FABRICATION AND TESTING OF A PORTABLE BREATHING EQUIPMENT FOR LOW PRESSURE CONDITIONS

A Project report submitted in partial fulfilment of the requirements for the award of the degree of

Bachelor of Technology
in
Mechanical Engineering

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APRIL 2023

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CERTIFICATE

This is to certify that the Project Report entitled **"FABRICATION AND TESTING OF A PORTABLE BREATHING EQUIPMENT FOR LOW PRESSURE CONDITIONS"** being submitted by **I. Vandana (320126520L13), CH. Anand (319126520071), P. Naveen Jani (319126520104), B. Surendra Varma (319126520067), K. Manoj (319126520090)** to the Department of Mechanical Engineering, ANITS is a record of the bonafide work carried out by them under the guidance of **M. PREM DHEERAJ.** The results embodied in the report have not been submitted to any other University or Institute for the award of any degree or diploma.

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ACKNOWLEDGEMENTS

We express immensely our deep sense of gratitude to **M. PREM DHEERAJ**, Assistant professor Department of Mechanical Engineering. Anil Neerukonda Institute of Technology and Sciences, Sangivalasa, Bheemunipatnam, Visakhapatnam District for his valuable guidance and encouragement at every stage of work made for the successful completion of the project.

We were very thankful to **Dr. K. Sri Rama Krishna**, Principal, ANITS and also to **Prof. B. Nagaraju**, Head of the Department, Mechanical Department. Anil Neerukonda Institute of Technology and Sciences, for their valuable support and facilities.

We express our sincere thanks to the members of non-teaching staff of mechanical engineering for their kind cooperation and support to carry on work.

Last but not the least, we like to convey our thanks to all who have contributed either directly or indirectly for the completion of this project work.

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ABSTRACT

Atmospheric pressure is an essential component of our environment and plays a critical role in the functioning of the human body. When the pressure drops below a certain threshold, it can have adverse effects on our health, particularly in our ability to breathe comfortably. In low-pressure environments, such as high altitudes or during thunderstorms and heavy rainfall, the difference in pressure between the surroundings and the lungs can make it difficult for the lungs to take in oxygen and release carbon dioxide through the process of diffusion. This can lead to a range of symptoms, including shortness of breath, dizziness, headache, nausea, and fatigue.

While there are some medications available to alleviate these symptoms, there is no cure for the underlying problem of pressure differences. However, individuals can take steps to reduce the impact of pressure changes, such as acclimating themselves to high altitudes gradually over several days or weeks.

In addition, specialized suits and equipment are available for use in extreme conditions, such as spacesuits and diving suits, that help regulate pressure and provide oxygen. These suits are typically only available to trained professionals and are not widely available for everyday use.

Overall, while the problem of pressure differences can be challenging to address, there are ways to mitigate its effects and ensure that people can breathe comfortably in a variety of conditions. By taking the necessary precautions and utilizing specialized equipment, individuals can protect themselves from the adverse effects of low-pressure environments.

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CHAPTER 1

INTRODUCTION

Individuals who travel to high-altitude zones often face numerous challenges, including difficulty breathing and exposure to extreme weather conditions. These challenges can lead to a range of health complications, including altitude sickness and hypoxia. Without proper monitoring and medical attention, these conditions can worsen, leading to potentially life-threatening situations.

To address these challenges, researchers and designers have been working to develop specialized suits that can help individuals navigate high-altitude environments safely. These suits are designed to provide a range of features, including grip soles for better traction on uneven terrain, various sensors for monitoring vital signs, and fabrics with different thermal properties to help regulate body temperature in extreme conditions.

One critical feature of these suits is the use of air compressors, which can help regulate air pressure and ensure that individuals can breathe comfortably in low-pressure environments. This feature can be particularly important for individuals who are not acclimated to high-altitude conditions, as it can help them avoid symptoms of altitude sickness, such as shortness of breath, nausea, and fatigue.

Overall, these suits have the potential to benefit a wide range of individuals, including researchers, soldiers, botanists, and others who need to operate in high-altitude environments. By providing a range of safety features and specialized equipment, these suits can help individuals navigate challenging conditions and ensure that they can operate safely and efficiently in even the most extreme environments. With continued research and development, these suits may become an essential tool for individuals operating in high-altitude zones, providing them with the support and protection they need to succeed.

1.1 OVERVIEW

Traveling in high altitude regions can present a range of challenges for individuals, including difficulty breathing normally, which can lead to health complications. Without proper monitoring and treatment, these complications can worsen, leading to potentially serious health issues.

One common problem associated with high altitude environments is orthostatic hypotension, which occurs when there is a sudden drop in blood pressure while standing, sitting, or lying down. This condition can lead to dehydration, prolonged bed rest, and even heart attacks in some cases. It is essential to monitor blood pressure levels and provide appropriate medical treatment to prevent these complications from occurring.

Another issue that can arise in high altitude environments is chronic obstructive pulmonary disease (COPD). This condition affects the alveoli in the lungs, which are responsible for the diffusion of oxygen and carbon dioxide in the bloodstream. When the pressure is low, the lungs may struggle to perform this diffusion process, leading to a range of respiratory problems. Proper medical treatment and monitoring are essential to manage these symptoms and prevent them from worsening.

To address these challenges, researchers and medical professionals are exploring a range of solutions, including specialized equipment and medication. For example, oxygen supplementation can help individuals breathe more easily in low-pressure environments, while medications such as acetazolamide can help alleviate symptoms of altitude sickness.

By providing appropriate medical treatment and support, individuals can better manage the challenges of traveling in high altitude regions and ensure their health and safety. If you start experiencing these symptoms, immediately for medical attention: Shortness of breath, even when resting.

These symptoms include dizziness:

- Fatigue and energy deficiency,
- Breathing difficulties,
- Appetite suppression.

1.2 COMPRESSORS

A compressor plays a critical role in numerous industrial processes by compressing a gas, usually air, to increase its pressure for use in various applications. Air compressors are a specific type of gas compressor that are commonly used in industries such as manufacturing, construction, and automotive. They are used to power tools, pneumatic systems, and spray guns, among other things.

Compressors work by reducing the volume of a gas while increasing its pressure. The gas is drawn into the compressor and then compressed by reducing its volume. This increased pressure then causes the gas to move through the system, powering machinery or other devices.

There are different types of compressors available for use, including reciprocating, rotary, and centrifugal compressors. Reciprocating compressors use pistons to compress the gas, while rotary compressors use rotating blades or screws. Centrifugal compressors use an impeller to increase the velocity of the gas, which is then slowed down and compressed by diffusers.

In addition to their use in industrial applications, compressors are also commonly used in household appliances such as refrigerators, air conditioners, and dehumidifiers. They are used to compress refrigerant gases, which then cool or dehumidify the air.

One important consideration when using a compressor is its energy efficiency. The more efficient the compressor, the less energy it will consume to compress the gas. This can result in significant cost savings over time. Regular maintenance and proper use can also help extend the life of a compressor and ensure it operates at peak efficiency.

Overall, compressors are a crucial component in many industries and applications. Understanding their functions and capabilities is important for anyone working with these devices.

- Compressors are devices that increase the pressure of fluids by reducing their volume.
- Compression means reducing the volume of fluids.
- The compressed fluid can be used for various applications or further processes.
- Compressors make use of the fact that gases are compressible.
- There are many types of compressors available today.
- The different types of compressors have their unique features and advantages.
- Compressors are widely used in industries such as manufacturing, oil and gas, and refrigeration.
- Compressors play a critical role in maintaining safe and efficient operations in

various processes.

- The performance of compressors can be optimized through regular maintenance and proper use.
- Proper selection and sizing of compressors are crucial for ensuring optimal performance and efficiency.

Figure 1.1 - Compressor

1.3 TYPES OF COMPRESSORS

1.3.1 Positive Displacement Compressors

Positive displacement compression is a technique used to compress air or gas by using one or more compression chambers that are closed off from the inlet. This method involves reducing the enclosed volume of the chamber through the displacement of one or more moving parts. As the volume decreases, the pressure inside the chamber increases, compressing the air or gas internally.

Once the pressure inside the chamber reaches the maximum pressure ratio, a port or valve opens, allowing the compressed air or gas to discharge into the outlet system. Positive displacement compressors are commonly used in various industrial and household applications, such as pneumatic tools, HVAC systems, and refrigeration units.

The advantage of positive displacement compression is that it can provide a steady flow of compressed air or gas at a constant pressure. This is useful in applications where a consistent output is required. However, positive displacement compressors can be limited in terms of the volume of air or gas they can compress, which can be a disadvantage in applications that require high flow rates.

Positive Displacement compressors are divided into two categories:

Reciprocating and rotary compressors.

a) Reciprocating Compressors

The piston compressor, also known as the reciprocating compressor, is one of the most used types of compressors. It works by using a moving piston to compress the air inside a cylinder. As the piston moves up and down, the volume of the cylinder decreases, causing the air to be compressed.

One of the advantages of piston compressors is their high efficiency at both full and partial loads, making them suitable for a variety of applications. However, they are also known for being quite noisy and requiring more space than other types of compressors. The high number of moving parts in a reciprocating compressor also means that maintenance costs can be higher than for other compressor types.

Reciprocating compressors can be either oil-lubricated or oil-free. Oil-lubricated compressors require regular maintenance to ensure that the oil stays clean and at the correct level. On the other hand, oil-free compressors are ideal for applications where oil contamination is a concern, such as in the food and beverage industry or in medical applications. Despite their disadvantages, piston compressors are widely used in a variety of industries, from manufacturing to transportation.

Figure 1.2 – Reciprocating compressor

i)Single-acting Compressors

The piston compressor is often preferred in industrial settings because it can produce high pressure air with relative ease. This makes it well-suited for applications such as powering pneumatic tools or providing air for use in chemical processes. However, due to its noisy operation, it is often housed in a separate room or enclosure to reduce the impact on workers.

In addition to their use in industrial settings, piston compressors can also be found in automotive engines. The pistons in an engine compress air and fuel, which is then ignited to produce the power necessary to move the vehicle. While these compressors are similar in design to those used in industrial settings, they often require more frequent maintenance due to the high number of cycles they undergo.

One common variation of the piston compressor is the two-stage compressor. This type of compressor uses two cylinders to further increase the pressure of the air, making it useful for applications that require high-pressure air, such as in paint spraying or sandblasting. Another variation is the scroll compressor, which uses a pair of interlocking spiral scrolls to compress air. While this type of compressor is quieter and requires less maintenance than a piston compressor, it is typically less efficient and not as widely used.

In conclusion, while the piston compressor has its drawbacks, it remains a popular choice in many industries due to its efficiency and versatility. Whether oil-lubricated or oil-free, it can produce high-pressure air with ease, making it an indispensable component in many manufacturing processes.

ii) Double-acting Compressors

The double-acting compressor is a type of positive displacement compressor that has gained popularity due to its high efficiency and ability to produce cheap electricity from compressed air. Unlike single-acting compressors that only compress the air on the downstroke of the piston, double-acting compressors compress the air on both the up-stroke and the downstroke, doubling the capacity of a given cylinder size. This results in higher compression efficiency and lower energy costs.

Double-acting compressors have many advantages over single-acting compressors. They can compress more air with the same amount of energy, which reduces the overall operating cost. Additionally, they are more efficient than single-acting compressors, which can lead to significant energy savings over time. Moreover, they produce a smoother and more constant air flow, which is beneficial for applications that require consistent pressure.

However, double-acting compressors also have some disadvantages. They require a higher initial cost and more space for installation than single-acting compressors. Additionally, they may require more maintenance due to their complex design and additional moving parts. Nevertheless, their advantages usually outweigh the disadvantages, making them a preferred choice for many applications, including manufacturing, construction, and transportation.

In conclusion, the double-acting compressor is a powerful and efficient type of positive displacement compressor that compresses air on both the up-stroke and the downstroke of the piston. Although it has some drawbacks, its benefits, including cheap electricity and high efficiency, make it a popular choice for various industries.

b) Rotary Compressors

The Rotary compressor is divided into five major types: lobe, screw, scroll, vane, and liquid ring compressors. Here we discuss each type in detail.

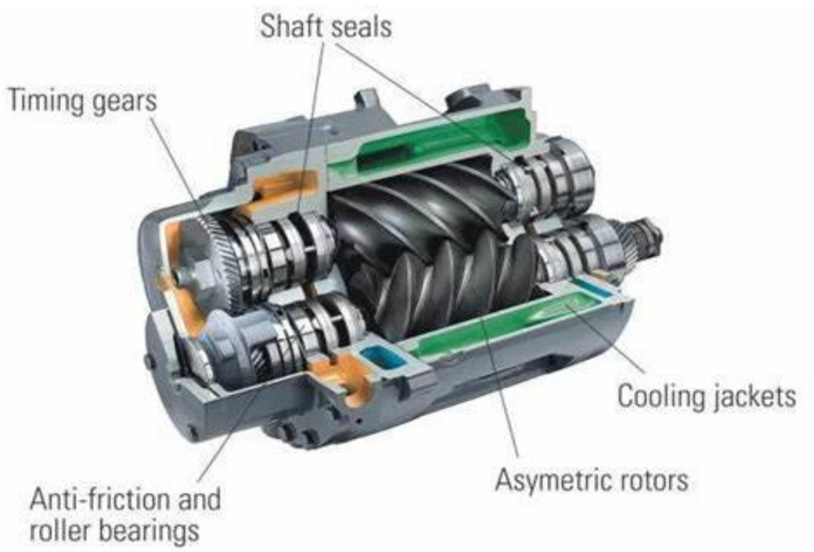


Figure 1.3 – Rotary compressor

i) Rotary Lobe Compressors

The rotary-lobe compressor is a type of positive displacement compressor that uses two intermeshing rotors to compress air. These rotors are mounted on parallel shafts and can have two or three lobes per rotor. The lobes on each rotor intermesh and rotate in opposite directions, creating chambers between the rotors that become smaller as the rotors turn. This reduction in volume compresses the air or gas that is trapped between the rotors, increasing its pressure.

The rotary-lobe compressor is often used in applications where a constant and pulse-free flow of air or gas is required, such as in the food and beverage industry or in wastewater treatment plants. The design of the rotary-lobe compressor allows for smooth and efficient operation, with minimal vibration and noise. Additionally, they require little maintenance and have a long lifespan. The size and capacity of the compressor can vary, depending on the specific application requirements.

ii) Rotary Screw Compressors

Rotary screw compressors are one of the most common types of compressors used in various industrial applications. They can provide a continuous supply of compressed air, making them suitable for large-scale operations that require a steady stream of compressed air. Unlike piston compressors, which operate with reciprocating motion, rotary screw compressors have a smooth, continuous motion that results in less vibration and noise.
Rotary screw compressors are highly efficient and can handle large volumes of compressed air, making them ideal for applications that require high air flow rates. They can also be designed to operate with oil injection or oil-free, depending on the specific application requirements. Oil-injected rotary screw compressors have a longer lifespan and can produce higher pressures, while oil-free compressors are suitable for applications that require clean, dry air, such as in the pharmaceutical or electronics industries.

One of the main advantages of rotary screw compressors is their low maintenance requirements. They have fewer moving parts compared to other types of compressors, which means less wear and tear and a longer lifespan. Moreover, they can operate continuously without the need for frequent shutdowns, which reduces downtime and increases productivity.

1.3.2 Dynamic Compressors

Dynamic compressors, unlike positive displacement compressors, operate by continuously increasing the velocity and momentum of a gas or fluid as it passes through the machine. They are commonly used in high-volume applications where the flow of gas or air needs to be continuous. The three types of dynamic compressors are centrifugal compressors, axial compressors, and mixed flow compressors. Centrifugal compressors work by accelerating the gas with a high-speed impeller that is rotated rapidly by an electric motor. Axial compressors, on the other hand, use a series of rotating and stationary blades to compress the gas as it flows through the machine. Mixed flow compressors, as the name suggests, are a combination of the other two types and utilize both centrifugal and axial compressor designs. Dynamic compressors are commonly used in large-scale industrial applications, such as power generation and oil and gas processing, where high volumes of gas need to be compressed efficiently.

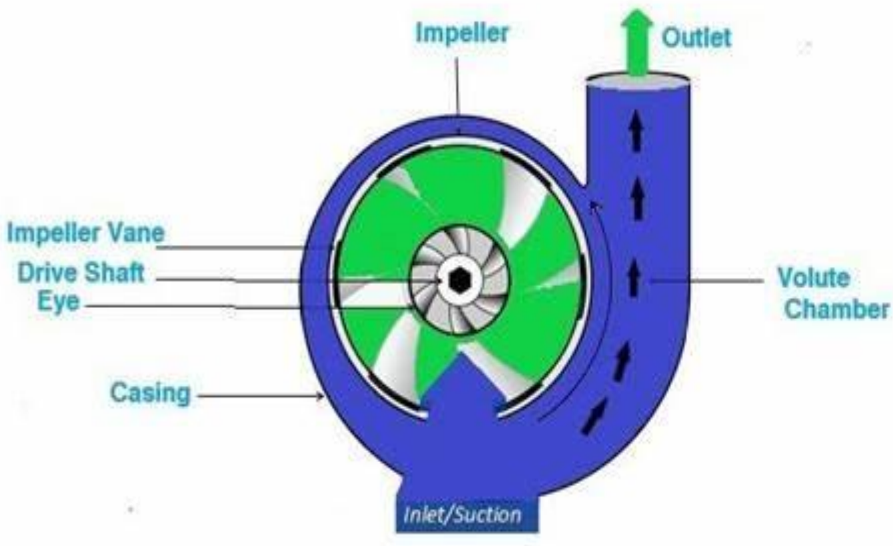


Figure 1.4 – Dynamic compressor

a) Centrifugal Compressors

Centrifugal compressors are widely used in various industrial applications, including air conditioning and refrigeration systems, gas pipelines, and oil refineries. They are popular because they offer high flow capacity per unit of installed space and weight, which makes them efficient and cost-effective.

In a centrifugal compressor, the gas enters the compressor near the centre of the impeller and is accelerated by the blades to high speeds. The kinetic energy of the gas is then converted to pressure energy as the gas passes through a diffuser, which slows down the gas and converts its velocity into pressure. Finally, the compressed gas is discharged through a volute casing.

One of the advantages of centrifugal compressors is that they have good reliability and require less maintenance than other types of compressors. They also operate quietly, which makes them ideal for use in noise-sensitive environments. However, their performance is more easily affected by changes in gas conditions, such as changes in pressure or temperature, than other types of compressors. This can lead to a decrease in efficiency or even compressor failure if the gas conditions are not carefully controlled.

Overall, centrifugal compressors are a reliable and efficient choice for industrial applications that require high flow capacity and low maintenance. Their unique design and performance characteristics make them an asset in many industries.

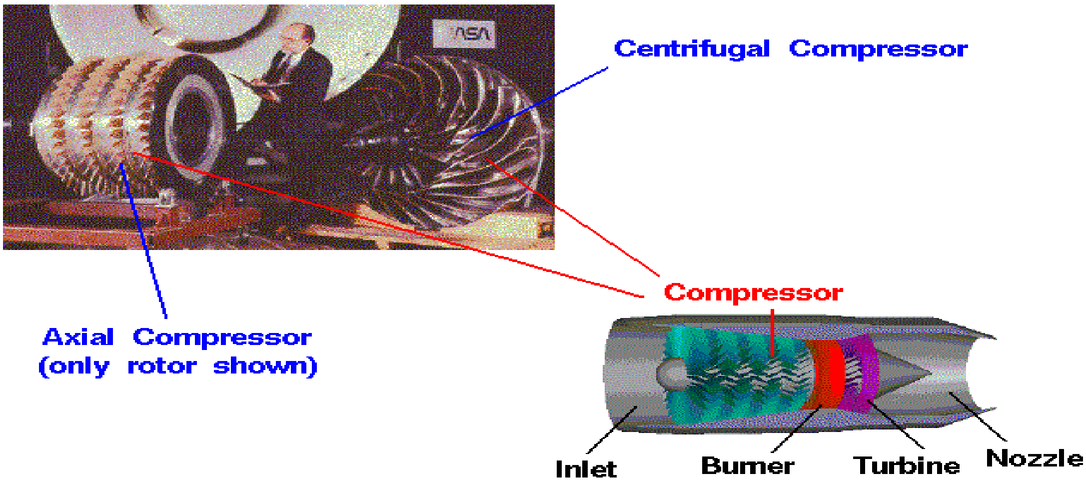


Figure 1.5 – Centrifugal compressor

b) Axial Compressors

Axial-flow compressors are a type of dynamic compressor that are commonly used in gas turbines to provide high-pressure air for combustion. In addition to gas turbines, axial-flow compressors are also used in jet engines, turbochargers, and other applications where high-flow capacity and efficiency are required.

The design of an axial-flow compressor consists of a series of rotating rotor blades and stationary stator blades. As air enters the compressor, it is accelerated by the rotor blades, which are mounted on a rotating shaft. The air is then diffused by the stator blades, which are fixed in place, causing the air to slow down and its pressure to increase. This process is repeated over several stages, with each stage increasing the pressure of the air until it reaches the desired level.

One of the key advantages of axial-flow compressors is their high efficiency. Because the air flows in a straight line through the compressor, there is less turbulence and energy loss compared to other types of compressors. Additionally, the use of multiple stages allows for a higher-pressure ratio, which further increases the efficiency of the compressor.
Another advantage of axial-flow compressors is their large mass flow rate. Because the air flows in a continuous stream through the compressor, it can handle a higher volume of air compared to other types of compressors. This makes them well-suited for applications where large volumes of air need to be compressed, such as in gas turbine engines or turbochargers.
However, there are also some disadvantages to axial-flow compressors. One major disadvantage is their complexity and cost. Because they require multiple stages of rotor and stator blades, they are more complex and expensive to manufacture than other types of compressors. Additionally, they can be sensitive to changes in operating conditions, such as variations in temperature or humidity, which can affect their performance and efficiency.
Despite their disadvantages, axial-flow compressors remain a popular choice for many applications due to their high efficiency and large mass flow rate. Ongoing research and development in the field of compressor design may lead to further improvements in their performance and cost-effectiveness in the future.

1.3.3 Compressor Nebulizer Machine

Compressor nebulizers have become an essential medical device for patients suffering from respiratory conditions. With the help of RespiRight technology, these devices help patients inhale respiratory medications in an efficient and thorough manner, ensuring maximum absorption by converting saline water and medications of varying viscosities into an aerosol mist.

One of the significant benefits of compressor nebulizers is their ease of use. The device can be conveniently used by children and older adults. The process is simple; patients just have to place the mouthpiece in their mouth and inhale the medication. This feature makes it an ideal choice for patients who have difficulty using inhalers.

Compressor nebulizers are highly effective in treating respiratory conditions such as asthma, acute bronchitis, cystic fibrosis, bronchial asthma, chronic bronchitis, emphysema, pneumoconiosis, chronic obstructive pulmonary disease, pulmonary infections, small airway disease, and many more. They ensure that the medication is atomized into fine particles faster, reaching the respiratory tract more effectively, and providing quick relief.

Another advantage of compressor nebulizers is their low noise level. Patients can comfortably use them without any discomfort as they produce noise levels less than 55 decibels when used from a meter away. The average nebulization rate is also more than 0.3 millilitres per minute, which ensures that the patient receives the medication at the right dosage and in a timely manner.

Overall, compressor nebulizers are highly beneficial for patients with respiratory conditions. They provide an easy and effective way to deliver medications to the lungs, ensuring maximum absorption and quick relief. With their RespiRight technology, low noise level, and high nebulization rate, compressor nebulizers are an excellent choice for patients seeking effective respiratory treatment.

Figure 1.6 – Compressor Nebulizer

Specifications

- **Product Dimensions** : 22 x 11 x 23 cm; 1.4 Kilograms
- **Manufacturer** : Nureca Limited
- **Item model number** : NECWZ_IGH00014
- **Country of Origin** : India
- **Item Weight** : 1 kg 400 g
- **Item Dimensions LxWxH** : 22 x 11 x 23 Centimetres
- **Net Quantity** : 1 count
- **Included Components** : Nebulizer
- **Generic Name** : Nebulizer

1.4 Sensors

For instance, consider a temperature sensor. A temperature sensor is an input device which provides an output signal that is proportional to the temperature of its surroundings. This signal is then used as an input to a main control system such as a processor or microcontroller. The temperature sensor converts the temperature, which is a physical quantity, into an electrical signal that can be interpreted by the main control system. The electrical signal can then be used to trigger an action such as turning on a heater or cooling system.

Sensors are essential components of many modern systems including industrial automation, automotive systems, and smart homes. They enable machines and systems to gather information about their environment and respond accordingly, allowing for efficient operation and better control. Sensors come in a variety of types and can measure many different physical quantities such as temperature, pressure, light, sound, and motion. The accuracy and reliability of a sensor are critical factors in ensuring the overall performance and safety of the system in which it is used. Advances in sensor technology have led to the development of smart sensors that can communicate wirelessly with other devices and even adapt to changing conditions.

A sensor is a device that detects and responds to some physical or chemical input by producing an output signal that can be measured or interpreted. Sensors are widely used in various applications, such as automotive, medical, industrial, and consumer electronics. Sensors are classified based on the physical or chemical quantity they measure, such as temperature, pressure, light, sound, and chemical composition.

Some common types of sensors include temperature sensors, pressure sensors, proximity sensors, motion sensors, and gas sensors. Temperature sensors measure the temperature of a system and provide an output signal proportional to the temperature. Pressure sensors measure the pressure of a fluid or gas and convert it into an electrical signal. Proximity sensors detect the presence or absence of an object without physical contact. Motion sensors detect motion or movement of an object or person. Gas sensors detect the presence of a specific gas or vapor in the air.

1.4.1 Different Types of Sensors

1. A temperature sensor measures the temperature of an object or environment.
2. A proximity sensor detects the presence or absence of an object without physical contact.
3. An accelerometer measures the acceleration of an object.
4. An IR sensor detects infrared radiation emitted or reflected by an object.
5. A pressure sensor measures the pressure of a fluid or gas.
6. A light sensor measures the intensity of light in an environment.
7. An ultrasonic sensor uses sound waves to measure distance or detect objects.
8. Smoke, gas, and alcohol sensors detect the presence of specific gases or particles in the air.
9. A touch sensor detects physical touch or pressure on a surface.
10. A color sensor measures the color of an object or light source.
11. A humidity sensor measures the amount of moisture in the air.
12. A position sensor detects the position of an object or its movement.
13. A magnetic sensor, such as a hall effect sensor, detects magnetic fields.
14. A microphone or sound sensor detects sound waves or vibrations in the air.
15. A tilt sensor detects changes in orientation or inclination.
16. A flow and level sensor measures the flow rate or level of a fluid.
17. A PIR sensor detects changes in infrared radiation emitted by living beings.
18. A touch sensor detects physical touch or pressure on a surface.
19. A strain and weight sensor measures strain or pressure on an object or surface.

1.4.2 Pressure sensor

Pressure sensors are critical devices in a wide range of applications, including industrial, automotive, medical, and aerospace systems. They are designed to detect changes in pressure and convert them into an electrical signal. The most common types of pressure sensors include capacitive, piezoelectric, strain gauge, and resonant pressure sensors.

Capacitive pressure sensors work by measuring the change in capacitance between two electrodes as a result of the applied pressure. Piezoelectric sensors use a crystal that generates an electric charge when subjected to pressure, while strain gauge sensors measure the deformation of a material under pressure. Resonant pressure sensors use a vibrating element that changes frequency in response to changes in pressure.

Pressure sensors can be used to measure different types of pressure, including absolute pressure, gauge pressure, and differential pressure. Absolute pressure sensors measure pressure relative to a perfect vacuum, while gauge pressure sensors measure pressure relative to atmospheric pressure. Differential pressure sensors measure the difference in pressure between two points.

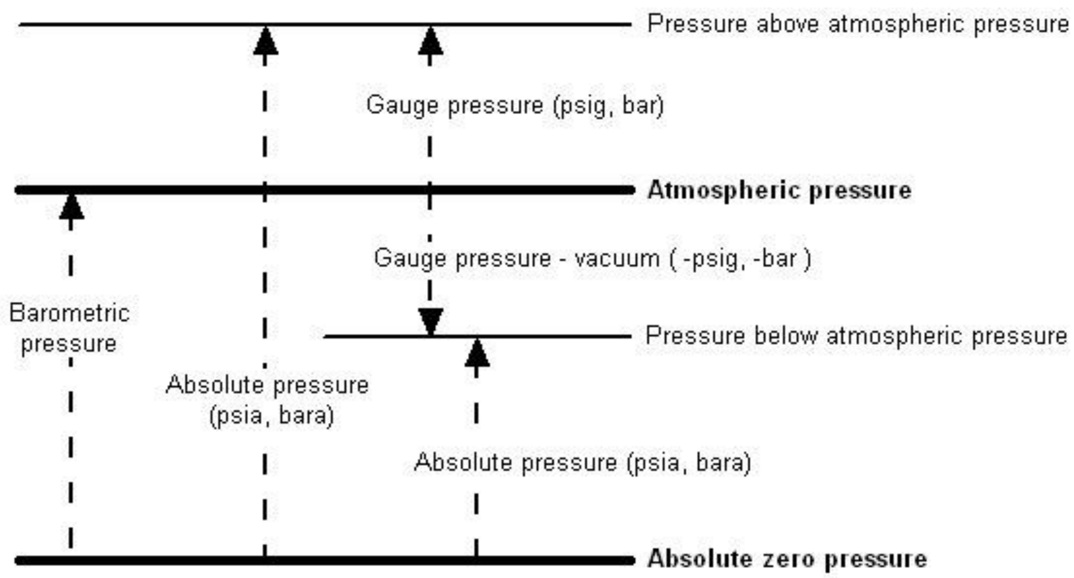
When selecting a pressure sensor, there are several specifications to consider, including accuracy, resolution, and response time. Additionally, environmental factors such as temperature, humidity, and vibration can affect the performance of pressure sensors.

Overall, pressure sensors are essential components in many systems, enabling precise and accurate measurements of pressure in a variety of applications.

Another difference between pressure sensors and pressure gauges is their applications. Pressure sensors are used in a wide variety of industries and applications where pressure measurements are critical, such as in the automotive industry, aerospace industry, medical industry, and manufacturing processes. They are often integrated into larger control systems where the pressure measurements are used to regulate and control processes, such as in hydraulic and pneumatic systems.

Pressure gauges, on the other hand, are often used in applications where a simple, visual reading of pressure is sufficient, such as in household and industrial applications. They are commonly found on air compressors, gas cylinders, and other equipment where pressure readings need to be monitored in real-time.

In summary, while pressure sensors and pressure gauges share similarities in their ability to measure pressure, they differ in terms of their output signals and applications. Pressure sensors provide an output signal that needs to be processed and calibrated, making them suitable for integration into larger control systems. Pressure gauges, on the other hand, provide a direct reading of pressure and are commonly used in simpler applications where real-time monitoring is sufficient.



a) Types of pressure sensors

There are six primary pressure sensor technologies used to sense pressure. These are:

- Potentiometric pressure sensors
- Inductive pressure sensors
- Capacitive pressure sensors
- Piezoelectric pressure sensors
- Strain gauge pressure sensors
- Variable reluctance pressure sensors

Potentiometric sensors use a Bourdon tube, capsule, or bellows to provide relatively coarse pressure measurements.

Inductive sensors use a linear variable differential transformer (LVDT) to vary the inductive coupling between primary and secondary coils.

Capacitive sensors use a deflected diaphragm to change the capacitance value, which can be calibrated to provide a pressure reading. Each type of pressure sensor has its own advantages and disadvantages, making them suitable for different applications. It is important to choose the right type of sensor for a particular application based on factors such as accuracy, sensitivity, and environmental conditions.

Piezoelectric pressure sensors are commonly used in applications where a high-frequency response is required, such as in engine knock sensors or acoustic emission sensors.

They are also used in industrial applications such as pressure measurements in hydraulic systems or force measurements in manufacturing processes.

Strain gauge pressure sensors are widely used in various applications, including aerospace, automotive, and biomedical industries. They offer high sensitivity and accuracy, making them ideal for applications where precise measurements are required. One of the main advantages of strain gauge sensors is their ability to detect small changes in pressure, which makes them suitable for measuring low-pressure systems. They are also relatively easy to manufacture and can be made in various shapes and sizes to fit specific applications. Variable reluctant pressure sensors are commonly used in automotive and industrial applications, such as fuel injection systems or tire pressure monitoring systems. They offer high reliability and are able to withstand harsh operating environments. One of the main advantages of these sensors is their simplicity and low cost, making them ideal for high-volume manufacturing. However, they may not offer the same level of accuracy as other types of pressure sensors.

In conclusion, each type of pressure sensor has its unique advantages and disadvantages, making them suitable for specific applications. It is important to choose the appropriate type of sensor based on the specific requirements of the application to ensure accurate and reliable pressure measurements.

Barometric pressure sensors are widely used in various applications such as weather forecasting, aviation, and navigation. These sensors can accurately measure atmospheric pressure and provide valuable information for predicting changes in weather patterns. They can also be used to determine altitude in aviation and navigation applications by measuring the difference in pressure at different heights. In addition to these traditional uses, barometric pressure sensors are now found in many electronic devices such as smartphones and smartwatches, where they can provide information on altitude, air pressure, and weather conditions. As technology continues to advance, the applications of barometric pressure sensors are likely to expand even further, providing more accurate and valuable data for a variety of industries and fields.

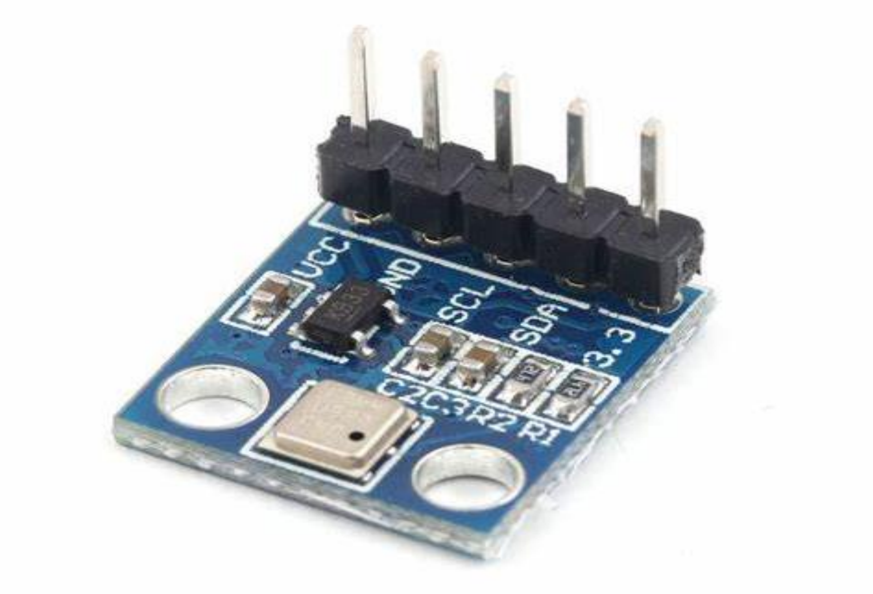


Figure 1.7 – Barometric pressure sensor

1.4.3 Temperature sensors

Temperature sensors are used to measure the temperature of various materials and environments. They are a crucial component in many industries, including geotechnical engineering, where they are used to monitor concrete, structures, soil, water, bridges, and other materials for structural changes due to seasonal variations. There are different types of temperature sensors available, including thermocouples and resistance temperature detectors (RTDs), which are commonly used in geotechnical engineering.

Thermocouples are made of two different metals that generate an electrical voltage in proportion to the change in temperature. When these metals are exposed to heat, they generate a small voltage that can be measured and interpreted as a temperature. Thermocouples are widely used due to their simplicity, durability, and accuracy.

RTDs, on the other hand, are variable resistors that change their electrical resistance in proportion to the change in temperature. They are made of materials that have a known resistance-temperature relationship, such as platinum, and are calibrated to provide accurate temperature measurements. RTDs are known for their high accuracy and stability over time, making them ideal for applications where precision is essential.

Temperature sensors have a wide range of applications in geotechnical engineering, including monitoring the temperature of concrete during curing, assessing the temperature of soil and water in various environmental conditions, and detecting temperature changes in bridges and other structures. The information provided by temperature sensors is essential in ensuring the safety and longevity of these structures, as well as in optimizing their performance and efficiency.

In conclusion, temperature sensors are essential tools for measuring the temperature of various materials and environments in geotechnical engineering. Thermocouples and RTDs are two common types of temperature sensors used for this purpose, providing accurate and reliable temperature measurements. With the help of these sensors, engineers and scientists can monitor and analyse temperature changes to ensure the safety and longevity of structures and materials, as well as to optimize their performance and efficiency.

A temperature sensor measures the temperature of an object by determining the voltage across a diode, which is directly proportional to the diode's resistance. This voltage is then converted into readable units of temperature, such as Fahrenheit or Celsius, and displayed on a readout unit. Temperature sensors are widely used in various applications, including geotechnical monitoring of structures such as bridges, dams, buildings, and power plants. By monitoring the internal temperature of these structures, engineers can detect potential issues, such as overheating, and take corrective actions to prevent damage or failure.

Temperature sensors are also used in consumer electronics, automotive, and medical applications to ensure optimal performance and safety. Overall, temperature sensors play a crucial role in enabling precise and accurate temperature measurements for a wide range of applications.

a) Types of Temperature sensors

- Negative Temperature Coefficient (NTC) Thermistors
- Resistance Temperature Detectors (RTDs)
- Thermocouples
- Semiconductor-Based Sensors

1.Negative Temperature Coefficient (NTC) thermistor

Thermistors are temperature sensing devices that are widely used in various industries. An NTC thermistor, also known as a negative temperature coefficient thermistor, is one of the most common types of thermistors. It exhibits an inverse relationship between resistance and temperature, meaning that its resistance decreases as temperature increases.

The NTC thermistor's resistance-temperature relationship is defined by its R-T table, which specifies the resistance at various temperatures. The small changes in resistance with temperature reflect accurately due to the large changes in resistance per degree Celsius. However, the output of an NTC thermistor is non-linear due to its exponential nature, and this can be a challenge when interpreting the readings.

To overcome the non-linearity of NTC thermistors, they can be linearized based on their application. This involves applying correction factors to the readings to make them linear over a specific temperature range. The effective operating range of NTC thermistors is -50 to 250°C for glass encapsulated thermistors or 150°C for standard thermistors.

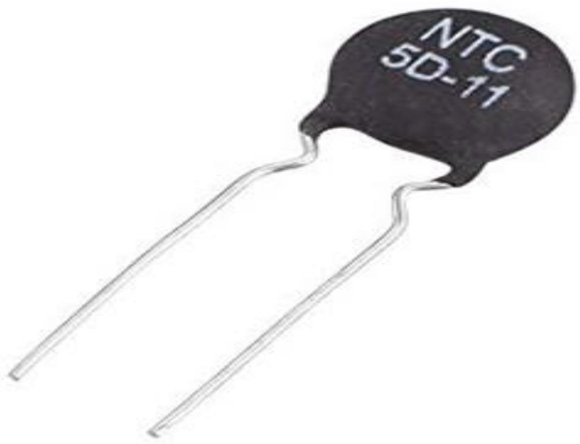


Figure 1.8 – Temperature sensor

2. Resistance Temperature Detector (RTD)

A resistance temperature detector, or RTD, is a type of temperature sensor that measures temperature by changing the resistance of the RTD element with temperature. RTDs typically consist of a wire or film wrapped around a ceramic or glass core. The choice of material for the RTD element affects the accuracy, stability, and repeatability of the sensor.

Platinum is the most accurate material for RTDs, offering a highly accurate linear output across a wide temperature range of -200 to 600°C. However, platinum RTDs are also the most expensive. Nickel and copper are less expensive materials for RTDs, but they are not as stable or repeatable as platinum.

Overall, the choice of RTD material depends on the specific application's accuracy and cost requirements. For high-precision applications that require accurate temperature measurement over a wide range, platinum RTDs are the ideal choice. For less demanding applications where cost is a significant factor, nickel, or copper RTDs may be suitable.

3. Thermocouples

A thermocouple is a type of temperature sensor that consists of two wires made of different metals that are electrically bonded at two points. When exposed to changes in temperature, the voltage between the two points changes in proportion to the temperature difference. However, thermocouples are nonlinear and require a conversion using a lookup table to convert the voltage reading into a temperature value.

Thermocouples have the advantage of operating across the widest temperature range of any temperature sensor, from -200°C to 1750°C. However, their accuracy is relatively low, ranging from 0.5°C to 5°C. Despite this, thermocouples are widely used in industrial applications where high temperatures are present, such as in furnaces, kilns, and power plants.

4. Semiconductor-based temperature sensors

Semiconductor-based temperature sensors are commonly used in integrated circuits (ICs). They typically consist of two diodes with temperature-sensitive voltage vs. current characteristics that are used to measure changes in temperature. While they offer a linear response, they have the lowest accuracy of the basic sensor types and the slowest responsiveness across a narrow temperature range, from -70°C to 150°C. Despite their limitations, semiconductor-based temperature sensors are widely used in electronic devices due to their small size, low power consumption, and ease of integration into integrated circuits.

1.5 Relay Module

Relay modules are commonly used in electrical systems to provide a means of controlling higher power systems using lower power devices. They are typically made up of several relays, each with its own circuit, allowing them to control multiple circuits using a single module. These modules are designed to make it easier to control the relays and provide protection against damage to the control circuitry.

Relay control modules are used in a wide range of applications, from simple control of lights and motors in homes and offices, to providing isolation between two circuits in industrial facilities. They are also used in automotive applications, such as controlling fans and pumps in cars, trucks, and other vehicles.

The modular design of relay modules makes them highly versatile and easy to install, which has contributed to their widespread use across various industries. They can be easily integrated into existing electrical systems, making them an ideal choice for retrofitting, or upgrading older systems. Overall, relay modules offer a reliable and cost-effective solution for controlling higher power systems with lower power devices.

A power relay module is a type of electrical switch that is used to control high-power circuits using low-power signals. It consists of an electromagnet that is activated by a low-power signal from a microcontroller or other control device. When the electromagnet is activated, it pulls a contact to either open or close an electrical circuit, depending on the desired function. Power relay modules are commonly used in a variety of applications, including industrial control systems, home automation, and automotive systems. They offer a reliable and efficient way to control high-power circuits with low-power signals, making them a popular choice in many different industries.

1.5.1 Types of Relay Module by Number of Channels

The number of relay module channels is an important consideration when selecting a relay module for a specific application. A 1-channel relay module has only one relay, while a 2-channel relay module has two relays and so on. The number of channels needed depends on the number of circuits that need to be controlled. A 1-channel relay module may be sufficient for a simple application, while a more complex system may require a 4-channel or 8-channel relay module. It's important to choose the right number of channels to avoid unnecessary costs or limitations in the system's functionality.

1-Channel Relay Module

A 1-channel relay module is an economical and straightforward solution for controlling a single device or circuit. With only one relay, these modules are easy to install and operate, making them an ideal choice for simple automation tasks. They are widely used in home automation systems, industrial control applications, and other electronics projects.

2-Channel Relay Module

A 2-channel relay module is a package containing two relays and their driver circuits, allowing control of two circuits with a single signal. This configuration is useful for controlling two separate loads, such as lights or motors, with one module. Using a 2-channel relay module can simplify wiring and reduce the number of components needed in a circuit.

4-Channel Relay Module

A 4-channel relay module is a versatile option that allows for the independent control of up to four separate circuits. This makes it a popular choice for applications where multiple devices or systems need to be controlled, such as home automation or industrial control systems. The 4-channel relay module can be easily interfaced with a microcontroller or other control device, providing reliable and efficient control over a variety of loads.

8-Channel Relay Module

An 8-channel relay module is a versatile solution that contains eight relays and their driver circuits, which can be controlled individually. These modules are commonly used in applications where multiple devices or systems need to be controlled simultaneously. For example, they can be used to control multiple lights or motors in an industrial setting or to automate home appliances. The 8-channel relay module offers a larger number of relays compared to the 1-channel, 2-channel, and 4-channel options, making it a popular choice for larger projects that require more control channels.

1.5.2 5V Relay Module

A 5v relay is an electromechanical switch that can be used in an automatic control circuit to control high-current devices using low-current signals. The input voltage required to activate the relay is typically between 0 and 5V, which makes it ideal for use with microcontrollers and other low-power control circuits.

5V Relay Pin Configuration

The pin configuration of the 5V relay is shown below. This relay includes 5-pins where each pin and its functionality are shown below.

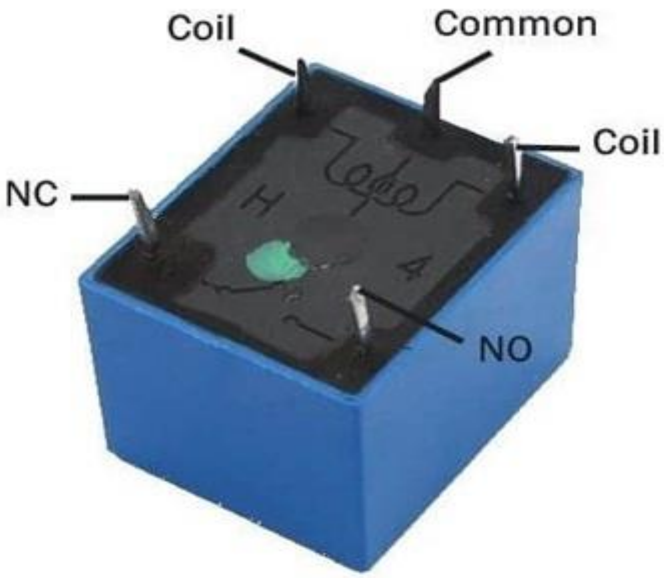


Figure 1.9 – Relay module

Pin1 (End 1): It is used to activate the relay; usually this pin one end is connected to 5Volts whereas another end is connected to the ground.

Pin2 (End 2): This pin is used to activate the Relay.

Pin3 (Common (COM)): This pin is connected to the main terminal of the Load to make it active.

Pin4 (Normally Closed (NC)): This second terminal of the load is connected to either NC/ NO pins. If this pin is connected to the load then it will be ON before the switch.

Pin5 (Normally Open (NO))**:** If the second terminal of the load is allied to the NO pin, then the load will be turned off before the switch.

1.5.3 Features

The 5V relay module is a commonly used device in electronic circuits to control high voltage and current loads. It operates with a 5V DC voltage and has a normal current of 70mA. The relay module is designed with five pins and made of plastic material. It has a maximum switching capacity of 300 operations per minute, an operating time of 10msec, and a release time of 5msec. The AC load current can be a maximum of 10A at 250VAC or 125VAC, while the DC load current can be a maximum of 10A at 30VDC or 28VDC.

This makes it suitable for controlling a wide range of devices such as motors, solenoid valves, lamps, and other high-power appliances. The 5V relay module is also very easy to interface with various microcontrollers such as PIC and Arduino, making it a popular choice among hobbyists and professionals alike. Its reliable performance and easy integration make it an essential component for many electronics projects.

1.5.4 5V Relay Module Pin Configuration

The pin configuration of the 5V relay module is shown below. This module includes 6-pins where each pin and its functionality are discussed below.

Figure 1.10 - Relay Module Pin Diagram

Normally Open (NO): The NO (Normally Open) pin of a relay module remains disconnected until a signal is provided to the signal pin, which activates the relay. Once activated, the common contact pin switches its connection from the NC (Normally Closed) pin to the NO pin, establishing a new connection.

Common Contact: This pin is used to connect through the load that we desire to switch by using the module.

Normally Closed (NC): The NC (Normally Closed) pin of a relay module is initially connected to the COM (Common) pin, forming a closed circuit. When an active high/low signal is provided to the signal pin from a microcontroller, the relay switches, and the common contact pin switches its connection to the NO (Normally Open) pin, breaking the NC connection and creating a new connection through the NO pin.

Signal Pin:

However, these modules generally work on an active high signal which will strengthen the relay coil to contact the common terminal with the normally open terminal.

5V VCC: This pin needs 5V DC to work. So 5V DC power supply is pr The signal pin on a relay module is crucial for controlling the relay. It can work in two different ways depending on the setup: active low or active high. In the case of active low, the relay will activate when an active low signal is provided to the signal pin. Conversely, in the active high case, the relay will trigger when a high signal is provided to the signal pin. The signal pin essentially acts as an interface between the relay and the microcontroller or other control device, allowing for easy and precise control of the connected load. Avoided to this pin.

Ground: This pin connects the GND terminal of the power supply. 5Volts 1-Channel Relay Module Components

The components in a 5v relay module with a single channel include a relay, output terminal, status LED, power LED, freewheeling diode, input connector & switching transistor.

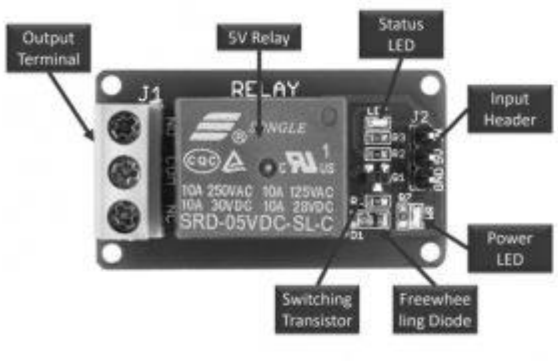


Figure 1.11 – Relay module components

The 5V relay is identifiable by its blue-coloured plastic coating, and it has the maximum operating voltage and current specifications displayed on the relay for both AC and DC loads. As the name suggests, the 5V relay operates on 5 volts, making it suitable for use with devices that require low voltage control signals.

The output terminal of a relay module is typically located on the left-hand side and is used to connect an AC or DC load, as well as an AC or DC input power source. Each output connector is connected to the relay through the NC, COM, and NO pins. The relay module comes with screws that can be used to securely connect wires and cables, ensuring a safe and reliable connection.

The maximum current supported by this module is 10A, making it suitable for a wide range of applications. The maximum contact voltage is 250V AC and 30V DC, providing a high level of safety and reliability for the connected load.

When dealing with high voltage and current loads, thick main cables should be used to ensure that the system can handle the load without any issues. Additionally, proper safety measures should be taken to prevent electrical shock or damage to the connected devices. The relay module's specifications and design make it a popular choice for controlling a wide range of loads, from solenoid valves and motors to lamps and other AC or DC loads.

i) Status LED

A status LED is typically connected to a relay module using a current limiting resistor located on the top right side of the module. When the relay is activated through a signal pin, the LED illuminates, indicating the status of the relay. The relay coil is supplied with DC power to activate the relay, allowing for precise control of the connected load. The LED provides a visual confirmation of the relay's status, making it easy to monitor the system's performance.

ii) Power LED

The power LED on a single channel relay module indicates the condition of the power source connected to the module. However, it is essential to note that if a power source above 5V is provided to both the Vcc and GND pins, the LED may be damaged due to the high voltage. Therefore, it is important to use the correct voltage to avoid damaging the module or any connected devices.

iii) Freewheeling Diode

A flyback diode can be connected across the coil in a relay module to prevent the back EMF (electromotive force) effect. This is especially important when dealing with inductive coils, as they can generate a back EMF voltage that can damage the circuit.

When current is supplied to an inductive load, it generates a magnetic field. When the current is turned off, the magnetic field collapses, generating a back EMF voltage. This voltage can cause a spike in the circuit, potentially damaging connected devices.

By connecting a flyback diode across the coil, the back EMF voltage is diverted away from the circuit, protecting it from damage. The diode allows the current to flow in a loop, preventing any voltage spikes that may occur due to the back EMF effect. This simple addition can greatly improve the reliability and longevity of the relay module and any connected devices.

1.6 ROTARY ENCODER

A rotary encoder is a versatile electro-mechanical device that measures and communicates the angular position or motion of a shaft or axle. This is achieved through the use of sensors that detect the movement of the shaft and convert it into analog or digital signals.

There are two main types of rotary encoder: absolute and incremental. An absolute encoder outputs a digital signal that indicates the current shaft position, making it an angle transducer. This type of encoder is useful in applications where it is critical to know the exact position of a rotating part, such as in robotics and CNC machines.

An incremental encoder outputs a series of pulses that provide information about the motion of the shaft. These pulses can be used to determine the shaft's speed, distance, and direction of rotation. Incremental encoders are commonly used in motor control systems and other applications that require accurate speed and position feedback.

Rotary encoders are used in a wide range of industrial and consumer applications. They are commonly used in industrial controls, robotics, photographic lenses, computer input devices such as optomechanical mice and trackballs, controlled stress rheometers, and rotating radar platforms. They are also found in consumer electronics such as audio equipment, digital cameras, and video game controllers.

In summary, rotary encoders are essential devices for monitoring and controlling mechanical systems. Their ability to accurately measure and communicate the position and motion of rotating parts makes them indispensable in a wide range of applications.

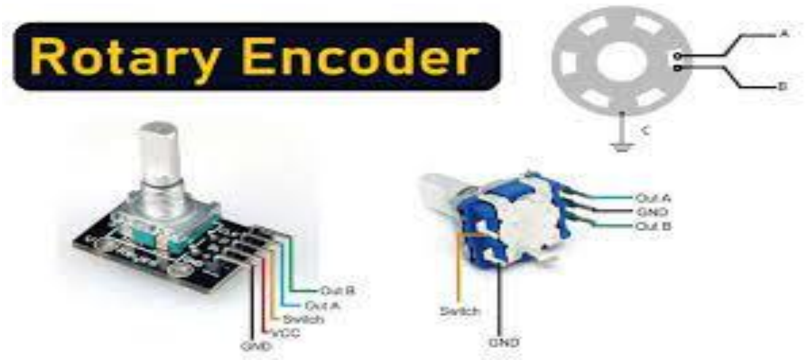


Figure 1.12 – Rotary encoder

1.7 MAPLESON CIRCUIT

The Mapleson Circuit Systems are widely used in the field of anaesthesiology for delivering aesthetic gases to patients during surgery. The circuit operates on the principle of drawing in fresh gases and anaesthetics, and removing exhaled carbon dioxide, while maintaining the necessary pressure and flow of gas for the patient's respiratory system.

The circuit consists of various components that work together to deliver gases and remove carbon dioxide from the patient. The face mask is placed towards the patient's end of the circuit, while the reservoir bag is located towards the operator's end. The reservoir bag accommodates fresh gas flow during expiration and acts as a reservoir available for the following inspiration. It also serves as a monitor of the patient's ventilatory pattern during spontaneous breathing and is a guide to tidal volume. The reservoir bag can be used to assist or control ventilation.

The corrugated tube is placed between the face mask and reservoir bag to provide flexibility and prevent any kinks in the circuit. The fresh gas flow inlet is located at a variable position and is adjusted to ensure that the appropriate number of aesthetic gases is delivered to the patient. The expiratory valve or Adjustable Pressure Limiting (APL) valve is located at a variable position and is used to regulate the pressure and flow of the gases during expiration.

The Mapleson circuit systems are versatile and are used in a variety of clinical situations where anaesthesia is required, including during surgery, emergency care, and intensive care units. By delivering gases and removing carbon dioxide in a controlled manner, these circuits help maintain the patient's respiratory function during surgery and anaesthesia.

Figure 1.13 – Mapleson circuit

1.8 ARDUINO BOARD

The Arduino platform is designed for anyone interested in creating interactive projects. Arduino boards are available in many different sizes and shapes, and they can be used to create a wide range of projects, from simple blinking LED lights to complex robotic systems.

The hardware components of an Arduino board include a microcontroller, which is the brain of the board, and other components like input/output pins, power regulators, and USB ports for programming and communication. The software components include the Arduino IDE, which provides an easy-to-use interface for writing, compiling, and uploading code to the board.

The Arduino platform has a vast community of users and developers who share their projects and knowledge online. This community provides access to a wide range of resources, including tutorials, forums, and libraries of pre-written code that can be used to speed up the development process.

The versatility and accessibility of the Arduino platform have made it a popular choice for hobbyists, educators, and professionals alike. It has been used in a wide range of applications, from controlling home automation systems to monitoring environmental data and even powering scientific experiments on the International Space Station.

The Arduino community has contributed to the platform by sharing their projects, code, and tutorials on online forums and websites. This has created a vast library of resources that can be used to learn about electronics and programming. With the availability of inexpensive Arduino boards and sensors, anyone can start experimenting and prototyping their own projects. The community also organizes events such as workshops, hackathons, and conferences to bring makers together and share their knowledge. This collaborative approach to learning and creating has made Arduino a popular choice for both beginners and experienced makers.

The Arduino board has evolved over time to meet the demands of a changing market. Originally designed as a tool for fast prototyping, it quickly gained popularity among hobbyists, students, and professionals alike. With the growth of the Internet of Things (IoT) and other emerging technologies, Arduino has expanded its offerings to include products for wearable technology, 3D printing, and embedded environments. Despite these changes, Arduino has remained committed to its open-source roots, encouraging a community of makers to share their knowledge and collaborate on projects.

Figure 1.14 – Arduino Board

1.8.1 Types of Arduinos

Arduino Type	Processor	Clock Speed	Digital I/O Pins	Analog Input Pins	PWM Pins	USB	Wireless Connectivity
Arduino UNO	ATmega328P	16 MHz	14	6	6	1 (Type-B)	N/A
Arduino NANO	ATmega328P	16 MHz	14	8	6	Micro USB	N/A
Arduino Leonardo	ATmega32u4	16 MHz	20	12	7	Micro USB	N/A
Arduino Micro	ATmega32u4	16 MHz	20	12	7	Micro USB	N/A
Arduino NANO Every	ATmega4809	20 MHz	22	14	6	Micro USB	N/A
Arduino NANO 33 BLE	nRF52840	64 MHz	14	8	14	Micro USB	Bluetooth 5
Arduino NANO 33 BLE Sense	nRF52840	64 MHz	20	8	14	Micro USB	Bluetooth 5
Arduino MKR Zero	SAMD21G18	48 MHz	8	7	7	Micro USB	N/A

Table 1.1 Types of Arduinos

1.8.2 Arduino UNO

Arduino Uno is a versatile and affordable microcontroller board that has gained immense popularity among hobbyists, educators, and professionals alike. It is based on the ATMega328P microcontroller, which is a powerful and efficient chip that can handle a variety of tasks. One of the key advantages of the Arduino Uno is its ease of use and accessibility. With a wide range of online resources, tutorials, and a supportive community, even beginners can quickly get started with programming and building projects.

The board's 14 digital I/O pins, six of which are 8-bit PWM pins, allow for a range of digital input and output operations. Additionally, the six analog input pins with 10-bit resolution make it possible to interface with sensors and other analog devices.

The board also has built-in communication ports like SPI, I2C, and UART, which enables it to communicate with other devices such as displays, sensors, and actuators.

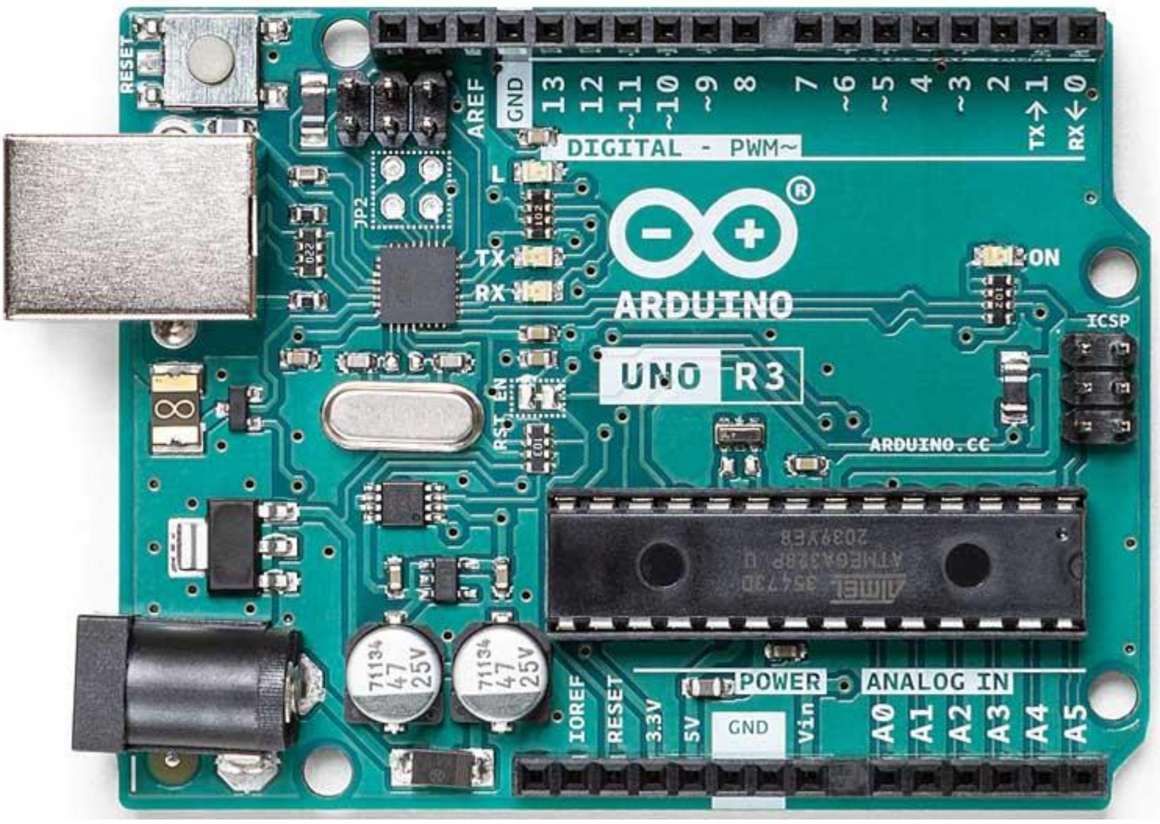


Figure 1.15 – Arduino UNO

Another advantage of the Arduino Uno is the availability of a wide range of premade modules and shields that can be easily plugged into the board, making it easy to expand its functionality and build prototypes quickly. These modules range from simple sensors and actuators to complex communication and wireless modules.

Whether you're a student, hobbyist, or professional, the Arduino Uno offers a great starting point for electronics and programming projects. With its low cost, expandability, and user-friendly interface, this microcontroller board has become the go-to choose for many people in the maker community. The Arduino Uno's flexibility and compatibility with various sensors, modules, and libraries make it suitable for projects of all types and complexities, making it an excellent tool for exploring the world of electronics and programming.

It is important to note that while there are many Arduino Uno boards available on the market, not all of them are genuine or officially licensed by Arduino. Many of these boards are clones or copies that are produced by third-party manufacturers. As a result, the appearance, colour, and quality of these boards may differ from the original Uno board. However, most of these clone boards still function in the same way as the original and offer similar features and functionality at a lower cost.

1.8.3 Arduino Nano

The Arduino Nano is a compact version of the Arduino Uno that is designed to be breadboard friendly. It offers many of the same features and functionality as the Uno, but in a smaller and more portable form factor. One of the major differences between the Nano and the Uno is the lack of a DC power jack on the Nano, which means that it must be powered through the USB port or an external power supply. The Nano also uses a Mini USB port instead of a USB B port, which is found on the Uno.

Another key difference between the Nano and the Uno is the USB-TTL converter chip. The Nano uses an FT232 chip from FTDI, which is a dedicated USB-UART bridge chip, whereas the Uno uses an ATMega16U2. This allows the Nano to be more compact and efficient, but it can also impact its compatibility with certain software and libraries.

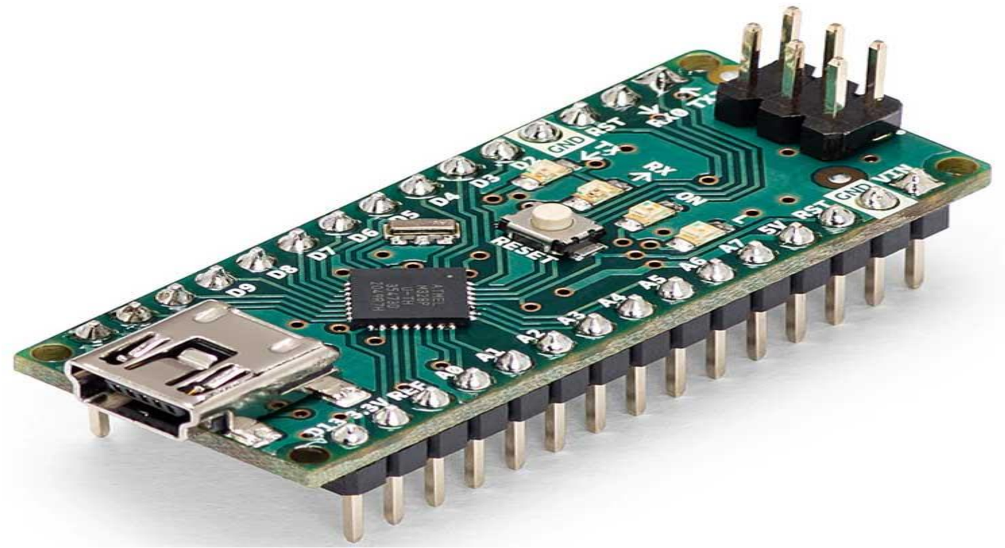


Figure 1.16 – Arduino NANO

Despite these differences, the Arduino Nano is still a popular choice among developers and hobbyists due to its small size, low cost, and versatility. It can be used for a wide range of projects, including robotics, automation, and electronics experimentation. Like the Uno, the Nano can be programmed using the Arduino IDE, which makes it easy to write and upload code to the board. Additionally, there are a variety of shields and modules available that can be easily connected to the Nano to expand its functionality.

1.8.4 Arduino Leonardo

The Arduino Leonardo is a microcontroller board that is powered by an ATmega32U4 chip, which is different from the ATMega328P chip used in other Arduino boards. One of the main advantages of the Leonardo is that it has more IO pins, with a total of 20, and more PWM and analog input pins, with 7 and 12 respectively.

The most significant difference between the Leonardo and other Arduino boards is the built-in USB communication capability of the ATmega32U4 chip. This eliminates the need for a second processor or a dedicated USB to UART bridge chip, which simplifies the board's design and reduces its cost. The board can connect to a computer as a Human Interface Device (HID) or as a Virtual (CDC) serial/COM port, which makes it ideal for use in projects that require USB connectivity.

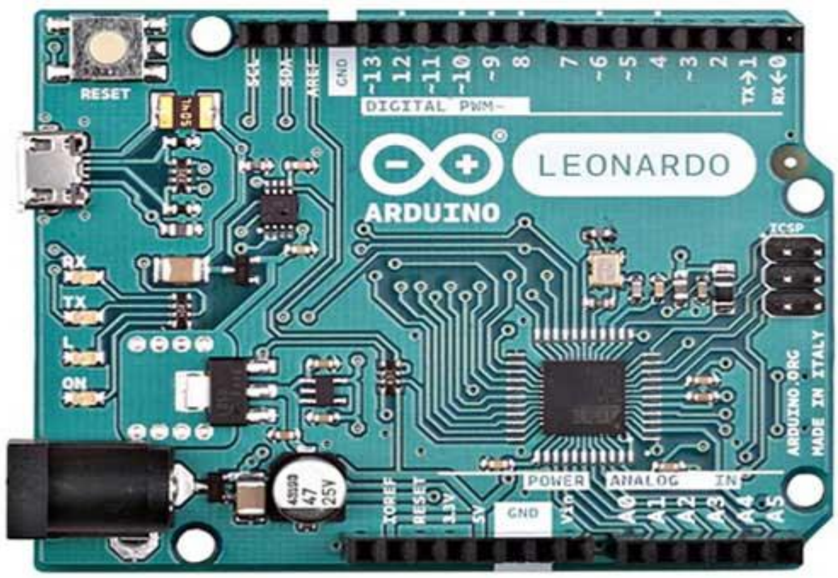


Figure 1.17 – Arduino Leonardo

Another advantage of the Leonardo is that it uses the Virtual COM port along with the bootloader to program the board. This means that the Leonardo can be programmed using the same programming environment as other Arduino boards, making it easy to learn and use. Additionally, the Leonardo is compatible with many of the same shields and modules as other Arduino boards, which allows for easy expansion and customization.

1.8.5 Arduino Micro

Arduino Micro is a small form-factor, breadboard-friendly board that shares the same functionalities as the Arduino Leonardo. It is essentially a Leonardo in a smaller form factor. The only notable difference is the lack of a DC input jack. Just like the Leonardo, the Micro has built-in USB communication capabilities, which allows it to connect to a computer as a Human Interface Device (HID) or as a Virtual COM port device. This makes the Micro ideal for projects that require USB connectivity, such as those involving computer peripherals or input devices.

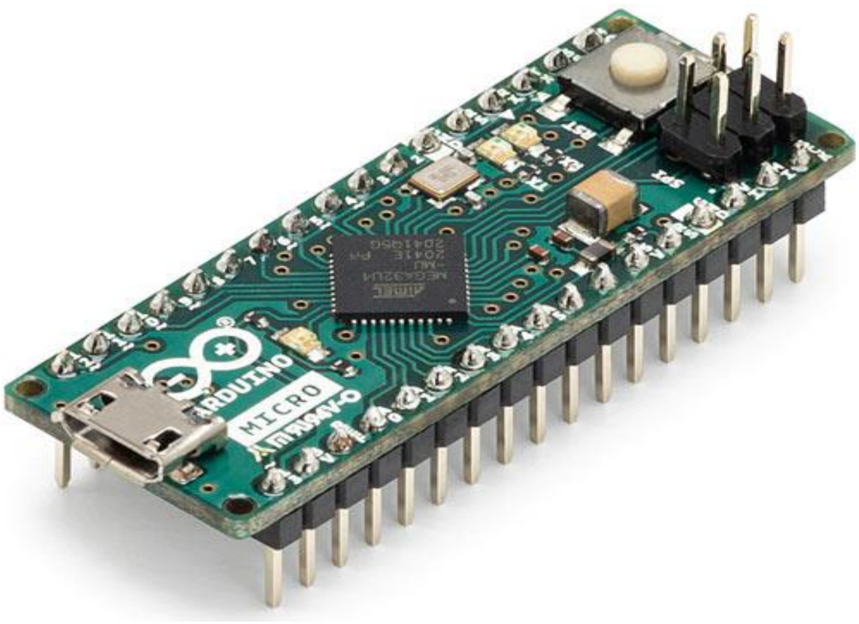


Figure 1.18 – Arduino Micro

CHAPTER 2

LITERATURE REVIEW

John B.West [1] in his work on "High-Altitude Medicine" has explored the medical implications of prolonged high-altitude exposure for military personnel in the Jammu-Kashmir region. He noted the potentially life-threatening health problems that can arise from such exposure, and proposes a device that simulates high-altitude effects by lowering atmospheric pressure in a controlled manner as a potential solution. Further research and testing is needed to determine the effectiveness and feasibility of this approach, but it is a promising avenue for addressing the medical challenges posed by high-altitude exposure.

Neeraj M Shah. et al. [2] in their 2015 article on "Wilderness medicine at high altitude" explored strategies for minimizing altitude-related medical emergencies and accurately diagnosing altitude-related illnesses. His work emphasizes the importance of proactive measures such as gradual acclimatization, proper hydration and nutrition, and prophylactic medications like acetazolamide to reduce risk. Accurate diagnosis of altitude-related illnesses such as Acute Mountain Sickness (AMS) is also crucial to prevent progression to more severe conditions.

Aastha Mishra.et al. [3] in his work outlines strategies to reduce the risk of altitude-related medical emergencies and accurately diagnose altitude-related illnesses. It highlights the importance of gradual acclimatization, proper hydration and nutrition, and prophylactic medications such as acetazolamide. Accurate diagnosis of altitude-related illnesses, including Acute Mountain Sickness (AMS), is essential to prevent the condition from progressing to more severe illnesses. Overall, the article underscores the need for proactive measures to minimize the health risks associated with high-altitude environments.

J. R. N. Lacey et al. [4] demonstrated the potential of using an electronic nose to analyse exhaled volatile organic compounds (VOCs) as a diagnostic tool for Acute Mountain Sickness (AMS). The study successfully differentiated between the breath prints of Sherpas and lowlanders, highlighting the potential of breath analysis as an objective tool to discriminate between different physiological responses to hypoxic conditions. The analysis of exhaled breath VOCs has the potential to be developed into a useful diagnostic and prognostic tool for not only AMS but other clinical conditions. The study also shows the possibility of gaining a better understanding of hypoxic adaptation through breath analysis.

M. Burtscher et al. [5] emphasized the importance of slow ascent, individual physiological responses, and proper treatment for safe and enjoyable high-altitude experiences. Despite progress in understanding acclimatization, there are still challenges that need to be addressed in future research. However, the traditional rules for safe high-altitude experiences remain essential.

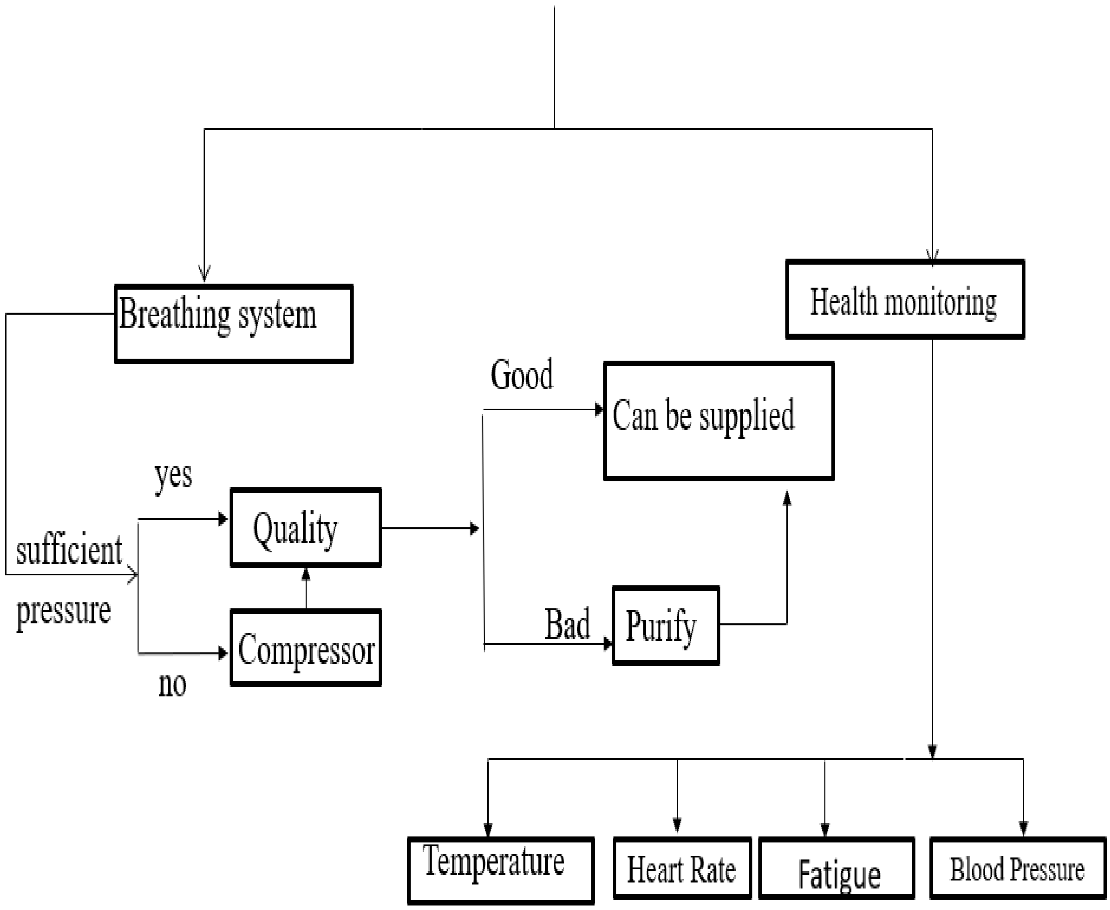
Scope of Work

From the literature review, it has been noticed that several authors have explored the possibilities of adding comfort to the people in the regions of low-pressure regions. They have considered medical and other biological factors that ensure the safety of human explorations in low pressure zone. In this work, we look forward to fabricate and test an equipment needed to enhance breathing capabilities at low pressure regions.

CHAPTER 3

METHODOLOGY

When the pressure around the surroundings is less than the atmospheric pressure, it can create a dangerous situation for individuals using breathing equipment. To solve this problem, the air needs to be pressurized through a compressor and sent into the body through a Mapleson circuit. Additionally, it's important to measure the quality of the air to ensure it's safe for breathing. By pressurizing the air, individuals can breathe safely and avoid the negative effects of low-pressure environments. Proper equipment maintenance and regular quality checks can help prevent potential issues and ensure the safety of those using the breathing equipment.



The experiment involves using a pressure sensor connected to an Arduino Uno board to measure atmospheric pressure, altitude, and temperature. This is achieved by programming the Arduino Uno board to calculate the pressure readings and setting a standard pressure as a reference point. When the calculated pressure is found to be less than the standard pressure, a relay module is activated to turn on a compressor and provide the necessary air into the body. This experiment demonstrates the practical application of Arduino Uno boards in real-world scenarios and highlights their versatility and usefulness in a wide range of projects and applications.

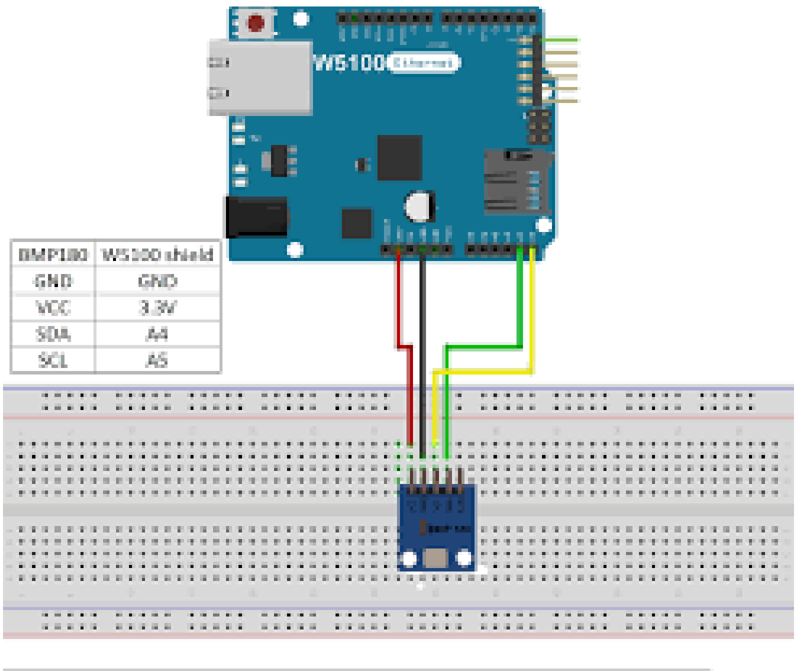


Figure 3.1 – Connections of Arduino

3.1 Connection from Arduino to Pressure Sensor

Connect the positive and negative wires of the nebulizer compressor to the common and normally open (NO) terminals of the relay module, respectively.

Connect the VCC and GND pins of the rotary encoder to the 5V and GND pins of the Arduino, respectively.

Connect the A and B pins of the rotary encoder to any two digital pins of the Arduino, for example, A and B to pins 2 and 3, respectively.

Connect the IN pin of the relay module to digital pin of the Arduino, for example, IN to pin 4, Connect the VCC and GND pins of the relay module to the 5V and GND pins of the Arduino, respectively**.**

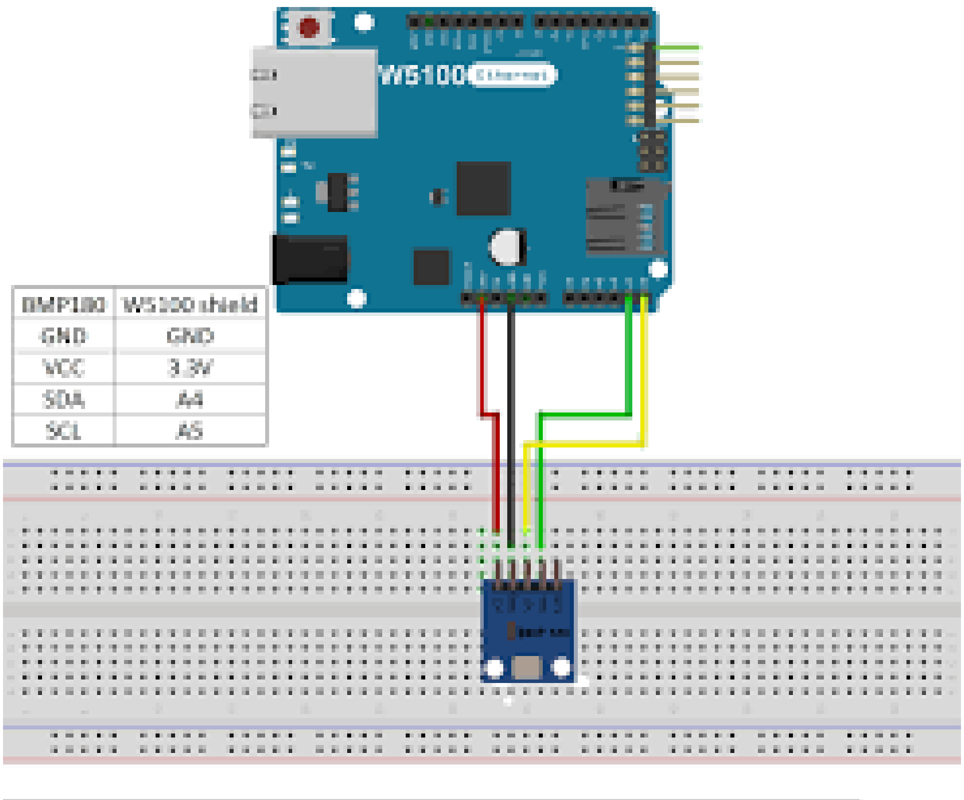


Figure 3.2 – Connections from Arduino to pressure sensor

3.2 Connections from Compressor to Relay Module to Arduino

Connect the VCC pin on the relay module to the 5V pin on the Arduino.

Connect the GND pin on the relay module to any GND pin on the Arduino.

Connect the IN pin on the relay module to a digital pin on the Arduino (e.g., pin 8).

Connect the COM (common) pin on the relay module to one of the power terminals of the device you want to control (e.g., the compressor).

Connect the NO (normally open) pin on the relay module to the other power terminal of the device you want to control.

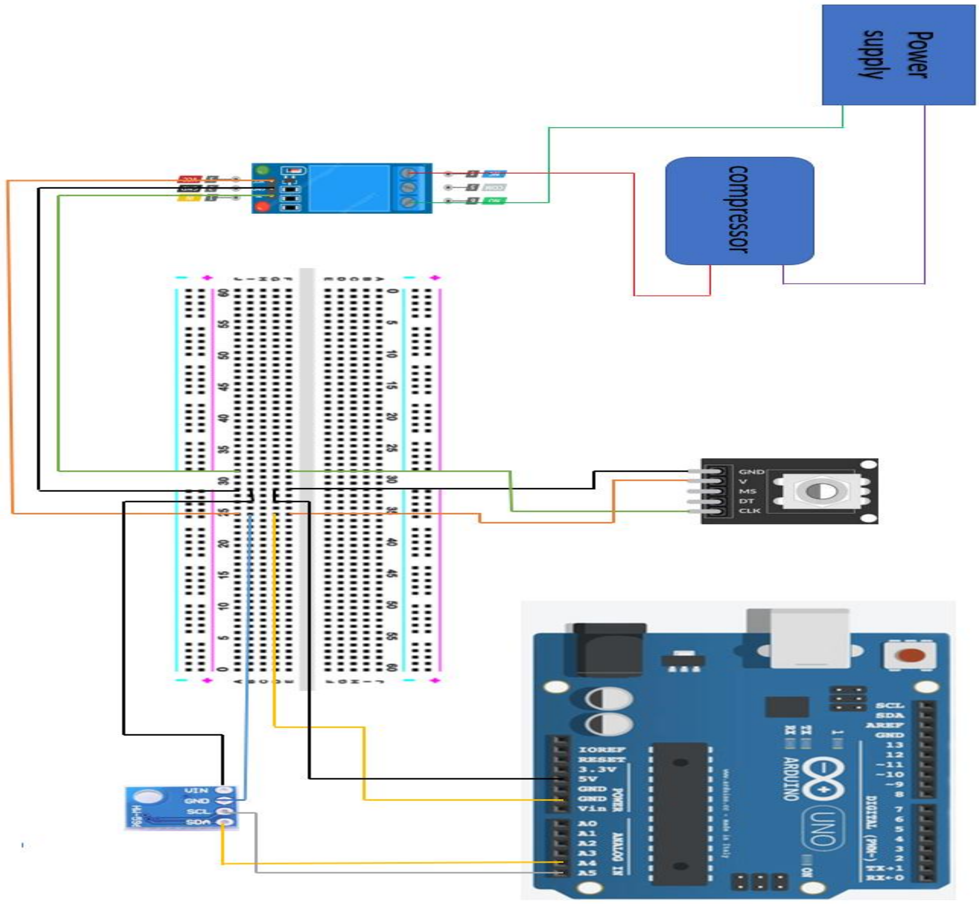


Figure 3.3 Overall Connections from compressors to pressure sensor

CHAPTER 4

4.1 Experimentation on pressure sensor

The experiment using the pressure sensor and Arduino Uno board highlights the power and flexibility of these microcontroller boards in various applications. The pressure sensor is a critical component in measuring atmospheric pressure, which has important implications in weather forecasting and aviation. The Arduino Uno board, with its numerous IO pins and programming capabilities, can accurately and efficiently calculate the pressure, altitude, and temperature readings from the sensor.

The use of a relay module to activate the compressor demonstrates how the Arduino Uno board can be integrated with other components to control physical systems. This has numerous applications in automation, robotics, and control systems. Overall, this experiment showcases the power and versatility of the Arduino Uno board in real-world scenarios and highlights its potential in a wide range of applications. With its low cost and ease of use, the Arduino Uno board has become a popular choice among hobbyists, educators, and professionals alike.

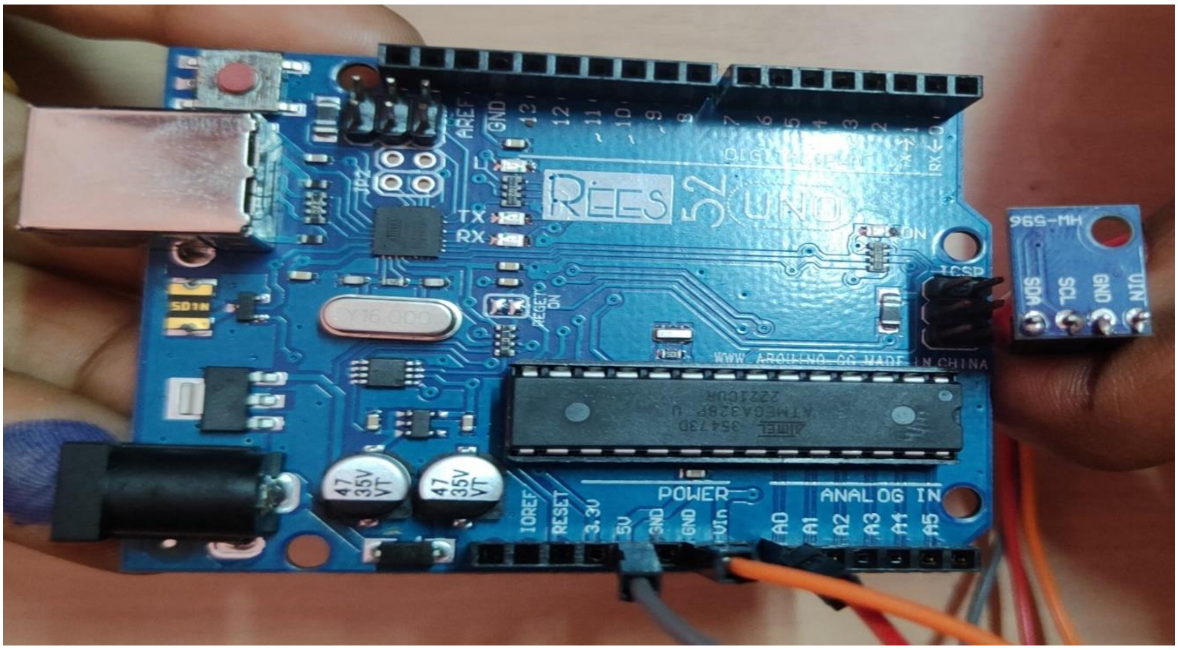
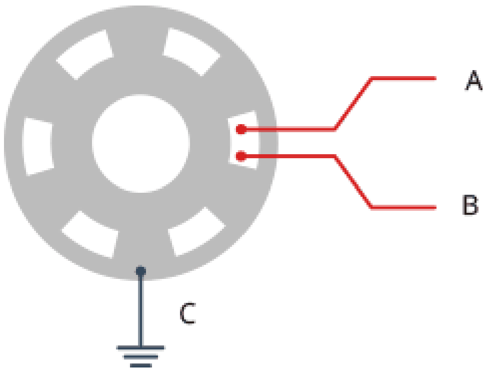


Figure 4.1 Experimentation on pressure sensor

Figure 4.2 Results of pressure sensor

4 .2 Experimentation on Rotary Encoder

Inside the encoder is a slotted disc that is connected to pin C, the common ground. It also has two contact pins A and B, as shown below.



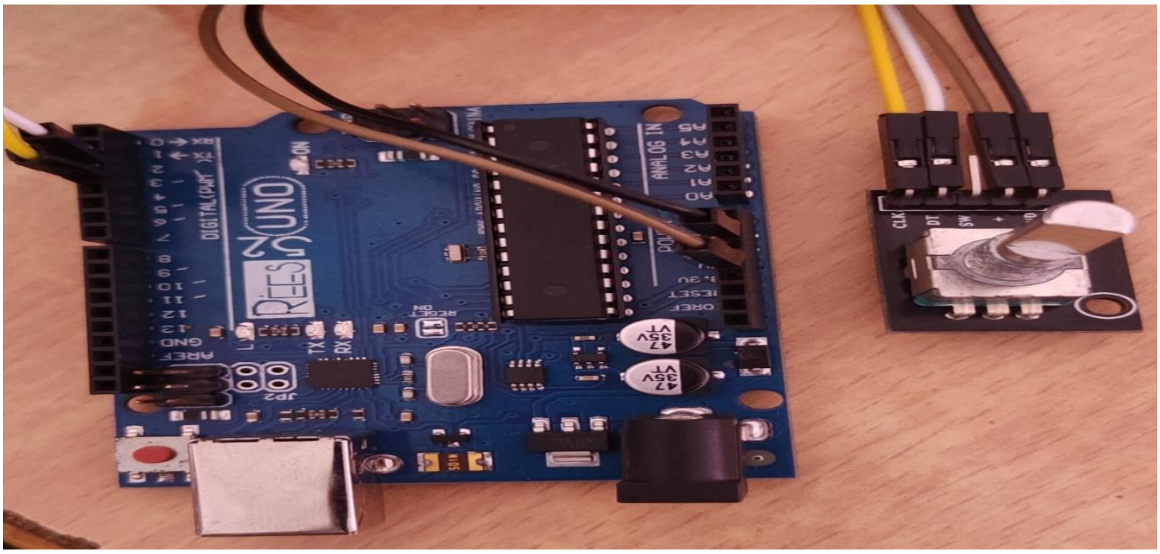


Figure 4.3 Experiment on Rotary Encoder

Rotary encoders are used to detect rotational movement and are common in various electronic devices. The rotary encoder consists of three pins: A, B, and C. When the knob is turned, the pins A and B make contact with the common ground pin C in a specific order depending on the direction of rotation. This contact generates two signals that are 90° out of phase because one pin makes contact with common ground before the other. This is referred to as quadrature encoding and can be used to determine the direction and speed of rotation. Rotary encoders are widely used in industrial, automotive, and consumer electronics applications, and can be interfaced with microcontrollers like Arduino for various projects and applications.

4.3 Experimentation on Relay module

Relays are useful in a variety of applications, especially when working with high-power circuits. By connecting relays to an Arduino board, you can easily control various high-power devices such as motors and power switches. This article covers the basics of relay and relay board connections, as well as a step-by-step guide on how to drive a relay using Arduino to control a DC circuit. The project includes detailed instructions and code snippets to help you understand and implement relay control with an Arduino board. With the information provided in this article, you can easily integrate relay control into your Arduino projects, making them more versatile and powerful. At the end of the article, you will find all the details to control an AC circuit (230 V lamp, dimmer etc) using Arduino.
There are different types of relays for multiple applications. The mechanical relay will consist of a coil which when activated, closes, or opens the switch (due to magnetic properties of the coil).

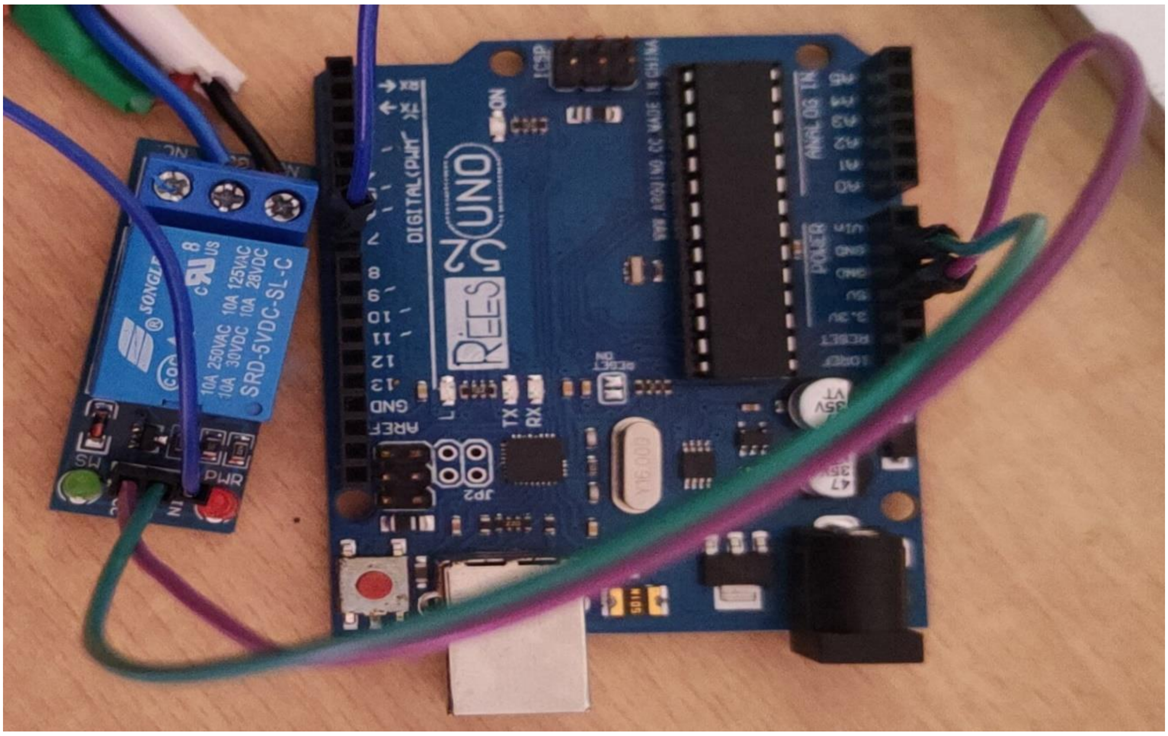


Figure 4.4 Experiment on Relay module

4.4 Experimentation on compressor

This scenario, an experiment was conducted using BMP180 pressure sensors, and now the task at hand is to write a code that displays the sensor values on a TFT LCD display. A relay module is connected to the Arduino, which will allow the code to control whether the compressor is on or off based on the pressure sensor values. The code will need to be set up to turn on the compressor when the pressure value from pressure sensor 1 is less than atmospheric pressure, and turn off the compressor when the pressure value is greater than atmospheric pressure.

To make this happen, the code needs to be written to read the pressure sensor values and display them on the TFT LCD display. The Arduino, the pressure sensors, the TFT LCD display, and the relay module all need to be connected through the breadboard. Once everything is connected and the code is uploaded to the Arduino, the TFT LCD display will show the pressure sensor values, and the compressor will turn on or off based on the values received from the pressure sensors.

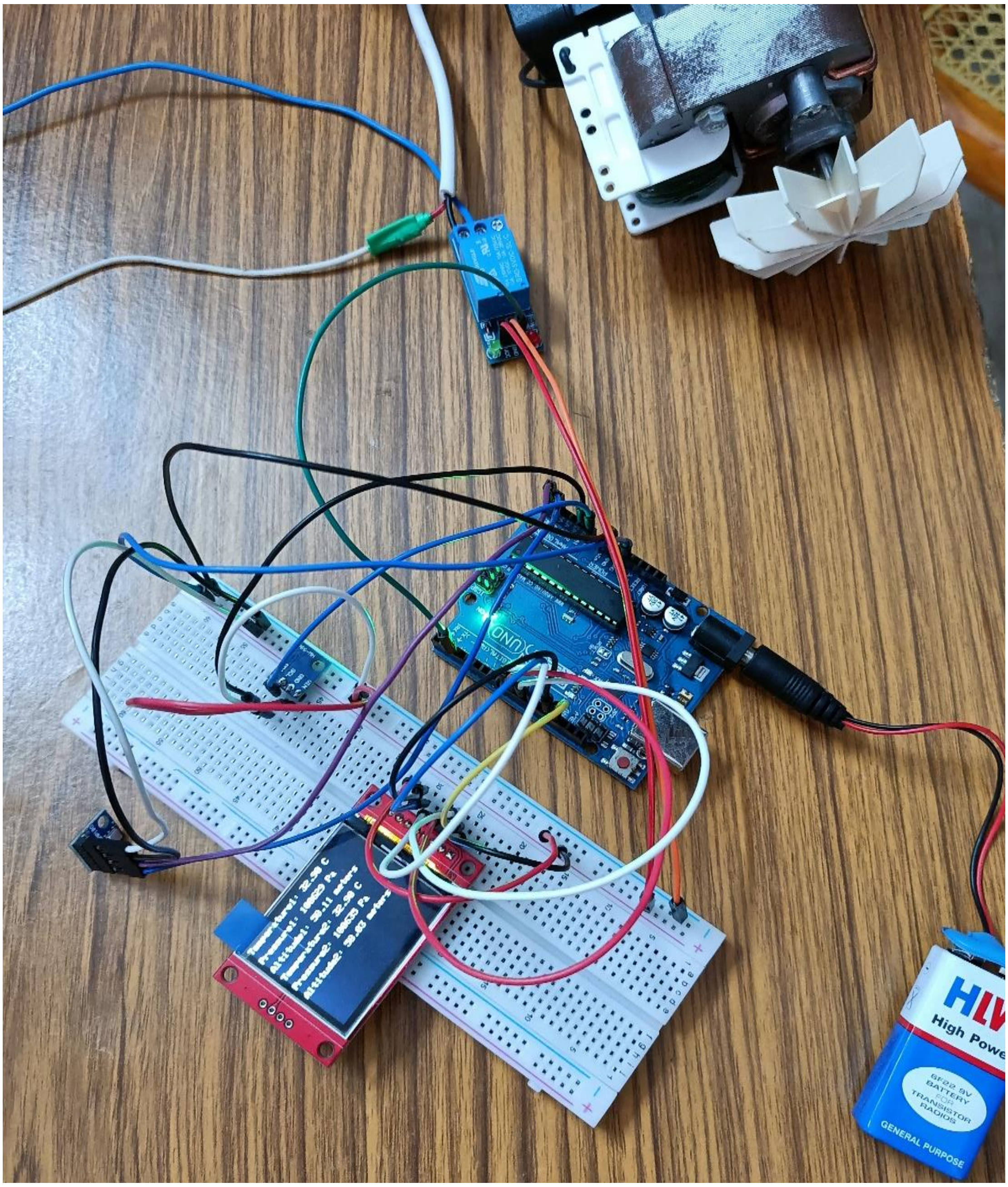


Figure 4.5 Connection from compressor to relay module.

CHAPTER 5

RESULTS AND DISCUSSION

5.1 RESULTS

The BMP180 pressure sensor connected to a TFT LCD display provides accurate and real-time pressure readings. The results are displayed on the screen, making it easy to monitor changes in pressure. This sensor is particularly useful for applications such as weather monitoring, altitude measurements, and drone navigation. With its precise measurements and clear display, the BMP180 pressure sensor is an excellent tool for any project that requires accurate pressure readings.

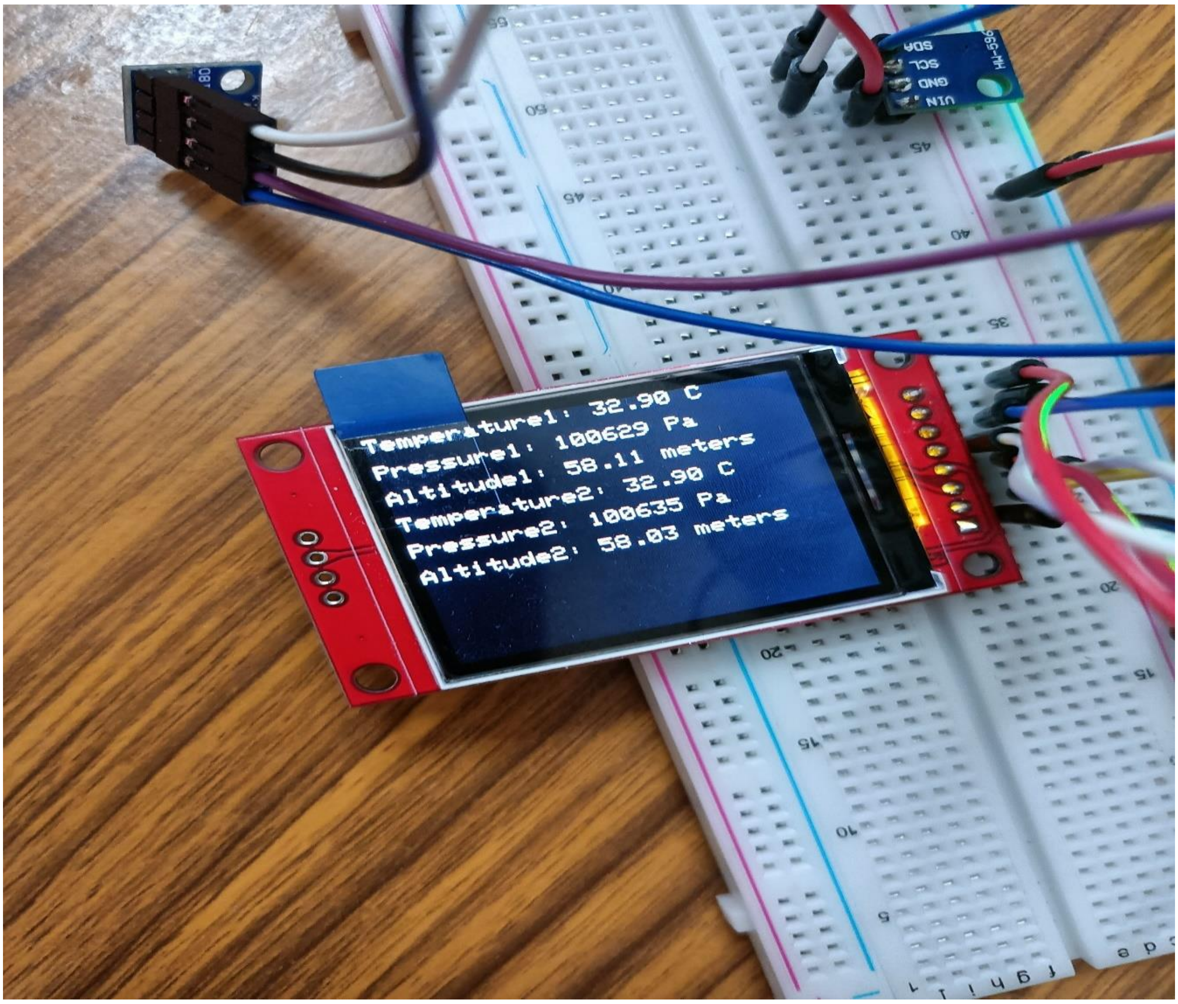
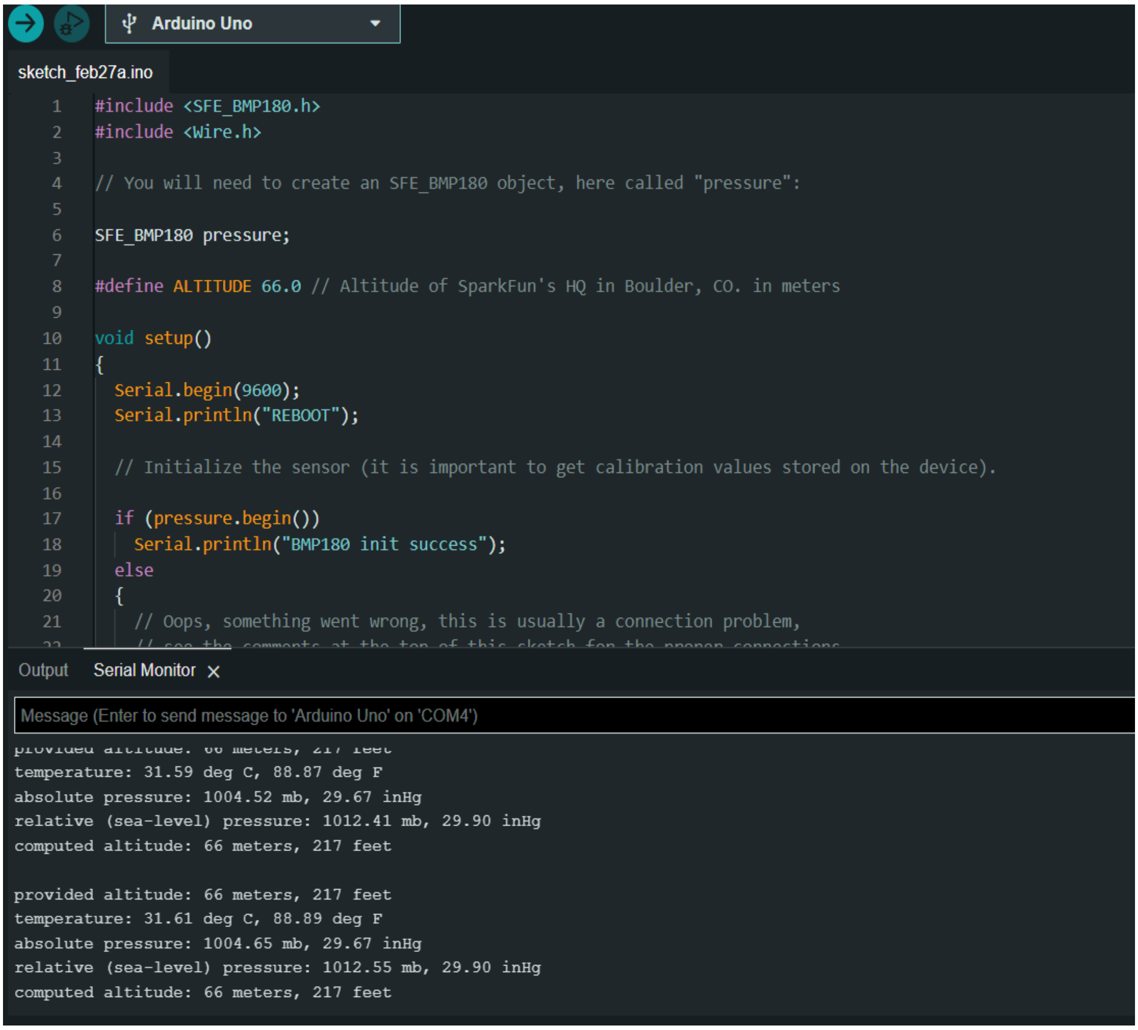


Figure No 5.1 Results displayed on TFT lcd

In this experiment, BMP180 pressure sensors were used to measure atmospheric pressure. The results were displayed on a TFT LCD display, providing a real-time visualization of the pressure changes. The data revealed fluctuations in the atmospheric pressure, which could have implications for various applications, such as weather forecasting or environmental monitoring. Overall, the experiment successfully demonstrated the functionality of BMP180 pressure sensors and highlighted their potential uses in a variety of fields.

P1	P2	t1	t2	time	compressor state
100629 Pa	100635 Pa	32.7 C	32.9 C	0 sec	off
100631 Pa	100637 Pa	32.7 C	33.8 C	20 sec	off
100632 Pa	100624 Pa	33.1 C	34.4 C	40 sec	off
100627 Pa	100628 Pa	32.8 C	34.1 C	60 sec	off
100514 Pa	100633 Pa	33.1 C	34.2 C	0 sec	off
99846 Pa	100629 Pa	32.8 C	33.6 C	20 sec	off
98974 Pa	100637 Pa	34.1 C	32.8 C	40 sec	off
98241 Pa	100644 Pa	33.6 C	34.1 C	60 sec	off
82651 Pa	100628 Pa	32.3 C	34.2 C	0 sec	off
82655 Pa	100637 Pa	32.6 C	31.5 C	20 sec	off
82721 Pa	100631 Pa	32.1 C	32.9 C	40 sec	off
82771 Pa	100636 Pa	32.5 C	33.7 C	60 sec	off
71774 Pa	100661 Pa	32.8 C	36.4 C	0 sec	on
71423 Pa	102131 Pa	32.9 C	36.7 C	20 sec	on
71439 Pa	103313 Pa	32.3 C	36.2 C	40 sec	on
71556 Pa	103825 Pa	32.6 C	36.8 C	60 sec	on

Table 5.1 Results



5.2 DISCUSSIONS

The use of a relay module to activate the compressor is just one example of how the Arduino Uno board can be integrated with other components to control physical systems. This technology has numerous applications in automation, robotics, and control systems, allowing for the creation of complex and sophisticated systems that can perform a wide range of tasks. By providing a simple and intuitive platform for programming and control, the Arduino Uno board has become a popular choice for hobbyists, educators, and professionals alike, enabling them to bring their ideas to life and push the boundaries of what is possible. Overall, this experiment showcases the power and versatility of the Arduino Uno board in real-world scenarios and highlights its potential to revolutionize the way we interact with technology.

CHAPTER 6
CONCLUSION AND FUTURE SCOPE

At high altitudes or in low-pressure conditions, the pressure difference between the surroundings and the lungs can cause difficulties in breathing for human beings. The exchange of oxygen and carbon dioxide in the alveoli through diffusion process becomes challenging due to the pressure difference. As a result, human beings may experience breathing problems in such conditions. It is essential to have proper equipment or systems in place to ensure the availability of breathable air in low-pressure environments. This is where technologies such as pressure sensors and relays controlled by Arduino boards can be useful in ensuring the safety and comfort of individuals in such environments.

The development of innovative equipment to address the challenges faced by individuals in high-altitude areas is an important advancement. The equipment includes features such thermal sensors, and air compressors, all of which are designed to alleviate the difficulties associated with living in high-altitude environments. These features enable, better breathing, and improved thermal regulation in high-altitude areas, which can be particularly helpful for individuals such as trekkers, researchers, and soldiers in emergency situations. This equipment highlights the importance of technological advancements in improving human life and enabling individuals to thrive in challenging environments.

FUTURE SCOPE

Innovative equipment has been developed to address the challenges individuals face in high-altitude areas, including thermal sensors and air compressors. These features can improve breathing and regulate body temperature, making high-altitude living easier for trekkers, researchers, and soldiers in emergency situations. Technological advancements play an essential role in improving human life and enabling people to thrive in challenging environments, highlighting the importance of ongoing research and development.

REFERENCES

[1] John B. West. American Thoracic Society. Volume 186. Issue 12, Pages:1201-1311(2012)
Source Link: https://www.atsjournals.org/doi/epdf/10.1164/rccm.201207-1323CI?role=tab

[2] Neeraj M Shah. et al. Wilderness medicine at high altitude. Open Access Journal of Sports Medicine 6, 319–328(2015)
Source Link: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4590685/pdf/oajsm-6-319.pdf

[3] Aastha Mishra.et al. Lungs at high-altitude: genomic insights into hypoxic responses. Journal of Applied Physiology, Volume 119 Issue 1, Pages1-100 (1Jul 2015)
Link: https://journals.physiology.org/doi/epdf/10.1152/japplphysiol.00513.2014

[4] J. R. N. Lacey et al. The Smell of Hypoxia: using an electronic nose at altitudeand proof of concept of its role in the prediction and diagnosis of acute mountain sickness. the Xtreme Everest 2 Research Group. Vol. 6 1-9 (2018)
Source Link: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6125242/pdf/PHY2-6-e13854.pdf

[5] M. Burtscher et al. High-altitude illnesses: old stories and new insights into the pathophysiology, treatment, and prevention. Sports Medicine and Health Science 3 59–69 (2021)
Source Link: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9219347/

APPENDIX

A.1 CODES WE USED

A.1.1 BMP 180 PRESSURE SENSOR

```
#include <Wire.h>
#include <Adafruit_BMP085.h>
#include <Adafruit_GFX.h>
#include <Adafruit_ST7735.h>
#define TFT_CS     10
#define TFT_RST    9
#define TFT_DC     8
// Initialize the display
Adafruit_ST7735 tft = Adafruit_ST7735(TFT_CS, TFT_DC, TFT_RST);
Adafruit_BMP085 bmp1;
Adafruit_BMP085 bmp2;
void setup()
{
  Serial.begin(9600);
  if (!bmp1.begin()) {
    Serial.println("Could not find a valid BMP085 sensor1, check wiring!");
    while (1) {}
  }
  Serial.begin(9600);
  if (!bmp2.begin()) {
```

```
    Serial.println("Could not find a valid BMP085 sensor2, check wiring!");
    while (1) {}
  }
  // Initialize the display
  tft.initR(INITR_BLACKTAB);
  tft.fillScreen(ST7735_BLACK);
  tft.setRotation(1);
}
void loop()
{
  Serial.print("Tempera0000000000000000000000ture1 = ");
  Serial.print(bmp1.readTemperature());
  Serial.println(" *C");
  Serial.print("Pressure 1= ");
  Serial.print(bmp1.readPressure());
  Serial.println(" Pa");
  // Calculate altitude assuming 'standard' barometric
  // pressure of 1013.25 millibar = 101325 Pascal
  Serial.print("Altitude 1= ");
  Serial.print(bmp1.readAltitude());
  Serial.println(" meters");
  Serial.println();
  Serial.print("Temperature2 = ");
```

```
Serial.print(bmp2.readTemperature());

Serial.println(" *C");

Serial.print("Pressure 2= ");

Serial.print(bmp2.readPressure());

Serial.println(" Pa");

// Calculate altitude assuming 'standard' barometric

// pressure of 1013.25 millibar = 101325 Pascal

Serial.print("Altitude 2= ");

Serial.print(bmp2.readAltitude());

Serial.println(" meters");

Serial.println();

// Clear the display

tft.fillScreen(ST7735_BLACK);

// Print temperature

tft.setCursor(0, 0);

tft.setTextColor(ST7735_WHITE);

tft.setTextSize(1);

tft.print("Temperature1: ");

tft.print(bmp1.readTemperature());

tft.println(" C");

// Print pressure

tft.setCursor(0, 15);

tft.print("Pressure1: ");
```

```
tft.print(bmp1.readPressure());
tft.println(" Pa");
// Calculate altitude assuming 'standard' barometric
// pressure of 1013.25 millibar = 101325 Pascal
tft.setCursor(0, 30);
tft.print("Altitude1: ");
tft.print(bmp1.readAltitude());
tft.println(" meters");
// Clear the display
//tft.fillScreen(ST7735_BLACK);
// Print temperature
tft.setCursor(0, 45);
tft.setTextColor(ST7735_WHITE);
tft.setTextSize(1);
tft.print("Temperature2: ");
tft.print(bmp2.readTemperature());
tft.println(" C");
// Print pressure
tft.setCursor(0, 60);
tft.print("Pressure2: ");
tft.print(bmp2.readPressure());
tft.println(" Pa");
// Calculate altitude assuming 'standard' barometric
```

```
  // pressure of 1013.25 millibar = 101325 Pascal
  tft.setCursor(0, 75);
  tft.print("Altitude2: ");
  tft.print(bmp2.readAltitude());
  tft.println(" meters");
  delay(2000);
}
```

A.1.2 INTEGRATED CODE OF BMP 180 PRESSURE SENSOR AND RELAY MODULE:

```
 #include <Wire.h>
#include <Adafruit_BMP085.h>
#include <Adafruit_GFX.h>
#include <Adafruit_ST7735.h>
#define TFT_CS     10
#define TFT_RST    9
#define TFT_DC     8
#define RELAY_PIN 3 // change to the pin you are using to control the relay module

// Initialize the display
Adafruit_ST7735 tft = Adafruit_ST7735(TFT_CS, TFT_DC, TFT_RST);

Adafruit_BMP085 bmp1;
Adafruit_BMP085 bmp2;
```

```
void setup()

{
  Serial.begin(9600);
  if (!bmp1.begin()) {
    Serial.println("Could not find a valid BMP085 sensor1, check wiring!");
    while (1) {}
  }
  Serial.begin(9600);
  if (!bmp2.begin()) {
    Serial.println("Could not find a valid BMP085 sensor2, check wiring!");
    while (1) {}
  }
  // Initialize the display
  tft.initR(INITR_BLACKTAB);
  tft.fillScreen(ST7735_BLACK);
  tft.setRotation(1);
 pinMode(RELAY_PIN, OUTPUT);
}

void loop()
{
  Serial.print("Temperature1 = ");
```

```
Serial.print(bmp1.readTemperature());

Serial.println(" *C");

Serial.print("Pressure 1= ");

Serial.print(bmp1.readPressure());

Serial.println(" Pa");

// Calculate altitude assuming 'standard' barometric

// pressure of 1013.25 millibar = 101325 Pascal

Serial.print("Altitude 1= ");

Serial.print(bmp1.readAltitude());

Serial.println(" meters");

Serial.println();

Serial.print("Temperature2 = ");

Serial.print(bmp2.readTemperature());

Serial.println(" *C");



Serial.print("Pressure 2= ");

Serial.print(bmp2.readPressure());

Serial.println(" Pa");

// Calculate altitude assuming 'standard' barometric

// pressure of 1013.25 millibar = 101325 Pascal

Serial.print("Altitude 2= ");

Serial.print(bmp2.readAltitude());
```

```
Serial.println(" meters");
Serial.println();
// Clear the display
tft.fillScreen(ST7735_BLACK);
// Print temperature
tft.setCursor(0, 0);
tft.setTextColor(ST7735_WHITE);
tft.setTextSize(1);
tft.print("Temperature1: ");
tft.print(bmp1.readTemperature());
tft.println(" C");
// Print pressure
tft.setCursor(0, 15);
tft.print("Pressure1: ");
tft.print(bmp1.readPressure());
tft.println(" Pa");
// Calculate altitude assuming 'standard' barometric
// pressure of 1013.25 millibar = 101325 Pascal
tft.setCursor(0, 30);
tft.print("Altitude1: ");
tft.print(bmp1.readAltitude());
tft.println(" meters");
// Clear the display
```

```
//tft.fillScreen(ST7735_BLACK);
// Print temperature
tft.setCursor(0, 45);
tft.setTextColor(ST7735_WHITE);
tft.setTextSize(1);
tft.print("Temperature2: ");
tft.print(bmp2.readTemperature());
tft.println(" C");
// Print pressure
tft.setCursor(0, 60);
tft.print("Pressure2: ");
tft.print(bmp2.readPressure());
tft.println(" Pa");
// Calculate altitude assuming 'standard' barometric
// pressure of 1013.25 millibar = 101325 Pascal
tft.setCursor(0, 75);
tft.print("Altitude2: ");
tft.print(bmp2.readAltitude());
tft.println(" meters");
delay(2000);
{
// read pressure value from BMP180
float pressure1 = bmp1.readPressure();
```

```
  float pressure2 = bmp2.readPressure();

  // check if pressure is greater than a certain value and turn on the relay if it is

  if (pressure1 > 101500 || pressure2 > 101500) {

    digitalWrite(RELAY_PIN, HIGH); // turn on relay

  } else {

    digitalWrite(RELAY_PIN, LOW); // turn off relay

  }

  // rest of the code to display temperature, pressure, altitude on the TFT display

}

}
```