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NEAR EAST UNIVERSITY

Faculty of Engineering

Department of Electrical and Electronic Engineering

AIR FLOW DETECTOR

Graduation Project
EE – 400

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ABSTRACT

As the life is getting more complicated, we figure out that most of the machines and equipments are replaced by more luxury or even more intelligent alternatives, and such an air flow detecting system is one that can assist the real world, and makes it easier to control automatically the performance of any required system.

This air flow detecting circuit is based on detecting the surrounding region for any air flow that may occur, in which an incandescent lamp senses the flow of air and responds by increasing the resistance of that lamp, and based on this fact we construct our circuit. We have improved it by putting a potentiometer in order to adjust the sensitivity. The idea behinds this application gives hands-free control over devices like any attached circuit.

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INTRODUCTION

Air flows are considered in some applications as an important issue. All of the Air flows and their distribution in a given building are caused by pressure differences that can be induced by wind, thermal buoyancy, mechanical ventilation, or a combination of these factors.

In this project we are going to design, build and test air flow detector. How to turn the switches on and off, Suggestion into where these switches can be used will be made.

The first chapter of this project is the background chapter, which include electronic component especially the components were used in this project with some explanation and the characteristic of them. And Safety guideline when doing electronic project because of any electric component it has a guideline safety, if you do not know what is it you will burn, or break the component so that before doing any electric project you have to be care about this chapter.

the second chapter we have discuss air flow definition and principles, and many applications that demonstrate the main idea of air flow principle are also discuss to come out with an obvious sight on air flow.

The third chapter is the most important chapter, which explains the hardware project in details, how we built it, How it work, what its input and output? With the circuit diagrams of air flow detector, the diagram of the first and second and stage circuits also will be shown. And the components for all of them were listed.

The aims of this project are:

- To design and build an air flow detector.
- To gain hands-on experience in electronic hardware project.
- To modify the original circuit where possible.
- To suggest potential real-life use of air flow detector.

CHAPTER ONE

ELECTRONIC COMPONENTS

1.1 Overview

This chapter presents an introduction to electronic components that are commonly used in hardware projects. Safety guidelines for electronic projects will also be described.

1.2 1ntroduction to Electronic Components

Electronics gets its name from the electron, a tiny particle which forms part of all atoms, which, as everybody knows, make up everything in the world. Atoms contain other types of particles - protons and neutrons - but it is the electrons which will be interesting us here.

Electrons and protons have the electrical property of charge. Protons have positive charge and electrons have negative charge and they normally balance each other out. We don't really need to know what charge is. It's just a property like weight or color, but it is this property which makes the whole of electronics happens. But keep in mind the fact that opposite charges attract and similar charges repel.

When electrons move together in a unified way we say there is a current flowing. Electrons are actually moving all the time in materials like metals but moving in a random disordered way. A current is when they all move together in one particular direction.

When you touch a lift button having walked across a synthetic carpet and you feel a shock that is electrons flowing through you to the ground. That's all a current is, simply the movement of electrons in a particular direction.

Electrons can't flow through every material. Materials that allow a current to flow easily are called conductors. Materials that don't allow a current to flow are called non-conductors or insulators. Metals are the most common conductors, plastics are typical insulators.

Conductor's	**non-conductors**
Gold	plastic
Copper	wood
Carbon	air

Copper is a good conductor. Copper tracks are used on the printed circuit boards to connect the components together. Solder is another good conductor. The solder makes the actual join between the leg of the component and the track.

The plastic that a printed circuit board is made of is an insulator. Currents can only flow up and down the copper tracks and not jump from one to another. For the same reason wires are surrounded by plastic coatings to stop them conducting where they shouldn't.

There are certain materials that are between the two extremes of conductor and non-conductor; we will come to them later.

A battery supplies the 'force' that makes the electrons move. This force is called the voltage. The bigger the voltage the more force. Mains electricity which is 240 volts is more powerful than an ordinary 9 volt battery.

Currents are measured in amps, and voltages are measured in volts (after the scientists Ampere and Volta). Voltages are sometimes called potential differences, or electromotive forces, but we won't use these terms here.

There is a big confusion for many people as to the difference between voltage and current. They talk about so many volts going through something when they really mean amps. So let's think about things in a different way.

Imagine water flowing through a pipe filling up a pond. The water represents the electrons and the pipe represents the wire. A pump provides the pressure to force the water through the pipe. The pump is the battery. How much water flows out the end of the pipe each second is the current. How hard the water is being pumped is the voltage.

A narrow pipe will take a long time to fill the pond, whereas a broad pipe will do it much faster using the same pump. Clearly the rate of flow depends on the thickness of the pipe. So we have the situation where the same voltage (pump pressure) can give rise to different currents (flow rate) depending on the pipe. Try to guess what the thickness of the pipe represents in this model of things (answer later).

An electric current requires a complete path - a circuit - before it can flow. In a circuit with a battery, the battery is both the starting flag and the finishing line for the electrons. A chemical reaction in the battery releases electrons which flow around the circuit and then back into the battery. The battery keeps the current flowing, feeding electrons in at one end and collecting them at the other. It takes energy to do this and so after a while the battery wears out.

Current flows into a component and the same amount of current always flows out of the component. It is not 'used up' in any way. As the current passes through components things happen (an LED lights up for instance) [1].

1.2.1 Resistors

Electrons move more easily through some materials than others when a voltage is applied. In metals the electrons are held so loosely that they move almost without any hindrance. We measure how much opposition there is to an electric current as resistance.

Resistors come somewhere between conductors, which conduct easily, and insulators, which don't conduct at all. Resistance is measured in ohms after the discoverer of a law relating voltage to current. Ohms are represented by the Greek letter omega.

Think back to the model of water flowing in a pipe. The thickness of the pipe must represent the resistance. The narrower the pipe the harder it is for the water to get through and hence the greater the resistance. For a particular pump the time taken to fill the pond is directly related to the pipe thickness. Make the pipe twice the size and the flow rate doubles, and the pond fills in half the time.

The resistors used in the kits are made of a thin film of carbon deposited on a ceramic rod. The less carbon the higher the resistance. They are then given a tough outer coating and some colored bands are painted on.

The main function of resistors in a circuit is to control the flow of current to other components. Take an LED (light) for example. If too much current flows through an LED it is destroyed. So a resistor is used to limit the current.

When a current flows through a resistor energy is wasted and the resistor heats up. The greater the resistance the hotter it gets. The battery has to do work to force the electrons through the resistor and this work ends up as heat energy in the resistor.

An important property to know about a resistor is how much heat energy it can withstand before it's damaged. resistors can dissipate about a 1/4 Watt of heat (compare this with a domestic kettle which uses up to 3 000 Watts to boil water) [8].

It's difficult to make a resistor to an exact value (and in most circuits it is not critical anyway). Resistances are given with a certain accuracy or tolerance. This is expressed as being plus or minus so much of a percentage. A 10% resistor with a stated value of 100 ohms could have a resistance anywhere between 90 ohms and 110 ohms. The resistors are 5% (that's what the gold band means) which is more than enough accuracy.

Real resistances vary over an enormous range. In the *Lie Detector* there is a 1 000 000 ohms resistor alongside a 470 ohms resistor. In circuit diagrams you will often see an 'R' instead of omega to represent ohms. This is a convention that dates from before the days of computers and laser printers when Greek letters were rarely found on typewriters. The letter 'k' means a thousand and its position shows the position of the decimal point.

Here are some examples:

10R = 10 ohms
10k = 10 kilohms = 10 000 ohms
4k7 = 4.7 kilohms = 4 700 ohm

1.2.1.1 Fixed value resistors

During manufacture, a thin film of carbon is deposited onto a small ceramic rod. The resistive coating is spiraled away in an automatic machine until the resistance between the two ends of the rod is as close as possible to the correct value. Metal leads and end caps are added; the resistor is covered with an insulating coating and finally painted with colored bands to indicate the resistor value

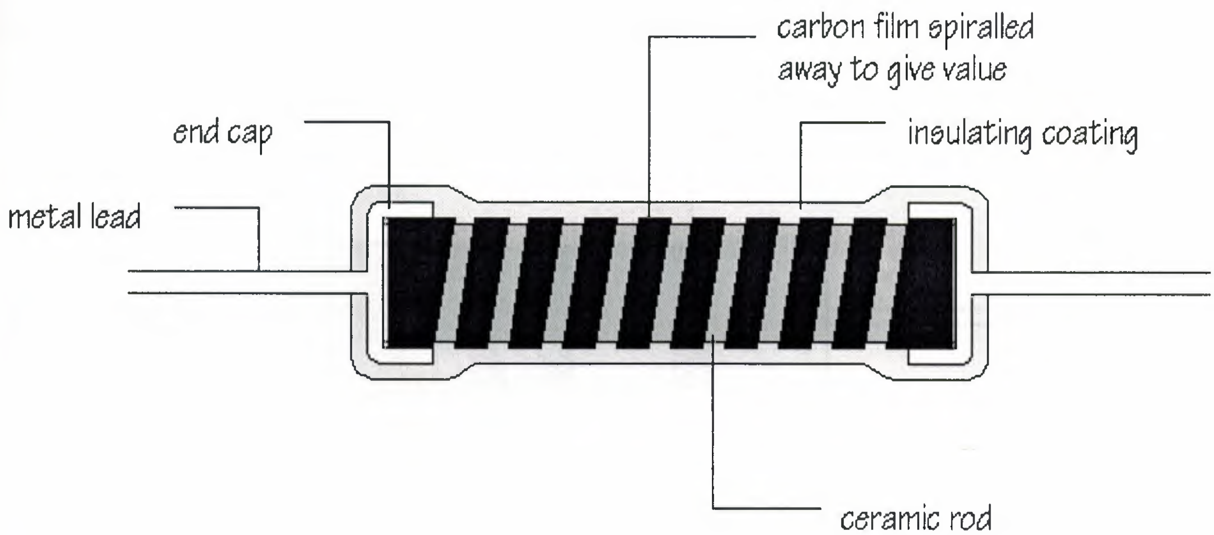


Figure 1.1: The diagram shows the construction of a carbon film resistor [4].

Carbon film resistors are cheap and easily available, with values within ±10% or ±5% of their marked, or 'nominal' value. Metal film and metal oxide resistors are made in a similar way, but can be made more accurately to within ±2% or ±1% of their nominal value. There are some differences in performance between these resistor types, but none which affect their use in simple circuits.

Wire wound resistors are made by winding thin wire onto a ceramic rod. They can be made extremely accurately for use in multimeters, oscilloscopes and other measuring equipment. Some types of wire wound resistors can pass large currents without overheating and are used in power supplies and other high current circuits.

1.2.1.2 Resistor Color Code

The resistor color code is a way of showing the value of a resistor. Instead of writing the resistance on its body, which would often be too small to read, a color code is used. Ten different colors represent the numbers 0 to 9. The first two colored bands on the body are the first two digits of the resistance, and the third band is the 'multiplier'. Multiplier just means the number of zeroes to add after the first two digits. Red represents the number 2, so a resistor with red, red, red bands has a resistance of 2 followed by 2 followed by 2 zeroes, which is 2 200 Ohms or 2.2 kilo Ohms.

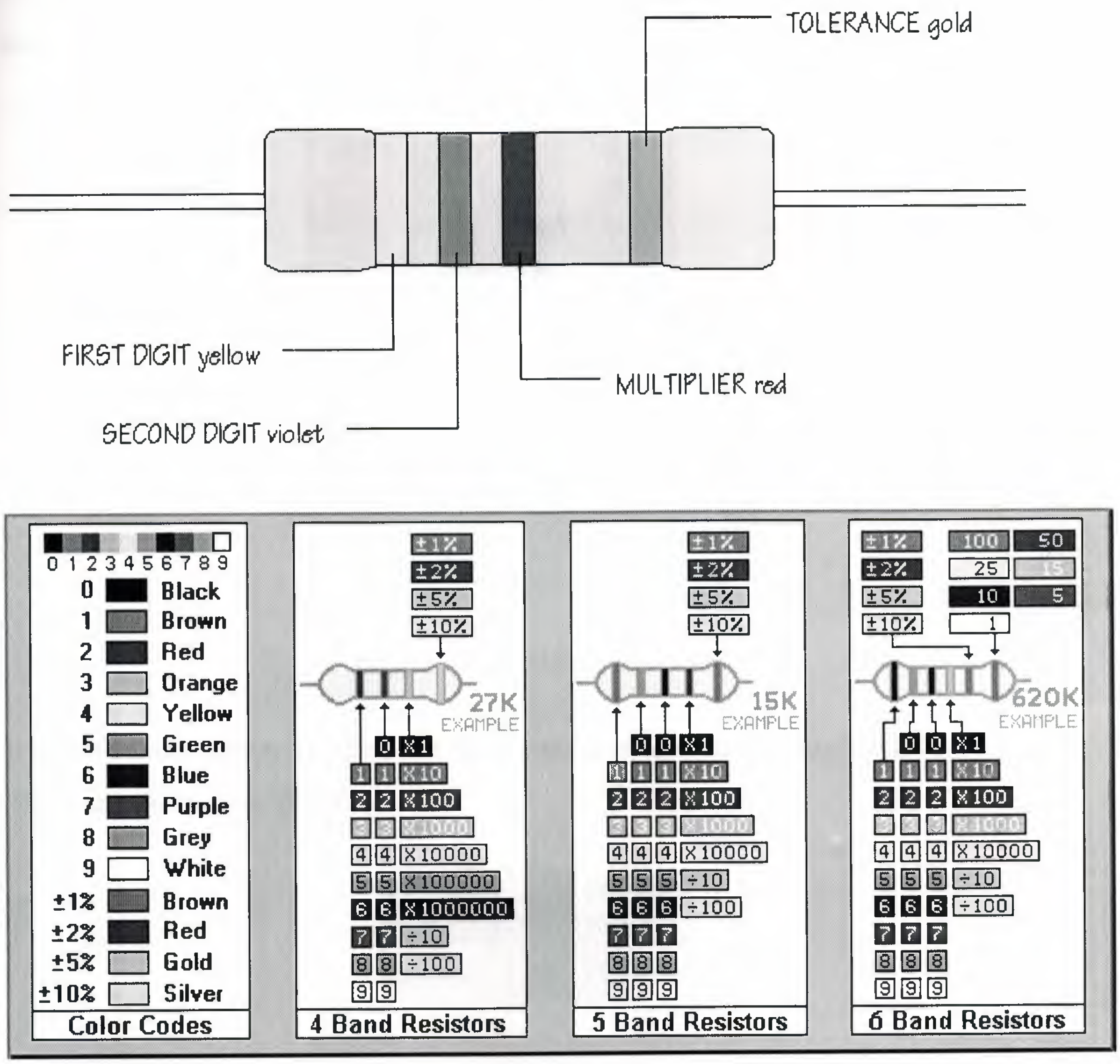


Figure 1.2: Color code identification [4].

While these codes are most often associated with resistors, then can also apply to capacitors and other components.

The standard color coding method for resistors uses a different color to represent each number 0 to 9: black, brown, red, orange, yellow, green, blue, purple, grey, white. On a 4 band resistor, the first two bands represent the significant digits. On a 5 and 6 band, the first three bands are the significant digits. The next band represents the multiplier or "decade"[8].

1.2.1.3 Resistors in series and parallel

In a series circuit, the current flowing is the same at all points. The circuit diagram shows two resistors connected in series with a 6 V battery:

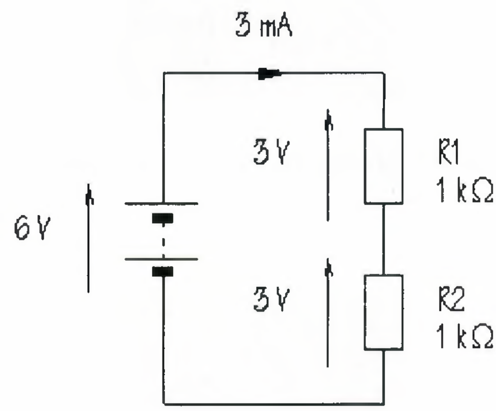


Figure 1.3: Resistors in series.

It doesn't matter where in the circuit the current is measured; the result will be the same. The total resistance is given by:

$$R_{\text{total}} = R_1 + R_2$$

The next circuit shows two resistors connected in parallel to a 6 V battery:

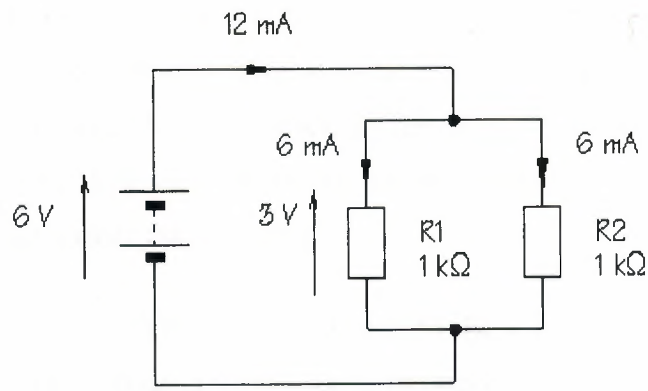


Figure 1.4: Resistors in parallel.

Parallel circuits always provide alternative pathways for current flow. The total resistance is calculated from:

$$R_{total} = \frac{R_1 \times R_2}{R_1 + R_2}$$

This is called the product over sum formula and works for any *two* resistors in parallel. An alternative formula is:

$$\frac{1}{R_{total}} = \frac{1}{R_1} + \frac{1}{R_2}$$

This formula can be extended to work for more than two resistors in parallel, but lends itself less easily to mental arithmetic. Both formulae are correct.

1.2.1.4 Variable Resistors

Unsurprisingly, variable resistors are resistors whose resistance can be varied. The variable resistors (called presets) have a metal wiper resting on a circular track of carbon. The wiper moves along the track as the preset is turned. The current flow through the wiper; and then; through part of the carbon track. The more of the track it has to go through the greater the resistance.

The presets have three legs. The top leg connects to the wiper and the other two legs to the two ends of the track. Generally only one of the track legs is actually used.

Variable resistors are used in circuits to vary things that need changing, like volume etc.

1.2.2 Capacitors

Capacitors are stores for electrical charges. Like tiny batteries they can cause a current to flow in a circuit. But they can only do this for a short time; they cannot deliver a sustained current. They can be charged up with energy from a battery, then return that energy back later. The capacitance of a capacitor is a measure of how much energy or charge it can hold.

In its simplest form a capacitor consists of two metal plates separated by a small gap. Air or another non-conductor fills the gap. The bigger plates has bigger capacitance. To stop capacitors becoming impractically large however they are often rolled up like Swiss rolls.

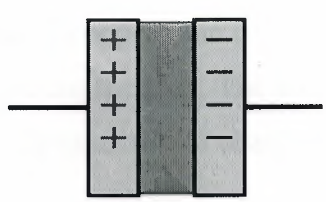


Figure 1.5: Capacitor contains

Another way of increasing the capacitance is to put some non-conducting material between the plates. This is called a dielectric. When the capacitor charges up the protons and electrons in the dielectric separate out a little which allows more charge to be stored on the plates than usual. Dielectrics are made of various materials. Ceramic dielectrics are common and are used in the capacitors.

Capacitance is measured in Farads after the scientist Michael Faraday. A Farad is quite a big unit. The capacitors in a *Flashing Lights* have capacitances of about 50 millionths of a Farad (and they're quite powerful capacitors). The symbol for a millionth is the Greek letter "μ" which you will often see represented as a 'u' (the closest to the Greek letter on an ordinary typewriter) [5].

Capacitors come in two flavors, electrolytic and non-electrolytic. Electrolytic capacitors use a special liquid or paste which is formed into a very thin dielectric in the factory. Non-electrolytic capacitors have ordinary dielectrics.

Electrolytic capacitors can store more charge than non-electrolytic capacitors but there are a couple of problems. They must be connected the right way around in a circuit or they won't work (anyone who has soldered a capacitor in a *Flashing Lights* backwards will know this). They also slowly leak their charge, and they have quite large tolerances. A 47uF capacitor might actually be as high as 80uF or as low as 10uF. In the *Flashing Lights* kit the capacitors control how fast the lights flash. You might have noticed that the rate can vary quite a lot from board to board and this is the reason.

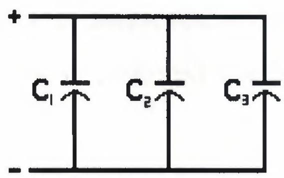
When a capacitor is connected to a battery it begins to charge. The current flows rapidly at first. Charge builds up on the two plates, negative charge on one plate and the same amount of positive charge on the other. The positive charge results from electrons leaving one of the plates and leaving positively-charged protons behind. But as the capacitor fills with charge it starts to oppose the current flowing in the circuit. It is as if another battery were working against the first. The current decreases and the capacitor charges more slowly. The plates become full of charge and it takes practically forever to squeeze the last drop in.

If a capacitor is shorted then it discharges. Charge flows out of the capacitor rapidly at first, then progressively more slowly. The last little drop just trickles out. The speed at which the capacitor empties depends on the resistance that connects across it. If a simple wire shorts out a capacitor then it empties in a flash, often with a spark if it's a big capacitor.

We've seen that when a capacitor is fully charged the current stops. In other words a continuous current cannot flow for ever through a capacitor. A continuous current is called a direct current or D.C.

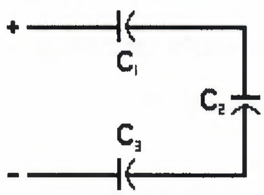
An alternating current (A.C.) however can flow through a capacitor. An alternating current is one which is continually changing its direction. Mains are A.C. and change its direction 50 times a second. An alternating current continually charges and discharges a capacitor and hence is able to keep flowing.

Here are some basic formulas for wiring capacitors in series or parallel. These are useful when you cannot find a component with the exact value that you are looking for.



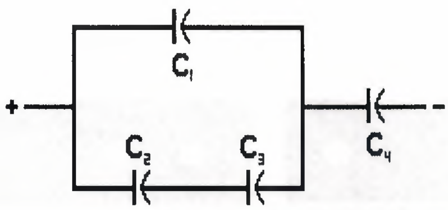
$$C = C_1 + C_2 + C_3$$

Capacitors in parallel



$$C = \frac{1}{\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}}$$

Capacitors in series



$$C = \frac{1}{\frac{1}{C_1 + \frac{1}{\frac{1}{C_2} + \frac{1}{C_3}}} + \frac{1}{C_4}}$$

Capacitors in series and parallel

Figure 1.6: Capacitors wiring.

1.2.3 Semiconductors

Now we come to what is probably the most important discovery in electronics this century. Without this discovery we wouldn't have televisions, computers, space rockets or transistor radios. Unfortunately it's also one of the hardest areas to understand in electronics. But don't lose heart, read the section through a few times until you've grasped the ideas.

Recall that the reason that metals are such good conductors is that they have lots of electrons which are so loosely held that they're easily able to move when a voltage is applied. Insulators have fixed electrons and so are not able to conduct. Certain materials, called semiconductors, are insulators that have a few loose electrons. They are partly able to conduct a current.

The free electrons in semiconductors leave behind a fixed positive charge when they move about (the protons in the atoms they come from). Charged atoms are called ions. The positive ions in semiconductors are able to capture electrons from nearby atoms. When an electron is captured another atom in the semiconductor becomes a positive ion.

These behaviors can be thought of as a 'hole' moving about the material, moving in just the same way that electrons move. So now there are two ways of conducting a current through a semiconductor, electrons moving in one direction and holes in the other. There are two kinds of current carriers.

The holes don't really move of course. It is just fixed positive ions grabbing neighboring electrons, but it appears as if holes are moving [5].

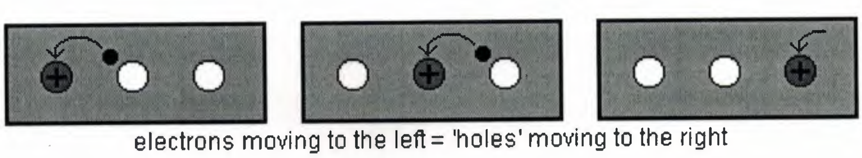


Figure 1.7: Moving of electrons.

In a pure semiconductor there are not enough free electrons and holes to be of much use. Their number can be greatly increased however by adding an impurity, called a donor. If the donor gives up some extra free electrons we get an n-type semiconductor (n for negative). If the donor soaks up some of the free electrons we get a p-type semiconductor (p for positive). In both cases the impurity donates extra current carriers to the semiconductor.

In n-type semiconductors there are more electrons than holes and they are the main current carriers. In p-type semiconductors there are more holes than electrons and they are the main current carriers. The donor atoms become either positive ions (n-type) or negative ions (p-type).

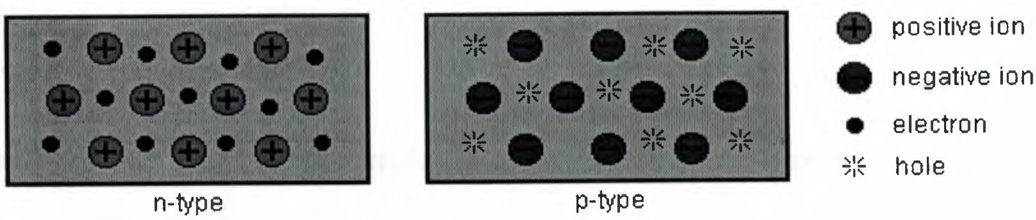


Figure 1.8: The tow types of semiconductors.

The most common semiconductors are silicon (basically sand) and germanium. Common donors are arsenic and phosphorus.

When we combine n-type and p-type semiconductors together we make useful devices, like transistors and diodes and silicon chips.

1.2.3.1 Transistors

Transistors underpin the whole of modern electronics. They are found everywhere - in watches, calculators, microwaves, hi-fi's. A Pentium(tm) computer chip contains over a million transistors! [3].

Transistors work in two ways. They can work as switches (turning currents on and off) and as amplifiers (making currents bigger). We'll only be looking at them as switches here. To understand them as amplifiers would involve a little mathematics.

Transistors are sandwiches of three pieces of semiconductor material. A thin slice of n-type or p-type semiconductor is sandwiched between two layers of the opposite type. This gives two junctions rather than the one found in a diode. If the thin slice is n-type the transistor is called a p-n-p transistor, and if the thin slice is p-type it is called a n-p-n transistor. The middle layer is always called the base, and the outer two layers are called the collector and the emitter.

We will consider the (more common) n-p-n transistor here, as used in the circuits. In a n-p-n transistor electrons are the main current carriers (because n-type material predominates).

When no voltage is connected to the base then the transistor is equivalent to two diodes connected back to back. Recall that current can only flow one way through a diode. A pair of back-to-back diodes can't conduct at all.

If a small voltage is applied to the base (enough to remove the depletion layer in the lower junction), current flows from emitter to base like a normal diode. Once current is flowing however it is able to sweep straight through the very thin base region and into the collector. Only a small part of the current flows out of the base. The transistor is now conducting through both junctions. A few of the electrons are consumed by the holes in the p-type region of the base, but most of them go straight through.

Electrons enter the emitter from the battery and come out of the collector. (Isn't that rather illogical you might say, electrons emitted from the collector? Yes it is, but the parts of a transistor are named with respect to conventional current, an imaginary current which flows in the opposite direction to real electron current.)

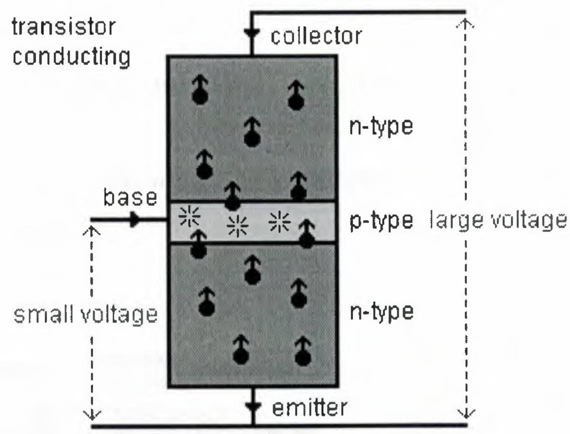
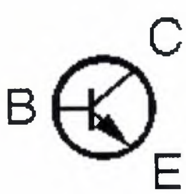


Figure1.9: Transistor conducting.

The difference between PNP and NPN transistors is that NPN use electrons as carriers of current and PNP use a lack of electrons (known as "holes"). Basically, nothing moves very far at a time. One atom simply robs an electron from an adjacent atom so you get the impression of "flow". It's a bit like "light pipes". In the case of "N" material, there are lots of spare electrons. In the case of "P" there aren't. In fact "P" is gasping for electrons.

Now we can see how a transistor acts as a switch. A small voltage applied to the base switches the transistor on, allowing a current to flow in the rest of the transistor.



This is the symbol used to represent an "NPN" transistor.

You can distinguish this from a "PNP" transistor (right) by the arrow which indicates current flow direction.

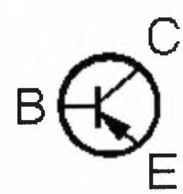


Figure 1.10: The difference between PNP and NPN transistors.

1.2.3.2 Diodes

A diode allows current to flow in only ONE direction.

If the cathode end (marked with a stripe) is connected so it is more negative than the anode end, current will flow.

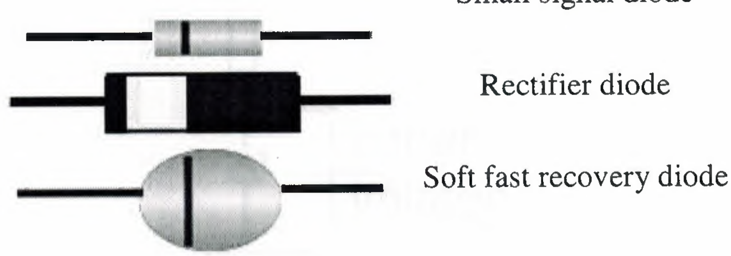


Figure 1.11: The picture shows three types of diodes [8].

A diode has a forward voltage drop. That is to say, when current is flowing, the voltage at the anode is always higher than the voltage at the cathode. The actual Forward Voltage Drop varies according to the type of diode. For example:

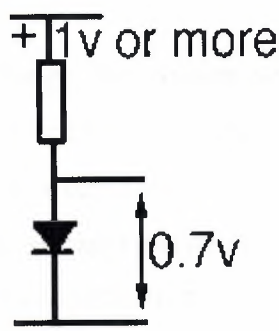


Figure 1.12: A diode forward voltage drop.

Silicone	diode	=	0.7v
Schottky	diode	=	0.3v
Germanium	diode	=	0.2v

In addition, the voltage drop increases slightly as the current increases so, for example, a silicon rectifier diode might have a forward voltage drop of 1 volt when 1 Amp of current is flowing through it.

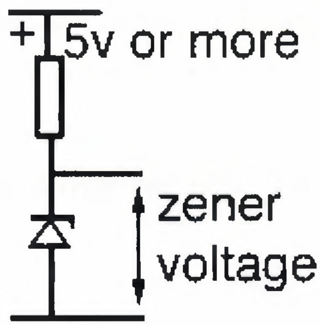


Figure 1.13: Zener diode

A ZENER diode allows current to flow in both directions. In the "forward" direction, no current will flow until the voltage across the diode is about 0.7 volts (as with a normal diode). In the reverse direction (cathode more positive than the anode) no current will flow until the voltage approaches the "zener" voltage, after which a LOT of current can flow and must be restricted by connecting a resistor in series with the zener diode so that the diode does not melt!

Within a certain supply voltage range, the voltage across the zener diode will remain constant. Values of 2.4 volts to 30 volts are common. Zener diodes are not available in values above around 33 volts but a different type of diode called an AVALANCHE diode works in a similar way for voltages between 100v and 300v. (These diodes are often called "zener" diodes since their performance is so similar).

Zener diodes are used to "clamp" a voltage in order to prevent it rising higher than a certain value. This might be to protect a circuit from damage or it might be to "chop off" part of an alternating waveform for various reasons. Zener diodes are also used to provide a fixed "reference voltage" from a supply voltage that varies. They are widely used in regulated power supply circuits.

1.2.3.2.1 Light Emitting Diodes (LEDs)

A diode consists of a piece of n-type and a piece of p-type semiconductor joined together to form a junction.

Electrons in the n-type half of the diode are repelled away from the junction by the negative ions in the p-type region, and holes in the p-type half are repelled by the positive ions in the n-type region. A space on either side of the junction is left without either kind of current carriers. This is known as the depletion layer. As there are no current carriers in this layer no current can flow. The depletion layer is, in effect, an insulator.

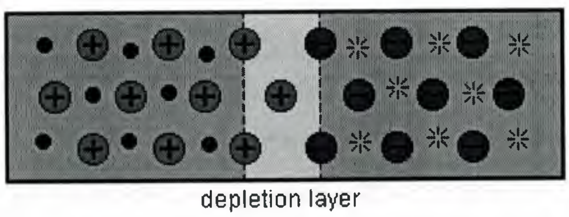


Figure 1.14: Depletion layer.

Now consider what would happen if we connected a small voltage to the diode. Connected one way it would attract the current carriers away from the junction and make the depletion layer wider. Connected the other way it would repel the carriers and drive them towards the junction, so reducing the depletion layer. In neither case would any current flow because there would always be some of the depletion layer left.

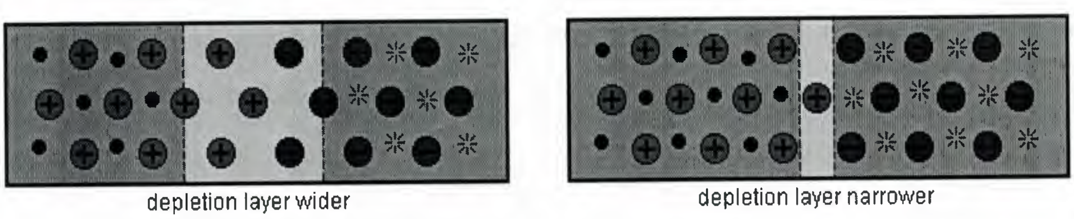


Figure 1.15: Reducing the depletion layer.

Now consider increasing the voltage. In one direction there is still no current because the depletion layer is even wider, but in the other direction the layer disappears completely and current can flow. Above a certain voltage the diode acts like a conductor. As electrons and holes meet each other at the junction they combine and disappear. The battery keeps the diode supplied with current carriers.

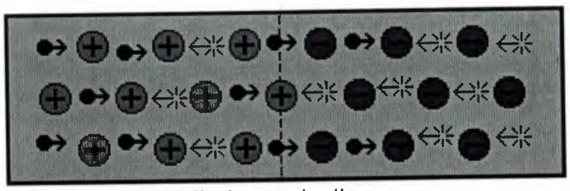


Figure 1.16: Diode conducting.

Thus a diode is a device which is an insulator in one direction and a conductor in the other. Diodes are extremely useful components. We can stop currents going where we don't want them to go. For example we can protect a circuit against the battery being connected backwards which might otherwise damage it.

Light emitting diodes (LEDs) are special diodes that give out light when they conduct. The fact that they only conduct in one direction is often incidental to their use in a circuit. They are usually just being used as lights. They are small and cheap and they last practically forever, unlike traditional light bulbs which can burn out.

The light comes from the energy given up when electrons combine with holes at the junction. The color of the light depends on the impurity in the semiconductor. It is easy to make bright red, green and yellow LEDs but technology has not cracked the problem of making cheap blue LEDs yet [3].

1.2.3.3 LM339

The LM3339 is a power audio amplifier for consumer applications. In order to hold system cost to a minimum, gain is internally fixed at 34 dB. A unique input stage allows ground referenced input signals. The output automatically self-centers to one-half the supply voltage.

The output is short circuit proof with internal thermal limiting. The package outline is standard dual-in-line. The LM339N uses a copper lead frame. The center three pins on either side comprise a heat sink. This makes the device easy to use in standard PC layouts.

Uses include simple phonograph amplifiers, intercoms, line drivers, teaching machine outputs, alarms, ultrasonic drivers, TV sound systems, AM-FM radio, small servo drivers, power converters, etc. The figure 1.10 shows the LM339N construction.

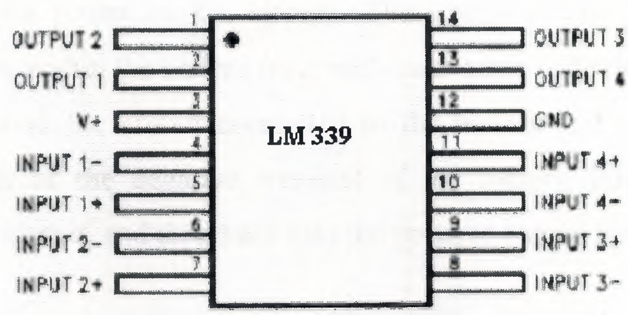


Figure 1.17: The LM339N construction [8].

1.2.4 Relay Driver

A relay is an electro-magnetic switch which is useful if you want to use a low voltage circuit to switch on and off a light bulb (or anything else) connected to the 220v mains supply.

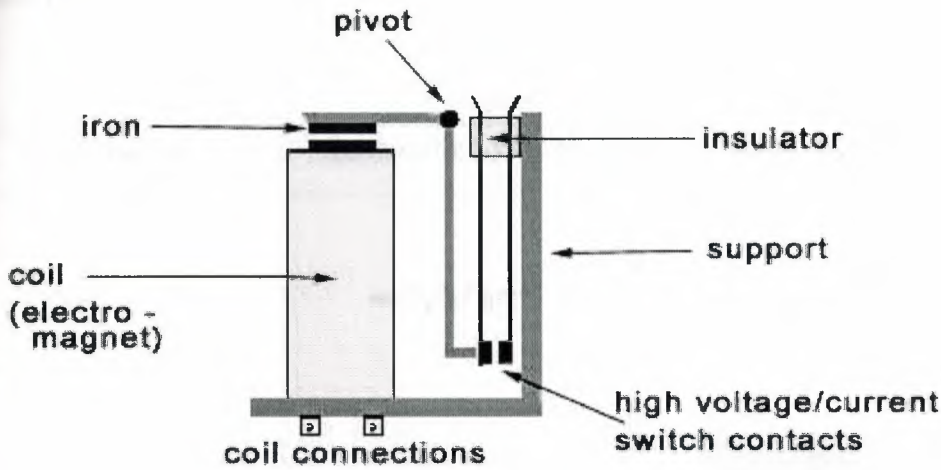


Figure1.18: A typical relay (with "normally-open" contacts).

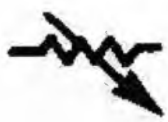
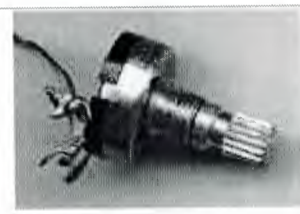
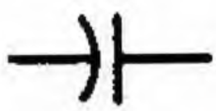
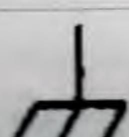
1.2.5 Batteries

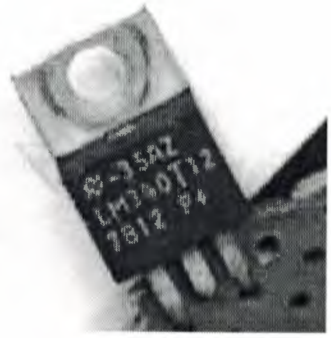
Batteries provide the power for the circuits. The source of this power is a chemical reaction. Chemicals within the battery react with each other and release electrons. These electrons flow around the circuit connected to the battery and make things happen. Electrons flow out of the negative terminal of the battery, through the wires and components of the circuit, and then back into the positive battery terminal.

Figure 1.19: Battery

It takes energy to do this and so eventually all the energy in the battery is used up. Occasionally the acid in the battery messily leaks out before it has been used and the battery has to be discarded.

Table 1.1 Description of some of the most common components and their schematic symbols [1].

Component	Schematic Symbol	Actual appearance
Resister		
Variable Resister		
Capacitor		
Diode		
Light emitting diode (LED)		
Chassis Ground		This is just a connection to ground.
		This is just a connection to

NPN Bipolar Transistor		
PNP Bipolar Transistor		

1.3 Safety Guidelines

1- We have taken care about chip pins when we plant it in the board to not be broken.

2- Be aware while soldering to not heat up the chip by the soldering iron long time on the pins.

3- While soldering be aware not be let to pins to be soldering together and check after soldering the pins in between space.

4- Be aware of the soldering iron position while stand by.

5- Be aware when turns up side down the board after the chip plant that the pins arrangement will be different.

6- The glass will have to be removed from lamp without breaking the filament. Wrap the glass in masking tape and it in a vise. Slowly crank down until the glass breaks, then remove the bulb and carefully peel back the tape. If the filament has broken, you will need another lamp.

1.4 Summary

This chapter presented an introduction to electronic components that are commonly used in hardware projects and how they function, how they must be connected. By applying the safety guidelines, the circuit should work smoothly.

CHAPTER TWO

AIR FLOW DEFINITION AND PRINCIPLES

2.1 Overview

This chapter presents the air flow definition and principles. It contains many applications that are commonly used in our daily life. It shows design specifications, explaning how computer cases air flow works having an explanation for other examples that are useful in some machines.

2.2 Introduction

Air flow occurs only when there is a difference between pressures. Air will flow from a region of high pressure to one of low pressure-- the bigger the difference, the faster the flow. Thus air flows in during inspiration because the alveolar pressure is less than the pressure at the mouth; air flows out during expiration because alveolar pressure exceeds the pressure at the mouth such that to double the flow rate one must quadruple the driving pressure.

When air flows at higher velocities, especially through an airway with irregular walls, flow is generally disorganized, even chaotic, and tends to form eddies. This is called turbulent flow, and is found mainly in the largest airways, like the trachea. A relatively large driving pressure is required to sustain turbulent flow. Driving pressure during turbulent flow is in fact proportional to the square of the flow rate such that to double the flow rate one must quadruple the driving pressure.

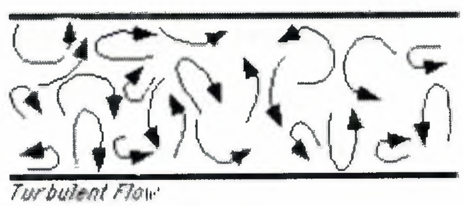


Figure 2.1: Turbulent Flow

When flow is low velocity and through narrow tubes, it tends to be more orderly and streamlined and to flow in a straight line. This type of flow is called laminar flow. Unlike turbulent flow, laminar flow is directly proportional to the driving pressure, such that to double the flow rate, one needs only double the driving pressure [5].

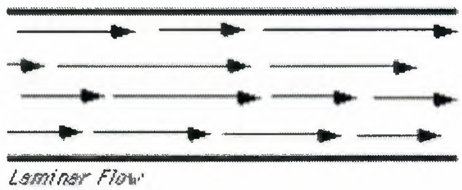


Figure 2.2: Laminar Flow.

2.3 Air Flow Definition

There are several equivalent air flow definitions that define and give a general description for it. Some of those definitions are listed bellow.

- Amount of air expressed in cubic feet per minute, that can be drawn through a 2" x 2" x 1" FPF sample at .5-inch water pressure differential.
- Amount of air expressed in cubic feet per minute, that can be drawn through a 2" x 2" x 1" foam sample at .5-inch water pressure differential. Air Flow is measured by a test (ASTM D3574).
- The motion of air relative to a body in it [5].

2.4 Air Flow Applications

2.4.1 Air Flow Small Commercial Buildings

Air flows and their distribution in a given building are caused by pressure differences that can be induced by wind, thermal buoyancy, mechanical ventilation, or a combination of these factors. Building-related properties such as the distribution of openings in the building shell, inner pathways, and occupant activity can also create indoor pressure differences. Two methods exist for characterizing indoor air flow rates:

performing air flow measurements using tracer gas techniques, and using mathematical models to model the indoor air flows.

Measurements based on tracer gas techniques can determine the air flows between the inside and the outside of the building, as well as interzonal air flows. However, because tracer gas measurements reflect the prevailing leakage and weather conditions at measurement time, their use in characterizing general building leakage is limited. To describe indoor air flows for any leakage and weather conditions, a number of mathematical models describing interzonal air flow have been developed. One advantage to using these mathematical models is that, in addition to air flows, they can also simulate indoor contaminant transport.

COMIS is one of the most recently developed air flow models. It can be used as a stand-alone program with input and output features, or as an infiltration module that can be integrated into thermal building simulation programs. COMIS is a FORTRAN-based code.

A recent study of small commercial buildings found that uncontrolled air flow -- including duct leakage, return air imbalance, and exhaust air/make-up air imbalance -- is widespread. Of 70 buildings studied, only 1 was identified as having no significant uncontrolled air flow. The causes of uncontrolled air flow include failure of design, poor workmanship, O&M problems, HVAC commissioning failures, materials degradation, and building retrofits. This study also found that the consequences of uncontrolled air flow are often quite severe and varied -- including high utility bills, occupant thermal discomfort, high humidity, mold and mildew growth, moisture damage to building materials, transport of pollutants to the occupied space, and back drafting of combustion equipment. The characteristics and causes of uncontrolled air flow have been largely unknown or misunderstood until recently, and diagnostic tools and methodologies for uncovering uncontrolled air flow have been largely unavailable. Standard methods of ensuring balanced air flows often fail because of measurement errors and flawed assumptions of test methodology [5].

2.4.1.1 Building Air Flows

Building air flows can be differentiated as:

1) Those that recirculate within the building.
2) Those that pass across the building envelope.

Those that recirculate are primarily the Return Air RA and Supply Air SA of heating/cooling systems. In the absence of duct leakage or restricted RA, these recirculation air flows do not affect building pressure and infiltration rates. Those that pass across the building envelope include exhaust Air EA, Make-up air MA, Outdoor Air OA, return leaks from outside, supply leaks to outside, and air flows induced by RA imbalance. Characterization of air flow across the building envelope is important because this air flows impacts energy use, indoor RH, ventilation, and pressure differentials.

2.4.2 Laminar Flow (Supplied-Air) Island Systems

Laminar flow (supplied-air) islands (SAI) provide a zone of clean air at a workstation. The supplied air may come from outside the plant or the air may be filtered plant air.

Laminar flow (supplied-air) islands are especially useful in limiting lead exposure when:

- An employee remains in a stationary position at the workstation for long periods of time. The SAI provides an envelope of clean air to a worker. The clean air flows down over the worker which normally keeps factory air from entering the clean air core.

- A supply of fresh, clean air is available. Note that outside air may not require cleaning and costs will be lower. If no outside source of clean air is available, intake air should be filtered.

- The air is tempered. Employees will not remain in an environment that is too hot or too cold. Note that if the air is not tempered employees will block off the air flow with cardboard or other material in the winter or try to increase the flow for cooling in the summer which could result in higher exposures.

Laminar Flow (Supplied Air) Islands are not always necessary if adequate capture velocity is provided to control airborne lead [2].

2.4.2.1 Design Specifications

The laminar flow (supplied-air) island (SAI) should be designed to provide a laminar flow of fresh air through the employee's breathing zone at a low enough velocity so that additional airborne lead dust is not generated through reentrainment.

- The SAI height is typically 80 inches from the floor but is often restricted by overhead clearance limits and other equipment installed in the area. Curtains are used to extend the length of the SAI to the operators breathing zone; cut pass throughs to prevent workers from disturbing dust collected on the curtains.
- The air flow is designed so that the velocity measured at the employee's breathing zone is 100-125 feet per minute.

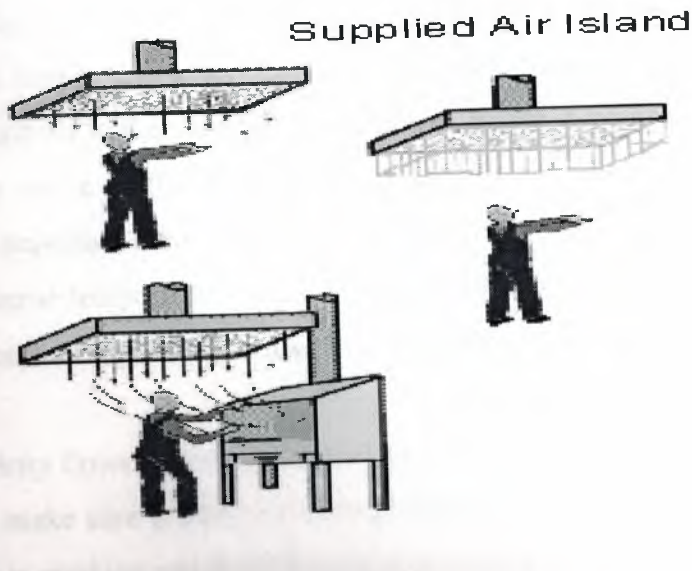


Figure 2.3: supplied Air Island [2].

Figure 2.4: Plastic curtains direct airflow toward the exhaust point [2].

SAIs can be used in conjunction with exhaust-ventilated work benches. In this case, the air should be approximately balanced so that make-up air provided is nominally equal to the amount of the exhaust air. It is recommended that the volume of make-up air be in the range of 90 to 110 percent of the exhaust volume.

2.4.3 Computer Cases Air Flow

In the early days of speedy 486 computing, big heatsink and fan combos weren't necessary, and neither was a bare heatsink. Things just weren't hot enough for anyone or any company to put extra cooling measures inside a computer. But things have changed. Now we're in the hundreds of megahertz and gigahertz range, and there's nothing more important than cooling our computer. Sure, a component may be tested to withstand extreme temperatures that we may never face in the daily life, but common sense says constant operation at extreme temperatures isn't such a wonderful idea.

In fact, electricity flows better in a cool environment. So if we are thinking of tweaking our machine, make sure it starts off chilled. There is no point tweaking other things if our computer is crashing and BSODing all over the place, spilling its guts in the form of

Illegal Operations and Page Faults. We must always start at the root, the most basic tweaking measure, even before over clocking. You must ventilate your machine.

Everything inside your computer generates heat. Whether it's the motherboard, hard drive, RAM modules, or your processor -- it just depends on the degree. The most effective way to make sure your machine is running cool is to make sure the ambient temperature is cooler than its internal temperature. This means making sure the air in and around your computer is at room temperature or cooler.

Overheating is the worst cause of electronic component death. You may also want to keep in mind that repeated cooling and heating of any component is bad. When something heats up it expands, and it will contract when it cools down. If this process is always repeated, you risk cracking the device. This is why its better to keep your computer running. All the components are in a constant, and don't go through temperature changes often.

The first step in tweaking your system is to make sure you have sufficient airflow through your case. This means having a power supply with a working fan. Some people don't even know that the fan inside their power supply is cooked until it's too late.

However, don't fall into the misconception that having more fans is better. Sometimes having just two fans is better than having 10 fans blowing and sucking all over the place. The best setup for a case is having cool air come in from the front and hot air expel from the back [2].

2.4.3.1 Two Fans Design

Above is a diagram of a typically ventilated case enclosure. There are two fans in this system -- one at the front that draws cool air into the system and one at the back (inside the power supply) that expels hot air out. This system works best if there aren't any dangling cables and wires inside the system. The worst cause of bad airflow is poorly laid out ribbon cables. If you're going to use this layout, you have to make sure that your ribbons are either neatly folded along the case or spliced. If you're using standard 40 wire IDE cables or a 50 wire SCSI-2 cable, then you can go ahead and splice your cable. Once you've done that, the cables will no longer block airflow like they did before and you can rest assured that you've tweaked your cables nicely.

The two Fan designs, while common, don't always give the best airflow. The red circles in the diagram indicate areas where there air isn't circulating properly. The lower circle is where all your expansion cards lie. They interrupt the airflow because there aren't any fans actually blowing onto the cards and the cards themselves are obstacles.

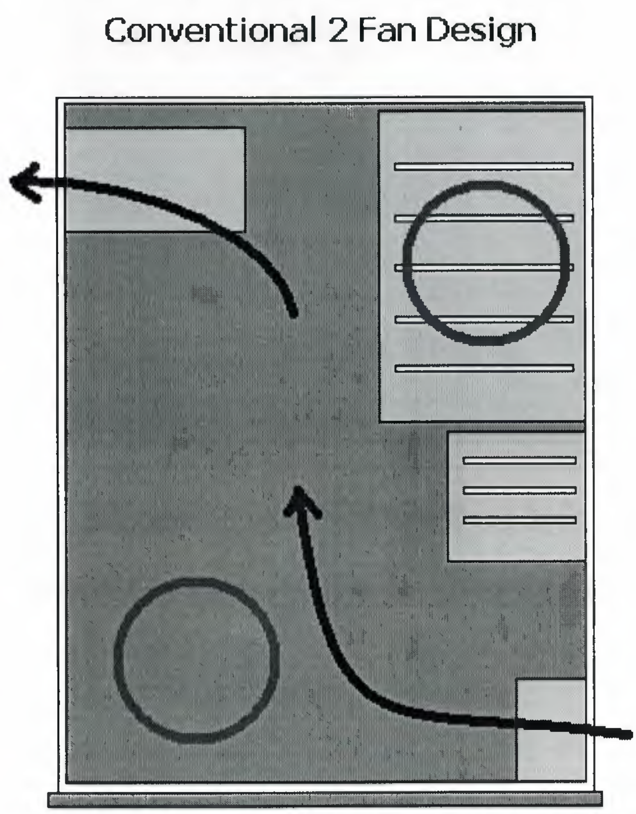
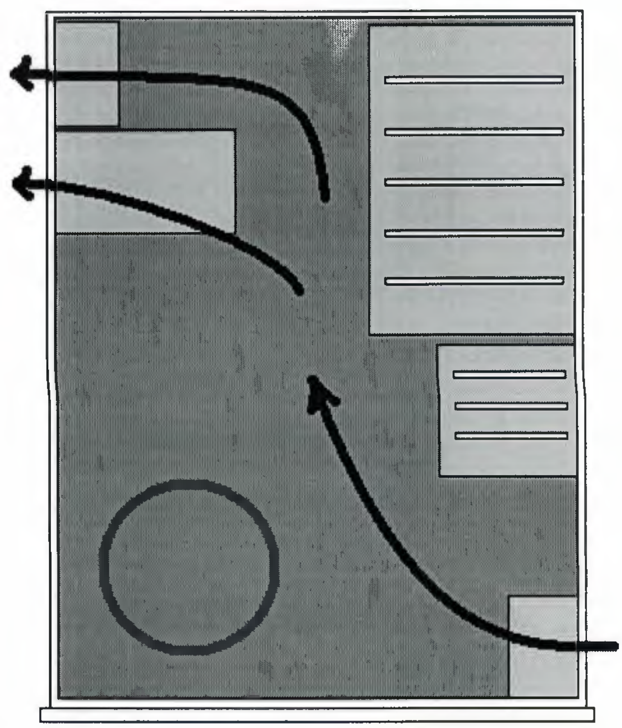


Figure 2.5: Conventional two Fan Design [2].

2.4.3.2 Three Fans Design

Here is another design that is becoming popular among case manufacturers. This design helps cool off the drives and help pull air through the case better. All the capacitors and transformers that are inside the power supply cause the fan to do a poor job of moving hot air out of the case. In this case, it's better to have negative pressure inside the case (caused by 2 outs and 1 in) so that cool air from the outside is always moving in from the front. There's still the issue of our AGP and PCI cards not getting the freeze treatment though.

3 Fan Design (2 out/1 in)

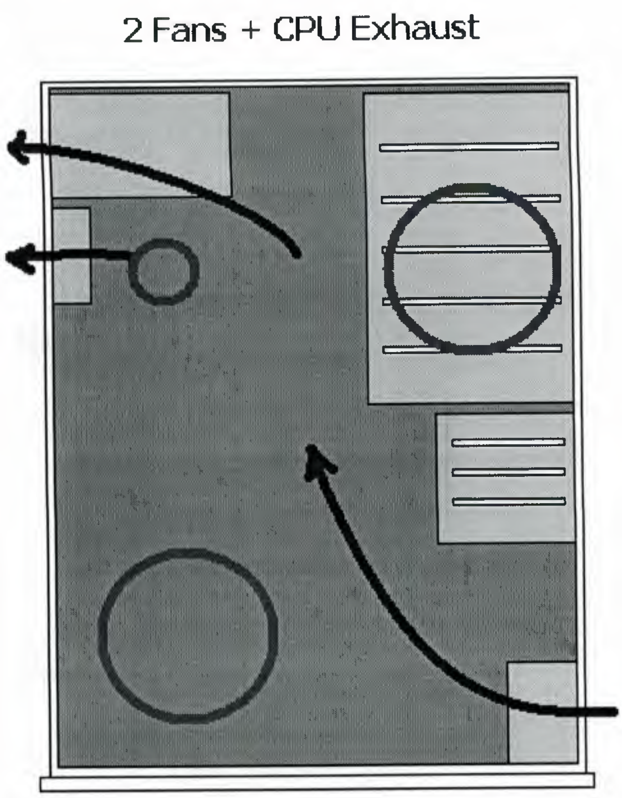


Adequate Cooling with One Dead Spot

Figure 2.6: Three Fans Design (2 out/1 in) [2].

2.4.3.3 Two Fans and CPU Exhaust

This type of case is also very popular. Taking a first glance inside the case you'll be delighted to see a fan right where the CPU is located. But this is usually a problem in disguise. Let's take a moment to remember that there is also a HSF (heatsink fan combo) on your CPU. The fan is likely to be blowing down onto the heatsink. This means that there is negative pressure above the heatsink because it is drawing air. Since our exhaust fan is blowing air out of the case, it too is drawing air from the same area. If our exhaust fan is drawing air and our CPU fan is also drawing air, then there's going to be turbulence -- a bad situation for smooth airflow.

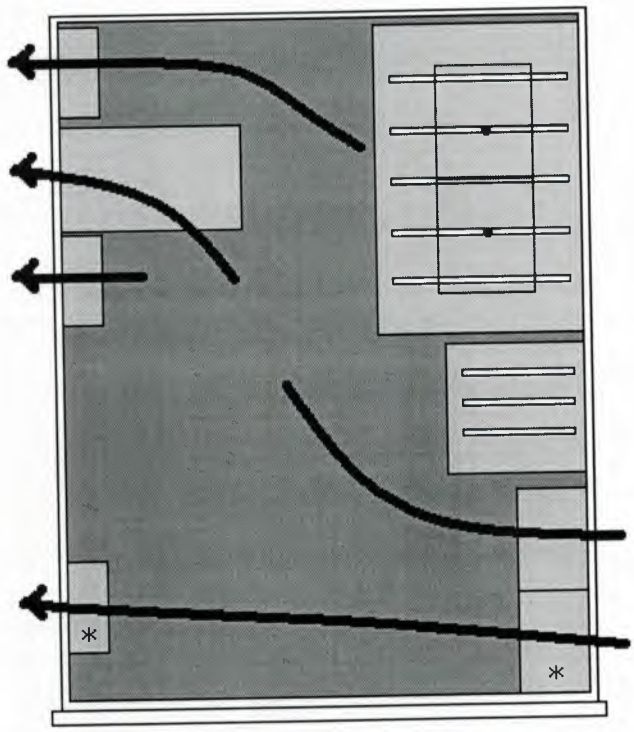


Too Many Dead Spots

Figure 2.7: two Fans and CPU Exhaust [2].

2.4.3.4 Tweak3D's Design

In this type you see a case that is well ventilated. All major areas of the case are covered and made sure that there is cool air going to all areas of the case while hot air is taken out. There are four fans blowing air out and six fans sucking air in. You may now be asking if this is bad since there more fans sucking in then there are blowing out. Well, if you take a look at the hard drive fans, they are in close quarters and don't really have room to move large amounts of air, therefore the power of the four hard drive fans approximately equal that of two fans. Two (effectively) fans sucking in at the top and two at the bottom give a well-rounded and balanced airflow since there are four fans expelling air at the back.



Top-Down View of Lower Section of Case (AGP/PCI) Expansion Erea

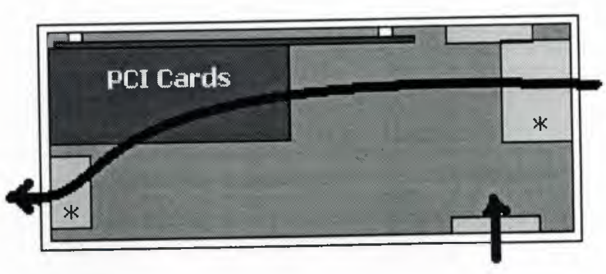


Figure 2.8: Tweak3D's Design [2].

2.5 Summary

In this chapter we have presented the air flow definition and principles. We have mentioned many applications that are commonly used in our daily life. And we dealt with the design specifications, explaning how computer case's air flow worked. We also explained other examples that are useful in some machines.

Now after reviewing the techniques of air flow detector, and already an explanation of the necessary components for the circuit is given, its time sitting up the circuit.

CHAPTER THREE

Air Flow Detector Circuit

3.1 Overview

In this chapter we will explain the design of air flow detector circuit, its functions and the use of it. This chapter also contains a brief explanation about the circuit and the components to be used.

3.2 Introduction

The circuit uses an incandescent lamp to detect airflow. With the filament exposed to air, a constant current source is used to slightly heat the filament. As it is heated, the resistance increases. As air flows over the filament it cools down, thus lowering its resistance. A comparator is used to detect this difference and light an LED. With a few changes, the circuit can be connected to a meter or ADC to provide estimation on the amount of air flow.

3.3 Schematic

The schematic shown below shows the air flow detector.

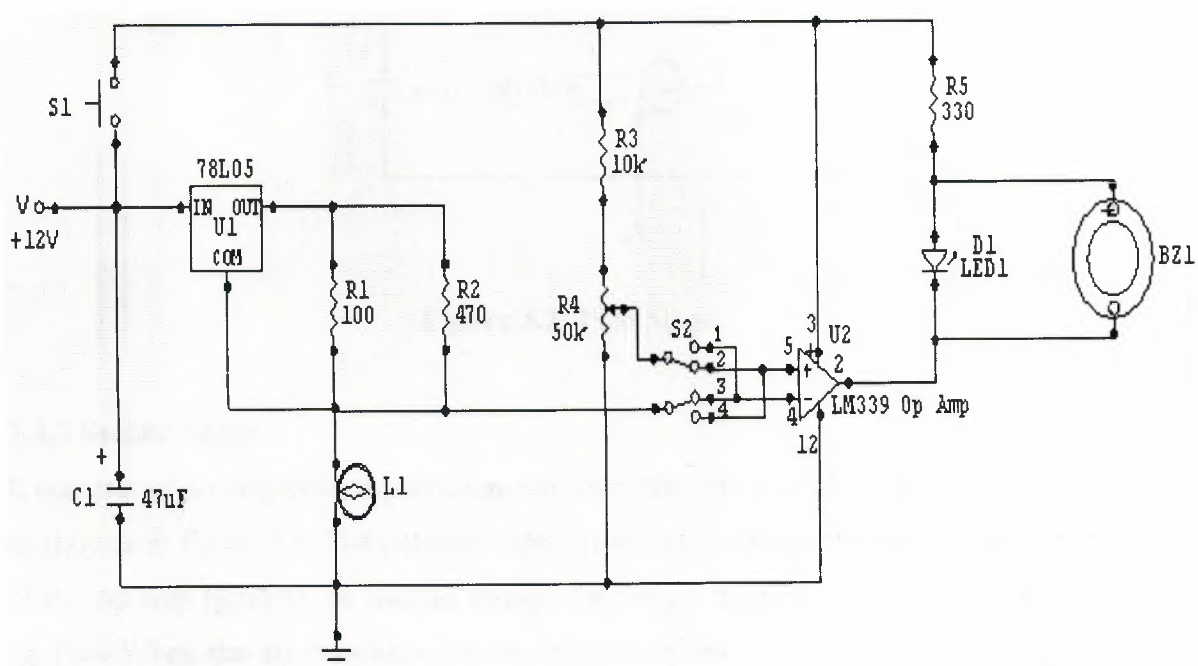


Figure 3.1: Air flow detector.

3.4 Working principles and the description of the stages used.

We divide the circuit into two stages:

3.4.1 First Stage

The first stage contains a fixed current supply that is composed of 78L05 voltage regulator and 2 resistance to heat the filament and increase its resistance.

The regulator supplies approximately 54.1 mA. This current keeps the filament hot to keep the resistance increased and fixed to the desired value.

The open circuit resistance of the filament without any air flow is approximately 11.4 Ohm. When the current is applied, the resistance increases to 24 ohm and oscillates between these values depending on the air flow.

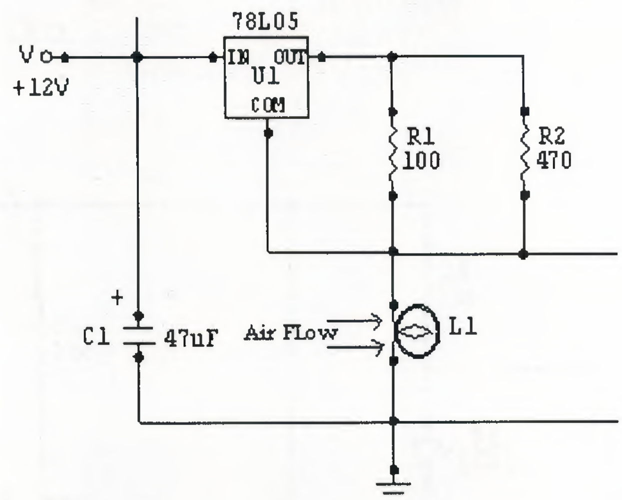


Figure 3.2: First Stage.

3.4.2 Second Stage

It consists of an amplifier, a potentiometer, two resistors 1 LED, 1 buzzer and 1 switch as showen in figure 3.3. The potentiometer allows us to change the voltage between pins of the op-amp (pin4-5), so we can change the output depending on the intensity of the air flow.When the air flow changes this balance of the comparator gives an output to drive the led and the buzzer and indicates that the air flow has increased or decreased.

The switch S2 is used to change inputs of pins 4-5 (inverting – non inverting) of the op-amp U2. This reverses the output, i.e. we get output when there is no air flow.

Shortly if pins 2-3 of S2 are connected to pins 5(+), 4(-) of U2 we get output when there is air flow. If we connect pins 1-4 of S2 to pins 4(+), 5(-) of U2 we get output when there is no air flow. This is caused by the voltage difference between pins 4-5 of U2.The measurements shows that.

At the steady state:
Approximately -0.350 and 0.350 the circuit can response to normal breath of a human being (pins 2-3 of S2 are connected to pins 5(+), 4(-) of U2 or 0.350 when pins 1-4 of S2 to pins 4(+), 5(-) of U2). (This can be adjusted to higher intensity of air flow by R4).In the first state the applied air flow can cause a difference that changes it to a maximum value 0.350 depending on the intensity. In the second state it oscillates between 0.350,-0.350.Briefly when the voltage becomes 0V the circuit begins to drive the buzzer and the LED.

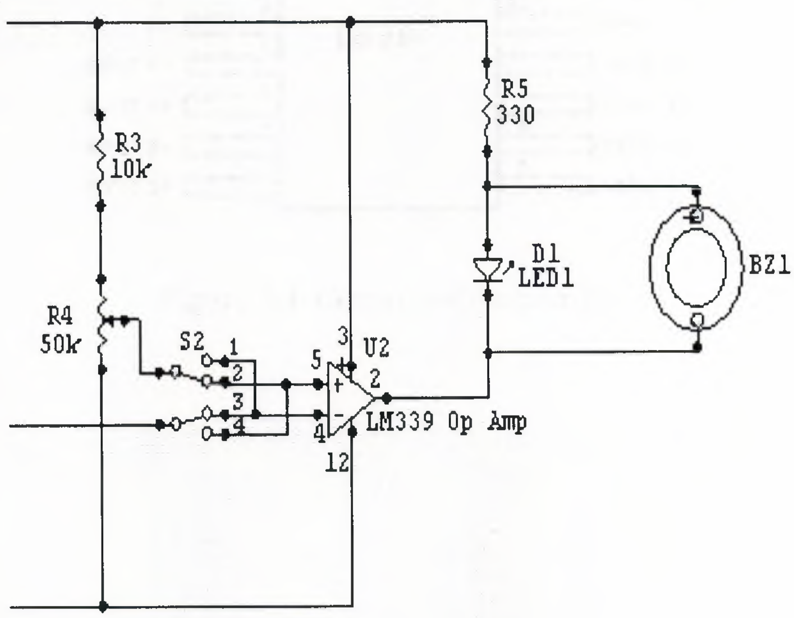


Figure 3.3: Second Stage.

3.5 Low Power Quad Voltage Comparators (LM339)

The LM339 device is a monolithic quad of independently functioning comparator designed to meet the needs for a medium speed, TTL compatible comparator for industrial applications. Since no antisaturation clamps are used on the output such as a Baker clamp or other active circuitry, the output leakage current in the OFF state is typically 0.5 nA. This makes the device ideal for system applications where it is desired to switch a node to ground while leaving it totally unaffected in the OFF state. Other features include single supply, low voltage operation with an input common mode range from ground up to approximately one volt below VCC. The output is an uncommitted collector so it may be used with a pull-up resistor and a separate output supply to give switching levels from any voltage up to 36V down to a VCE SAT above ground (approx. 100 mV), sinking currents up to 15 mA. In addition it may be used as a single pole switch to ground, leaving the switched node unaffected while in the OFF state. Power dissipation with all four comparators in the OFF state is typically 4 Mw from a single 5V supply (1 mW/comparator) [6].

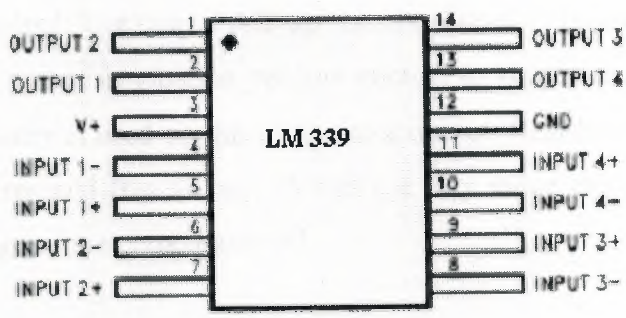


Figure 3.4: Connection diagram [6].

The amplifier is an op-amp and a part of the IC LM339 shown in figure 3.5. It is used as a comparator.

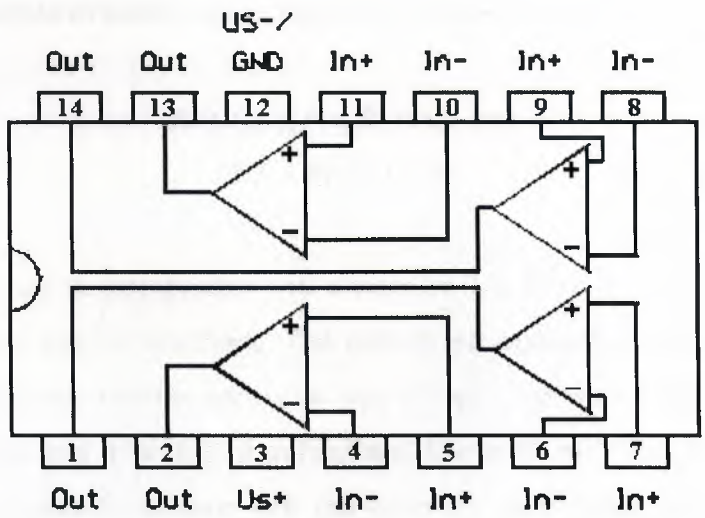


Figure 3.5: The IC LM339[6].

3.5.1 Comparator Circuits

Figure 3.6 shows a basic comparator circuit for converting low level analog signals to a high level digital output. The output pull-up resistor should be chosen high enough so as to avoid excessive power dissipation yet low enough to supply enough drive to switch whatever load circuitry is used on the comparator output. Resistors R1 and R2 are used to set the input threshold trip voltage (VREF) at any value desired within the input common mode range of the comparator [6].

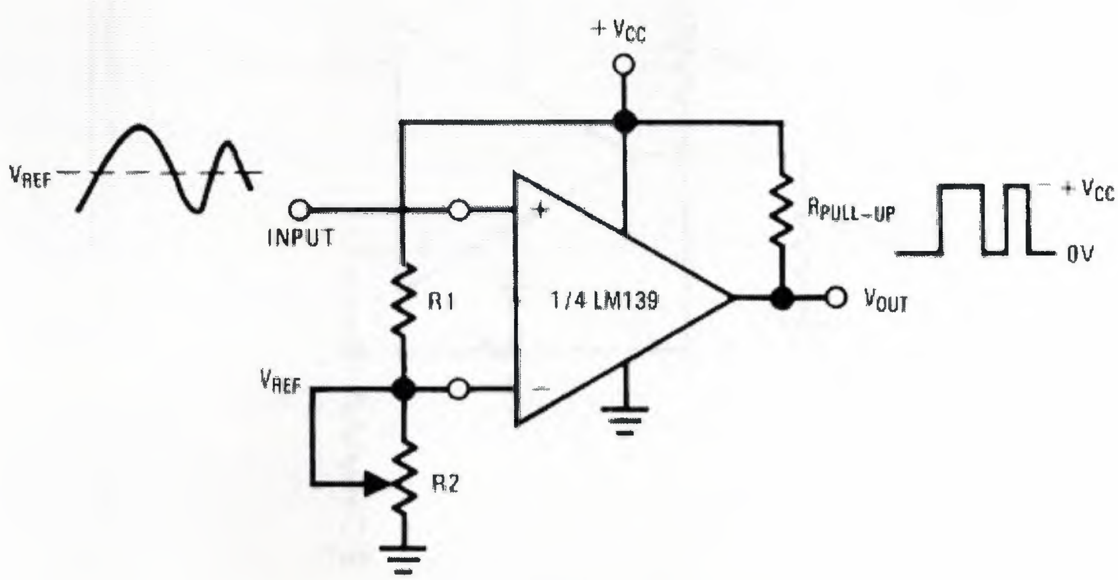


Figure 3.6: Basic comparator circuit [6].

3.5.2 Comparators with Hysteresis

Figure 3.7 shows a comparator with a small amount of positive feedback. In order to insure proper comparator action, the components should be chosen as follows:

$$RPULL\text{-}UP < RLOAD \text{ and}$$
$$R1 > RPULL\text{-}UP$$

This will insure that the comparator will always switch fully up to +VCC and not be pulled down by the load or feedback. The amount of feedback is chosen arbitrarily to insure proper switching with the particular type of input signal used. If the output swing is 5V, for example, and it is desired to feedback 1% or 50 mV, then R1 ≈ 100 R2. To describe circuit operation, assume that the inverting input goes above the reference input (VIN > VREF). This will drive the output, VO, towards ground which in turn pulls VREF down through R1. Since VREF is actually the non-inverting input to the comparator; it too will drive the output towards ground insuring the fastest possible switching time regardless of how slow the input moves. If the input then travels down to VREF, the same procedure will occur only in the opposite direction insuring that the output will be driven hard towards +VCC [6].

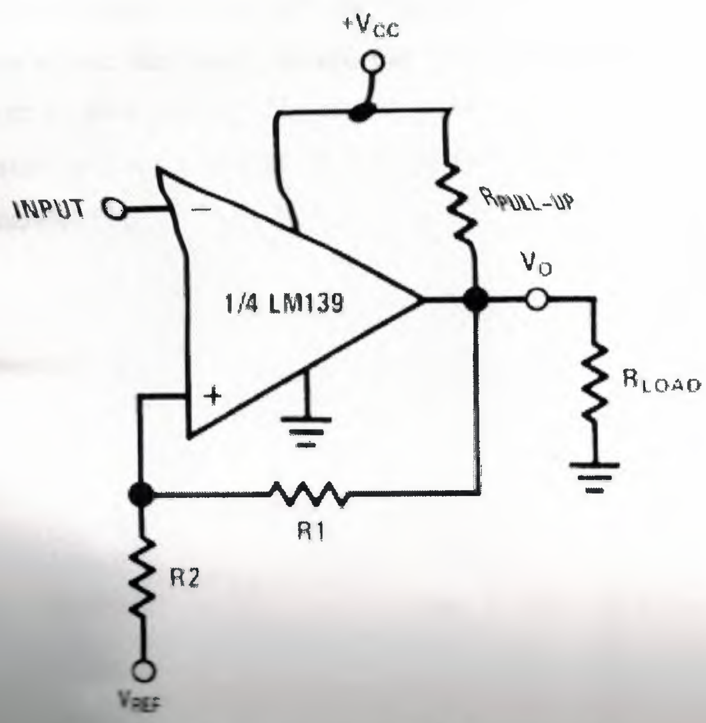


Figure 3.7: Comparator with hysteresis [6].

3.6 IC Voltage Regulators (78L05)

Voltage regulators comprise a class of widely used ICs. Regulators IC units contain the circuitry for reference source, comparator amplifier, control device, and overload protection all in single IC. Although the internal construction of the IC is somewhat different from that described for discrete voltage regulator circuit, the external operation is much the same. IC units provide regulation of either a fixed positive voltage, a fixed negative voltage, or an adjustably set voltage.

A power supply can be build using a transformer connected to the ac supply line to step the ac voltage to desired amplitude, then rectifying that ac voltage, filtering with a capacitor and RC filter, if desired, and finally regulating the dc voltage using an IC regulator. The regulators can be selected for operation with load currents from hundreds of milliamperes to tens of amperes, corresponding to power ratings from milliwatts to tens of watts.

3.6.1 Three-Terminal Voltage Regulators

Figure 3.8 shows the basic connection of a three – terminal voltage regulator IC to a load. The fixed voltage regulator has an unregulated dc input voltage, Vi, applied to one input terminal, a regulated output dc voltage, Vo, from a second terminal, with the third terminal connected to ground. For a selected regulator, IC device specifications list a voltage range over which the input voltage can vary to maintain a regulated output voltage over a range of load current. The specifications also list the amount of output voltage change resulting from a change in load current (load regulation) or in input voltage (line regulation) [7].

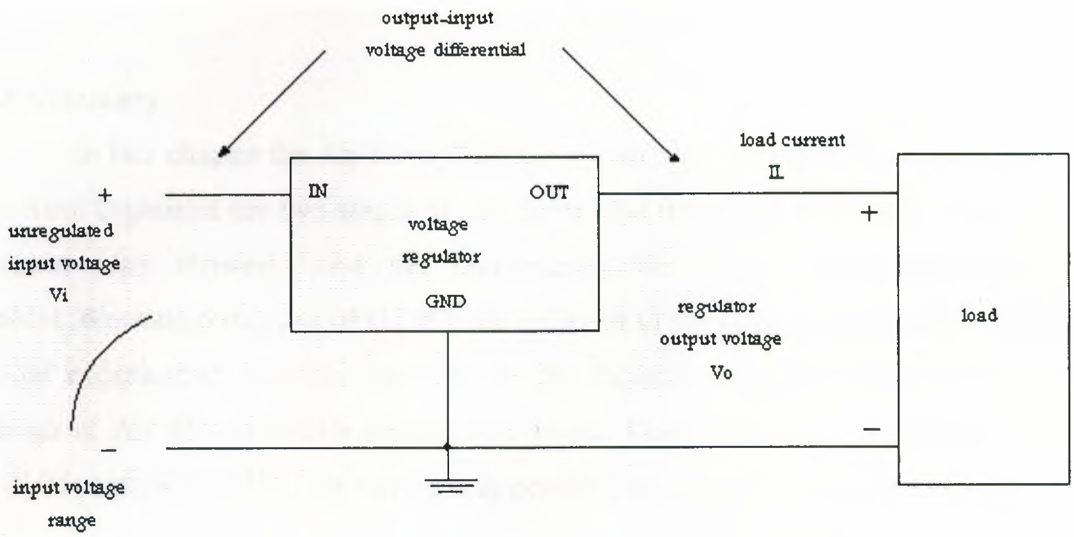


Figure 3.8: Block representation of three-terminal voltage regulator [7].

3.7 Components Used in Air Flow Detector

The components used in the air flow detector circuit are listed below:

Table 3.1: Components list.

Symbol of the component	Value and description
R1	100 Ohm 1/4W Resistor.
R2	470 Ohm 1/4W Resistor.
R3	10k 1/4W Resistor.
R4	50K 1/4W Resistor.
R5	330 1/4W Resistor.
C1	47uF Electro lytic Capacitor.
U1	78L05 Voltage Regulator (Used as a fixed current source)
U2	LM339 Op Amp (Used as a comparator).
L1	#47 Incandescent lamp with glass removed.
D1	LED.
BZ1	Buzzer.
S2	S2 SPST miniature toggle type switch.
S1	Pushbutton switch.
Battery	8x1.5 V AA size battery.
Miscellaneous	Board, Wire, Sockets for ICs.

3.8 Summary

In this chapter the Air Flow Detector circuit was presented. Also in this chapter we have explained the two stages of the circuit and the diagram of the first and second circuits also showed. And the components for all of them were listed on Table1.Working principles of U2, S2 and behavior of the circuit are explained in details. Some experimental data are included in the explanation part. Figure 3.9 shows the design of Air Flow Detector circuit on a board. Data sheets for the voltage regulator (78L05) and (IC LM339) are shown in appendix 1 and appendix 2 respectively.

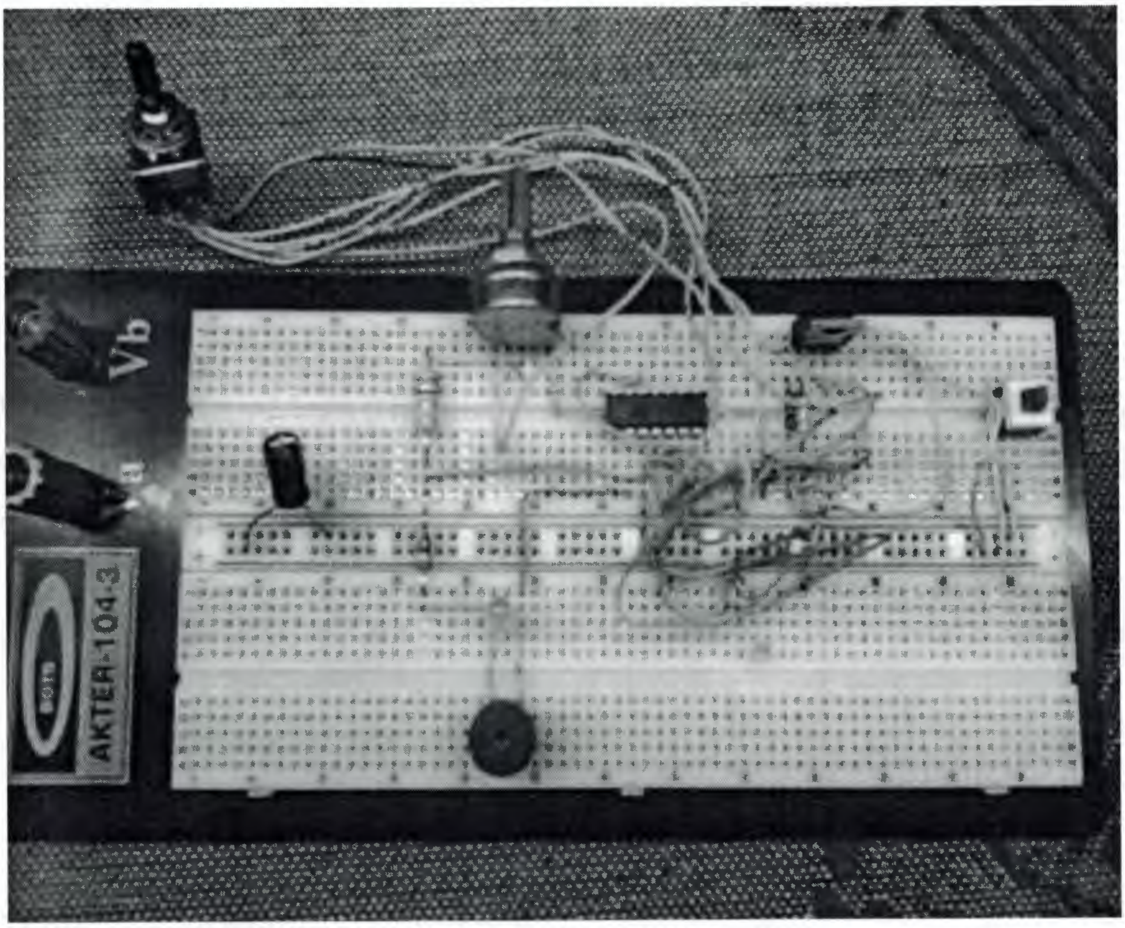


Figure 3.9: Air Flow Detector project photograph.

CONCLUSION

We could build the Air Flow Detector circuit combining the analog components, analog components such as resistors, capacitors and voltage regulator, also, we used an IC like the operational amplifier used as a comparator and the circuit uses an incandescent lamp to detect airflow in the input and a Buzzer on the output stage.

Far from this project we have accomplished our aims that were:

- To design and build an air flow detector.
- To gain hands on experience in electronic hardware project
- To suggest potential real-life use of air flow sensors.
- How to use the electronic parts description book

In the first chapter we have seen different types of electronic components and the safety way of using them in any electric circuit, also we learned how to measure them without expecting an error.

In the second chapter we have discussed air flow definition and principles, and many applications that demonstrate the main idea of air flow principle were also discussed to come out with an obvious sight on air flow.

The third chapter was mainly about constructing the circuit in which the potentiometer allowed us to change the voltage between pins of the op-amp IC, where we realized that the sensitivity of incandescent lamp mainly depends on the potentiometer value where by adjusting its value a better sensitivity of air flow in the surrounding is achieved. Also, we could achieve two cases of air flow detection alarming by changing the toggle switch position, in the first case air flow was needed, but in the second one was not.

How to solve problems that face constructing the air flow detecting circuit Noise interference and malfunctioning, and the improvements that occur on the circuit, just like the Sensitivity to make it suitable for varies applications cause the air flow detecting circuit to be designed for general use purposes. also, the development that occur on the circuit to enhance it and to make it suitable for different uses.

• GENERAL APPLICATIONS FOR THE AIR FLOW DETECTOR

In a general sense, the circuit demonstrates an air flow sensor, which is able to detect any movement of air in the surrounding region, whereby, an automatic control of an attached electronic circuit to this sensor can be applied.

Basically, most of the applications of Air Flow Detector Circuit depend on the place where it is used, in other words, for some applications the air flow is needed, but in others it is not. So two types of this circuit are designed and this is achieved by the position of the miniature toggle type switch (S2) as mentioned in the previous chapter.

As the first case when the flow of air is unwanted, as it is the case when the flow of air can cause unwanted mess or dust coming in, then we can control that automatically by closing and opening the path, as doors, windows or any opening that can leads to the flow of air, and this mainly can be applied in homes, industrial places, companies....etc.

Also, in agricultural place as greenhouses the regulation of air flow is of a great interest, and in chemical laboratories where the air can undergo chemical reaction with some chemical substances to yield unwanted results.

And in the second case when the air flow is desired, where in here many applications are undertaken, especially, in the electronic world where overheating is exist, overheating is the worst cause of electronic component death. Every thing inside your computer for example generates heat. Whether it is the motherboard, hard drive, RAM modules, or your processor. It just depends on the degree. So it is better to have continues cool air coming in by mains of fans, and our circuit plays an important role here to detect if the cool air stops to produce an alarm indicating the problem or malfunctioning of the cooling system. Also, this is not just in computer cases but it is every where that overheating is exist for example, in industrial machines, and in the power generators, transformers…etc.

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APPENDIX 1

DATA SHEETS

Voltage regulator 78L05 [6].

Parameter	Symbol	Value	Unit
Input Voltage (for V_O = 5V, 8V)	V_I	30	V
(for V_O = 12V to 18V)		35	V
(for V_O = 24V		40	V
Operating Junction Temperature Range	T_J	0 ~ +150	°C
Storage Temperature Range	T_{STG}	-65 ~ +150	°C

Parameter	Symbol	Conditions		Min.	Typ.	Max.	Unit
Output Voltage	V_O	T_J = 25 °C		4.8	5.0	5.2	V
Line Regulation (Note1)	ΔV_O	T_J = 25 °C	7V $\leq V_I \leq$ 20V	-	8	150	mV
			8V $\leq V_I \leq$ 20V	-	6	100	mV
Load Regulation (Note1)	ΔV_O	T_J = 25 °C	1mA $\leq I_O \leq$ 100mA	-	11	60	mV
			1mA $\leq I_O \leq$ 40mA	-	5.0	30	mV
Output Voltage	V_O	7V $\leq V_I \leq$ 20V	1mA $\leq I_O \leq$ 40mA	-	-	5.25	V
		7V $\leq V_I \leq V_{MAX}$ (Note 2)	1mA $\leq I_O \leq$ 70mA	4.75	-	5.25	V
Quiescent Current	I_Q	T_J = 25 °C		-	2.0	5.5	mA
Quiescent Current Change — with line	ΔI_Q	8V $\leq V_I \leq$ 20V		-	-	1.5	mA
Quiescent Current Change — with load	ΔI_Q	1mA $\leq I_O \leq$ 40 mA		-	-	0.1	mA
Output Noise Voltage	V_N	T_A = 25 °C, 10Hz $\leq f \leq$ 100KHz		-	40	-	μV/Vo
Temperature Coefficient of V_O	$\Delta V_O/\Delta T$	I_O = 5mA		-	-0.65	-	mV/ °C
Ripple Rejection	RR	f = 120Hz, 8V $\leq V_I \leq$ 18V, T_J = 25 °C		41	80	-	dB
Dropout Voltage	V_D	T_J = 25 °C		-	1.7	-	V

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APPENDIX 2

IC LM339 [6].

Symbol	Parameter	LM139,A LM239,A	LM339,A	Unit
V_{CC}	Supply Voltage	±18 to 36	±18 to 36	V
V_{id}	Differential Input Voltage	±36	±36	V
V_I	Input Voltage	-0.3 to +36	-0.3 to +36	V
	Output Short-circuit to Ground - (note 1)	Infinite		
P_{tot}	Power Dissipation	570	570	mW
T_{oper}	Operating Free-air Temperature Range LM239,A	-55, +125 -40, +105	0, +70	°C
T_{stg}	Storage Temperature Range	-65, +150	-65, +150	°C

Symbol	Parameter	LM139A - LM239A LM339A			LM139 - LM239 LM339			Unit
		Min.	Typ.	Max.	Min.	Typ.	Max.	
V_{io}	Input Offset Voltage – (note 2) $T_{amb} = +25°C$ $T_{min.} \leq T_{amb} \leq T_{max}$		1	2 4		1	5 9	mV
I_{io}	Input Offset Current $T_{amb} = +25°C$ $T_{min.} \leq T_{amb} \leq T_{max}$		3	25 100		5	50 150	nA
I_{ib}	Input Bias Current (I_I^+ or I_I^-) - (note 3) $T_{amb} = +25°C$ $T_{min.} \leq T_{amb} \leq T_{max}$		25	100 300		25	250 400	nA
A_{vd}	Large Signal Voltage Gain (V_{CC} = 15V, R_L =15kΩ, V_O = 1 to 11V)	50	200		50	200		V/mV
I_{CC}	Supply Current (all comparators) V_{CC} = +5V, no load V_{CC} = +30V, no load		1.1 1.3	2 2.5		1.1 1.3	2 2.5	mA
V_{icm}	Input Common Mode Voltage Range - (note 4) (V_{CC} = 30V) $T_{amb} = +25°C$ $T_{min.} \leq T_{amb} \leq T_{max}$	0 0		V_{CC}^+ -1.5 V_{CC}^+ -2	0 0		V_{CC}^+ -1.5 V_{CC}^+ -2	V
V_{id}	Differential Input Voltage - (note 6)			V_{CC}^+			V_{CC}^+	V
V_{OL}	Low Level Output Voltage (V_{id} = -1V, I_{sink} = 4mA) $T_{amb} = +25°C$ $T_{min.} \leq T_{amb} \leq T_{max}$		250	400 700		250	400 700	mV
I_{OH}	High Level Output Current (V_{id} = 1V) (V_{CC} = V_O = 30V) $T_{amb} = +25°C$ $T_{min.} \leq T_{amb} \leq T_{max}$		0.1	 1		0.1	 1	nA µA
I_{sink}	Output Sink Current (V_{id} = -1V, V_O = 1.5V)	6	16		6	16		mA
t_{re}	Response Time – (note 5) (R_L = 5.1kΩ connected to V_{CC}^+)		1.3			1.3		µs
t_{rel}	Large Signal Response Time (R_L = 5.1kΩ connected to V_{CC}^+, e_I = TTL, $V_{(ref)}$ = +1.4V)		300			300		ns