

VARICOSE VEIN DIAGNOSIS SYSTEM AND THERAPY

Submitted in partial fulfillment of the requirements for the award of
Master of Technology degree in Medical Instrumentation

by

Haritha. K (41440005)



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

SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

Accredited with Grade “A” by NAAC

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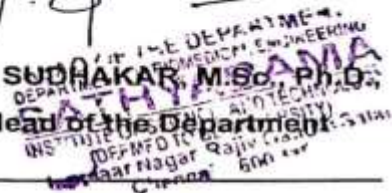
This is to certify that this Project report is the bonafide work of **Haritha. K** (Reg. No. **41440005**) who carried out the project entitled "**Varicose vein diagnosis system and therapy**" under our supervision from **November 2022 to April 2023**.

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Submitted for Viva-voce Examination held on 05-05-2023

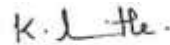
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DECLARATION

I, **Haritha. K** (Reg. No. **41440005**) hereby declare that the Project report entitled "**Varicose vein diagnosis system and therapy**" done by me under the guidance of **Dr. J. Bethanne Janney, M.E., Ph.D.**, Department of Biomedical Engineering is submitted in partial fulfillment of the requirements for the award of **Master of Technology** degree in **Medical Instrumentation**.

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ABSTRACT

Nowadays, Varicose veins are common among old age people. Varicose veins are inflamed and tangled veins on the legs. They are caused by Chronic Venous Insufficiency (CVI), which makes the valve to damage permanently. As it is a chronic disease, it cannot be cured permanently. It is also referred to as varicose veins or varicosities. They are red or bluish-purple in color. They are extremely painful. It usually happens when the veins become weak, dilated, enlarged, and filled up with blood. It is more common in women. Varicose veins appear on the surface layer. It primarily affects the veins in the legs and it is caused by strain in the lower body veins. It occurs when a defected valve in the vein permits blood to flow in the opposite direction. Mainly it occurs due to increase in intravenous pressure. It can also occur due to genetic predisposition. Risk factors of varicose vein are female gender, age more than 50, increase in abdominal pressure. It also affects the person mentally. Varicose veins are not a life-threatening disease but it should be controlled with proper care at right time. Two main symptoms that affects people with varicose vein are pain and poor blood circulation. To manage life with these symptoms, it is essential to construct a system that aids in the diagnosis and treatment of varicose veins. Two types of therapies are used in this project. They are cooling therapy and compression therapy. Peltier module and compression module are used in this project.

Keywords: *Varicose vein, Peltier module, Compression therapy*

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LIST OF ABBREVIATIONS

ABP	-	Ambulatory Blood Pressure
AC	-	Alternating Current
AREF	-	Analog Reference
BP	-	Blood Pressure
CEAP	-	Clinical, Etiological, Anatomical and Pathophysiological
CNN	-	Convolutional Neural Network
CPU	-	Central Processing Unit
CVI	-	Chronic Venous Insufficiency
DC	-	Direct Current
DVT	-	Deep Vein Thrombosis
EECP	-	Enhanced External Counter Pulsation
EEPROM	-	Electrically Erasable Programmable Read – Only Memory
EMG	-	Electromyography
GND	-	Ground
ICSP	-	In – Circuit Serial Programming
IDE	-	Integrated Development Environment
IOREF	-	Input/Output Reference
IOT	-	Internet Of Things
LCD	-	Liquid Crystal Display
MRI	-	Magnetic Resonance Imaging
NHS	-	National Health Service

NIR LED	-	Near InfraRed Light Emitting Diode
NTC	-	Negative Temperature Coefficient
PC	-	Personal Computer
PCD	-	Pneumatic Compression Device
PPG	-	Photo Plethysmography
PTC	-	Positive Temperature Coefficient
RISC	-	Reduced Instruction Set Computer
SCL	-	Serial Clock
SDA	-	Serial Data
SPI	-	Serial Peripheral Interface
SRAM	-	Static Random Access Memory
TEC	-	Thermo Electric Cooler
TTL	-	Transistor – Transistor Logic
UART	-	Universal Asynchronous Receiver – Transmitter
USB	-	Universal Serial Bus

CHAPTER – 1

INTRODUCTION

Varicose veins are dilated subcutaneous vein (Jaqueline Raetz et al.,2019). It is a chronic disease. They are open sores that lies between ankle and knee. Common treatment for Varicose vein is compression therapy. It helps to improve blood circulation. For effective compression therapy, correct amount of pressure should be applied. If low pressure is applied, it delays the recovery and if high pressure is applied, it leads to increase in pain. Amount of pressure that should be applied over varicose vein is 60mmHg. This value varies according to patient's arterial insufficiency. The pressure on the ankle should be high and it decreases steadily towards the knee. Compression therapies are usually given by using Compression stockings, bandages and pneumatic compression devices (Gustavo Coelho Rezende et al.,2022).

Main disadvantages of using bandage are - It should be given by trained medical practitioner, the pressure varies on patient's movement and loss of elasticity over a time period. Main disadvantages of using compression stockings are - It causes skin allergy and size should be prescribed by medical practitioners. Main disadvantage of using pneumatic compression devices is – it looks bulky and makes noise.

Compression bandages involves wrapping of bandage over affected area to increase the pressure on the affected area to regulate the blood supply. These are very low weight and economic friendly. Two types of compression bandages are available. Long Stretch bandages are extended up to 100% and it generates moderate pressure during resting & standing. Short Stretch bandages are less stretchable and generates less pressure during resting and generates high pressure during standing (Gustavo Coelho Rezende et al.,2022). Stockings can be applied by themselves without getting help from medical staffs. PCDs are divided into 3types namely Fixed PCD, Semi-portable PCD and portable PCD. In fixed PCD, the user cannot move around. Semi portable PCD can be carried around by user. Portable

PCD can be carried around by user freely while it is in operating mode (Gustavo Coelho Rezende et al.,2022).

According to CEAP (Clinical, Etiological, Anatomical and Pathophysiological) classification, varicose vein is classified as c2 stage. CEAP was developed by an International and HOC committee of the American Venous forum in the year 1994. Duplex ultrasound scan is used to assess varicose vein in lower limb. It is a painless procedure that examines the valve function and helps to determine the amount of blood that is flowing in opposite direction. Venogram is also used to assess varicose vein, in which a special dye is injected into the veins and are further studied using x-ray.

According to the report of National Health service (NHS) in the year 2022, 3 in 10 adults were affected by varicose vein. Varicose veins are not life threatening, but if left untreated, it develops into deep vein thrombosis (DVT). DVT (Deep Vein Thrombosis) is a condition in which the blood clot occurs in a deep vein. There are 5 stages in the progression of vein disease.

Stage 1: It is called spider veins. Dilated skin capillaries are visible under the skin.

Stage 2: It is called varicose vein. The veins are rope-like and bulged.

Stage 3: Varicose veins causes leg edema in which chronic leg swelling occurs.

Stage 4: Skin color changes. Brown stains starts to appear. The epidermis becomes thin.

Stage 5: In final stage, leg ulcers start to develop.

In order to control vein disease from getting severe, cooling therapy and compression therapy are used.

Cooling therapy helps to shrink blood vessels and prevents swelling. Existing methods like taking cold water bath, icepacks and Soaking legs in cold water may help to recover but it affects our daily life as it is time consuming.

Compression therapy helps to reduce leg swelling. Existing method is compression stocking, which helps to reduce venous pressure in leg. 20-30mmHg

compression stockings were used widely. If the compression stockings are used over a month, its elasticity starts to reduce and efficiency decreases.

In order to overcome the above problems, different method of cooling and compression therapy can be followed.

Peltier module can be used for cooling therapy, which can be worn all day without disturbance to daily life. Peltier module along with CPU fan is used in this project. If the temperature is higher than the threshold value, the cooling therapy starts automatically.

Blood pressure measuring cuff and motor is used to provide compression therapy. The cuff will be inflated and deflated according to subject's pain. It can be worn according to the need.

Laser therapy: The laser is used to treat the affected area. The heat produced by the laser causes the veins to shrink and collapse. Following laser therapy, the vein will be examined using ultrasound. The benefits of laser therapy include no cuts, no stitches, no pain, it is a minimally invasive procedure, it has a high success rate, quick recovery, and it is a day care procedure. The procedure takes 30 to 60 minutes to complete. It is used to treat smaller varicose and spider veins. A strong flash of light quickly heals, shrinks, and dissolves blood vessels. There was no need for surgery or needles.

Sclerotherapy: It is a medical procedure for destroying or removing varicose veins. A salt solution is injected directly into the vein, which begins to irritate the lining of the blood vessel, causing it to collapse and stick together, causing the blood to clot. The vessels are transformed into scar tissue, which eventually fades away. This method has been in use since the 1930s. The procedure takes approximately 15 to 30 minutes to complete. Itching, bruising, veins becoming lumpy and hard, inflammation, swollen legs, and the formation of small ulcers are all possible side effects. Small and medium-sized varicose veins were marked and closed throughout this treatment. It should be cured and gone within a few weeks. Sclerotherapy is an effective treatment

method when used correctly. This procedure does not necessitate the use of an anesthetic.

Radiofrequency ablation therapy: It is a non-invasive procedure. It employs a catheter to deliver heat to the affected vein while also cutting off blood flow to the vein. The treatment takes 45 to 60 minutes to complete. The risks of this procedure include bleeding, infection, blood clots, skin irritation, and a burning sensation.

Ambulatory Phlebectomy: It is a minor surgical procedure used to remove a cluster of varicose veins. It is used to treat both asymptomatic and symptomatic skin superficial veins. The operation takes 45 to 60 minutes to complete. To remove the affected vein, a small hook is inserted through a small incision. Minor skin punctures can be used to treat small varicose veins. After treatment, the marks are minor.

CHAPTER – 2

LITERATURE SURVEY

Panner Selvi et al., (2021) used a decision tree algorithm to create a system for predicting varicose veins. It is a diagnostic and therapeutic treatment for varicose veins. The decision tree algorithm is a machine learning concept. Wearable socks have sensors attached to them. The dataset is predefined based on sensor values. The Arduino UNO is linked to a spO2 sensor, a force sensor, and an accelerometer sensor. The spO2 sensor is used to calculate the heart rate and O2 level. Low blood circulation occurs when values remain constant, i.e., when the leg is inactive for an extended period of time. The ATmega 328p microcontroller chip is used in this application. The sensor's output is sent to the PC. The decision tree algorithm is a type of supervised learning. Peltier crystal is also linked to Arduino UNO for thermal treatment, as well as a relay, which aids in changing the temperature of normal blood flow.

Vignesh Murugesan et al., (2022) created a device that predicts varicose veins and reduces them using artificial pressure generation. It is a minimally invasive procedure. It is a varicose vein diagnostic and therapeutic procedure that uses artificial vibration production. It is both inexpensive and simple to use. The value of venous hypertension is measured here. If the value of venous hypertension is less than the normal pressure in the leg, the artificial pressure generator will be activated to compensate for the pressure in the leg. If both pressures are equal, no operation is performed. If the venous hypertension value exceeds the normal pressure, a blood pressure alert will be issued.

Wang Yixuan et al., (2021) created a varicose vein prevention method. In this article, a thin film pressure sensor is utilized to determine if a person is standing, and it enables users to customize their standing and massage time using their phone. After the predetermined period, the instrument begins to massage automatically, allowing the user to focus on their task.

Anantha Padmanabhan et al., (2000) created the Good Vibe gadget, which aids in the detection and prevention of varicose veins. The gadget continually monitors blood pressure and temperature in the afflicted region. If the blood pressure increases beyond the threshold value and the body temperature rises, it suggests poor blood flow. This data is relayed to the gadget, and it begins vibrating automatically. Vibrations can also be manually regulated. Pressure and temperature fluctuations are obtained using a pressure stimulator and NTC thermistors. The output variations are shown visually on a website. It is accomplished with the Raspberry Pi.

Shing-Hong Liu et al., (2021) used illumination rheography to identify deeper venous blockage in the lower limbs. It employs a non-intrusive approach. It is a method for assessing non-ionizing radiation. The entire system is built around a smart device with PPG detectors, a gyroscope, and a new software. A gyroscope is used to track S signals. A smartphone app controls the detectors and also directs foot movement and stores the signal.

Kumara et al., (2019) created an IOT-based stress monitoring system. Because the foot is a shock absorber and stress carrier, our work focuses on foot stress. It aids in determining the amount of foot stress delivered to the foot and takes preventative measures to keep it from developing other serious illnesses.

Liu et al., (2021) released a paper on identifying and categorizing venous congestion. It is a hybrid of the oscillometric and PPG techniques. It employs a cuff pressure control module in conjunction with an oscillometric ABP monitor. PPG is implanted in little cuffs for the toes and fingertips. It is a non-invasive method of monitoring CBP alterations.

Mahan Rahimi et al., (2017) developed compression treatment. It is a wearable object with a mechanized hooking system. It provides a variety of stimulation patterns and may be used while working. A flexible force sensor is used to measure the strain on the skin.

Tomasz Urbanek et al., (2020) created compression treatment equipment for leg oedema that may also be utilized for heart failure patients. Patients who do not have heart failure can benefit from local leg compression. Pneumatic sequential compression is a temporary solution that should be carried out under supervision.

Mervis et al., (2020) released an article on compression treatment that year. Stockings, inelastic bandages, elastic bandages, multicomponent bandage systems, garments, and pneumatic compression devices are the compression therapy methods covered in this study.

Cuglan et al., (2022) created a technique to assess the impact of EECP on venous leg symptoms. It demonstrates a decrease in edema following EECP treatment. Only a modest improvement is seen in the venous leg. It provides great outcomes for venous leg using a compression cuff.

Krishna Rani et al., (2020) used multi scalar CNN to create a method for studying numerous varicose veins in the lower limbs. It is a system for non-invasive vein detection. It is based on the CNN algorithm with MRI imaging. The flex sensor measures the angular movement of the leg. The Arduino controller is used to communicate with the PC. The level of damaged veins is determined via image processing. The flex sensor detects swell and, based on the swell, the servomotor gripper holds the leg, which is effective and simple to use. It is appropriate for all age groups.

Zhu R et al., (2019) created a technique for analyzing varicose veins in the lower limbs. Deep convolutional neural networks are used to improve the efficiency of recognizing different forms of varicose veins. When compared to previous deep neural networks, our network captures information properly and quickly. The network has a high recognition accuracy and a quick operating speed. It is appropriate for small embedded devices.

Cui H et al., (2019) created a machine to treat swollen veins. The prior process model had issues such as high error rates and low performance. A diverse

assessment approach is given by LabVIEW. A mix of hardware and software is used to perform critical factor validation, pressure detector quality analysis, windbag force verification and validation, hydraulic actuator air tightness checking, and suction side of the pump functional testing. The multi-functional testing system has the benefits of high precision, quick speed, and flexibility.

Abinaya chandramohan et al., (2021) created a system that uses EMG signals to regulate varicose veins. A comparison between the approximate pressure in the leg and the normal pressure that builds up in that location is required in this article. The technology uses EMG signals to identify the precise value if the peak pressure is lower than average to guarantee that the fake pressure generator provides enough pressure to account for all pressures. When compared to other therapy methods, this technology will be more efficient, user-friendly, and cost-effective. This device will be more user-friendly and cost-effective than before and after device operation, and it has the potential to reduce accumulation by 74%. Varicose vein sufferers can benefit from technology that is safer than the vast majority of therapeutic therapies.

James Skelly (2020) developed pressure-sensing apparel to improve CVI therapy. To monitor the pressure applied by a compression boot, the garment incorporates a tiny accelerometer sensor on four stages, including the insole, the left ankle, the lower thigh, and the upper thighs. The observed data is remotely transferred via WIFI to a mobile application designed to visualize the data and communicate with the hardware. Individuals or carers may monitor the data shown on the mobile application to ensure that the right force contour has been applied to the thigh. According to medical professionals, if this power is used effectively, the recuperation time might be reduced from six months to sixty days.

Aiyse altay (2020) created a technology for visualizing blood vessels in order to detect vascular disorders early. A gadget employing NIR LED light with an operational wavelength of 850 nm was created using optical and electrical components. For image and video analysis, data visualization frameworks such as the open - source software package OpenCV were employed. The optimum imaging conditions for the gadget were refined through testing. Diabetes, a disorder that can lead to a variety of

vascular disease concerns, was chosen to highlight anomalies in the vascular architecture and to evaluate the device's efficacy. Near infrared images of people at various stages of this illness revealed superficial vascular systems. The vessel images collected from the participants revealed that the vascular architecture of diabetes patients had degraded more than that of healthy persons, as expected. Persons' angiography pictures must be compared to photographs in order to get a clear judgement on the accuracy of the images, and the images must be examined by a vascular surgery specialist.

CHAPTER – 3

AIM AND SCOPE

The aim of the present work is to develop a system, in which the symptoms of varicose vein are managed and controlled from getting severe life-threatening disease. Main symptoms that affect people with varicose vein are pain, swelling and poor blood circulation. In order to overcome above symptoms, Peltier module and compression module are used for managing these symptoms from getting severe.

3.1 EXISTING SYSTEM

According to research, many ideas were developed to diagnose and manage varicose veins. In some paper, they have only diagnosed varicose vein without providing therapy. In some paper, they have developed system which looks bulky and makes noise. In some paper, the developed system is not portable.

3.1.1 Disadvantages

- System looks bulky and makes noise.
- Managing varicose vein with either cooling therapy or compression therapy.
- It is time consuming and it affects day-to-day life.

3.2 PROPOSED SYSTEM

The proposed system is to make a system which helps to manage the symptoms of varicose vein namely automated cooling therapy to reduce pain and to improve blood circulation in the affected part and manual compression therapy to reduce leg swelling and to reduce pain.

3.2.1 Advantages

- It integrates both cooling and compression therapy.
- It won't affect day-to-day activities.
- It is portable.
- Cooling therapy works on autonomous mode.
- Compression therapy can be used for any person without any customization.

3.3 SCOPE

This project can be used for people with varicose vein who have severe pain. It is portable, so it can be worn anywhere without any limitations. This can be worn by people of any age. This can be customized according to their wish.

CHAPTER – 4

METHODS AND PROCESS USED

4.1. BLOCK DIAGRAM

Microcontroller is the main unit which integrates both input and output. 5V power supply is given to the microcontroller. The input data are collected from sensors. The input data are displayed over LCD display. According to the customized program, the output is performed. The input sensors that are connected to microcontroller are temperature sensor, force sensor and knee moment detection sensor. Here accelerometer is used as knee moment detection sensor. Cooling therapy device and compression therapy device are connected at output.

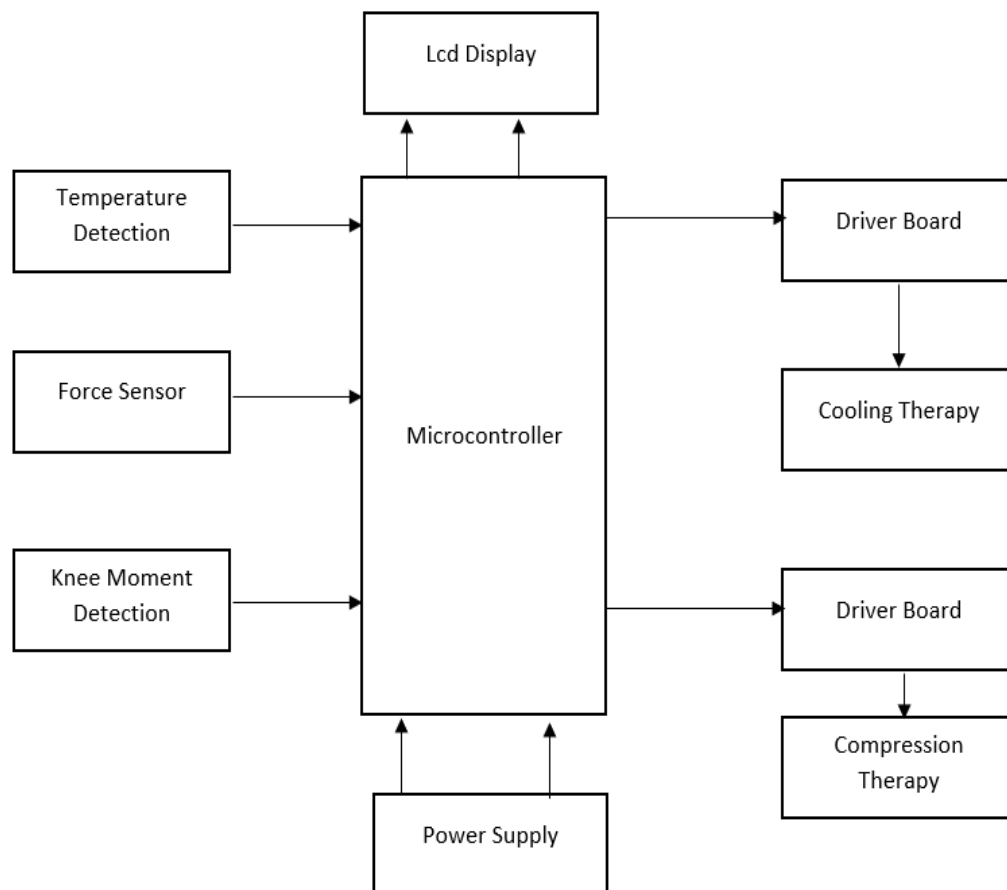


Fig. 4.1: Block diagram

4.2 CIRCUIT DIAGRAM

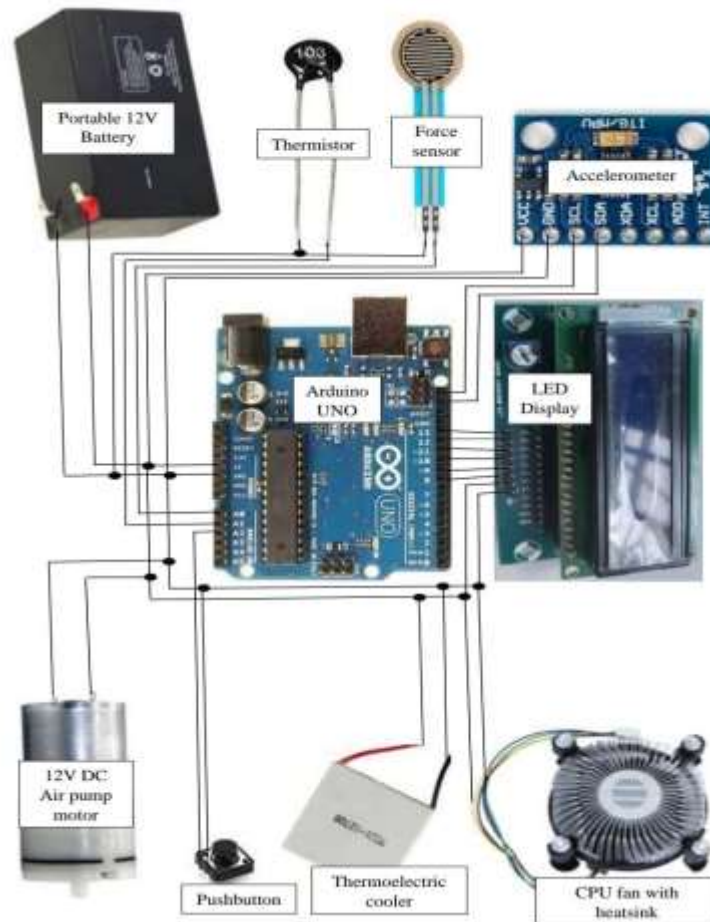


Fig. 4.2: Circuit diagram

Positive terminal of 12V Rechargeable battery is connected to 5V of Arduino UNO through capacitor and transistor to step down the current. Negative terminal of 12V Rechargeable battery is connected to GND of Arduino UNO. One end of thermistor is connected to A1 of Arduino UNO and other end of thermistor is connected to GND of Arduino UNO. One end of force sensor is connected to A0 of Arduino UNO and other end of force sensor is connected to Ground of Arduino UNO. SCL of Accelerometer is connected to I2C SCL of Arduino UNO. SDA of Accelerometer is connected to I2C SDA of Arduino UNO. VCC of Accelerometer is connected to 5V of Arduino UNO. GND of Accelerometer is connected to GND of Arduino UNO. One end of 12V DC Air pump motor is connected to 5V of Arduino UNO and other end of 12V DC Air pump motor is connected to GND of Arduino UNO.

One end of pushbutton is connected to A2 of Arduino UNO and other end is connected to GND of Arduino UNO. Positive terminal of Thermo Electric Cooler (TEC) is connected to 5V of Arduino UNO and negative terminal of Thermo Electric Cooler (TEC) is connected to GND of Arduino UNO. Positive terminal of CPU fan with heat sink is connected to 5V of Arduino UNO and negative terminal of CPU fan with heat sink is connected to GND of Arduino UNO. D7 pin of LCD Breakout board is connected to 13th pin of Arduino UNO. D6 pin of LCD Breakout board is connected to 12th pin of Arduino UNO. D5 pin of LCD Breakout board is connected to 11th pin of Arduino UNO. D4 pin of LCD Breakout board is connected to 10th pin of Arduino UNO. EN pin of LCD Breakout board is connected to 9th pin of Arduino UNO. RS pin of LCD Breakout board is connected to 8th of Arduino UNO. VCC pin of LCD Breakout board is connected to 5V of Arduino UNO. GND pin of LCD Breakout board is connected to GND of Arduino UNO.

4.3 FLOW DIAGRAM

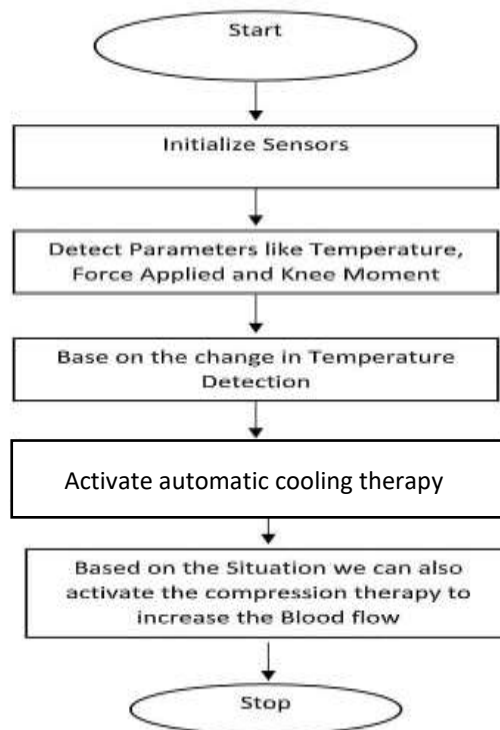


Fig. 4.3: Flow diagram

When power supply is given to sensors, the output starts to display in LCD. The accelerometer values help to identify the knee movement because people with

varicose vein should not move their legs after some extent. If the temperature in the affected area increases, the CPU fan along with thermo electric cooler is used to cool the temperature in the affected part. It works in an autonomous mode. When the person with varicose vein feels pain in the leg. They can use compression therapy which is done by using motor and BP cuff to increase blood flow. This compression therapy is used during leisure time as it works in manual mode. It can be turned ON using pushbutton and turned OFF using either pushbutton or by force sensor for easy access.

4.4 COOLING THERAPY

Cooling therapy is an essential therapy that helps people with varicose vein to reduce pain and it helps to improve poor blood circulation. This cooling therapy can be used by people with any stage of vein disease but heating therapy has limitation that it causes vasodilation, which make cases worse. Cool temperature helps to reduce the symptoms of varicose vein. It helps to shrink muscles and it helps to push the blood back into the heart. If the congested blood leaves the varicose vein, it makes the vein to shrink and it reduces the discomfort in the legs caused by the congestion of blood in varicose vein. People with varicose vein may feel burning sensation due to the damaged veins. Cool temperature helps the valve to function properly. In this project, cooling therapy is given by using CPU fan with heat sink and Thermo Electric Cooler (TEC). Thermo Electric Cooler (TEC) is used to produce cool air and CPU fan with heat sink helps to circulate cold air and the heat produced by Thermo Electric Cooler (TEC) get dissipated into the heat sink. This cooling therapy works on autonomous mode i.e., it works on sensor-based control. Using this project, we can help people with varicose vein to reduce pain and to improve poor blood circulation. It mainly helps to manage symptoms from getting severe.

4.4.1 BLOCK DIAGRAM

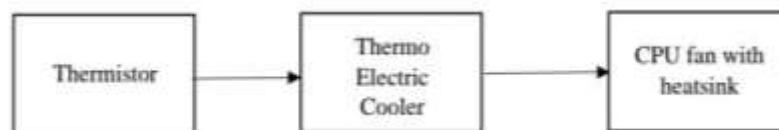


Fig. 4.4: Block diagram of cooler therapy

4.4.2 FLOW DIAGRAM

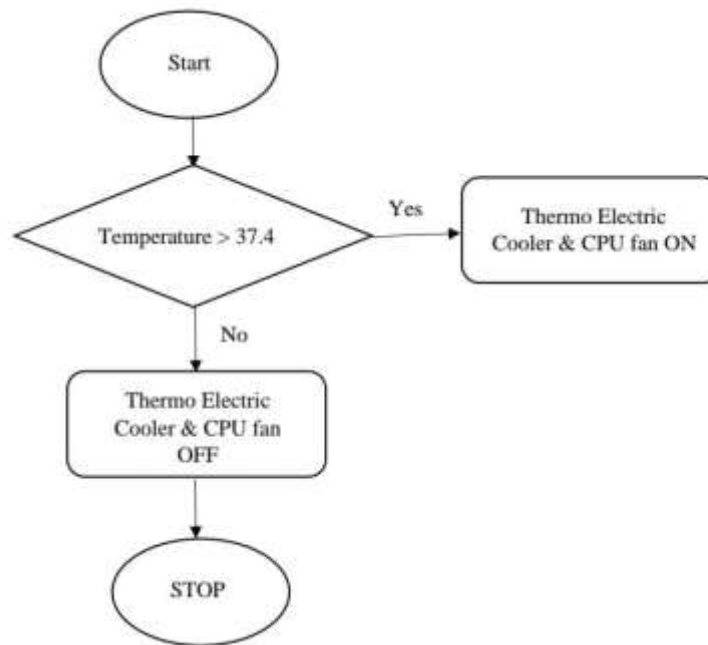


Fig. 4.5: Flow diagram of cooling therapy

Greater than value is used to compare temperature of the affected area and the pre-set value. If the temperature of the affected area is greater than the pre-set value then the thermo electric cooler and CPU fan will be turned ON otherwise it will be in OFF condition. It works on autonomous mode.

4.5 COMPRESSION THERAPY

Compression therapy is a common treatment that helps people with varicose vein to reduce pain and swelling in leg. This compression therapy can be used by people with any stage of vein disease. It helps to reduce venous pressure which decreases swelling in leg. It prevents blood clots. 20 to 30mmHg pressure is normally applied for varicose vein. For cases with severe pain, the pressure increases from 30 to 40mmHg. Due to varicose vein, the pressure starts to built-up in the veins causing them to twist. By applying compression, the built-up pressure reduces and makes the blood to flow smoothly.

In this project compression therapy is given by using 12V DC Air pump motor and BP cuff. 12V DC Air pump motor is used to absorb air from the atmosphere and the absorbed air is pushed into the BP cuff for inflation. This compression therapy

works on manual mode. The compression value changes from person to person according to the pain. So, it cannot work on autonomous mode. The cuff will be connected to the nozzle of the motor. According to the pain, the BP cuff can be inflated and deflated manually using pushbutton. It can also be turned off by applying pressure in the force sensor which is placed under foot for easy access.

4.5.1 BLOCK DIAGRAM

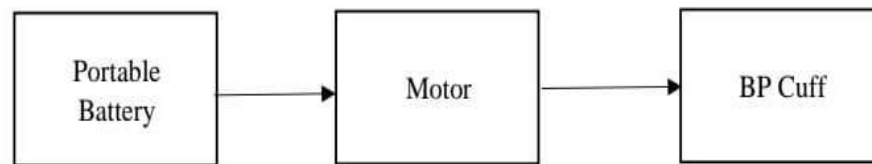


Fig. 4.6: Block diagram of compression therapy

4.6 HARDWARE REQUIREMENTS

- Arduino UNO Board
- Thermistor
- Force sensor
- Accelerometer
- Thermo Electric Cooler
- CPU fan with heatsink
- 12V DC Air pump motor
- 12V Portable Battery

4.6.1 ARDUINO UNO BOARD

The Arduino Uno board is a basically a microcontroller board based on the AT Mega 328P microcontroller. The Arduino boards are used to read inputs from sensors and turn it into an output such as turning on a light or motor. The Arduino boards were created by David cuartiellles and Massimo Banzi at the Interaction Design Institute in Ivrea, Italy in the year 2005. The Arduino software is based on the Arduino Integrated Development Environment (IDE). The IDE is used to write and upload programs to Arduino using C and C++.

This microcontroller board has 14 digital I/O pins out of which 6 can be used as PWM output, 6 analog inputs, 16MHz ceramic resonator, a USB Connection, a power jack, an ICSP header and a reset button. Communications can be done using UART, I2C and SPI. Power supply connector used in Arduino UNO board is Barrel plug. USB serial processor used in Arduino UNO is ATmega16U2 16MHz.

The AT mega 328P is an 8-bit microcontroller from Microchip. It has 32 KB flash memory, 2KB SRAM, 1 KB EEPROM, 32 registers and 10-bit analog to digital converter. It is based on the RISC architecture. It consumes low power and lost cost. Hence this type microcontroller is used in Arduino boards. Arduino boards are inexpensive when compared to microcontrollers. Arduino software can run in almost all operating system such as Windows and Linux. The Arduino software (IDE) is flexible and easy to use.

4.6.1.1 SPECIFICATIONS

- MICROCONTROLLER - ATMEGA 328P
- OPERATING VOLTAGE - 5 VOLT
- INPUT VOLTAGE - 7 to 12V
- DC CURRENT PER I/O PIN - 20mA
- DIGITAL I/O PINS - 14 (6 for PWM OUTPUT)
- EEPROM - 1KB
- CLOCK SPEED - 16 MHZ
- LENGTH - 68.6 mm
- WIDTH - 53.4 mm
- WEIGHT - 25 g

4.6.1.2 TYPES OF ARDUINO BOARD

- Arduino UNO
- Red Board
- LilyPad Arduino
- Arduino Mega
- Arduino Leonardo

4.6.1.3 ADVANTAGES

- Open source.
- User friendly.
- Cost effective.
- Portable.
- Easy to learn programming.
- simplified program language to execute.
- Low power consumption.

The Arduino Uno board can be powered either by USB or by an external power supply. The power source is assigned automatically. External (non-USB) power can be supplied either by an AC-to-DC adapter (wall-wart) or a battery. Connect the adapter by inserting a 2.1mm center - positive plug into the board's power jack. Battery leads can be inserted into the power connector's GND and Vin pin headers. The board can be powered by an external supply ranging from 6 to 20 volts. However, if less than 7V is supplied, the 5V pin may supply less than five volts, causing the board to become unstable. When more than 12V is applied, the voltage regulator may overheat and damage the board. The suggested range for Arduino UNO is 7 to 12 volts.

The power connectors are as follows:

- Vin is the voltage applied to the Arduino board when it is powered by an external source (as opposed to 5 volts from the USB connection or other regulated power sources). This pin can be used to supply voltage or to access voltage, if it is supplied via the power jack.
- 5V pin receives a controlled 5V from the board's regulator. The board can be powered by the DC power jack (7 - 12V), the USB connector (5V), or the VIN pin on the board (7-12V). Using the 5V or 3.3V pins to supply power bypasses the regulator and may cause damage to your board.
- The on-board regulator generates a 3.3Volt supply, which is 3V3. 50 mA is the maximum current draw.
- GND refers to the pins that are connected to the ground.

- IOREF, the voltage reference with which the microcontroller runs, is provided by this pin on the Arduino board. The IOREF pin voltage can be read by a correctly constructed shield, which can then select the right power supply or enable voltage translators on the outputs to function with 5V or 3.3V.

Using the `pinMode()`, `digitalRead()` and `digitalWrite()` functions in Arduino programming, the 14 digital input/output pins can be used as input or output pins. Each pin operates at 5 volts and can deliver or receive a maximum of 40 milliamperes. It also contains a 20-50kOhm internal pull-up resistor that is unplugged by default. Some of the 14 pins have specific roles, which are detailed below:

- Serial Pins 0 (Rx) and 1 (Tx): TTL serial data is received and transmitted via the Rx and Tx pins. They're linked together using the ATmega328P USB to TTL serial chip.
- External Interrupt Pins 2 and 3 can be set to cause an interrupt on a low value, a rising or falling edge or a value change.
- PWM Pins 3, 5, 6, 9 and 11: Using the `analogWrite()` method, these pins give an 8-bit PWM output.
- SPI Pins 10 (SS), 11 (MOSI), 12 (MISO) and 13 (SCK): SPI communication is carried out using these pins.
- LEDs built-in Pin 13: This pin is connected to an integrated LED; when pin 13 is HIGH, the LED is turned on; when pin 13 is LOW, the LED is turned off.



Fig. 4.7: Arduino UNO board

There are 6 analog input pins in addition to the 14 digital pins, each of which has a resolution of 10 bits or 1024 possible values. They measure from 0 to 5 volts,

but by using the AREF pin with the analog Reference() function, this limit can be raised. Wire library also uses analog pins 4 (SDA) and 5 (SCA) for TWI communication. There are few more pins on the Arduino Uno, which are listed below:

- With the analogReference() function, AREF is used to provide a reference voltage for analog inputs.
- The microcontroller is reset by setting this pin to LOW.

A computer or Arduino board or other microcontrollers can all be communicated using Arduino. UART TTL (5V) serial communication is supported by the ATmega328P microcontroller and can be accessed via digital pins 0 (Rx) and 1 (Tx). This serial communication is channelled through USB by an ATmega16U2 on the board, which appears to software on the computer as a virtual com port. There is no need for an extra driver because the ATmega16U2 firmware uses normal USB COM drivers. On Windows, however, a.inf file is necessary.

A serial monitor is included in the Arduino software, allowing simple textual data to be transferred to and from the Arduino board. Any of the Uno's digital pins can be used for serial communication using this library.

4.6.2 THERMISTOR

Thermistor is an analog component. It is an electronic component which is used to measure temperature. Two types of thermistors are there. They are Positive Temperature Coefficient (PTC) and Negative Temperature Coefficient (NTC). For NTC type thermistor, the resistance decreases when temperature increases and for PTC type thermistor, the resistance increases when temperature decreases.

4.6.2.1 SPECIFICATIONS

- MODEL NAME: NTC 103 Thermistor
- TYPE: 5mm epoxy coated disc
- OPERATING TEMPERATURE: -20°~+125°C
- MAXIMUM POWER RATING: 500mW
- RESISTANCE TOLERANCE: ±15%
- THERMAL DISSIPATION CONSTANT: 6mW/°C
- Lead spacing: 5.0mm

- Economical.
- Easily obtainable temperature sensor.
- Easy to use and adaptable.
- Good stability and durability.
- Provides high accuracy.



Fig. 4.8: Thermistor

4.6.3 FORCE SENSOR

Force sensor is an analog component. It helps to measure physical pressure. They are economical and easy to use. When force increases, its resistance decreases. It is a round sensor with a diameter of 18.28mm.

4.6.3.1 SPECIFICATIONS

- MODEL NAME: Interlink 402
- SIZE: 12.5mm
- FORCE RANGE: 0 to 20lb
- POWER SUPPLY: <1mA
- Actuation force is 0.1N.
- Sensitivity range to 10N.
- Cost effective.
- Ultra-thin with thickness of 0.45mm.
- Robust up to 10M actuations.
- Simple model.
- Easy to integrate.



Fig. 4.9: Force sensor

4.6.4 ACCELEROMETER

Accelerometer is an analog component. It is a 6-axis motion tracking device that combines 3 axis gyroscopes and 3 axis accelerometers. It consists of Digital Motion Processor. It consists of 6 16-bit analog-to-digital converters, 3 for digitizing gyroscope outputs and 3 for digitizing accelerometer output. Enhanced bias and sensitive temperature stability reduces the need for user calibration. Improved low frequency noise performance. Digitally programmable low pass filter. User programmable interrupts. MEMS structure hermetically sealed and bonded at wafer level.

4.6.4.1 SPECIFICATIONS

- VDD: 2.375V – 3.46V
- VLOGIC: 1.71V to VDD
- SERIAL INTERFACES SUPPORTED: I²C
- GYROSCOPE OPERATING CURRENT: 3.6mA
- STANDBY CURRENT: 5 μ A
- ACCELEROMETER OPERATING CURRENT: 500 μ A
- EXTERNAL CLOCK INPUT: 32.768kHz or 19.2MHz
- FSYNC pin supports image, video and GPS synchronization.



Fig. 4.10: Accelerometer

4.6.5 THERMO ELECTRIC COOLER (TEC)

A Peltier module is a device that utilizes the Peltier effect to create a temperature difference between two surfaces. The Peltier effect is a thermoelectric phenomenon that occurs when a current flows through two dissimilar materials, resulting in heat being absorbed or emitted at the junction between the two materials. In a Peltier module, two different types of semiconductors, known as p-type and n-

type materials, are sandwiched together between two metal plates. When an electric current is passed through the junctions of the two semiconductors, one junction becomes hot while the other becomes cold. This is due to the transfer of heat from one side of the module to the other, creating a temperature difference. The direction of the heat transfer depends on the direction of the electric current, and the amount of heat transfer is directly proportional to the magnitude of the current. This means that by controlling the amount and direction of the current, the temperature difference between the two sides of the module can be adjusted. In a cooling application, the cold side of the Peltier module is placed in contact with the object to be cooled, while the hot side is exposed to the surrounding environment. Heat is absorbed from the object and transferred to the hot side of the module, where it is dissipated into the air or another cooling medium. Overall, the Peltier module provides a solid-state, compact, and efficient cooling solution that can be used in a variety of applications, including refrigeration, electronics cooling, and temperature control in scientific experiments.

4.6.5.1 SPECIFICATIONS

- HOT SIDE TEMPERATURE: 25 - 50°C
- Qmax: 50 - 57Watts
- DELTA Tmax: 66 - 75°C
- I_{max}: 6.4Amps
- V_{max}: 14.4 – 16.4V
- MODULE RESISTANCE: 1.98 – 2.30Ω
- MAXIMUM OPERATING TEMPERATURE: 138°C
- LIFE EXPECTANCY: 2,00,000 Hours
- FAILURE RATE: 0.2%



Fig. 4.11: Thermo Electric Cooler

4.6.6 CPU FAN WITH HEATSINK

It is used to reduce temperature by providing cooling air.

4.6.6.1 SPECIFICATIONS

- Easy to install.
- Large air volume.
- 30mm Aluminium air-cooling fin.
- 7 blades fan.
- SIZE: 10.2 * 10.2 * 7 centimetres
- BRAND: Intel
- POWER CONNECTOR TYPE: 4-Pin
- VOLTAGE: 12 Volts
- COOLING METHOD: Air
- WEIGHT: 250Grams
- FAN DIMENSIONS: 80mm



Fig. 4.12: CPU fan with heat sink

4.6.7 12V DC Air pump motor

12V DC Air pump motor is used to absorb air from atmosphere. It is based on 370 micro-DC motor. It is durable and long lasting.

4.6.7.1 SPECIFICATIONS

- RATED VOLTAGE: DC 12V
- LOAD: Air
- CURRENT (WITH LOAD): <250mA
- LENGTH: 68mm
- DIAMETER: 24mm
- FLOW: 3.0LPM
- SIZE: D27*65mm
- WEIGHT: 65.00 Gram
- MAXIMUM PRESSURE: >600mmHg
- NOISE: <60dB



Fig. 4.13: 12V DC Air pump motor

4.6.8 12V PORTABLE BATTERY

It is used to provide power supply to electronic components.

4.6.8.1 SPECIFICATIONS

- BRAND: SANCA
- MODEL: RB1231
- VOLTAGE: 12V
- BATTERY TYPE: Sealed Lead Acid Rechargeable Battery
- BATTERY CAPACITY: 1.3Ah
- DIMENSION: 97*43*52mm
- MAXIMUM CHARGING CURRENT: 0.39A



Fig. 4.14: 12V portable battery

4.6 SOFTWARE REQUIREMENTS

4.6.1 ARDUINO IDE

Arduino IDE is an open-source software that helps to write and upload the code to Arduino board.

4.6.1.1 TO DOWNLOAD SOFTWARE

Step 1: Open Internet Explorer and search for Arduino IDE.

Step 2: Click the link that appears on the top of the search page. (www.arduino.cc)

Step 3: Click Software on that website.

Step 4: Select Arduino IDE 2.0.4 tab and choose the download options according to the system model.

Step 5: Click Just Download and it starts to download in background.

Step 6: Open the downloaded file location.

Step 7: Click the file and it starts to download.

Step 8: Give required permission and choose the storage path and install it.

4.6.1.2 TO CREATE AND RUN PROGRAM

Step 1: Open Arduino IDE.

Step 2: Open file and click New Sketch.

Step 3: Open the Tools from the Menu bar and select Port as Arduino UNO.

Step 4: Enter the code in the working space and save it.

Step 5: Verify and Compile the code.

Step 6: Select Serial plotter from Menu bar to view the Graphical representation and select Serial Monitor in Tools from Menu bar to view the values obtained as output.

CHAPTER – 5

RESULTS AND DISCUSSION

Existing therapies for varicose vein are interfering with day-to-day life. This drawback helped me to design a portable system to give cooling therapy and compression therapy that can be worn during leisure time. This cooling therapy and compression therapy are more important for people with varicose vein that causes pain, swelling in leg and poor blood circulation.

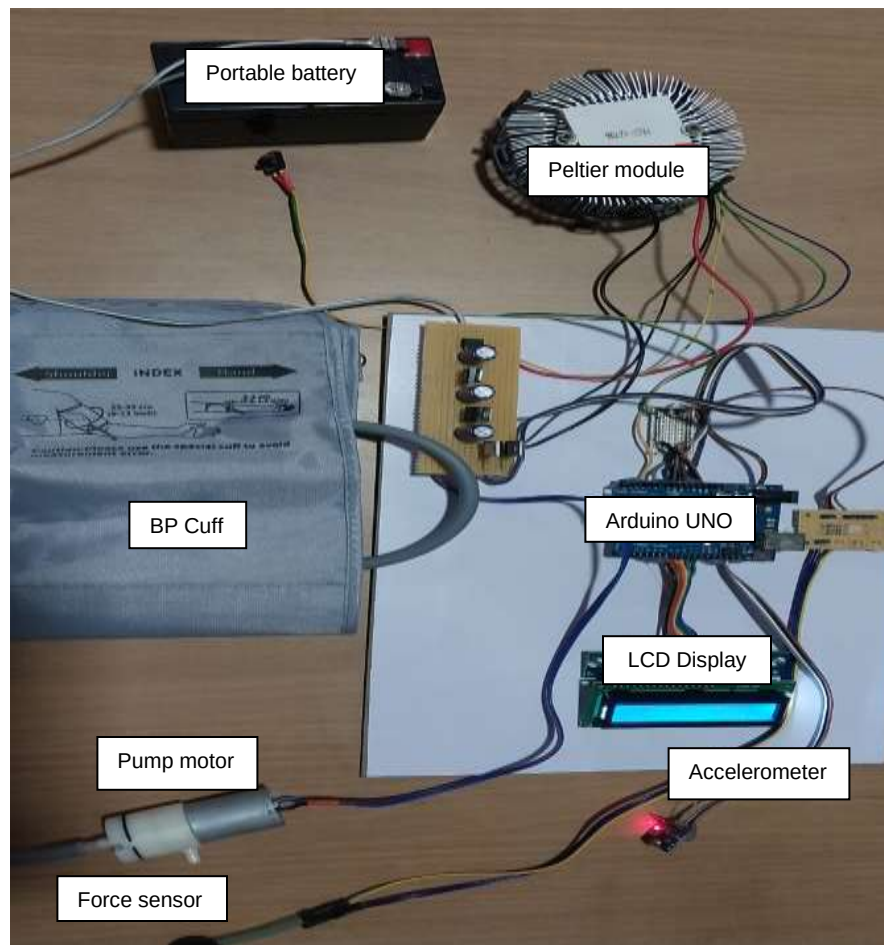


Fig. 5.1: Hardware setup

Fig. 5.1 displays the hardware setup. Arduino UNO, LCD display with breakout board, accelerometer, thermistor, force sensor, thermo electric cooler, CPU fan with heat sink, portable battery, 12V DC Air pump motor and BP cuff are used. Arduino UNO is used to process output for every input according to the customized program. LCD display with breakout board is used to display values of temperature, force and

tilting axes X and Y. Accelerometer is used to find the angle of knee movement. Thermistor is used to measure the temperature of varicose vein affected part. Force sensor is used to measure the amount of force applied on the knee and it helps to stop the compression therapy. Thermo electric cooler is used to produce cool air. CPU fan with heat sink is used to circulate cool air to the affected part and heat air gets dissipated by using heat sink. Portable battery is used to provide power supply. 12V DC Air pump motor is used to absorb air from surroundings and it helps to inflate BP cuff. BP cuff is used for compression therapy.



Fig. 5.2: Starting of LCD display

In Fig. 5.2, the LCD starts to display the name of the device for 2 seconds.

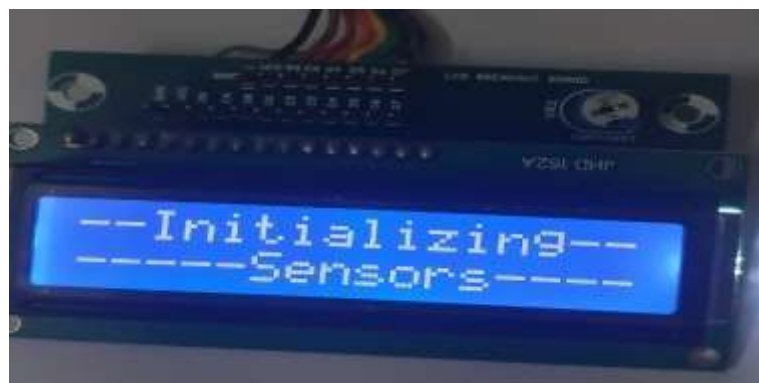


Fig. 5.3: Initializing sensors

Fig. 5.3 shows initialization of sensor after power supply is given.

Fig. 5.4 displays the initialized values in the LCD. It consists of values of temperature, force and tilting axes X and Y.



Fig. 5.4: Initial values

Fig. 5.5 shows the accelerometer is tilted, the X and Y values are changed from -99 to -63 and 0 to -26.



Fig. 5.5: Tilting axes are changed

Fig. 5.6 displays the BP cuff is in deflated state.

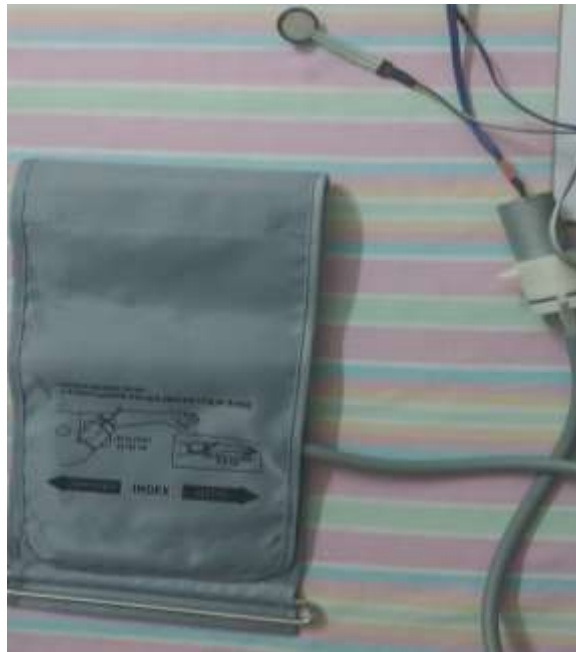


Fig. 5.6: Deflated cuff

In the Fig. 5.7 image, when the pushbutton is clicked, the motor starts and the BP cuff starts to inflate. When the person feels pressure in the leg due to compression, it can be turned OFF by using push button or if the person do not have easy access to pushbutton, then the person can apply pressure on the foot to turn OFF motor. The force sensor is placed under the foot. It can be worn only during leisure time. It works in manual mode.



Fig 5.7: Force sensor is pressed to stop inflation

In Fig. 5.8, when the temperature increases in the affected area, the CPU fan along with Thermo electric cooler is turned ON automatically after it reaches the threshold value of 37.4°C and above and it turns OFF when the temperature value reaches below 37.4°C. It can be worn during any time as it won't disturb the day-to-day life. It works in autonomous mode. The temperature displayed in LCD is 39.1°C so CPU fan turned ON automatically.

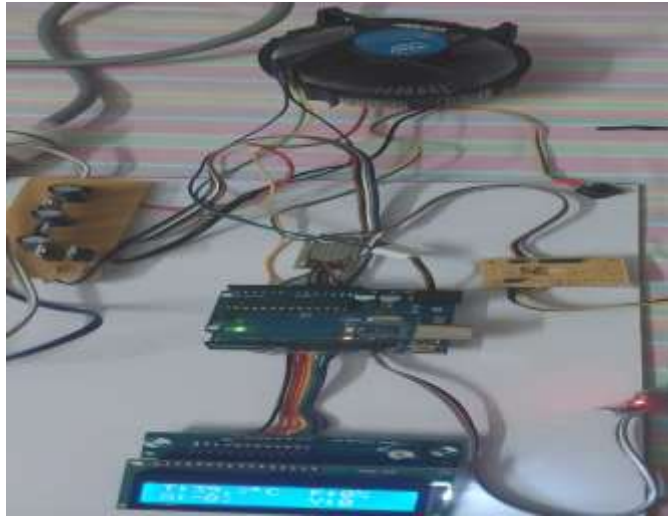


Fig. 5.8: Fan turns ON when temperature increases

Fig. 5.9 displays the temperature is reduced to 35.6°C. So, The CPU fan turned OFF automatically.

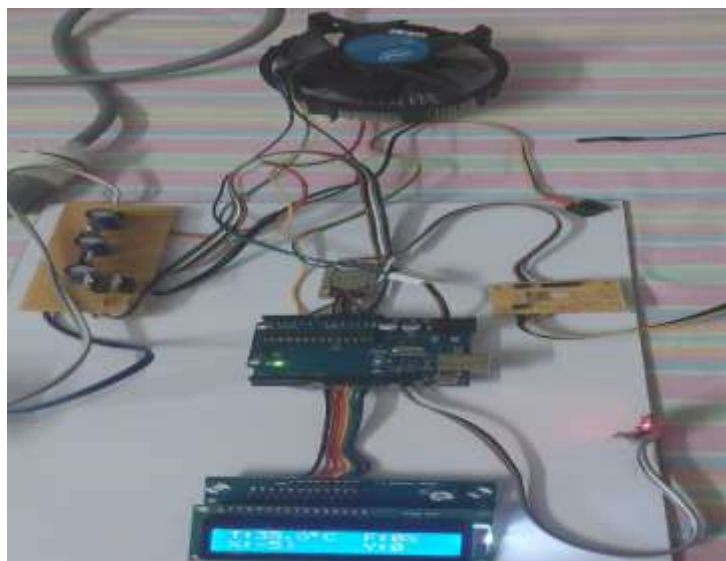


Fig. 5.9: Fan turns OFF when temperature decreases

In Fig. 5.10, the X and Y values of accelerometer is show in serial monitor of Arduino IDE because we cannot able to monitor the knee movement axes over the LCD display as it is attached to the leg. For the easy access, the X and Y values of knee movement can be viewed through PC for continuous monitoring.

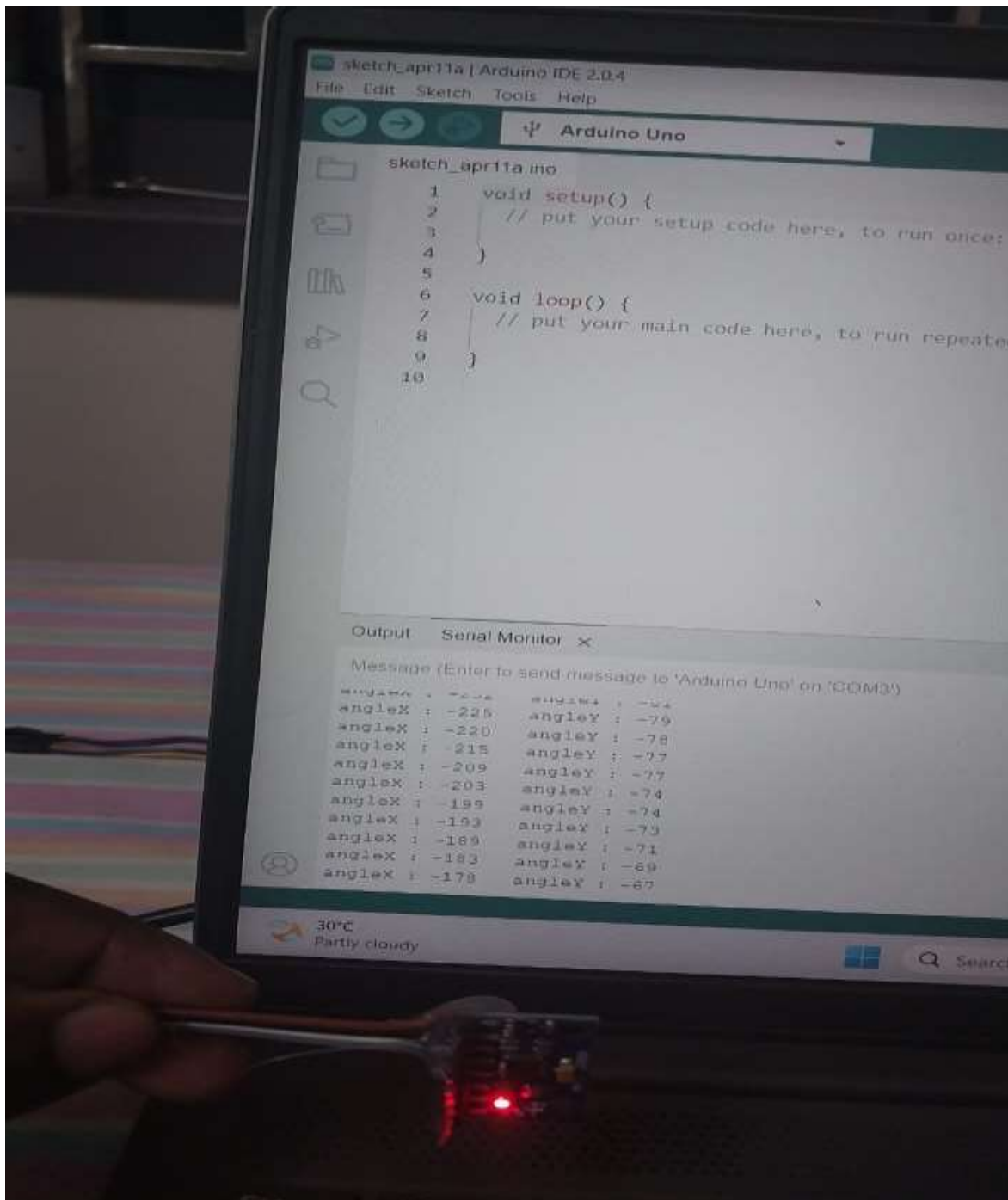


Fig. 5.10: X and Y values are shown in serial monitor of Arduino IDE

Fig. 5.11 displays same tilting values of X and Y axes on both LCD display and Serial monitor.

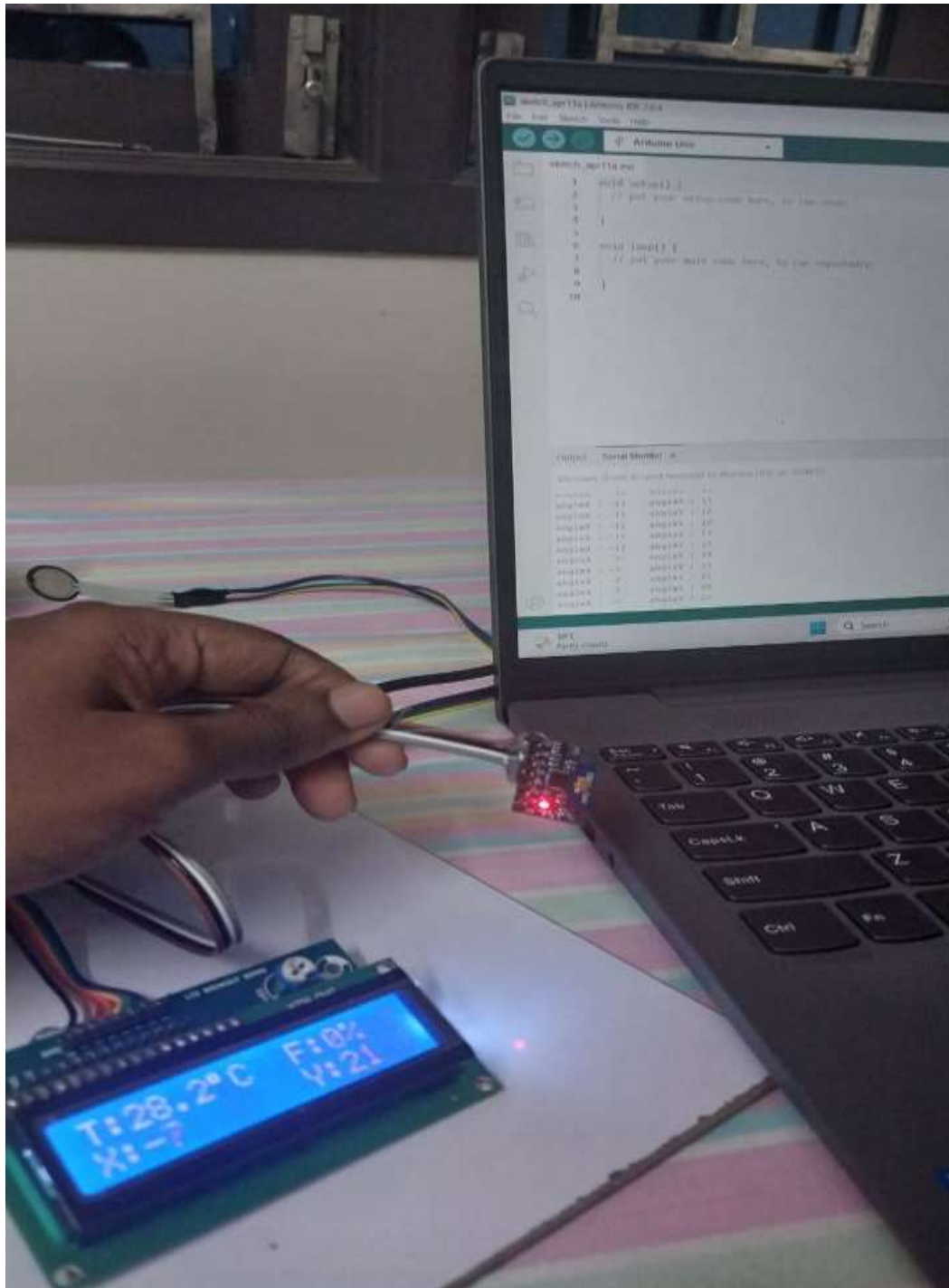


Fig. 5.11: X and Y values can be seen in both PC and LCD display

CHAPTER – 6

CONCLUSION AND FUTURE SCOPE

With the help of Varicose vein therapy, people with varicose vein can do their day-to-day activities without any disturbance. Now a days, 8 in 10 people were affected by this vein disease. If the varicose vein is identified at earlier stage, it can be managed and controlled using these therapies. If it left untreated, it leads to serious life-threatening disease like leg ulcers. Many people feared of getting therapies because the existing therapies consumes more time and it disturbs their day-to-day activities. If they are working professionals, they cannot spend more time for therapy. To overcome this problem, these therapies can be used. Cooling therapy is portable and can be worn everywhere. As it works under autonomous mode, it turns ON and OFF automatically without disturbing their work. Compression therapy is a very small device so it can be kept handy and it can be used during leisure time as it works under manual mode. In future, image processing can be done along with this therapy to know the flow of blood and status of varicose vein which will be very helpful for people with varicose vein as they know the status of the vein disease and they act accordingly.

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