NEAR EAST UNIVERSITY

FACULITY OF ENGINEERING

INFANT INCUBATOR

Levent ÜNLÜYÜCÜ

Murat AYDOĞDU

Gültekin BULUT

Graduation Project Thesis

Department Of Biomedical Engineering

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We Certify That This Thesis Is Satisfactory For The Award Of The Degree Of Bachelor Of Science (B, Sc.) In Biomedical Engineering

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ABSTRACT

An infant incubator is a piece of equipment common to pediatric hospitals, birthing centers and neonatal intensive care units. While the unit may serve several specific functions, it is generally used to provide a safe and stable environment for newborn infants, often those who were born prematurely or with an illness or disability that makes them especially vulnerable for the first several months of life.

Perhaps the most obvious function of an infant incubator is to protect infants during the earliest stage of life, when they're most vulnerable. As fully enclosed and controllable environments, incubators can be used to protect babies from a wide range of possible dangers. Incubators are fully temperature controlled, shielding infants from harmful cold, and they provide insulation from outside noise, making it easier for them to get plenty of comfortable rest. Incubator environments can be kept sterile, protecting infants from germs and minimizing the risk of infection. The enclosure also keeps out all airborne irritants like dust and other allergens. The cradle of the incubator is a roomy and comfortable surface, so it's possible to leave the infant in place while many examinations and even simple medical procedures are administered. This protects infants from too much handling, which can be a concern in the case of some premature births.

Design and development of microcontroller based temperature and humidity controller for an infant incubator monitors and controls these two parameters constantly which are very critical for the normal growth of the new born (premature) babies.

CONTENTS

LIST OF ABBREVIATIONS

°C. : Celsius degree

°F. : Fahrenheit degree

V. : Volt

W. : Watt

DC. : Direct current

AC. : Alternating current

A. : Amper

Hz. : Hertz

D. : Diode

L. : Transformer

R. : Resistor

C. : Capacitor

mm. : Milimeter

cm. : Centimeter

nF. : Nanofarad

µV. : Microvolt

mV. : Milivolt

Ω : Ohm

RAM. : Random Access Memory

LCD. : Liquid Crystal Display

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1. INTRODUCTION

Of the four million babies worldwide who die in the first month of life, one million die on their first day. Preterm birth is attributed, either directly or indirectly, to at least 25 percent of neonatal deaths, and low birth weight (LBW) newborns are at the greatest risk. About half of the worldwide total, or 1.8 million babies each year, die for lack of a consistent heat until they have the body fat and metabolic rate to stay warm. Premature infants are babies born prior to the normal 36 or 37 days and also they could have some problems with their respiratory systems so as the heart diseases. The majority of these deaths and diseases could be prevented if infants had access to high tech lifesaving infant incubators. Premature and problematic babies born could not keep a stable body temperature to the required level and in order to better their healthy conditions is required sterile environment, fresh air circulation, silence, enough humidity and temperature. For those necessary things is produced infant incubator. Sadly, first world incubators cost over $15,000 and cannot be serviced and maintained locally and are not designed for use in the challenging developing world market.

Figure 1.1. Infant Incubator

1.1. Infant Incubator

Infant incubator is a biomedical device which provides warmth, humidity, and oxygen all in a controlled environment as needed by the new born.

It provides a safe and clean environment, which has fresh air, clean and sterile ambient conditions for the babies. In addition to these, the incubator environment provides a homogeneous and stable temperature, a relative humidity (RH) level and oxygen gas concentration that are needed especially for intensive care of the premature baby. Since the incubator is a medical device and has a lot of limitations as other medical equipment, the most suitable humidity measurement and humidifying method have to be used. For continuous recording and control of the RH level, many kinds of electrical transducers can be employed such as resistive, capacitive, lithium chloride, electrolytic and integrated circuit (IC) type RH sensors which measure the RH level in the air [1].

Infant incubator is used mainly to keep a baby's core temperature stable at 37 degrees Celsius. The core temperature of the human body needs to be kept at a constant temperature of 37 degrees Celsius because the temperature goes too high or too low, then the organs can be damaged and illness or death can result. Premature babies (babies born before they are due to be born) have undeveloped nervous systems and also lack the energy to regulate their own temperature, which drop significantly because of heat loss from conduction (heat loss to cooler surfaces in direct contact with the infant), convection (heat loss to air moving past the infant), radiation (heat loss to cooler objects not in direct contact with the infant), and water evaporation (heat loss from the infant's lungs and skin surface). Whereas term neonates naturally regulate their body temperature to some extent, premature infants have thinner skin, which allows surface blood vessels to more readily lose heat to the environment; a large ratio of surface area to volume, resulting in greater heat losses from radiation and convection; and there is no subcutaneous fat to either metabolize into heat or act as an insulator. Prolonged cold stress in neonates can cause oxygen deprivation, hypoglycemia, metabolic acidosis, and rapid depletion of glycogen stores; therefore, energy conservation provided by thermal support is critical and hence their temperature needs to be maintained by an incubator [2].

We can only give small babies a small amount of food for growing. We want them to use all of their energy for growth rather than wasting it on keeping warm, so sometimes we use the incubator to help them grow faster. Every year, about 1 million infants in the developing world die due to heat loss and dehydration that can be prevented by an intensive care unit. Thus the function of the incubator is to compensate for these disadvantages and provide a congenial atmosphere for the infants. Incubators are fully temperature controlled, shielding infants from harmful cold, and they provide insulation from outside noise, making it easier for them to get plenty of comfortable rest. Incubator environments can be kept sterile, protecting infants from germs and minimizing the risk of infection [3].

- Taking care of babies with respiratory problems,
- Risk arising from pregnancy (diabetes, high blood pressure, kidney filure) car efor babies,
- At birth, the remaining oxygen (asphyxia) follow-up treatment of infants,
- Pre-mature babies lung enhancing agent (surfactant) inhaler implementation support,
- Follow-up and treatment of infected infants,
- Advanced age or follow-up and treatment of infants of mothers with very young.

1.2. History of Infant Incubator

The problem of premature and congenitally ill infants is not a new one. As early as the 17th and 18th centuries, there were scholarly papers published that attempted to share knowledge of interventions. It was not until 1922, however, that hospitals started grouping the newborn infants into one area, now called the Neonatal Intensive-Care Unit (NICU). Before the industrial revolution, premature and ill infants were born and cared for at home and either lived or died without medical intervention. In the mid-nineteenth century, the infant incubator was first developed, based on the incubators used for chicken eggs. Dr. Stephane Tarnier is generally considered to be the father of the incubator (or isolate as it is now known), having developed it to attempt to keep premature infants in a Paris maternity ward warm. Other methods had been used before, but this was the first closed model; in addition, he helped convince other physicians that the treatment helped premature infants. France became a forerunner in assisting premature infants, in part due to its concerns about a falling birth rate. After Trainer retired, Dr. Pierre Budin, followed in his footsteps, noting the limitations of infants in incubators and the importance of breast milk and the mother's attachment to the child. [4].

Budin is known as the father of modern perinatology and his seminal work The Nursling (Le Nourisson in French) became the first major publication to deal with the care of the neonate. Another factor that contributed to the development of modern neonatology was thanks to Dr. Martin Couney and his permanent installment of premature babies in incubators at Coney Island. A more controversial figure, he studied under Dr. Budin and brought attention to premature babies and their plight through his display of infants as sideshow attractions at Coney Island and the World's Fair in New York and Chicago in 1933 and 1939, respectively [4].

French physician Alexandre Lion's incubator, patented in 1889, was commonly used in baby incubator exhibits at expositions. These incubators varied greatly from the infant incubators utilized in modern neonatal intensive care units. The A-Y-P's incubators regulated the temperature inside the unit and pulled in outside air for ventilation, nothing more. They would have been beneficial to well preemies needing no special care beyond steady warmth. The incubators exhibited at fairs and expositions had no ability to aid babies who could not breathe on their own, and there was at the time (and for many subsequent decades) no therapy for such children [4] .

Neonatal Intensive Care Units were established in hospitals to take care of sick and premature babies. Even before that it was only in the 1930's that incubators were set up in hospitals at all. The first incubators developed in 1860 looked like an old-fashioned stove and was similar to the incubators used for chicken eggs. The main purpose was to keep newborn babies bodies at proper temperatures. In 1889 a Doctor Alexandre Lion created an incubator made of glass that was see through. He also adapted an automatic heating system for it so that it didn't have to be constantly monitored and the babies could be cared for more easily. Unfortunately these incubators were extremely expensive and difficult to create, and hospitals could not justify the use of them. Few people could afford it on their own and the care of babies, especially premature babies was still something that most doctors and hospitals did not deal with.

In order to build funding for his invention which was proven to increase premature infant survival rate to 72%, Dr. Lion started displaying the incubators with live babies as an exhibit. They were put in store-fronts on busy streets throughout France. The babies were displayed as a sideshow and people were charged admission to see them. The incubators were advertised as “The Amazing Mechanized Mom”.

It may seem a bit appalling, however for desperate parents who wanted to save their baby it was free medical care and the best chance for survival.

Figure 1.2. First Incubator

1.3. Types Of Infant Incubator

An incubator is basically a controlled micro-environment where the baby's needs are all met and vital signs can be carefully monitored. The incubator provides oxygenation or even mechanical ventilation (in cases of respiratory failure), optimum temperature, humidity and fluid balance, isolation from infection, and constant observation of heart rate, blood pressure, body temperature or any other signs that might indicate a problem.

1.3.1. Transport Incubator

Babies that need to be transported between hospitals or from one area of the facility to another are often carried in an incubator; for this reason, many incubators are designed with portability in mind. Some incubators are double-walled to provide better insulation.

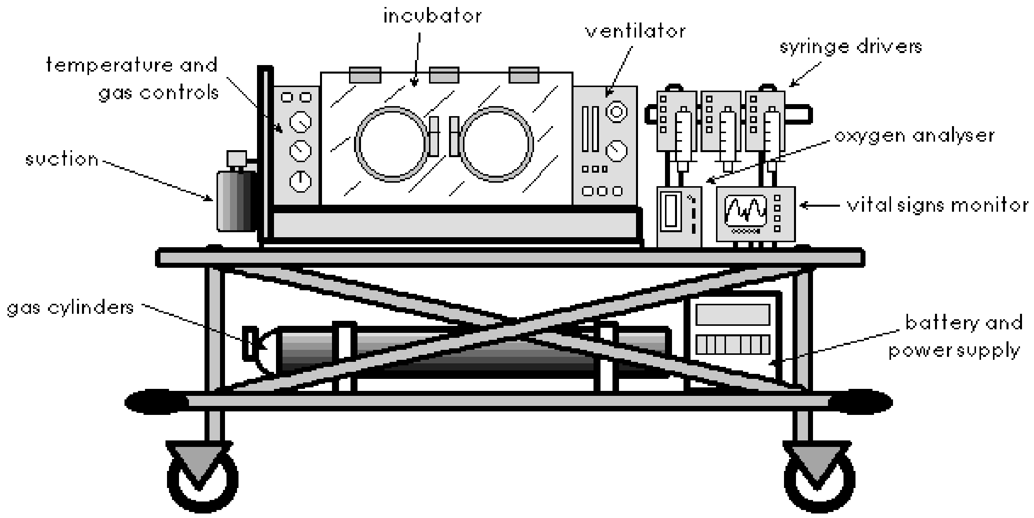


Figure 1.3. Transport Incubator

1.3.2. Radiant Warmer Infant Incubator

Incubators and radiant warmers are used to maintain the body temperature of newborn infants. This is best done so that the energy expended for metabolic heat production is minimized. The heat output of these devices is usually regulated by servo control to keep the skin temperature constant at a site on the abdomen where a thermistor probe is attached.

In incubators, air temperature can also be controlled as an alternative to skin temperature servo control. Increased ambient humidity, heat shields and clothing have been used to decrease the evaporative or no evaporative heat loss of infants in incubators under certain conditions. Double-walled incubators, by adding a second inner layer of Plexiglas, reduce radiant heat loss. They may also reduce total heat loss, but only if air temperature is controlled rather than skin temperature. The minimal oxygen consumption under a radiant warmer is the same or perhaps slightly higher than it is for the same infant in an incubator. Compared with incubators, the partition of body heat loss is quite different under radiant warmers. Radiant warmers increase convective and evaporative heat loss and insensible water loss but eliminate radiant heat loss or change it to net gain. A heat shield of thin polyethylene film can be used with a radiant warmer to reduce heat loss by convection and evaporation. The major advantage of the radiant warmer is the easy access it provides to critically-ill infants without disturbing the thermal environment. Its major disadvantage is the increase in insensible water loss produced by the radiant warmer. Most infants can be safely and adequately cared for in either incubator or radiant warmer bed. A 400 watt radiant warmer placed 50 cm. above the baby will be sufficient. This method is effective only if the room temperature is kept high (above 25 °C/77 °F). Spot lights or bulbs are dangerous because they focus the heat and may burn the baby [5].

However radiant heaters have several disadvantages:

- If a baby is left for a prolonged period under a radiant heater it risks becoming dehydrated if enough fluids are not given, especially if it is very premature.
- If the temperature of the radiant heater is not monitored adequately, there is also a risk of overheating or first degree burns.
- There should never be more than one baby under one lamp because of the risk of cross infection and of unequal heat distribution causing some babies to be too warm and others not warm enough.

Thus radiant heaters should only be used for short periods - for example, in the delivery room, for resuscitation or during procedures in intensive care units. This method of heating should be replaced by other alternatives as soon as possible. The equipment must have a temperature control that is either automatic or manual or both.

It is essential that the newborn's axillary temperature be taken frequently to ensure that it is not becoming either cold or overheated, and the temperature of the radiant heater should be adjusted if necessary.

Figure 1.4. Radiant Warmer infant incubator

1.3.3. Servo-Controlled Incubators

The servo control system adjusts the environmental temperature to keep the skin temperature constant. Changes in incubator temperature must be observed since the neonate's skin temperature will not change. Air-heated incubators are widely used for the care of very small and sick newborns. They provide a clean, warm environment, where the temperature and humidity can be controlled and oxygen can be supplied if necessary. Incubators also allow easy observation of the naked infant if necessary, and isolation. Incubators have numerous advantages moreover nursing staff must regulate and record the incubator air temperature regularly. Even if the incubator has heat-sensitive probes that monitor skin temperature, nursing staff must take the baby's body temperature regularly (every 4-6 hours) and adjust the temperature of the incubator if necessary to ensure that the newborn maintains normal body temperature. It should be possible to regulate the air temperature inside the incubator between 30-37 °C (86-98.6 °F).

Staff should make use of the port-holes and small inlets in the incubator as far as possible, because opening the main lid or canopy allows much of the warm air to escape and the baby will be exposed to cold.

Nursing staff should follow instructions such as [6];

- Set the temperature control to maintain the neonate's temperature within the normal range. Usually a set point of 36.5 ^{0}C (97.7 ^{0}F) skin temperature will maintain a normal temperature.
- Care should be taken to prevent the probe from coming off the skin. If this should occur, the unit will sense a lower temperature and increase the environmental temperature, possibly over-heating the neonate.
- Use closed sleeves in portholes to prevent heat loss.
- Keep incubator away from cold walls, air currents, windows and other cold objects.
- With neonates less than 1500 grams, use a heat shield over the neonate or a double walled incubator to decrease radiant heat loss and oxygen consumption.
- VLBW neonates may require use of a Heating pad in conjunction with methods described above to maintain temperature ideally. These neonates should be cared for in a servo control incubator. Both the ambient temperature and the neonate's temperature should be recorded and compared together, to avoid masking of the neonate's true condition.
- Both these temperatures should be stable in order to state that the neonate's temperature is stable. If a neonate starts to become febrile, the incubator temperature drops, but there is no change in body temperature. Alternately, a decreasing body temperature would be corrected and held steady by an increase in the servo controlled ambient temperature. These changes in the neonate may be detected by noting changes in the environmental temperature.

1.3.4. Manually Controlled Incubator

The temperature in an incubator may be controlled by a thermostat. This keeps the environment at a set temperature and allows one to monitor the neonate's temperature.

The temperature is set to provide a neutral thermal environment. Instructions should be followed;

- Appropriate start temperatures and temperature ranges should be selected.
- Neonates in manually controlled incubators shouldn't be wrapped in blankets except for weaning to an open crib.
- Use closed sleeves in portholes to prevent heat loss.
- Keep incubator away from cold walls, air currents, windows and other cold objects.
- With neonates less than 1500 grams, use a heat shield over the neonate or a double walled incubator to decrease radiant heat loss and oxygen consumption.
- VLBW neonates may require use of a heating pad in conjunction with methods described above to maintain temperature ideally. The incubator's ambient temperature should be recorded simultaneously with the neonate's axillary or skin temperature so that changes in the neonate's temperature can be interpreted appropriately.

1.4. Our Purpose

Baby Incubator is one of the quite essential life supportive equipment for the premature babies in the hospitals. Unfortunately, there is a lack of low cost infant incubators in the developing world. The aim of the thesis is to design and develop a microcontroller based temperature control using Aurduino Uno kit, temperature and humidity control, alarm system.

Advances in electronic techniques coupled with economical prices make humidity and temperature control cost-effective with highly accurate and stable performance. In this work main focus will be to;

- Design and develop hardware for temperature and humidity control,
- The development of software using Aurduino kit.

The developed system should be accurate, economical, user friendly and must provide the required environment for the growth of the premature baby. So that we can provide the lower cost to use it for 3rd World countries.

1.5. Basıc Instrumentation System Of Devıce

The primary purpose of medical instrumentation system is to measure or determine the presence of some physical quantity that may some way assist the medical personnel to make better diagnosis and treatment. The basic block diagram is shown in figure below;

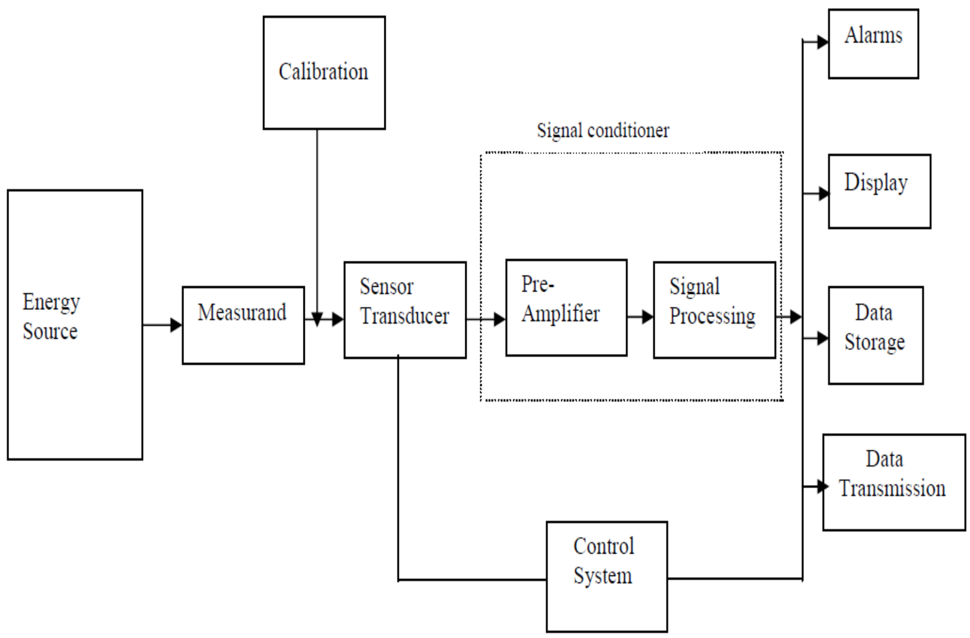


Figure 1.5. Block diagram of bio-medical instrumentation system

1.5.1. Measurand

The physical quantity or condition that the instrumentation system measure is called measurand. The source for the measurand is the human body, which generates a variety of signals.

1.5.2. Transducer / Sensor

A transducer converts one form of energy to another. The primary function of the transducer is to provide a usable output in response to the measurand, which may be a specific physical quantity, property or condition.

Basically, a sensor converts a physical measurand to an electrical signal. Depending on the transducer, the output produced is in the form of voltage, current, resistance, or capacitance. The sensor should be minimally invasive and interface with the living system with minimum extraction or energy. The primary function of the transducer is to provide a usable output in response to the measurand.

1.5.3. Signal Conditioner

For interfacing analog signals to the microprocessor or microcontroller, use is made of some kind of data acquisition system. The function of the system is to acquire and digitize data, often from hostile clinical environments, without any degradation in the resolution or accuracy of the signal. Signal conditioner converts the output of the transducer into an electrical quantity suitable for operation of the display or recording system or control purposes. Signal conditioning usually includes functions such as amplification, conversion analog to digital or signal transmission circuitry. Buffer amplifier help in increasing the sensitivity of instruments by amplification of the original signal or its transduced form. The A/D converter carries out the process of the analog to digital conversion. The higher the no of bits, the higher the precision of conversion. Since software costs generally far exceed the hardware costs, the analog or digital interface structure must permit software effective transfers of data and command and status signals to avail of the full capability of the micro controller.

1.5.4. Display System

A visible representation of the quantity. It may be on the chart recorder, or on the screen of a cathode tube or in numeric form or LCD display.

1.5.5. Alarm System

With upper and lower adjustable thresholds to indicate when the measurand goes beyond present limits.

1.5.6. Data Transmission

Standard interface connections can be used so that the information obtained may be carried to other parts of an integrated system or to transmit from one location to another.

1.5.7. Data Storage

To maintain the data for future reference. It may be a hard copy on a paper or on magnetic or semiconductor memories.

1.5.8. Control System

It controls all the operations of the instrument. It consists of a microprocessor or a micro-controller and software stored inside it to provide the necessary controls. The control logic provides the necessary interface between the microcontroller system and the elements of the acquisition unit in providing the necessary timing control. It has to ensure that the correct analog signal is selected, samples data at correct time, initiate the A/D conversion process and signals to the microcontroller or microprocessors on completion of conversion.

2. LITRATURE SURVEY

2.1. Premature Infant Physiology

Premature infants are babies born prior to the normal 36 or 37 weeks of gestation within the womb. As a result, their physiological systems are underdeveloped making the infant vulnerable to a number of health complications. Some common problems include jaundice caused by an immature liver, respiratory complications caused by fragile, underdeveloped lungs, and hypoglycemia, hypoxia and even death caused by an immature response of the nervous system to cold stress. These inadequate thermoregulations, wherein their physiology is not able to compensate for the heat they lose from the body are by far the leading causes of death in premature infants. Heat is lost via evaporative, conductive, convective and radioactive means. Premature infants lack muscle mass, which allows adults to shiver and produce heat when necessary, as well as heat generating brown fat, which makes up about 5% of the body weight in preterm infants. This heat loss is enhanced by their large surface area to volume ratio (about 4 times the adult ratio). Furthermore, their immature skin allows for excessive water loss from the body causing a considerable evaporative heat loss and a potentially fatal imbalance of salts and acids in the infant's system. In evaporative heat loss, moisture from the body first diffuses across the epidermis (general outer layer of skin). Then it evaporates off from the skin's surface cooling the infant. Premature infants have a thin, underdeveloped stratum corneum, or the rough, outer layer of the epidermis which protects the skin from external agents, that enables excess of water to diffuse out.

2.2. Thermal Protection In New Born

Thermal protection of the newborn is the series of measures taken at birth and in the first days of life to ensure that the newborn does not become either cold or overheated and maintains a normal body temperature of 36.5 - 37.5 °C (97.7 - 99.5 °F). Since the consequences of an environment that is too cold or too warm are serious, it is important to know what is the optimal - i.e. the most suitable - thermal environment for the new born baby. This is the range of thermal conditions under which a new born baby can maintain normal body temperature. The range is narrow, especially in low birth weight or sick babies. Basically speaking, the smaller and more premature the new born is, the less it tolerates cold and heat. Thus there is no single environmental temperature that is appropriate for all sizes, gestational ages and conditions of new born babies. What is appropriate for a healthy baby is too cold for a preterm baby, and what is appropriate for the preterm baby is too hot for the preterm infant.

The newborn cannot regulate its temperature as well as an adult. It therefore cools down or heats up much faster and is able to tolerate only a limited range of environmental temperatures. The smaller the new born, the greater the risk. Thermal stability improves gradually as the baby increases in weight. The temperature inside the mother's womb is 38 °C (100.4 °F). Leaving the warmth of the womb at birth, the wet new born finds itself in a much colder environment and immediately starts losing heat thus the thermal protection of newborns is very important but not difficult. The basic principles are the same whether the baby is born at home or in an institution. As most cooling of the newborn occurs during the first minutes after birth, it is important to act quickly to prevent heat loss. The new born baby loses heat in four different ways. Heat loss is mainly due to evaporation of amniotic fluid from the baby's body. But loss of body heat also occurs by conduction if the baby is placed naked on a cold surface (e.g. a table, weighing scale or cold mattress); by convection if the naked new born is exposed to cooler surrounding air; and by radiation from the baby to cooler objects in the vicinity (e.g. a cold wall or a window) even if the baby is not actually touching them.

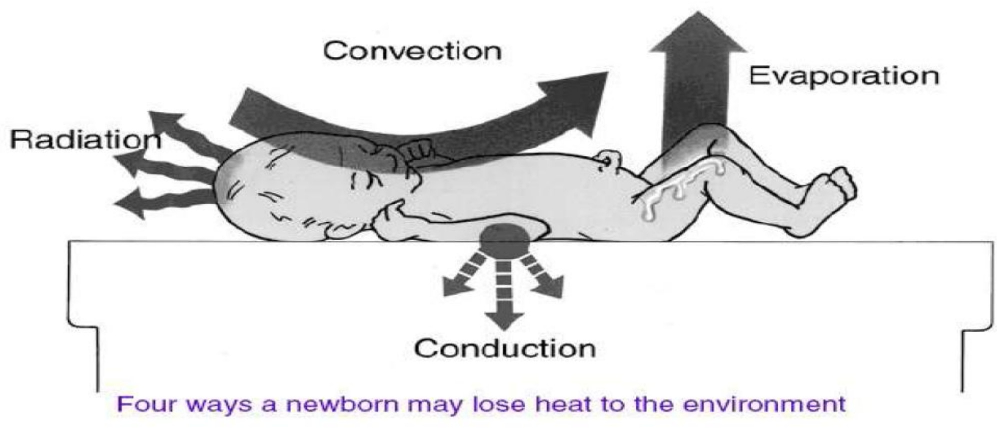


Figure 2.1. Heat losses

Heat loss increases with air movement, and a baby risks getting cold even at a room temperature of 30 °C (86 °F) if there is a draught. Most cooling of the new born occurs during the first minutes after birth. In the first 10 - 20 minutes, the new born who is not thermally protected may lose enough heat for the body temperature to fall by 2 - 4 °C (3.6 - 7.2 °F), with even greater falls in the following hours if proper care is not given. If heat loss is not prevented and is allowed to continue, the baby will develop hypothermia, i.e. a body temperature below normal. A hypothermic baby, especially if it is small or sick, is at increased risk of developing health problems and of dying. However, if heat loss is prevented, the new born will stay warm and will have a much better chance of remaining healthy, or of surviving if it is already sick. In trying to keep babies warm, it is important to make sure they do not become overheated. The mechanisms described above may act in reverse and cause hyperthermia, i.e. a body temperature above normal. Although less common, hyperthermia is as dangerous as hypothermia.

2.3 Cold Stress or Hypothermia

Cold stress in the neonatal period can be defined as a body temperature measurement less than 36.5 °C (97.6 °F) rectally with system wide associated. The normal responses to cold stress for the adult are either not present or not adequately effective for the neonate.

Full term neonates have a very limited ability to shiver to produce heat and preterm infants have none. Additionally, preterm neonates have unstable vasomotor responses and therefore cannot vasoconstrictor adequately to slow down heat losses. Preterm infants have limited stores of brown fat and therefore inadequately produce heat metabolically.

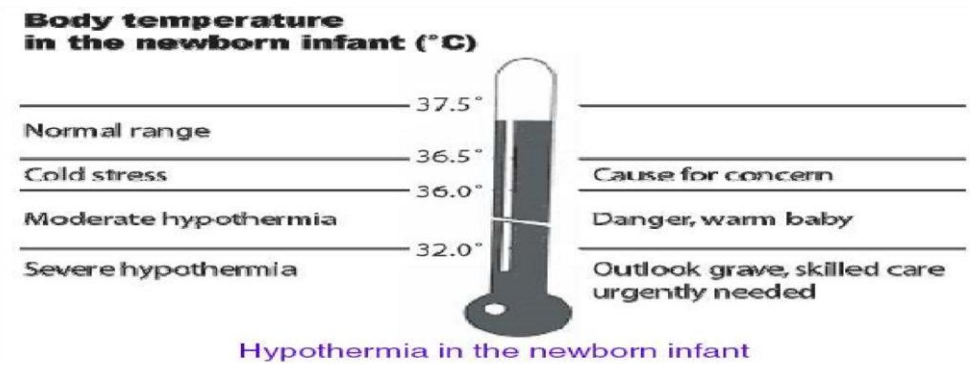


Figure 2.2. Temperature ranges in Hypothermia

While in the adult model, control of body temperature is achieved by a complex system which via negative feed-back basically creates a balance between heat production, heat gain and heat loss. The key of this system is a central controller located in the hypothalamus and limbic system, which based on information from central and peripheral thermo receptors (multiple-input), controls the action of the so-called effectors: thermogenesis, the vasomotor system, sweat secretion and thermoregulatory behavior, through the efficient nervous system. Body temperature therefore is the result of the combined action of the detectors, controller system and the effectors. In the case of newborn infants, especially preterm infants, immaturity of the thermoregulatory system makes the infant more vulnerable to changes of environmental temperature. In the infant model, the physiology of the response to cold stress is related to the oxidation of brown fat or Brown adipose tissue. In full term newborn infants, non-shivering thermogenesis (oxidation of brown adipose tissue) is the major route of a rapid increase of heat production in response to cold exposure. The consequences of cold stress can be quite severe [7].

As the body temperature decreases, the baby becomes less active, lethargic, hypotonic, sucks poorly and their cry becomes weaker. Respiration becomes shallow and slow and the heart-beat decreases. Sclerema hardening of skin with redness – develops mainly on the back and the limbs. The face can also become bright red. As the condition progresses it causes profound changes in body metabolism resulting in impaired cardiac function, hemorrhage (especially pulmonary), jaundice and death [8].

2.4. Management of Cold Stress

Newborns found to be hypothermic must be rewarmed as soon as possible. The temperature of the room where the rewarming takes place should be at least 25 °C (77 °F). Cold clothes should first be removed and replaced with pre-warmed clothes and a cap. The newborn should be quickly rewarmed; if a warming device is used, the baby should be clothed and its temperature should be checked frequently during the rewarming process. It is very important to continue feeding the baby to provide calories and fluid. Breast-feeding should resume as soon as possible. If the infant is too weak to breast feed, breast milk can be given by nasogastric tube, spoon or cup. It is important to be aware that hypothermia can be a sign of infection. Every hypothermic newborn should therefore be assessed for infection. In hospital a diagnosis of hypothermia is confirmed by measuring the actual body temperature with a low-reading thermometer, if available. The method used for rewarming depends on the severity of the hypothermia and the availability of staff and equipment. In cases of mild hypothermia (body temperature 36.0 - 36.4 °C / 96.8 - 97.5 °F), the baby can be rewarmed by skin-to-skin contact, in a warm room (at least 25 °C / 77 °F). In cases of moderate hypothermia (body temperature 32 - 35.9 °C /89.6 - 96.6 °F) the clothed baby may be rewarmed;

- Under a radiant heater,
- In an incubator, at 35 - 36 °C (95 - 96.8 °F),
- By using a heated water-filled mattress,
- In a warm room; the temperature of the room should be 32 - 34 °C / 89.6 – 93.2 °F (more if the baby is small or sick),
- In a warm cot: if it is heated with a hot water bottle or hot stone, these should be removed before the baby is put in,
- If nothing is available or if the baby is clinically stable, skin-to-skin contact with the mother can be used in a warm room (at least 25° C / 77° F).

The rewarming process should be continued until the baby's temperature reaches the normal range. The temperature should be checked every hour, and the temperature of the device being used or the room adjusted accordingly. The baby should continue to be fed.In cases of severe hypothermia (body temperature below 32° C / 89.6° F), studies suggest that fast rewarming over a few hours is preferable to slow rewarming over several days. Rapid rewarming can be achieved by using a thermostatically controlled heated mattress set at 37 - 38° C (98.6 - 100.4° F) or an air-heated incubator, with the air temperature set at 35-36° C (95 - 96.8° F). If no equipment is available, skin to - skin contact or a warm room or cot can be used. Feeding should continue, to provide calories and fluid and to prevent a drop in the blood glucose level which is a common problem in hypothermic infants. If this is not possible, monitoring blood glucose becomes important and an intravenous line should be set up to administer glucose if needed. Once the baby' s temperature reaches 34 °C (93.2 °F), the rewarming process should be slowed down to avoid overheating. The temperature of the incubator and the baby' s body temperature should be checked every hour [5].

2.5. Hyperthermia

Hyperthermia can be defined as a rectal temperature greater than 37.0 °C (98.6 °F). Determination of an external source of heat gain versus an actual febrile state can be made by observing for peripheral vasoconstriction as demonstrated by a higher rectal temperature versus a distal temperature of the foot. In the presence of overheating, the opposite would occur. Hyperthermia should not be confused with fever, which is a raised body temperature in response to infection with microorganisms or other sources of inflammation. However, it is not possible to distinguish between fever and hyperthermia by measuring the body temperature or by clinical signs, and when the newborn has a raised temperature it is important to consider both causes. Infection should always be suspected first, unless there are very obvious external reasons for the baby becoming overheated. Hyperthermia can cause increased metabolic demands for the neonate. The neonate may have increased oxygen requirements, apnea, dehydration, metabolic acidosis and in worse case scenarios heat stroke, brain damage, shock and death [5].

2.6. Management of Hyperthermia

The baby should be moved away from the source of heat, and undressed partially or fully, if necessary. If the baby is in an incubator, the air temperature should be lowered. It is important that the baby be breast-fed more frequently to replace fluids. Every hyper thermic baby should be examined for infection. When hyperthermia is severe i.e. body temperature above 40 °C (104 °F) the baby can be given a bath. The water should be warm. If it is possible to measure the water temperature, it should be about 2 °C (3.6 °F) lower than the baby's body temperature. Using cooler or cold water is dangerous. It may not achieve the desired effect and the baby may very quickly become hypothermic. If the baby cannot breast-feed extra fluids should be given intravenously or by tube.

3. INADEQUACY OF CURRENT DEVICES

There is currently a wide range of incubators available to developing countries. Although each one is very beneficial in one or more areas, they all have specific areas where they need improvement. Our goal is to find a good balance to try and incorporate these benefits into one single incubator. One example of a low-cost solution is the embrace 4 infant warmer. There are many downfalls to this $25 design. First of all, it does not have any form of temperature control. It also does not have any protection against infections and since it has no light source, it cannot help with jaundice. Lastly, it does not allow for the baby's body to be easily observed, as can be done with more traditional incubators, and is extremely important, as many of the infants in the most need of warmth are pre-mature infants, which often face many other complications. Given this downfalls, it is extremely cost efficient, which can sometimes be the determining factor when budgets are thin. Another example is the "car part" incubator. This solution, while mildly low-cost (still $1,000/incubator), requires working parts from vehicles (and no one wants to take parts from a working vehicle). It also has not been tested for its ability to prevent infections and does not allow direct access to the infant through "sleeves", as does many current incubators. It is also fairly complicated to build and does not have a humidifier. The main advantage of this system is that all of the parts should be locally available. A third example (and the best one we could find) is the HEBI6 (Hemel Baby Incubator). This incubator costs around $500, not including the light bulbs, and it must be shipped from the Amsterdam airport [9].

It prevents infections (and claims to do this better than most modern incubators, despite the fact that it's made of wood) and has sleeves to access the infant, but it does not have fine temperature control as it is heated solely by turning on/off the lightbulbs. Another incubator that was developed for use in Haiti, after the devastating earthquake this past winter was the suitcase incubator. Although there is not much information on how it was made, there are many advantages and disadvantages that can be determined based on this idea. First of all, it is extremely portable, which is more convenient for short term use, as opposed to a more long-term use in a developing country's hospital. It must be relatively cheap since you would simply use a suitcase as a shell. It is unclear how well insulated this could be, or how well it could circulate the air while preventing infections [9].

4. MATERIAL NEEDED

4.1 Aurduino Uno Kit

Aurduino is an open source electronics prototyping platform based on flexible, easy tousle hardware and software. It's intended for artists, designers, hobbyists, and Aurduino can sense the environment by receiving input from a variety of sensors and can affect its surroundings by controlling lights, motors, and other actuators. The microcontroller on the board is programmed using the Aurduino programming language (based on wiring) and the Aurduino development environment (based on Processing). Aurduino projects can be stand alone or they can communicate with software running on a computer. Anyone interested in creating interactive objects or environments. Aurduino boards can be purchased preassembled or do it oneself kits. Hardware design information is available for those who would like to assemble an Aurduino by hand. There are sixteen official Aurduino that have been commercially produced to date [10].

The Aurduino Uno is a microcontroller board based on the ATMEGA328 (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz. ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller simply connect it to a computer with a USB cable or power it with a AC. to DC adapter or battery to get started [10].

The Uno differs from all preceding boards in that it does not use the FTDI USB to serial driver chip. Instead, it features the ATMEGA16U2 (ATMEGA8U2 up to version R2) programmed as a USB - to - serial converter. Revision 2 of the Uno board has a resistor pulling the 8U2 HWB line to ground, making it easier to put into DFU mode. Revision 3 of the board has the following new features;

- Pin out: Added SDA and SCL pins that are near to the AREF pin and two other new pins placed near to the RESET pin, the IOREF that allow the shields to adapt to the voltage provided from the board. In future, shields will be compatible both with the board that uses the AVR, which operate with 5 V. and with the Aurduino Uno that operate with 3.3 V. The second one is a not connected pin that is reserved for future purposes.

- Stronger reset circuit.
- ATMEGA 16U2 replace the 8U2. The Aurduino Uno can be powered via the USB connection or with an external power supply. The power source is selected automatically. External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) or battery. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the Ground and Vin pin headers of the power connector.

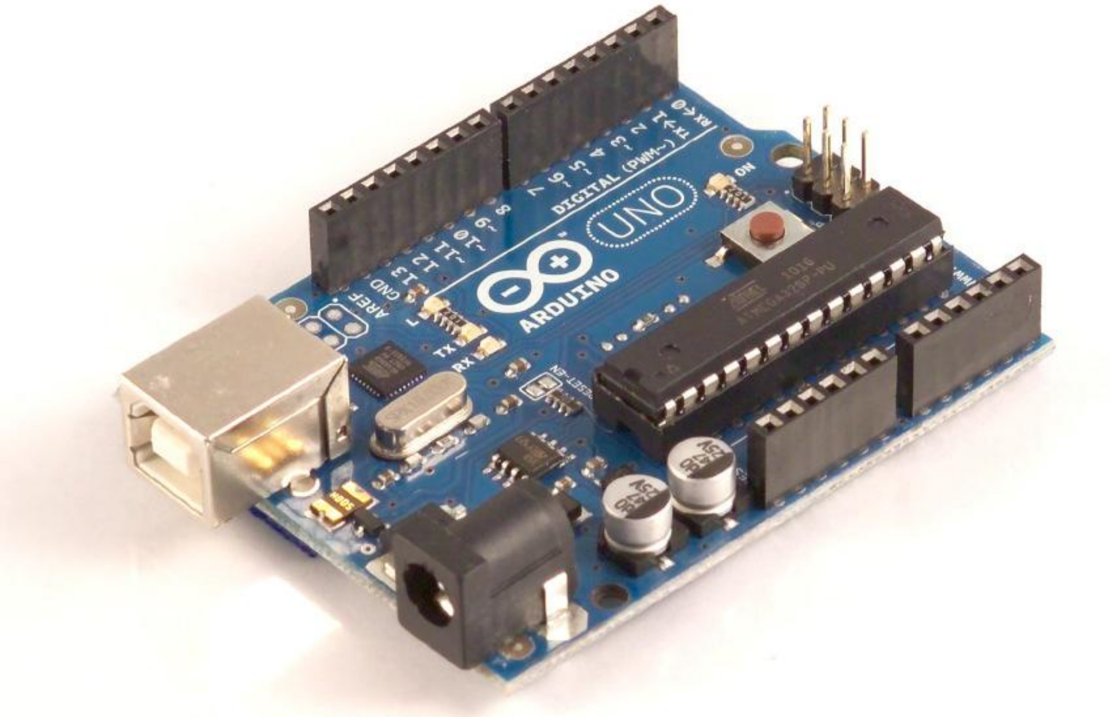


Figure 4.1. Aurduino Uno Kit

4.1.1. Power

The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7 V. , however, the 5 V. pin may supply less than five volts and the board may be unstable. If using more than 12V. , the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts [11].

The power pins are as follows;

- **VIN:** The input voltage to the Aurduino board when it's using an external power source (as opposed to 5 volts from the USB connection or other regulated power source). You can supply voltage through this pin, or, if supplying voltage via the power jack, access it through this pin.
- **5 V. :** This pin outputs a regulated 5 V. from the regulator on the board. The board can be supplied with power either from the DC power jack (7-12 V.), the USB connector (5 V.), or the VIN pin of the board (7-12 V.). Supplying voltage via the 5V. or 3.3 V. pins by passes the regulator, and can damage your board. We don't advise it.
- **3.3 V. :** A 3.3 volt supply generated by the on-board regulator. Maximum current draw is 50 mA.
- **GND. :** Ground pins.

4.1.2. Memory

The ATMEGA328 has 32 kB. (with 0.5 kB. used for the boot loader). It also has 2 kB. of SRAM and 1 kB. of EEPROM (which can be read and written with the EEPROM library) [11].

4.1.3. Input and Output

Each of the 14 digital pins on the Uno can be used as an input or output, using pin Mode, digital Write, and digital Read functions. They operate at 5 volts. Each pin can provide or receive a maximum of 40 mA. and has an internal pull up resistor (disconnected by default) of 20-50 K. ohms. In addition, some pins have specialized functions [11]:

- **Serial:** 0 (RX) and 1 (TX). Used to receive (RX) and transmit (TX) TTL serial data.

These pins are connected to the corresponding pins of the ATMEGA8U2 USB-to-TTL Serial chip.

- **External Interrupts:** 2 and 3. These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change in value. See the attach Interrupt () function for details.
- **PWM:** 3, 5, 6, 9, 10, and 11. Provide 8-bit PWM output with the analog write function.
- **SPI:** 10(SS), 11(MOSI), 12(MISO) and 13(SCK). These pins support SPI communication using the SPI library.
- **LED:** There is a built in LED connected to digital pin 13. When the pin is HIGH value, the LED is on, when the pin is LOW, it's off.

The Uno has 6 analog inputs, labeled A0 through A5, each of which provide 10 bits of resolution. By default they measure from ground to 5 volts, though is it possible to change the upper end of their range using the AREF pin and the analog Reference function. Additionally, some pins have specialized functionality:

- **TWI:** A4 or SDA pin and A5 or SCL pin. Support TWI communication using the Wire library. There are a couple of other pins on the board:
- **AREF:** Reference voltage for the analog inputs. Used with analog Reference.
- **Reset:** Bring this line LOW to reset the microcontroller. Typically used to add a reset button to shields which block the one on the board.

The Aurduino Uno has a number of facilities for communicating with a computer, another Aurduino, or other microcontrollers. The ATmega328 provides UART TTL (5V) serial communication, which is available on digital pins 0 (RX) and 1 (TX). An ATmega16U2 on the board channels this serial communication over USB and appears as a virtual com port to software on the computer. The 16U2 firmware uses the standard USB COM drivers, and no external driver is needed. However on Windows, a.inf file is required [12].

The Aurduino software includes a serial monitor which allows simple textual data to be sent to and from the Aurduino board. The RX and TX LEDs on the board will flash when data is being transmitted via the USB to serial chip and USB connection to the computer (but not for serial communication on pins 0 and 1). A Software Serial library allows for serial communication on any of the Uno's digital pins. The ATMEGA328 also supports I2C (TWI) and SPI communication. The Arduino software includes a Wire library to simplify use of the I2C bus [12].

The Arduino Uno is a microcontroller board based on the ATMEGA328 (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz. crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the ATMEGA8U2 programmed as a USB-to-serial converter [12].

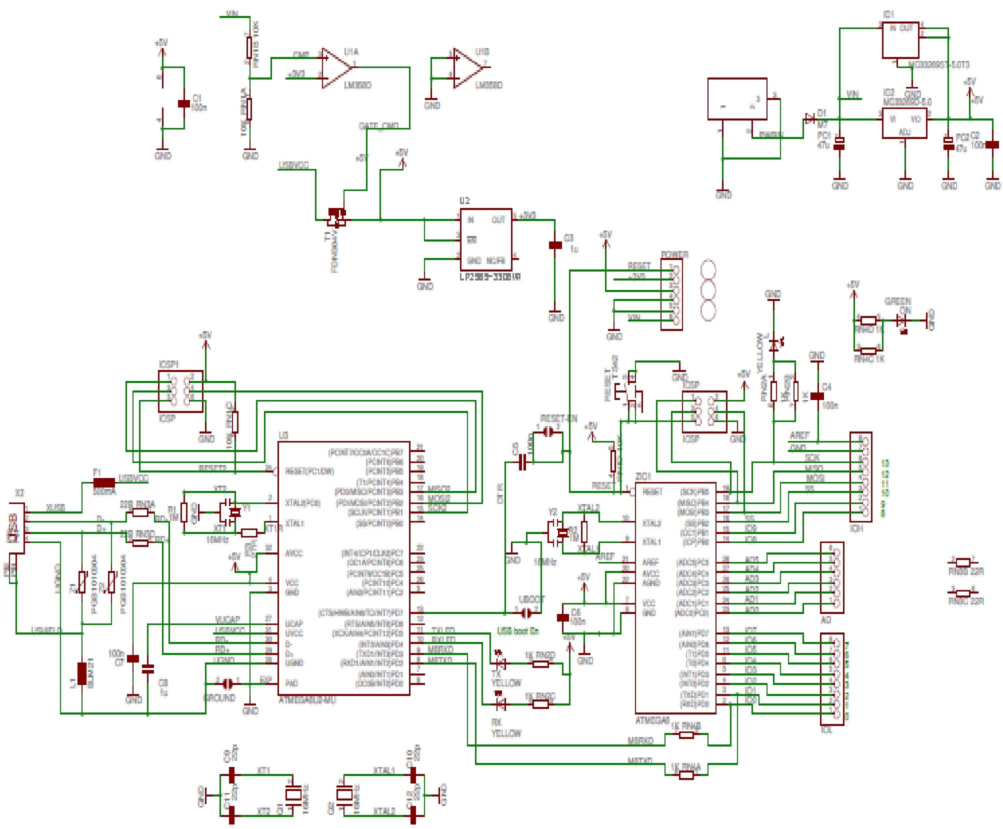


Figure 4.2. Schematic diagram of Aorduino

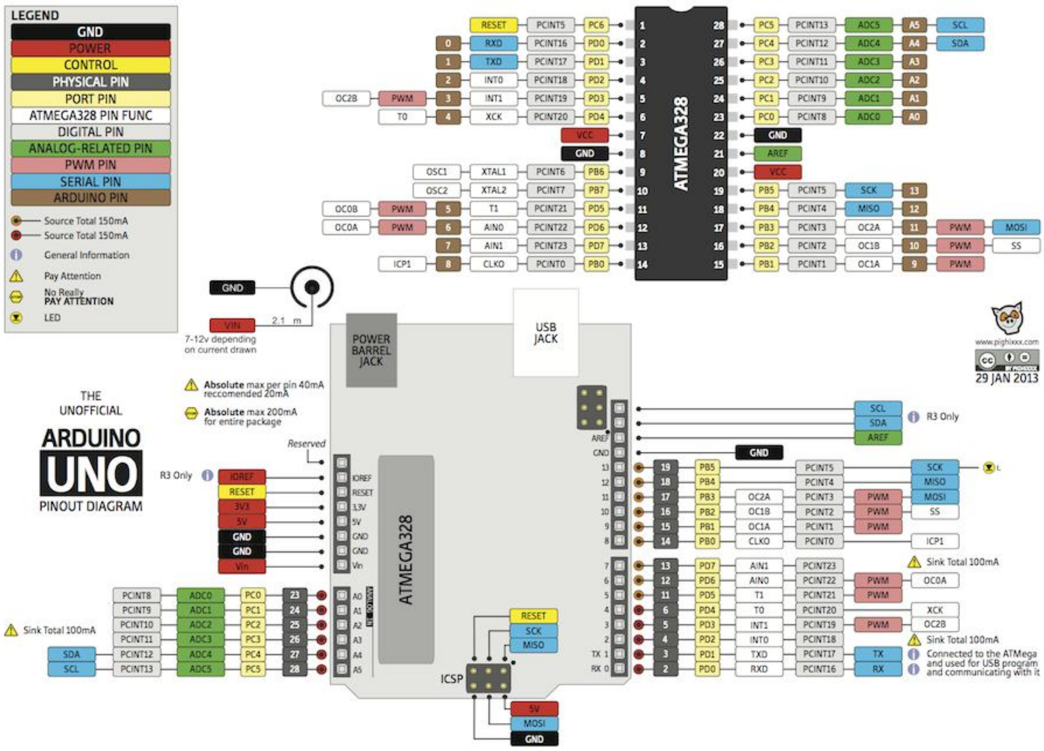


Figure 4.3. Pin out diagram of Aorduino

4.2 Phototherapy

Phototherapy (light therapy) is a way of treating jaundice. Special lights help break down the bilirubin in your baby's skin so that it can be removed from his or her body [13].

This lowers the bilirubin level in your baby's blood During phototherapy, the bilirubin level in your baby's blood will be checked at least once every day. Phototherapy is stopped when the bilirubin level decreases [13].

There are two ways to give phototherapy;

- Using a “biliblanket”, a covered pad with flexible tubes of lights,
- Using a phototherapy light, a special spotlight above an incubator.

Your baby's doctor will decide which method of phototherapy is best for baby. The biliblanket and phototherapy spotlight are often used together.

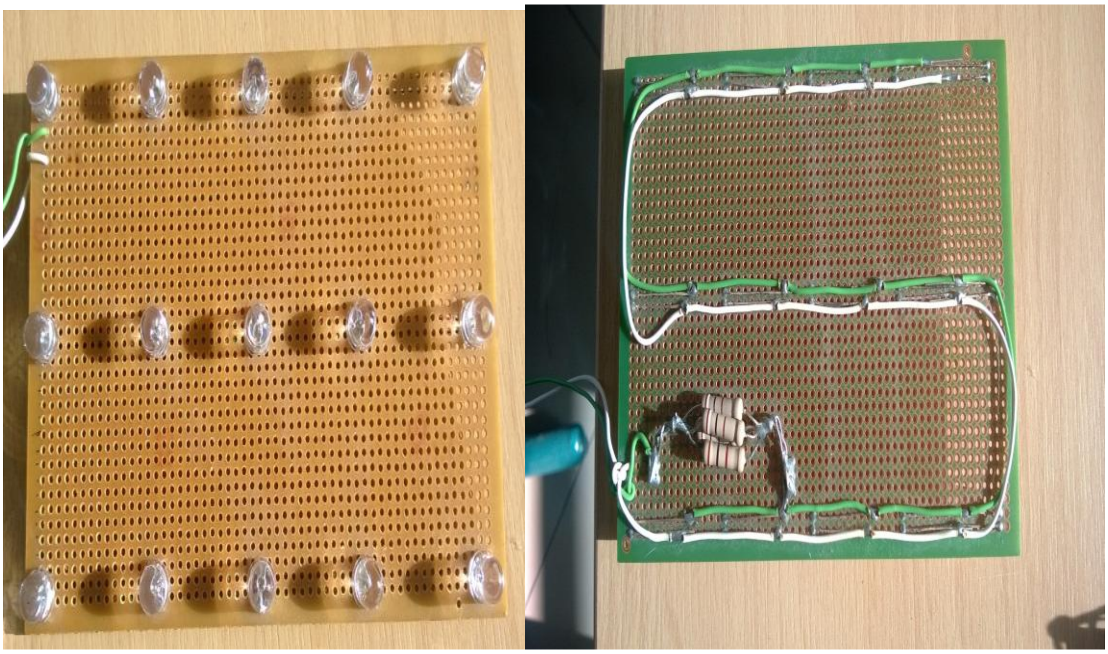


Figure 4.4. Ultraviolet leds for phototheraphy

4.3 Liquid Crystal Display (LCD)

The system has been designed to monitor the temperature of infants body and humidity of the chamber so that the new born baby can get similar environment as it get when its in mother's womb. To display the parameters LMB162A is used. The block diagram of Liquid Crystal Display (LCD) is shown in figure [14].

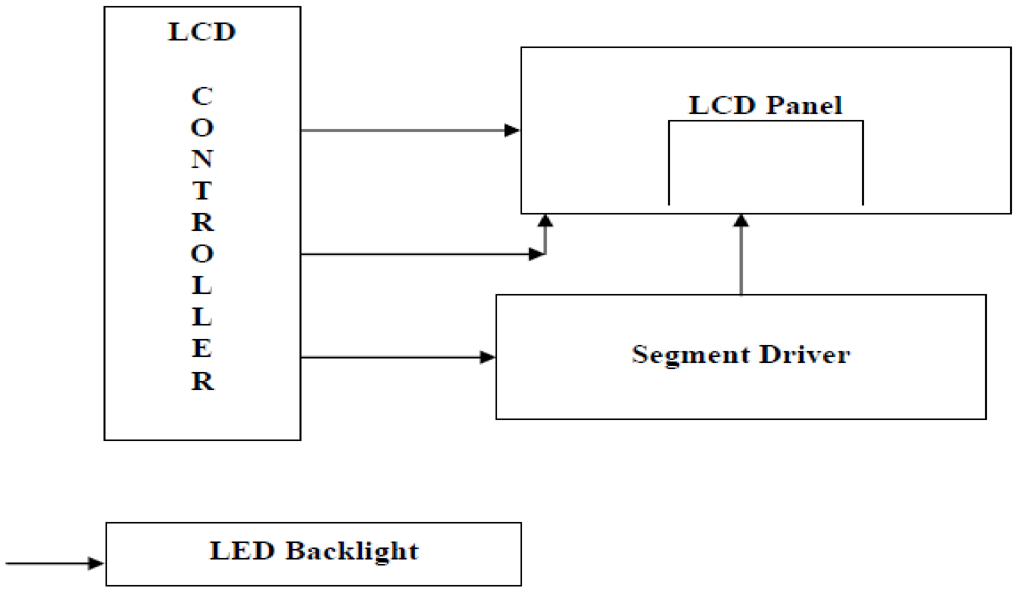


Figure 4.5. LMB162A Block diagram

The LCD Controller has two 8-bit registers, the Instruction register (IR) and the data register (DR). The Instruction register (IR) is a write only register to store instruction codes like display clear or cursor shift as well as addresses for the Display Data RAM (DR) RAM) or the Character Generator RAM (CG RAM). The data register (DD) is a read or write register used for temporarily storing data to be read or written from the DD RAM or CG RAM. Data written into the DR is automatically written into DD RAM or CG RAM by an internal operation of the display controller. The DR is also used to store data when reading out data from DD RAM or CG RAM. When address information is written into IR, data is read out from DD RAM or CG RAM to DR by an internal operation. Data transfer is then completed by reading the DR. After performing a read from the DR, data in the DD RAM or CG RAM at the next address is sent to the DR for the next read cycle [14].

This post will explain about How to control LCD (model LMB162A) using microcontroller such as AVR. Furthermore, I will add the basic information about LCD that will help you to be more familiar with LCD, especially when u used another micro.

Figure 4.6. Liquid crystal display (LCD)

Usually We use LCD model LMB162A (16 Characters x 2 lines) for electronics research purpose. Please goggling it on web (need the datasheet to be more clear about this LCD). This LCD has a driver on it. So, all we have to do is to understand How the driver works. First, we have to know the hardware and How to set up all the components

Hardware;

- There are 16 PIN in the LCD,
- PIN 1 = GND,
- PIN 2 = +5 Volt,
- PIN 3 = Voltage variable,
- PIN 4 = RS (control pin),
- PIN 5 = R/W (control pin),
- PIN 6 = E (control pin),
- PIN 7 = DB0 (data pin),
- PIN 8 = DB0 (data pin),
- PIN 9 = DB0 (data pin),
- PIN 10 = DB0 (data pin),
- PIN 11 = DB0 (data pin),
- PIN 12 = DB0 (data pin),
- PIN 13 = DB0 (data pin),
- PIN 14 = DB0 (data pin),
- PIN 15 = + 5 Volt,
- PIN 16 = GND.

4.4. DHT11 Humidity & Temperature Sensor

This DFRobot DHT11 Temperature & Humidity Sensor features a temperature & humidity sensor complex with a calibrated digital signal output. By using the exclusive digital-signal-acquisition technique and temperature & humidity sensing technology, it ensures high reliability and excellent long-term stability. This sensor includes a resistive-type humidity measurement component and an NTC temperature measurement component, and connects to a high-performance 8-bit microcontroller, offering excellent quality, fast response, anti-interference ability and cost-effectiveness [15].

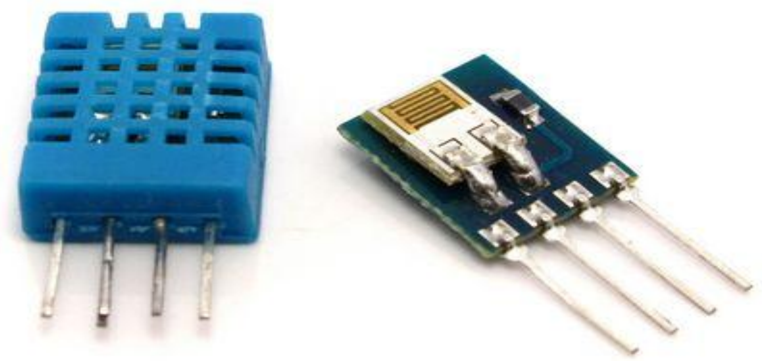


Figure 4.7. DHT11 Humidity & Temperature sensor

Each DHT11 element is strictly calibrated in the laboratory that is extremely accurate on humidity calibration. The calibration coefficients are stored as program in the OTP memory, which are used by the sensor's internal signal detecting process. The single-wire serial interface makes system integration quick and easy [15].

Its small size, low power consumption and up-to-20 meter signal transmission making it the best choice for various applications, including those most demanding ones. The component is 4-pin single row pin package. It is convenient to connect and special packages can be provided according to user' s request [15].

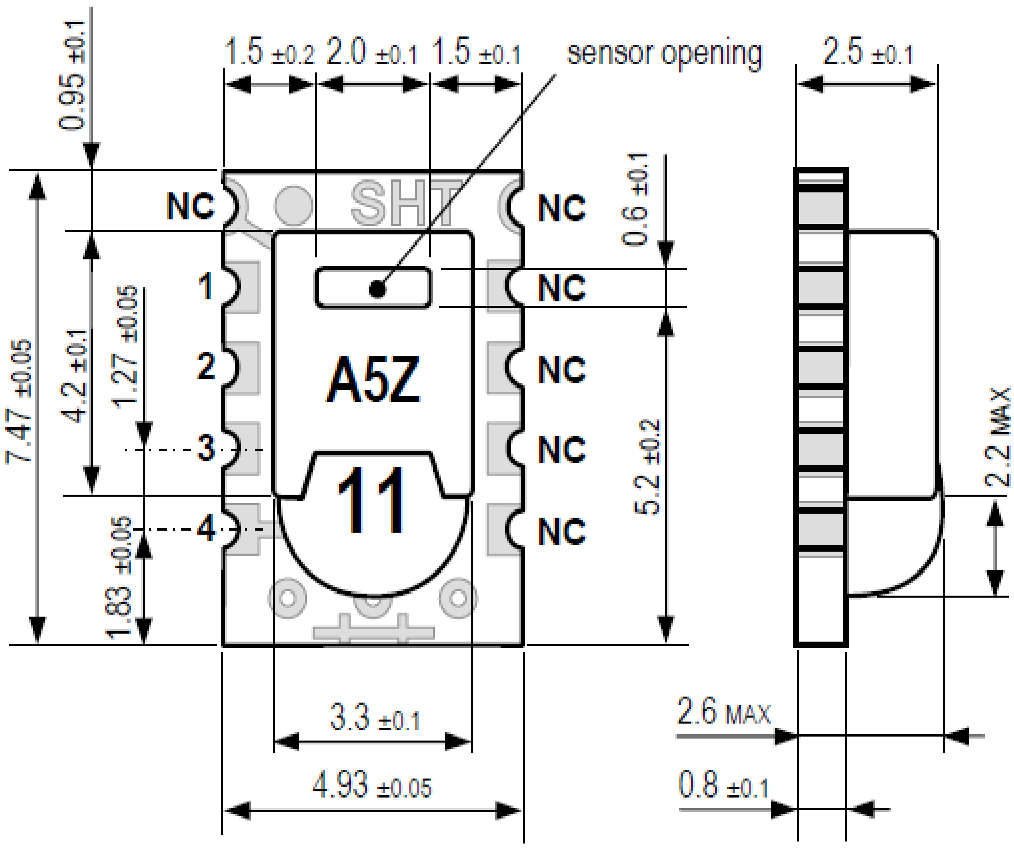


Figure 4.8. Dimensions of DHT11 Humidity & Temperature sensor

Table 4.1. Technical specifications of DHT11 Humidity & Temperature sensor

Item	Measurement Range	Humidity Accuracy	Temperature Accuracy	Resolution	Package
DHT11	20-90%RH 0-50 ℃	±5%RH	±2℃	1	4 Pin Single Row

Table 4.2. Detailed specifications of DHT11 Humidity & Temperature sensor

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

4.4.1. Typical Application

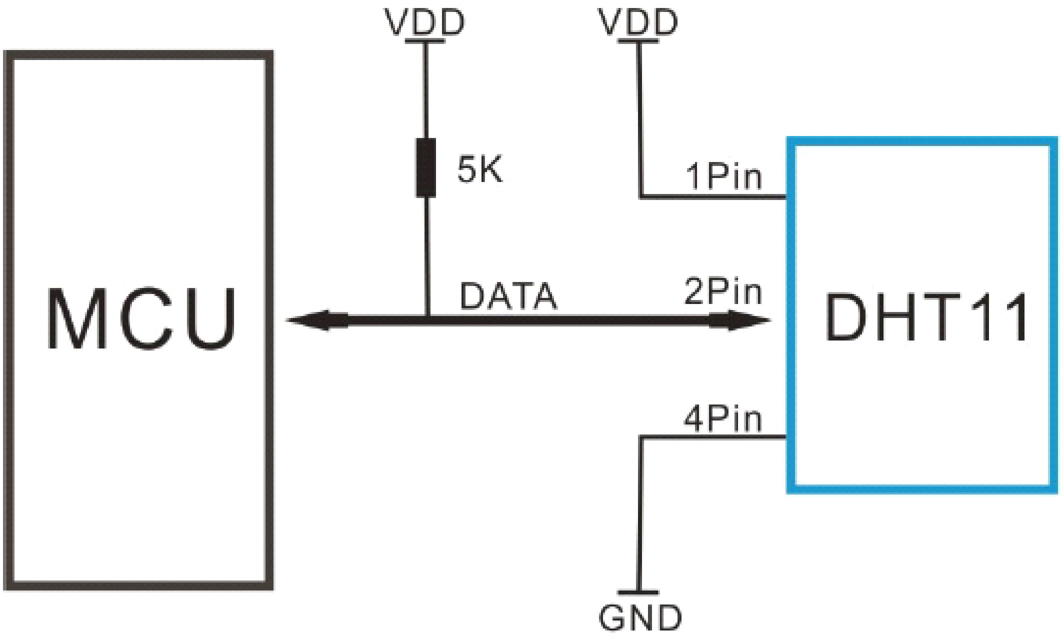


Figure 4.9. Ends of DHT11 Humidity & Temperature sensor

When the connecting cable is shorter than 20 meter, a 5K pull-up resistor is recommended; when the connecting cable is longer than 20 meter, choose an appropriate pull-up resistor as needed [15].

4.4.2. Power and Pin

DHT11's power supply is 3-5.5 V. DC. When power is supplied to the sensor, do not send any instruction to the sensor in within one second in order to pass the unstable status. One capacitor valued 100 nF. can be added between VDD and GND for power filtering [15].

4.4.3. Communication Process Serial Interface (Single-Wire Two-Way)

Single-bus data format is used for communication and synchronization between MCU and DHT11 sensor. One communication process is about 4ms. Data consists of decimal and integral parts. A complete data transmission is 40bit, and the sensor sends higher data bit first [15].

4.4.4. Data format

8bit integral RH data + 8bit decimal RH data + 8bit integral T data + 8bit decimal T data + 8bit check sum. If the data transmission is right, the check-sum should be the last 8bit of "8bit integral RH data + 8bit decimal RH data + 8bit integral T data + 8bit decimal T data"[15].

4.4.5. Overall Communication Process

When MCU sends a start signal, DHT11 changes from the low-power-consumption mode to the running-mode, waiting for MCU completing the start signal. Once it is completed, DHT11 sends a response signal of 40-bit data that include the relative humidity and temperature information to MCU. Users can choose to collect (read) some data. Without the start signal from MCU, DHT11 will not give the response signal to MCU. Once data is collected, DHT11 will change to the low-power-consumption mode until it receives a start signal from MCU again [15].

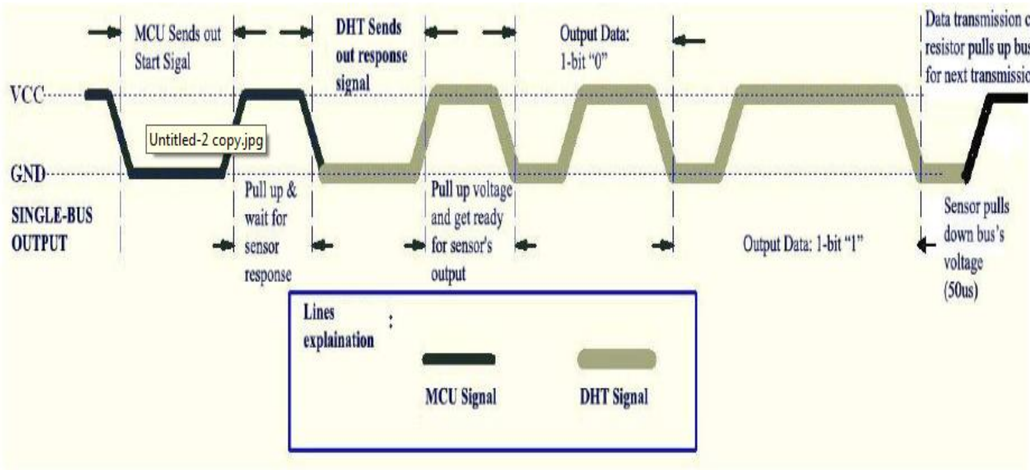


Figure 4.10. Overall Communication Process

4.4.6. MCU Sends Out Start Signal to DHT

Data Single-bus free status is at high voltage level. When the communication between MCU and DHT11 begins, the program of MCU will set Data Single-bus voltage level from high to low and this process must take at least 18ms to ensure DHT's detection of MCU's signal, then MCU will pull up voltage and wait 20-40us for DHT's response [15].

4.4.7. DHT Responses to MCU

Once DHT detects the start signal, it will send out a low-voltage-level response signal, which lasts 80us. Then the program of DHT sets Data Single-bus voltage level from low to high and keeps it for 80us for DHT’ s preparation for sending data [15].

When DATA Single-Bus is at the low voltage level, this means that DHT is sending the response signal. Once DHT sent out the response signal, it pulls up voltage and keeps it for 80us and prepares for data transmission [15].

When DHT is sending data to MCU, every bit of data begins with the 50 us low-voltage-level and the length of the following high-voltage-level signal determines whether data bit is "0" or "1".

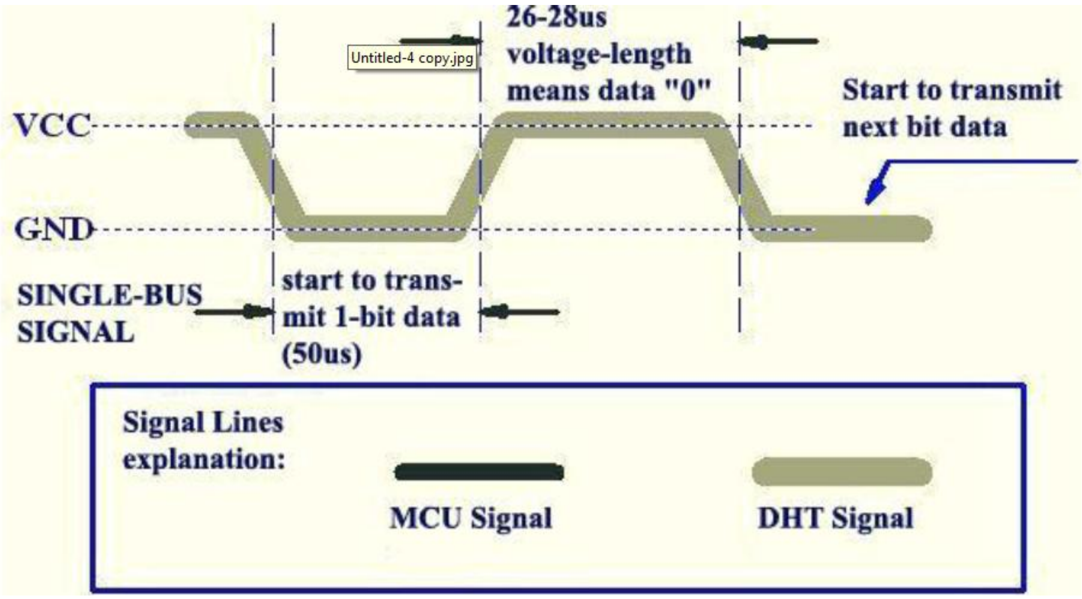


Figure 4.11. High-voltage-level signal determination "0" case

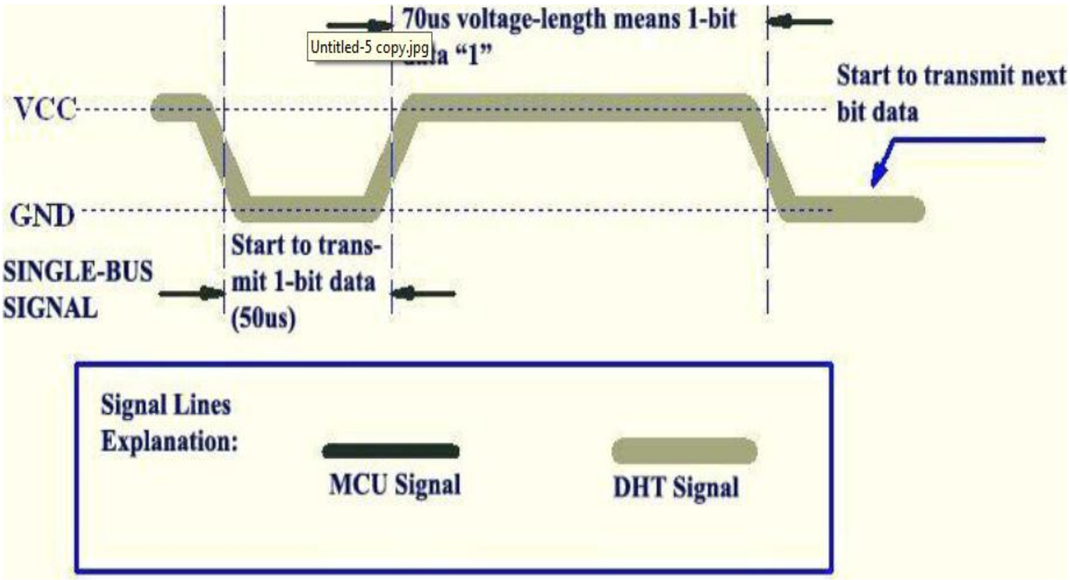


Figure 4.12. High-voltage-level signal determination "1" case

The response signal from DHT is always at high-voltage-level, it suggests that DHT is not responding properly and please check the connection. When the last bit data is transmitted, DHT11 pulls down the voltage level and keeps it for 50us. Then the Single-Bus voltage will be pulled up by the resistor to set it back to the free status [15].

Table 4.3. Electrical characteristics

VDD=5V, T = 25℃ (unless otherwise stated)

	Conditions	Minimum	Typical	Maximum
Power Supply	DC	3V	5V	5.5V
Current Supply	Measuring	0.5mA		2.5mA
	Average	0.2mA		1mA
	Standby	100uA		150uA
Sampling period	Second	1		

Note: Sampling period at intervals should be no less than 1 second.

4.4.8. Attentions of Application

Operating conditions; Appling the DHT11 sensor beyond its working range stated in this datasheet can result in 3% RH signal shift/discrepancy. The DHT11 sensor can recover to the calibrated status gradually when it gets back to the normal operating condition and works within its range. Please refer to (3) of this section to accelerate its recovery [15].

Please be aware that operating the DHT11 sensor in the non-normal working conditions will accelerate sensor's aging process.

4.4.9. Attention to Chemical Materials

Vapor from chemical materials may interfere with DHT's sensitive-elements and debase its sensitivity. A high degree of chemical contamination can permanently damage the sensor [15].

4.4.10. Temperature Affect

Relative humidity largely depends on temperature. Although temperature compensation technology is used to ensure accurate measurement of RH, it is still strongly advised to keep the humidity and temperature sensors working under the same temperature. DHT11 should be mounted at the place as far as possible from parts that may generate heat [15].

4.4.11. Light Affect

Long time exposure to strong sunlight and ultraviolet may debase DHT's performance [15].

4.4.12. Connection Wires

The quality of connection wires will affect the quality and distance of communication and high quality shielding-wire is recommended [15].

4.4.13. Other Attentions

- Welding temperature should be below 260 Celsius and contact should take less than 10 seconds [15].
- Avoid using the sensor under dew condition.
- Do not use this product in safety or emergency stop devices or any other occasion that failure of DHT11 may cause personal injury.

4.4.14. Declaim

This datasheet is a translated version of the manufacturer's datasheet. Although the due care has been taken during the translation, D-Robotics is not responsible for the accuracy of the information contained [15].

4.5. Incubator Fan

Interest has been growing in integrated circuits for controlling the speed of cooling fans in personal computers and other electronic equipment. Compact electrical fans are cheap and have been used for cooling electronic equipment for more than half a century. However, in recent years, the technology of using these fans has evolved significantly. This article will describe how and why this evolution has taken place and will suggest some useful approaches for the designer [16].

4.5.1. Heat Generation and Removal

The trend in electronics, particularly consumer electronics, is towards smaller products with enhanced combinations of features. Consequently, lots of electronic components are being shoehorned into very small form factors. An obvious example is the notebook PC. Thin and "Lite," notebook PCs have shrunk significantly, yet their processing power has been maintained or increased. Other examples of this trend include projection systems and set-top boxes. What these systems all have in common, besides significantly smaller and still decreasing size, is that the amount of heat they must dissipate does not decrease; often it increases. In the notebook PC, much of the heat is generated by the processor; in the projector, most of the heat is generated by the light source. This heat needs to be removed quietly and efficiently [16].

The quietest way to remove heat is with passive components such as heat sinks and heat pipes. However, these have proved insufficient in many popular consumer electronics products and they are also somewhat expensive. A good alternative is active cooling, introducing a fan into the system to generate airflow around the chassis and the heat-generating components and efficiently removing heat from the system. A fan is a source of noise, however. It is also an additional source of power consumption in the system a very important consideration if power is to be supplied by a battery [16].

The fan is also one more mechanical component in the system, not an ideal solution from a reliability standpoint.

Speed control-one way to answer some of these objections to the use of a fan - can have these advantages;

- Running a fan slower reduces the noise it emits,
- Running a fan slower can reduce the power it consumes,
- Running a fan slower increases its reliability and lifetime.

There are many different types of fans and ways of controlling them. We will discuss here various fan types and the advantages and disadvantages of control methods in use today.

One way to classify fans is as;

- 2-wire fans,
- 3-wire fans,
- 4-wire fans.

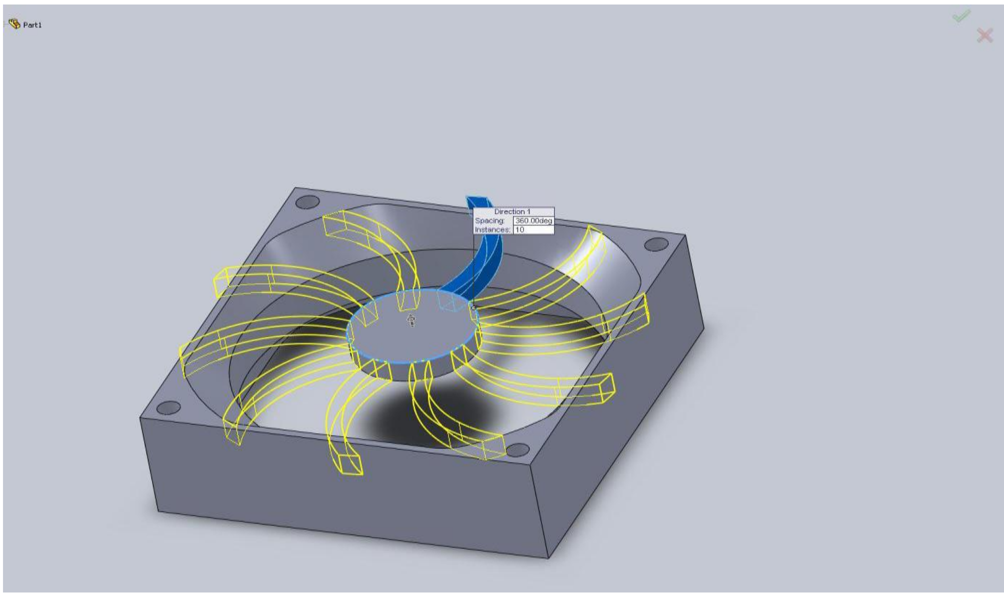


Figure 4.13. Incubator fan

The methods of fan control to be discussed here include;

- No fan control,
- On/off control,
- Linear (continuous dc) control,
- Low-frequency pulse-width modulation (PWM),
- High-frequency fan control.

4.5.2. Fan Types

A 2-wire fan has power and ground terminals. A 3-wire fan has power, ground, and a tachometric ("tach") output, which provides a signal with frequency proportional to speed. A 4-wire fan has power, ground, a tach output, and a PWM-drive input. PWM, in brief, uses the relative width of pulses in a train of on-off pulses to adjust the level of power applied to the motor [16].

A 2-wire fan is controlled by adjusting either the DC. voltage or pulse width in low-frequency PWM. However, with only two wires, a tach signal is not readily available. This means that there is no indication as to how fast the fan is running or indeed, if it is running at all. This form of speed control is open-loop [16].

A 3-wire fan can be controlled using the same kind of drive as for 2-wire fans variable dc or low-frequency PWM. The difference between 2-wire fans and 3-wire fans is the availability of feedback from the fan for closed-loop speed control. The tach signal indicates whether the fan is running and its rate of speed [16].

The tach signal, when driven by a DC voltage, has a square-wave output closely resembling the "ideal tach". It is always valid, since power is continuously applied to the fan. With low- frequency PWM, however, the tach signal is valid only when power is applied to the fan - that is, during the on phase of the pulse. When the PWM drive is switched to the off phase, the fan's internal tach signal-generation circuitry is also off. Because the tach output is typically from an open drain, it will float high when the PWM drive is off. Thus, while the ideal tach is representative of the actual speed of the fan, the PWM drive in effect "chops" the tach signal output and may produce erroneous readings. In order to be sure of a correct fan speed reading under PWM control, it is necessary to periodically switch the fan on long enough to get a complete tach cycle. This feature is implemented in a number of Analog Devices fan controllers, such as the ADM1031 and the ADT7460 [16].

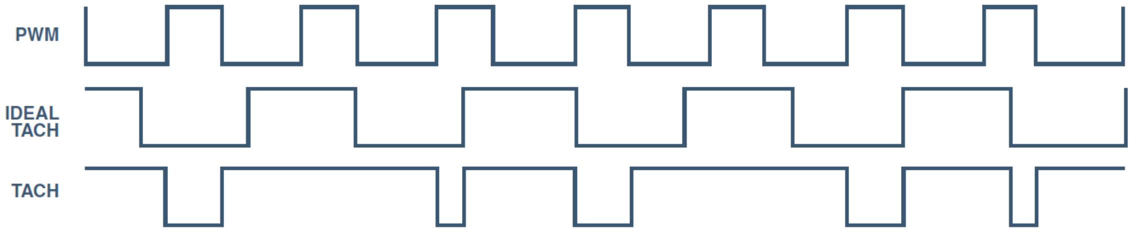


Figure 4.14. Tachometer-output waveforms in 3-wire fans - ideal, and under PWM control

4.5.3. Fan Control

4.5.3.1. No Control

The simplest method of fan control is not to use any at all; just run a fan of appropriate capacity at full speed 100% of the time. The main advantages of this are guaranteed fail-safe cooling and a very simple external circuit. However, because the fan is always switched on, its lifetime is reduced and it uses a constant amount of power even when cooling is not needed. Also, its incessant noise is likely to be annoying [16].

4.5.3.2. On/off Control

The next simplest method of fan control is thermostatic, or on/off control. This method is also very easy to implement. The fan is switched on only when cooling is needed, and it is switched off for the remainder of the time. The user needs to set the conditions under which cooling is needed - typically when the temperature exceeds a preset threshold [16].

The Analog Devices ADM1032 is an ideal sensor for on/off fan control using a temperature set point. It has a comparator that produces a THERM output - one that is normally high but switches low when the temperature exceeds a programmable threshold. It automatically switches back to high when the temperature drops a preset amount below the THERM limit. The advantage of this programmable hysteresis is that the fan does not continually switch on/off when the temperature is close to the threshold [16].

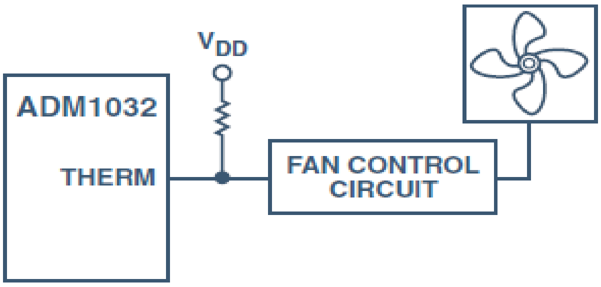


Figure 4.15. Is an example of a circuit using the ADM1032.

The disadvantage of on/off control is that it is very limited. When a fan is switched on, it immediately spins up to its full speed in an audible and annoying manner. Because humans soon become somewhat accustomed to the sound of the fan, its switching off is also very noticeable. (It can be compared to the refrigerator in your kitchen. You didn't notice the noise it was making until it switched off.) So from an acoustic perspective, on/off control is far from optimal [16].

4.5.3.3. Linear control

At the next level of fan control, linear control, the voltage applied to the fan is variable. For lower speed (less cooling and quieter operation) the voltage is decreased, and for higher speed it is increased. The relationship has limitations. Consider, for example, a 12 V. fan (rated maximum voltage). Such a fan may require at least 7 V. to start spinning. When it does start spinning, it will probably spin at about half its full speed with 7 V. applied. Because of the need to overcome inertia, the voltage required to start a fan is higher than the voltage required to keep it spinning. So as the voltage applied to the fan is reduced, it may spin at slower speeds until, say, 4 V., at which point it will stall. These values will differ, from manufacturer to manufacturer, from model to model, and even from fan to fan. The Analog Devices ADM1028 linear fan-control IC has a programmable output and just about every feature that might be needed in fan control, including the ability to interface accurately to the temperature-sensing diode provided on chips, such as microprocessors, that account for most of the dissipation in a system. (The purpose of the diode is to provide a rapid indication of critical junction temperatures, avoiding all the thermal lags inherent in a system. It permits immediate initiation of cooling, based on a rise in chip temperature.) In order to keep the power used by the ADM1028 at a minimum, it operates on supply voltages from 3.0 V. to 5.5 V., with +2.5-V. full scale output [16].

5-V. fans allow only a limited range of speed control, since their start - up voltage is close to their 5-V. full speed level. But the ADM1028 can be used with 12-V. fans by employing a simple step-up booster amplifier with a circuit such as that shown

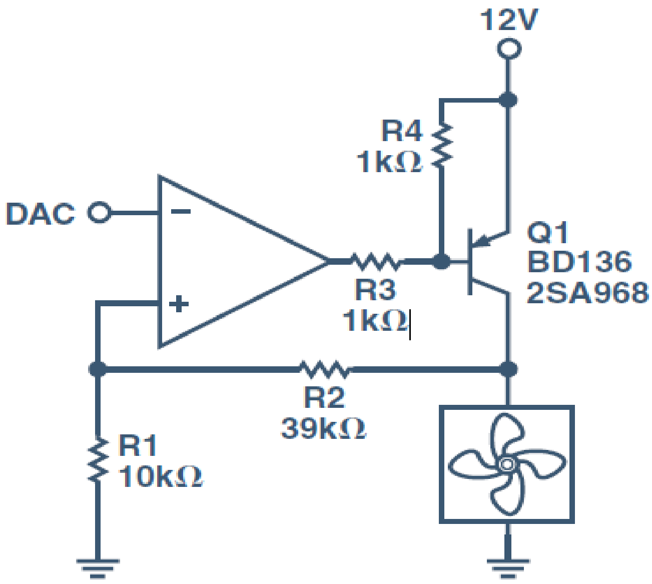


Figure 4.16. Boost circuit for driving a 12 V fan, using the output from the linear fan-control ADM1028's DAC.

The principal advantage of linear control is that it is quiet. However, as we have noted, the speed-control range is limited. For example, a 12 V. fan with a control voltage range from 7 V. to 12 V. could be running at half speed at 7 V. The situation is even worse with a 5 V. fan. Typically, 5 V. fans will require that 3.5 V. or 4 V. be applied to get them started, but at that voltage they will be running at close to full speed, with a very limited range of speed control. But running at 12 V., is far from optimum from an efficiency perspective. That is because the boost transistor dissipates a relatively large amount of power (when the fan is operating at 8 V., the 4 V. drop across the transistor is not very efficient). The external circuit required is also relatively expensive [16].

4.5.3.4. PWM Control

The prevalent method currently used for controlling fan speed in PCs is low-frequency PWM control. In this approach, the voltage applied to the fan is always either zero or full-scale—avoiding the problems experienced in linear control at lower voltages [16].

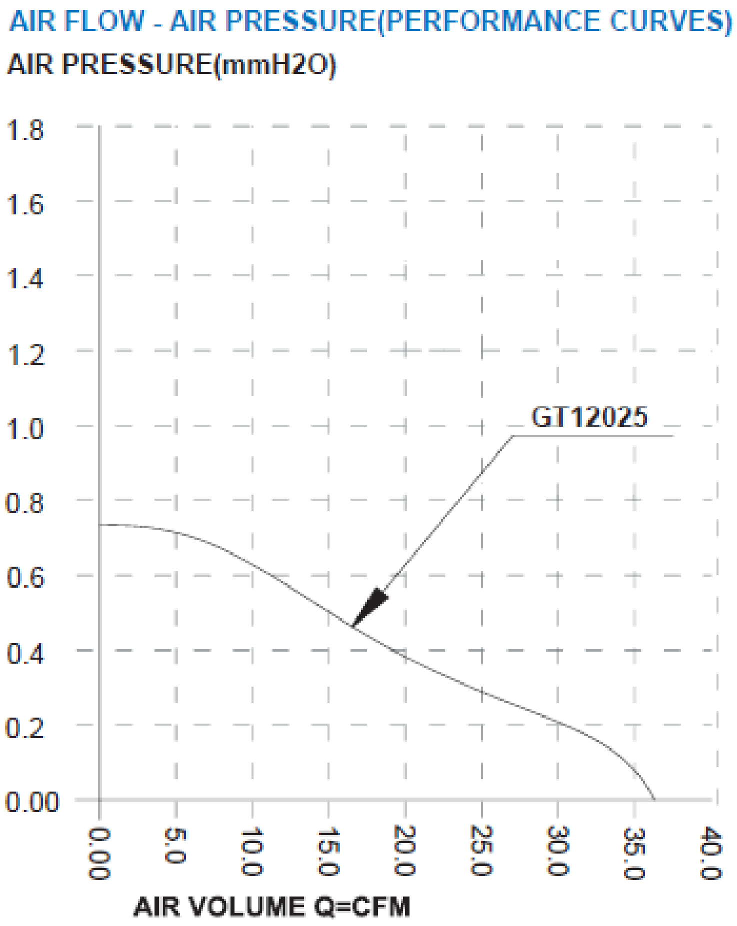


Figure 4.17. Performance curve of the fan

Model GT12025-EDLA1

Specifications	
Bearing System	Entering Bearing
Operation Voltage (V DC)	7.5 ~ 13.8
Rated Voltage (V DC)	12.0
Rated Current (AMP)	0.12
Input Power (Watt)	1.44
Fan Speed (RPM)	950 ± 150
Air Volume (CFM)	35.8
Airflow (m³ / min)	1.02
Static Pressure (mmH2O)	0.75
Noise Level (dBA)	18.0
MTBF (hours / 25° C)	35000
Safety	CE, UL, TUV
Dimension (mm)	120 x 120 x 25
Total Weight (gram)	144.5
Connector Type	3 & 4 Pin Connectors

Figure 4.18. Technical specification of fan

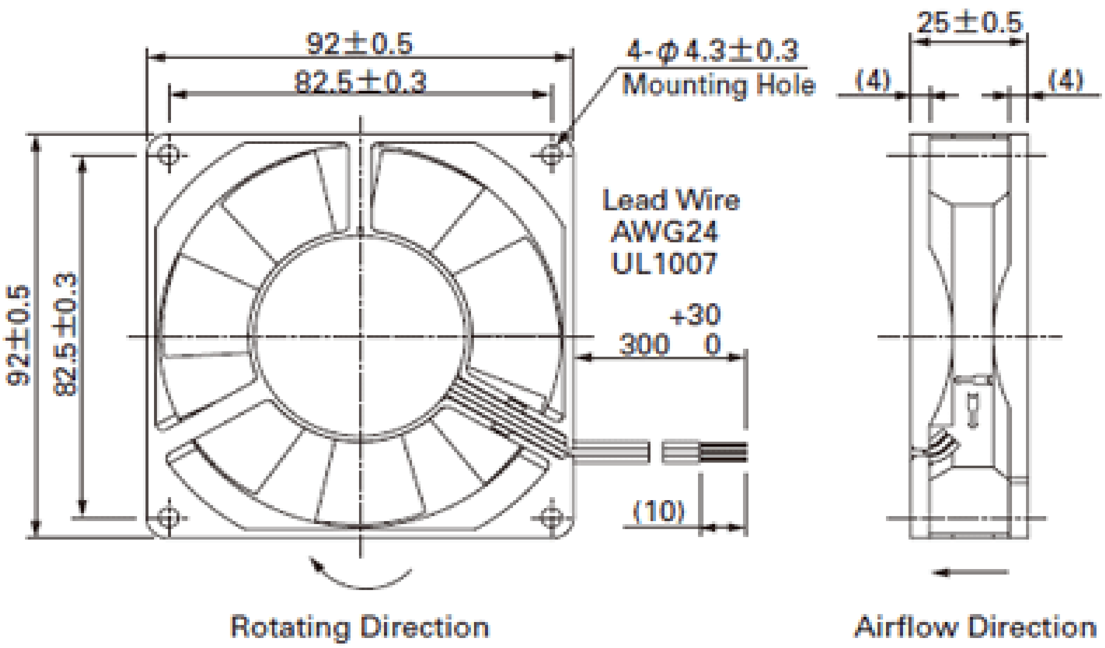


Figure 4.19. Dimension of fan

4.6. Pressure Sensor

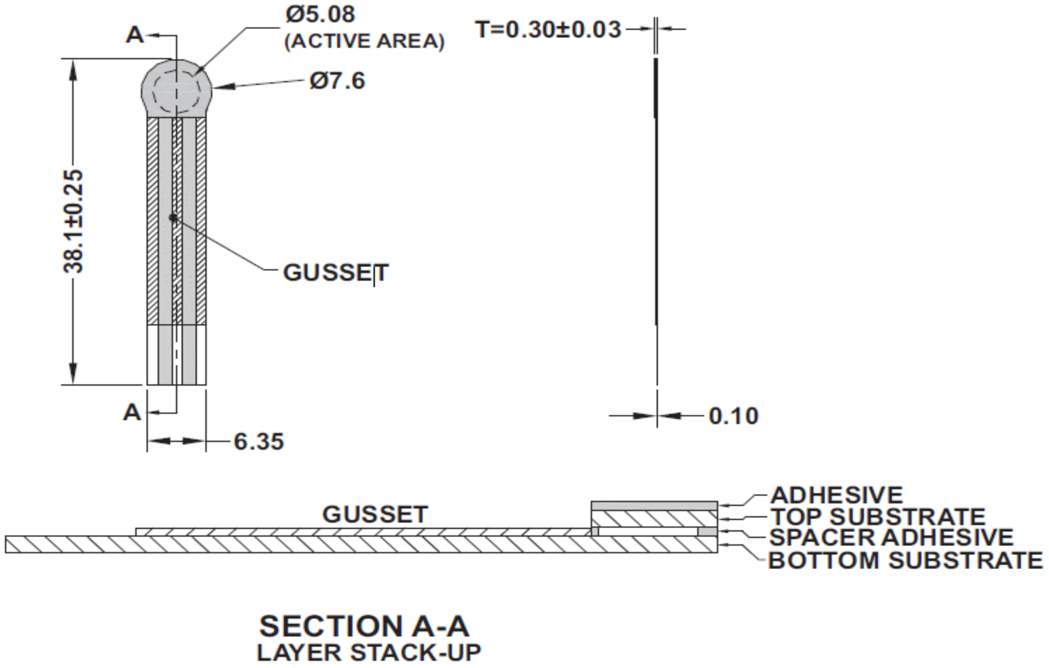


Figure 4.20. Dimension of pressure sensor

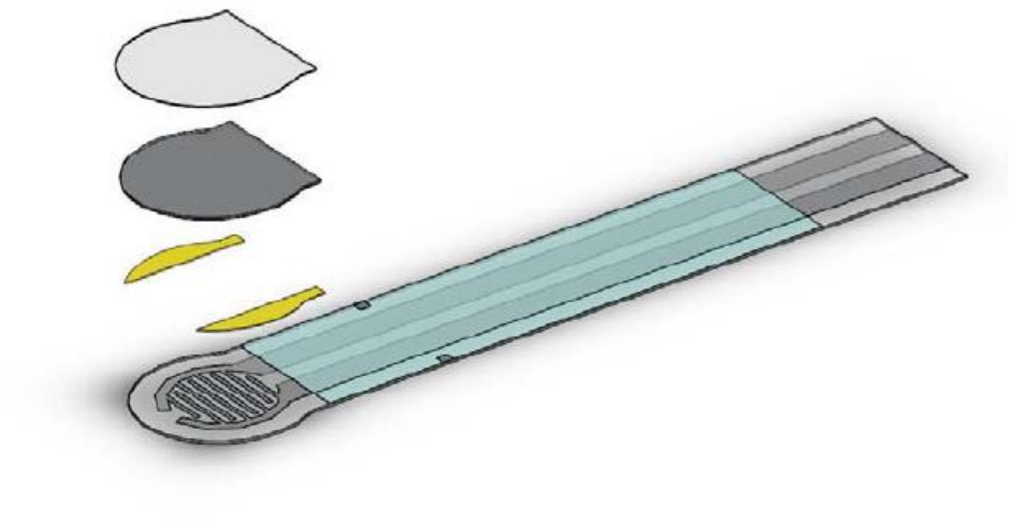


Figure 4.21. Exploded view of pressure sensor

Interlink Electronics FSR 400 series is part of the single zone force sensing ResistorTM family. Force sensing resistors, or FSRs, are robust polymer thick film (PTF) devices that exhibit a decrease in resistance with increase in force applied to the surface of the sensor. This force sensitivity is optimized for use in human touch control of electronic devices such as automotive electronics, medical systems, and in industrial and robotics applications. The standard 400 sensor is a round sensor 7.62 mm in diameter. Custom sensors can be manufactured in sizes ranging from 5mm to over 600 mm. Female connector and short tail versions can also be ordered [17].

4.6.1. Application Information

For specific application needs please contact Interlink Electronics support team. An integration guide and Hardware Development Kit (HDK) are also available FSRs are two-wire devices with a resistance that depends on applied force. To the right is a force vs. resistance graph that illustrates a typical FSR response characteristic. Please note that the graph values are reference only and actual values are dependent upon actuation system mechanics and sensor geometry [18].

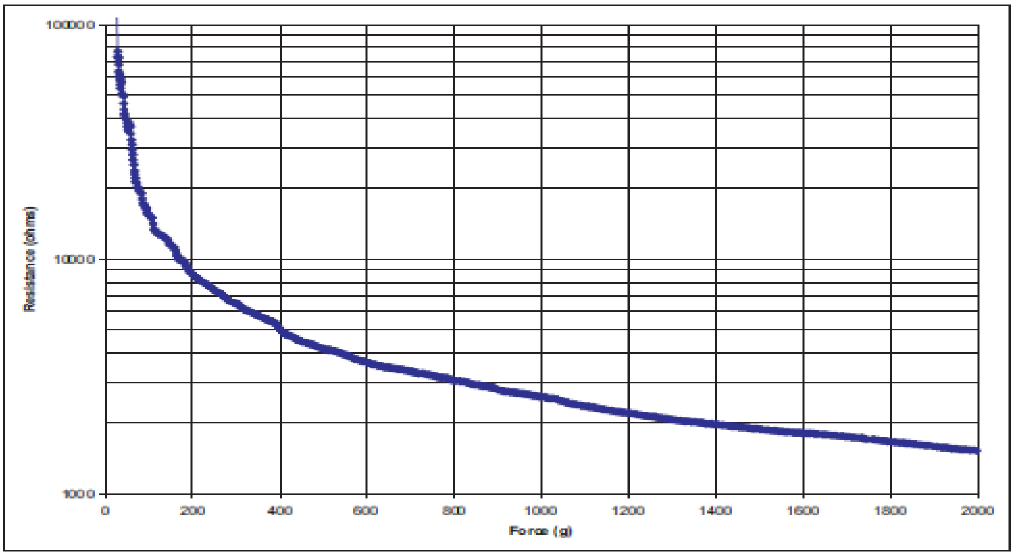


Figure 4.22. Curve of pressure sensor

$$V_{OUT} \quad \frac{R_M V}{R_M \quad R_{FSR}}$$

Figure 4.23. For a simple force-to-voltage conversion, the FSR device is tied to a measuring resistor in a voltage divider and the output is described by the upper equation

In the shown configuration, the output voltage increases with increasing force. If RFSR and RM are swapped, the output swing will decrease with increasing force. The measuring resistor, RM, is chosen to maximize the desired force sensitivity range and to limit current. Depending on the impedance requirements of the measuring circuit, the voltage divider could be followed by an op-amp. A family of force vs. VOUT. curves is shown on the graph below for a standard FSR in a voltage divider configuration with various RM resistors. A. V. + of +5V. was used for these examples. Please note that the graph values are for reference only and will vary between different sensors and applications. Refer to the FSR integration guide for more integration methods and techniques [18].

Parameter	Value
Actuation Force*	~0.2N min
Force Sensitivity Range*	~0.2N - 20N
Force Resolution	Continuous (analog)
Force Repeatability Single Part	+/- 2%
Force Repeatability Part to Part	+/- 6%
Non-Actuated Resistance	>10 Mohms
Hysteresis	+10% Average $(R_{F+} - R_{F-})/R_{F+}$
Device Rise Time	< 3 microseconds
Long Term Drift 1kg load, 35 days	< 5% log10 (time)
Operating Temperature Performance	
Cold: -40C after 1 hour	-5% average resistance change
Hot: +85C after 1 hour	-15% average resistance change
Hot Humid: +85C 95RH after 1 hour	+10% average resistance change
Storage Temperature Performance	
Cold: -25C after 120 hours	-10% average resistance change
Hot: +85C after 120 hours	-5% average resistance change
Hot Humid: +85C 95RH after 240 hours	+30% average resistance change
Tap Durability 10 Million actuations, 1kg, 4Hz	-10% average resistance change
Standing Load Durability 2.5kg for 24 hours	-5% average resistance change
EMI	Generates No EMI
ESD	Not ESD sensitive
UL:	All materials UL grade 94 V-1 or better
RoHS:	Compliant

Figure 4.24. Pressure sensor**,** temperature sensor and durability technical specification.

4.7. 12V. 2A. DC. Switch Power

This part of the hardware provides the required energy for working of the various integrated circuits that has been developed. The schematic of power supply circuit is as shown figure.

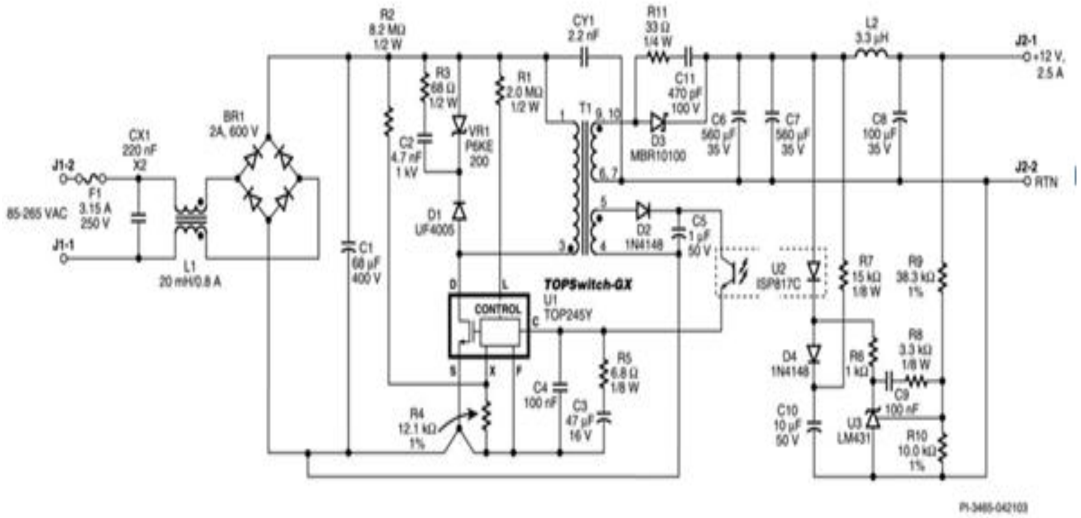


Figure 4.25. 12V. 2A. DC. Power supply circuit

The power supply system has an input which is either ac or dc and, for our discussions, a dc output. This dc output is used to power some form of electronic circuitry. The power supply circuit converts the 220 V. AC. into 12 V. DC. at which various integrated circuits can work efficiently. Hence it can be achieved by using various components [19].

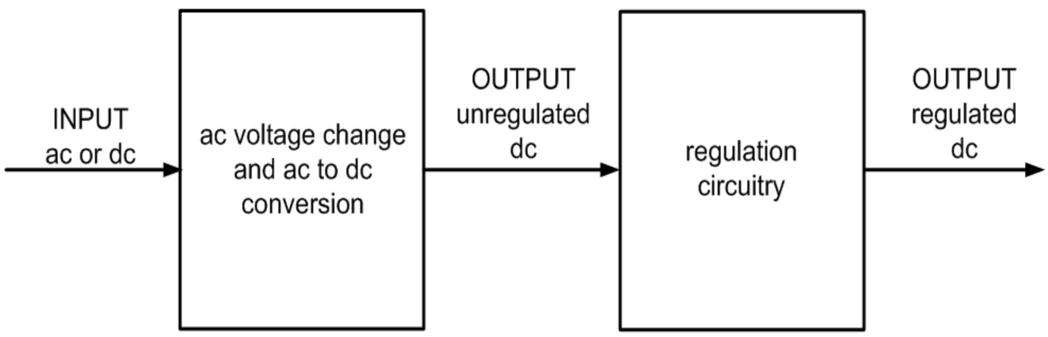


Figure 4.26. Power supply system

Mains powered equipment must be properly protected by a fuse and double pole power switch. The mains powered equipment container (box) must be earthed if metallic or double insulation techniques employed to provide input to output isolation.

A lot of consumer electronic units (TV, DVD players and the like) utilize double insulation techniques, so their mains input power lead only contains Live and Neutral wires, rather than also including an earth wire as well. Double insulation techniques present at least two 'high voltage' insulation barriers between the mains input circuitry and the system being powered. For example, the mains transformer has its primary (high voltage) winding on one bobbin and its secondary winding a separate bobbin. Thus, if the primary winding burns up, the mains voltage cannot reach the 'secondary side [19].

Table 4.4. Power supply technical specification.

Manufacturer	Power Integrations
Category	AC/DC and DC/DC Conversion
Sub-Category	AC/DC SMPS - Single Output
Tech Tips	Viewing the Product Training Module (PTM) below, is recommended.
Outputs and Type	1 Isolated
Voltage Out	12 V
Current Out	2.5 A
Output Power	30 W
Voltage In	85 ~ 265 VAC
Efficiency @ Conditions	>83%, 120Vin, 12 V @ 2.5 A >84%, 240Vin, 12 V @ 2.5 A
Features	Current Limit (Adj. or Fixed) Over Current Protection Short Circuit Protection Under Voltage Protection, Brown-Out Zero Load Regulation
No-load Input Power @ Voltage	260 mW @ 120 V 420 mW @ 240 V
Switching Frequency	132 kHz
Internal Switch	Yes
Component Count + Extras	39 + 3
Design Author	Power Integrations
Application / Target Market	AC Adapters White Goods
Main I.C.	TOP245 TOPSwitch-GX

4.7.1. Transformer

Step down the voltage level from 220 V. AC. to required voltage level. Here 9-0-9 rating transformer has been used. A transformer is an electrical device that transfers energy between two circuits through electromagnetic induction. A transformer may be used as a safe and efficient voltage converter to change the AC voltage at its input to a higher or lower voltage at its output without changing the frequency. Other uses include current conversion, isolation with or without changing voltage and impedance conversion. A transformer most commonly consists of two windings of wire that are wound around a common core to provide tight electromagnetic coupling between the windings. The core material is often a laminated iron core.

The coil that receives the electrical input energy is referred to as the primary winding, the output coil is the secondary winding.

An alternating electric current flowing through the primary winding (coil) of a transformer generates a varying electromagnetic field in its surroundings which induces a varying magnetic flux in the core of the transformer. The varying electromagnetic field in the vicinity of the secondary winding induces an electromotive force in the secondary winding, which appears as a voltage across the output terminals. If a load is connected across the secondary winding, a current flows through the secondary winding drawing power from the primary winding and its power source.

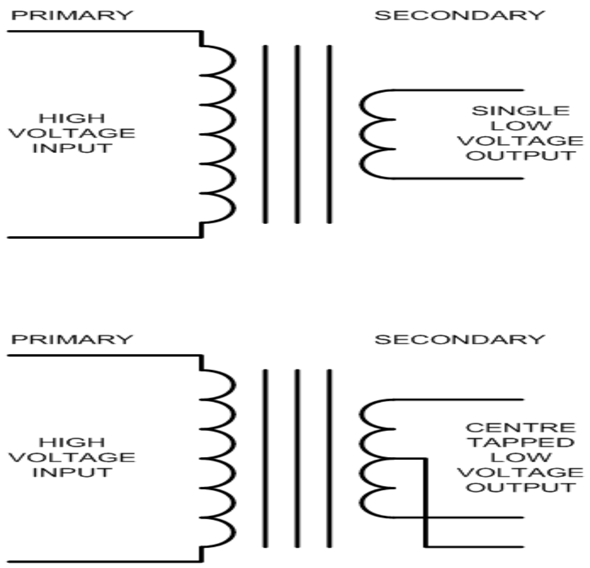


Figure 4.27. Step down the voltage transformer

4.7.2. Primary Side

Usually single 240 V. winding or two 120 V. windings Might have tapings to allow operation from other supplies such as 200 V., 220 V., 240 V., 100 V., 110 V. etc. These multi tapped transformers are usually fitted to test equipment that could be used all over the world. Also, in the UK and in Europe the mains frequency is 50 Hz., but elsewhere could be 60 Hz. You can use a transformer designed for 50 Hz. on a 60 Hz.

supply, but a transformer designed for 60 Hz. could well overheat when run from a 50 Hz. supply beware imported goods, especially those designed for USA (60 Hz.) market.

4.7.3. Secondary Side

Can be many different arrangements, or just simple. Efficiency usually ~90% for small (<20 V. A.) units, rising to 95% for larger (~100 to 200 V. A.) units

4.7.4. Full Wave Rectifier

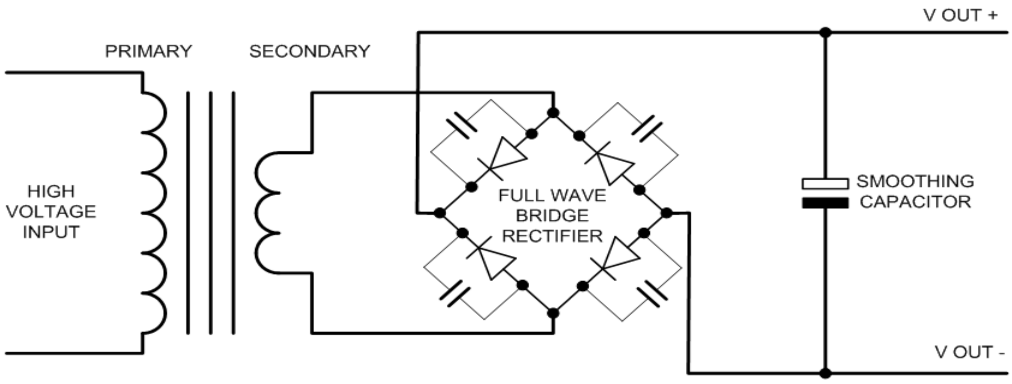


Figure 4.28. Full wave rectifier

Full Wave Rectifier is composed of four diodes which are placed as shown It converts the alternating voltage to a unidirectional voltage. A rectifier is an electrical device that converts alternating current (AC.), which periodically reverses direction, to direct current (DC.), which flows in only one direction. The process is known as rectification. Physically, rectifiers take a number of forms, including vacuum tube diodes, mercury-arc valves, copper and selenium oxide rectifiers, semiconductor diodes, silicon-controlled rectifiers and other silicon-based semiconductor switches. Historically, even synchronous electromechanical switches and motors have been used. Early radio receivers, called crystal radios, used a "cat's whisker" of fine wire pressing on a crystal of galena (lead sulfide) to serve as a point-contact rectifier or "crystal detector" [19].

4.7.5. The Smoothing Capacitor

Is used for ripple rejection of the unidirectional voltage obtained at rectifier end. A capacitor (originally known as a condenser) is a passive two-terminal electrical component used to store energy electrostatically in an electric field. The forms of practical capacitors vary widely, but all contain at least two electrical conductors (plates) separated by a dielectric (i.e., insulator). The conductors can be thin films of metal, aluminum foil or disks, etc. The 'no conducting' dielectric acts to increase the capacitor's charge capacity. A dielectric can be glass, ceramic, plastic film, air, paper, mica, etc. Capacitors are widely used as parts of electrical circuits in many common electrical devices. Unlike a resistor, a capacitor does not dissipate energy. Instead, a capacitor stores energy in the form of an electrostatic field between its plates.

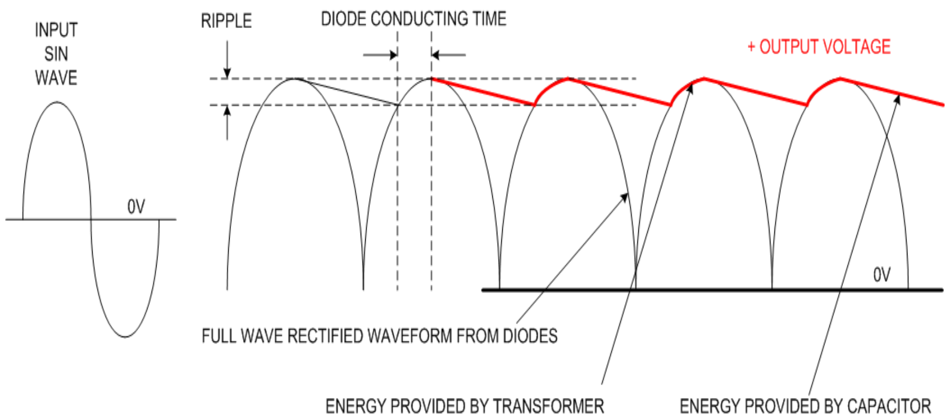


Figure 4.29. Smoothing circuite changing wave

The output from the transformer and rectifiers follows the sin waveform. The smoothing capacitor ‘fills in’ the low voltage portions, so reducing the ripple voltage amplitude. The larger the capacitor (for a given load), the smaller the ripple voltage, but the higher the peak current through the rectifiers.

4.8. Zener Diode

A Zener diode is a diode which allows current to flow in the forward direction in the same manner as an ideal diode, but also permits it to flow in the reverse direction when the voltage is above a certain value known as the breakdown voltage, "Zener knee voltage", "Zener voltage", "avalanche point" or "peak inverse voltage". For small Zener diodes (the ones most commonly used for reference purposes) don't cause too much current to flow through them. They drift with temperature. Usually about 5 mA. is the optimum. If possible, use a Zener diode around 5V. to 6V. for your design these have the smallest temperature coefficient. Zener diodes do produce wideband noise (they are often used as a noise source) do decouple them with a capacitor 1nF. is usually sufficient. If there is a large variation in the supply voltage providing their current, think about using a constant current source rather than a series resistor.

Table 4.5. Example of Zener diode voltage range

BZY88 ...	WORKING VOLTAGE V_Z AT I_Z = 1 mA				TEMPERATURE COEFFICIENT S_Z AT I_Z = 1 mA				DIFFERENTIAL RESISTANCE r_{diff} AT I_Z = 1 mA		
	MIN.	NOM.	MAX.		MIN.	TYP.	MAX.		TYP.	MAX.	
C2V7	1,9	2,15	2,4	V	−4,5	−1,7	−0,6	mV/°C	310	390	Ω
C3V0	2,1	2,4	2,7	V	−5,0	−1,8	−0,6	mV/°C	340	420	Ω
C3V3	2,4	2,75	3,0	V	−4,5	−1,9	−0,5	mV/°C	360	440	Ω
C3V6	2,7	3,0	3,3	V	−4,5	−2,05	−0,5	mV/°C	410	430	Ω
C3V9	3,0	3,3	3,6	V	−3,5	−2,4	−0,5	mV/°C	410	430	Ω
C4V3	3,3	3,6	3,9	V	−2,7	−2,25	−0,5	mV/°C	410	430	Ω
C4V7	3,7	4,1	4,3	V	−2,5	−2,0	−0,3	mV/°C	390	420	Ω
C5V1	4,3	4,65	5,0	V	−2,1	−1,9	−0,3	mV/°C	340	370	Ω
C5V6	4,8	5,3	5,7	V	−1,8	−1,4	0	mV/°C	310	350	Ω
C6V2	5,7	5,9	6,5	V	0	+1,6	+3,0	mV/°C	100	250	Ω
C6V8	6,3	6,7	6,9	V	+2	+3,2	+3,7	mV/°C	15	70	Ω
C7V5	7,0	7,45	7,8	V	+3	+4,2	+5,9	mV/°C	8,0	20	Ω
C8V2	7,8	8,1	8,5	V	+4,3	+5,0	+6,0	mV/°C	10	20	Ω
C9V1	8,55	9,0	9,5	V	+4,5	+6,0	+7,0	mV/°C	12	24	Ω
C10	9,3	9,9	10,5	V	+6,0	+6,6	+7,0	mV/°C	20	50	Ω
C11	10,3	10,9	11,5	V	+7,1	+8,3	+9,0	mV/°C	25	70	Ω
C12	11,3	11,9	12,5	V	+7,6	+8,7	+9,2	mV/°C	25	80	Ω
C13	12,3	12,9	13,0	V	+9,1	+10,1	+11,1	mV/°C	25	90	Ω
C15	13,8	14,9	15,5	V	+11	+12,5	+13	mV/°C	35	95	Ω
C16	15,3	15,8	16,9	V	+12	+13	+14	mV/°C	45	100	Ω
C18	16,7	17,8	18,9	V	+14	+15	+16,5	mV/°C	50	120	Ω
C20	18,7	19,8	21,0	V	+16	+17	+18,5	mV/°C	60	140	Ω
C22	20,6	21,8	23,1	V	+17	+19	+21	mV/°C	70	150	Ω
C24	22,5	23,8	25,7	V	+19	+21	+23	mV/°C	85	200	Ω
C27	24,7	26,6	28,5	V	+21	+22,5	+25	mV/°C	90	300	Ω
C30	27,5	29,5	31,5	V	+22	+24	+29	mV/°C	180	350	Ω
C33	29,5	32,5	34,5	V	+23	+26	+35	mV/°C	250	450	Ω

4.9. Resistor

A resistor is a passive two-terminal electrical component that implements electrical resistance as a circuit element. Resistors act to reduce current flow, and, at the same time, act to lower voltage levels within circuits. Resistors may have fixed resistances or variable resistances, such as those found in thermistors, varistors, trimmers, photo resistors, humistors and potentiometers [20].

4.9.1. Identifying Resistor Value and Functions

Components and wires are coded are with colors to identify their value and function.

Table 4.6. Resisters colors for measuring its amount

Color	Digit	Multiplier	Tolerance (%)
Black	0	10^0 (1)	
Brown	1	10^1	1
Red	2	10^2	2
Orange	3	10^3	
Yellow	4	10^4	
Green	5	10^5	0.5
Blue	6	10^6	0.25
Violet	7	10^7	0.1
Grey	8	10^8	
White	9	10^9	
Gold		10^{-1}	5
Silver		10^{-2}	10
(none)			20

The colors brown, red, green, blue, and violet are used as tolerance codes on 5-band resistors only. All 5-band resistors use a colored tolerance band. The blank (20 %) "band" is only used with the "4-band" code (3 colored bands + a blank "band").

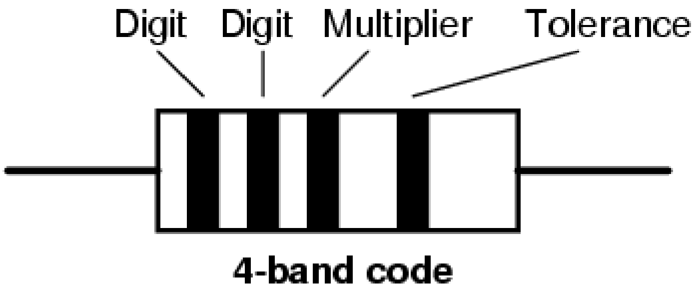


Figure 4.30. Four color in resistance

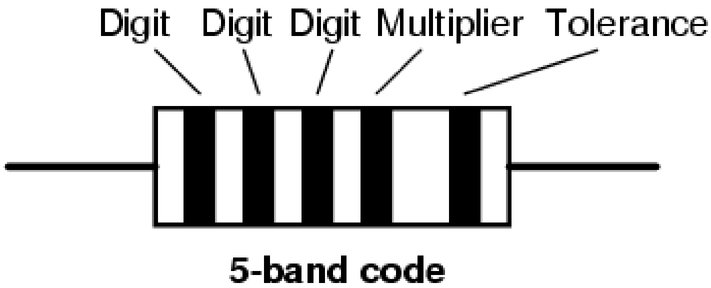


Figure 4.31. Five color in resistance

4.10. Transistor

A transistor is a semiconductor device used to amplify and switch electronic signals and electrical power. It is composed of semiconductor material with at least three terminals for connection to an external circuit. A voltage or current applied to one pair of the transistor's terminals changes the current through another pair of terminals. Because the controlled (output) power can be higher than the controlling (input) power, a transistor can amplify a signal. Today, some transistors are packaged individually, but many more are found embedded in integrated circuits [21].

4.10.1. BC237 Transistor (NPN)

Features;

- Low current (max. 100 mA.),
- Low voltage (max. 45 V.).

Applications;

- General purpose switching and amplification.

PINNING

PIN	DESCRIPTION
1	emitter
2	base
3	collector

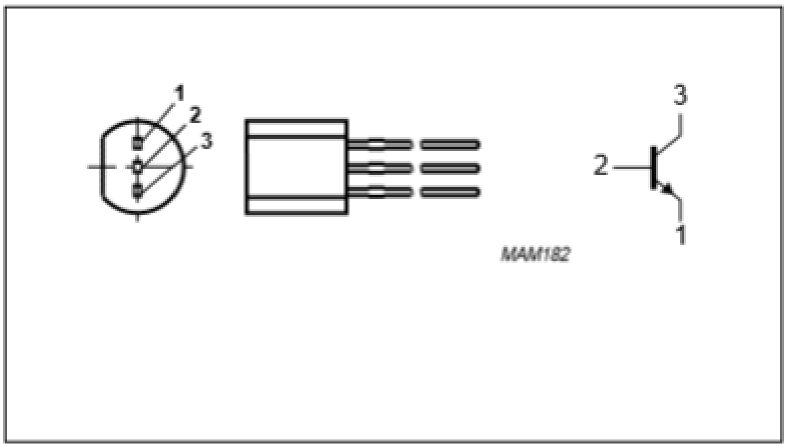
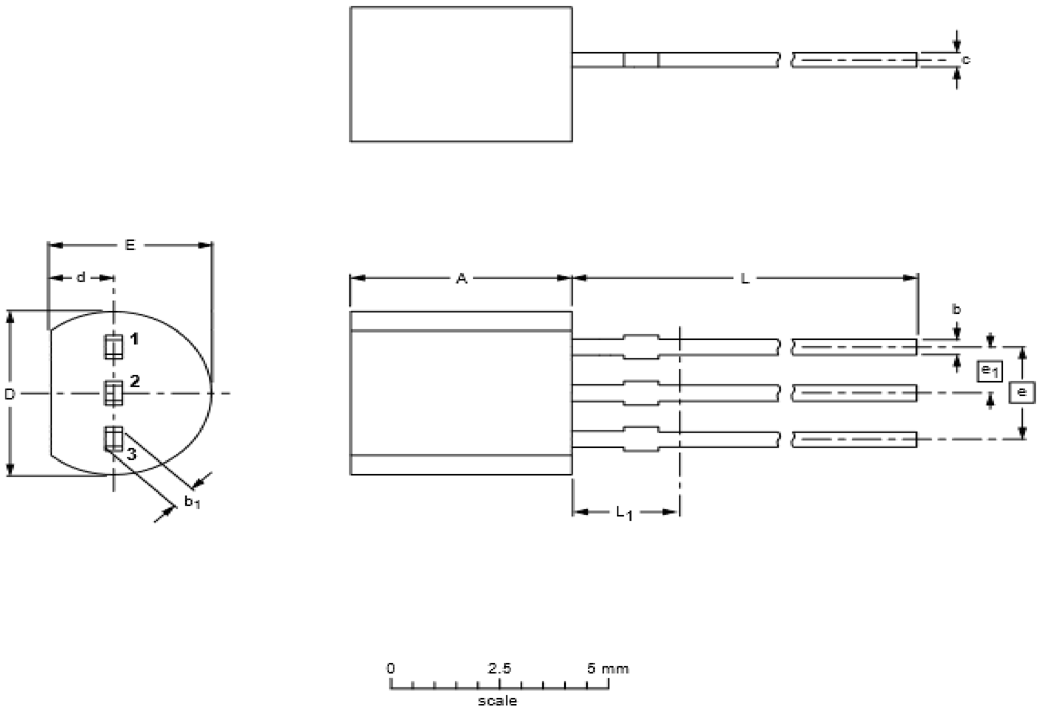


Figure 4.32. Ends of BC237

Table 4.7. Technical specification of BC237

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V_{CBO}	collector-base voltage	open emitter	–	50	V
V_{CEO}	collector-emitter voltage	open base	–	45	V
I_{CM}	peak collector current		–	200	mA
P_{tot}	total power dissipation	$T_{amb} \leq 25$ °C	–	500	mW
h_{FE}	DC current gain	$I_C = 2$ mA; $V_{CE} = 5$ V			
	BC237		120	460	
	BC237B		200	460	
f_T	transition frequency	$I_C = 10$ mA; $V_{CE} = 5$ V; f = 100 MHz	100	–	MHz



DIMENSIONS (mm are the original dimensions)

UNIT	A	b	b_1	c	D	d	E	e	e_1	L	L_1(1)
mm	5.2 5.0	0.48 0.40	0.66 0.56	0.45 0.40	4.8 4.4	1.7 1.4	4.2 3.6	2.54	1.27	14.5 12.7	2.5

Figure 4.33. Dimension of BC237

4.11. Buzzer

Buzzer or beeper is an audio signaling device which may be mechanical, electromechanical, or piezoelectric. Typical uses of buzzers and beepers include alarm devices, timers and confirmation of user input such as a mouse click or keystroke [22].

Figure 4.34. Buzzer

4.11.1. Features

- The PS series are high-performance buzzers that employunimorph piezoelectric elements and are designed for easy incorporation into various circuits.
- They feature extremely low power consumption in comparison to electromagnetic units.
- Because these buzzers are designed for external excitation, the same part can serve as both a musical tone oscillator and a buzzer.
- They can be used with automated inserters. Moisture-resistant models are also available.
- The lead wire type (PS1550L40N) with both-sided adhesive tape installed easily is prepare.

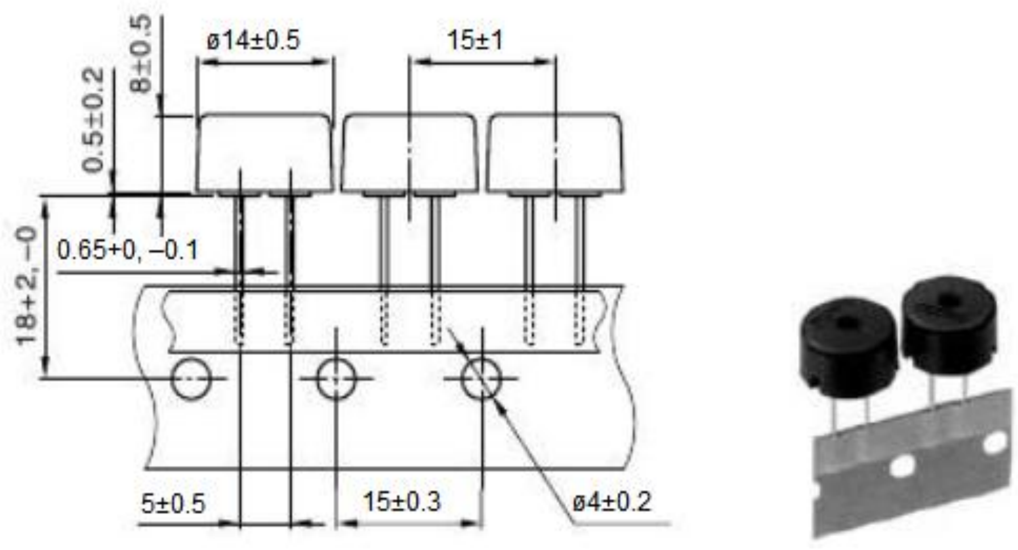


Figure 4.35. Buzzer dimensions

- High sound pressure.
- Miniature size (ø14×T8mm.).
- Suitable for automatic radial taping machine(15mm-pitch)

- Now, microcomputers are widely used for microwave ovens, air conditioners, cars, toys, timers, and other alarm equipment.

- Externally driven piezoelectric sounders are used in digital watches, electronic calculators, telephones and other equipment. They are driven by a signal (ex, 2048Hz. or 4096Hz.) from an LSI and provide melodious sound.

SPECIFICATIONS AND CHARACTERISTICS

Sound pressure	75dBA/ 10cm min.	[at 4kHz, 3V o-P rectangular wave, measuring temperature: 25±5°C, humidity: 60±10%]
Temperature range	Operating −20 to +70°C Storage −30 to +80°C	
Maximum input voltage	30V o-P max.	[without DC bias]
Minimum delivery unit	1750 pieces	[350 pieces/1 reel×5 reels]

FREQUENCY SOUND PRESSURE CHARACTERISTICS

SINE WAVE DRIVE **SQUARE WAVE DRIVE**

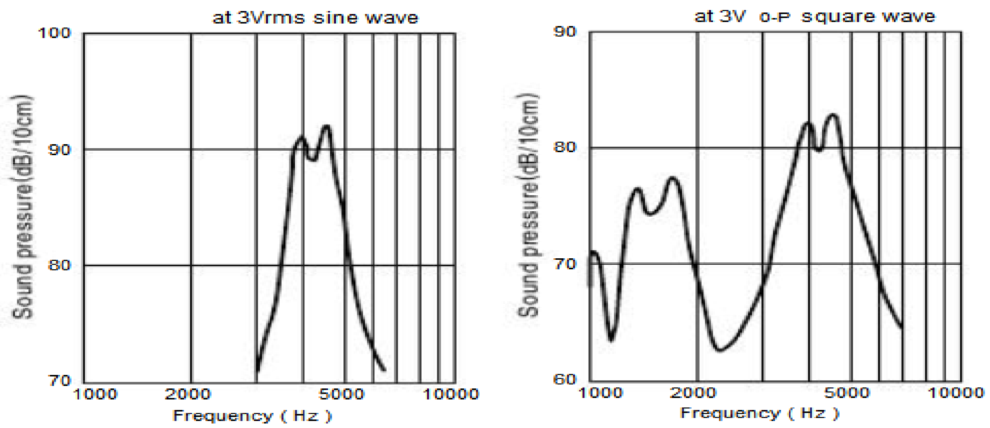


Figure 4.36. Specific and frequency sound pressure characteristics graphes

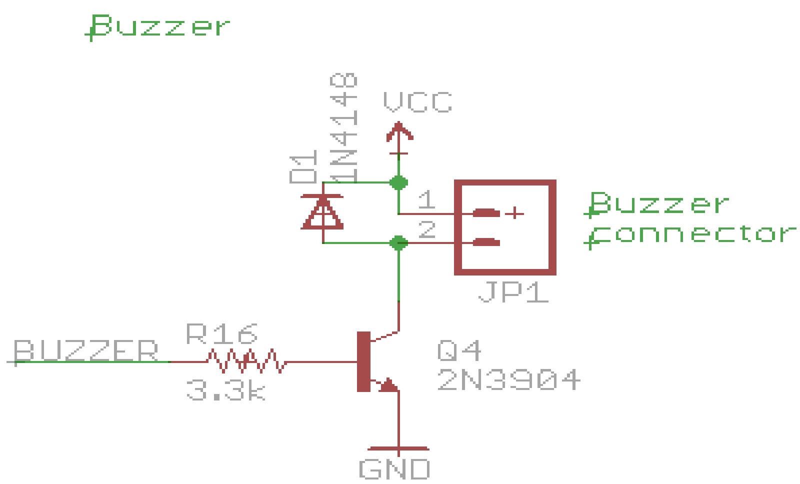


Figure 4.37. Buzzer circuite

4.12. Potentiometer

A potentiometer is a manually adjustable electrical resistor that uses three terminals. In many electrical devices, potentiometers are what establish the levels of output. For example, in a loudspeaker, a potentiometer is used to adjust the volume. In a television set, computer monitor or light dimmer, it can be used to control the brightness of the screen or light bulb [23].

Figure 4.38. Potentiometer

4.12.1. How It Works

Potentiometers, sometimes called pots, are relatively simple devices. One terminal of the potentiometer is connected to a power source, and another is hooked up to a ground a point with no voltage or resistance and which serves as a neutral reference point. The third terminal slides across a strip of resistive material. This resistive strip generally has a low resistance at one end, and its resistance gradually increases to a maximum resistance at the other end. The third terminal serves as the connection between the power source and ground, and it usually is operated by the user through the use of a knob or lever

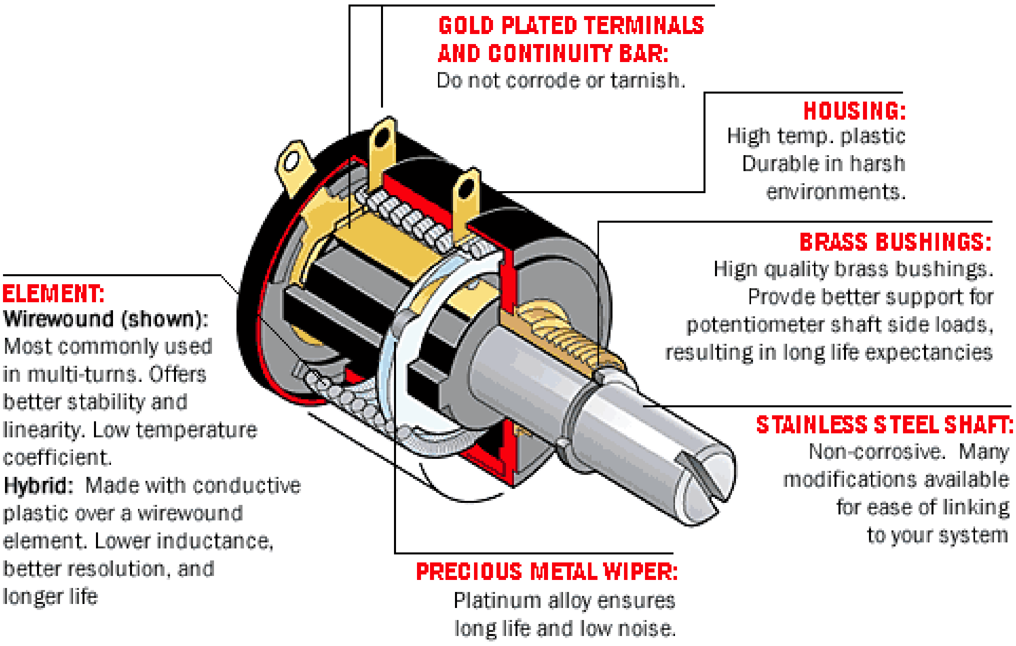


Figure 4.39. Internal specification of the potentiometers showing how it's work.

The user can adjust the position of the third terminal along the resistive strip to manually increase or decrease resistance. The amount of resistance determines how much current flows through a circuit. When used to regulate current, the potentiometer is limited by the maximum resistivity of the strip.

4.12.2. Controlling Voltage

Potentiometers also can be used to control the potential difference, or voltage, across circuits. The setup involved in utilizing a potentiometer for this purpose is a little more complicated.

It involves two circuits, with the first circuit consisting of a cell and a resistor. At one end, the cell is connected in series to the second circuit, and at the other end, it is connected to a potentiometer in parallel with the second circuit.

The potentiometer in this arrangement drops the voltage by an amount equal to the ratio between the resistance allowed by the position of the third terminal and the highest possible resistivity of the strip. In other words, if the knob controlling the resistance is positioned at the exact halfway point on the resistive strip, then the output voltage will drop by exactly 50 percent, no matter what the input voltage is. Unlike with electrical current regulation, voltage regulation is not limited by the maximum resistivity of the strip.

4.12.3. Rheostats

When only two of the three terminals are used, the potentiometer acts as a type of variable resistor called a rheostat. One end terminal is used, along with the sliding terminal. Rheostats typically are used to handle higher levels of current or higher voltage than potentiometers. For example, rheostats might be used to control motors in industrial machinery.

4.12.4. On-Off Switch Circuit

Pushbutton switches are mechanical switches defined by the method used to activate the switch. The activation method is typically in the form of a plunger that is pushed down to open or close the switch.

4.12.5. Switching Mechanism

There are several pole and throw configurations for pushbutton switches. The number of switch contact sets used is known as the number of poles and the number of conducting positions (single or double) is referred to as the throw. Switching mechanisms function differently by type; the five types of switches are described below

Single pole single throw (SPST) is a switch that makes or breaks the connection of a single conductor in a single branch circuit. This switch typically has two terminals. It is commonly referred to as a simple on-off switch and can be used to switch the power supply to a circuit.

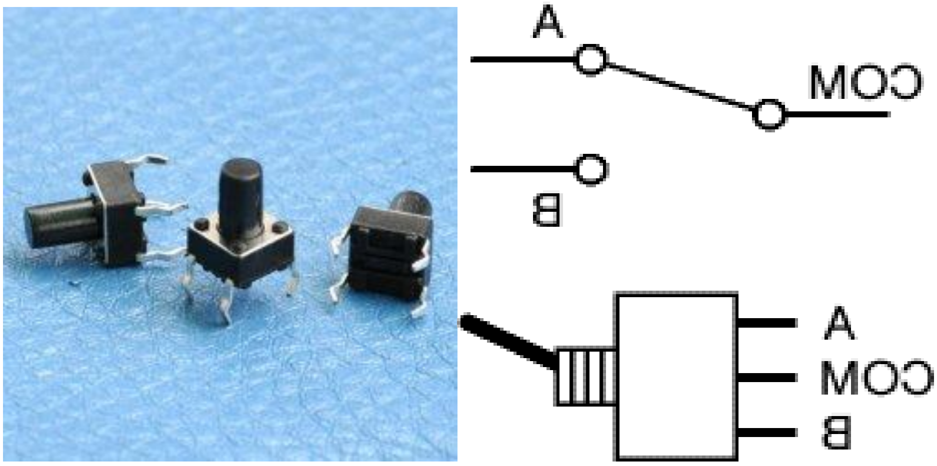


Figure 4.40. On-Off switch circuit.

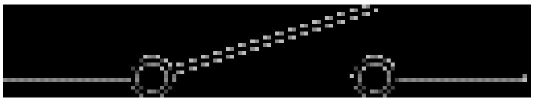


Figure 4.41. On-Off switch circuit symbol

SPST switches can also work as "push-to-make" on, where when the button is released it returns to its normally open (off) position or vice-versa.

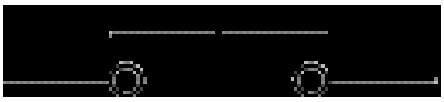


Figure 4.42. Other (On)-Off switch circuit symbol

Single pole double throw (SPDT) is a switch that makes or breaks the connection of a single conductor with either of two other single conductors. This switch typically has 3 terminals, and is commonly used in pairs and called a "Three-Way" switch. The switch can be in both on/off positions, switching on a separate device in each case. For example, a SPDT switch can be used to switch on a red lamp in one position and a green lamp in another position. Special versions can have a third switch position which turns both circuits off.

4.13. Relay

A relay is an electrically operated switch. Many relays use an electromagnet to operate a switching mechanism mechanically, but other operating principles are also used.

Relays are used where it is necessary to control a circuit by a low power signal (with complete electrical isolation between control and controlled circuits), or where several circuits must be controlled by one signal. The first relays were used in long distance telegraph circuits, repeating the signal coming in from one circuit and re-transmitting it to another. Relays were used extensively in telephone exchanges and early computers to perform logical operations. type of relay that can handle the high power required to directly control an electric motor or other loads is called a contactor. Solid-state relays control power circuits with no moving parts, instead using a semiconductor device to perform switching. Relays with calibrated operating characteristics and sometimes multiple operating coils are used to protect electrical circuits from overload or faults in modern electric power systems these functions are performed by digital instruments still called "protective relays" [24].

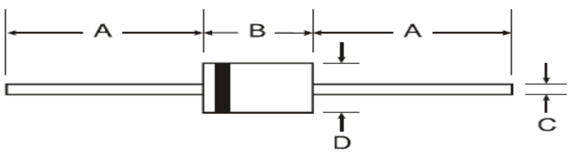
Figure 4.43. Relay

Table 4.8. Technical specifications of Relay

Maximum operation voltage of contact	AC: 250V DC: 30V
Maximum operation current of contact	10A
Maximum switching power	1750VA 210W
Rated voltage of coil (Ue)	3~48V DC
Rated power consumption of coil	360mW, 450mW(48VDC)
Attract voltage of coil	≤75%Ue
Release voltage of coil	≥10%Ue
Maximum voltage of coil	110%Ue
Electrical life	1×10^5 times
Mechanical life	1×10^7 times

4.14. Diode

In electronics, a diode is a two-terminal electronic component with asymmetric conductance; it has low (ideally zero) resistance to current in one direction, and high (ideally infinite) resistance in the other [25].



Dim	DO-41 Plastic	
	Min	Max
A	25.40	—
B	4.06	5.21
C	0.71	0.864
D	2.00	2.72
All Dimensions in mm		

Figure 4.44. Dimension of Diode

4.14.1. Features

Diffused Junction;

- High current capability and low forward voltage drop,
- Surge overload rating to 30A. peak,
- Low reverse leakage current,
- Lead free finish, RoHS compliant.

4.14.2. Mechanical Data Case DO-41

- Case material; molded plastic. UL flammability classification rating 94V-0
- Moisture sensitivity; level 1 per J-STD-020D
- Terminals: finish - bright tin plated leads solder able per MIL-STD-202, method 208
- Polarity; cathode band
- Mounting position; any
- Ordering information
- Marking; type number
- Weight; 0.30 grams (approximate)

4.15. Atmel ATMEGA328P Controller

A microcontroller (abbreviated Mc. or MCU) is essentially an entire computer system on a single, tiny microchip! While not as fast or powerful as your desktop or laptop computer, a microcontroller excels at being very small, very inexpensive, and can operate on very little power (great for battery-powered devices).

Microcontrollers are the heart of what's called "Embedded Computing" - a term used to describe using these tiny computers inside everyday things to make them "smart" - things like microwaves, cars, cellphones, TVs, and so on.

A microcontroller has many subsystems on board it's tiny little chip. The central part is the microprocessor core - it's the brain of the computer that carries out program instructions.

Other subsystems include;

- RAM (Random Access Memory); where the software can store data temporarily. This memory is lost when the power is turned off, so it's usually used to store information that the program generates as it runs through it's instructions.
- Flash memory; where the software program is stored. This memory is not lost when the power goes off. It is similar to the SD card in your smartphone or digital camera.
- EEPROM (Electronically Erasable Programmable Read Only Memory); a special type of memory that can retain data after the power is turned off. This is a good place to store things like configuration settings, that need to be remembered for next time the system is powered up. It only stores data, not program code.
- IO (Input/Output) Systems; this is how the microcontroller communicates with the outside world. There's many different types of I/O, such as digital (1s and 0s), analog (variable voltage), PWM (Pulse Width Modulation) which falls somewhere between digital and analog, and many types of computer protocols like Serial, I2C, Parallel, CAN, 2WI, and more.

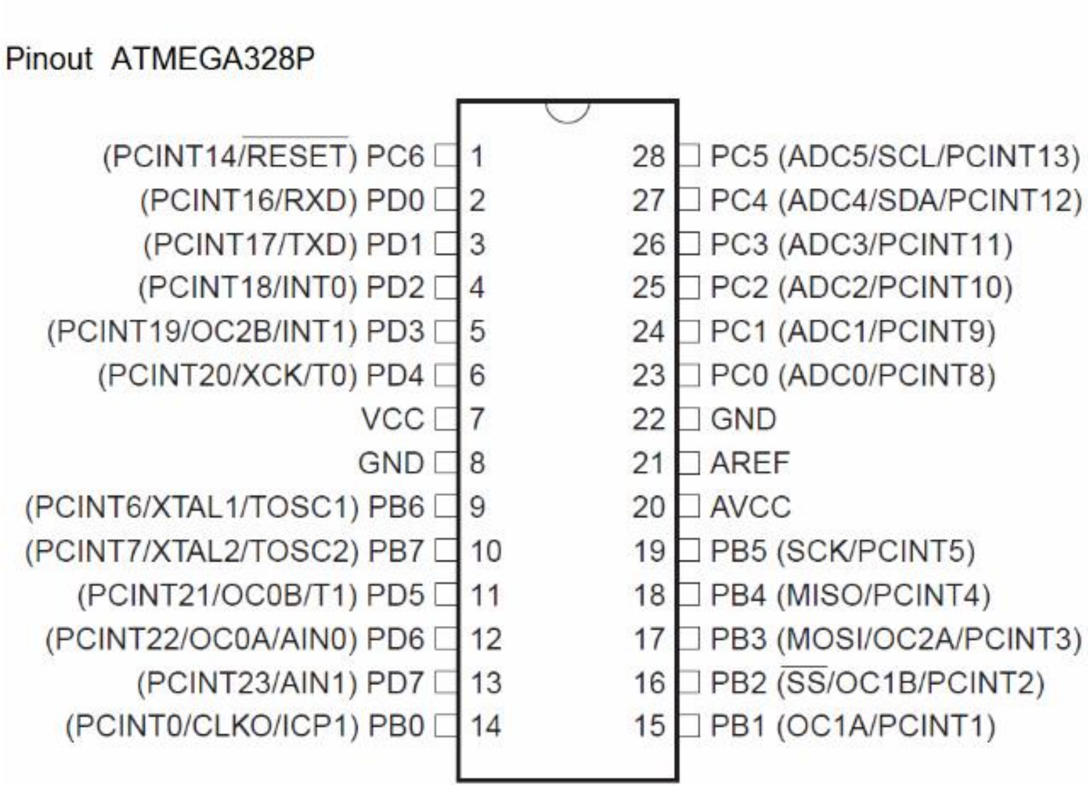


Figure 4.45. Atmel Atmega 328P Controller pin out connectors

4.15.1. Features

- High performance, low power Atmel®AVR® 8-Bit microcontroller family
- Advanced
  - 131 Powerful instructions – most single clock cycle execution
  - 32 x 8 General purpose working registers
  - Fully Static operation
  - Up to 20 MIPS throughput at 20MHz.
  - On-chip 2-cycle multiplier
  - High endurance non-volatile memory segments
  - 4/8/16/32KBytes of in-system self-programmable flash program memory
  - 256/512/512/1KBytes EEPROM

- 512/1K/1K/2KBytes Internal SRAM
- Write/erase cycles: 10,000 flash/100,000 EEPROM
- Data retention: 20 years at 85C/100 years at 25 °C(1)
- Optional boot code section with independent lock bits in-system programming by On-chip boot program true read-while-write Operation
- Programming lock for software security

- Peripheral Features
  - Two 8-bit Timer/Counters with separate prescaler and compare mode
  - One 16-bit Timer/Counter with separate prescaler, compare mode, and capture mode
  - Real time counter with separate oscillator
  - Six PWM channels
  - 8-channel 10-bit ADC in TQFP and QFN/MLF package
  - 6-channel 10-bit ADC in PDIP package
- Temperature Measurement
  - Programmable serial USART
  - Master/Slave SPI serial interface
  - Byte-oriented 2-wire serial interface (Philips I2C compatible)
  - Programmable watchdog timer with separate on-chip oscillator
  - On-chip analog comparator

5. CONSTRUCTION

Transparent infant incubator chamber, chamber is made up of plastic and inside it there is temperature humidity control unit, Arduino controller, 2 fans, incubator resistance, LCD panel, UV leds and pressure sensor for measuring weight.

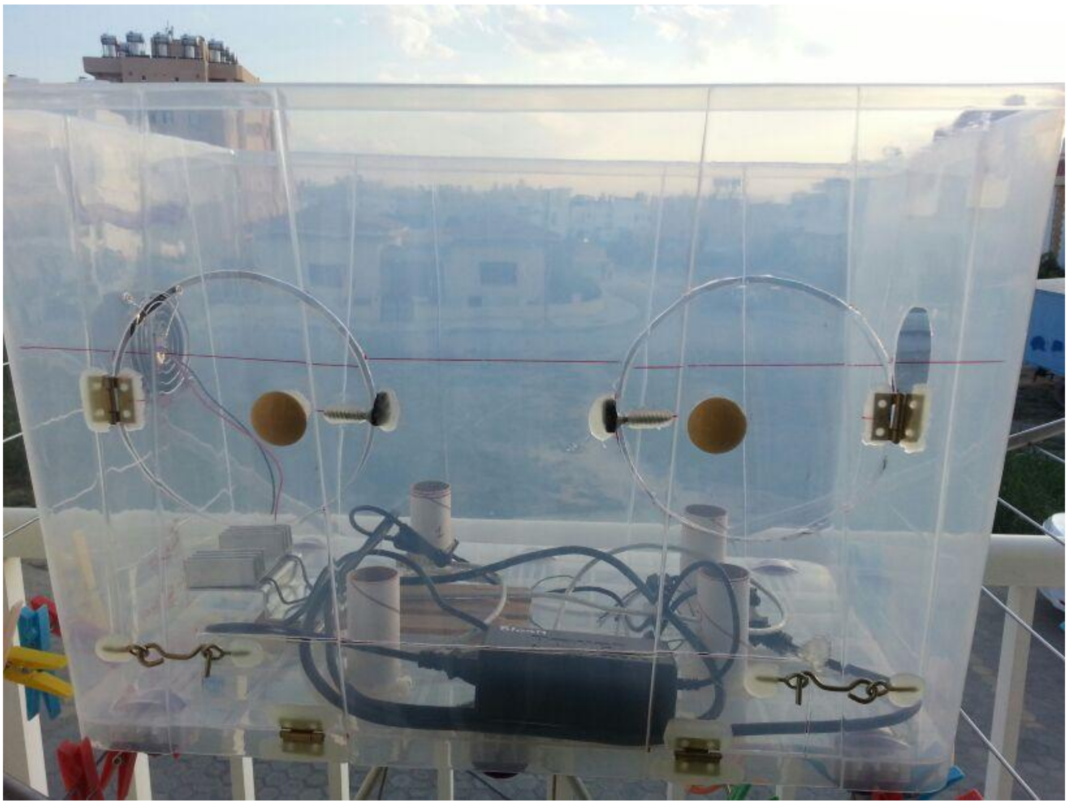


Figure 5.1. Our infant incubator of chamber

5.1. The Temperature and Humidity control

The temperature and humidity in the chamber need to sensed and read before controlling them. Sensors is placed inside the infant incubator where the baby is kept and the sensed temperature and humidity is given to the Aurduino Uno Microcontroller.

Temperature and humidity sensed the inside of incubator as connected to the Aurduino. First A program is written and uploaded to the Aurduino which makes the temperature and humidity to be displayed on the monitor. Aurduino uno is the controller used here. The program is written to control temperature, humidity, resistance and pressure sensor.

We used the resistance for heating. We have established temperature of infant incubator between 24 °C - 38 °C. when the temperature in the chamber falls down below 24 °C Aurdino Uno Controller sent to command to turn on the resistance. The resistance works with 220 volt and 50Hz. We don't connect the Aurdino output to the resistance input. In order to do this we used the circuit and parts of the circuit are 1 transistor, 1 relay, 1 k ohm resistor and 1 diode. Aurdino sents to base leg of transistor 1 code to trigger the transistor. We reads the temperature, humidity and weight values on the LCD. We connected Aurdino outputs to the LCD inputs to show us the values. If the temperature is required enough heat which is 24 °C the resistance turn off by Aurdino. When the temperature goes beyond 30 °C fan works to control the environment heating.

5.2. Driver Circuit

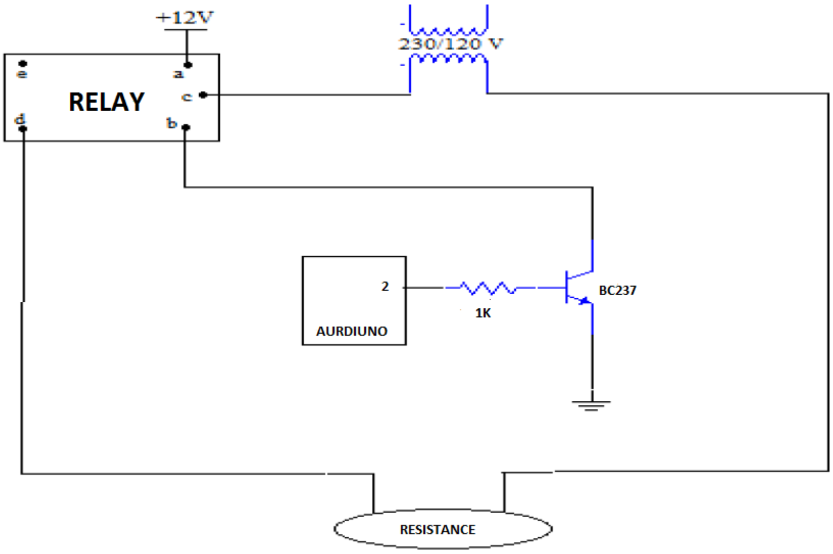


Figure 5.2. On-Off electrical switch

Relay as we saw above the figure works 12 volts. We provide 12 volts from power supply. Relay, also enables the opening and closing of an electrical circuit is an electrical switch. Switch is controlled by an electromagnet. Relay provides to turn on/off the resistance for heating resistance.

Resistor of 1 k. privents the output of aurdino tolerance current. Transistor acts as a switch and allows current flow to the relay. Aurdino outputs sent 5V. to base end of transistor in this case transistor is activated by Aurdino and transistor trigger relay and is worked the driver circuit.

We used UV leds for phototherapy treatment. We mounted it on the roof of infant incubator. We adjusted it manually by the help of switch. Phototherapy device has 15 UV leds. When we want to turn on the device we press the switch and again in order to turn off the device we press the switch.

Also to determine any problem in the infant incubator or to hear without occurring any problem inside it. We set up alarm system which is connected Aurdino Uno controller. When the temperature falls down under the 24 °C the buzzer is triggered and start giving alarm loudly. Temperature goes upon to 38 °C buzzer start again alarm and thus we can interfere immediately or we can control. When the temperature is below than 24 °C, Aurdino controller trigger the resistance and resistance start heating and is heated inside of the chamber. When the temperature is upper than 38 °C Aurdino trigger 2 fans and fans cools inside incubator. Also we used red light emitted diode for warning.

There is a pressure sensor that is connected Aurdino. Pressure sensor control the baby of weight in every 2 seconds.

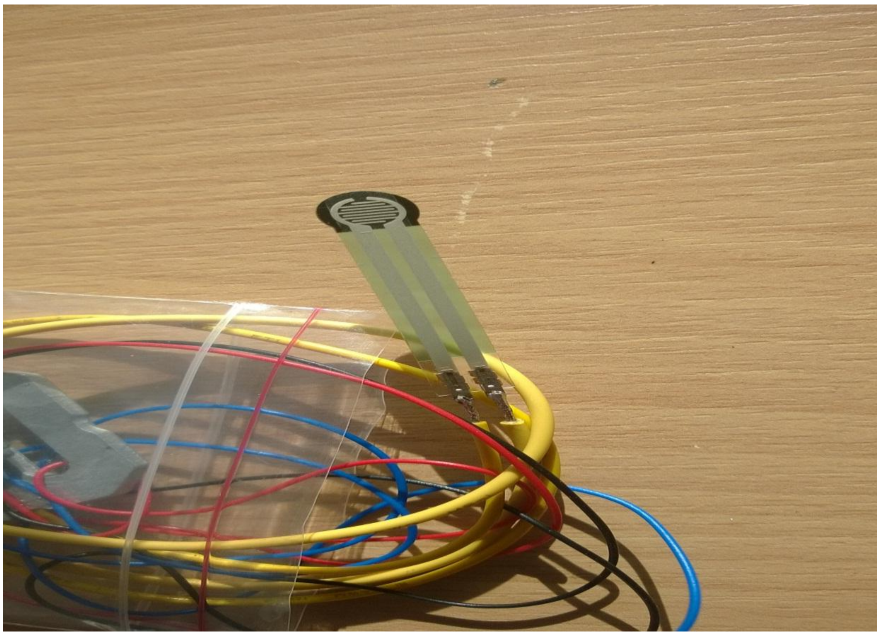


Figure 5.3. Pressure sensor connected with circuit wires.

6. CONCLUSION

The project is developed keeping in mind the medical conditions available in Rural areas. This Equipment can be effectively used by technicians in a small health care center. It can be a lifesaving machine for low birth weight infants. The components can be easily fixed. The chamber is sufficient enough to accommodate the baby comfortably. As the electronic part is separated from the compartment the baby is kept the baby can be assured safe. The Aurduino Uno microcontroller used here is efficient in controlling the temperature of the system. The temperature of the system can be understood from readings on the monitor. This project is simple and efficient in maintaining the temperature of the chamber irrespective of the outside temperature and is designed at a low cost. We can incorporate the idea of Peltier effect to control the temperature of the chamber. They can be used either for heating or for cooling (refrigeration), although in practice the main application is cooling. It can also be used as a temperature controller that either heats or cools. But Peltier elements are costly and shows poor power efficiency.

6.1. Future Researches

Many researchers and companies are trying to develop Peltier coolers that are both cheap and efficient. If such type of Peltier elements are developed we can also introduce it in Infant incubators, future incubators should minimize heat loss from the neonate and eddies around him/her. An unresolved issue is exposure to high noise levels in the Neonatal Intensive Care Unit (NICU). Strategies aimed at modifying the behavior of NICU personnel, along with structural improvements in incubator design, are required to reduce noise exposure. Light environment should be taken into consideration in designing new models of incubators.

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8. APPENDIX

```
#include <dht11.h>
#include <LiquidCrystal.h>

dht11 DHT11;
LiquidCrystal lcd(12, 11, 5, 4, 3, 2);
int weight0=0;
float weight=0;
int buzzer=6, fan=0, heater=1;

#define DHT11PIN 8

 void setup()
{

lcd.begin(16, 2);

pinMode(6,OUTPUT);
pinMode(0,OUTPUT);
pinMode(1,OUTPUT);

}

void loop()
{

int chk = DHT11.read(DHT11PIN);
weight0 = analogRead(A0);
weight = weight0/102.4;

switch (chk)
{
```

```
case 0: lcd.println("ok"); break;
case -1: lcd.println("Checksum error");break;
case -2: lcd.println("Time out error");break;
default: lcd.println("Unknown error");break;
}
lcd.clear();

lcd.display();
lcd.write("Temp (oC): ");
lcd.println((float)DHT11.temperature, 2);
lcd.setCursor(0,2);
lcd.write("Humi. (%): ");
lcd.println((float)DHT11.humidity, 2);

delay(1000);

lcd.display();
lcd.write("Temp (oC): ");
lcd.println((float)DHT11.temperature, 2);
lcd.setCursor(0,2);
lcd.write("weight : ");
lcd.println(weight, 2);

delay(200);



if((float)DHT11.temperature < 24)
{

digitalWrite(heater,HIGH);
analogWrite(buzzer,20);

}
```

```
if((float)DHT11.temperature < 30)
{
 digitalWrite(fan,LOW);
}else
{
 digitalWrite(fan,HIGH);
}

if((float)DHT11.temperature > 24)
{
 analogWrite(buzzer,0);
}

 if((float)DHT11.temperature > 27)
{
 digitalWrite(heater,LOW);
}

 if((float)DHT11.temperature >30)
 { digitalWrite(fan,HIGH);
}else
{
digitalWrite(fan,LOW);
}

if((float)DHT11.temperature > 38 || (float)DHT11.temperature < 24 )
{
 analogWrite(buzzer,100);
}else
{
 analogWrite(buzzer,0);
}
```

```
delay(2000);
}
double Fahrenheit(double celsius)
{
  return 1.8 * celsius + 32;
}

double Kelvin(double celsius)
{
return celsius + 273.15;
}
double dewPoint(double celsius, double humidity)
{
 double A0= 373.15/(273.15 + celsius);
 double SUM = -7.90298 * (A0-1);
 SUM += 5.02808 * log10(A0);
 SUM += -1.3816e-7 * (pow(10, (11.344*(1-1/A0)))-1);
 SUM += 8.1328e-3 * (pow(10,(-3.49149*(A0-1)))-1) ;
 SUM += log10(1013.246);
 double VP = pow(10, SUM-3) * humidity;
 double T = log(VP/0.61078); // temp var
 return (241.88 * T) / (17.558-T);
}

double dewPointFast(double celsius, double humidity)
{
double a = 17.271;
double b = 237.7;
double temp = (a * celsius) / (b + celsius) + log(humidity/100);
double Td = (b * temp) / (a - temp);
return Td;
}
```