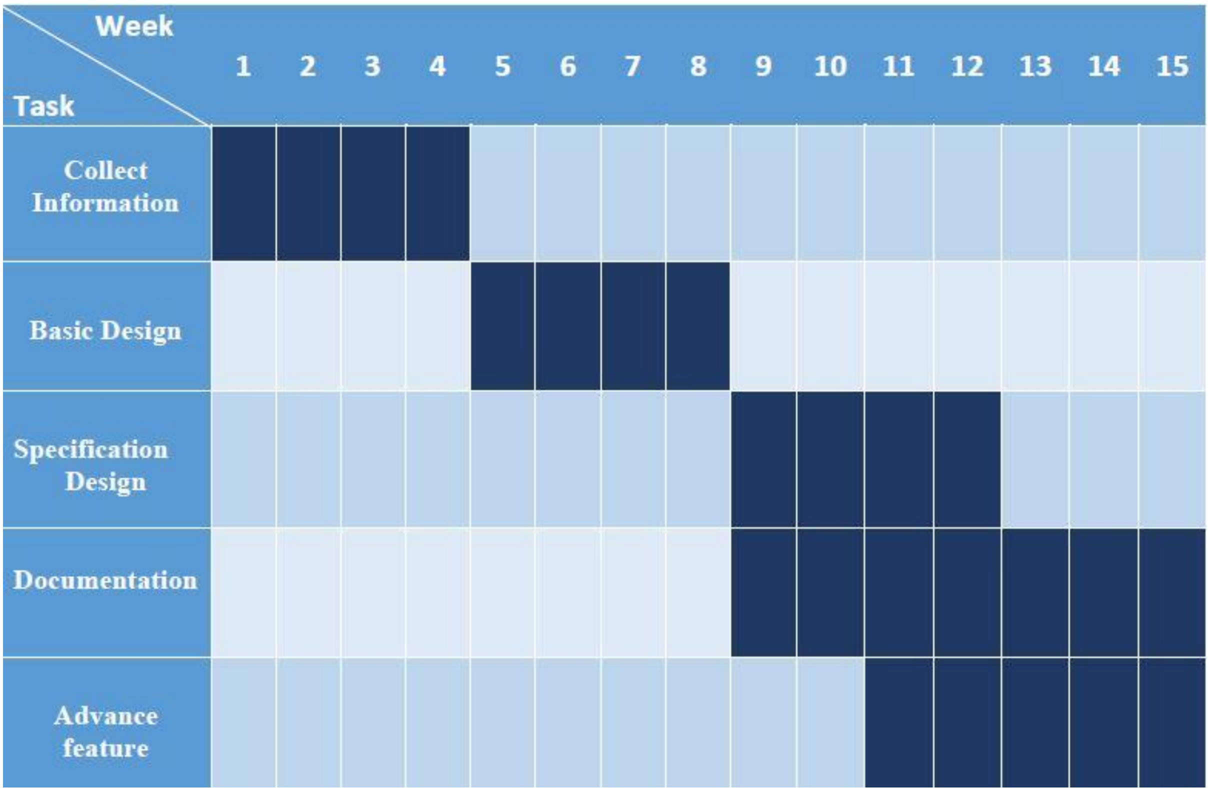
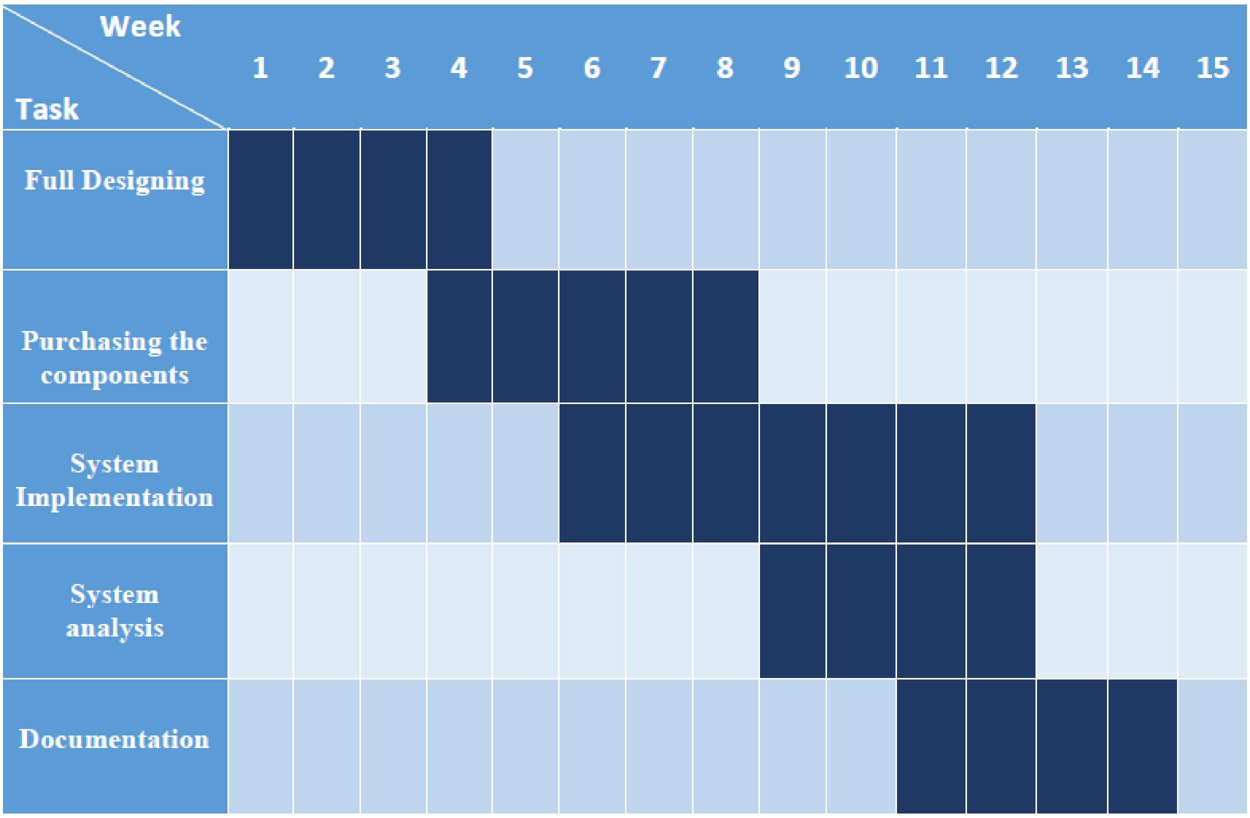


Table 1.5 Current Semester Plans



2.1 Introduction

The skin is the largest organ of the body, accounting for about 15% of the total adult body weight. It performs many vital functions, including protection against external physical, chemical, and biologic assailants, as well as prevention of excess water loss from the body and a role in thermo regulation. Figure 2.1 illustrates the skin layer [7]

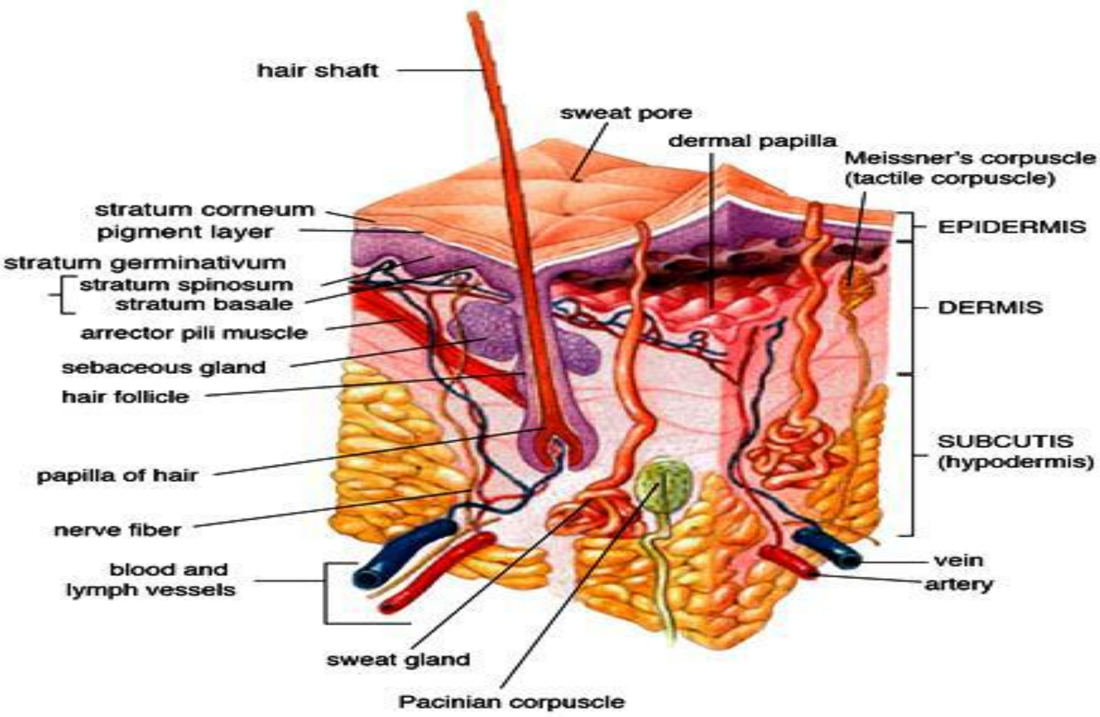


Figure 2.1: Skin layer

2.2 The structure of the skin

The skin is the largest organ of the body, it is an organ because it consists of different tissues that are joined to perform specific activities. The skin has two principle parts. The superficial, thinner portion is called the epidermis. The epidermis is composed of epithelial tissue and is attached to the deeper, thicker part called the dermis. The dermis is composed of connective tissue. Below the dermis is a subcutaneous layer, which consists of connective and adipose tissues [8].

2.2.1 Epidermis layer

The epidermis is a vascular: oxygen and nutrients are supplied by interstitial fluid from the Dermis. The epidermis is composed of stratified keratinized squamous epithelium and contains four principle cells.

About 90% of the epidermal cells are keratinocytes which produce keratin. Keratin helps to Waterproof and protect the skin and underlying tissues from heat, light, microbes and many chemicals. 8% of the epidermal cells are melanocytes which produce the pigment melanin. Langerhans cells are the third cell in the epidermis, they interact with helper T cells (white blood cells) in immune responses.

The merkel cell is the fourth type of cell in the epidermis and is found in the deepest layer of Hairless skin. These cells make contact with the end of nerve cells and are thought to function in the sensation of touch.

The epidermis is composed of four or five layers, and has a relatively uniform thickness over the body; typically 0.1mm in the four layer regions. Where exposure to friction is greatest e.g. on the soles of the feet and the palms of the hands it is thicker at 1-2mm and has five layers

Epidermis is divided into the following 5 sublayers or strata: Figure. 2.2
• Stratum corneum.
• Stratum lucidum.
• Stratum granulosum.
• Stratum spinosum.

• Stratum basal.

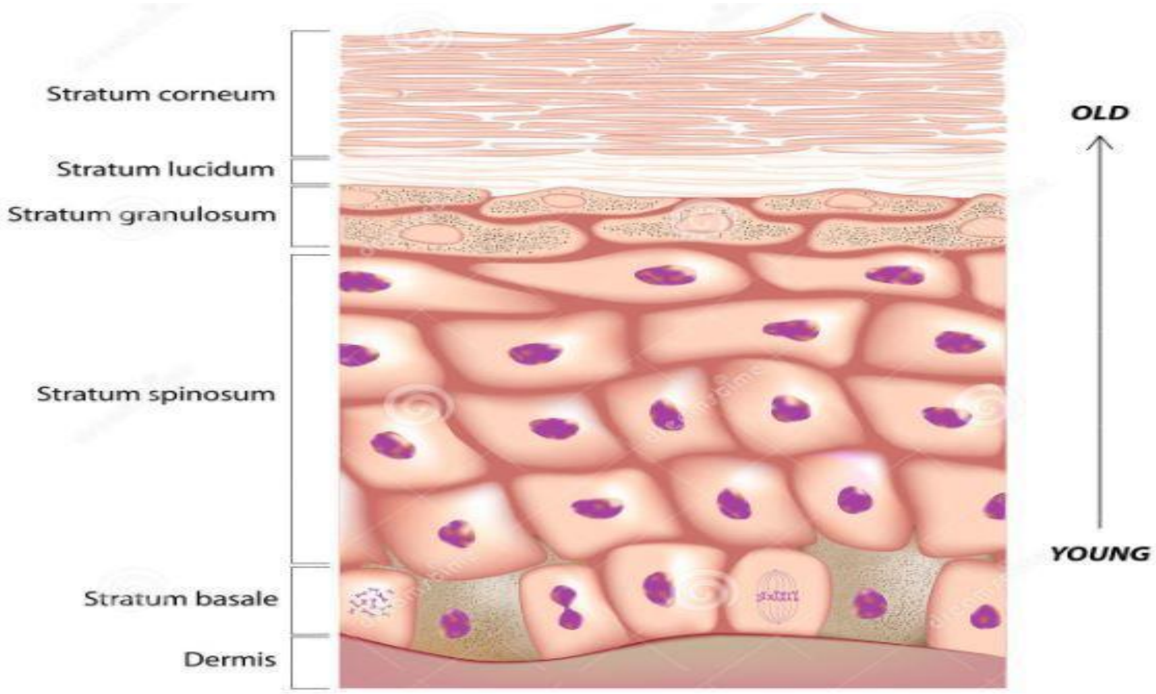


Figure 2.2: Epidermis layer

The cells on the surface of the epidermis are flat, thin, non-nucleated, dead cells, in which the Cytoplasm has been replaced by fibrous keratin. These cells are continuously shed and replaced by cells which originated in the basal layers. This process is called keratinization and takes about 2-4 weeks.

2.2.1.1 Stratum corneum

The final outcome of keratinocyte maturation is found in the stratum corneum, which is made-up of layers of hexagonal-shaped, non-viable cornified cells known as corneocytes. In most areas of the skin, there are 10±30 layers of stacked corneocytes with the palms and soles having the most. Each corneocyte is surrounded by a protein envelope and is filled with water-retaining keratin proteins. The cellular shape and orientation of the keratin proteins add strength to the stratum corneum. Surrounding the cells in the extracellular space are stacked layers of lipid bilayers.

The resulting structure provides the natural physical and water retaining barrier of the skin.

The corneocyte layer can absorb three times its weight in water but if its water content drops below 10% it no longer remains pliable and cracks. The movement of epidermal cells to this layer usually takes about 28 days and is known as the epidermal transit time.

2.2.1.2 Stratum lucidum

The stratum lucidum (Latin for "clear layer") is a thin, clear layer of dead skin cells in the Epidermis named for its translucent appearance under a microscope. It is readily visible by light microscopy only in areas of thick skin, which are found on the palms of the hands and the soles of the feet.

Located between the stratum granulosum and stratum corneum layers, it is composed of three to five layers of dead, flattened keratinocytes. The keratinocytes of the stratum lucidum do not feature distinct boundaries and are filled with eleidin, an intermediate form of keratin.

The thickness of the lucidum is controlled by the rate of mitosis of the epidermal cells. In addition, melanosomes determine the darkness of the stratum lucidum. The cells of the stratum lucidum are flattened. They are surrounded by an oily substance that is the result of the exocytosis of lamellar bodies accumulated while the keratinocytes are moving through the stratum spinosum and stratum granulosum.

2.2.1.3 Stratum granulosum

Continuing their transition to the surface the cells continue to flatten, lose their nuclei and their cytoplasm appears granular at this level.

2.2.1.4 Stratum spinosum

As basal cells reproduce and mature, they move towards the outer layer of skin, initially Forming the stratum spinosum. Intercellular bridges, the desmosomes, which appear as `prickles' at a microscopic level, connect the cells. Langerhans cells are dendritic, immunologically active cells derived from the bone marrow, and are found on all epidermal surfaces but are mainly located in the middle of this layer. They play a significant role in immune reactions of the skin, acting as antigen-presenting cells.

2.2.1.5 Stratum basale

The innermost layer of the epidermis which lies adjacent to the dermis comprises mainly Dividing and non-dividing keratinocytes, which are attached to the basement membrane by Hemi desmosomes. As keratinocytes divide and differentiate, the move from this deeper layer to the surface. Making up a small proportion of the basal cell population is the pigment (melanin) producing melanocytes. These cells are characterized by dendritic processes, which stretch between relatively large numbers of neighboring keratinocytes. Melanin accumulates in melanosomes that are transferred to the adjacent keratinocytes where they remain as granules.

2.2.2 Dermis layer

The dermis is the thickest layer of the skin. The dermis ranges in thickness from 2 4mm, it tends to be very thick in the palms and soles and thin in areas such as the eyelids. It is also thicker on the back (posterior) than the front (anterior) of the body. The dermis is composed of connective tissue containing collagen and elastic fibers, which makes it tough and elastic. When the skin is overstretched rupture of elastic fibers occurs resulting in permanent striate or stretch marks, such as may be found in pregnancy, obesity or weight loss. Collagen is the protein that gives skin its tensile strength, although this ability declines with age, when wrinkles may develop.

There are several structures found in the dermis.

Blood vessels

Supply oxygen and nutrients to sweat glands and the dermis.

Lymph vessels

The lymphatic system is responsible for the transportation of particulate and liquid material, such as protein from the extracellular compartment of the dermis. Lymph vessels are broad lumen, with single-cell thick walls that transport fluid away from the skin to the lymph nodes, maintaining homeostasis in the tissues.

Sensory nerve endings

The skin is an important sensory organ. Incoming stimuli are received by sensory receptors in the dermis.

2.2.3 Subcutaneous layer (Hypodermis)

This is a layer of fat, which lies between the skin and the underlying structures it provides Insulation, an energy reserve and cushioning. There are blood vessels within this layer, which supply the blood vessels of the dermis. Fibers from the dermis extend into the subcutaneous layer and anchor the skin to it. The subcutaneous layer attaches the dermis to underlying structures and organs [8].

2.3 The skin function

Skin performs the following functions:

1**. Protection:** an anatomical barrier from pathogens and damage between the internal and External environment in bodily defense; Langerhans cells in the skin are part of the adaptive immune system.

2. Sensation: contains a variety of nerve endings that react to heat and cold, touch, pressure, Vibration, and tissue injury.

3. Heat regulation: the skin contains a blood supply far greater than its requirements which Allows precise control of energy loss by radiation, convection and conduction. Dilated blood vessels increase perfusion and heat loss, while constricted vessels greatly reduce cutaneous blood flow and conserve heat.

4. Control of evaporation: the skin provides a relatively dry and semi-impermeable barrier to fluid loss. [4] Loss of this function contributes to the massive fluid loss in burns.

5. Esthetics and communication: others see our skin and can assess our mood, physical state and attractiveness.

6. Storage and synthesis: acts as a storage center for lipids and water, as well as a means of Synthesis of vitamin D by action of UV on certain parts of the skin.

7. Excretion: sweat contains urea, however its concentration is 1/130th that of urine, Hence excretion by sweating is at most a secondary function to temperature regulation.

8. Absorption: the cells comprising the outermost 0.25–0.40 mm of the skin are "almost Exclusively supplied by external oxygen", although the "contribution to total respiration is

Negligible". [9] In addition, medicine can be administered through the skin, by ointments or by means of adhesive patch, such as the nicotine patch oriontophoresis. The skin is an important site of transport in many other organisms.

9. Water resistance: The skin acts as a water resistant barrier so essential nutrients aren't washed out of the body [8].

2.4 Wound Definition

A wound is a type of injury which happens relatively quickly in which skin is torn, cut, or punctured (an *open* wound), or where blunt force trauma causes
a contusion (a *closed* wound).

In pathology, it specifically refers to a sharp injury which damages the dermis of the skin.

2.4.1 Classification of wounds

According to level of contamination a wound can be classified as

- clean wound, a wound made under sterile conditions where there are no organisms present in the wound and the wound is likely to heal without complications.
- contaminated wound, where the wound is as a result of accidental injury where there are pathogenic organisms and foreign bodies in the wound.
- infected wound, where the wound has pathogenic organisms present and multiplying showing clinical signs of infection, where it looks yellow, oozing pus, having pain and redness.
- colonized wound, where the wound is a chronic one and there are a number of organisms present and very difficult to heal as in a bedsore.

2.4.1.1 Open Wounds

Open wounds can be classified according to the object that caused the wound. The types of open wound are:

- Incisions or incised wounds, caused by a clean, sharp-edged object such as a knife, razor, or glass splinter.
- Lacerations, irregular tear-like wounds caused by some blunt trauma. Lacerations and incisions may appear linear (regular) or stellate (irregular). The term *laceration* is commonly misused in reference to incisions.
- Abrasions (grazes), superficial wounds in which the topmost layer of the skin (the epidermis) is scraped off. Abrasions are often caused by a sliding fall onto a rough surface.
- Avulsions, injuries in which a body structure is forcibly detached from its normal point of insertion. A type of amputation where the extremity is pulled off rather than cut off.
- Puncture wounds, caused by an object puncturing the skin, such as a splinter, nail or needle.
- Penetration wounds, caused by an object such as a knife entering and coming out from the skin.
- Gunshot wounds, caused by a bullet or similar projectile driving into or through the body. There may be two wounds, one at the site of entry and one at the site of exit, generally referred to as a "through-and-through."

2.4.1.2 Closed Wounds

Closed wounds have fewer categories, but are just as dangerous as open wounds. The types of closed wounds are:

- Hematomas, also called a blood tumor, caused by damage to a blood vessel that in turn causes blood to collect under the skin.
  - Hematomas that originate from internal blood vessel pathology are petechiae, purpura, and ecchymosis. The different classifications are based on size.

    - Hematomas that originate from an external source of trauma are contusions, also commonly called bruises.
- Crush injury, caused by a great or extreme amount of force applied over a long period of time.

2.4.2 Blood coagulation

Blood Coagulation (also known as clotting) is the process by which blood changes from a liquid to a gel, forming a clot. It potentially results in hemostasis, the cessation of blood loss from a damaged vessel, followed by repair. The mechanism of coagulation involves activation, adhesion, and aggregation of platelets along with deposition and maturation of fibrin. Disorders of coagulation are disease states which can result in bleeding (hemorrhage or bruising) or obstructive clotting (thrombosis).[1]

Coagulation is highly conserved throughout biology; in all mammals, coagulation involves both a cellular (platelet) and a protein (coagulation factor) component.[2]

The system in humans has been the most extensively researched and is the best understood.[3]

Coagulation begins almost instantly after an injury to the blood vessel has damaged the endothelium lining the vessel. Exposure of blood to the space under the endothelium initiates two processes: changes in platelets, and the exposure of sub-endothelial tissue factor to plasma Factor VII, which ultimately leads to fibrin formation. Platelets immediately form a plug at the site of injury; this is called primary hemostasis. Secondary hemostasis occurs simultaneously: Additional coagulation factors or clotting factors beyond Factor VII (listed below) respond in a complex cascade to form fibrin strands, which strengthen the platelet plug.[4]

2.4.3 Wound Dressing & Bandages

A Dressing is a sterile pad or compress [1] applied to a wound to promote healing and/or prevent further harm. A dressing is designed to be in direct contact with the wound, as distinguished from a bandage, which is most often used to hold a dressing in place. Dressings are frequently used in first aid and nursing.

A Bandage is a piece of material used either to support a medical device such as a dressing or splint, or on its own to provide support to or to restrict the movement of a part of the body. When used with a dressing, the dressing is applied directly on a wound, and a bandage used to hold the dressing in place. Other bandages are used without dressings, such as elastic bandages that are used to reduce swelling or provide support to a sprained ankle. Tight bandages can be used to slow blood flow to an extremity, such as when a leg or arm is bleeding heavily.

Bandages are available in a wide range of types, from generic cloth strips to specialized shaped bandages designed for a specific limb or part of the body. Bandages can often be improvised as the situation demands, using clothing, blankets or other material

2.5 Wound Management

The overall treatment depends on the type, cause, and depth of the wound as well as whether or not other structures beyond the skin (dermis) are involved. Treatment of recent lacerations involves examining, cleaning, and closing the wound. Minor wounds, like bruises, will heal on their own, with skin discoloration usually disappearing in 1–2 weeks. Abrasions, which are wounds with intact skin (non-penetration through dermis to subcutaneous fat), usually require no active treatment except keeping the area clean, initially with soap and water. Puncture wounds may be prone to infection depending on the depth of penetration. The entry of puncture wound is left open to allow for bacteria or debris to be removed from inside.

2.5.1 Cleaning

Evidence to support the cleaning of wounds before closure is poor.[2] For simple lacerations, cleaning can be accomplished using a number of different solutions, including tap water and sterile saline solution.[2] Infection rates may be lower with the use of tap water in regions where water quality is high.[2] Cleaning of a wound is also known as wound toilet.[3]

2.5.2 Closure

If a person presents to a healthcare center within 6 hours of a laceration they are typically closed immediately after evaluating and cleaning the wound. After this point in time, however, there is a theoretical concern of increased risks of infection if closed immediately.[4]

Thus some healthcare providers may delay closure while others may be willing to immediately close up to 24 hours after the injury.[4] A single study has found that using clean non sterile gloves is equivalent to using sterile gloves during wound closure.[5][6]

If closure of a wound is decided upon a number of techniques can be used. These include bandages, a cyanoacrylate glue, staples, and sutures. Absorbable sutures have the benefit over non absorbable sutures of not requiring removal. They are often preferred in children.[7] Buffering the pH of lidocaine makes the freezing less painful.[8]

Adhesive glue and sutures have comparable cosmetic outcomes for minor lacerations <5 cm in adults and children.[9] The use of adhesive glue involves considerably less time for the doctor and less pain for the person with the cut. The wound opens at a slightly higher rate but there is less redness.[10] The risk for infections (1.1%) is the same for both. Adhesive glue should not be used in areas of high tension or repetitive movements, such as joints or the posterior trunk.[9]

2.5.3 Dressing

In the case of clean surgical wounds, there is no evidence that the use of topical antibiotics reduces infection rates in comparison with non-antibiotic ointment or no ointment at all.[11] Antibiotic ointments can irritate the skin, slow healing, and greatly increase the risk of developing contact dermatitis and antibiotic resistance.[11] Because of this, they should only be used when a person shows signs of infection and not as a preventative.[11]

The effectiveness of dressings and creams containing silver to prevent infection or improve healing is not currently supported by evidence.[12]

Chapter 2

Anatomical Background & Wound Management

Chapter 3

Technology Background

3.1 Introduction

3.2 Sensors.

3.3 Pump.

3.4 Microprocessor (Arduino).

3.5 Wi-Fi.

3.1 Introduction

This chapter provides technical and theoretical background about all system elements and components.

3.2 Sensors

3.2.1 Humidity-Temperature Sensor – model (DHT-11).

This sensor is going to measure the Humidity-Temperature level of a wound. The sensor has to be small, with high accuracy and has to operate in narrow range of temperature.

The dimensions of the sensor are as follows: (13.5*8.3*4) mm (L*W*D) which is considered as a small sensor in order to fit inside the dressing easily.

Table 3.1 Humidity-Temperature Sensor

Item	Measurement Range	Humidity Accuracy	Temperature Accuracy
DHT11	20-90%RH 0-50 ℃	±5%RH	±2℃

Parameters	Conditions	Minimum	Typical	Maximum
Humidity				
Resolution		1%RH	1%RH	1%RH
			8 Bit	
Repeatability			±1%RH	
Accuracy	25℃		±4%RH	
	0-50℃			±5%RH
Interchangeability	Fully Interchangeable			
Measurement Range	0℃	30%RH		90%RH
	25℃	20%RH		90%RH
	50℃	20%RH		80%RH
Response Time (Seconds)	1/e(63%)25℃, 1m/s Air	6 S	10 S	15 S
Hysteresis			±1%RH	
Long-Term Stability	Typical		±1%RH/year	
Temperature				
Resolution		1℃	1℃	1℃
		8 Bit	8 Bit	8 Bit
Repeatability			±1℃	
Accuracy		±1℃		±2℃
Measurement Range		0℃		50℃
Response Time (Seconds)	1/e(63%)	6 S		30 S

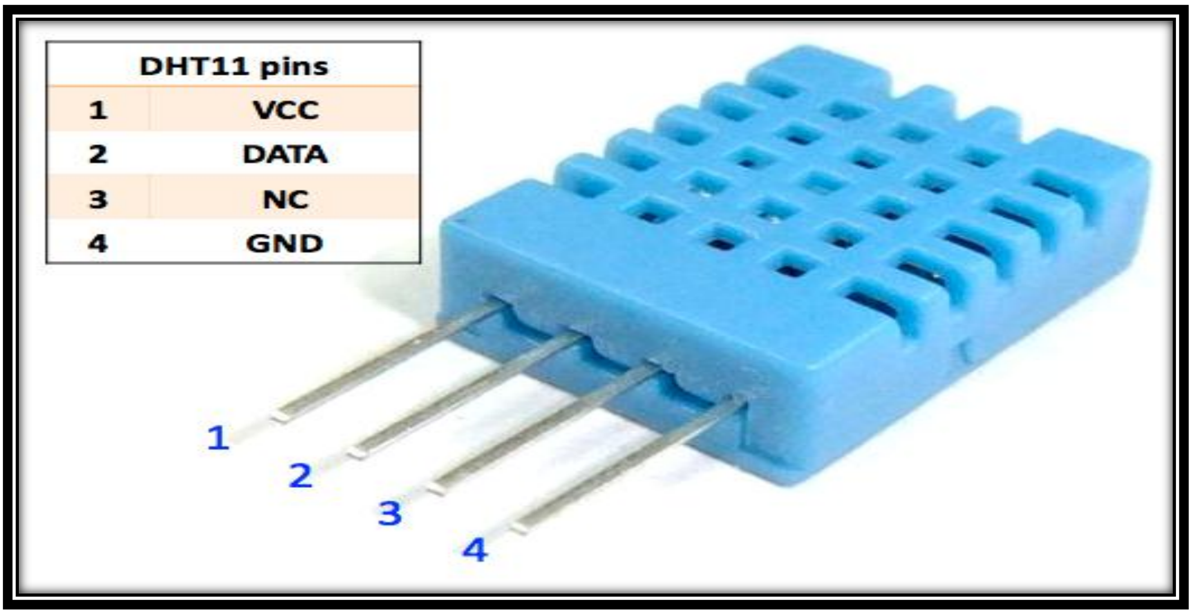


Fig 3.1 Humidity-Temperature sensor

3.2.1 Pressure Sensor – Model (FSR-406).

This sensor is going to measure the bandage pressure at two different positions. The sensor has to be small size and can withstand binding, because it is placed over a moving muscle.

The FSR-406 is suitable for this project. It has a very small time response up to 3 micro seconds which is pretty fast response. Any increase in pressure will lead to decrease in resistance.

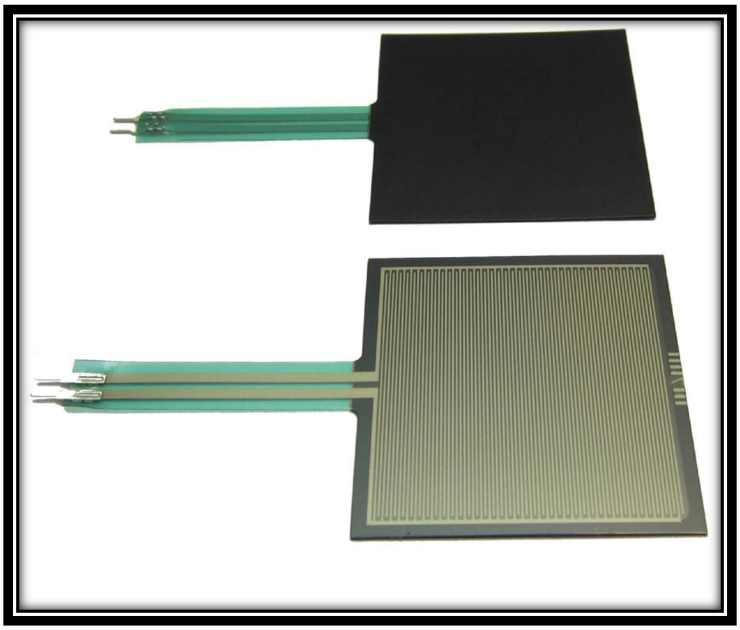


Fig 3.2 Pressure Sensor

The sensor features are:

- ➔ This sensor can sense the slightest change about 0.1N Force.
- ➔ It can operate in a temperature range (-30 ^{o}C – 70 ^{o}C).
- ➔ Its dimension are (43.69*43.69) square-like shape.

3.3 Pump

Fig 3.3 DC Water Pump

12V Water Pressure Diaphragm Pump

It has unique features:

Flow rate: 4.3 L/min

Water pressure: 35 PSI

3.4 Microprocessor (Arduino Uno)

3.4.1 What is Arduino?

Arduino is an open-source prototyping platform based on easy-to-use hardware and software. Arduino boards are able to read inputs and turn it into an output. You can tell your board what to do by sending a set of instructions to the microcontroller on the board.

3.4.2 Characteristics of Arduino

1. Simple and accessible user experience.
2. Inexpensive - Arduino boards are inexpensive compared to other microcontrollers' platforms.
3. Simple, clear programming environment.
4. Open source and extensible software.
5. It runs on Mac, Windows, and Linux.

In this project, we selected the Arduino because The System needs an ADC and Wi-Fi transmission operations. In addition, we selected Arduino Uno rather than the Arduino Mega because a Software Serial library allows serial communication on any of the Uno's digital pins.

3.4.3 ADC Operation

An analog-to-digital converter (ADC) is a device that converts a continuous physical quantity (usually voltage) to a digital number that represents the quantity's amplitude. As shown in figure:

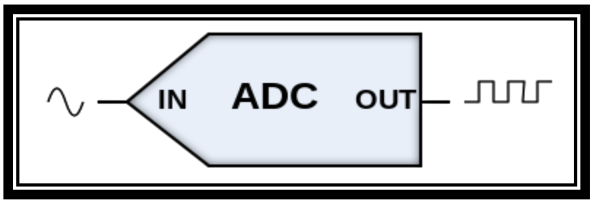


Fig 3.4 ADC schematic

The conversion involves quantization of the input, so it necessarily introduces a small amount of error. Furthermore, instead of continuously performing the conversion, an ADC does the conversion periodically, sampling the input.

➔ Range

An ADC is defined by its bandwidth (the range of frequencies it can measure and its signal to noise ratio). The actual bandwidth of an ADC is characterized primarily by its sampling rate, and to a lesser extent by how it handles errors such as aliasing. The dynamic range of an ADC is influenced by many factors, including the resolution, linearity and accuracy how well the quantization levels match the true analog signal and jitter (small timing errors that introduce additional noise).

➔ADC types

1. A direct-conversion ADC or flash ADC
2. A successive-approximation ADC
3. A ramp-compare ADC
4. The Wilkinson ADC
5. An integrating ADC
6. A delta-encoded ADC or counter-ramp
7. A pipeline ADC
8. A sigma-delta ADC
9. A time-interleaved ADC
10. An ADC with intermediate FM stage
11. A time-stretch analog-to-digital converter (TS-ADC)

3.5 WI-FI

3.5.1 Wi-Fi Technology

Wi-Fi is a local area wireless computer network technology that allows electronic devices to connect to the network.

The Wi-Fi Alliance defines Wi-Fi as any "wireless local area network" (WLAN) product based on the (IEEE) 802.11 standards. However, the term "Wi-Fi" is used in general English as a synonym for "WLAN" since most modern WLANs are based on these standards. "Wi-Fi" is a trademark of the Wi-Fi Alliance. The "Wi-Fi Certified" trademark can only be used by Wi-Fi products that successfully complete Wi-Fi Alliance interoperability certification testing.

Many devices can use Wi-Fi, e.g. personal computers, video-game consoles, smart-phones, digital cameras, tablet computers and digital audio players. These can connect to a network resource such as the Internet via a wireless network access point.

Wi-Fi technology may be used to provide Internet access to devices that are within the range of a wireless network that is connected to the Internet. The coverage of one or more interconnected access points (hotspots) can extend from an area as small as a few rooms to as large as many square kilometers. Coverage in the larger area may require a group of access points with overlapping coverage.

3.5.2 Uses of WIFI

To connect to a Wi-Fi LAN, a computer has to be equipped with a wireless network interface controller. The combination of computer and interface controller is called a station. For all stations that share a single radio frequency communication channel, transmissions on this channel are received by all stations within range. The transmission is not guaranteed to be delivered and is therefore a best-effort delivery mechanism. A carrier wave is used to transmit the data. The data is organized in packets, referred to as "Ethernet frames".

3.5.3 Wi-Fi radio spectrum

802.11b and 802.11g use the 2.4 GHz ISM band. Because of this choice of frequency band, 802.11b and g equipment may occasionally suffer interference from microwave ovens, cordless telephones, and Bluetooth devices. A Wi-Fi signal occupies five channels in the 2.4 GHz band. 802.11a uses the 5 GHz U-NII band, which, for much of the world, offers at least 23 non-overlapping channels rather than the 2.4 GHz ISM frequency band, where adjacent channels overlap.

3.5.4 WIFI Range

The Wi-Fi signal range depends on the frequency band, radio power output, antenna gain and antenna type as well as the modulation technique. Line-of-sight is the thumbnail guide but reflection and refraction can have a significant impact.

Due to the complex nature of radio propagation at typical Wi-Fi frequencies, particularly the effects of signal reflection off trees and buildings, algorithms can only approximately predict Wi-Fi signal strength for any given area in relation to a transmitter.] This effect does not apply equally to long-range Wi-Fi, since longer links typically operate from towers that transmit above the surrounding foliage.

The practical range of Wi-Fi essentially confines mobile use to such applications as inventory-taking machines in warehouses or in retail spaces, barcode-reading devices at checkout stands, or receiving/shipping stations.

Mobile use of Wi-Fi over wider ranges is limited, for instance, to uses such as in an automobile moving from one hotspot to another. Other wireless technologies are more suitable for communicating with moving vehicles.

Chapter 4

Conceptual Design

4.1 Introduction

4.2System Main Block Diagram.

4.3System sub-Block Diagram.

4.4Interconnection.

4.5Data Flow between System Elements.

4.6Software Modules.

4.1 Introduction

This chapter explains the conceptual system design. It explains the system sub-blocks and the data flow between system components as well as the interaction between related components. Further, we provide description of software module necessary for the system operation.

4.2 System Main Block Diagram.

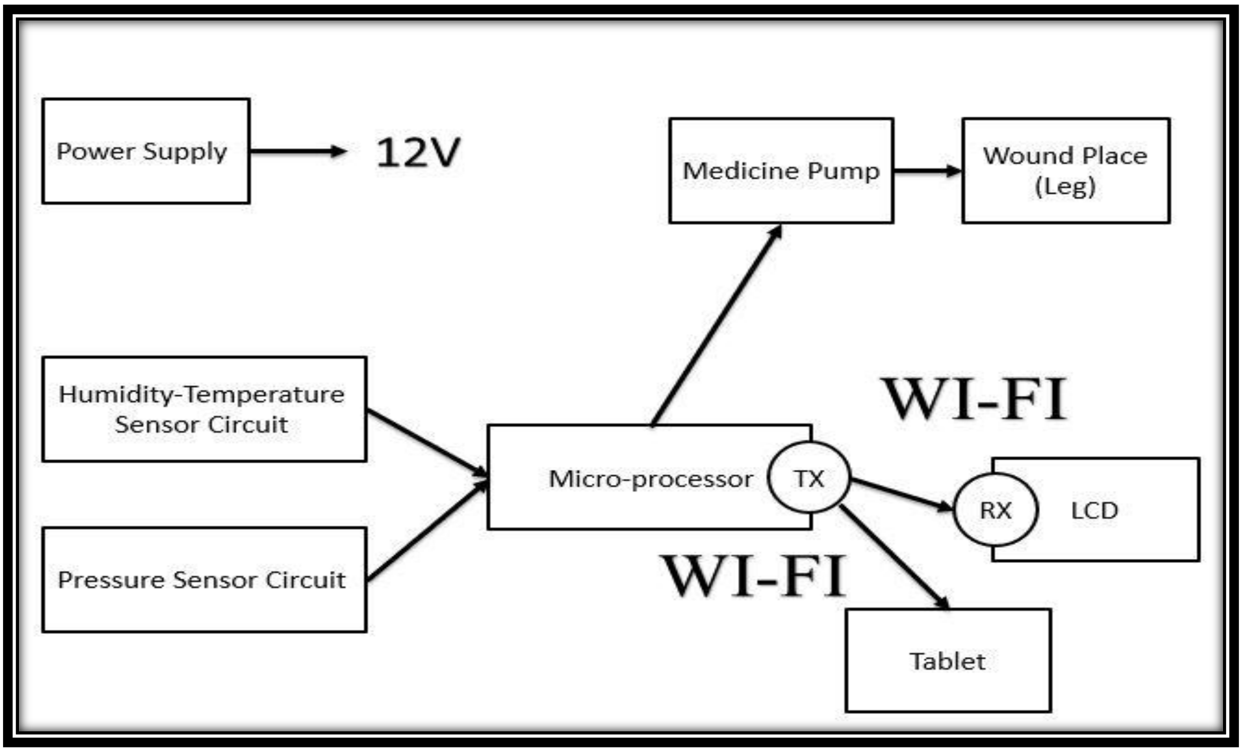


Fig 4.1 Main Block Diagram

This project is meant to measure three parameters;Humidity, Pressure and Temperature. By using 4 sensors in total 2 Humidity-Temperaturesensors, 2 pressure sensor all the sensors will reside inside the wound dressing except for one of the Humidity-Temperature sensor that will be left outside the dressing as a reference Humidity-Temperature sensor.

The sensors will measure the physical changes and convert them to a change in voltage and The micro-processor will convert it from analogue signal to digital signal and compare them with a pre-defined values and send them to both an LCD watch like and a Tablet Device with an android application that view the data on its monitor .

The system will monitor the wound and measure its humidity in order to detect a serious bleeding.In case of bleeding, the system will launch the alarm to alert the nursing stuff in order to apply the required first aid.

As a reaction system when the alarm is launched the microprocessor will trigger the medicine pump that contain a chemical substance that will be sprayed over the wound in order to stop bleeding and force the blood to coagulate.

"This reaction system is considered as emergency interruption and not as treatment"

4.3 System Sub-Blocks Diagram.

In this section the sub-blocks are described briefly:

4.3.1 Pressure Sensor Blocks.

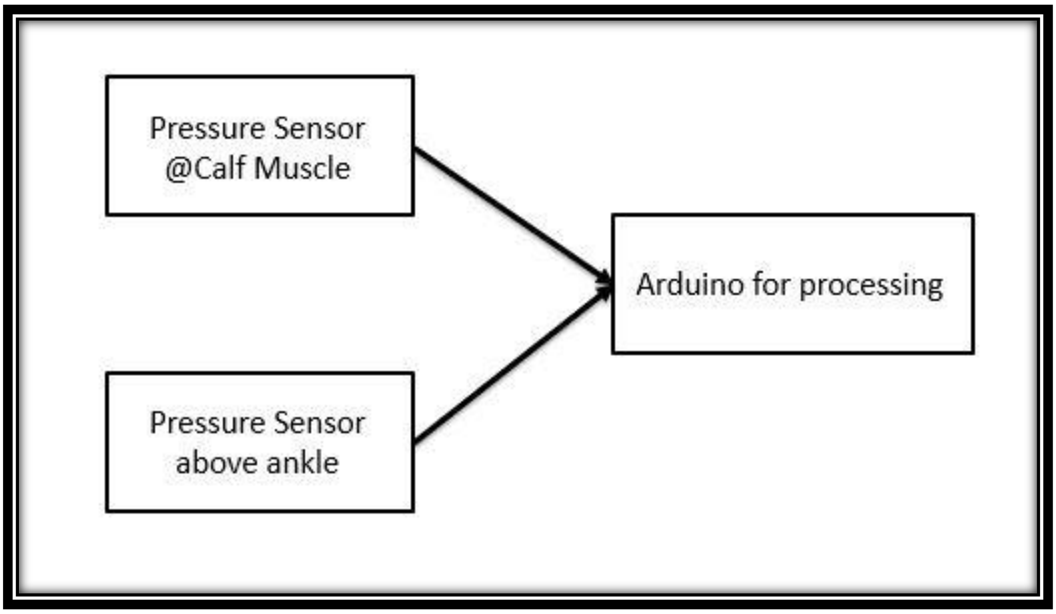


Fig 4.2 Pressure Sensor Blocks

These sensors are placed at two places:

- ➔ The first sensor will be placed at the calf muscle, the pressure sensor will be connected to vcc supply voltage to change the physical change into voltage change based on voltage divider principle
- ➔ The second sensor will be placed slightly above the ankle, it also convert the bandage pressure into a voltage by using the same principle.
- ➔ Both values will be transmitted to microprocessor to compare with pre-defined values.

4.3.2 Humidity-Temperature Sensor Blocks.

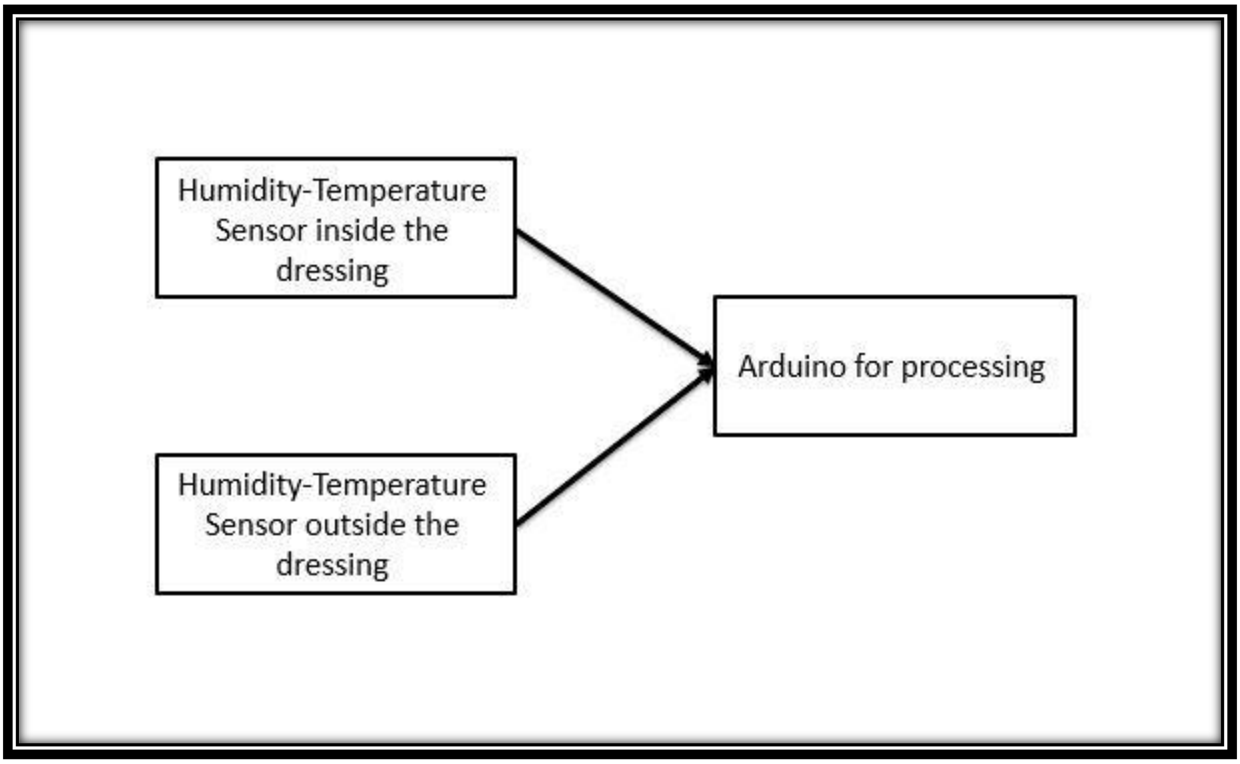


Fig 4.3 Humidity-Temperature Sensor Blocks

These sensors are placed at two different positions:

- ➔ The first sensor is placed inside the wound dressing to measure Humidity-Temperature to make sure the patient is not feeling itchy and start scratching the dressing and if there is a bleeding that lead to more pressure on the wound and might open the wound.
- ➔ The second sensor is placed outside the wound dressing as a reference Humidity-Temperature.

4.3.3 Medicine Pump Blocks.

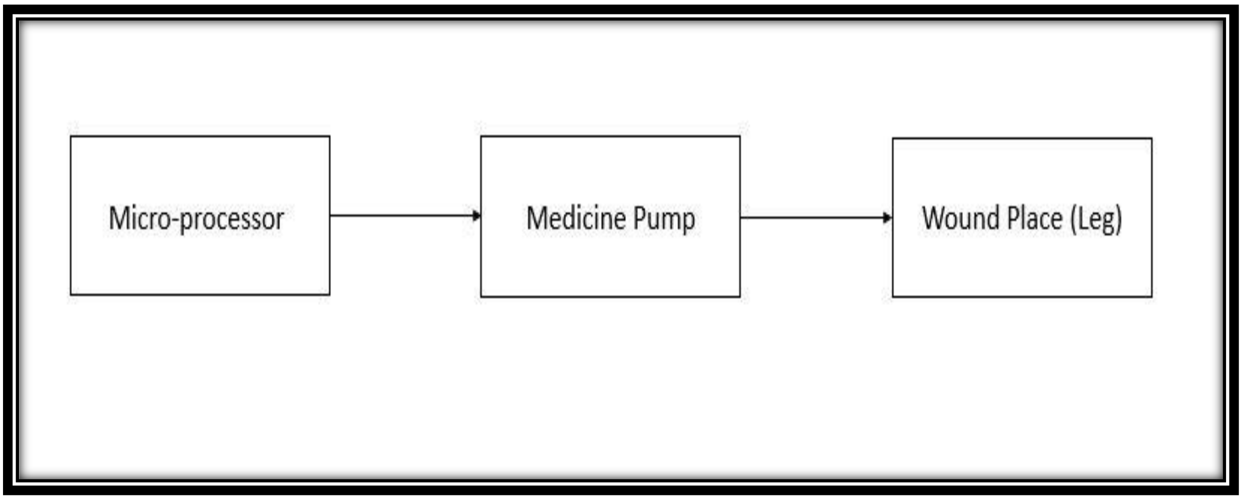


Fig 4.4 Medicine Pump Blocks

When the alarm is launched, the microprocessor will trigger the medicine pump to spray the chemical substance over the wound in order to stop bleeding.

The medicine pump is consisted of a small container to reserve the substance and a pump with tubes that connect the pump with the container and at the other side of the tube there is a spray output with a mechanical valve used to block the tube path and not to drip or spoil the content (only used when storing the device).

4.4 Interconnection

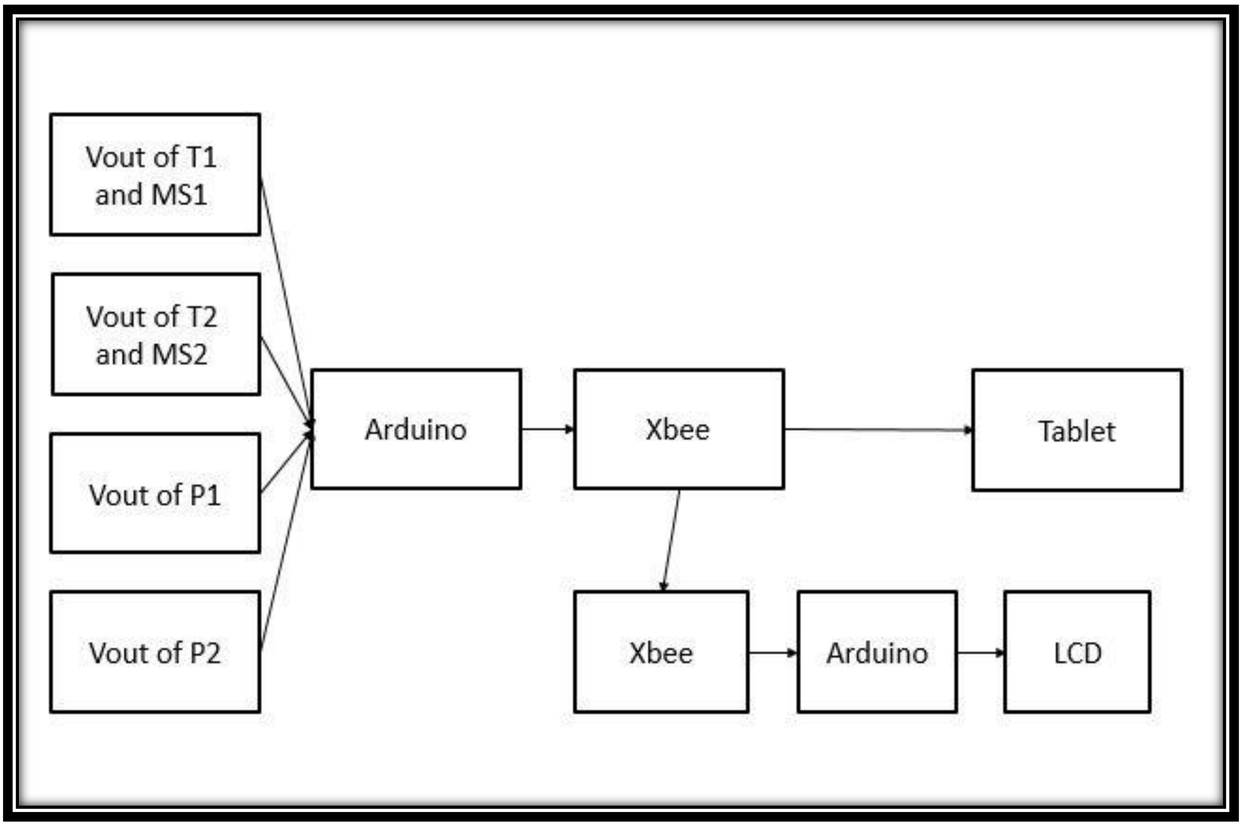
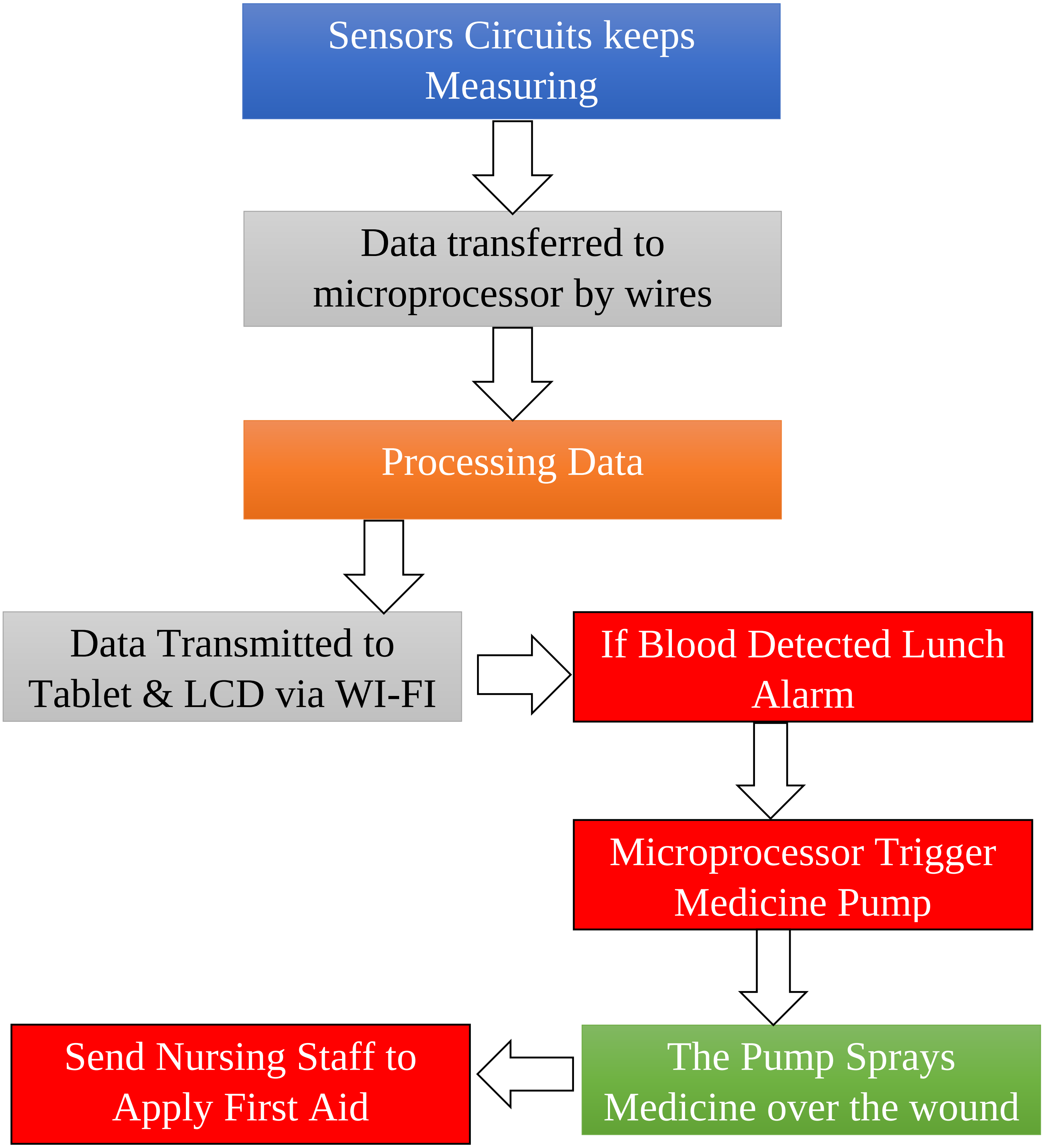
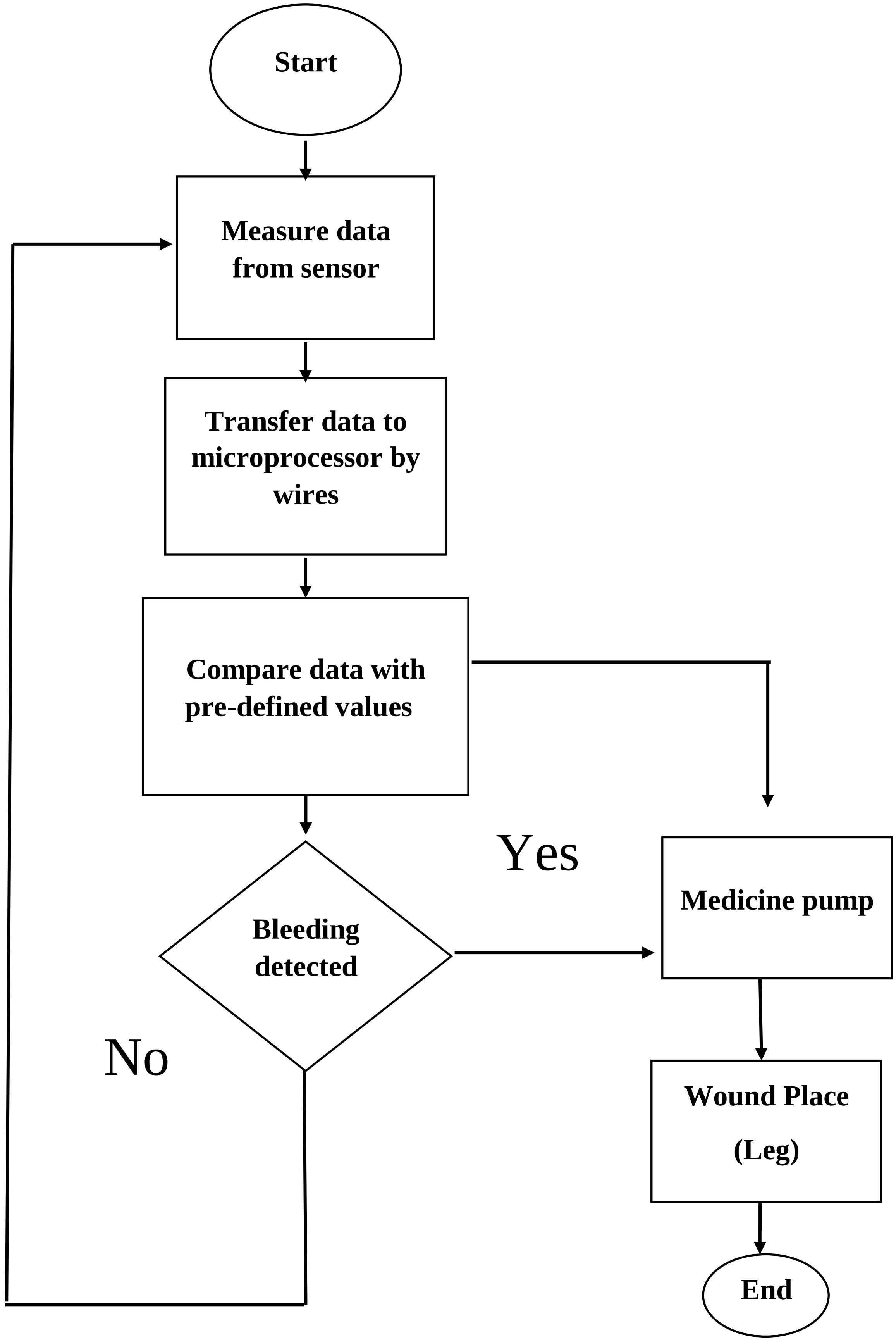


Fig 4.5 Interconnection Block Diagram

4.5 Data Flow between System Elements.



4.5.1 Flow Chart for The System



4.6 Software Module

4.6.1 Arduino Device

In this project, we selected the Arduino Uno rather than the Arduino Mega because a Software Serial o allows serial communication on any of the Uno's digital pins and it is cheaper than the Mega.

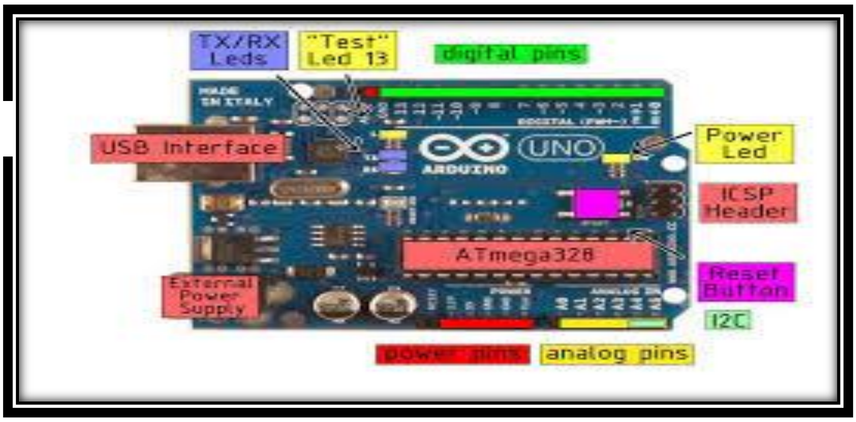


Fig 4.6 Microprocessor Arduino (UNO)

The connection between the two Arduinos (one to transmit the data from the sensing system and other to receive and display it on LCD screen) will be wirelessly via Xbee module, as shown in the figure 3.8.

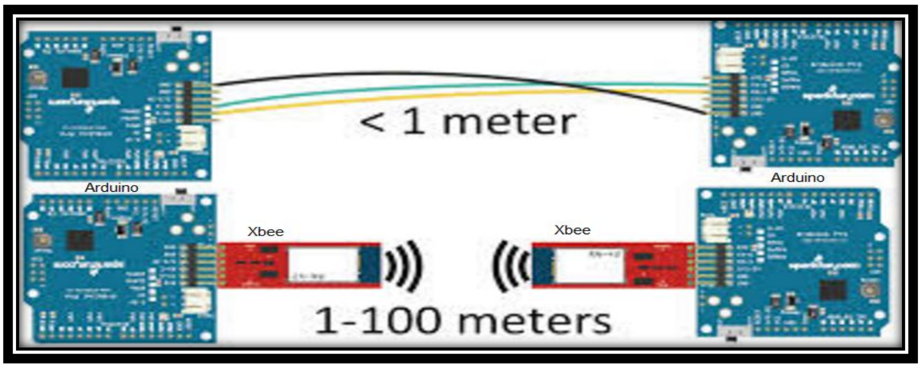


Fig 4.7 Connection between Two Arduino

The XBee Shield give us Arduino a seamless interface to XBee –. With XBee, instead of being tied down by a serial cable – away from a paired device – your Arduino can pass data over the air to another device hundreds of feet away.

XBee is controlled over a serial interface – in the most basic operation they can be used as a wireless serial cable. Setting up XBee networks and addresses is also simplified with Digi's free software –

The XBees can operate either in a transparent data mode or in a packet-based application programming interface (API) mode. In the transparent mode, data coming into the Data IN (DIN) pin is directly transmitted over-the-air to the intended receiving radios without any modification. Incoming packets can either be directly addressed to one target (point-to-point) or broadcast to multiple targets (star).

4.6.2 Tablet device

Tablets are an effective way to bring a touch-screen interface, computational power, and wireless connectivity to a range of scientific instruments.

The Device has to be fast at processing a 1GB Quad Core is preferred, an SD card slot should be available, a good visual quality.

Chapter 5

System Design

5.1 Introduction

This chapter gives a detail description of the system design and operation. We explain the logical succession of the project tasks to achieve the desired requirements. The general block diagram is divided into a sub-blocks to briefly clarify the function of each step alone. Furthermore, the needs of each stage, either hardware or software, to accomplish its function is determined. Finally, the alternative parts, according to their functions and the availability are mentioned.

The conceptual design of the system is shown in Figure 4.1. It is composed of two main parts: sensing part and processing part. The sensing part contains moisture sensor to measure the presence of blood or any other Secretions. A pressure sensor to measure the pressure of the dressing over two places above the ankle and on the calf muscle to make sure it gives the required pressure. The temperature sensor that measures the temperature inside the dressing and compares it to another temperature sensor outside the dressing.

The microprocessor function is to receive data from sensing elements and compare it with pre-defined values and do the process and send It via Wi-Fi to both the tablet and to the LCD, in case of bleeding the microprocessor will trigger a medicine pump to deliver a chemical substance that has the ability to stop bleeding the system is running by a 12v battery to supply all the sections in the system, a voltage regulator is used to ensure a steady -+ 5v is assured to be delivered.

5.2 Hardware Design

In this project, to detect the presence of blood from a wound, a Humidity-Temperature sensors needed. It has to be small to fit inside the dressing and has to be accurate in measuring values.
After a brief study, Humidity-Temperature sensor, DHT 11 was chosen because it is small size and wide range.

5.2.1 Humidity-Temperature Sensor Circuit

➔Sensor to arduino connection

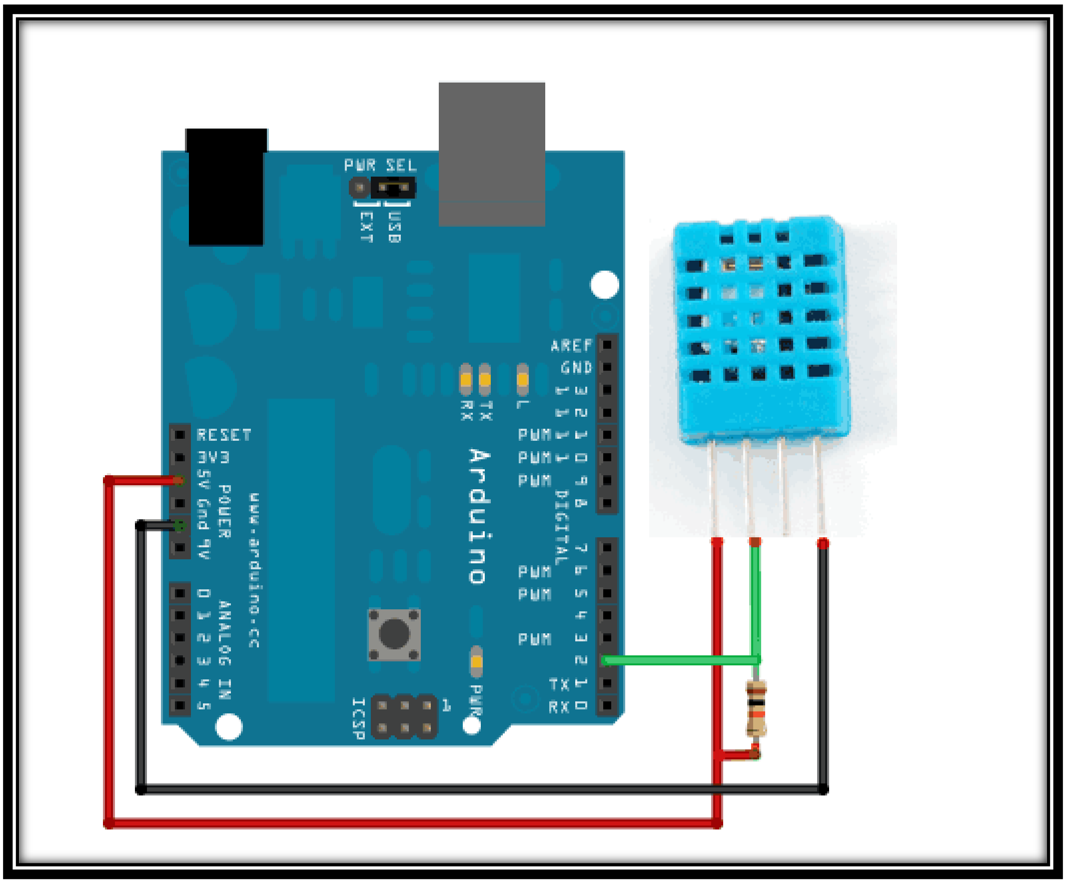


Figure 5.1 Sensor to arduino connection

Figure 5.1 shows the connection to measure the change in Humidity-Temperature, a change in Humidity and temperature will be transferred to the Micro-processor.

➔ Differential Stage

In this stage the reading that will be measure from the sensors will be subtracted … the humidity from the wet skin will be subtracted from the dry skin.

$$V_{diff} = (V\ wound - V\ dry)$$

$$V_{diff} = (V\ inside - V\ outside)$$

5.2.2 Pressure Sensor Circuit.

➔ Voltage Divider Circuit

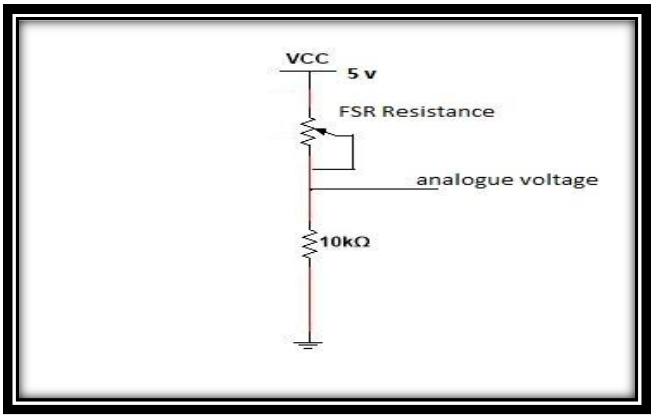


Fig 5.2 sensor in voltage divider circuit

The analogue voltage is calculated by the following relation:

$$Vout = \frac{Rm}{Rm + FSR\ Resistance} * Vcc \qquad \textbf{Eq .. 5.1}$$

Rm : the Resistance of 10k ohm that is connected to the sensor (Voltage Divider).

FSR Resistance: the Sensor's Variable Resistance

5.2.3 Medicine Pump Circuit

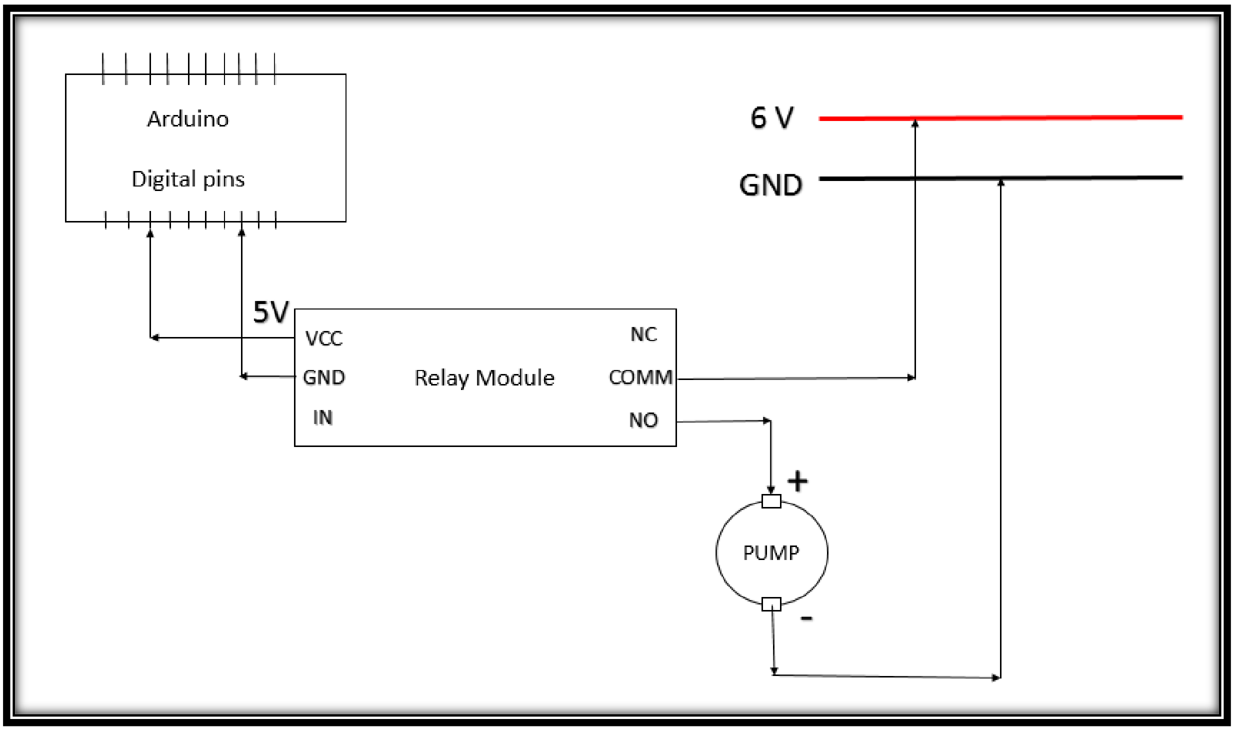


Fig 5.3 Pump connection with the Arduino

The Relay Module will work as a switch when the Arduino trigger the pump at bleeding cases the pump is connected to a 6-v battery to run it.

The pump is connected to a container with tubes that reach the wound dressing and has a spray end.

5.3 Software Design

In this section, we will discuss how to connect the sensors to the Arduino board and perform a full transmission and reception between two Xbee modules generally.

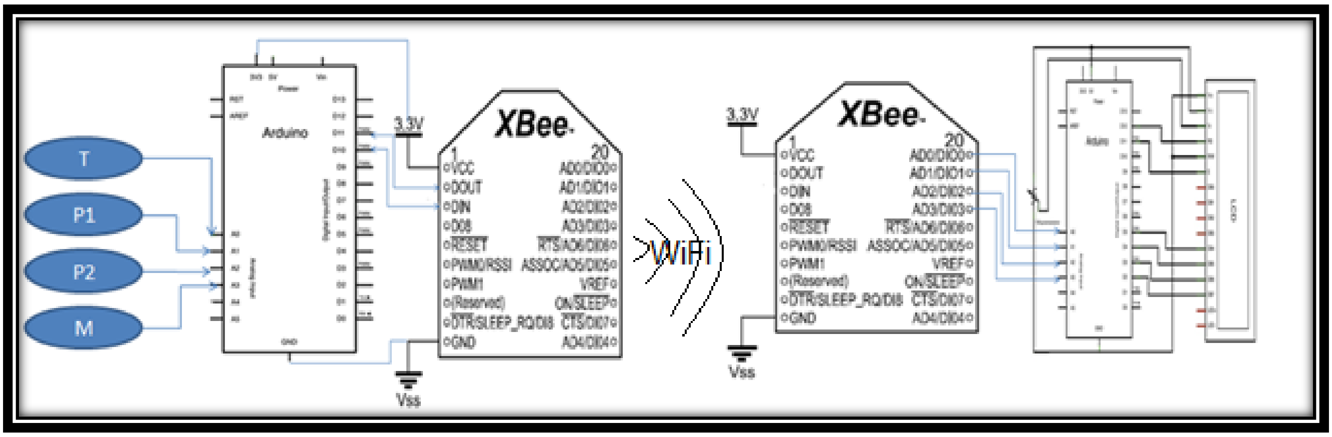


Fig 5.4 Arduino Connection to XBee

The output voltages of the sensors (temperature, pressure and moisture) will be transferred via wires to Arduino.

5.3.1 DHT11 with Arduino

DHT11 is cheaper sensor to measure Temperature and humidity. The output analog value of this sensor will be processed by Arduino program. The result will be temperature in Celsius and if there no pressure, suitable pressure or high pressure.


```
#define DHT11PIN 2

void setup()
{
  Serial.begin(9600);

}


void loop()
{

 int chk = DHT11.read(DHT11PIN);

  switch (chk)
  {

  H= Serial.read((float)DHT11.humidity, 2);

 T= Serial.read((float)DHT11.temperature, 2);



  delay(1000);
}
```

Fig 5.5 Temperature and humidity code at Arduino program.

mary_ard1

```
int fsrPin = 0;      // the FSR and 10K pulldown are connected to a0
int fsrReading;      // the analog reading from the FSR resistor divider
int fsrVoltage;      // the analog reading converted to voltage
unsigned long fsrResistance;  // The voltage converted to resistance, can be very big so make "long"
unsigned long fsrConductance;
long fsrForce;        // Finally, the resistance converted to force

void setup(void) {
  Serial.begin(9600);   // We'll send debugging information via the Serial monitor
}

void loop(void) {
  fsrReading = analogRead(fsrPin);
  fsrVoltage = map(fsrReading, 0, 1023, 0, 5000);

  fsrResistance = 5000 - fsrVoltage;     // fsrVoltage is in millivolts so 5V = 5000mV
  fsrResistance *= 10000;                // 10K resistor
  fsrResistance /= fsrVoltage;


  fsrConductance = 1000000;           // we measure in micromhos so
  fsrConductance /= fsrResistance;


  delay(10000);
  }
```

Fig 5.6 Pressure code at Arduino program.

sketch_may08a §

```
{
pinMode(A3, INPUT); // to define the pin A3 as an input.
int x = analogRead(A3); //Reads the analog value on pin A3 into x.
Serial.print("Analog value: ");
Serial.println(x); //As we change the analog value, x should also change.
}
```

Fig 5.7 Analog to digital converter in Arduino program.

The result of arduino codes will be sent wirelessly from zigbee module to another to reach the receiver arduino. At receiver arduino will be collected the readings of sensors and then show it on LCD screen and tablet.

RX_Arduino §

```
int H;
int P;
int fsrVoltage;
int fsrResistance;
int fsrConductance;
int fsrForce;
int array[6]={H,P,fsrVoltage,fsrResistance,fsrConductance,fsrForce};
void setup() {
Serial.begin(9600);
}
void loop() {
if (fsrVoltage == 0) {
    Serial.print("No P");
  } else {
    if (fsrConductance <= 1000) {
      Serial.print("OK P ");
    } else {
      Serial.print("High P");
}
  }
Serial.print("H=");
Serial.println((float)DHT11.humidity,2);
Serial.print("T=");
Serial.println((float)DHT11.temperature,2);
delay(1000);
}
```

Fig 5.8 the code of receiver arduino.

This figure describe the steps of the software programming of the ZigBee

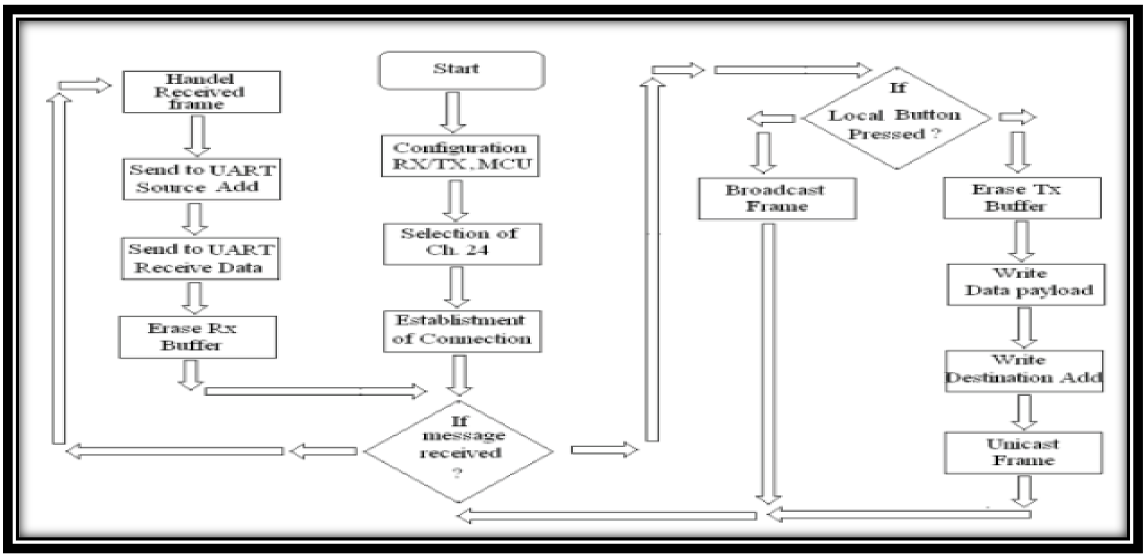


Fig 5.9 Flow chart of the Xbee program

5.3.2 XBee module

After this operation we need to connect the Arduino to Xbee module in order to transmit the data to another Xbee module over a long distance (>100m)

In this project, The X-CTU software was be used to provide a simple interface to configure and update the XBee transceivers. With this software, firmware updates are a breeze and configuration is simple.

Steps of the Software

1. Pass data from XBee another from one serial port to another**.**
2. Set up a second XBee module to also connect to wireless network. It will get a unique IP address.
3. Destination IP Address – of each to the other XBee.

Then we will configure the first XBee as a coordinator and the second as router.

5.3.3 LCD Screen

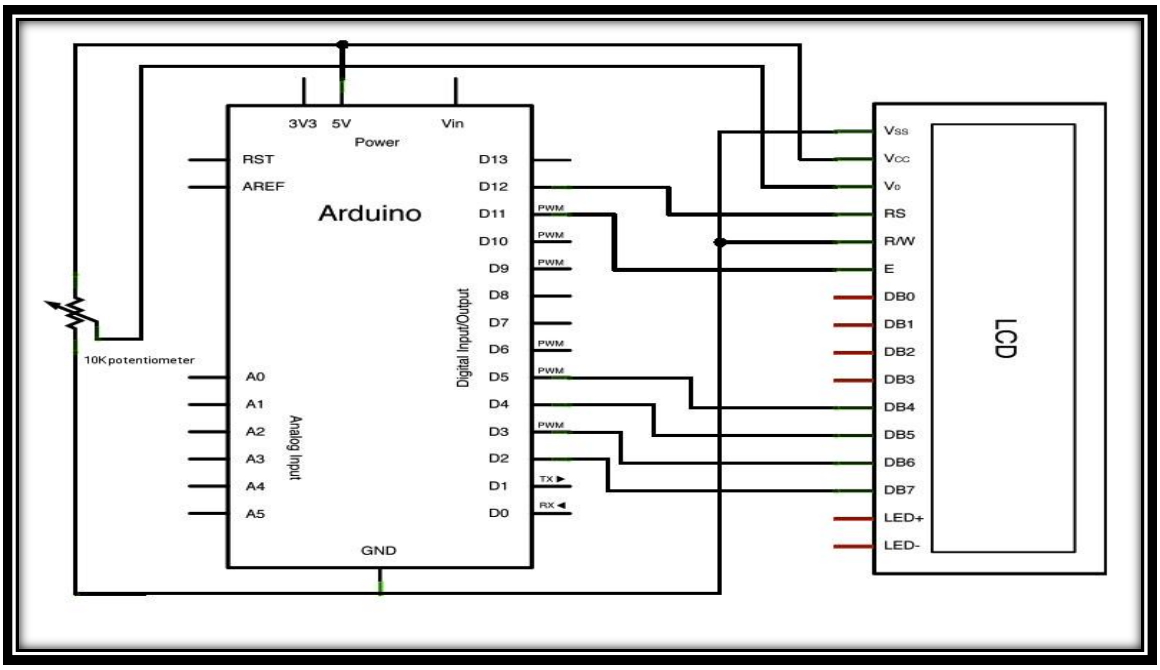


Fig 5.10 LCD display schematic

The LCD is connected to the Arduino by using wires and attached to a watch-like that can be wearied on the patient forearm the results will be shown so that the patient can be aware of his medical state. The potentiometer is used to control the contrast of a 16x2 LCD Screen.

This LCD was used to show the results of sensors reading.

Chapter 6

Results, Analysis and recommendation

6.1 Results and Analysis

6.2 Recommendation

6.1 Results and Analysis

6.1.1 Results

This chapter implies the data and the analysis of the implementation of the project and what are the things concluded from them …. As a reminding of the project

The project idea is about a device that have the ability to daily monitoring the moisture of a wound in order to afford the minimum condition for a wound to heal properly.

The data that has been measured are:
1- Wound Dressing state (tight, comfort, loose (no pressure)).

2- Temp in (inside the Dressing).

3- Temp out (outside the Dressing).

4- Humidity reading.

- ➔ A sample of 10 persons were taken as a Random sample The result were taken in a period of 1 week….The Room temperature in those days are in range of (25-31) C and the humidity was (43-46) % .

NO	Gender	Age	Temp Out	Temp in	Humidity reading
1	Male	23	28 C	29 C	45 %
2	Female	25	26 C	27 C	50 %
3	Female	20	25 C	28 C	68 %
4	Female	30	30 C	27 C	53 %
5	Male	21	28 C	26 C	60 %
6	Male	22	29 C	28 C	56 %
7	Male	26	28 C	26 C	40 %
8	Male	64	30 C	25 C	30 %
9	Female	52	30 C	28 C	44 %
10	Female	25	31 C	29 C	50 %

Table 6.1 Data at dry skin

After making some Tests over a real Patients, the Result have increased in the following manner.

NO	Gender	Age	Temp Out	Temp in	Humidity reading
1	Male	23	28 C	32 C	78 %
2	Female	25	26 C	33 C	79 %
3	Female	20	25 C	32 C	83 %
4	Female	30	30 C	33 C	76 %
5	Male	21	28 C	31 C	88 %
6	Male	22	29 C	33 C	82 %
7	Male	26	28 C	34 C	75 %
8	Male	64	30 C	33 C	77 %
9	Female	52	30 C	34 C	76 %
10	Female	25	31 C	35 C	78 %

Table 6.2 Data at wet skin

6.1.2 Analysis

The previous tables shows the data from the sensors in both the dry skin and at wet skin

From there the system is going to work and give alarm at certain cases

1- When the humidity only increases above 75 % of the Wound.
2- When the temperature only inside the wound dressing goes above 37 C.
3- When the pressure goes above a pressure of (900-1023) >> Analogue Reading.
4- The Medicine Pump will spray the Chemical Substance for 4 seconds only when the humidity goes above 75 %.

6.2 Recommendation

After analyzing the results the team recommend the following:

- ➔ Developing The System in order to provide a voice message about the reading values (Temperature & Humidity).
- ➔ Study the composition of the coagulation substance and try to find or make similar substance, since this substance is difficult to find in the Palestinian market.
- ➔ Increase the number of patients who are taking part in testing the system.

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Chapter 5: …… (Equations)……

1. INTERLINK ELECRONICS → FSR 406 Data Sheet (Appendix A).