PPU College Of Engineering and Technology

The Home of Competent Engineers and Researchers

Electrical Engineering Department

Biomedical and Communication Engineering Program

Graduation Project

Tele-Controlled Microscope

Project Team

Sarah Sharabati | **Mohammed Jabari** | **Areen Abufara**

Sameha Idkadk | **Muntasser Jabari** | **Mahmoud khallaf**

Project Supervisors

Dr. Murad Abusubaih

Eng. Ali Amro

Hebron – Palestine

2013-2014

Palestine Polytechnic University

Hebron – Palestine

College of Engineering

Electrical Engineering Department

Tele-Controlled Microscope

Project Team

Sarah Sharabati | **Areen Abufara** | **Sameha Idkadk**

Mohammed Jabari | **Muntasser Jabari** | **mahmoud khallaf**

In the guidance of our supervisor, and by the acceptance of all members in the testing committee, this project is delivered to department of electrical engineering in the college of engineering and technology, to be as a partial fulfillment of the requirement of the department for the degree of B.sc.

Supervisor signature

....

Testing committee signature

....

The head of department signature

....

جامعة بوليتكنك فلسطين

فلسطين – الخليل

كلية الهندسة

دائرة الهندسة الكهربائية

فريق المشروع

سارة الشرباتي	عرين ابو قارة	سميحة ادكيدك
محمد الجعبري	منتصر الجعبري	محمود خلاف

بناءا على نظام كلية الهندسة والتكنولوجيا وإشراف ومتابعة المشرف المباشر على المشروع وموافقة أعضاء اللجنة المناقشة، تم تقديم هذا العمل إلى دائرة الهندسة الكهربائية. وذلك للوفاء بمتطلبات درجة البكالوريوس في هندسة الأجهزة الطبية.

توقيع المشرف

....

توقيع اللجنة المناقشة

....

توقيع رئيس اللجنة

....

Abstract

Telemedicine, once a specialty niche, is quickly becoming a new standard of care for hospitals and healthcare providers across the world. Driven by patient demand and an imperative to improve healthcare quality and accessibility, telemedicine is now a near-requirement for modern medical institutions. Organizations not adopting these technologies expose themselves to declining clinical outcomes.

The idea of this project is to enable Tele-Control of medical microscopes to allow remote monitoring and consultation. The project idea is inline with the trend in Telemedicine. Within the telecommunication part, it is aimed at studying and analyzing the potential of different communication technologies for achieving a system with reasonable performance. In this regard, it is planned to implement the communication part using the wired IP network (Internet) and the 3G networks. This adds the ability of achieving the system within Palestine and worldwide. Within the biomedical engineering part, it is aimed at studying and analyzing the medical microscopy technology, and studying several types of motors, and micro controllers in order to choose the appropriate components and implement them to produce a system that fulfills the project goals.

يعاني العالم عموما والعالم العربي خصوصا من نقص الأطباء ذوي الاختصاص ,مما يؤثر سلبا في كفاءة علاج المرض بالاضافة الى الحاجة لسفر المريض الى البلد الذي يقيم فيه الطبيب المختص.

يهدف هذا المشروع الى تمكين الطبيب المختص من تشخيص حالة المريض عن بعد دون الحاجة الى سفر المريض للطبيب المختص وذلك من خلال تصميم جهاز مايكروسكوب مرتبط بكاميرا ومحركات حتى يتمكن الطبيب من عينات من أنسجة المريض من خلال الكاميرا ويتم التحكم بقاعدة الأنسجة للأعلى وللأسفل ولليمين واليسار من خلال المحركات حتى يتم التشخيص بأعلى كفاءة لاعطاء العلاج المناسب لكل حالة مرضية.كذلك يمكن ان يقوم الطبيب من خلال هذا المشروع من تدريس التلاميذ حالات مرضية في أماكن نائية. في حال تعذر تواجد الطبيب المختص يمكننا المشروع من الاستفادة من خبرات طبيب مختص اخر متواجد في منطقة أخرى.

من أهم فوائد المشروع: تقليل التكلفة الواقعة على المريض,توفير الزمن الضائع أثناء السفروتمكين الطبيب المختص من تشخيص أكبر قدر من الحالات المرضية.

Contents

Chapter Three: Conceptual Design

Chapter Four: Project Design & Calculations

Chapter Four : Hardware system Design

Chapter Five : Hardware and Software System Interfacing

Chapter Six : system Design

Chapter Seven :

List of Figures

List of Tables

List of Equations

CHAPTER ONE

Introduction

1.1 Overview.

1.2 Project Objectives.

1.3 Literature Review.

1.4 Time Plan.

1.5 Project Cost.

1.1 Overview

Telemedicine is a broad term within Health Information Technology ("Health IT") that encompasses methods for electronically transmitting medical information to sustain and/or improve a patient's health status. These methods can include: store-and-forward technology for documents and images; remote monitoring of a patient's vital signs; secure messaging; e-mail exchange of data, alerts and reminders between physicians and patients; and the ability to observe, diagnose and recommend treatment via videoconference.

There are multiple products and services and respective industries that are involved in developing the various applications of telemedicine, including information technology vendors, medical device manufacturers, pharmacies, hospitals, and nursing homes.

In the current environment of a shortage of healthcare professionals, greater incidence of chronic conditions, and rising healthcare costs, telemedicine offers a potential tool to improve efficiency in the delivery of healthcare. The need for telemedicine is further compounded by the following factors:

1- Significant increase in the population.
2- Shortage of healthcare professionals being educated, trained and licensed.
3- Increasing incidence of chronic diseases around the world, including diabetes, congestive heart failure and obstructive pulmonary disease.
4- Need for efficient care of the elderly, home-bound, and physically challenged patients.
5- Lack of specialists and health facilities in rural areas.
6- Adverse events, injuries and illness at hospitals and physician's offices.
7- Need to improve community and population health.

Telemedicine can play an important role in providing solutions to these challenges. For instance, telemedicine maximizes the use of existing health care professionals by allowing them to remotely diagnose, monitor and recommend treatment for patients located in rural areas. In addition, telemedicine limits patient exposure to infections by eliminating or limiting the need to visit a hospital or a physician's office for healthcare services.

As medical microscope is an important instrument that helps pathologist in studying cells, bacteria or viruses, and finding possible cures for a sickness, we would like to design a fully functional remote microscope, and check its ability to provide pathologists and researchers the opportunity to completely operate microscopy instrumentation remotely.

1.2 Project Objectives:

The main objectives of the project are:

1- The main goal of the project is design of a Tele-Controlled microscope that allows a pathologist to render a diagnosis by examining tissue samples or body fluids under a remotely located microscope. The transmitting workstation consists of suitable camera mounted on a motorized microscope. The image from the camera will be transmitted to the receiving workstation where the consulting pathologist sits.

2- The system also allows the pathologist to control the microscope platform directions remotely. Furthermore, when it is necessary, it allows another pathologist who sits at another workstation to see the images and talk with the first pathologist.

1.3 Literature Review:

In [1], the authors identified the need to control and view, in as close to real time as possible, images being viewed on a remote microscope. The goal was to develop a system that would be versatile, easy to learn and readily adapted from existing materials and that would allow several users to simultaneously view and control the microscope.

The paper of [2] also applies telepathology-remote microscopy for intraoperative diagnoses on frozen sections, after preparation and staining of the cryosection in the hospital, the slide was examined in Institute of Pathology using a remote-controlled microscope (Leica DMRXA) and a special telepathological software (Leica TPS1). Data were transferred via two ISDN connections in parallel.

In [3] The Beckman institute remote microscopy project provides web based remote control of microscopes in the ITG as part of the World Wide Laboratory. There are a number of advantages to providing remote access to imaging instrumentation. First, it provides access to unique and/or expensive instruments without requiring the user to be physically present at the site of the instrument. In addition, it provides the opportunity for collaboration and/or consultation with researchers anywhere in the world, thus providing for a network of distributed expertise. Finally, this technology presents unprecedented opportunities for education and training.

In [4] the authors identified the need to control and view, in as close to real time as possible, images being viewed on a remote microscope. The goal was to develop a system that would be versatile, easy to learn and readily adapted from existing materials and that would allow several users to simultaneously view and control the microscope.

1.4 Time Schedule

The time plan, represents the main stages of the establishing the project, is divided into the two semesters as shown in the following tables.

The Table 1.1 shows the activities that done in the project First Semester, and the time of each one.

Table 1.1: Table Time for the First Semester

Activities \ Weeks	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
System Definition	■	■	■													
System Analysis				■	■	■										
System Design							■	■	■	■	■	■	■			
Presentation Preparing														■	■	■
Documentation				■	■	■	■	■	■	■	■	■	■	■	■	

The following table defines the main tasks in the project:

Table 1.2 Time Table for the Second Semester

Weeks / Activities	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Collecting data	■	■	■	■												
Design				■	■	■	■	■	■	■	■	■				
Analysis					■	■	■	■	■	■						
Building and testing the system									■	■	■	■	■			
Documentation					■	■	■	■	■	■	■	■	■	■	■	
Prepare for presentation															■	■

1.5 Project Cost

Table 1.3: Project Cost

Component	Cost
Microscope	*400$*
Arduino Microcontroller,	*100$*
DC-Motors	130$
Video Camera	*400$*
component construction	*210$*
Total	*1240$*

CHAPTER TWO

Physiology Background

Chapter Two

Physiological Background

2.1 Introduction

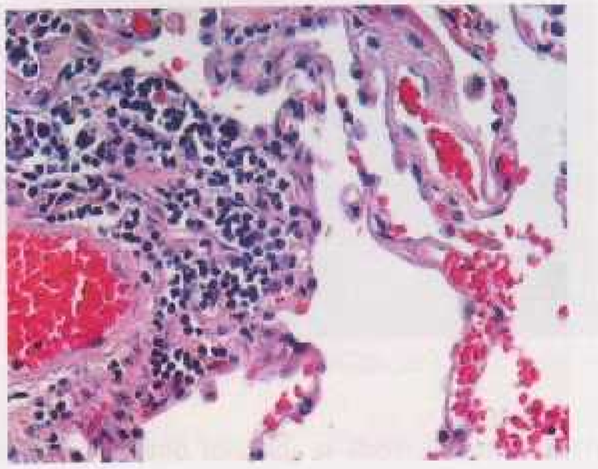
Microbiology, the branch of science that has so vastly extended and expanded our knowledge of the living world. New technologies contributed to widen the circle of discoveries and watch unless we see. Many several micro-organisms were undiscovered until recently when it was discovered optical microscope in the seventeenth century. Human saw what he has not seen of bacteria cells, algae, fungi and can be seen how feed and reproduce and how they invade our bodies. Medical microscope used in the study of many of the scientific and medical fields. So that it uses in Histology, Hematology, Bacteriology and other Routine tests and will study these field in this chapter.

2.2 Histology

Histology is the study of the microscopic anatomy of cells and tissues of plants and animals .It is commonly performed by examining cells and tissues by sectioning and staining, followed by examination under a light microscope or electron microscope. Histological studies maybe conducted via tissue culture ,where live cells can be isolated and maintained in a proper environment outside the body for various research projects. The ability to visualize or differentially identify microscopic structures is frequently enhanced through the use of histological stains. Histology is an essential tool of biology and medicine.

Histopathology, the microscopic study of diseased tissue, shown finger 2.1, is an important tool in anatomical pathology, since accurate diagnosis of cancer and other diseases usually requires histopathological examination of samples. Trained physicians, frequently board certified as pathologists ,are the personnel who perform histopathological examination and provide diagnostic information based on their observations.

The trained scientists who perform the preparation of histological sections are histotechnicians, histology technicians (HT), histology technologists (HTL), medical scientists, medical laboratory technicians, or biomedical scientists. Their field of study is called histotechnology.



Finger 2.1: Microscopic View of a Histological Specimen of Human.[1]

Knowing the histology of a cancer is important for determining the type of cancer you have and the best treatment plan. After a biopsy or full removal of a tumor, a small sample of tissue is examined under a microscope to determine the cellular components and structure, or histology, of the cancer.

Cancer

Cancer is a class of diseases characterized by out-of-control cell growth. There are over 100 different types of cancer, and each is classified by the type of cell that is initially affected.

Cancer harms the body when damaged cells divide uncontrollably to form lumps or masses of tissue called tumors (except in the case of leukemia where cancer prohibits normal blood function by abnormal cell division in the blood stream). Tumors can grow and interfere with the digestive, nervous, and circulatory systems, and they can release hormones that alter body function. Tumors that stay in one spot and demonstrate limited growth are generally considered to be benign.

More dangerous, or malignant, tumors form when two things occur;

A cancerous cell, shown in figure 2.2, manages to move throughout the body using the blood or lymph systems, destroying healthy tissue in a process called invasion

A cancerous cell manages to divide and grow, making new blood vessels to feed itself in a process called angiogenesis.

When a tumor successfully spreads to other parts of the body and grows, invading and destroying other healthy tissues, it is said to have metastasized. This process itself is called metastasis, and the result is a serious condition that is very difficult to treat.

Finger 2.2: Cancer Cell

Extracting cancer cells and looking at them under a microscope is the only absolute way to diagnose cancer. This procedure is called a biopsy. Other types of molecular diagnostic tests are frequently employed as well. Physicians will analyze body's sugars, fats, proteins, and DNA at the molecular level. For example, cancerous prostate cells release a higher level of a chemical called PSA (prostate-specific antigen) into the bloodstream that can be detected by a blood test. Molecular diagnostics, biopsies, and imaging techniques are all used together to diagnose cancer.[2]

2.3 Hematology

Hematology is the study of blood, the blood-forming organs, and blood diseases Hematology includes the study of etiology, diagnosis ,treatment, prognosis, and prevention of blood diseases that affect the production of blood and its components, such as blood cells, hemoglobin, blood proteins, and the mechanism of coagulation. The laboratory work that goes into the study of blood is frequently performed by a medical technologist. Hematologists also conduct studies in oncology the medical treatment of cancer.

Blood diseases involving the red blood cells testes under microscope include:

1) Polycythemia
2) Hypochromic anemia

Blood diseases involving the White blood cells testes under microscope include:

1- Acquired immune deficiency syndrome (AIDS), is a progressive disease that results from infection of white blood cells by the HIV virus

2- Leukemia is a cancer that develops in white blood cells. Under normal conditions, blood cells are formed within the bone marrow, which can create a range of blood cell types.

3- Granulocytes is occurs when the blood does not contain enough neutrophils, a type of white blood cell. The cells responsible for making blood may not produce enough neutrophils to meet the needs of the body or neutrophils may be destroyed too quickly within the body. Since neutrophils help make up a portion of the immune system, people with agranulocytosis are unable to effectively fight off infection.[3]

Blood diseases involving the platelet cells testes under microscope include:

Thrombocytosis, shown in figure 2.3, is the presence of high platelet counts in the blood, and can be either primary (also termed essential and caused by a myeloproliferactive disease) or reactive (also termed secondary). Although often symptomless (particularly when it is a secondary reaction), it can predispose to thrombosis in some patients.

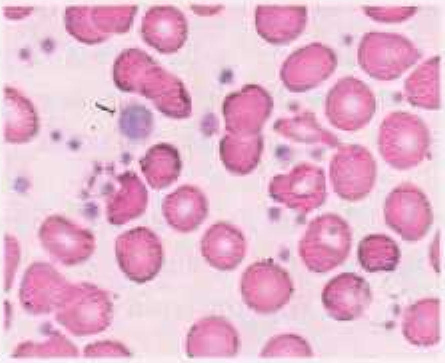


Figure 2.3: Thrombocytosis. [4]

2.4 Bacteriology

Many human infections are caused by either bacteria or viruses. Bacteria are tiny single-celled organisms, thought by some researchers to be related to plants. They are among the most successful life forms on the planet, and range in habitat from ice slope to deserts.

2.4.1 Bacteria

Singular 'bacterium.' Microscopic single cell (unicellular) life form that exists practically everywhere in the Earth's environment, and is simpler than the cells of animals, fungi, and plants. Of about three million species of bacteria believed to exist, only about 4,000 are known and

Bacteria can be beneficial for instance, gut bacteria help us to digest food but some are responsible for a range of infections. These disease causing varieties are called pathogenic bacteria. Many bacterial infections can be treated successfully with appropriate antibiotics, although antibiotic-resistant strains are beginning to emerge. Immunization is available to prevent many important bacterial diseases.

2.4.2 Parasitic

micro parasite is a parasite that completes a full life cycle within one host and can be transmitted directly to conspecific hosts. They often reproduce within a host's cells and are generally too small to be seen with then a ked eye.

Most are viruses, bacteria and fungi with a smaller number being protists. Examples include Salmonella and HIV.

2.4.3 Virus:

A virus are tiny organisms that may lead to severe illnesses in humans, animals and plants. This may include flu or a cold to something more life threatening like HIV/AIDS.

Viruses by themselves are not alive. They cannot grow or multiply on their own and need to enter a human or animal cell and take over the cell to help them multiply. These viruses may also infect bacterial cells.

The virus particle or the virions attack the cell and take over its machinery to carry out their own life processes of multiplication and growth. An infected cell will produce viral particles instead of its usual products.

Viruses do not have the chemical machinery needed to survive on their own. They, thus seek out host cells in which they can multiply. These viruses enter the body from the environment or other individuals from soil to water to air via nose, mouth, or any breaks in the skin and seek a cell to infect.

A cold or flu virus for example will target cells that line the respiratory (i.e. the lungs) or digestive (i.e. the stomach) tracts. The HIV (human immunodeficiency virus) that causes AIDS attacks the T-cells (a type of white blood cell that fights infection and disease) of the immune system.

2.4 Routine tests

Such as checking urine and feces .Microscopic urinalysis is often done as part of an overall urinalysis. After a urine sample is collected, it's put into a centrifuge. It's a special machine that separates the liquid in the urine from solid components that may be present, such as blood cells, mineral crystals, or microorganisms. Any solid materials are then viewed under a microscope.

The results of a microscopic urinalysis may point to a urinary tract infection (UTI), kidney problems, a metabolic disorder such as diabetes, or a urinary tract injury. If test results are abnormal, other tests may be needed before a definite diagnosis can be made.

Chapter Three

Theoretical Background

3.1 Introduction

3.2 Microscope

3.3 DC Motors

3.4 Microcontroller (Arduino)

3.5 Digital Camera

3.6 Global System for Mobile Communication (GSM)

3.7 Third Generation (3G) Network

3.8 Third Generation (3G) GSM Modem

3.9 SIM Card

3.10 Digital Subscriber Line (DSL)

3.11 Digital Subscriber Line (DSL Modem

3.12 Multi Input Multi Output (MIMO) Wi-fi System

3.13 Multi Input Multi Output (MIMO) Wi-Fi Router

3.14 Voice Over IP(VoIP) .

3.1 Introduction

This chapter discusses the technologies and components that needed to the system implementation. It provides an overview about Microscope, DC-Motors,Microcontroller (Arduino), Digital Camera,GSM Network, VOIP Technology, DSL Technology, Modems, and the Programming language.

3.2 Microscope

3.2.1 Introduction

Microscope is an important diagnostic instrument which is routinely employed in the pathology laboratories of hospitals to investigate a range of biopsy specimens and other tissue samplesproduces enlarged images of small objects, allowing them to be viewed at a scale convenient for examination and analysis.

3.2.2 Microscope Parts

1. Ocular Lens (Eyepiece) - where you look through it to see the image of your specimen. Magnifies the specimen 10X actual size.

2. Body tube - the long tube that supports the eyepiece and connects it to the objectives.

3. Nosepiece - the rotating part of the microscope at the bottom of the body tubewhich holds theobjectives.

4. Objective Lenses - (low, medium, high). Depending on the microscope, you may have 2, 3 or more objectives attached to the nosepiece; they vary in length (the shortest is the lowest poweror magnification; the longest is the highest power or magnification).

5. Arm - part of the microscope that you carry the microscope with it; connects the head and base of the microscope.

6. Course Adjustment Knob - large, round knob on the side of the microscope used for "rough" focusing of the specimen; it may move either the stage or the upper part of the microscope. Location may vary depending on microscope - it may be on the bottom of the arm or on the top.

7. Fine Adjustment Knob - small, round knob on the side of the microscope used to fine-tune the focus of your specimen after using the coarse adjustment knob. As with the coarse adjustment knob, location may be vary depending on the microscope.

8. Stage - large, flat area under the objectives; it has a hole in it (see aperture) that allows light through; the specimen/slide is placed on the stage for viewing.

9. Stage Clips - clips on top of the stage which holds the slide in place.

10. Aperture - the hole in the stage that concentrates light through the specimen for better viewing.

11. Diaphragm - controls the amount of light going through the aperture; may be adjusted.

12. Light or Mirror - source of light usually found near the base of the microscope; used to direct light upward through the microscope. The light source makes the specimen easier to see.

3.2.3 Types of microscope:

There is several types of microscope such as optical microscope, confocal microscope, and electron microscope. In the following section give brief description of each type.

3.2.3.1 Optical Microscope:

The optical microscope, or "light microscope", is a type of microscope which uses visible light and a system of lenses to magnify images of small samples. Optical microscopes are the oldest design of microscope and were possibly designed in their present compound form in the 17th century. Basic optical microscopes can be very simple, although there are many complex designs which aim to improve resolution and sample contrast. Historically optical microscopes were easy to develop and are popular because they use visible light so that samples may be directly observed by eye.

3.2.3.1.1 Types of optical microscope:

Several types of optical microscope are available such as stereoscope, and compound microscope.

1. **Dissection or Stereoscope**

A stereoscope shown in figure 3.1 is a binocular microscope that magnifies at a relatively low power for viewing three-dimensional, opaque objects, such as flowers, insects, mineral specimens, generally the magnification of a stereoscope is between 20x and 50x, and specimens are lighted from above. The three-dimensional image is produced by two objective lenses plus the eyepieces.

Figure 3.1: Stereoscope [5]

2. **Compound Microscope**

Compound microscope is a tool that can be used for many purposes. The image seen with this type of microscope is two dimensional. This microscope is the most commonly used. It has high magnification. The source of radiation for image formation is visible light, glass slides are used in it. However, it has a low resolution, and individual cells can't be seen. The magnification adjustments of this microscope by changing objectives.

A compound microscope uses more than one lens to magnify the objects to be studied. Following are some of the basic types of compound microscopes:

a. Monocular compound microscope

Monocular compound microscope shown in figure 3.2, using a single light as a sample illuminator and compound lenses for magnification, these have a single eyepiece. This is a bit uncomfortable, as the person need to close one eye to get a clear image. The eyepiece has a power of about 10X and the objectives or lenses on the nosepiece range from 2X to 50X depending on your particular microscope.

Figure 3.2: Monocular Inclined Microscope [6]

B. Binocular compound microscope

Binocular compound microscope shown in figure 3.3, becoming more common. It has dual eyepiece to enable both eyes viewing the sample image. This makes it more comfortable to use and thereby more popular. Dual eyepiece scopes are used widely in high school and college classrooms. Binocular microscopes have all the same characteristics as the monocular compound microscope.

Figure 3.3: Binocular compound microscope.

3. Confocal Microscope

This microscope shown in figure 3.4, uses a laser light. This light is used because of the wavelength, Laser light scan across the specimen with the aid of scanning mirrors. Then image is placed on a digital computer screen for analysis.

Figure 3.4: Confocal Microscope.

3.2.3.2 Electron microscope

Two main types of Electron microscope is available scanning electron microscope (SEM) and transmission electron microscope (TEM).

A. Scanning electron microscope (SEM)

SEM microscope shown in figure 3.5 is a type of electron microscope that produces images of a sample by scanning it with a focused beam of electrons. The electrons interact with electrons in the sample, producing various signals that can be detected and that contain information about the sample's surface topography and composition. The electron beam is generally scanned in a raster scan pattern, and the beam's position is combined with the detected signal to produce an image. SEM can achieve resolution better than 1 nanometer. Specimens can be observed in high vacuum, low vacuum and in environmental SEM specimens can be observed in wet conditions.

Figure 3.5: Scanning electron microscope (SEM).

B. Transmission electron microscope (TEM)

TEM microscope shown in figure 3.6 it operates on the same basic principles as the light microscope but uses electrons instead of light. This gives a 2-D view. TEMs uses electrons as "light source" and their much lower wavelength makes it possible to get a resolution thousand times better than with a light microscope.

Figure 3.6: Transmission electron microscope (TEM)

3.3 DC Motors

3.3.1 Introduction

At the most basic level, electric motors exist to convert electrical energy into mechanical energy. This is done by way of two interacting magnetic fields; one stationary, and another attached to a part that can move. A number of types of electric motors exist. DC motors have the potential for very high torque capabilities (although this is generally a function of the physical size of the motor), are easy to miniaturize, and can be "throttled" via adjusting their supply voltage. DC motors are also not only the simplest, but the oldest electric motors.

A. Transmission electron microscope (TEM)

TEM microscope, shown in figure 3.6,itoperates on the same basic principles as the light microscope but uses electrons instead of light. This gives a 2-D view. TEMs uses electrons as "light source" and their much lower wavelength makes it possible to get a resolution thousand times better than with a light microscope.

Figure 3.6: Transmission Electron Microscope (TEM)

3.3 DC Motors

3.3.1 Introduction

At the most basic level, electric motors exist to convert electrical energy into mechanical energy. This is done by way of two interacting magnetic fields; one stationary, and another attached to a part that can move. A number of types of electric motors exist. DC motors have the potential for very high torque capabilities (although this is generally a function of the physical size of the motor), are easy to miniaturize, and can be "throttled" via adjusting their supply voltage. DC motors are also not only the simplest, but the oldest electric motors.

DC motors are, driven from a DC power supply, the input voltage to a dc motor is assumed to be constant, because that assumption simplifies the analysis of motors and the comparisons between different types of motors.[17]

3.3.2 The equivalent circuit of a DC motor

In a DC motor, the supply voltage E and current I is given to the electrical port or the input port and derive the mechanical output i.e. torque T and speed ω from the mechanical port or output port.

The input and output port variables of the Direct Current Motor are related by the parameter K.

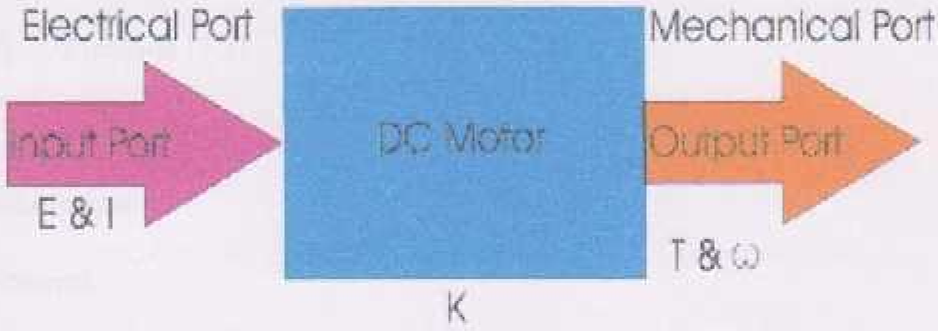


Figure 3.7: DC-Motor Input and Output

To understand the DC motor in details let's consider the diagram below,
The direct current motor is represented by the circle in the center, on which is mounted the brushes, where we connect the external terminals, from where supply voltage is given. On the mechanical terminal we have a shaft coming out of the Motor, and connected to the armature, and the armature-shaft is coupled to the mechanical load. On the supply terminals we represent the armature resistance Ra in series. Now, let the input voltage E, is applied across the brushes. Electric current which flows through the rotor armature via brushes, in presence of the magnetic field, produces a torque τ, due to this torque τ the dc motor armature rotates. As the armature conductors are carrying currents and the armature rotates inside the stator magnetic field, it produces an emfEa. The internal generated voltage in this machine is given by the equation:

$Ea = K\O\omega$... Equation (3.1)

Where:

Ea: Armature voltage

Ø: Flux

k: Constant

ω: Speed of rotation

And the induced torque developed by the machine is given by:

$\tau_{ind} = K\O I_a$ ... Equation (3.2)

Where:

τ ind : Induced torque.

I_a armature current

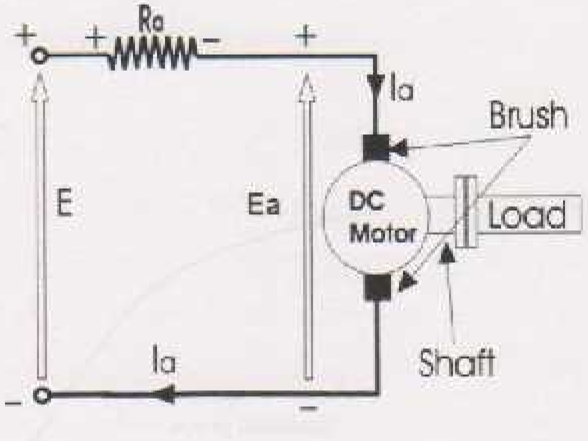


Figure 3.8: The Equivalent Circuit of a DC Motor.

3.3.3 The Magnetization Curve of a DC Machine

Ea is directly proportional to flux and the speed of rotation of the machine. Ea is therefore related to the field current. Field current in a dc machine produces a field magneto motive force given by Fp = NFIF. Magneto motive force produces a flux in the machine in accordance with its magnetization curve.

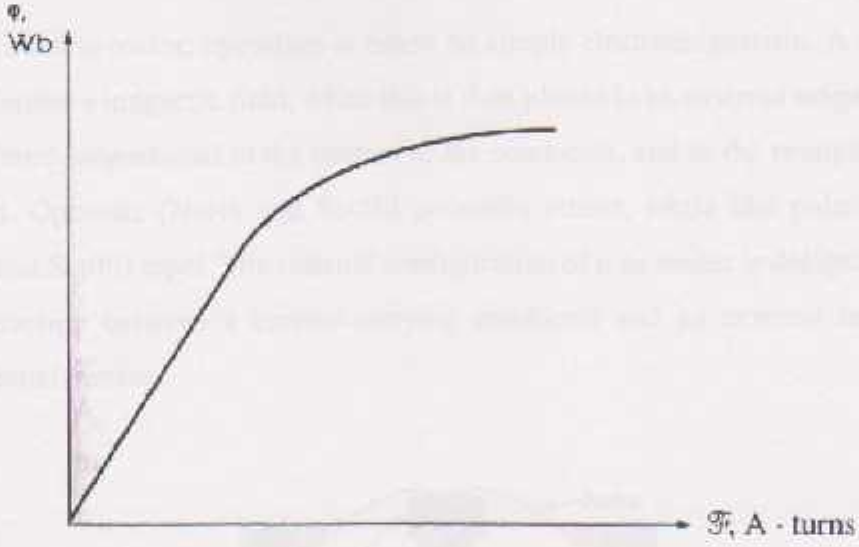


Figure 3.9: the Magnetization Curve of a Ferromagnetic Material.

Since If is proportional to magneto motive force and since Ea is proportional to flux, magnetization curve can represented as a plot of Ea versus field current for a given speed ω_0.

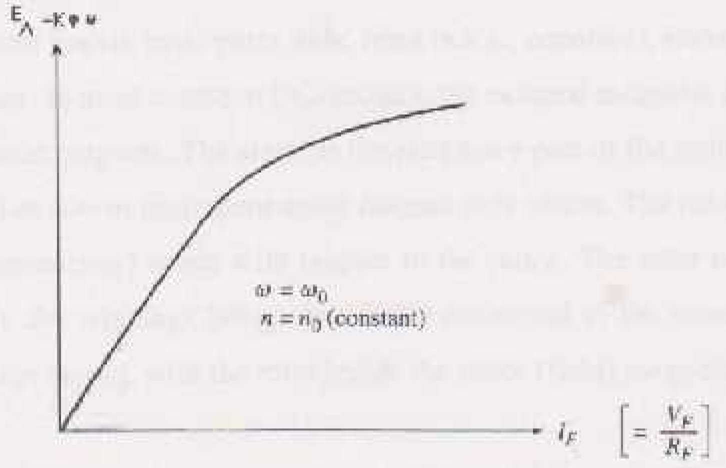


Figure 3.10: The Magnetization Curve of a DC Machine.

3.3.4 DC Motors Principles of Operation

In any electric motor, operation is based on simple electromagnetism. A current-carrying conductor generates a magnetic field; when this is then placed in an external magnetic field, it will experience a force proportional to the current in the conductor, and to the strength of the external magnetic field. Opposite (North and South) polarities attract, while like polarities (North and North, South and South) repel. The internal configuration of a dc motor is designed to harness the magnetic interaction between a current-carrying conductor and an external magnetic field to generate rotational motion.

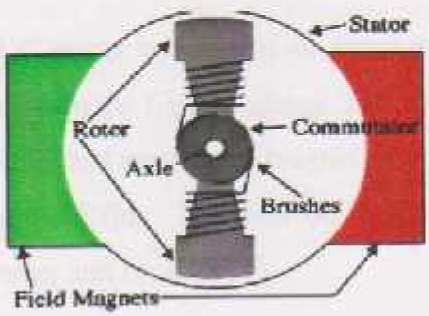


Figure 3.11 A Common DC Motor Parts

Every DC-motor has six basic parts, axle, rotor (a.k.a., armature), stator, commutator, field magnet(s), and brushes. In most common DC- motors, the external magnetic field is produced by high-strength permanent magnets. The stator is the stationary part of the motor, this includes the motor casing, as well as two or more permanent magnet pole pieces. The rotor (together with the axle and attached commutator) rotate with respect to the stator. The rotor consists of windings (generally on a core), the windings being electrically connected to the commutator. Figure 3.4 shows a common motor layout, with the rotor inside the stator (field) magnets.

The geometry of the brushes, commutator contacts, and rotor windings are such that when power is applied, the polarities of the energized winding and the stator magnet(s) are misaligned, and the rotor will rotate until it is almost aligned with the stator's field magnets. As the rotor reaches alignment, the brushes move to the next commutator contacts, and energize the next winding.

In real life, though, dc motors will always have more than two poles (three is a very common number). In particular, this avoids "dead spots" in the commutator.

3.3.5 Types of DC motors

There are five types of dc motors separately excited and shunt DC- motors, motor, compounded DC- motor, series dc motor and permanent – magnet DC.

Permanent Magnet DC Motor

The permanent magnet DC-motor consists of an armature winding as in case of a usual motor, but does not necessarily contain the field windings. The construction of these types of DC-motor are such that, radially magnetized permanent magnets are mounted on the inner periphery of the stator core to produce the field flux. The rotor on the other hand has a conventional dc armature with commutator segments and brushes [8]

3.4 Microcontroller (Arduino)

The Arduino microcontroller is an open-source electronics prototyping platform based on flexible, easy-to use hardware and software. It's intended for artists, designers, hobbyists and anyone interested in creating interactive objects or environments.

Arduino 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 Arduino programming language (based on Wiring) and the Arduino development environment (based on Processing). Arduino projects can be stand-alone or they can communicate with software running on a computer (e.g. Flash, Processing, Max MSP).

The boards can be built by hand or purchased preassembled; the software can be downloaded for free.

In this project Arduino Mega 2560 is used to programming the three DC gear motors because it's a larger, more powerful Arduino board. Has extra digital pins. PWM pins, analog inputs, serial ports.

The main advantages of Arduino microcontroller:

1. Inexpensive – Arduino boards are relatively inexpensive compared to other microcontroller plate forms.
2. Simple, clear programming environment – the Arduino programming environment is easy to use for beginners, yet flexible enough for advanced users.
3. Open source and extensible software- the Arduino software is published as open source tools, available for extensible by experienced programmers.
4. Open source and extensible hardware – the Arduino is based on Atmel's ATMEGA8and ATMEGA168 microcontroller.[9]

3.5 Digital Camera

Rapidly advancing technology has made digital imaging within reach of every microscope. There are now so many digital cameras available for microscopy. The digital microscope is an optical microscope with a video camera or digital camera attached or a microscope with an integrated camera, it is capable of displaying what's on the stage as a digital image.

Figure 3.12: MEM 1300 Digital Camera

3.6 Global System for Mobile Communication (GSM)

3.6.1 GSM Definition

GSM or Global system for mobile communication is a world-wide standard for digital wireless mobile phones. GSM is the second generation cellular standard developed to provide voice services and data delivery using digital modulation.

GSM exists in four main versions, based on the band used: GSM-900, GSM-1800, GSM-850 and GSM-1900, where GSM-900 (900 MHz) and GSM-1800 (1.8 GHz) are used in most of the world, excluding the United States and Canada. The United States and Canada use GSM-850 and GSM-1900 (1.9 GHz) instead, since in the U.S. the 900 and 1800 bands were already allocated.[10]

3.6.2 GSM Network

A GSM network consists of several functional entities whose functions and interfaces are defined in the standard.

The GSM network can be divided into four main parts:

- The Mobile Station (MS):
- The Base Station Subsystem (BSS):
- Base Station Controller (BSC): The Network and Switching Subsystem (NSS): It is responsible for performing call processing and subscriber related functions. The different

components of the NSS are (Mobile switching center (MSC), Home location register (HLR) HLR, Visitor location register (VLR), Equipment identity register (EIR), Authentication Center AUC).

The Operation and Support Subsystem (OSS): It is connected to components of the NSS and the BSC, in order to control and monitor the GSM system

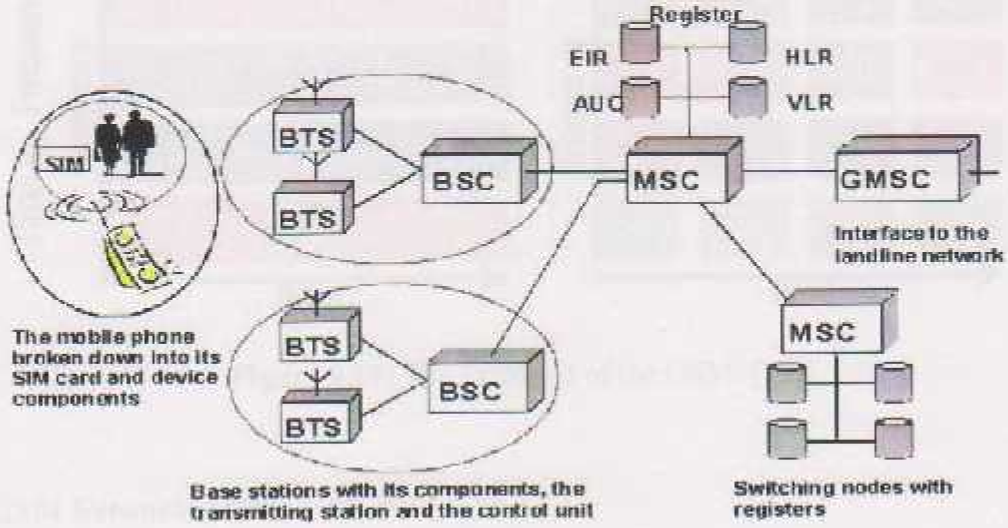


Figure 3.13: Architecture of the GSM network.

3.6.3 The principle of the GSM

GSM operates at two principles:

- Time division Multiplexing (TDMA):

  It is very simple, where the radio frequency is shared by different users in time. This way many users talk at the same time on the same frequency. This has to be done, because as we now frequency or Bandwidth is a scarce resource and is not available in plentiful so it must be shared.[11]

- Frequency Division Multiplexing (FDMA):

In this principle, users use different frequencies.

Now, GSM uses a combination of TDMA and FDMA. This means that users are not only sharing the channel in time but also in frequency. The standard operation of GSM was able to provide data transfer speed up to 9.6 kbps. The principle of the GSM is presented in figure 3.16.

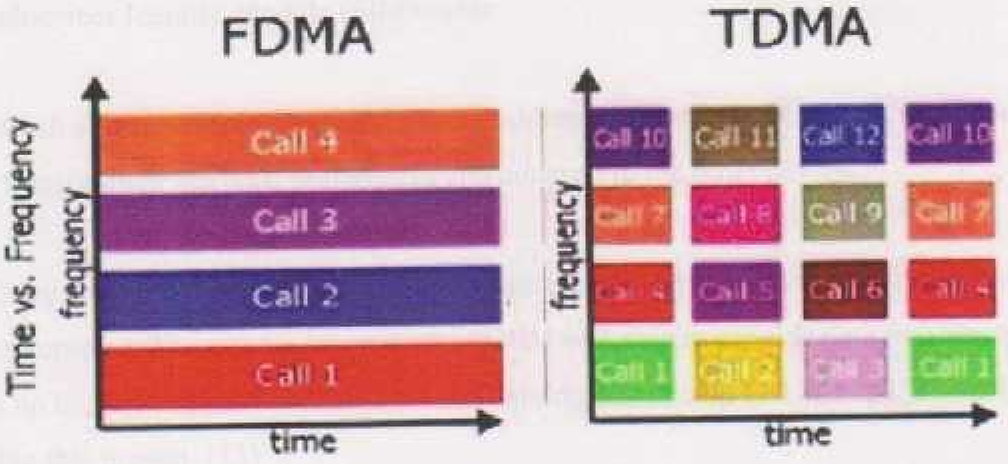


Figure 3.14: The Principle of the GSM. [12]

3.6.4 GSM Network Areas

- The GSM network is made up of geographic areas, these areas are defined as:
- Cell: Cell is the basic service area that given radio coverage by one BTS. These cells are of five different sizes (macro, micro, femto, and umbrella and Pico cells). Macro cells are the largest cells where Pico cells are the smallest.
- Location Area: A group of cells, where this is the area that is paged when a subscriber gets an incoming call. Each Location Area is served by one or more BSCs.
- MSC/VLR Service Area: The area covered by one MSC is called the MSC/VLR service area.
- PLMN: The area covered by one network operator is called PLMN. A PLMN can contain one or more MSCs.

Why GSM?

There are several reasons why GSM is so popular among operators and their customers:

- Clear voice quality

- International roaming
- Spectral flexibility
- Tight security
- Data support
- Subscriber Identity Module (SIM) cards

Which allow customers to buy a new or additional phone, or a GSM PC Card modem, and instantly transfer their settings, preferences and contacts to the other device.

There are more advantages for GSM, which it can process the weak signal inside buildings by using a repeater. The standard operation of GSM was able to provide data transfer speed from 9.6 Kbps up to 14.4 kbps, where in GPRS the data rate can be up to 171 kbps. Therefore, GPRS was used in this project. [13]

3.7 Third Generation (3G) network

3.7.1 Definition of 3G

3G is the third generation of wireless technologies. It comes with enhancements over previous wireless technologies, like high-speed transmission, advanced multimedia access and global roaming. 3G is mostly used with mobile phones and handsets as a means to connect the phone to the Internet or other IP networks in order to make voice and video calls, to download and upload data and to surf the net.

3.7.2 Advantage of 3G:

- Several times higher data speed.
- Enhanced audio and video streaming.
- Video-conferencing support.
- Web and WAP browsing at higher speeds.
- IPTV (TV through the Internet) support.

- Greater security than their 2G predecessors.

3.7.3 3G Technical Specifications (Data rate)

- High Mobility

  144 kbps for rural outdoor mobile use. This data rate is available for environments in which the 3G user is traveling more than 120 kilometers per hour (km/h) in outdoor environments such as in a train or car (vehicular traffic).

- Full Mobility

  384 kbps for pedestrian users traveling less than 120 km/h in urban outdoor environments.

- Limited Mobility

  At least 2 Mbps with low mobility (less than 10 km/h) in stationary indoor and short-range outdoor environments. These maximum data rates illustrated the potential for 3G technology and are available only in stationary indoor environments.

3.7.4 The Required for Using 3G

- Device (e.g. a mobile phone) that is 3G compatible. An example is the iPhone.
- Subscribed to a service provider to get 3G network connectivity.
- Your device is connected to the 3G network through its SIM card or its 3G data card (which can be of different types: USB, PCMCIA etc.), which are both generally provided/sold by the service provider.

3.7.5 Security

3G networks offer greater security than their 2G predecessors. By allowing the UE (User Equipment) to authenticate the network it is attaching to, the user can be sure the network is the intended one and not an impersonator. 3G networks use the KASUMI block cipher instead of the older A5/1 stream cipher. However, a number of serious weaknesses in the KASUMI cipher have been identified.

In addition to the 3G network infrastructure security, end-to-end security is offered when application frameworks such as IMS are accessed, although this is not strictly a 3G property.

Why Third Generation (3G) network?

Because we want to transfer video and 2G does not support video transmission and the video needs to be high speed and 3G speed up to 348kbps Snaked, and for the protection of 3G more protection from the 2 G

3.8 Third Generation (3G) GSM Modem

3.8.1 Definition of Third Generation (3G) GSM Modem:

A GSM modem is a specialized type of modem which accepts a SIM card, and operates over a subscription to a mobile operator, just like a mobile phone. From the mobile operator perspective, a GSM modem looks just like a mobile phone.

3G modem support or can handle the (HSDPA) standard, and can support high speed or data rate. Also it contain a (RS232+USB) interface .figure 3.17 show the HSDPA Modem. [14]

This modem has the following features:

- USB interface.
- Based on Simcom module SIM5216E.
- With TCP/IP stack.
- WCDMA/HSDPA 900/2100MHz.
- GPRS class 12.
- EDGE class12.

Figure 3.15: HSDPA SIM5216 Modem.

3. 9 SIM Card

A Subscriber Identity Module (SIM) card is a portable memory chip used by all GSM devices, including phones and GSM/GPRS modems. These cards hold the personal information of the account holder, including his phone number, address book, text messages, and other data. One of the biggest advantages of SIM cards is that they can easily be removed from one mobile phone and used in any other compatible phone to make a call. This means that, if the user wants to buy a new handset, he can activate it quickly by inserting his old SIM card. The user's phone number and personal information is carried on the card, so there's no need to do anything else to transfer this information. [15]

3.9.1 SIM Cards Sizes

SIM cards are made in three different sizes to accommodate different devices. Most phones use mini-SIM or micro-SIM cards, which are quite small. The mini is (25 mm by 15 mm), and the micro is (15 mm by 12 mm). Full-sized cards are much larger, (85.6 mm by 53.98 mm), and are too big for most phones. All cards are only 0.76 mm thick. However, the microchip contacts are in the same arrangement. This means that, with the proper adapter, the smaller cards can be used in devices designed for larger ones.

3.9.2 Structure of SIM Card.

The SIM Card consist of many component like shown in figure 3.18:

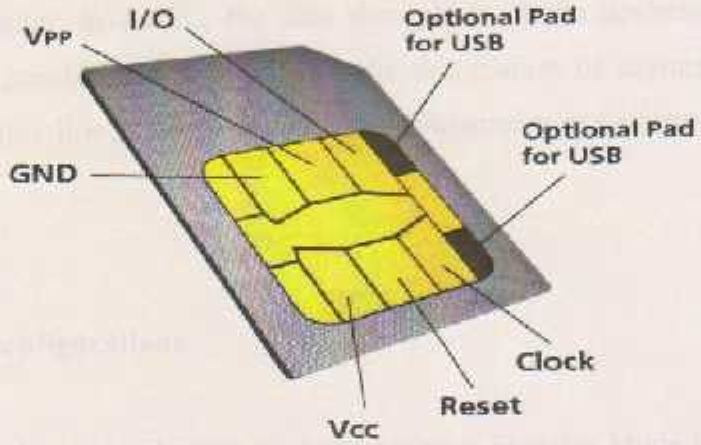


Figure 3.16: Structure of SIM Card.

3.10 Digital Subscriber line (DSL)

3.10.1 DSL Definition

Digital subscriber line (DSL, originally digital subscriber loop) is a family of technologies that provide Internet access by transmitting digital data over the wires of a local telephone network. In telecommunications marketing, the term DSL is widely understood to mean asymmetric digital subscriber line (ADSL), the most commonly installed DSL technology. DSL service is delivered simultaneously with wired telephone service on the same telephone line. This is possible because DSL uses higher frequency bands for data. On the customer premises, a DSL filter on each non-DSL outlet blocks any high frequency interference, to enable simultaneous use of the voice and DSL services.

3.10.2 DSL Bit Rate

The bit rate of consumer DSL services typically ranges from 256 kbit/s to 40 Mbit/s in the direction to the customer (downstream), depending on DSL technology, line conditions, and service-level implementation. In ADSL, the data throughput in the upstream direction, (the direction to the service provider) is lower, hence the designation of asymmetric service. In symmetric digital subscriber line (SDSL) services, the downstream and upstream data rates are equal.

3.10.3 Protocols and configurations

Many DSL technologies implement an Asynchronous Transfer Mode (ATM) layer over the low-level bit stream layer to enable the adaptation of a number of different technologies over the same link.

DSL implementations may create bridged or routed networks. In a bridged configuration, the group of subscriber computers effectively connect into a single subnet. The earliest implementations used DHCP to provide network details such as the IP address to the subscriber equipment, with authentication via MAC address or an assigned host name. Later implementations often use Point-to-Point Protocol (PPP) or Asynchronous Transfer Mode (ATM) (Point-to-Point Protocol over Ethernet (PPPoE) or Point-to-Point Protocol over ATM (PPPoA)), while authenticating with a user id and password and using Point-to-Point Protocol (PPP) mechanisms to provide network details. [16]

3.10.4 Transmission methods

Transmission methods vary by market, region, carrier, and equipment:

- 2B1Q: Two-binary, one-quaternary, used for IDSL and HDSL.
- CAP: Carrier less Amplitude Phase Modulation - deprecated in 1996 for ADSL, used for HDSL.
- TC-PAM: Trellis Coded Pulse Amplitude Modulation, used for HDSL2 and SHDSL.
- DMT: Discrete multi-tone modulation, the most numerous kind, also known as OFDM (Orthogonal frequency-division multiplexing).

3.10.5 DSL technologies

DSL technologies include:

- ISDN Digital Subscriber Line (IDSL), uses ISDN based technology to provide data flow that is slightly higher than dual channel ISDN.
- High Data Rate Digital Subscriber Line (HDSL / HDSL2), was the first DSL technology that used a higher frequency spectrum of copper, twisted pair cables.
- Symmetric Digital Subscriber Line (SDSL / SHDSL), the volume of data flow is equal in both directions.
- Symmetric High-speed Digital Subscriber Line (G.SHDSL), a standardized replacement for early proprietary SDSL.
- Asymmetric Digital Subscriber Line (ADSL), the volume of data flow is greater in one direction than the other.
- Asymmetric Digital Subscriber Line 2 (ADSL2), an improved version of ADSL
- Asymmetric Digital Subscriber Line 2 Plus (ADSL2+), a version of ADSL2 that doubles the data rates by using twice the spectrum.
- Asymmetric Digital Subscriber Line plus Plus (ADSL++), technology developed by Centillium Communications (Centillium has been acquired by TranSwitch Corp.) for the Japanese market that extends downstream rates to 50 Mbit/s by using spectrum up to 3.75 MHz
- Bonded DSL Rings (DSL Rings), A shared ring topology at 400 Mbit/s

- Rate-Adaptive Digital Subscriber Line (RADSL), designed to increase range and noise tolerance by sacrificing up stream speed
- Very High Speed Digital Subscriber Line (VDSL)
- Very High Speed Digital Subscriber Line 2 (VDSL2), an improved version of VDSL
- Ether loop Ethernet Local Loop
- (Extended-) Reach Digital Subscriber Line
- Uni-DSL (Uni Digital Subscriber Line or UDSL), technology developed by Texas Instruments, backwards compatible with all DMT standards
- Gigabit Digital Subscriber Line (GDSL), based on binder MIMO technologies.[11]
- Universal High bit rate Digital Subscriber Line (UHDSL) using fiber optics. Developed in 2005 by RLH Industries, Inc. Converts HDSL-1, 2 or 4 copper service into fiber optic HDSL service.
- Internet Protocol Subscriber Line (IPSL), developed by Rim Semiconductor in 2007, allowed for 40 Mbit/s using 26 AWG copper telephone wire at a 5,500 ft (1,700 m) radius, 26 Mbit/s at a 6,000 ft (1,800 m) radius. The company operated until2008.

3.11 Digital Subscriber line (DSL) Modem

A digital subscriber line (DSL) modem is a device used to connect a computer or router to a telephone line which provides the digital subscriber line service for connectivity to the Internet, which is often called DSL broadband.

The term DSL modem is technically used to describe a modem which connects to a single computer, through a USB port or is installed in a computer PCI slot. The more common DSL router which combines the function of a DSL modem and a home router, is a standalone device which can be connected to multiple computers through multiple Ethernet ports or an integral wireless access point. Also called a residential gateway, a DSL router usually manages the connection and sharing of the DSL service in a home or small office network.

DSL Modem usually has a series of LED status lights which show the status of parts of the DSL communication link:

- Power light - indicates that the modem is turned on and has power.
- Ethernet lights - There is usually a light over each Ethernet jack. A steady (or sometimes flashing) light indicates that the Ethernet link to that computer or device is functioning
- DSL light - a steady light indicates that the modem has established contact with the equipment in the local telephone exchange (DSLAM) so the DSL link over the telephone line is functioning.
- Internet light - a steady light indicates that the IP address and DHCP protocol are initialized and working, so the system is connected to the Internet.
- Wireless light - only in wireless DSL modems, this indicates that the wireless network is initialized and working.

Many routers provide an internal web page to the local network for device configuration and status reporting. Most DSL routers are designed to be installed by the customer for which a CD or DVD containing an installation program is supplied. The program may also activate the DSL service. Upon powering the router it may take several minutes for the local network and DSL link to initialize, usually indicated by the status lights turning green.

Figure 3.17: Cisco DPC3000 CABLE Modem.

3.12 Multi Input Multi Output (MIMO) Wi-Fi System.

Multiple-input multiple-output (MIMO) in figure 2.7. Can extend the capabilities of the 3G and 4G systems to provide customers with increased data throughput for mobile high-speed data applications.

MIMO system use multiple antennas at both the transmitter and receiver to increase the capacity of the wireless channel. This leads higher spectral efficiency (more bits per second per hertz of bandwidth).

With **MIMO**, it may be possible to provide in excess of 1 Mbps for 2.5G wireless **TDMA EDGE** and as high as 20 Mbps for 4G system.

With **MIMO**, different signal are transmitted out of each antenna simultaneously in the same bandwidth and then separated at the receiver.

MIMO can support multiple independent channels in the same bandwidth, provide the multipath environment is rich enough.

This means that high capacities are theoretically possible, unless there is direct line-of-sight between the transmitter and receiver.

If the number of transmitting antennas is N, and the number of receiving antennas is M, this lead the Shannon limit on channel capacity C is:

$$C\,Z = \beta \log_2(1 + N * M * SNR0)$$

Where, SNR0 is the average signal-to-noise ratio at the receiver in signal input signal output system (SISO), and β is the bandwidth of the system.

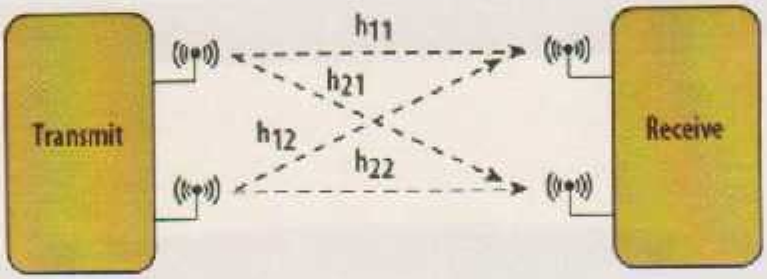


Figure 3.18: Multi Input Multi Output (MIMO) Wi-Fi System

3.13 Multi Input Multi Output (MIMO) Wi-Fi Router

Cisco Linksys E3000

A wireless-N router with simultaneous 2.4 and 5 GHz bands designed to increase bandwidth. Optimized for smoother and faster HD (high data rate) video streaming, file transfers, and wireless gaming. It contains three antennas, and it has four port, for Ethernet network and USB interface. Built-in AV media server streams entertainment content. The USB port provides connectivity to storage devices for file sharing at home or over the internet.

The router comes with 4 LAN ports and WAN port on the back. All are Gigabit-capable, meaning they support throughput up to 1,000Mbps on our 2.4GHz frequency tests, the router scores, as expected, weren't as high as those of the 5GHz frequency. It scored 43.5Mbps on the close-range throughput test and 33.6 Mbps on the long-range test. On the mixed-mode test, where the router was set to work with both N and legacy G wireless clients, it scored 44.4 Mbps.

The Linksys E3000 offers very good range, up to 280 feet in the 2.4 GHz band and about 250 feet with its 5 GHz bands. Both are long among high-end true dual-band routers.

Figure 3.19: MIMO Linksys E3000 router

In general Table 2.1 contains other specifications of MIMO Linksys E3000 shown in figure 3.19.

Data link Protocol	Ethernet, Gigabit Ethernet, IEEE 802.11a, IEEE 802.11b, IEEE 802.11n, IEEE 802.11g, Fast Ethernet
Data Transfer Rate	300 Mbps
Network /Transport Protocol	L2TP, PPTP, PPPOE
Encryption Algorithm	WPA2, WPA2-Enterprise, WPA-Enterprise, WPA
Antennas	3 Internal

Table 3.1: General Features of MIMO Linksys E3000 Router

3.14 VoIP Over IP (VoIP)

3.14.1 Definition of VoIP

Technology that allows telephone calls to be made over computer networks like the Internet. VoIP converts analog voice signals into digital data packets and supports real-time, two-way transmission of conversations using Internet Protocol (IP).

Adoption:

- Consumer market.
- PSTN and mobile network providers.
- Corporate use.

3.14.2 Protocols

Voice over IP has been implemented in various ways using both proprietary and open protocols and standards. Examples of the network protocols used to implement VoIP include:

- H.323
- Media Gateway Control Protocol (MGCP).
- Session Initiation Protocol (SIP).
- Real-time Transport Protocol (RTP).
- Session Description Protocol (SDP).
- Inter-Asterisk eXchange (IAX).
- Jingle XMPP VoIP extensions.

3.14.3 Advantages:

- Operational cost: VoIP can be a benefit for reducing communication and infrastructure costs.
- Portability.
- Mobility.
- Scalability.
- Features.
- Standardization.
- Easy to Use.
- Possibility of integrating sound and image technologies and data at the same time.

3.14.4 Challenges:

- Quality of service
- Susceptibility to power failure
- Emergency calls:
- Lack of redundancy
- Number portability
- PSTN integration
- Security
- Caller ID
- Compatibility with traditional analog telephone sets
- Fax handling
- Support for other telephony devices

3.15 Socket Programming

3.15.1 Definition

A socket is one of the most fundamental technologies of computer networking. Sockets allow applications to communicate using standard mechanisms built into network hardware and operating systems.

3.15.2 Point-to-Point Communication

A socket represents a single connection between exactly two pieces of software. More than two pieces of software can communicate in client/server or distributed systems.

Sockets are bidirectional, meaning that either side of the connection is capable of both sending and receiving data.

3.15.3 Interface Types

Socket interfaces can be divided into three categories. Perhaps the most commonly-used type:

1- The stream

2-Datagram sockets

3 -Raw socket.

3.15.4 Addresses and Ports

Sockets are typically used in conjunction with the Internet protocols (IP), Transmission Control Protocol (TCP), and User Datagram Protocol (UDP). Libraries implementing sockets for Internet Protocol use TCP for streams, UDP for data grams, and IP itself for raw sockets. [18].

3.16 System Software

3.16.1 Introduction

A programming language is an artificial language designed to communicate instructions to a machine, particularly a computer. Programming languages can be used to create programs that control the behavior of a machine and/or to express algorithms precisely. There are a lot of programming language that is used to build out a computer program, where choosing any language depends on the tasks of the program. In this project 3G-GSM Modems configured by a code called (AT Commands) this code has written in a programming language called Visual Basic 6.0 (VB6), and my project need C#, Matlab.

3.16.2 Visual Basic 6.0 (VB6)

Visual Basic is designed to be relatively easy to learn and use. Visual Basic was derived from BASIC and enables the rapid application development (RAD) of graphical user interface (GUI) applications.

Visual Basic 6.0 was the final edition of the software. This version improved the productivity and ability for web applications, which led to the development of Visual Basic .NET. Visual Basic 6.0 cannot be developed on Windows Vista, Windows 7 or Windows Server 2008. Microsoft ceased mainstream support in 2005, and all support in 2008. VB6 is very easier to learn VB6 was interpreter based language.VB6 used Active service page (ASP) to build web applications. In this project, visual basic will be used for configuration modem.

3.16.3 Visual Studio (C#)

C# is a simple, modern, object-oriented, and type-safe programming language that combines the high productivity of rapid application development languages with the raw power of C and C++. The C# Programming Language is the definitive technical reference for C#. Moving beyond the online documentation, reference materials, and code samples from the C# design team. Next follows a detailed and complete technical specification of the C# 1.0 language, as delivered in Visual Studio .NET 2002 and 2003. Topics covered include Lexical Structure, Types, Variables, Conversions, Expressions, Statements, Namespaces, Exceptions, Attributes, and Unsafe Code.The second part of the book provides an introduction to and technical specification of the four major new features of C# 2.0: Generics, Anonymous Methods, Iterators, and Partial Types. Reference tabs and an exhaustive print index allow readers to easily navigate the text and quickly find the topics that interest them most. An enhanced online index allows readers to quickly and easily search the entire text for specific topics. With the recent acceptance of C# as a standard by both the International Organization for Standardization (ISO) and ECMA, understanding the C# specification has become critical. The C# Programming Language is the definitive reference for programmers who want to acquire an in-depth knowledge of C#.

3.16.4 Matlab

MATLAB (matrix laboratory) is a numerical computing environment and fourth-generation programming language. Developed by Math Works, MATLAB allows matrix manipulations, plotting of functions and data, implementation of algorithms, creation of user interfaces, and interfacing with programs written in other languages, including C, C++, Java, and FORTRAN.

Chapter Four

Hardware System Design

4.1 General System Operations

This chapter explains in details the Tele-Controlled Microscope design, and final schematic diagram for the system. An overall block diagram of the system is shown in figure 4.1.

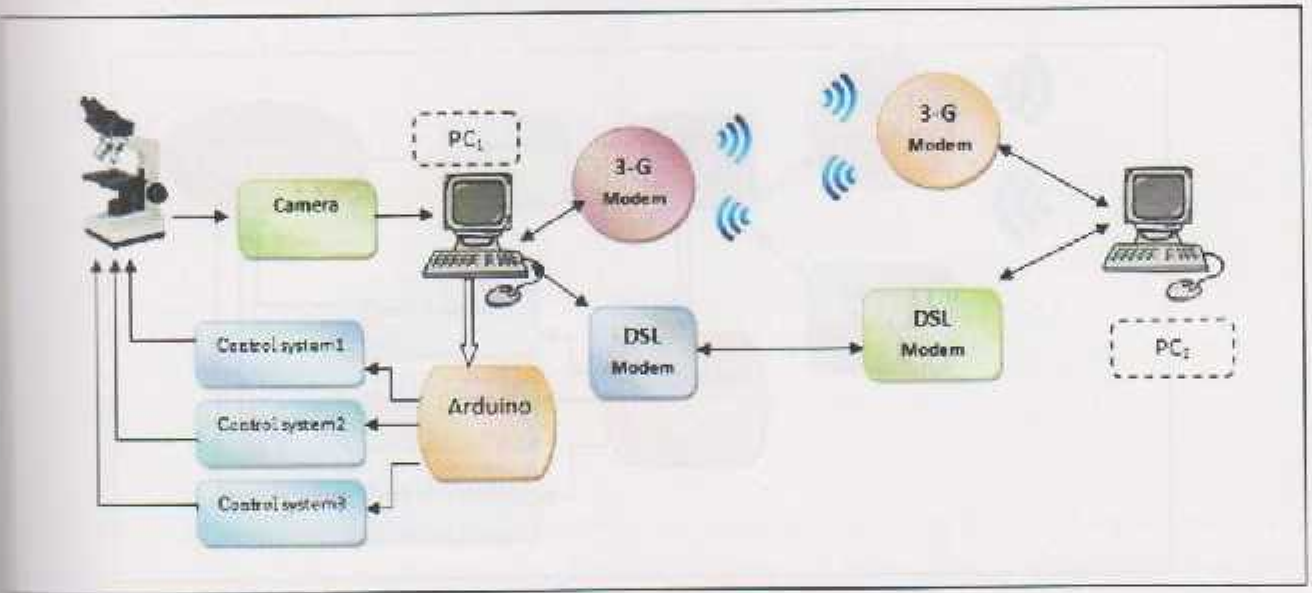


Figure 4.1: System Block Diagram

The system consists of two parts, microscope unit and doctor's unit. The microscope unit consists of microscope, camera, Motors, PC_1, 3G-GSM Modem, microcontroller and energy source. The doctor's unit consists of PC_2, 3G-GSM Modem and wired network.

In microscope unit, a camera takes the video from microscope and transfers it to PC1, then the PC1 sends the video to the doctors unit by 3G-GSM modem or wired network, the doctor can see the transmitted video via PC2 in the doctors unit, additionally, the doctor can control the video and microscope stages via PC2 keyboard, the doctor commands will be sent by the 3G-GSM Modem or wired network, PC1 in the microscope unit receives the commands and transfers them to the microcontroller. These commands are processed by the microcontroller to activate the associated motors in the required direction. The following sections talk about main components of the system.

4.2 Microscope Unit

When the doctor send commands to the microscope unit, the camera records video from the microscope and passes it to PC_1, then PC_1 converts the video to many frames by MATLAB program to become a modem capable of receiving and sending it as shown in figure 4.2.

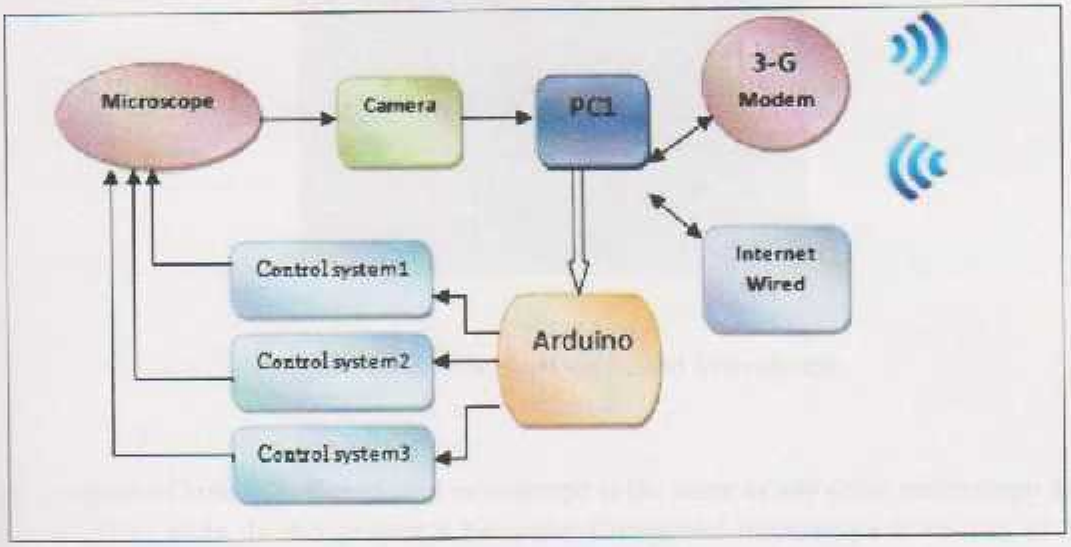


Figure 4.2: Microscope Unit Block Diagram.

Finally, in microscope unit, if the doctor resides within the patient's country; the video will be sent wireless by 3-G Modem. Then, if the doctor resides outside the patient's country; the video will be sent wired by internet.

4.2.1 Binocular Compound Microscope

A binocular Compound microscope, shown in figure 4.3, sis a light microscope that is adapted to the use of both eyes. It is a compound microscope that has two eyepieces used to view down one optical channel and objective lens.

Figure 4.3: Binocular Compound Microscope

The purpose of binocular Compound microscope is the same as any other microscope to zoom in a specific item or slide. In this project a binocular Compound microscope is chosen as it has the important features required in the project; a suitable digital camera adaptor can be added to the microscope by simply removing one of the eyepieces. Additionally, the mechanical stage of the microscope contains separate knops for lateral movements of the specimen slide in both the X (right and left) and Y (back and backward) directions, and axial movement in Z direction (Up and Down); in this project the mentioned knops are connected to the DC-Motors (described in section3.3) and controlled electrically. Furthermore, the microscope price is relatively acceptable.

4.2.2 Gear DC-Motors

The main task of the motor is to convert the electrical energy to mechanical energy required to move the microscope stages.

The DC-Motor speed can be controlled with high accuracy and efficiency, and can be reduced to any desirable level using the correct combination of gears in a gear motor, decreasing the speed is accomplished by increasing torque. In this project a low speed, relatively high torque motor is required to move the microscope stages. Hence, the Gear-DC Motors are used in this project. Furthermore, programming it is relatively simple and its cost is relatively low.

In this project two types of geared DC-Motors are used in order to control the movement of the microscope stage in the six directions, up, down, left, right, forward and backward. HV155 DC-Motor, shown in figure4.4 (A), does not provide large torque. Hence two motors of type HV155 are used for the direction left, right, forward and backward. 455A722 DC-Motor, shown in figure4.4 (B), provides relatively higher torque, as a result, it is used for moving the stage up and down.

Figure 4.4: A) HV155 Gear DC-Motor B) 455A722 12V Gear DC-Motor

The specifications of gear DC-Motors HV155 is:

1- Core Construction is Iron Core
2- Current Rating is 440 mA
3- Length is 67.5mm
4- Maximum Output Torque is 25 Ncm
5- Output Speed 62 rpm
6- Power Rating is 7.2 W
7- Shaft Diameter is 4mm
8- Supply Voltage is 12v DC
9- Width is 30mm

For more details see Appendix A

4.2.3 Microcontroller (Arduino)

In this project Arduino Mega 2560 is used (appendix B) for programming the three DC-Motors because as it has several important features such as extra digital pins, PWM pins, analog inputs, serial ports.

The Arduino Mega 2560, shown in figure 4.5, is a microcontroller board based on the ATmega2560. It has 54 digital input/output pins (of which 15 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), 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 an AC-to-DC adapter or battery to get started. The operating voltage is 5volts.

Figure 4.5: Arduino Mega Microcontroller Chip.

4.2.4 Digital Camera

In this project t a MEM1300 digital camera, shown in figure 4.6, is chosen (appendix C). It has a 1.3 megapixel. It is professionally designed for microscope, where it can be connected to microscope eyepiece tube.

Figure 4.6: MEM1300 digital camera

MEM1300 captures stills photos of 1280*1024 pixel and video clips of 640*480 pixel. The special design of IC Board enables MEM1300 offer true color and bright image, and with advanced imaging software, excellent microscopy reports can be created by setting density, contrast, saturation, sharpness and exposing time. MEM1300 keeps the balance between resolution and transmitting rate. It is provided with USB connector which enable the user to plug it in to computer, and software that allows viewing a live microscope image on the computer.

4.2.5 3-G GSM Modem

In this project the HSDPA 3G-Modem is used because it works at frequency 900/1800MHz in the GSM, and the Rate Downlink up to 7.2Mbps on it and UMTS capable networks Uplink up to 384Kbps, EDGE data up to 236.8Kbps and Driver Automatically install driver, no CD required, SD Built-in Micro SD memory up to 4G, as shown in figure 4.7.

Figure 4.7: HSDPA 3G-Modem.

Data Supports Data functions:

- Op Sys Supports Microsoft Windows 2000/XP/Vista/7.
- Interface USB 2.0 interface.
- Antenna High performance internal antenna.
- Slot SIM card slot and built-in micro SD memory expansion slot.

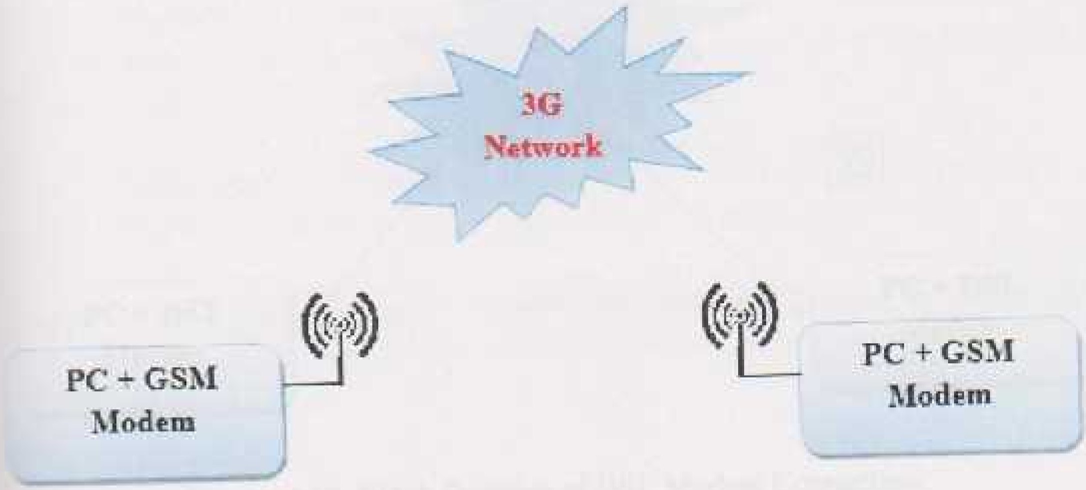


Figure 4.8: Block Diagram of GSM Modem Connection

4.2.6 DSL Modem

In this project the Cisco DPC3000 CABLE modem is used, shown in figure 4.8, because it is one of the best types of DSL modem and does not have any cutting in Information.

The specification of DPC3000 CABLE modem is:

1- Interface type USB or Fast Ethernet.
1 x USB - 4 pin USB Type B.
1 x Network - Ethernet 10Base-T/100Base-TX - RJ-45.
2- Connectivity Technology is wire.
3- Compliant Standards UL 1950, FCC Part 15 B
4- Power Device Power adapter – External.
5- OS Required Microsoft Windows 98SE/2000/ME/XP

Figure 4.9: Cisco DPC3000 cable Modem

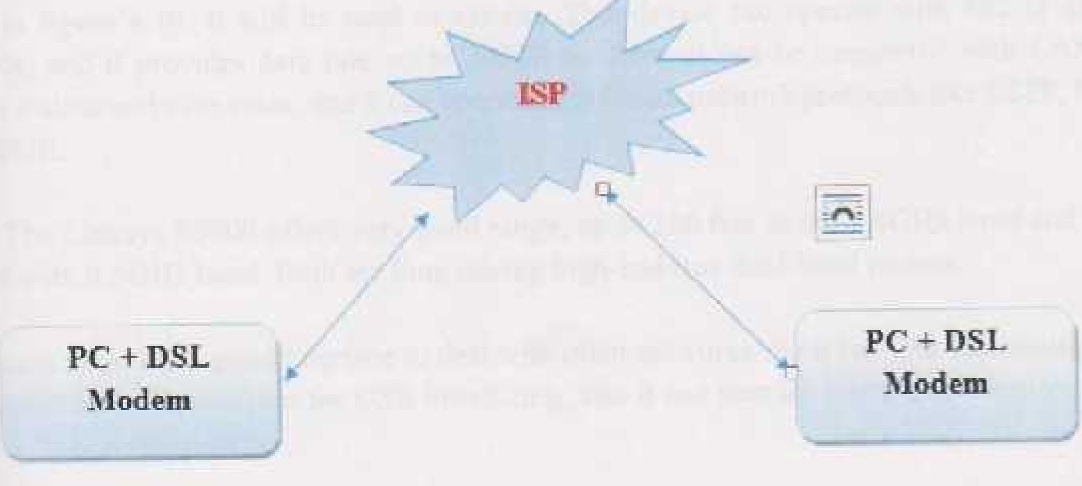


Figure 4.10: Block Diagram of DSL Modem Connection

4.2.7 MIMO Device

4.2.7.1 CISCO Link Sys E3000 MIMO Device

This section discusses how the MIMO transceiver device works in the system, and the way to connect this device other device. In this system the MIMO transceiver is operating at 2.4 GHz frequency, and it used 802.11n to transmit and receive data which provide 300Mbps, and this device contain with 3 antennas for transmitter and 3 antennas for receiver.

The MIMO transceiver connect with microcontroller in serial, and it also takes the data from the microcontroller after processing it to transmit by 802.11n standard to the receiver throughout MIMO Wi-Fi access point, as shown in figure 4.10.

Figure 4.11 :Block Diagram of MIMO Wi-Fi Devices Connection

The chosen MIMO device is CISCO link Sys E3000. It is a MIMO access point device as shown in figure 4.10. It will be used in system. This device can operate with 802.11 a/b/g/n standards, and it provides data rate up to 300Mbps. Also, it can be connected with LAN and wireless station and vice versa, and it can operate at different network protocols like L2TP, PPTP, and PPPOE.

The Linksys E3000 offers very good range, up to 280 feet in the 2.4GHz band and about 250 feet with it 5GHz band. Both are long among high-end true dual-band routers.

This access point has a good interface to deal with other networks. So it has four interfacing port for Ethernet network, one port for USB interfacing, also it one port for internet connection.

Figure 4.12: CISCO Linksys E3000 Device

4.2.7.2 Access point

The access point is an important component in this system, especially on MIMO scenario. It lies between MIMO transmitter and MIMO receiver, so that the data in this scenario must go through to this device. The main function of the access point in MIMO system is receive to datagram MIMO transmitter and broadcast it to other receiving Laptop, operating in the 802.11n mode.

4.3 Doctors unit

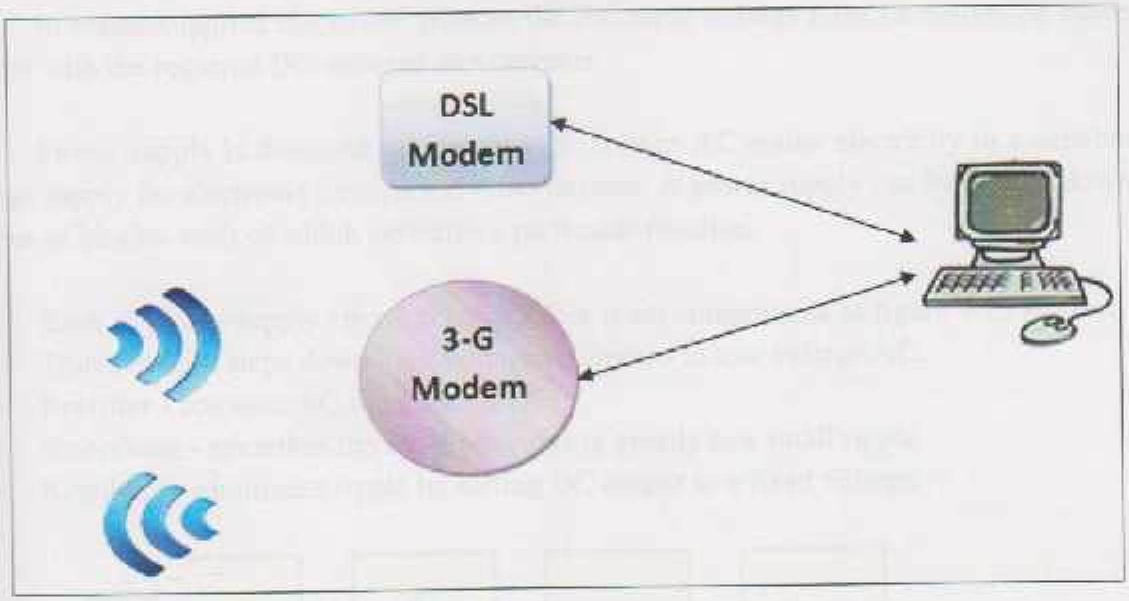


Figure 4.13: Doctors Unit

In doctor unit we have PC, DSL modem and 3G GSM modem and we talk about it in last section.

PC for send data and display the video, DSL modem to receive video and send command if the microscope unit and doctor unit in different country, and 3G GSM modem to receive video and send command if the microscope unit and doctor unit in the same country.

4.4 Power Supply

In mains-supplied electronic systems the AC input voltage must be converted into a DC voltage with the required DC voltages and currents.

Power supply is designed to convert high voltage AC mains electricity to a suitable low voltage supply for electronic circuits and other devices. A power supply can by broken down into a series of blocks, each of which performs a particular function.

Each of power supply circuit contain a four main components as figure 4.13 shown:

- Transformer - steps down high voltage AC mains to low voltage AC.
- Rectifier - converts AC to pulsating DC.
- Smoothing - smoothes the DC from varying greatly to a small ripple.
- Regulator - eliminates ripple by setting DC output to a fixed voltage.

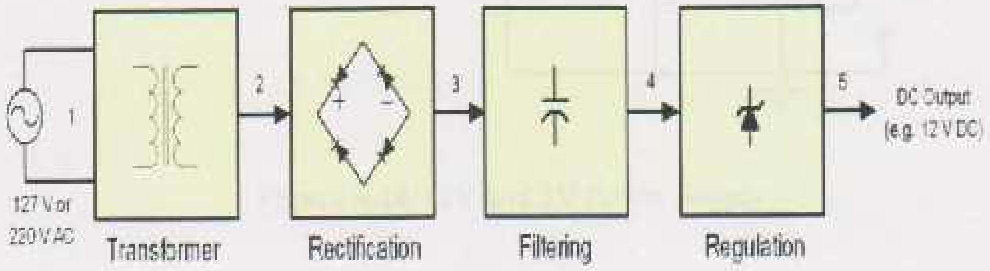


Figure 4.14: Power Supply Circuit

As shown in figure 4.14, output signal from each stage of power supply circuit.

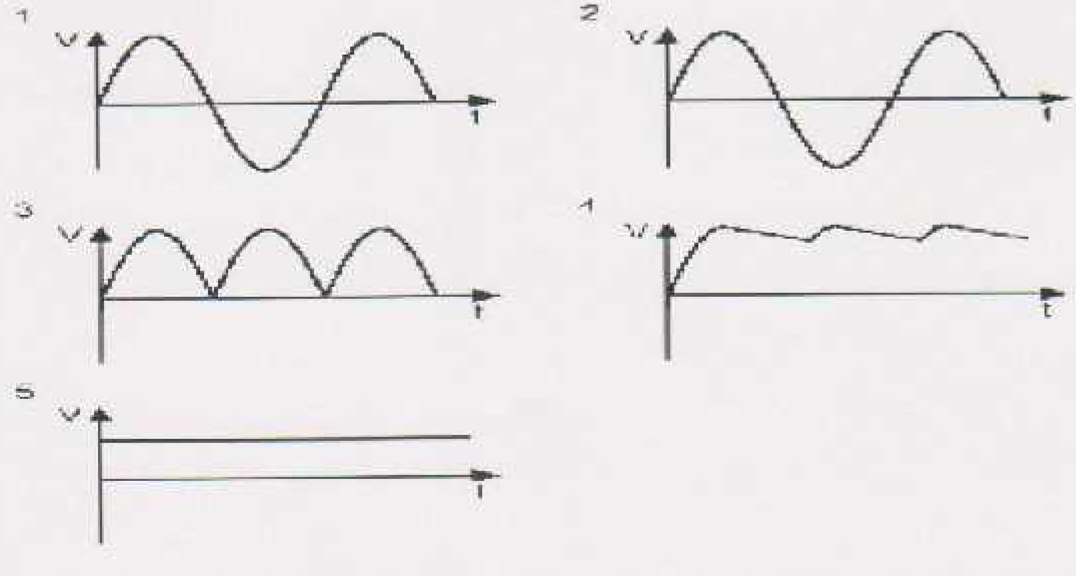


Figure 4.15: Output Signal from Each Main Component of Power Supply.

As the DC-gear motors implemented in the project required 12V and the microcontroller (Arduino) required 5V, a 12V & 5V power supplies are designed to fulfill the required power for the system components. Figure 4.14 depicts the circuit diagram of the designed power supply.

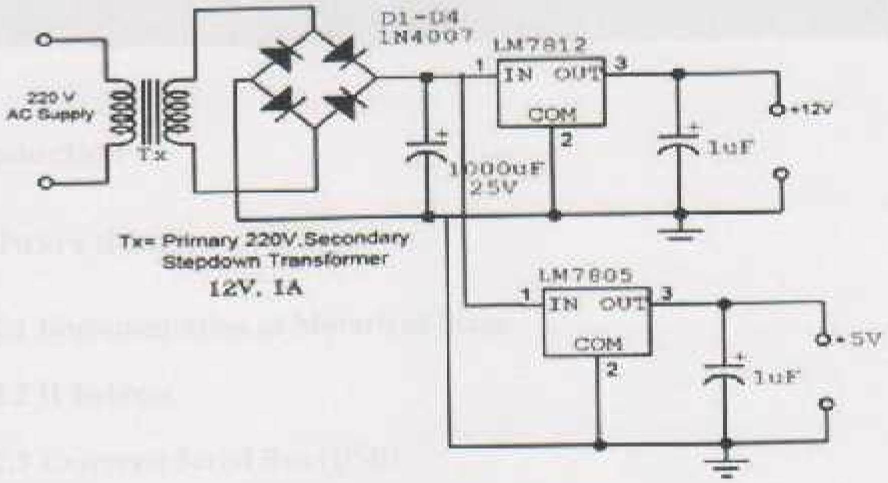


Figure 4.16:12V and 5V Power Supply

Chapter Five

Hardware and Software System Interfacing

5.1 Introduction

5.2 Hardware design

5.2.1 Implementation of Motorized Stage

5.2.2 H-Bridges

5.2.3 Universal Serial Bus (USB)

5.2.4 Ethernet Cable

5.2.5 Microcontroller Interfacing (Arduino)

5.2.6 Camera Interfacing

5.2.7 GSM Modem Interfacing

5.2.8 DSL Modem Interfacing

5.3 Software Design

5.3.1 Matlab Programming

5.3.2 C++ language

5.3.3 Visual Basic Studio 6 (C#)

5.1 Introduction

In the previous chapter a conceptual design was presented. In this chapter a hardware and software interface will be discussed.

5.2 Hardware design

This chapter provides a description of connections between hardware devices as shown in Figure 5.1.

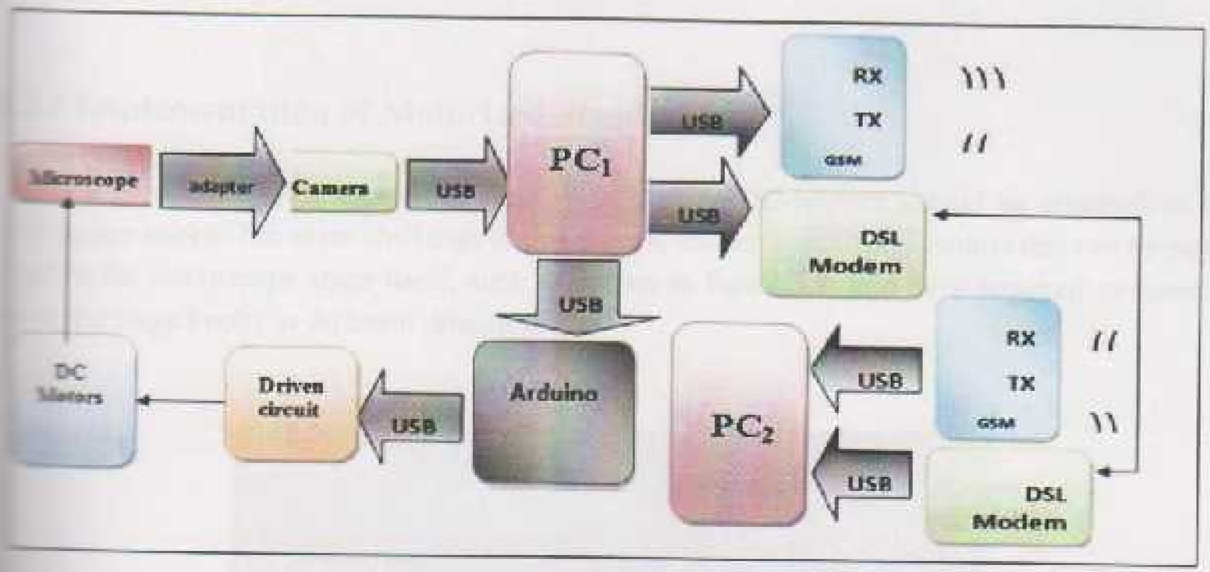


Figure 5.1: Hardware Design

In microscope unit, the connection between microscopes, gear DC-Motors, microcontroller and PC_1 shown in figure 5.2.

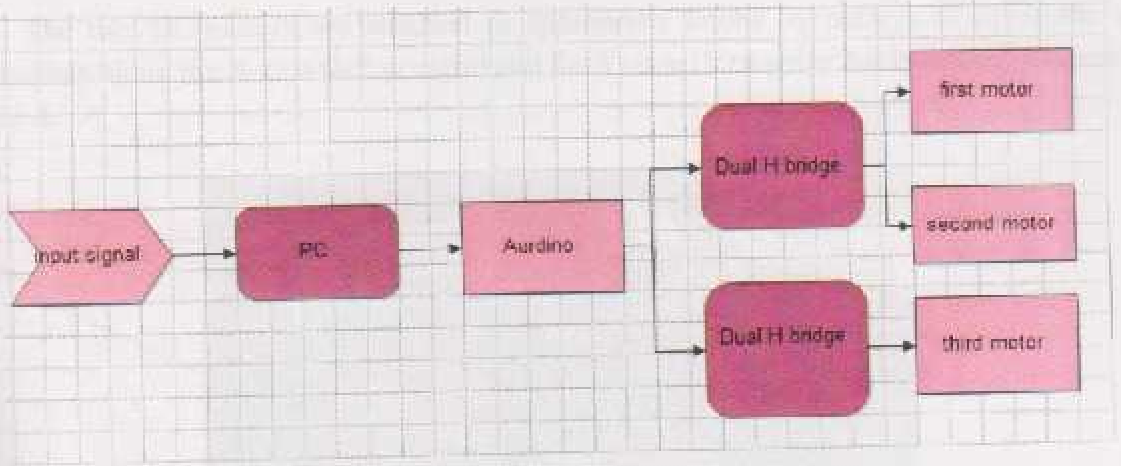


Figure 5.2: Control System Hardware Design

5.2.1 Implementation of Motorized Stage

To implement the motorized stage, a small size DC-Motors should be attached to the microscope knobs. The main challenge in this stage is chosen a small size motors that can be easily fixed in the microscope stage itself, such as shown in figure 5.3, and have required moment to move the stage knobs in different directions.

Figure 5.3: DC-Motors Fixed in the Microscope Stage

The two DC-motors are attached to appropriate knobs by pulleys to move the slide continuously along the X-axis (left or right) and the Y-axis (forward or backward) by as shown in figure 5.4.

Figure 5.4: Attaching Gear DC-Motors to Microscope knobs for XY direction

The third motor is fixed in the microscope arm in order to control the third direction (z movement) up and down. It is attached to the coaxial focusing knob as shown in figure5.5.

Figure 5.5: Connected Gear DC-Motor for Z Direction.

In order to avoid any pressure in the microscope knobs that may be created by motors when any one of the knobs reaches its track terminals, a micro-switch, shown in figure 5.6, is connected in the terminals of each knob track.

Figure 5.6: Micro limit Switches

A micro-switch is a simple switch that is turned on and off via a small lever that sticks out of the top. This switch would be placed at the end of an axes travel, and as soon as the stage will reach the upper or lower levels, it will change the corresponding micro switch case. Hence the supply voltage circuit will be opened.

5.2.2 H-Bridges

The H-bridge is a circuit used in electronic control of high current devices, particularly where the device polarity may be reversed, e.g. DC motors.

The H-Bridge is principally a configuration of 4 switches, which are switched in a specific manner to control the direction of the current through the DC motor. (For DC motors, the direction of rotation of the armature of the motor is changed by changing the direction of the current flowing through it).

A simplified diagram shown in figure 5.7 illustrates the operation of H-bridge configuration.

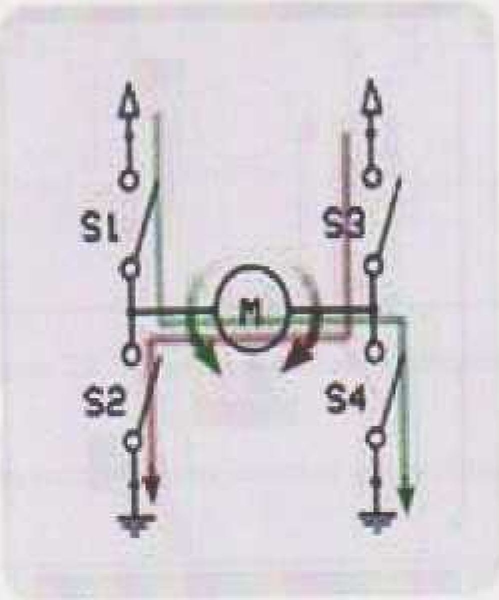


Figure 5.7: H-Bridge Principle of Operation

There are two possible paths for the current:

1) The red path, where the current is directed to the motor through the switches S_3 and S_2, causing the motor to turn clockwise.

2) The green path, where the current is directed to the motor through the switches S_1 and S_4, causing the motor to turn anti-clockwise.

The switches of the H-bridge can be replaced by appropriate transistors as shown in figure 5.8. Hence, allowing low current controller drive high energy motors, a pair of PNP transistors (or p-type MOSFETS) at the top and a pair of NPN (or n-type MOSFETS) at the bottom.

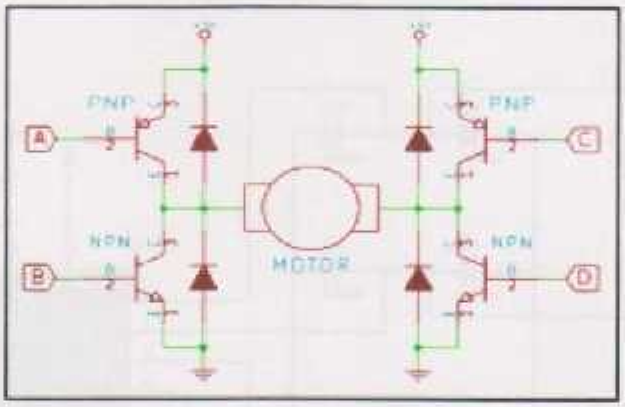


Figure 5.8: H Bridge with PNP Transistors

According to the transistors state, the motor direction will be determined as shown in table 5.1.

T1	T2	T3	T4	Motor direction
OFF	ON	OFF	ON	Clockwise
ON	OFF	ON	OFF	Counter Clockwise
OFF	OFF	OFF	OFF	Stop

Table 5.1 States of Transistors and Motor Behavior

The 298 dual-H-bridge driver is used .If we have a different motor supply voltage from our logic voltage we need drivers between the logic and the power transistors. There are a couple chips and they depend really on how powerful motors are to use one or both, both are dual H-bridge chips (so we can control 2 motors) as shown in figure5.9.

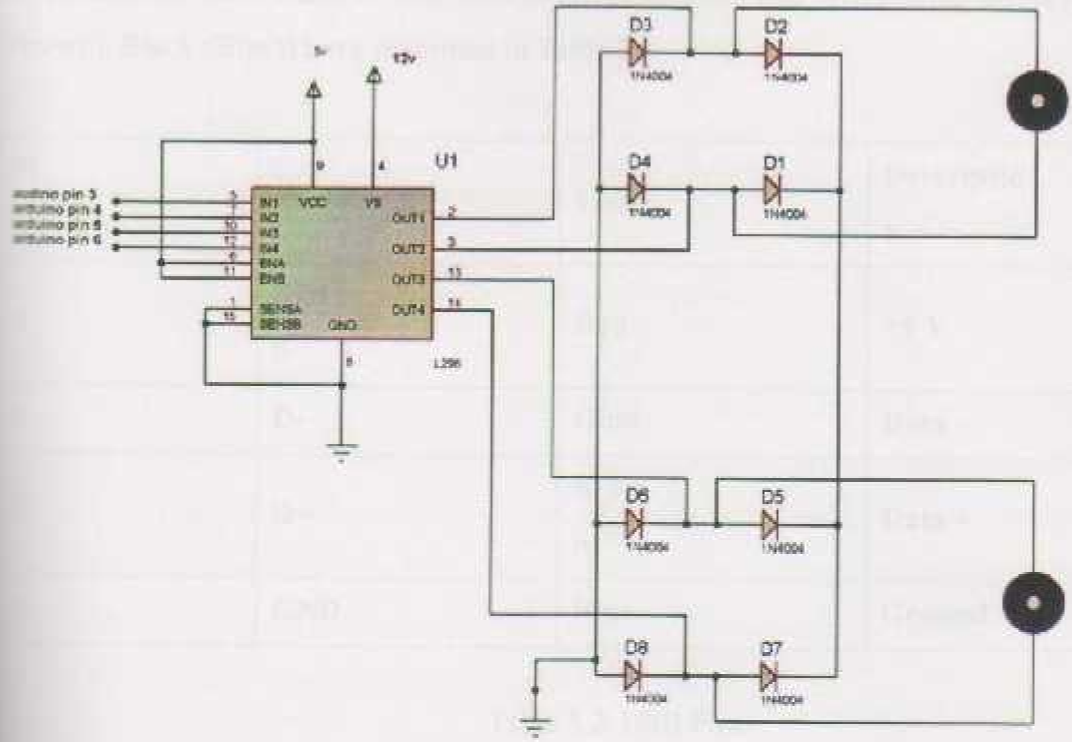


Figure 5.9: Dual H Bridge Connected with Motors.

5.2.3 Universal Serial Bus (USB)

USB was designed to standardize the connection of computer peripherals and defines the cables, connectors and communications protocols used in a bus for connection, communication and power supply between computers and electronic devices as shown in Figure 3.12.

Figure 5.10: USB Interface

The system needs USB to connect between the PC and the Arduino and connect between the PC and 3G GSM Modem. The USB interface consists four wires (Red, White (Gold), Green (Brown), Black (Blue)) have described in Table 3.1

[illegible]	Name	Color	Description
[illegible]	VBUS	Red	+5 V
[illegible]	D-	Gold	Data -
[illegible]	D+	Brown	Data +
[illegible]	GND	Blue	Ground

Table 5.2: USB Pins

They only send digital data, ones and zeroes. This is the PHYSICAL layer of USB communication. The data signals are D+ and D- , D- signal goes in one wire, to the other end, and back to the sender on the other wire. The receiver just notes which way the power was transmitting, forward or backward, to determine if it was a one or a zero. This way, 'noise' would influence both data lines at the same time and be ignored by the signal processor. The USB divides the available bandwidth into frames, and the host controls the frames. Frames contain 1,500 bytes, and a new frame starts every millisecond. During a frame, isochronous and interrupt devices get a slot so they are guaranteed the bandwidth they need. Bulk transfers use whatever space is left.

How is data sent across the USB?

When the software requires data transfer to occur between it and the USB, it sends a block of data called an I/O Request Packet (IRP) to the appropriate pipe, and the software is later notified when this request is completed successfully or terminated by error. Other than the presence of an IRP request, the pipe has no interaction with the USB. As suggested by the name Universal Serial

Thus, data transmission in the bus occurs in a serial form. Bytes of data are broken up and sent along the bus one bit at a time, with the least significant bit first as illustrated by Figure 3.13.

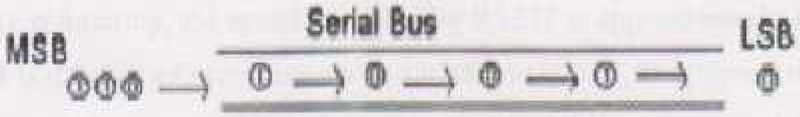


Figure 5.11: Serial Transmission of the Binary Sequence

An eight bit "SYNC" synchronization field is used by inputs to correct their timing for accepting data. Part of this field is a special symbol used to mark the start of a packet. The 8 bit Packet Identifier (PID) which uses 4 bits to determine the type, and hence format, of the packet data. The remaining 4 bits are a 1's complement of this, acting as check bits. Part of this field determines which of the four groups (token, data, handshake, and special) that the packet belongs to and also specifies an input, output or setup instruction.

This system used USB as interface between 3G GSM modem and PC, and interface between camera and PC not RS232 for many reasons:

- USB is intended as a high speed upward extensible fully standardized interface between 1 computing device using a single port and N peripherals using one port each with all control being accomplished by signals within the data stream.
- RS232 was intended as a 1:1 relatively low speed semi-standardized interface between 1 computing device and 1 peripheral per port with hardware control being an integral part of operation. In this project we use USB interface for the following reason.

The advantages for USB over RS232:

Availability:

The USB ports due to their compact size are usually present in the modern computers. A computer may possess two to eight USB ports. On the other hand RS232 ports are too bulky and consume more space than the USB.

2) Speed:

There is a large difference between the speeds of both ports. The RS232 transmits by sending single bit of data over every clock cycle. The rate of clock pulses ranges from 150 to 115200. Roughly estimating, the speed provided by RS232 is approximately 10Mbps for internet usage. The USB is capable of providing up to 480Mbps (USB 2.0) of speed which is much more than the former port. However, the speed provided by the USB is generally limited by the factors such as number of devices connected to the same bus and also on the speed of the host computer.

3) Power:

The USB port has an inbuilt power supply of 5 volts along with the signaling pins. The devices nowadays utilize 5 volt or less to operate. Thus, one does not need an external cord to power them, they can effectively use the power provided by the USB port. This makes the device more portable as one does not have to carry additional power cords with them.

4) Plug and play:

The devices working with the RS232 port has a command transfer phase to communicate with each other using UART. The computer does not know what type of device is been connected to it. The plug and play feature supported in USB port of computer. Through this feature, the computer can easily detect the device connected to it by some sort of drivers installed in computer or the device is configured to install its drivers automatically as it is connected to the computer.

Ethernet Cable

Ethernet cables are used to connect PC's and other electronic devices to networks, the internet and to each other. In this project, the connection between sending card and receiving card by one of the most common languages or protocols used with a LAN, it is the Ethernet. Is a physical and data link layer technology for local area networks (LANs). Ethernet uses a bus or star topology and supports data transfer rates of 10 Mbps. Later, "Fast Ethernet" standards increased the maximum data rate to 100 Mbps. Today, Gigabit Ethernet technology further extends peak performance up to 1000 Mbps. The Ethernet specification served as the basis for the IEEE 802.3 standard, and Ethernet uses the CSMA/CD access method to handle simultaneous demands. Ethernet use IP (Internet Protocol), data travels over Ethernet inside protocol units called frames.

The run length of individual Ethernet cables is limited to roughly 100 meters. The type of Ethernet used cable is Cat 5E – Enhanced Cat 5 cabling that helps to prevent cross-talk, works for 10/100Mb and 1000 Mb or Gigabit Ethernet.

Figure 5.12: Ethernet Cable

Inside the Ethernet cable, there are 8 colors coded wires. These wires are twisted into 4 pairs of wires; each pair has a common color theme. One wire in the pair being a solid or primarily solid colored wire, and the other being a primarily white wire with a colored stripe, finally a straight Ethernet cable used to connect PC to DSL Modem.

5.2.5 Interfacing Microcontroller (Arduino)

In this project, Arduino Mega 2560 microcontroller have been used to programming three DC gear motors, it is joint with PC_1 by USB.

The driven circuit have been connected to Arduino Mega 2560 microcontroller via digital and analog pins on the Arduino board which has 54 digital input/output pins (of which 15 can be used as PWM outputs), 16 analog inputs.

Description of the Arduino pins:

The power pins:

VIN. The input voltage to the Arduino 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.

2-GND. Ground pins.

Input and Output Pins:

Each of the 54 digital pins on the Mega can be used as an input or output .they operate at 3.3 volts ,and in this project the pins number(3,4) are used for the first motor, pins(5,6) for the second motor and pins (7,8) for third motor.

The open –source Arduino environment makes it easy to write code and upload it to the I/O board. It runs on Windows, Mac OS X, and Linux. The environment is written in C++ language.

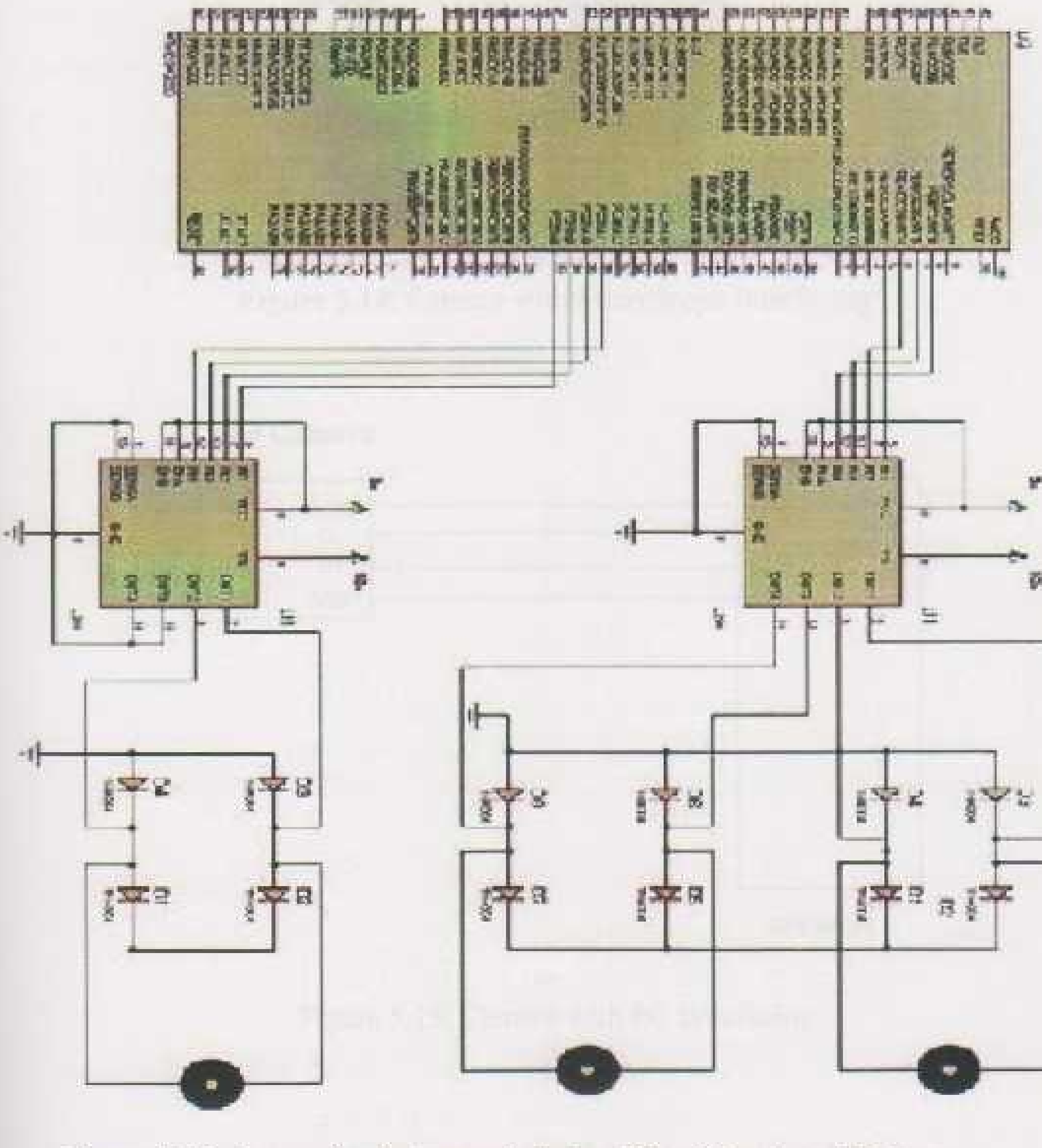


Figure 5.13: Connection between Arduino, Drive Circuit and Motors.

5.2.6 Camera interfacing

The camera linked with the eyepiece by special **adapter**, and connected to PC_1 using **USB** port as shown in figure 5.12. PC1 takes video from the camera, analyzes it and divides it into many frames using MATLAB software; these frames will be sent to the doctors unit by Modems.

Figure 5.14: Camera with Microscope Interfacing

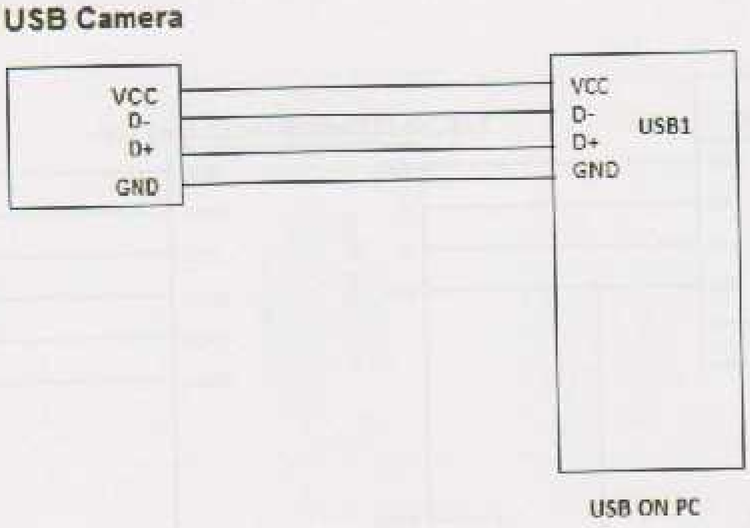


Figure 5.15: Camera with PC Interfacing

5.2.7 GSM Modem Interfacing

In this system, two GPRS modems have been used at the two sides. Figure 4.2 shows the Nokia internet stick CS-11 GPRS modem with the main input and output interfaces.

The sub-interfaces are:

- Power supply (5V/2A): 5 Pins one for Ground and four for BATT+.
- Charger interface: 5 Pins.
- SIM interface: 6 Pins are:
  1) CCIN: For knowing if there is a SIM Card in the holder or not.
  2) CCRST: For Reset
  3) CCIO: For Input /Output data.
  4) CCCLK: For control
  5) CCVCC: Supply 3V
  6) CCGND: For Ground.
- Serial interface USB: 4 Pins (VBUS 3V, D- , D+, GND).

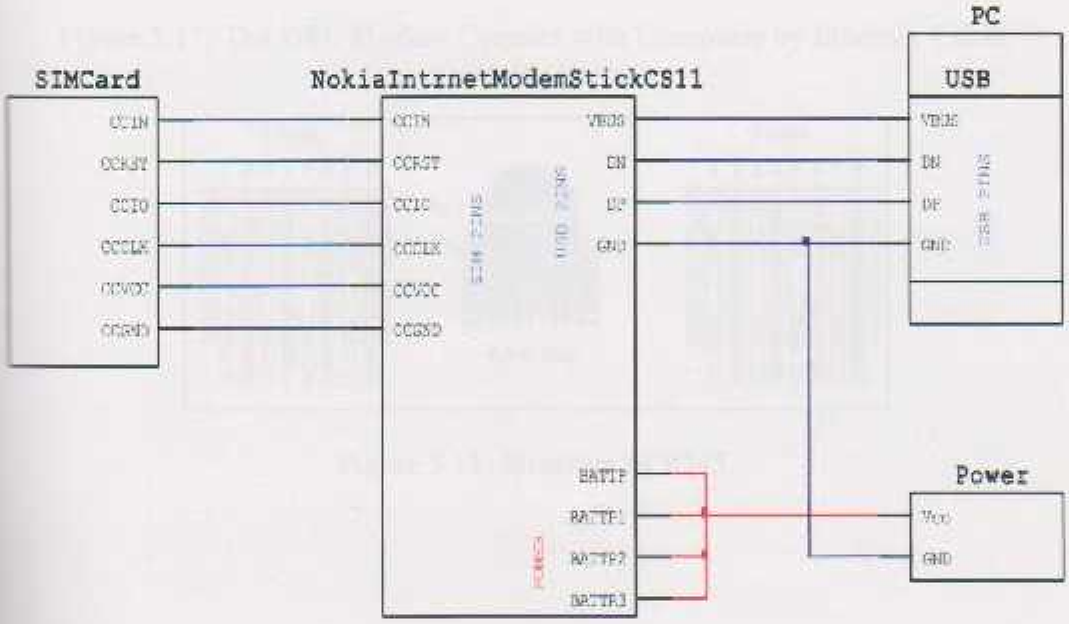


Figure 5.16: Interface GSM Modem

5.2.8 DSL modem interfacing

A DSL router consists of a box which has an **RJ11 jack** to connect to a standard subscriber telephone line. It has several **RJ45** jacks for Ethernet cables to connect it to computers or printers, creating a local network. It usually also has a **USB** jack which can be used to connect to computers via a USB cable, to allow connection to computers without an Ethernet port. A wireless DSL router also has antennas to allow it to act as a wireless access point, so computers can connect to it forming a wireless network. Power is usually supplied by a cord from a wall wart transformer. The figure 5.17 shows the DSL modem and how to link it with the computer by Ethernet Cable.

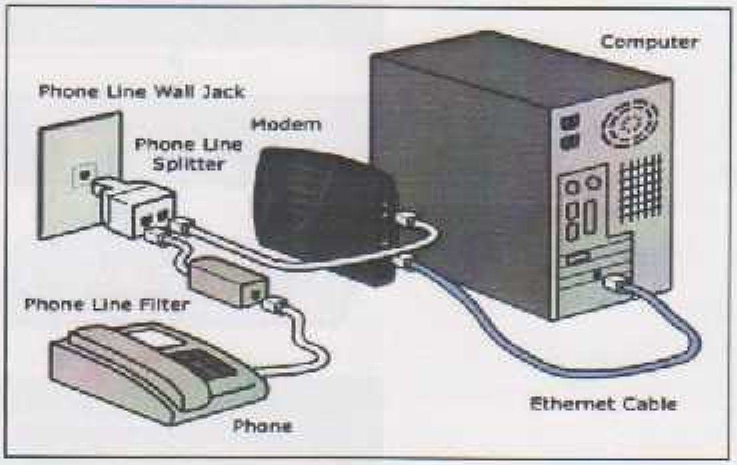


Figure 5.17: The DSL Modem Connect with Computer by Ethernet Cable.

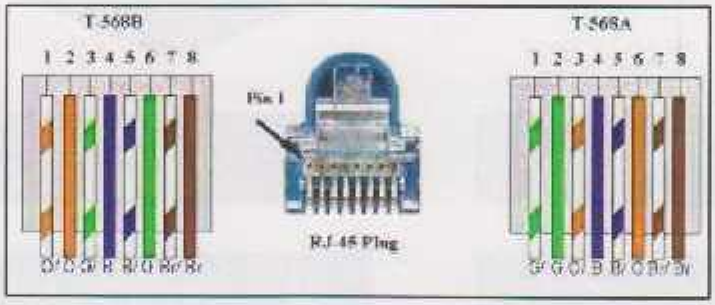
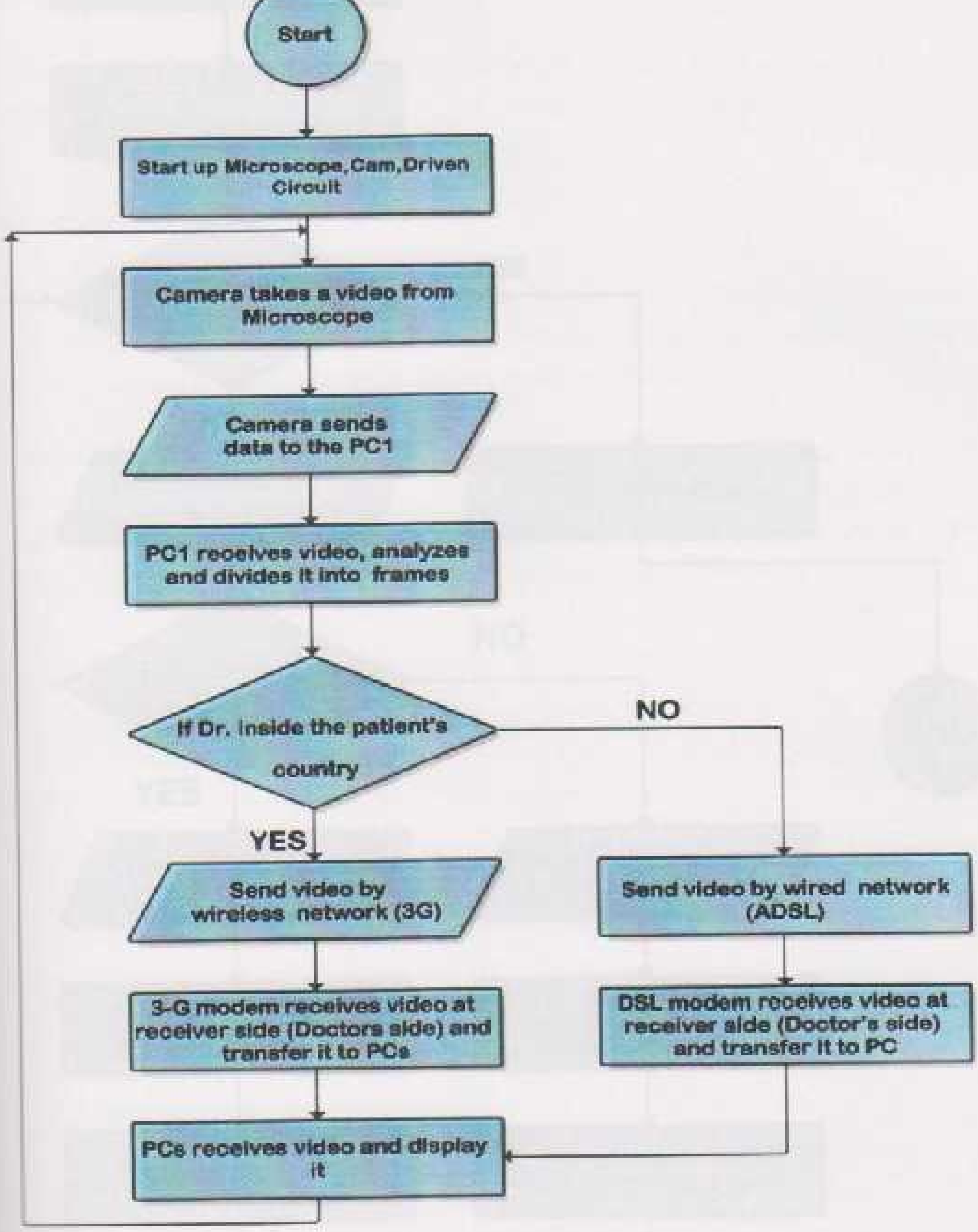
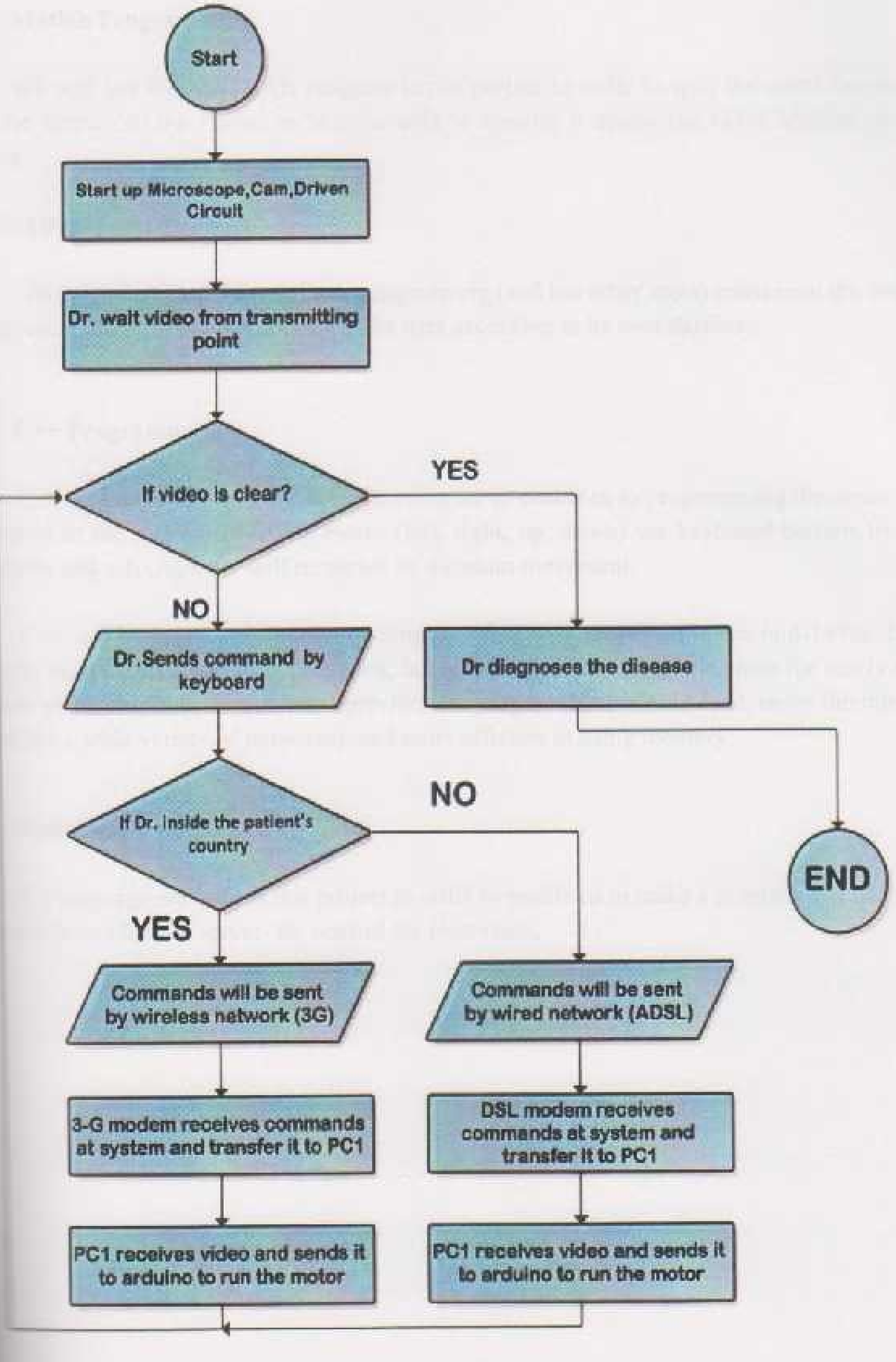


Figure 5.18: Structure of RJ45.

5.3 Software design

The following flow chart figure 5.19 summarizes the principle of operation of the system:




Start
Start up Microscope,Cam,Driven Circuit
Dr. wait video from transmitting point
If video is clear?
YES
NO
Dr.Sends command by keyboard
Dr diagnoses the disease
If Dr. inside the patient's country
NO
YES
END
Commands will be sent by wireless network (3G)
Commands will be sent by wired network (ADSL)
3-G modem receives commands at system and transfer it to PC1
DSL modem receives commands at system and transfer it to PC1
PC1 receives video and sends it to arduino to run the motor
PC1 receives video and sends it to arduino to run the motor

5.3.1 Matlab Programming

We will use the MATLAB program in our project in order to split the video that we get from the camera to the frame; to become able to transfer it across the GSM Modem or DSL Modem.

MATLAB program definition:

Program MATLAB is a software engineering (and has other areas) carries out the analysis and representation of data by processing the data according to its own database.

5.3.2 C++ Programming

C++ language are used in this project in order to enable us to programming the motor. Will we control in the movement of the motor (left, right, up, down) via keyboard buttons by C++ commands and ach character will represent be a certain movement.

C++ is a high-level programming language that was developed in the mid-1970s. It was originally used for writing UNIX programs, but is now used to write applications for nearly every available platform. Compared to most previous languages, C is easier to read, more flexible (can be used for a wide variety of purposes), and more efficient at using memory.

5.3.3 Visual basic studio 6 (C#)

C# language are used in this project in order to enable us to make a program that can sends command from client to server for control the motorized.

Chapter six

Software Design Implementation

6.1 Introduction

Software is an important part in any technological system. Operating and controlling any component in this project requires software handling.

This chapter explains the required software with detailed steps and procedures of programming every used component in this project.

It should be noted that most of the designed system has been programmed using the Arduino and MATLAP software.

6.2 Arduino Programming

When we connected the Arduino microcontroller to PC, then follow these steps to get successfully connection between Arduino and PC.

Downloading the Arduino software from Arduino Homepage as shown in figure 6.1.

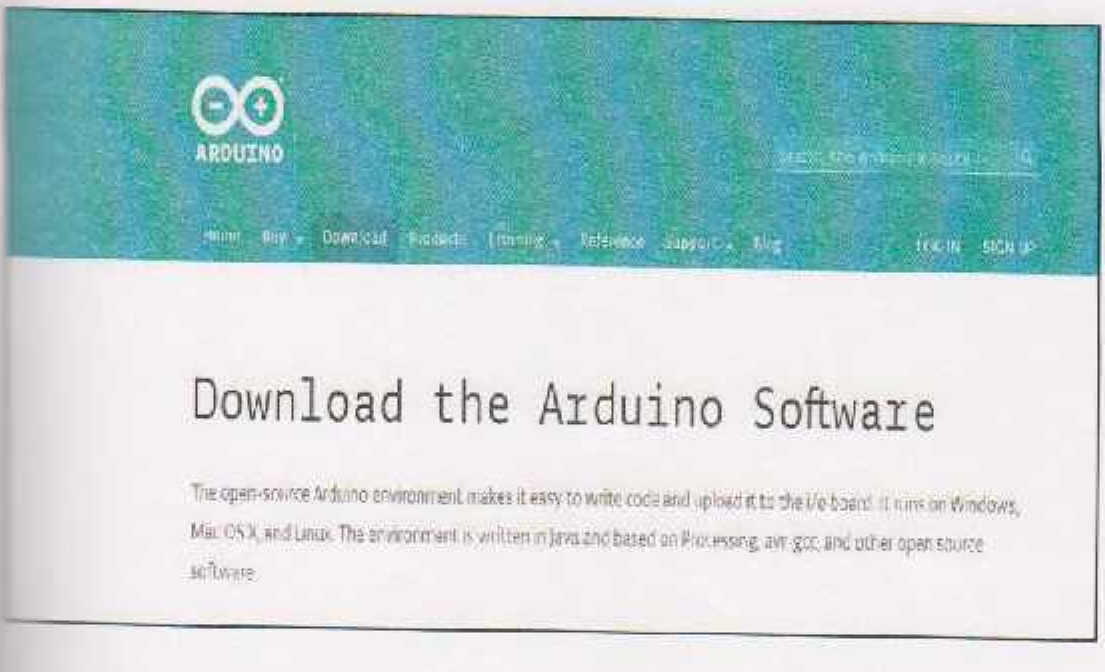


Figure6.1: Downloading the Arduino Software Homepage.

After downloading the Arduino software on PC, Then we double click on Arduino application to get the window as shown in figure 6.2.

Figure 6.2: Arduino program application.

Arduino programming steps:

1- First step: selecting Arduino board

Selecting the entry in the Tools >> Board >> menu that corresponds to the chosen Arduino. We choose the Arduino Mega 2560, as shown in figure 6.3.

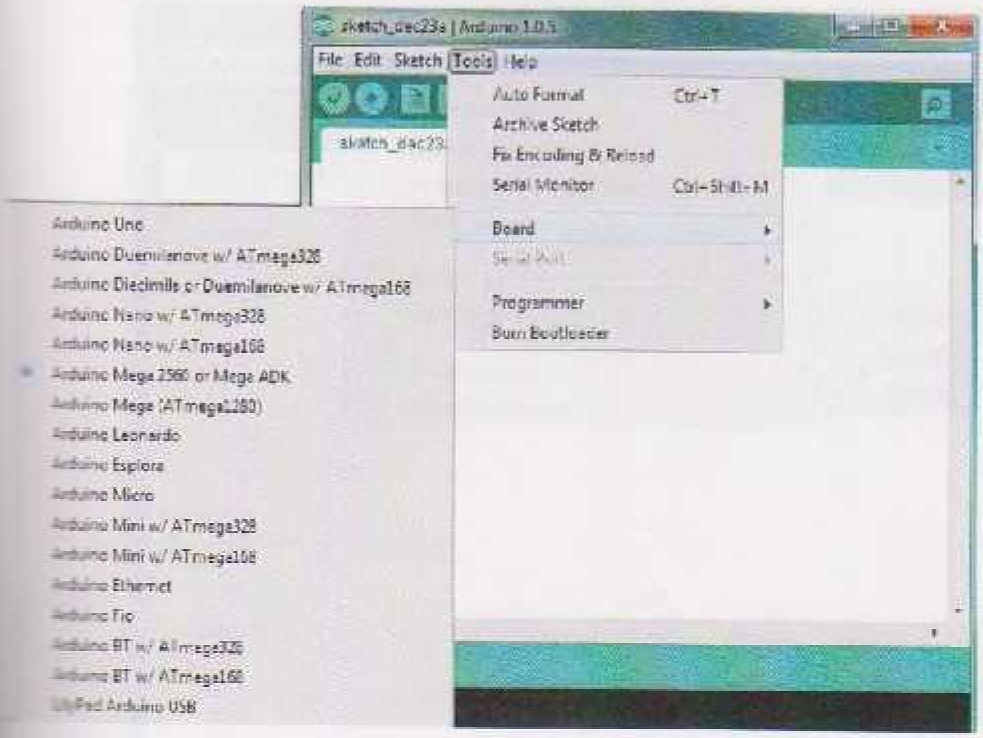


Figure 6.3: selecting Arduino board

2 – Second step: Selecting the Serial Port

The board communicates with the PC via a USB interface, but with a serial protocol .all this menus is that we must select the correct serial port number.

Selecting the serial device of the Arduino board is from Tools >> serial port menu .as shown in figure 6.4, COM3 serial port is selected in this project.

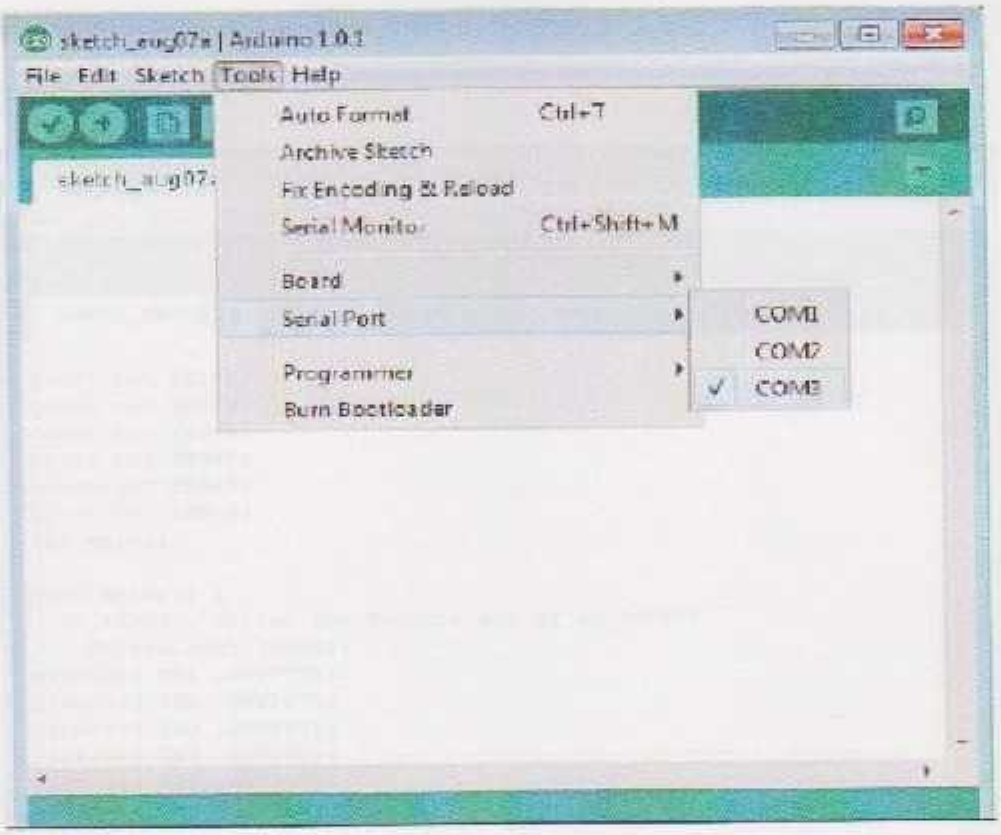


Figure 6.4: Selecting the Serial Port.

3 – Third step: writing the program as shown in figure 6.5.

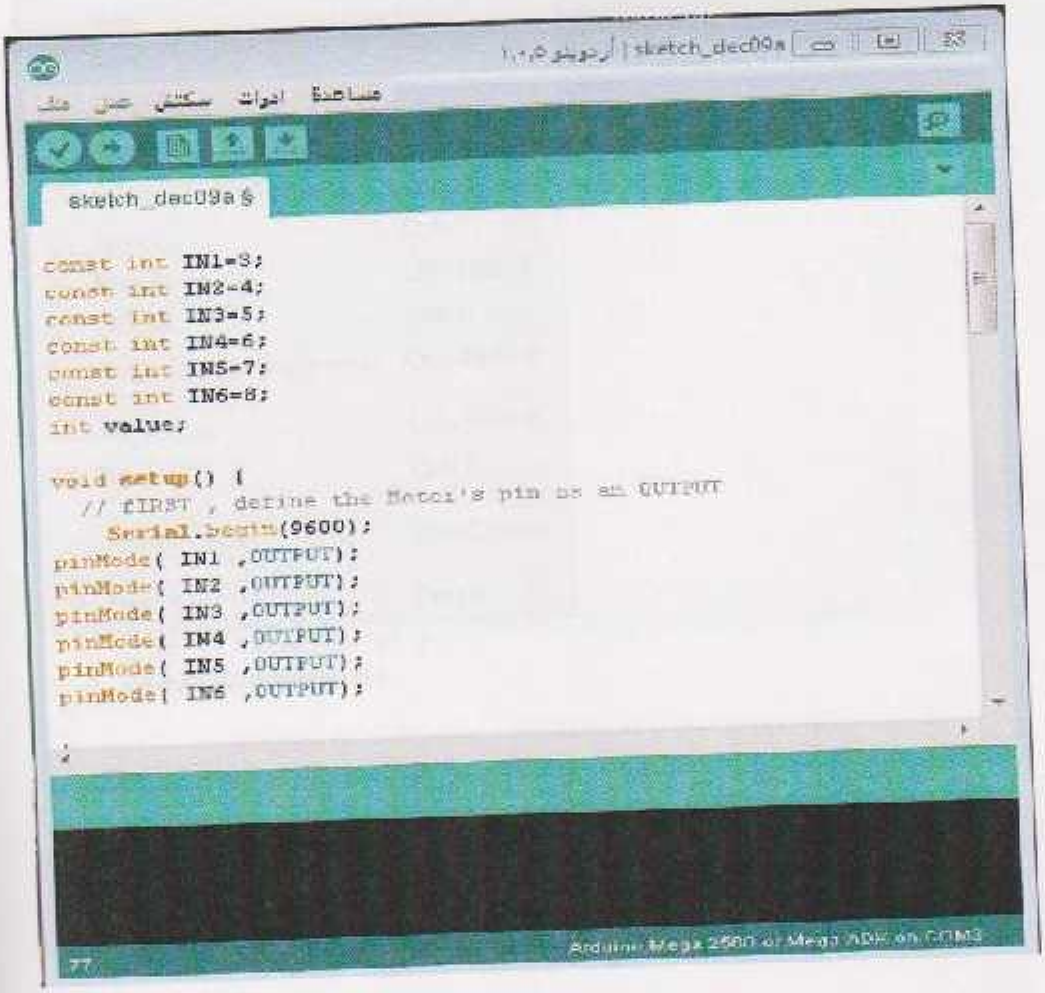


Figure 6.5: writing the program

4– Forth step: Uploading the program

After writing the program and compiling it uploading the code by selecting File >> Upload to I/O board as shown in figure 6.6. If the upload is successful, the message "Done uploading" will appear in the status bar.

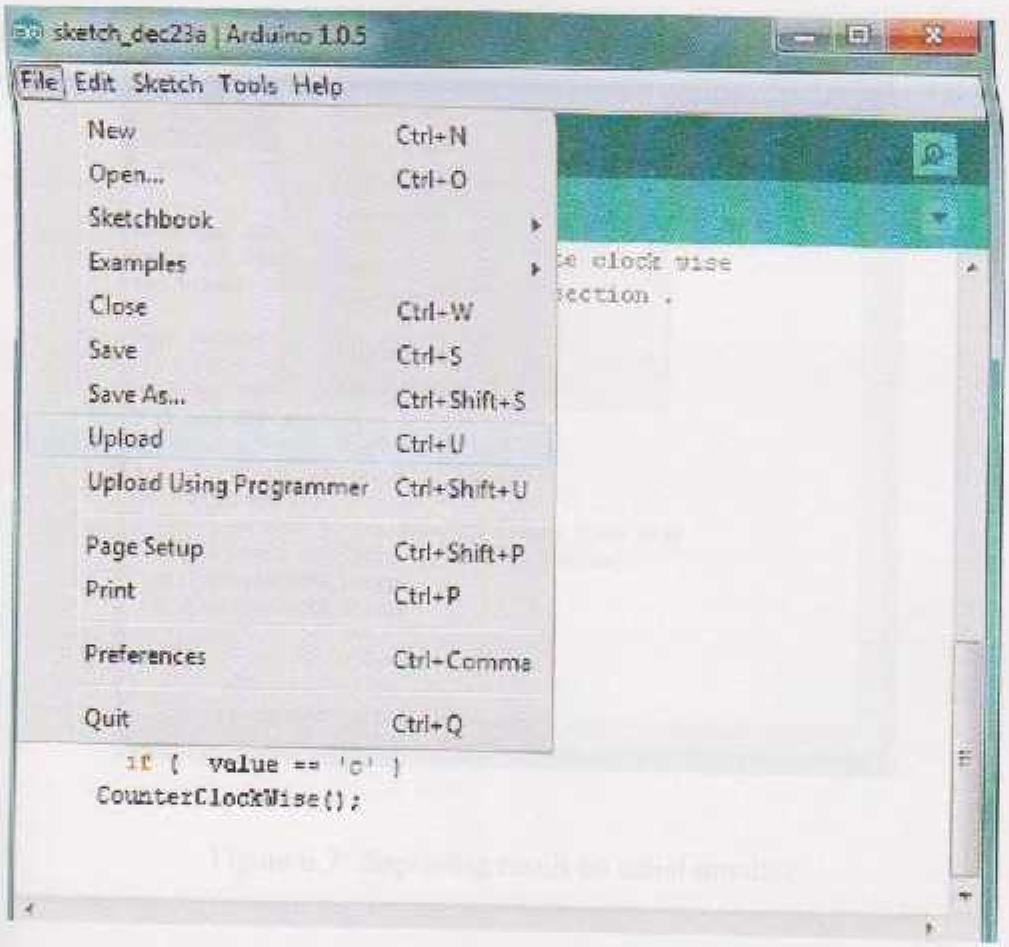


Figure 6.6: Uploading the program.

Sixth step: displaying result on serial monitor.

Result on the serial monitor is displaying by selecting Tools >>Serial monitor as shown figure 6.7

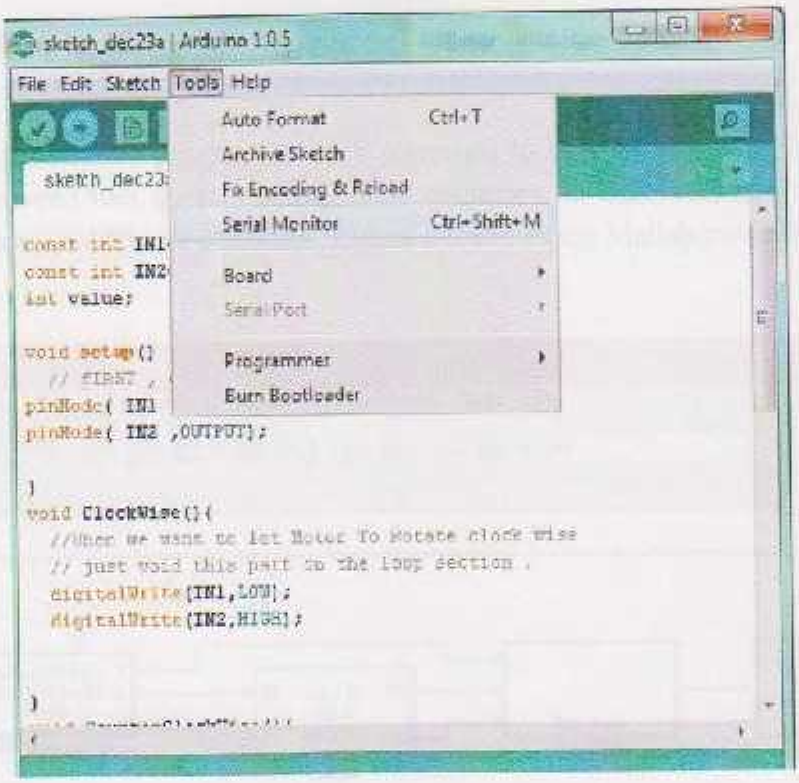


Figure 6.7: displaying result on serial monitor

Figure 6.8 shows the serial monitor on which the results are displayed to make sure that the code works properly.

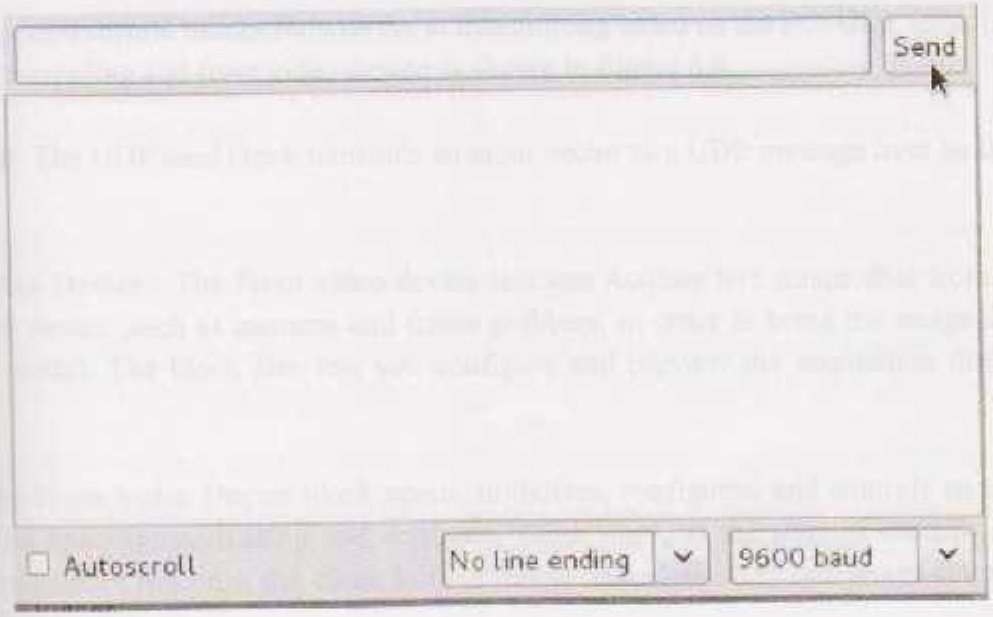


Figure 6.8: serial monitor.

6.3 Transferring video

We need the Matlab program in both scenarios to transfer video .in GSM scenario we transfer video between two doctors in the same countries, in DSL scenario we transfer video between two doctors in different countries. Figure 6.9 shows the Matlab program that transferring the video.

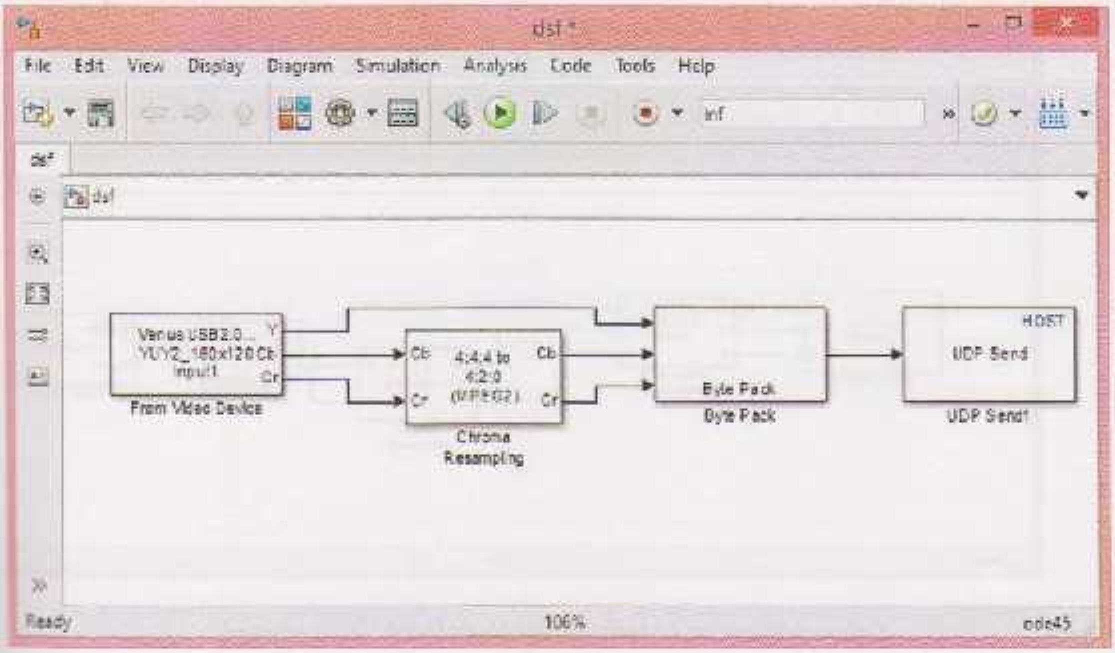


Figure 6.9: Matlab Program that transmitting the video.

We need several blocks for a server to transmitting video on the PC: UDP send, Byte pack, Chroma Resampling and from video device as shown in Figure 6.9.

UDP send: The UDP send block transmits an input vector as a UDP message over an IP network port.

From Video Device : The From video device lets you Acquire live image data from an image acquisition device ,such as cameras and frame grabbers, in order to bring the image data into a Simulink model. The block also lets you configure and preview the acquisition directly from Simulink.

The From Video Device block opens, initializes, configures, and controls an acquisition device. The opening, initializing and configure occur once, at the start of model's execution. During the model's run time, the block buffers image data, delivering one image frame for each simulation time step.

Chroma Resampling: The Chroma Resampling block down samples or up samples chrominance component of a pixel to reduce the bandwidth required for transmission or storage of a signal.

Byte Pack: Using the input port, the block converts data of one or more data type into single uint8 vector for output. With the options available, you specify the input data type and the alignment of the data in output vector. Because UDP messages are in uint8 data format, use this block before a UDP send block to format the data for transmission using the UDP protocol.

Figure 6.10 Shows the Matlab program, which receives the video in both scenarios, and display it one computer in monitoring room.

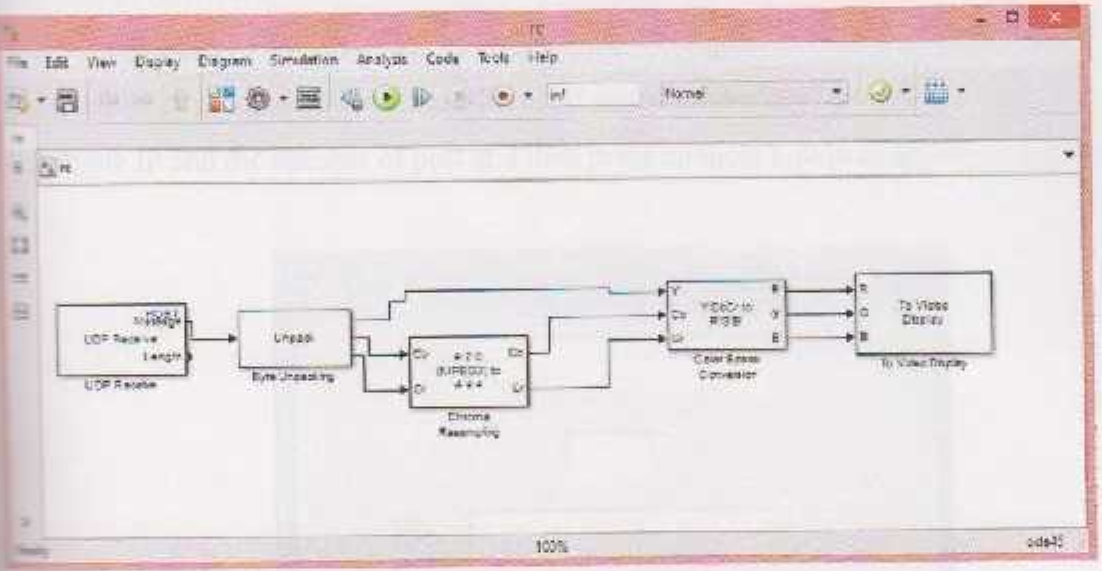


Figure 6.10: Matlab program that receives the video.

We need several blocks for a client to display the receiving the video on the PC: UDP receive, Byte unpacking, Chroma Resampling, Color Space Conversion and to Video Display as shown in Figure 6.10.

UDP Receive: The UDP Receive block receives UDP packets from in IP network and saves them in a buffer. With each sample, the block output emits the contents of a single UDP packet as a data vector.

Byte Unpacking: This block is the exact analog of the pack block. It can receive a vector of one of the following types: double, int8, unit8, int16, unit16, int32, unit32 and Boolean.

Chroma Resampling: The Chroma Resampling block down samples or up samples chrominance component of pixel to reduce the bandwidth required for transmission or storage of a signal.

Color Space Conversion: The Color Space Conversion block converts color information between color spaces .Use the conversion parameter to specify the color spaces you are converting between. Your choices are R'G'B' to Y'CbCr, Y'CbCr to R'G'B' ,R'G'B' to intensity ,R'G'B' to HSV, HSV to R'G'B' , sR'G'B' to XYZ , XYZ to sR'G'B', sR'G'B' to L*a*b* and L*a*b* to sR'G'B'.

To Video Display: The To Video Display block sends video data to your computer screen.

6.4 Program to Send Commands

This program use to send command from doctor side to the microscope to zoom controlling, this happen by use two program: Client Software and Sever Software.

6.4.1 Client Software

- Open the client application from Microsoft visual studio 2007 program.
- Fill the IP and the number of port and then press connect button as shown in Figure 6.11.

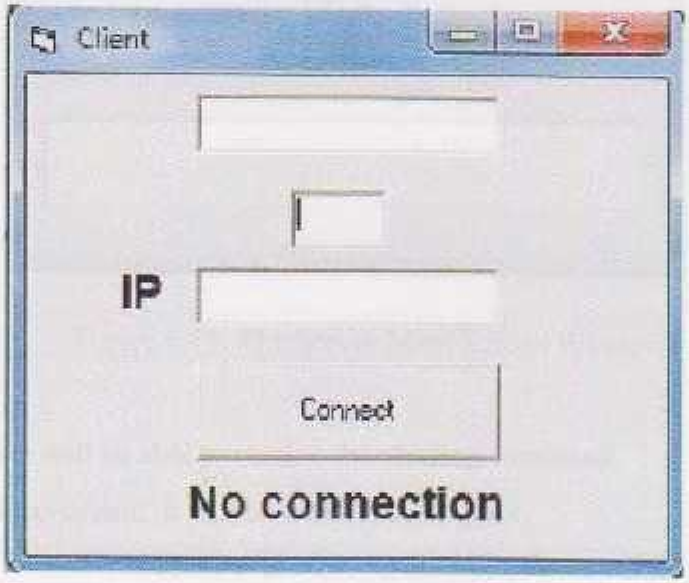


Figure 6.11: Connect Window.

- After enter the IP and port number, the application will enter to the main screen window.
- Transfer command that needed to send.

6.4.2 Server Software

- Open the server application from Microsoft visual studio 2007 program, the application will enter to the main screen window as shown in Figure 6.13.

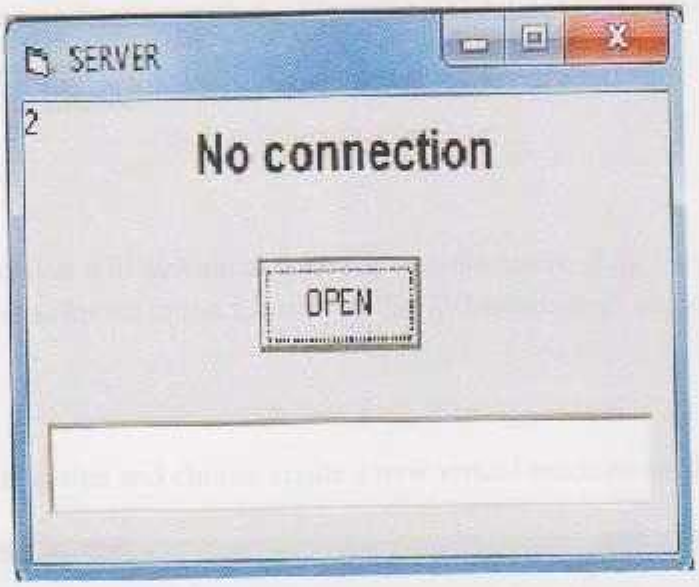


Figure 6.13: The Server Main Screen Window

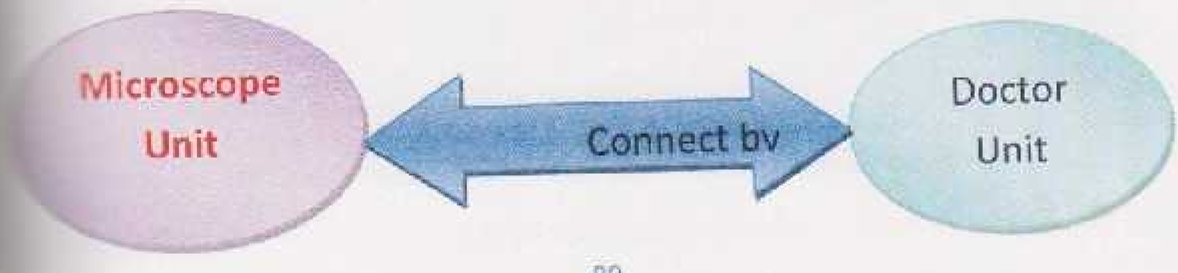
- After that, the server will be able to receive the sending command.
- After receiving the command, it will be transfer to Arduino.

6.5 Voice e over internet protocol (VOIP)

In this project we use this technique to connect receiver (doctor 1) in one location

With another receiver (doctor 2) in other location to diagnose the blood sample coming from transmitter side

VoIP is accomplished by using software called Elastix server and x-light 4 as phone



For stability we will install the Elastix on a dedicated server rather than using a normal computer. The used version will be Elastix 1.0.

After installing the software on the server, using browser, connect to https://ipaddress/ (e.g. https://10.10.175.4) to be presented with the Elastix initial Admin in login screen.

Set –up and configuring Elastix.

Initial installation

The Elastix version will download from the website below (http://www.elastix.org) And download another software to run Elastix called (VMware work station)

Steps to installation:

1-open VMware work station and choose create a new virtual machine as show below.

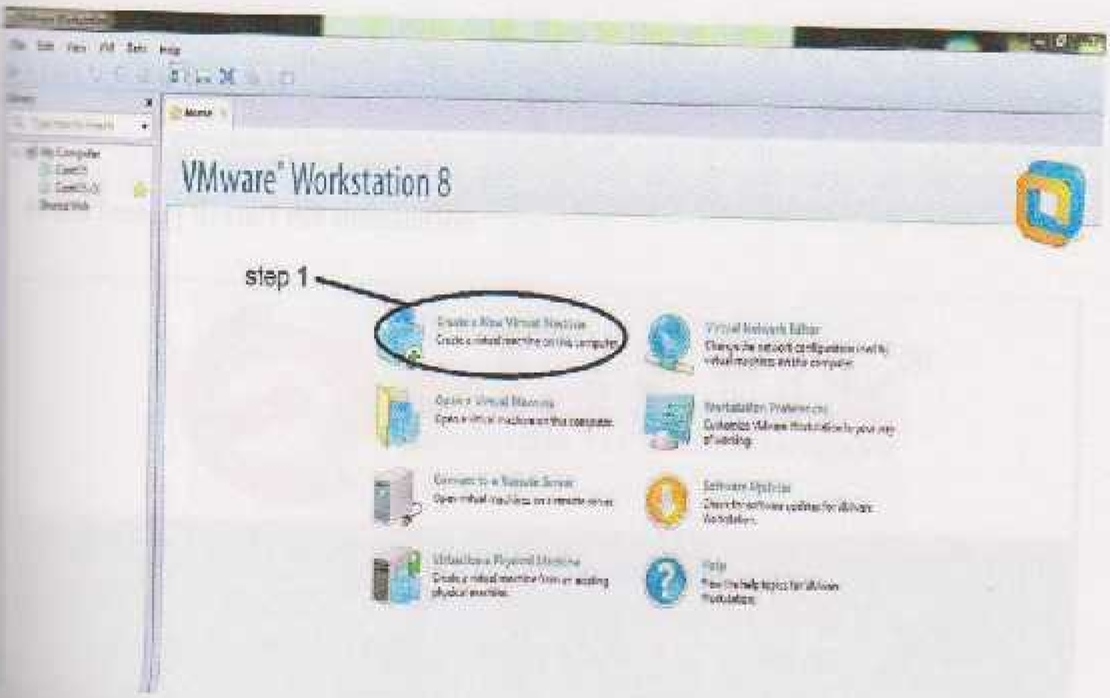


Figure 6.14: VMware Workstation 8 Window

Step 2: run to begin installation as show below.

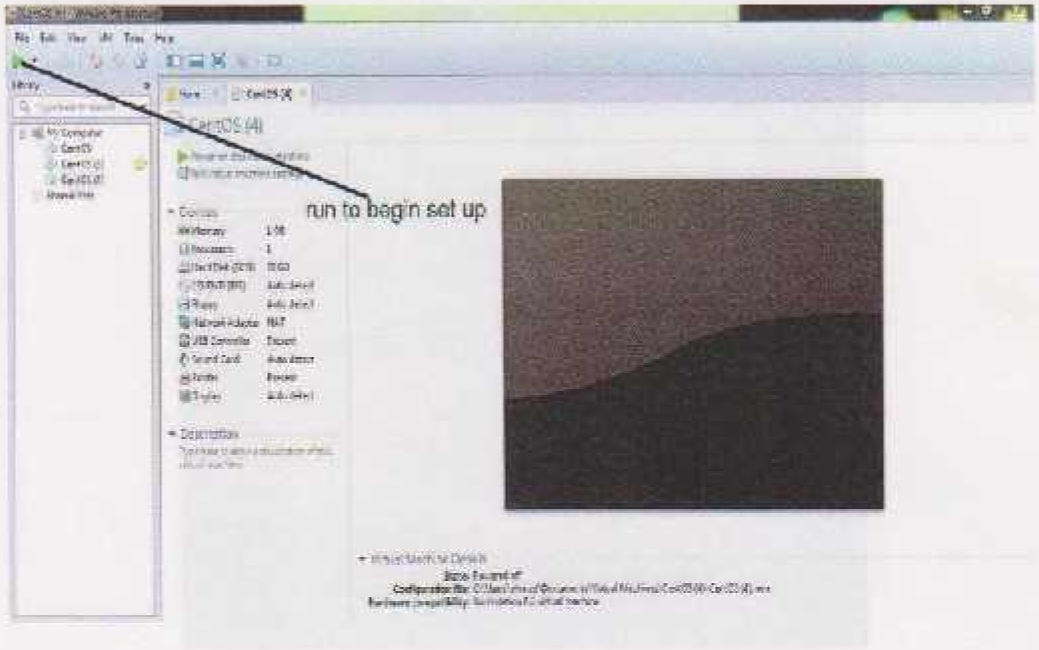


Figure 6.15: Run to Begin Setup

Step 3: press [enter] to start the installation

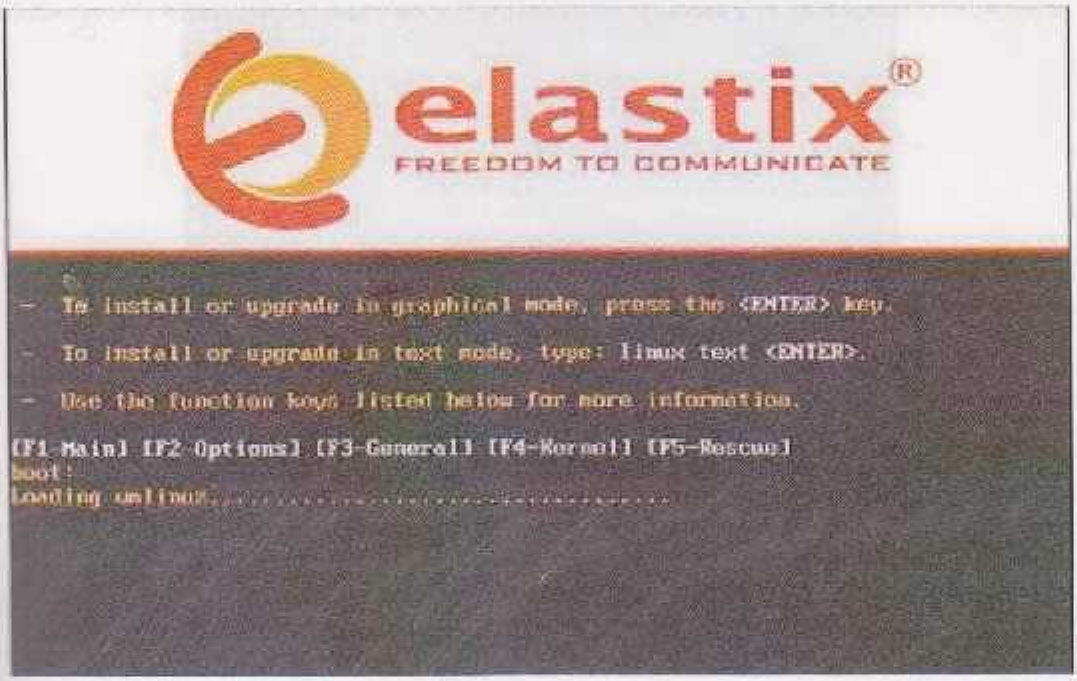


Figure 6.16: Elastix Profile

The following graph to enter information that need to server.

1) Enter IP address and sub net mask (e.g.: **10.10.1.1, 255.255.0.0).**

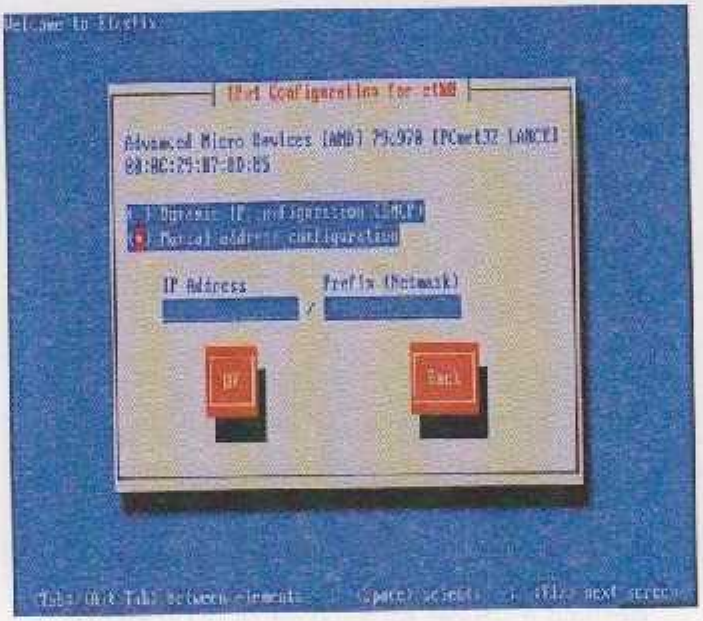


Figure 6.17: Login Window.

2) Enter server name as: PPU – Hebron server.

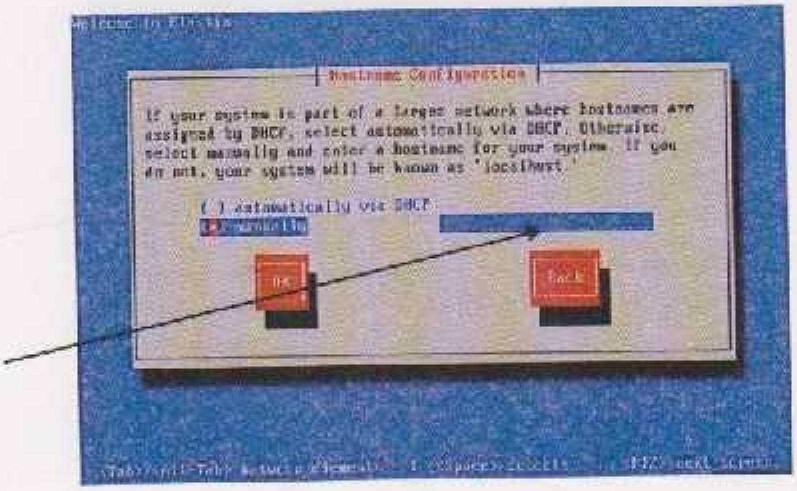


Figure 6.18: Hostname Configuration

3) Enter IP of gateway this IP used to access to server on Google page (10.10.75.4).

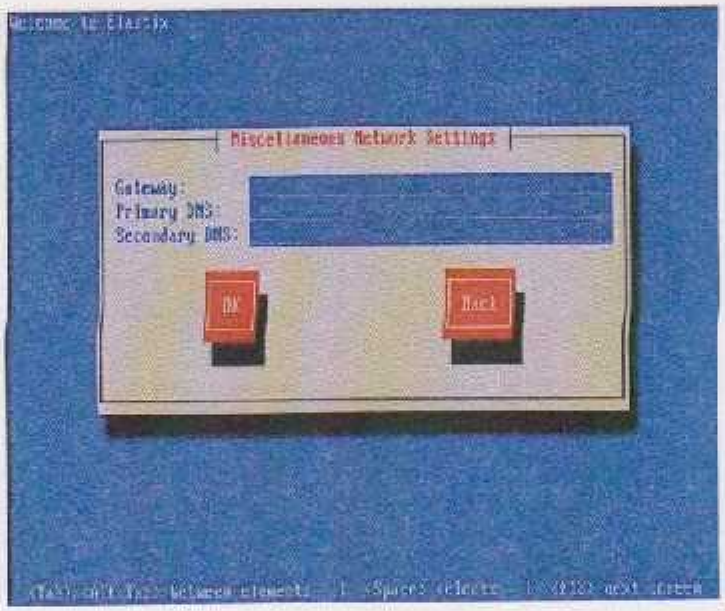


Figure 6.19: Miscellaneous Network Settings

4) Enter password. As a secret to access into server.

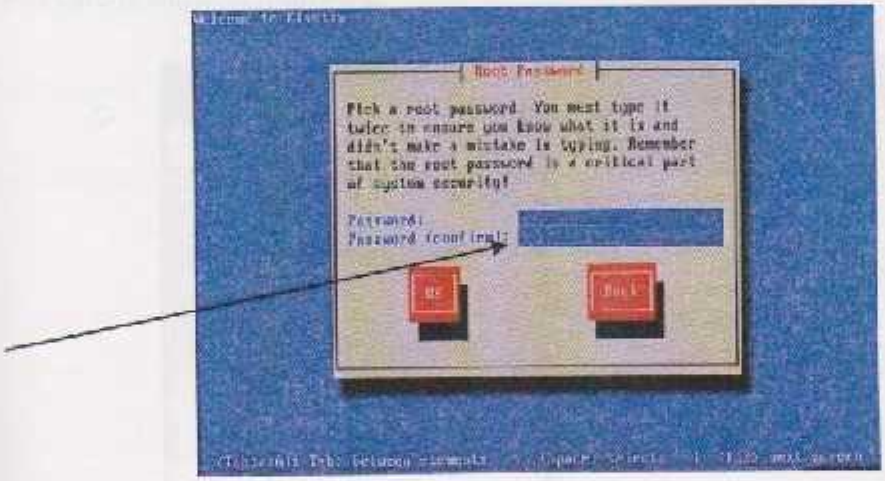


Figure 6.20: Root Password.

After the previous steps complete access to Google page and write IP address which you choose it in previous step (e.g. http://10.10.75.4) then enter user name and password you choose.

When you access to main page of Elastix server make extensions to call it by VoIP as following:

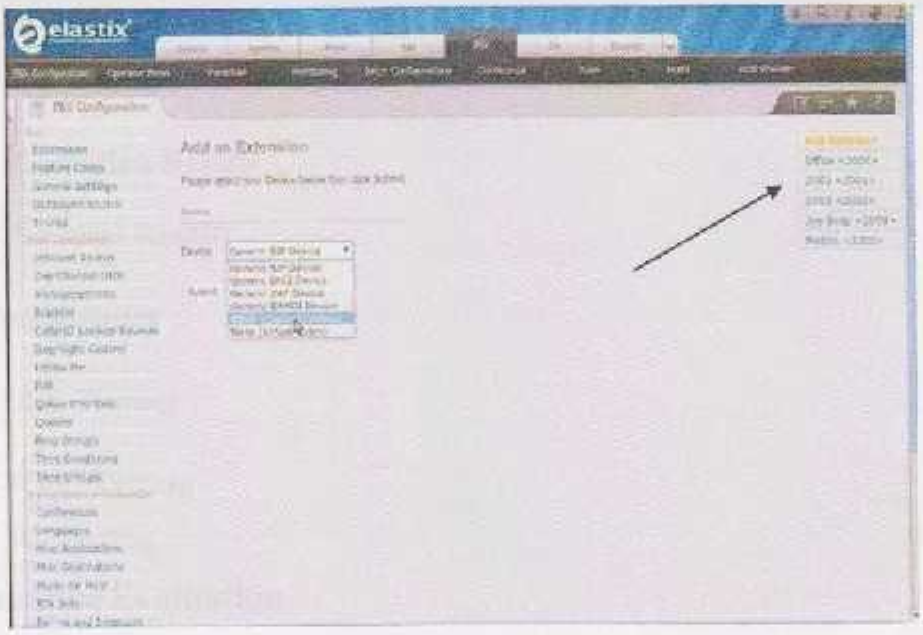


Figure 6.21: Main Page of Elastix Server

Phone software is show in following:

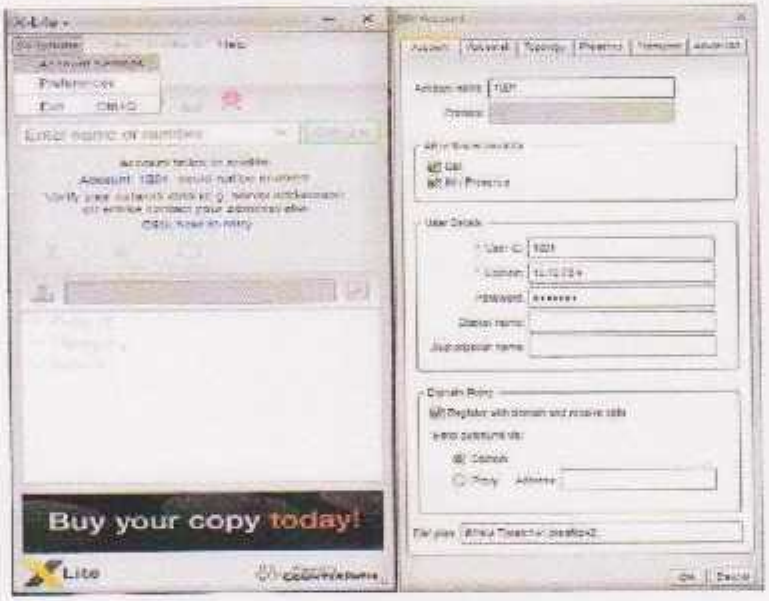


Figure 6.22: Phone Software Window

Chapter Seven

Results and Future Works

7.1 Hardware Results

- **7.1.1 Simulation Results**
- **7.1.2 Practical Results**

7.2 Software Results

- **7.2.1 DSL Testing**
- **7.2.2 Wi-Fi Testing**
- **7.2.2 3G Testing**

7.3 Performance Evaluation

- **7.3.1 Delay**
- **7.3.2 Data rate**
- **7.3.3 Coverage**

7.4 Challenges

7.5 Recommendations

7.1 Hardware Results

This section describes the simulation and practical hardware results of the project.

7.1.1 Simulation Results

This section describes the simulation results of the H-bridge and motor in both directions (clockwise and counterclockwise) states. In the clockwise state, the transistors T_2, T4 are on, and T_1, T3 are off, in the H-Bridge, in this case the motor will move clockwise as shown in Figure 7.1.

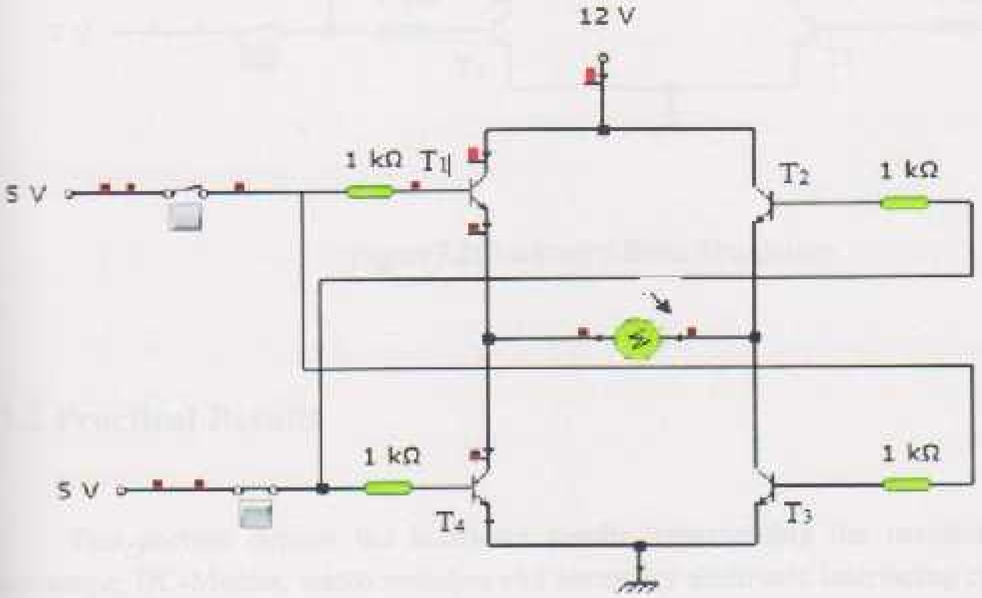


Figure 7.1: Forward State Simulation

In the counterclockwise state, the transistors T_1, T_3 are on, and T_2, T_4 are off, as shown in Figure 7.2.

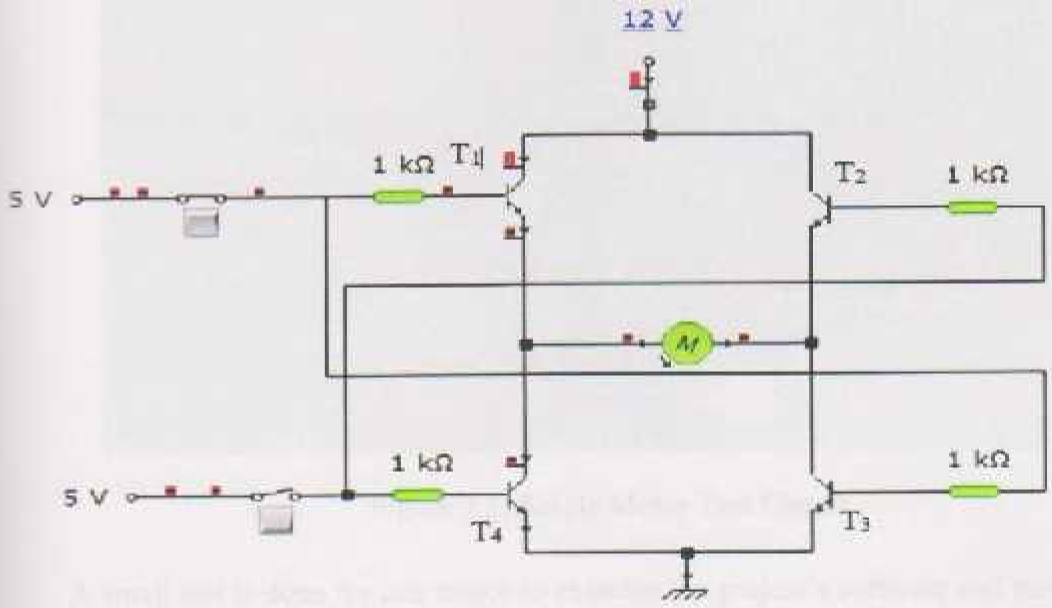


Figure7.2:Backword State Simulation

7.1.2 Practical Results

This section depicts the hardware results, representing the connections between the microscope, DC-Motors, micro switches and necessary electronic interfacing circuits.

6 Single Motor Test circuit

After downloading the software programming for DC- motors by using Arduino software connected in Arduino board. The wires of the DC- motor and Arduino board connected to their suitable pins in H-bridge in order to move the DC-motor in both directions. Figure 7.3 depicts these connections.

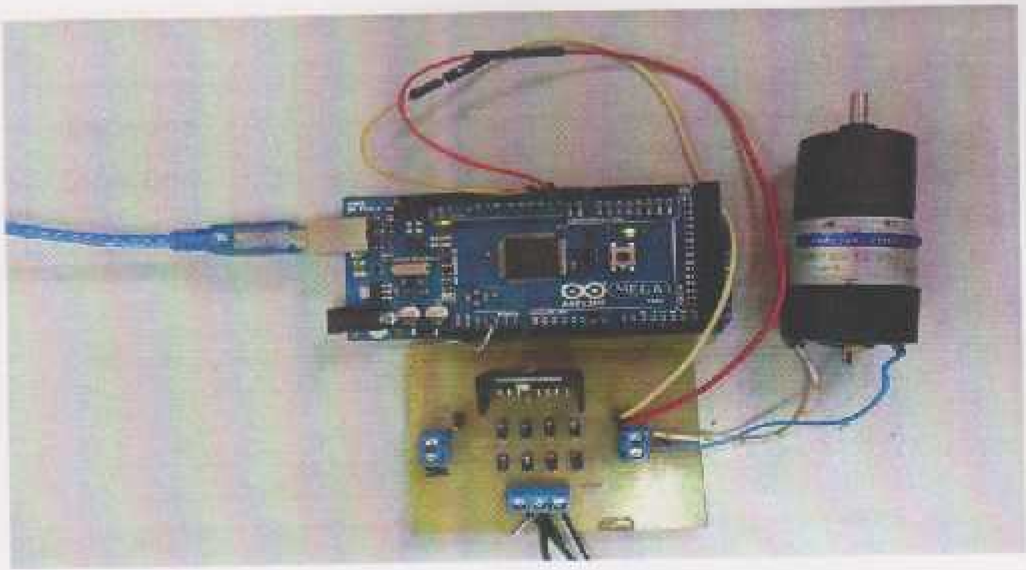


Figure 7.3: Single Motor Test Circuit

A small test is done for one motor to examine the project's software and motor motions in both direction (clockwise and counterclockwise).

7.1.2.2 Overall Hardware Motorized Microscope Results

The following figures depict the complete motorized microscope, showing the three DC-motors and the corresponding two micro-switches for each DC-motor. Each DC-motor moves the microscope stage in one of the three directions.

Figure 7.4: Moving the Slide along the Y-axis (Forward)

Figure 7.5: Moving the Slide along the Y-axis (Backward)

Figure 7.6: Moving the Slide along the X-axis (Right)

Figure 7.7: Moving the Slide along the X-axis (Left)

Figure 7.8: Moving the Slide along the X-axis (Up)

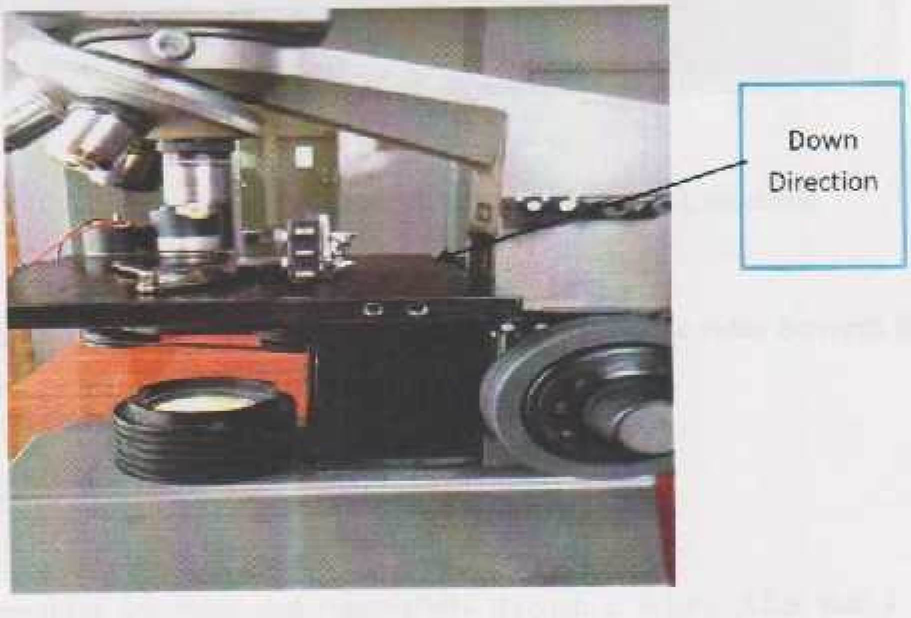


Figure 7.9: Moving the Slide Along the Z-axis (Down)

7.2 Software Results

7.2.1 DSL Testing

The two computers are connected successfully through a DSL modems. After that a test is applied to initialize the DSL modems as shown in figure 7.10.

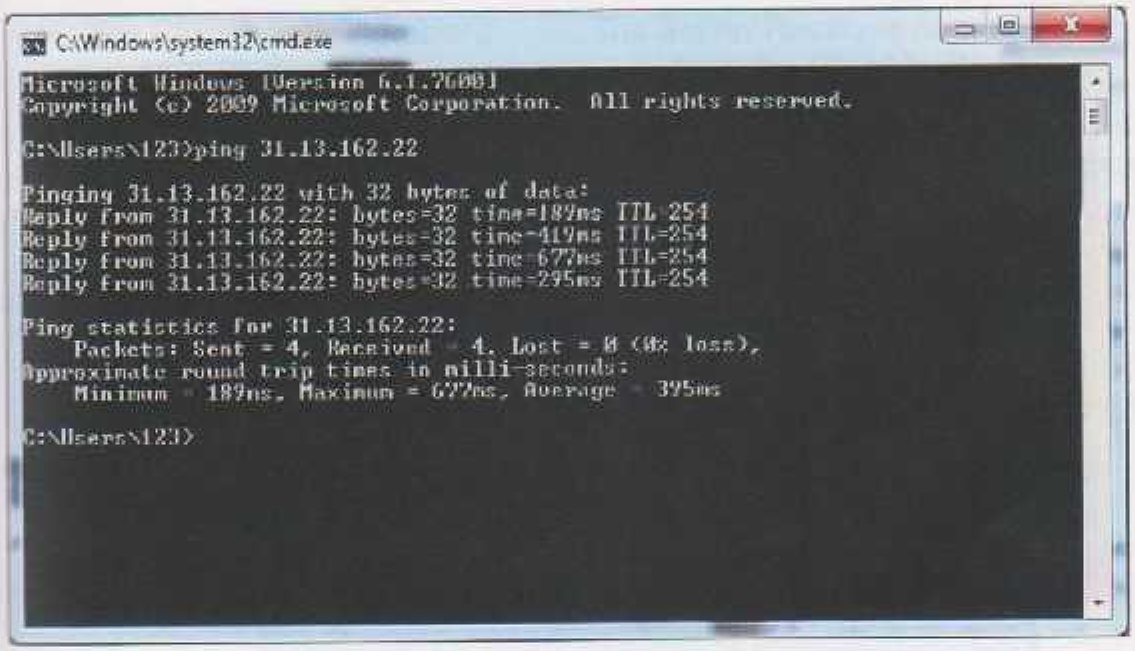
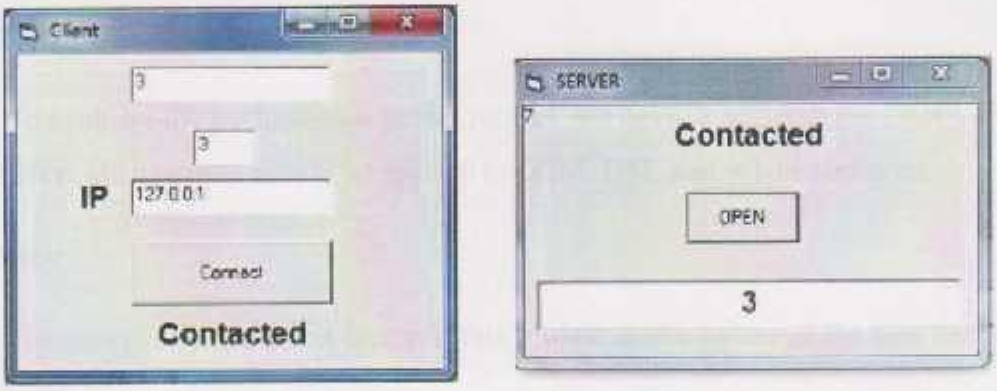


Figure 7.10: shows confirm the connection between two DSL modems.

After initialize two DSL modems, they have been used to transfer video between the two computer, and the process has been done successfully.

7.2.2 Wi-Fi Testing

The two computers are connected successfully through a Wi-Fi. After that a test is transfer data from client to server as shown in figure 7.11.



The Client sends number 3 **The Server Receives number 3 from the Client by Wi-Fi**

Figure 7.11: Shows Confirm The Transfer of Data from Client to Server Through the Wi-Fi.

7.2.2 3G Testing

The two computers are connected successfully through a 3G. After that a test is send message from device to another for initiate the 3G GSM Modem.

Figure 7.12: shows sending message success.

7.3 Performance Evaluation

To evaluate the performance in this project, we have to measure the Delay, Data Rate and Rang. This measurements should be applied to GSM, DSL and Wi-Fi scenarios.

7.3.1 Delay

The delay is a significant factor in this project as the nature of the sent data required fast transmission.

The delay defined how long it take for an entire message to completely arrive at the destination from the time the first bit is sent out from the source.

The delay is made of four component: propagation time, transmission time, queuing time and processing delay.

1) Propagation Time: measures the time required for a bit to travel from the source to the destination. The propagation time is calculated by dividing the distance by the propagation speed.

$$Propagation = \frac{\text{Distance}}{\text{Propagation speed}}$$

2) Transmission Time: the time required for transmission of a massage depends on the size of the message and the bandwidth of the channel.

$$Transmission\ Time = \frac{\text{DistMessage sizeance}}{\text{Bandwidth}}$$

3) Queuing Time: the time needed for each intermediate or end device to hold the message before it can processed. The queuing time is not a fixed factor; it changes with the load imposed on the network. When there is heavy traffic on the network, the queuing time increases.

4) Processing Time: the time it take routers to process the packet header. Processing delay is a key component in network delay.

The delay in GSM scenario from the moment of sending the message from the module to completely arrive at the mobile is 9 sec.If the size of the message increases, the delay increases. The reported result is an average of multiple experiments, and delay in voice.

But in Wi-Fi scenario, we have conducted three experiments to obtain the delay. This delay was measured by using Ping. The Ping is a computer network administration utility used to test the reachability of a host on an internet protocol (IP) network and it to measure the round-trip time for message sent from the originating host to a destination computer.

The first experiment was when we placed the transmitter and the access point and the receiver "personal computer" in the same floor, the average delay in this case was 0.6 msec which was obtain from 15 readings.

The second one when we placed access point and the transmitter in the same floor and placed the receiver "personal computer" in another floor, in this case the delay was 1.1 msec gotten from 15 readings.

The third one when we placed the transmitter in the first floor and the access point in the second floor and placed the receiver "personal computer" in the third floor, in this case the delay was 9 msec obtained from 15readings.

7.3.2 Data rate

In this project, Cisco Linksys E300 supports 802.11g standard. It operates at a maximum physical layer bit rate of 300 Mbps or about 115Mbps, average throughput. This is much more comparator to 3G GSM which provides 144Kbps data rate and 80Kbps throughput.

7.3.3 Coverage

A Wi-Fi signal provide coverage typically up to 250 feet from an AP depending on factors such as walls.

A GSM signal provides far more widespread coverage of several miles or more from a cell site.

The previous measurements and results compared to previous project are summarized in the following table 7.1:

Table 7.1: Summarized results

	3G GSM	Wi-Fi	MIMO Wi-Fi
Delay	**3 sec**	**6.7 m sec**	**9 msec**
Data Rate	**300 Kbps**	**54 Mbps**	**150 Mbps**
Range	**Several Miles**	**200 feet**	**250 feet**

7.4 Challenges

Several challenges faced the students during the design. The main hardware challenges can be summarized as follows:

1. Finding an appropriate microscope that can be moved in the three directions.
2. Finding an appropriate microscope that has a good mechanical strength to enable three motors and six micro-switches to be connected to it.
3. Connecting motors, micro-switches and interface components in relatively small size microscope.
4. Finding the optimal DC-motors for the project that has small size with the required electrical characteristics such as sensitivity power and torque.
5. Finding the optimal camera that has an adaptor that fits with the eye-peace of the microscope and fulfill the required features for sending good quality images.
6. When we transmission by using DSL this require static IP address.
7. We face many problem in transferring video by Matlab.
8. We face a problem for choosing suitable 3G modem.
9. Difficult problem to make interface between two different network.

The main software challenges:

1. Learning Arduino language for programming the motors.
2. Learning micro-switches programming language for controlling the motor stage movements.

7.5 Recommendations

After completing the hardware design of the project successfully, several applications can be suggested such as increasing the consulting units and use the principle of this project in other medical diagnostic devices that needed international experts.

Appendix

```
const int IN1=3؛
const int IN2=4؛
const int IN3=5؛
const int IN4=6؛
const int IN5=7؛
const int IN6=8؛
int value؛
const int buttonPin1 = 9;    // the number of the pushbutton pin
 const int buttonPin2 = 10;    // the number of the pushbutton pin
const int buttonPin3 = 11;    // the number of the pushbutton pin
 const int buttonPin4 = 12;    // the number of the pushbutton pin
const int buttonPin5 = 13;    // the number of the pushbutton pin
 const int buttonPin6 = 14;  // the number of the pushbutton pin
 int buttonState1 = 0;         // variable for reading the pushbutton status
  int buttonState2 = 0;         // variable for reading the pushbutton status
 int buttonState3 = 0;         // variable for reading the pushbutton status
 int buttonState4 = 0;         // variable for reading the pushbutton status
 int buttonState5 = 0;         // variable for reading the pushbutton status
 int buttonState6 = 0;         // variable for reading the pushbutton status

 void setup()}
  //  fIRST , define the Motor's pin as an OUTPUT
    Serial.begin (9600);
   pinMode( IN1 ,OUTPUT);
   pinMode( IN2 ,OUTPUT);
   pinMode( IN3 ,OUTPUT);
```

```
  pinMode( IN4 ,OUTPUT(;
  pinMode( IN5 ,OUTPUT);
  pinMode( IN6 ,OUTPUT);
  pinMode(buttonPin1, INPUT);
  pinMode(buttonPin2, INPUT);
  pinMode(buttonPin3, INPUT);
  pinMode(buttonPin4, INPUT);
  pinMode(buttonPin5, INPUT);
  pinMode(buttonPin6, INPUT);
{
void ClockWise1()
 {
  digitalWrite(IN1,LOW);
  digitalWrite(IN2,HIGH);
}
void ClockWise2(){
  digitalWrite(IN3,LOW);
  digitalWrite(IN4,HIGH);
}
void ClockWise3(){
  digitalWrite(IN5,LOW);
  digitalWrite(IN6,HIGH);
}
void CounterClockWise1(){
  digitalWrite(IN1,HIGH);
  digitalWrite(IN2,LOW);
```

```
}
void CounterClockWise2()
{
 digitalWrite(IN3,HIGH);
 digitalWrite(IN4,LOW);
}
void CounterClockWise3()
{
 digitalWrite(IN5,HIGH);
 digitalWrite(IN6,LOW);
}
void Stop1()
{
// When we want to let Motor To Rotate clock wise
 // just void this part on the loop section.
 digitalWrite(IN1,LOW);
 digitalWrite(IN2,LOW);
}

 void Stop2()
{
 digitalWrite(IN3,LOW);
 digitalWrite(IN4,LOW);
 }


 void Stop3()
{
```

```
 digitalWrite(IN5,LOW);
 digitalWrite(IN6,LOW);

}
void Stop4()
{
 digitalWrite(IN1,LOW);
 digitalWrite(IN2,LOW);
 digitalWrite(IN3,LOW);
 digitalWrite(IN4,LOW);
 digitalWrite(IN5,LOW);
 digitalWrite(IN6,LOW);

}

void loop (){
 value =Serial.read();

buttonState1 = digitalRead(buttonPin1);
   if ( value == '2')
    {
     if (buttonState1 == HIGH )
      ClockWise1));

     else
      Stop1();
  {
```

```
buttonState2 = digitalRead(buttonPin2);
      if (  value == '3')
      {
        if (buttonState2 == HIGH)
          CounterClockWise1();
        else
         Stop1();

      }

buttonState3 = digitalRead(buttonPin3);
   if (  value == '5')
      }
if (buttonState3 == HIGH )
      ClockWise2();
       else
        Stop2();
      }

buttonState4 = digitalRead(buttonPin4);
       if (  value == '6')
}
       if (buttonState4 == HIGH)
        CounterClockWise2();
        else
           Stop2();
```

```
}

buttonState5 = digitalRead(buttonPin5);

        if ( value == '8')

        }

         if (buttonState5 == HIGH )

          ClockWise3();

           else

            Stop3() ;

        }


buttonState6 = digitalRead(buttonPin6);

        if ( value == '9')

}

        if (buttonState6 == HIGH)

        CounterClockWise3() ;

         else

          Stop3();



        }

  else

  Stop4();

  }
```

Linksys E3000 | High Performance Wireless-N Router

From the worldwide leader in wireless networking

...atures

- ...e visitors simple and password-protected ...rnet access
- ...A, WPA2, and other enhanced security features
- ...am your stored multimedia to devices around ...r home
- ...o 300 Mbps wireless speeds*
- ...abit Ethernet 10/100/1000 Mbps wired speed
- ...nded wireless coverage for larger homes
- ...z band avoids interference from 2.4 GHz ...eless networks
- ...nect and share USB storage throughout your home and ...the Internet. Includes built-in UPnP AV media server
- ...mized for streaming HD video
- ...mized for wireless gaming

...ecifications

...Name	Linksys E3000
...	High Performance Wireless-N Router
...umber	E3000
...of Antennas	6 Total, 3 Internal Antennas per Each 2.4 GHz and 5 GHz Radio Band
...able (Yes/No)	No
...	802.11b: CCK, QPSK, BPSK 802.11g: OFDM 802.11a: OFDM 802.11n: BPSK, QPSK, 16-QAM, 64-QAM
...ensitivity	2.4 GHz 11 Mbps: -87 dBm @ Typical 54 Mbps: -77 dBm @ Typical MCS15 (20MHz): -71 dBm @ Typical MCS15 (40MHz): -68 dBm @ Typical 5 GHz 54 Mbps: -74 dBm @ Typical MCS15 (20 MHz): -68 dBm @ Typical MCS15 (40 MHz): -65 dBm @ Typical
...Gain in dBi	2.4 GHz: RIFA 1 and RIFA 2 and RIFA 3 <= 4 dBi (Typical) 5 GHz: RIFA 1 and RIFA 2 and RIFA 3 <= 3.5 dBi (Typical)
...	Supported
...eatures	WEP, WPA, WPA2
...Bits	Up to 128-Bit Encryption

Environmental

Dimensions	8.86" x 1.38" x 7.09" (225 x 35 x 180 mm)
Weight	15.94 oz (452 g)
Power	12V, 2A
Certification	FCC, IC, CE, Wi-Fi A/B/G/N
Operating Temperature	32 to 104°F (0 to 40°C)
Storage Temperature	-4 to 140°F (-20 to 60°C)
Operating Humidity	10 to 80% Noncondensing
Storage Humidity	5 to 90% Noncondensing

Minimum System Requirements

- **Internet Browser:** Internet Explorer 6, Safari 3, or Firefox 2 for Optional Browser-Based Configuration
- **PC:** Wireless Network-Enabled PC with CD or DVD Drive, Running Windows XP SP3, Windows Vista SP1, or Windows 7
- **Mac:** Wireless Network-Enabled Mac with CD or DVD Drive, Running OS X Tiger 10.4.11, Leopard 10.5.8, or Snow Leopard 10.6.1

Package Contents

- Linksys E3000 High Performance Wireless-N Router
- CD-ROM with Cisco Connect Software
- Ethernet Network Cable
- Power Adapter

...performance for wireless is derived from IEEE Standard 802.11 specifications. Actual performance can vary, including lower wireless ... data throughput rate, range and coverage. Performance depends on many factors, conditions and variables, including distance ... point, volume of network traffic, building materials and construction, operating system used, mix of wireless products used, ... and other adverse conditions.

...are subject to change without notice.

CISCO

Olympus CHBS Microscope - All Olympus 4x, 10x, 40x, HI 100x

Shipping Dimensions & Weight:

- 8" x 10" x 15" / 20cm x 25cm x 38cm
- Weight: 16 lbs / 7.3 kgs

Description | Reviews (0) | Related Products

This is an older style Olympus microscope. It is in excellent condition and features quality optics and workmanship. The microscope has been re-built to original factory specifications. It is ideal for educational or medical use. It is priced to sell at a tremendous price.

Specifications	
Style:	Binocular
Eyepiece:	Olympus WF10x
Nosepiece:	Quadruple
Focusing:	Coaxial coarse & fine adjustment mechanisms
Stage:	Mechanical stage
Objectives:	4x, 10x, FL 40x, HI 100x All Olympus
Substage:	Abbe Condenser 1.25 N.A. with rack & pinion
Light Source:	Built in illumination with variable intensity

ADINCO
ADVANCED INSTRUMENTS & COMPONENTS

HV155 DC-motor with gearbox

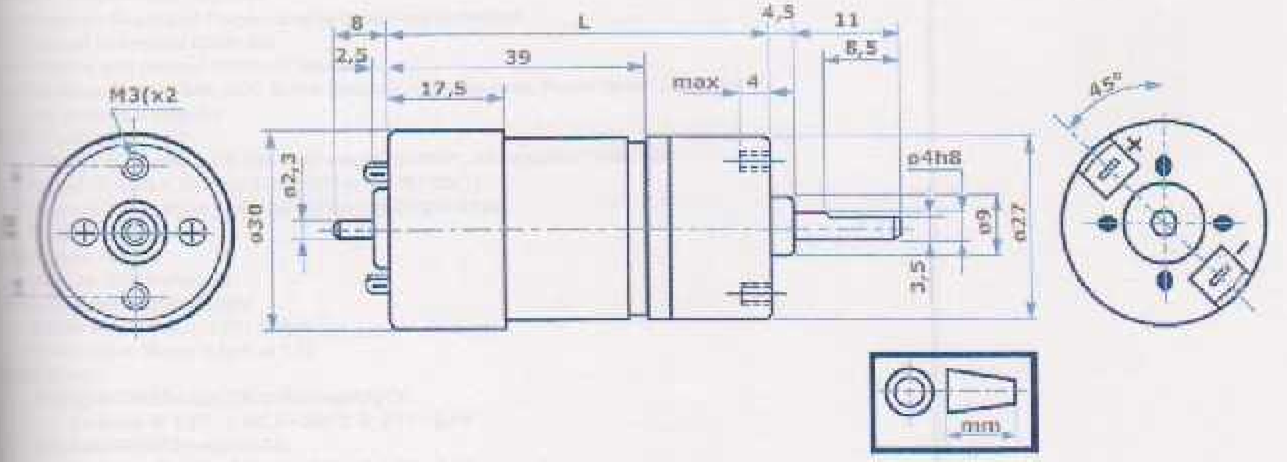
otor data

otor order number	Type	Nominal voltage (V)	Current at max. torque (mA)	Ratio	Maximum torque (mNm)	Speed at no load (rpm)	Speed at max. torque (rpm)	Diameter (mm)	Length (mm)
-03-12-0010	HV155-12-10	12	620	10:1	50	660	460	30/27	62,5
-03-12-0021	HV155-12-21	12	600	21:1	100	315	235	30/27	62,5
-03-12-0043	HV155-12-43	12	580	43:1	180	115	115	30/27	67,5
-03-12-0090	HV155-12-90	12	440	90:1	250	75	62	30/27	67,5
-03-24-0010	HV155-24-10	24	300	10:1	50	660	460	30/27	62,5
-03-24-0021	HV155-24-21	24	285	21:1	100	315	235	30/27	62,5
-03-24-0043	HV155-24-43	24	280	43:1	180	155	115	30/27	67,5
-03-24-0090	HV155-24-90	24	215	90:1	250	75	62	30/27	67,5

eneral data

ark suppression	-
ximum radial shaft load	10 N
ximum axial shaft load	5 N
ss of motor	100 grams
mperature range	-20°C to +60°C

mensional drawing



Features

- High Performance, Low Power Atmel® AVR® 8-Bit Microcontroller
- Advanced RISC Architecture
  - 135 Powerful Instructions – Most Single Clock Cycle Execution
  - 32 x 8 General Purpose Working Registers
  - Fully Static Operation
  - Up to 16 MIPS Throughput at 16MHz
  - On-Chip 2-cycle Multiplier
- High Endurance Non-volatile Memory Segments
  - 64K/128K/256KBytes of In-System Self-Programmable Flash
  - 4Kbytes EEPROM
  - 8Kbytes Internal SRAM
  - Write/Erase Cycles:10,000 Flash/100,000 EEPROM
  - Data retention: 20 years at 85°C/ 100 years at 25°C
  - 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
    - Endurance: Up to 64Kbytes Optional External Memory Space
- Atmel® QTouch® library support
  - Capacitive touch buttons, sliders and wheels
  - QTouch and QMatrix® acquisition
  - Up to 64 sense channels
- JTAG (IEEE std. 1149.1 compliant) Interface
  - Boundary-scan Capabilities According to the JTAG Standard
  - Extensive On-chip Debug Support
  - Programming of Flash, EEPROM, Fuses, and Lock Bits through the JTAG Interface
- Peripheral Features
  - Two 8-bit Timer/Counters with Separate Prescaler and Compare Mode
  - Four 16-bit Timer/Counter with Separate Prescaler, Compare- and Capture Mode
  - Real Time Counter with Separate Oscillator
  - Four 8-bit PWM Channels
  - Six/Twelve PWM Channels with Programmable Resolution from 2 to 16 Bits (ATmega1281/2561, ATmega640/1280/2560)
  - Output Compare Modulator
  - 8/16-channel, 10-bit ADC (ATmega1281/2561, ATmega640/1280/2560)
  - Two/Four Programmable Serial USART (ATmega1281/2561, ATmega640/1280/2560)
  - Master/Slave SPI Serial Interface
  - Byte Oriented 2-wire Serial Interface
  - Programmable Watchdog Timer with Separate On-chip Oscillator
  - On-chip Analog Comparator
  - Interrupt and Wake-up on Pin Change
- Special Microcontroller Features
  - Power-on Reset and Programmable Brown-out Detection
  - Internal Calibrated Oscillator
  - External and Internal Interrupt Sources
  - Six Sleep Modes: Idle, ADC Noise Reduction, Power-save, Power-down, Standby, and Extended Standby
- I/O and Packages
  - 54/86 Programmable I/O Lines (ATmega1281/2561, ATmega640/1280/2560)
  - 64-pad QFN/MLF, 64-lead TQFP (ATmega1281/2561)
  - 100-lead TQFP, 100-ball CBGA (ATmega640/1280/2560)
  - RoHS/Fully Green
- Temperature Range:
  - -40°C to 85°C Industrial
- Ultra-Low Power Consumption
  - Active Mode: 1MHz, 1.8V: 500µA
  - Power-down Mode: 0.1µA at 1.8V
- Speed Grade:
  - ATmega640V/ATmega1280V/ATmega1281V:
    - 0 - 4MHz @ 1.8V - 5.5V, 0 - 8MHz @ 2.7V - 5.5V
  - ATmega2560V/ATmega2561V:
    - 0 - 2MHz @ 1.8V - 5.5V, 0 - 8MHz @ 2.7V - 5.5V
  - ATmega640/ATmega1280/ATmega1281:
    - 0 - 8MHz @ 2.7V - 5.5V, 0 - 16MHz @ 4.5V - 5.5V
  - ATmega2560/ATmega2561:
    - 0 - 16MHz @ 4.5V - 5.5V

8-bit Atmel Microcontroller with 64K/128K/256K Bytes In-System Programmable Flash

ATmega640/V
ATmega1280/V
ATmega1281/V
ATmega2560/V
ATmega2561/V

2549P–AVR–10/2012

1. Pin Configurations

Figure 1-1. TQFP-pinout ATmega640/1280/2560

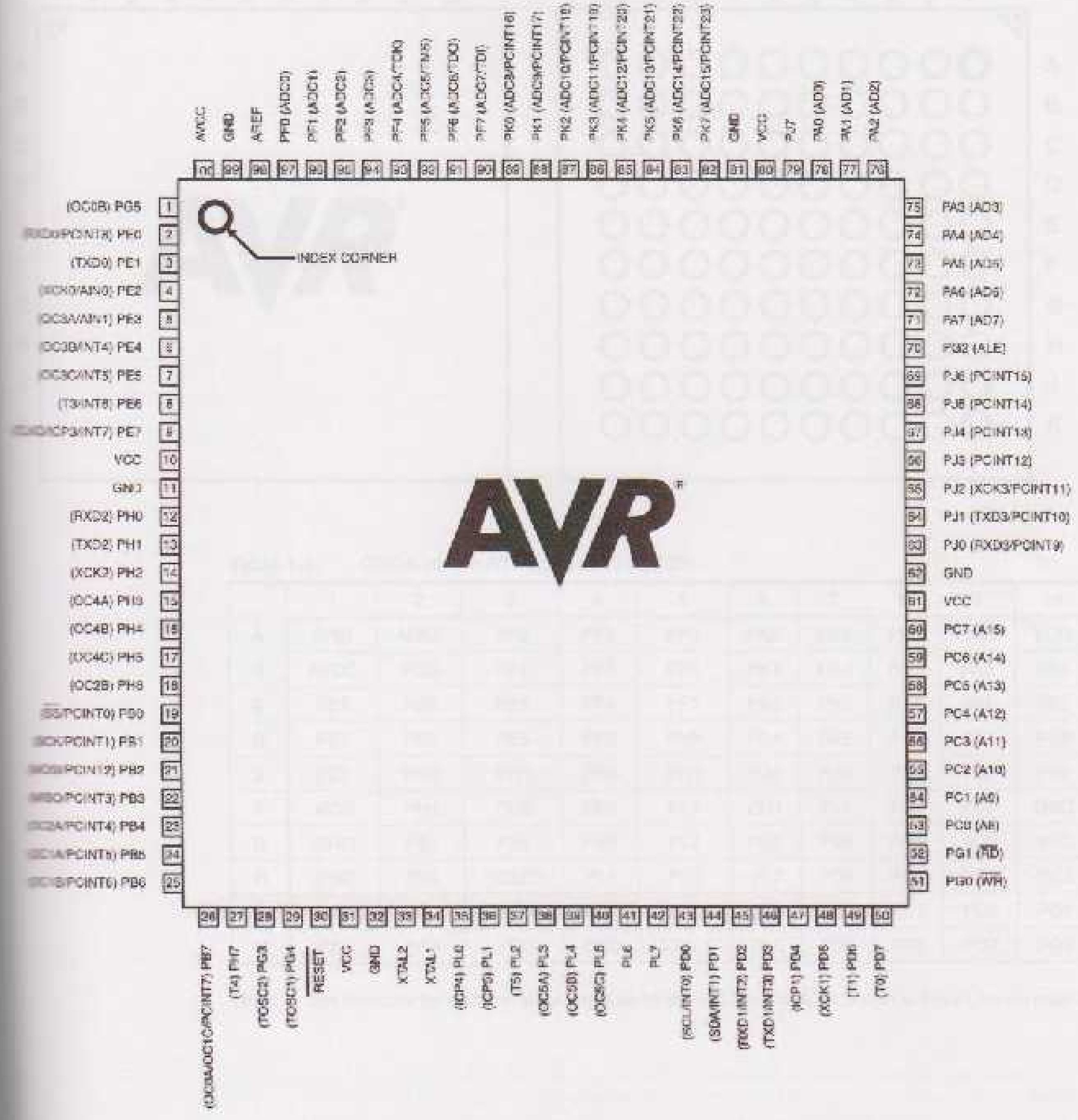


Figure 1-2. CBGA-pinout ATmega640/1280/2560

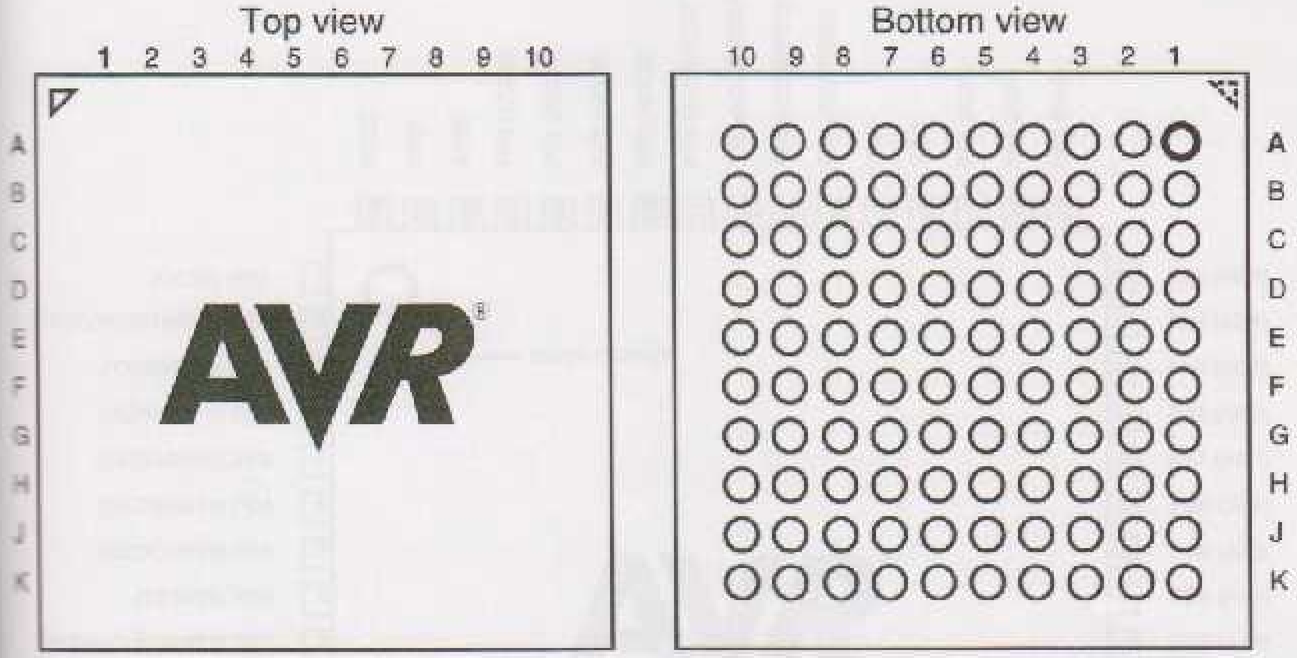
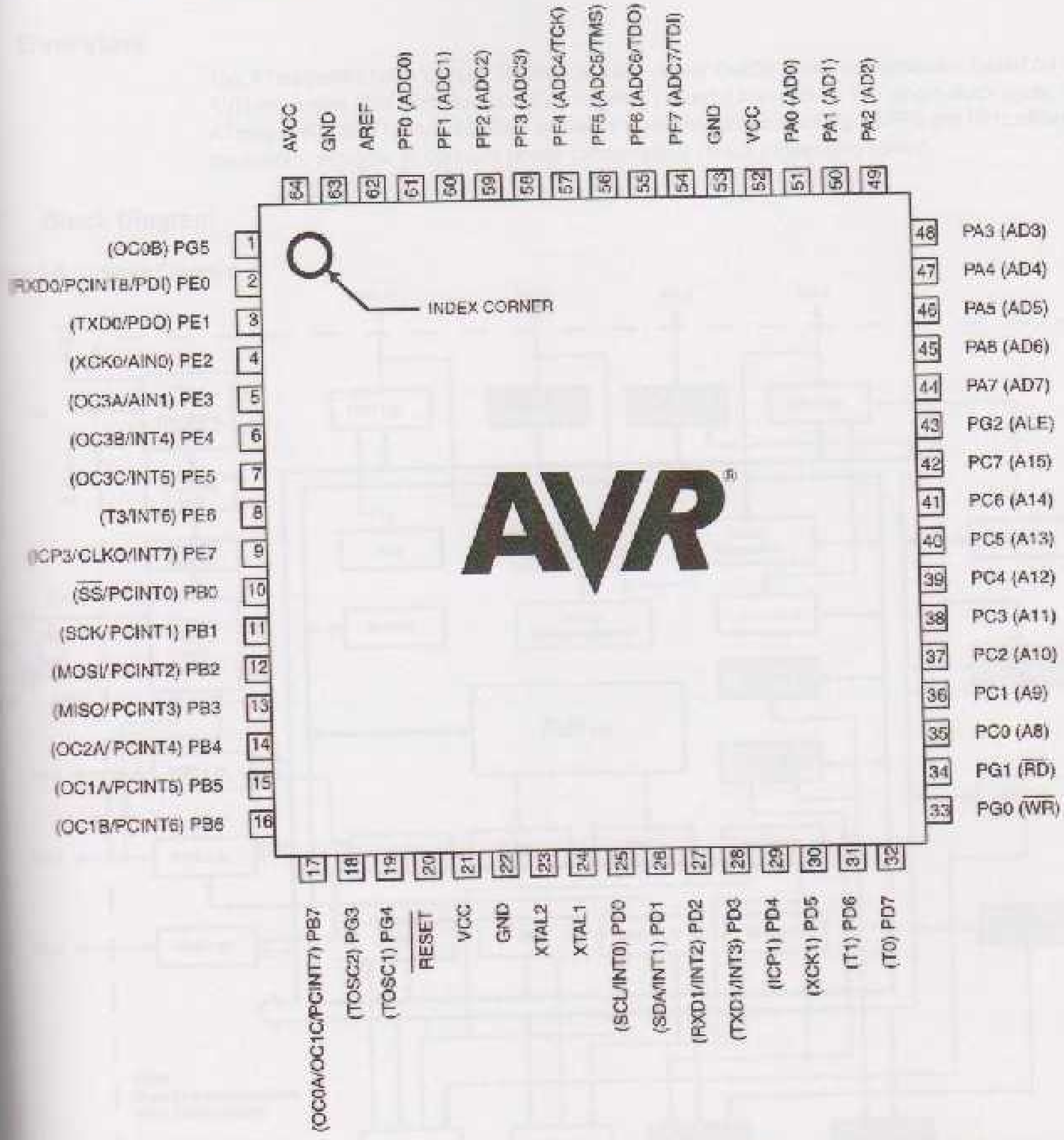


Table 1-1. CBGA-pinout ATmega640/1280/2560

	1	2	3	4	5	6	7	8	9	10
A	GND	AREF	PF0	PF2	PF5	PK0	PK3	PK6	GND	VCC
B	AVCC	PG5	PF1	PF3	PF6	PK1	PK4	PK7	PA0	PA2
C	PE2	PE0	PE1	PF4	PF7	PK2	PK5	PJ7	PA1	PA3
D	PE3	PE4	PE5	PE6	PH2	PA4	PA5	PA6	PA7	PG2
E	PE7	PH0	PH1	PH3	PH5	PJ6	PJ5	PJ4	PJ3	PJ2
F	VCC	PH4	PH6	PB0	PL4	PD1	PJ1	PJ0	PC7	GND
G	GND	PB1	PB2	PB5	PL2	PD0	PD5	PC5	PC6	VCC
H	PB3	PB4	RESET	PL1	PL3	PL7	PD4	PC4	PC3	PC2
J	PH7	PG3	PB6	PL0	XTAL2	PL6	PD3	PC1	PC0	PG1
K	PB7	PG4	VCC	GND	XTAL1	PL5	PD2	PD6	PD7	PG0

Note: The functions for each pin is the same as for the 100 pin packages shown in Figure 1-1 on page 2.

Figure 1-3. Pinout ATmega1281/2561



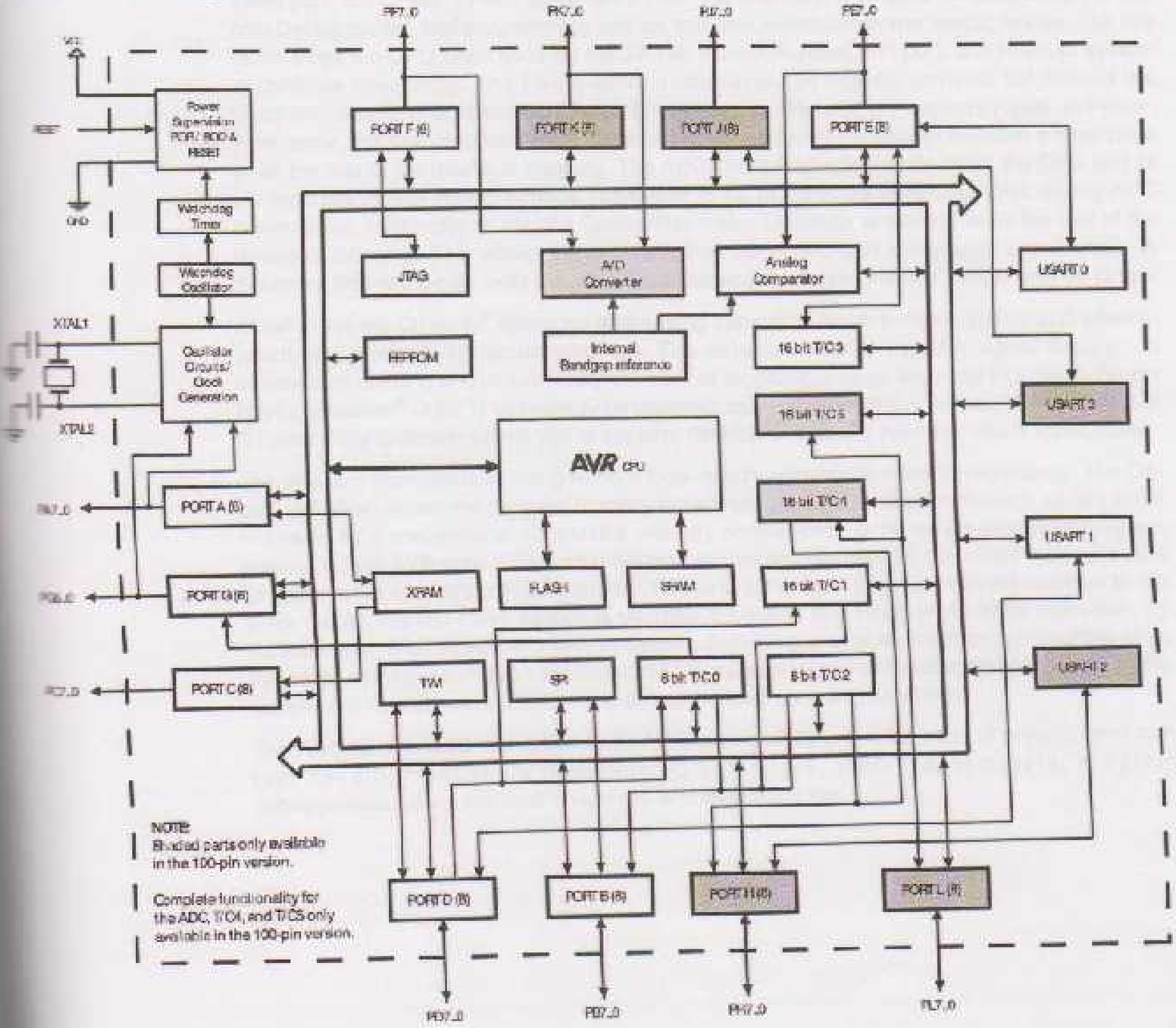
Note: The large center pad underneath the QFN/MLF package is made of metal and internally connected to GND. It should be soldered or glued to the board to ensure good mechanical stability. If the center pad is left unconnected, the package might loosen from the board.

2. Overview

The ATmega640/1280/1281/2560/2561 is a low-power CMOS 8-bit microcontroller based on the AVR enhanced RISC architecture. By executing powerful instructions in a single clock cycle, the ATmega640/1280/1281/2560/2561 achieves throughputs approaching 1 MIPS per MHz allowing the system designer to optimize power consumption versus processing speed.

2.1 Block Diagram

Figure 2-1. Block Diagram



The Atmel® AVR® core combines a rich instruction set with 32 general purpose working registers. All the 32 registers are directly connected to the Arithmetic Logic Unit (ALU), allowing two independent registers to be accessed in one single instruction executed in one clock cycle. The resulting architecture is more code efficient while achieving throughputs up to ten times faster than conventional CISC microcontrollers.

The ATmega640/1280/1281/2560/2561 provides the following features: 64K/128K/256K bytes of In-System Programmable Flash with Read-While-Write capabilities, 4Kbytes EEPROM, 8 Kbytes SRAM, 54/86 general purpose I/O lines, 32 general purpose working registers, Real Time Counter (RTC), six flexible Timer/Counters with compare modes and PWM, 4 USARTs, a byte oriented 2-wire Serial Interface, a 16-channel, 10-bit ADC with optional differential input stage with programmable gain, programmable Watchdog Timer with Internal Oscillator, an SPI serial port, IEEE® std. 1149.1 compliant JTAG test interface, also used for accessing the On-chip Debug system and programming and six software selectable power saving modes. The Idle mode stops the CPU while allowing the SRAM, Timer/Counters, SPI port, and interrupt system to continue functioning. The Power-down mode saves the register contents but freezes the Oscillator, disabling all other chip functions until the next interrupt or Hardware Reset. In Power-save mode, the asynchronous timer continues to run, allowing the user to maintain a timer base while the rest of the device is sleeping. The ADC Noise Reduction mode stops the CPU and all I/O modules except Asynchronous Timer and ADC, to minimize switching noise during ADC conversions. In Standby mode, the Crystal/Resonator Oscillator is running while the rest of the device is sleeping. This allows very fast start-up combined with low power consumption. In Extended Standby mode, both the main Oscillator and the Asynchronous Timer continue to run.

Atmel offers the QTouch® library for embedding capacitive touch buttons, sliders and wheels-functionality into AVR microcontrollers. The patented charge-transfer signal acquisition offersrobust sensing and includes fully debounced reporting of touch keys and includes Adjacent KeySuppression® (AKS™) technology for unambiguous detection of key events. The easy-to-use QTouch Suite toolchain allows you to explore, develop and debug your own touch applications.

The device is manufactured using Atmel's high-density nonvolatile memory technology. The On-chip ISP Flash allows the program memory to be reprogrammed in-system through an SPI serial interface, by a conventional nonvolatile memory programmer, or by an On-chip Boot program running on the AVR core. The boot program can use any interface to download the application program in the application Flash memory. Software in the Boot Flash section will continue to run while the Application Flash section is updated, providing true Read-While-Write operation. By combining an 8-bit RISC CPU with In-System Self-Programmable Flash on a monolithic chip, the Atmel ATmega640/1280/1281/2560/2561 is a powerful microcontroller that provides a highly flexible and cost effective solution to many embedded control applications.

The ATmega640/1280/1281/2560/2561 AVR is supported with a full suite of program and system development tools including: C compilers, macro assemblers, program debugger/simulators, in-circuit emulators, and evaluation kits.

2.2 Comparison Between ATmega1281/2561 and ATmega640/1280/2560

Each device in the ATmega640/1280/1281/2560/2561 family differs only in memory size and number of pins. Table 2-1 summarizes the different configurations for the six devices.

Table 2-1. Configuration Summary

Device	Flash	EEPROM	RAM	General Purpose I/O pins	16 bits resolution PWM channels	Serial USARTs	ADC Channels
ATmega640	64KB	4KB	8KB	86	12	4	16
ATmega1280	128KB	4KB	8KB	86	12	4	16
ATmega1281	128KB	4KB	8KB	54	6	2	8
ATmega2560	256KB	4KB	8KB	86	12	4	16
ATmega2561	256KB	4KB	8KB	54	6	2	8

Pin Descriptions

VCC

Digital supply voltage.

GND

Ground.

Port A (PA7..PA0)

Port A is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port A output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port A pins that are externally pulled low will source current if the pull-up resistors are activated. The Port A pins are tri-stated when a reset condition becomes active, even if the clock is not running.

Port A also serves the functions of various special features of the ATmega640/1280/1281/2560/2561 as listed on page 78.

Port B (PB7..PB0)

Port B is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port B output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port B pins that are externally pulled low will source current if the pull-up resistors are activated. The Port B pins are tri-stated when a reset condition becomes active, even if the clock is not running.

Port B has better driving capabilities than the other ports.

Port B also serves the functions of various special features of the ATmega640/1280/1281/2560/2561 as listed on page 79.

Port C (PC7..PC0)

Port C is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port C output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port C pins that are externally pulled low will source current if the pull-up resistors are activated. The Port C pins are tri-stated when a reset condition becomes active, even if the clock is not running.

Port C also serves the functions of special features of the ATmega640/1280/1281/2560/2561 as listed on page 82.

2.3.6 Port D (PD7..PD0)

Port D is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port D output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port D pins that are externally pulled low will source current if the pull-up resistors are activated. The Port D pins are tri-stated when a reset condition becomes active, even if the clock is not running.

Port D also serves the functions of various special features of the ATmega640/1280/1281/2560/2561 as listed on page 83.

2.3.7 Port E (PE7..PE0)

Port E is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port E output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port E pins that are externally pulled low will source current if the pull-up resistors are activated. The Port E pins are tri-stated when a reset condition becomes active, even if the clock is not running.

Port E also serves the functions of various special features of the ATmega640/1280/1281/2560/2561 as listed on page 86.

2.3.8 Port F (PF7..PF0)

Port F serves as analog inputs to the A/D Converter.

Port F also serves as an 8-bit bi-directional I/O port, if the A/D Converter is not used. Port pins can provide internal pull-up resistors (selected for each bit). The Port F output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port F pins that are externally pulled low will source current if the pull-up resistors are activated. The Port F pins are tri-stated when a reset condition becomes active, even if the clock is not running. If the JTAG interface is enabled, the pull-up resistors on pins PF7(TDI), PF5(TMS), and PF4(TCK) will be activated even if a reset occurs.

Port F also serves the functions of the JTAG interface.

2.3.9 Port G (PG5..PG0)

Port G is a 6-bit I/O port with internal pull-up resistors (selected for each bit). The Port G output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port G pins that are externally pulled low will source current if the pull-up resistors are activated. The Port G pins are tri-stated when a reset condition becomes active, even if the clock is not running.

Port G also serves the functions of various special features of the ATmega640/1280/1281/2560/2561 as listed on page 90.

2.3.10 Port H (PH7..PH0)

Port H is a 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port H output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port H pins that are externally pulled low will source current if the pull-up resistors are activated. The Port H pins are tri-stated when a reset condition becomes active, even if the clock is not running.

Port H also serves the functions of various special features of the ATmega640/1280/2560 as listed on page 92.

3.11 Port J (PJ7..PJ0)

Port J is a 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port J output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port J pins that are externally pulled low will source current if the pull-up resistors are activated. The Port J pins are tri-stated when a reset condition becomes active, even if the clock is not running.

Port J also serves the functions of various special features of the ATmega640/1280/2560 as listed on page 94.

3.12 Port K (PK7..PK0)

Port K serves as analog inputs to the A/D Converter.

Port K is a 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port K output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port K pins that are externally pulled low will source current if the pull-up resistors are activated. The Port K pins are tri-stated when a reset condition becomes active, even if the clock is not running.

Port K also serves the functions of various special features of the ATmega640/1280/2560 as listed on page 96.

3.13 Port L (PL7..PL0)

Port L is a 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port L output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port L pins that are externally pulled low will source current if the pull-up resistors are activated. The Port L pins are tri-stated when a reset condition becomes active, even if the clock is not running.

Port L also serves the functions of various special features of the ATmega640/1280/2560 as listed on page 98.

3.14 $\overline{\text{RESET}}$

Reset input. A low level on this pin for longer than the minimum pulse length will generate a reset, even if the clock is not running. The minimum pulse length is given in "System and Reset Characteristics" on page 372. Shorter pulses are not guaranteed to generate a reset.

3.15 XTAL1

Input to the inverting Oscillator amplifier and input to the internal clock operating circuit.

3.16 XTAL2

Output from the inverting Oscillator amplifier.

2.3.17 AVCC

AVCC is the supply voltage pin for Port F and the A/D Converter. It should be externally connected to V_{CC}, even if the ADC is not used. If the ADC is used, it should be connected to V_{CC} through a low-pass filter.

2.3.18 AREF

This is the analog reference pin for the A/D Converter.

3. Resources

A comprehensive set of development tools and application notes, and datasheets are available for download on http://www.atmel.com/avr.

4. About Code Examples

This documentation contains simple code examples that briefly show how to use various parts of the device. Be aware that not all C compiler vendors include bit definitions in the header files and interrupt handling in C is compiler dependent. Please confirm with the C compiler documentation for more details.

These code examples assume that the part specific header file is included before compilation. For I/O registers located in extended I/O map, "IN", "OUT", "SBIS", "SBIC", "CBI", and "SBI" instructions must be replaced with instructions that allow access to extended I/O. Typically "LDS" and "STS" combined with "SBRS", "SBRC", "SBR", and "CBR".

5. Data Retention

Reliability Qualification results show that the projected data retention failure rate is much less than 1 ppm over 20 years at 85°C or 100 years at 25°C.

6. Capacitive touch sensing

The Atmel®QTouch® Library provides a simple to use solution to realize touch sensitive interfaces on most Atmel AVR® microcontrollers. The QTouch Library includes support for the QTouch and QMatrix® acquisition methods.

Touch sensing can be added to any application by linking the appropriate Atmel QTouch Library for the AVR Microcontroller. This is done by using a simple set of APIs to define the touch channels and sensors, and then calling the touch sensing API's to retrieve the channel information and determine the touch sensor states.

The QTouch Library is FREE and downloadable from the Atmel website at the following location: www.atmel.com/qtouchlibrary. For implementation details and other information, refer to the Atmel QTouch Library User Guide - also available for download from the Atmel website.

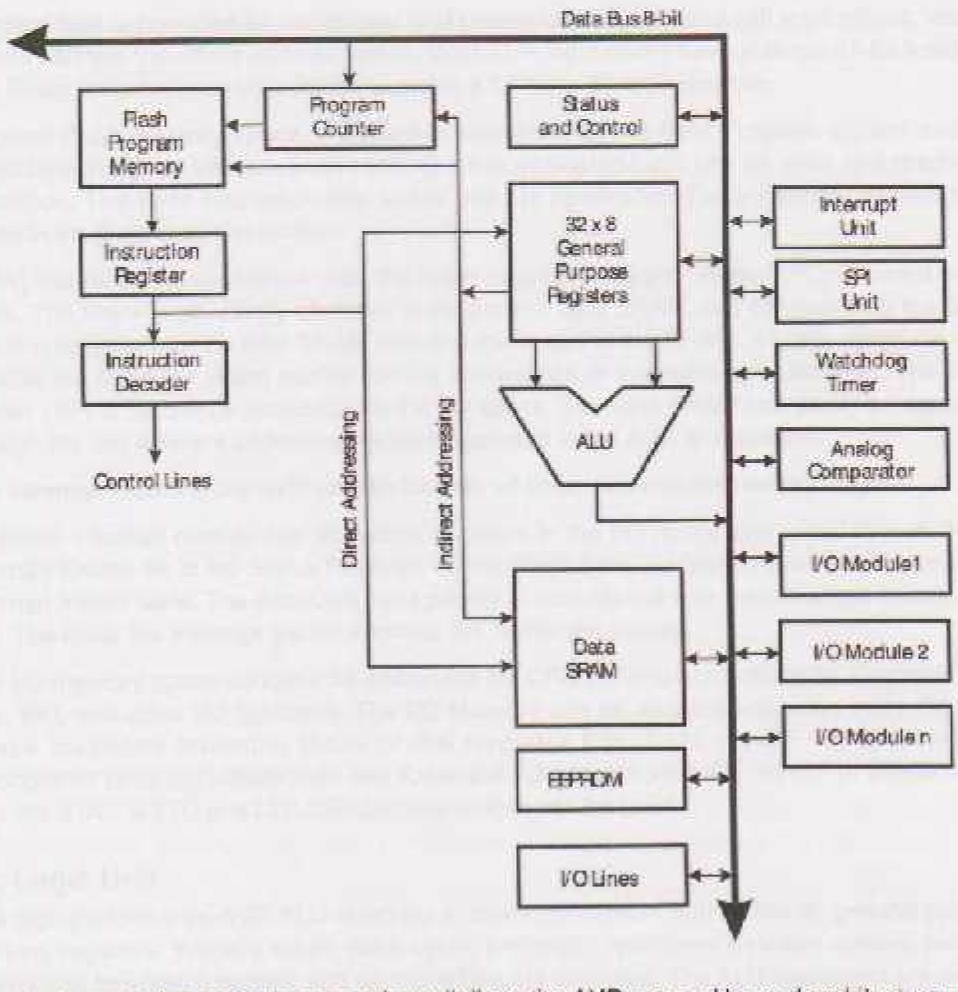
7. AVR CPU Core

7.1 Introduction

This section discusses the AVR core architecture in general. The main function of the CPU core is to ensure correct program execution. The CPU must therefore be able to access memories, perform calculations, control peripherals, and handle interrupts.

7.2 Architectural Overview

Figure 7-1. Block Diagram of the AVR Architecture



In order to maximize performance and parallelism, the AVR uses a Harvard architecture – with separate memories and buses for program and data. Instructions in the program memory are executed with a single level pipelining. While one instruction is being executed, the next instruction is pre-fetched from the program memory. This concept enables instructions to be executed in every clock cycle. The program memory is In-System Reprogrammable Flash memory.

The fast-access Register File contains 32 × 8-bit general purpose working registers with a single clock cycle access time. This allows single-cycle Arithmetic Logic Unit (ALU) operation. In a typical ALU operation, two operands are output from the Register File, the operation is executed, and the result is stored back in the Register File – in one clock cycle.

Six of the 32 registers can be used as three 16-bit indirect address register pointers for Data Space addressing – enabling efficient address calculations. One of the these address pointers can also be used as an address pointer for look up tables in Flash program memory. These added function registers are the 16-bit X-, Y-, and Z-register, described later in this section.

The ALU supports arithmetic and logic operations between registers or between a constant and a register. Single register operations can also be executed in the ALU. After an arithmetic operation, the Status Register is updated to reflect information about the result of the operation.

Program flow is provided by conditional and unconditional jump and call instructions, able to directly address the whole address space. Most AVR instructions have a single 16-bit word format. Every program memory address contains a 16-bit or 32-bit instruction.

Program Flash memory space is divided in two sections, the Boot Program section and the Application Program section. Both sections have dedicated Lock bits for write and read/write protection. The SPM instruction that writes into the Application Flash memory section must reside in the Boot Program section.

During interrupts and subroutine calls, the return address Program Counter (PC) is stored on the Stack. The Stack is effectively allocated in the general data SRAM, and consequently the Stack size is only limited by the total SRAM size and the usage of the SRAM. All user programs must initialize the SP in the Reset routine (before subroutines or interrupts are executed). The Stack Pointer (SP) is read/write accessible in the I/O space. The data SRAM can easily be accessed through the five different addressing modes supported in the AVR architecture.

The memory spaces in the AVR architecture are all linear and regular memory maps.

A flexible interrupt module has its control registers in the I/O space with an additional Global Interrupt Enable bit in the Status Register. All interrupts have a separate Interrupt Vector in the Interrupt Vector table. The interrupts have priority in accordance with their Interrupt Vector position. The lower the Interrupt Vector address, the higher the priority.

The I/O memory space contains 64 addresses for CPU peripheral functions as Control Registers, SPI, and other I/O functions. The I/O Memory can be accessed directly, or as the Data Space locations following those of the Register File, 0x20 - 0x5F. In addition, the ATmega640/1280/1281/2560/2561 has Extended I/O space from 0x60 - 0x1FF in SRAM where only the ST/STS/STD and LD/LDS/LDD instructions can be used.

7.3 ALU – Arithmetic Logic Unit

The high-performance AVR ALU operates in direct connection with all the 32 general purpose working registers. Within a single clock cycle, arithmetic operations between general purpose registers or between a register and an immediate are executed. The ALU operations are divided into three main categories – arithmetic, logical, and bit-functions. Some implementations of the architecture also provide a powerful multiplier supporting both signed/unsigned multiplication and fractional format. See the "Instruction Set Summary" on page 416 for a detailed description.

7.4 Status Register

The Status Register contains information about the result of the most recently executed arithmetic instruction. This information can be used for altering program flow in order to perform conditional operations. Note that the Status Register is updated after all ALU operations, as specified in the "Instruction Set Summary" on page 416. This will in many cases remove the need for using the dedicated compare instructions, resulting in faster and more compact code.

The Status Register is not automatically stored when entering an interrupt routine and restored when returning from an interrupt. This must be handled by software.

7.4.1 SREG – AVR Status Register

The AVR Status Register – SREG – is defined as:

Bit	7	6	5	4	3	2	1	0	
0x3F (0x5F)	I	T	H	S	V	N	Z	C	SREG
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	
Initial Value	0	0	0	0	0	0	0	0	

- **Bit 7 – I: Global Interrupt Enable**

The Global Interrupt Enable bit must be set for the interrupts to be enabled. The individual interrupt enable control is then performed in separate control registers. If the Global Interrupt Enable Register is cleared, none of the interrupts are enabled independent of the individual interrupt enable settings. The I-bit is cleared by hardware after an interrupt has occurred, and is set by the RETI instruction to enable subsequent interrupts. The I-bit can also be set and cleared by the application with the SEI and CLI instructions, as described in the "Instruction Set Summary" on page 416.

- **Bit 6 – T: Bit Copy Storage**

The Bit Copy instructions BLD (Bit LoaD) and BST (Bit STore) use the T-bit as source or destination for the operated bit. A bit from a register in the Register File can be copied into T by the BST instruction, and a bit in T can be copied into a bit in a register in the Register File by the BLD instruction.

- **Bit 5 – H: Half Carry Flag**

The Half Carry Flag H indicates a Half Carry in some arithmetic operations. Half Carry is useful in BCD arithmetic. See the "Instruction Set Summary" on page 416 for detailed information.

- **Bit 4 – S: Sign Bit, $S = N \oplus V$**

The S-bit is always an exclusive or between the Negative Flag N and the Two's Complement Overflow Flag V. See the "Instruction Set Summary" on page 416 for detailed information.

- **Bit 3 – V: Two's Complement Overflow Flag**

The Two's Complement Overflow Flag V supports two's complement arithmetics. See the "Instruction Set Summary" on page 416 for detailed information.

- **Bit 2 – N: Negative Flag**

The Negative Flag N indicates a negative result in an arithmetic or logic operation. See the "Instruction Set Summary" on page 416 for detailed information.

- **Bit 1 – Z: Zero Flag**

The Zero Flag Z indicates a zero result in an arithmetic or logic operation. See the "Instruction Set Summary" on page 416 for detailed information.

- **Bit 0 – C: Carry Flag**

The Carry Flag C indicates a carry in an arithmetic or logic operation. See the "Instruction Set Summary" on page 416 for detailed information.

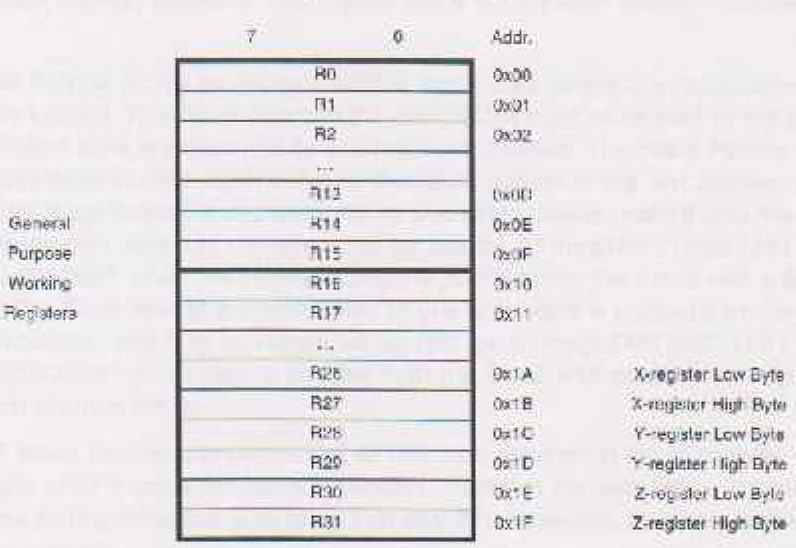
7.5 General Purpose Register File

The Register File is optimized for the AVR Enhanced RISC instruction set. In order to achieve the required performance and flexibility, the following input/output schemes are supported by the Register File:

- One 8-bit output operand and one 8-bit result input
- Two 8-bit output operands and one 8-bit result input
- Two 8-bit output operands and one 16-bit result input
- One 16-bit output operand and one 16-bit result input

Figure 7-2 shows the structure of the 32 general purpose working registers in the CPU.

Figure 7-2. AVR CPU General Purpose Working Registers



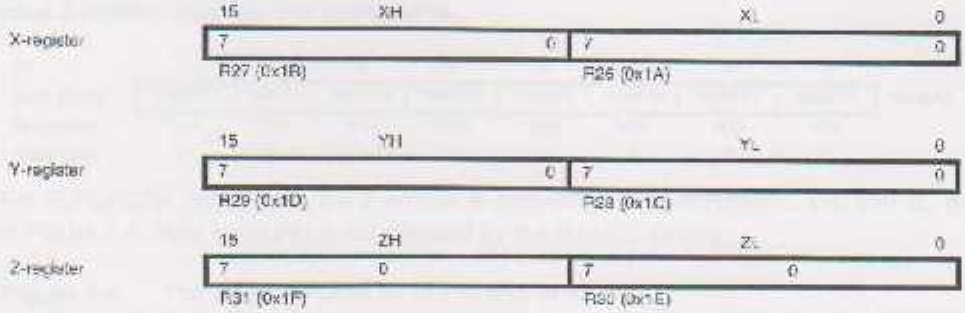
Most of the instructions operating on the Register File have direct access to all registers, and most of them are single cycle instructions.

As shown in Figure 7-2, each register is also assigned a data memory address, mapping them directly into the first 32 locations of the user Data Space. Although not being physically implemented as SRAM locations, this memory organization provides great flexibility in access of the registers, as the X-, Y- and Z-pointer registers can be set to index any register in the file.

7.5.1 The X-register, Y-register, and Z-register

The registers R26..R31 have some added functions to their general purpose usage. These registers are 16-bit address pointers for indirect addressing of the data space. The three indirect address registers X, Y, and Z are defined as described in Figure 7-3 on page 16.

Figure 7-3. The X-, Y-, and Z-registers



In the different addressing modes these address registers have functions as fixed displacement, automatic increment, and automatic decrement (see the "Instruction Set Summary" on page 416 for details).

7.6 Stack Pointer

The Stack is mainly used for storing temporary data, for storing local variables and for storing return addresses after interrupts and subroutine calls. The Stack Pointer Register always points to the top of the Stack. Note that the Stack is implemented as growing from higher memory locations to lower memory locations. This implies that a Stack PUSH command decreases the Stack Pointer.

The Stack Pointer points to the data SRAM Stack area where the Subroutine and Interrupt Stacks are located. This Stack space in the data SRAM must be defined by the program before any subroutine calls are executed or interrupts are enabled. The Stack Pointer must be set to point above 0x0200. The initial value of the stack pointer is the last address of the internal SRAM. The Stack Pointer is decremented by one when data is pushed onto the Stack with the PUSH instruction, and it is decremented by two for ATmega640/1280/1281 and three for ATmega2560/2561 when the return address is pushed onto the Stack with subroutine call or interrupt. The Stack Pointer is incremented by one when data is popped from the Stack with the POP instruction, and it is incremented by two for ATmega640/1280/1281 and three for ATmega2560/2561 when data is popped from the Stack with return from subroutine RET or return from interrupt RETI.

The AVR Stack Pointer is implemented as two 8-bit registers in the I/O space. The number of bits actually used is implementation dependent. Note that the data space in some implementations of the AVR architecture is so small that only SPL is needed. In this case, the SPH Register will not be present.

Bit	15	14	13	12	11	10	9	8	
0x3E (0x5E)	SP15	SP14	SP13	SP12	SP11	SP10	SP9	SP8	SPH
0x3D (0x5D)	SP7	SP6	SP5	SP4	SP3	SP2	SP1	SP0	SPL
	7	6	5	4	3	2	1	0	
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	
	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	
Initial Value	0	0	1	0	0	0	0	1	
	1	1	1	1	1	1	1	1	

7.5.1 RAMPZ – Extended Z-pointer Register for ELPM/SPM

Bit	7	6	5	4	3	2	1	0	
0x3B (0x5B)	RAMPZ7	RAMPZ6	RAMPZ5	RAMPZ4	RAMPZ3	RAMPZ2	RAMPZ1	RAMPZ0	RAMPZ
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	
Initial Value	0	0	0	0	0	0	0	0	

For ELPM/SPM instructions, the Z-pointer is a concatenation of RAMPZ, ZH, and ZL, as shown in Figure 7-4. Note that LPM is not affected by the RAMPZ setting.

Figure 7-4. The Z-pointer used by ELPM and SPM

Bit (Individually)	7		0	7		0	7		0
		RAMPZ			ZH			ZL	
Bit (Z-pointer)	23		16	15		8	7		0

The actual number of bits is implementation dependent. Unused bits in an implementation will always read as zero. For compatibility with future devices, be sure to write these bits to zero.

7.5.2 EIND – Extended Indirect Register

Bit	7	6	5	4	3	2	1	0	
0x3C (0x5C)	EIND7	EIND6	EIND5	EIND4	EIND3	EIND2	EIND1	EIND0	EIND
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	
Initial Value	0	0	0	0	0	0	0	0	

For EICALL/EIJMP instructions, the Indirect-pointer to the subroutine/routine is a concatenation of EIND, ZH, and ZL, as shown in Figure 7-5. Note that ICALL and IJMP are not affected by the EIND setting.

Figure 7-5. The Indirect-pointer used by EICALL and EIJMP

Bit (Individually)	7		0	7		0	7		0
		EIND			ZH			ZL	
Bit (Indirect-pointer)	23		16	15		8	7		0

The actual number of bits is implementation dependent. Unused bits in an implementation will always read as zero. For compatibility with future devices, be sure to write these bits to zero.

7.6 Instruction Execution Timing

This section describes the general access timing concepts for instruction execution. The AVR CPU is driven by the CPU clock clk_{CPU}, directly generated from the selected clock source for the chip. No internal clock division is used.

Figure 7-6 on page 18 shows the parallel instruction fetches and instruction executions enabled by the Harvard architecture and the fast-access Register File concept. This is the basic pipelining concept to obtain up to 1 MIPS per MHz with the corresponding unique results for functions per cost, functions per clocks, and functions per power-unit.

Figure 7-6. The Parallel Instruction Fetches and Instruction Executions

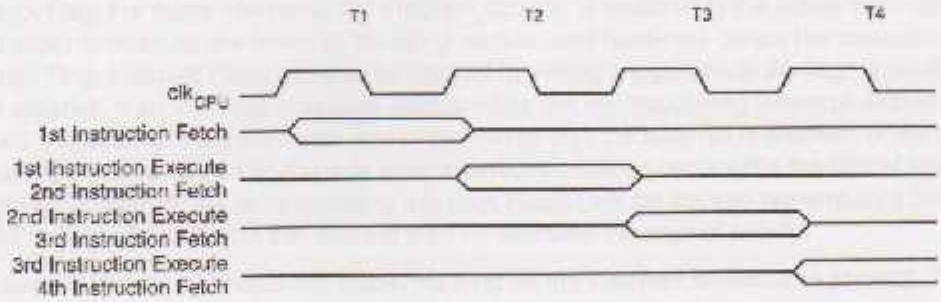
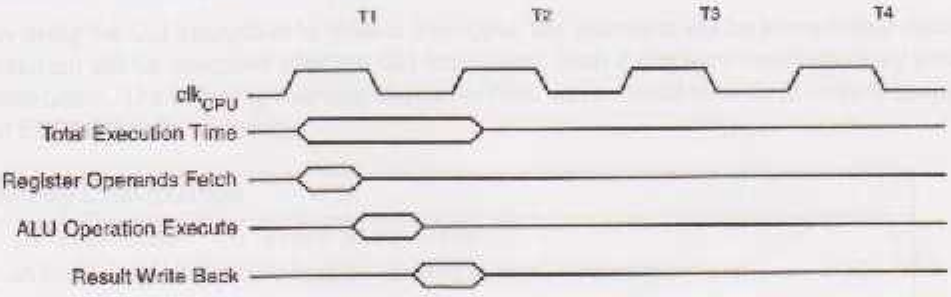


Figure 7-7 shows the internal timing concept for the Register File. In a single clock cycle an ALU operation using two register operands is executed, and the result is stored back to the destination register.

Figure 7-7. Single Cycle ALU Operation



7.8 Reset and Interrupt Handling

The AVR provides several different interrupt sources. These interrupts and the separate Reset Vector each have a separate program vector in the program memory space. All interrupts are assigned individual enable bits which must be written logic one together with the Global Interrupt Enable bit in the Status Register in order to enable the interrupt. Depending on the Program Counter value, interrupts may be automatically disabled when Boot Lock bits BLB02 or BLB12 are programmed. This feature improves software security. See the section "Memory Programming" on page 335 for details.

The lowest addresses in the program memory space are by default defined as the Reset and Interrupt Vectors. The complete list of vectors is shown in "Interrupts" on page 105. The list also determines the priority levels of the different interrupts. The lower the address the higher is the priority level. RESET has the highest priority, and next is INT0 – the External Interrupt Request 0. The Interrupt Vectors can be moved to the start of the Boot Flash section by setting the IVSEL bit in the MCU Control Register (MCUCR). Refer to "Interrupts" on page 105 for more information. The Reset Vector can also be moved to the start of the Boot Flash section by programming the BOOTRST Fuse, see "Memory Programming" on page 335.

When an interrupt occurs, the Global Interrupt Enable I-bit is cleared and all interrupts are disabled. The user software can write logic one to the I-bit to enable nested interrupts. All enabled interrupts can then interrupt the current interrupt routine. The I-bit is automatically set when a Return from Interrupt instruction – RETI – is executed.

There are basically two types of interrupts. The first type is triggered by an event that sets the Interrupt Flag. For these interrupts, the Program Counter is vectored to the actual Interrupt Vector in order to execute the interrupt handling routine, and hardware clears the corresponding Interrupt Flag. Interrupt Flags can also be cleared by writing a logic one to the flag bit position(s) to be cleared. If an interrupt condition occurs while the corresponding interrupt enable bit is cleared, the Interrupt Flag will be set and remembered until the interrupt is enabled, or the flag is cleared by software. Similarly, if one or more interrupt conditions occur while the Global Interrupt Enable bit is cleared, the corresponding Interrupt Flag(s) will be set and remembered until the Global Interrupt Enable bit is set, and will then be executed by order of priority.

The second type of interrupts will trigger as long as the interrupt condition is present. These interrupts do not necessarily have Interrupt Flags. If the interrupt condition disappears before the interrupt is enabled, the interrupt will not be triggered.

When the AVR exits from an interrupt, it will always return to the main program and execute one more instruction before any pending interrupt is served.

Note that the Status Register is not automatically stored when entering an interrupt routine, nor restored when returning from an interrupt routine. This must be handled by software.

When using the CLI instruction to disable interrupts, the interrupts will be immediately disabled. No interrupt will be executed after the CLI instruction, even if it occurs simultaneously with the CLI instruction. The following example shows how this can be used to avoid interrupts during the timed EEPROM write sequence.

Assembly Code Example

```
in r16, SREG      ; store SREG value
cli    ; disable interrupts during timed sequence
sbi EECR, EEMPE   ; start EEPROM write
sbi EECR, EEPE
out SREG, r16     ; restore SREG value (I-bit)
```

C Code Example

```
char cSREG;
cSREG = SREG; /* store SREG value */
/* disable interrupts during timed sequence */
__disable_interrupt();
EECR |= (1<<EEMPE); /* start EEPROM write */
EECR |= (1<<EEPE);
SREG = cSREG; /* restore SREG value (I-bit) */
```

When using the SEI instruction to enable interrupts, the instruction following SEI will be executed before any pending interrupts, as shown in this example.

Assembly Code Example

`sei ; set Global Interrupt Enable`
`sleep; enter sleep, waiting for interrupt`
`; note: will enter sleep before any pending`
`; interrupt(s)`

C Code Example

`__enable_interrupt(); /* set Global Interrupt Enable */`
`__sleep(); /* enter sleep, waiting for interrupt */`
`/* note: will enter sleep before any pending interrupt(s) */`

7.8.1 Interrupt Response Time

The interrupt execution response for all the enabled AVR interrupts is five clock cycles minimum. After five clock cycles the program vector address for the actual interrupt handling routine is executed. During these five clock cycle period, the Program Counter is pushed onto the Stack. The vector is normally a jump to the interrupt routine, and this jump takes three clock cycles. If an interrupt occurs during execution of a multi-cycle instruction, this instruction is completed before the interrupt is served. If an interrupt occurs when the MCU is in sleep mode, the interrupt execution response time is increased by five clock cycles. This increase comes in addition to the start-up time from the selected sleep mode.

A return from an interrupt handling routine takes five clock cycles. During these five clock cycles, the Program Counter (three bytes) is popped back from the Stack, the Stack Pointer is incremented by three, and the I-bit in SREG is set.

L298

DUAL FULL-BRIDGE DRIVER

- OPERATING SUPPLY VOLTAGE UP TO 46 V
- TOTAL DC CURRENT UP TO 4 A
- LOW SATURATION VOLTAGE
- OVERTEMPERATURE PROTECTION
- LOGICAL "0" INPUT VOLTAGE UP TO 1.5 V (HIGH NOISE IMMUNITY)

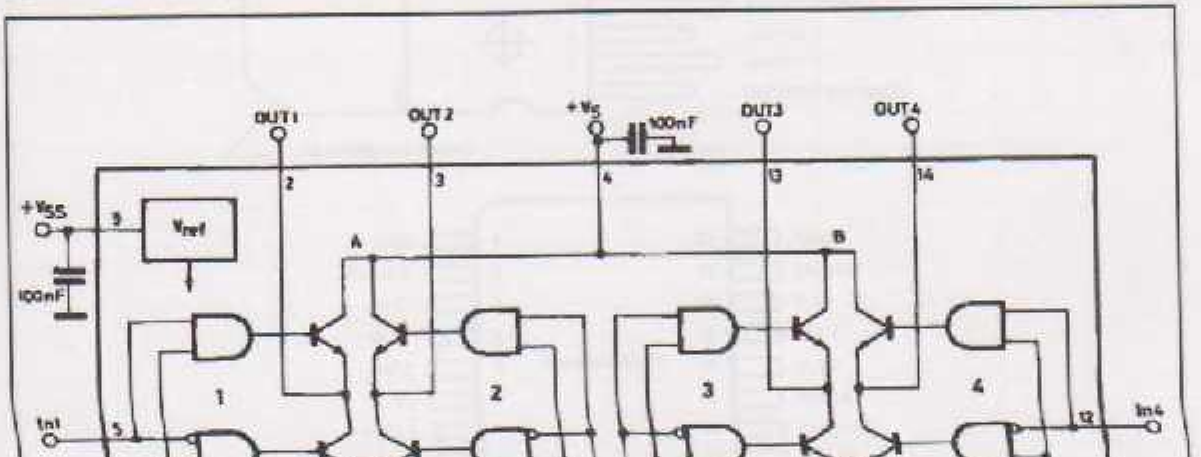
Multiwatt15 PowerSO20

ORDERING NUMBERS : L298N (Multiwatt Vert.)
L298HN (Multiwatt Horiz.)
L298P (PowerSO20)

DESCRIPTION

The L298 is an integrated monolithic circuit in a 15-lead Multiwatt and PowerSO20 packages. It is a high voltage, high current dual full-bridge driver designed to accept standard TTL logic levels and drive inductive loads such as relays, solenoids, DC and stepping motors. Two enable inputs are provided to enable or disable the device independently of the input signals. The emitters of the lower transistors of each bridge are connected together and the corresponding external terminal can be used for the connection of an external sensing resistor. An additional supply input is provided so that the logic works at a lower voltage.

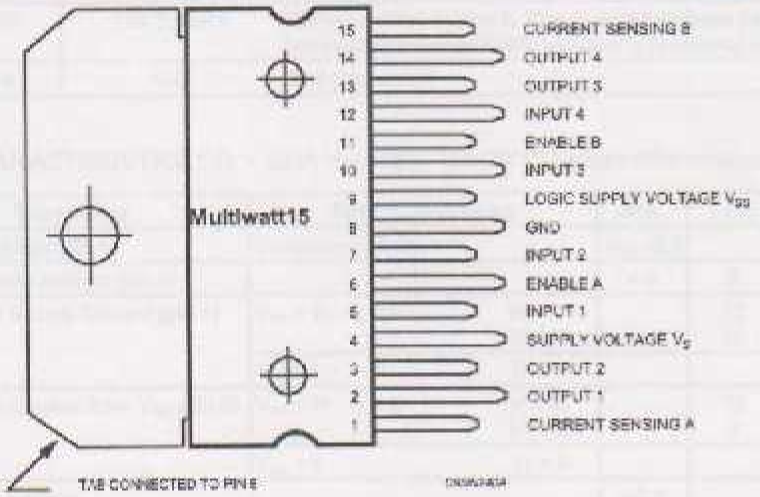
BLOCK DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_S	Power Supply	50	V
V_{SS}	Logic Supply Voltage	7	V
V_I, V_{en}	Input and Enable Voltage	–0.3 to 7	V
I_O	Peak Output Current (each Channel) – Non Repetitive (t = 100μs) –Repetitive (80% on –20% off; t_{on} = 10ms) –DC Operation	 3 2.5 2	 A A A
V_{sens}	Sensing Voltage	–1 to 2.3	V
P_{tot}	Total Power Dissipation (T_{case} = 75°C)	25	W
T_{op}	Junction Operating Temperature	–25 to 130	°C
T_{stg}, T_j	Storage and Junction Temperature	–40 to 150	°C

PIN CONNECTIONS (top view)



THERMAL DATA

Symbol	Parameter		PowerSO20	Multiwatt15	Unit
$R_{th\ j\text{-}case}$	Thermal Resistance Junction-case	Max.	–	3	°C/W
$R_{th\ j\text{-}amb}$	Thermal Resistance Junction-ambient	Max.	13 (*)	35	°C/W

(*) Mounted on aluminum substrate

PIN FUNCTIONS (refer to the block diagram)

MW.15	PowerSO	Name	Function
1;15	2;19	Sense A; Sense B	Between this pin and ground is connected the sense resistor to control the current of the load.
2;3	4;5	Out 1; Out 2	Outputs of the Bridge A; the current that flows through the load connected between these two pins is monitored at pin 1.
4	6	V_S	Supply Voltage for the Power Output Stages. A non-inductive 100nF capacitor must be connected between this pin and ground.
5;7	7;9	Input 1; Input 2	TTL Compatible Inputs of the Bridge A.
6;11	8;14	Enable A; Enable B	TTL Compatible Enable Input: the L state disables the bridge A (enable A) and/or the bridge B (enable B).
8	1,10,11,20	GND	Ground.
9	12	VSS	Supply Voltage for the Logic Blocks. A100nF capacitor must be connected between this pin and ground.
10; 12	13;15	Input 3; Input 4	TTL Compatible Inputs of the Bridge B.
13; 14	16;17	Out 3; Out 4	Outputs of the Bridge B. The current that flows through the load connected between these two pins is monitored at pin 15.
–	3;18	N.C.	Not Connected

ELECTRICAL CHARACTERISTICS (V_S = 42V; V_{SS} = 5V, T_j = 25°C; unless otherwise specified)

Symbol	Parameter	Test Conditions		Min.	Typ.	Max.	Unit
V_S	Supply Voltage (pin 4)	Operative Condition		V_{IH} +2.5		46	V
V_{SS}	Logic Supply Voltage (pin 9)			4.5	5	7	V
I_S	Quiescent Supply Current (pin 4)	V_{en} = H; I_L = 0	V_i = L V_i = H		13 50	22 70	mA mA
		V_{en} = L	V_i = X			4	mA
I_{SS}	Quiescent Current from V_{SS} (pin 9)	V_{en} = H; I_L = 0	V_i = L V_i = H		24 7	36 12	mA mA
		V_{en} = L	V_i = X			6	mA
V_{iL}	Input Low Voltage (pins 5, 7, 10, 12)			–0.3		1.5	V
V_{iH}	Input High Voltage (pins 5, 7, 10, 12)			2.3		VSS	V
I_{iL}	Low Voltage Input Current (pins 5, 7, 10, 12)	V_i = L				–10	μA
I_{iH}	High Voltage Input Current (pins 5, 7, 10, 12)	Vi = H ≤ V_{SS} –0.6V			30	100	μA
V_{en} = L	Enable Low Voltage (pins 6, 11)			–0.3		1.5	V
V_{en} = H	Enable High Voltage (pins 6, 11)			2.3		V_{SS}	V
I_{en} = L	Low Voltage Enable Current (pins 6, 11)	V_{en} = L				–10	μA
I_{en} = H	High Voltage Enable Current (pins 6, 11)	V_{en} = H ≤ V_{SS} –0.6V			30	100	μA
$V_{CEsat(H)}$	Source Saturation Voltage	I_L = 1A I_L = 2A		0.95	1.35 2	1.7 2.7	V V
$V_{CEsat(L)}$	Sink Saturation Voltage	I_L = 1A (5) I_L = 2A (5)		0.85	1.2 1.7	1.6 2.3	V V
V_{CEsat}	Total Drop	I_L = 1A (5) I_L = 2A (5)		1.80		3.2 4.9	V V
V_{sens}	Sensing Voltage (pins 1, 15)			–1 (1)		2	V

ELECTRICAL CHARACTERISTICS (continued)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
T_1 (V_i)	Source Current Turn-off Delay	0.5 V_i to 0.9 I_L (2); (4)		1.5		μs
T_2 (V_i)	Source Current Fall Time	0.9 I_L to 0.1 I_L (2); (4)		0.2		μs
T_3 (V_i)	Source Current Turn-on Delay	0.5 V_i to 0.1 I_L (2); (4)		2		μs
T_4 (V_i)	Source Current Rise Time	0.1 I_L to 0.9 I_L (2); (4)		0.7		μs
T_5 (V_i)	Sink Current Turn-off Delay	0.5 V_i to 0.9 I_L (3); (4)		0.7		μs
T_6 (V_i)	Sink Current Fall Time	0.9 I_L to 0.1 I_L (3); (4)		0.25		μs
T_7 (V_i)	Sink Current Turn-on Delay	0.5 V_i to 0.9 I_L (3); (4)		1.6		μs
T_8 (V_i)	Sink Current Rise Time	0.1 I_L to 0.9 I_L (3); (4)		0.2		μs
fc (V_i)	Commutation Frequency	I_L = 2A		25	40	KHz
T_1 (V_{en})	Source Current Turn-off Delay	0.5 V_{en} to 0.9 I_L (2); (4)		3		μs
T_2 (V_{en})	Source Current Fall Time	0.9 I_L to 0.1 I_L (2); (4)		1		μs
T_3 (V_{en})	Source Current Turn-on Delay	0.5 V_{en} to 0.1 I_L (2); (4)		0.3		μs
T_4 (V_{en})	Source Current Rise Time	0.1 I_L to 0.9 I_L (2); (4)		0.4		μs
T_5 (V_{en})	Sink Current Turn-off Delay	0.5 V_{en} to 0.9 I_L (3); (4)		2.2		μs
T_6 (V_{en})	Sink Current Fall Time	0.9 I_L to 0.1 I_L (3); (4)		0.35		μs
T_7 (V_{en})	Sink Current Turn-on Delay	0.5 V_{en} to 0.9 I_L (3); (4)		0.25		μs
T_8 (V_{en})	Sink Current Rise Time	0.1 I_L to 0.9 I_L (3); (4)		0.1		μs

1) 1)Sensing voltage can be –1 V for t ≤ 50 μsec; in steady state V_{sens} min ≥ – 0.5 V.
2) See fig. 2.
3) See fig. 4.
4) The load must be a pure resistor.

Figure 1 : Typical Saturation Voltage vs. Output Current.

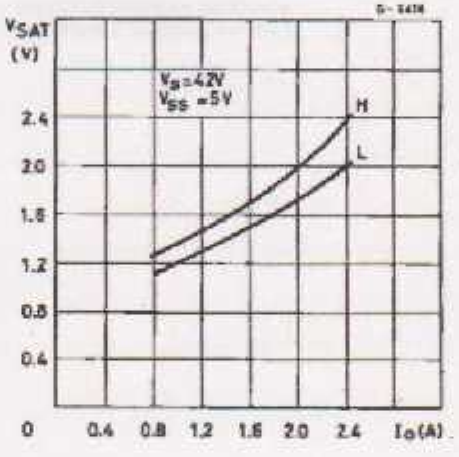
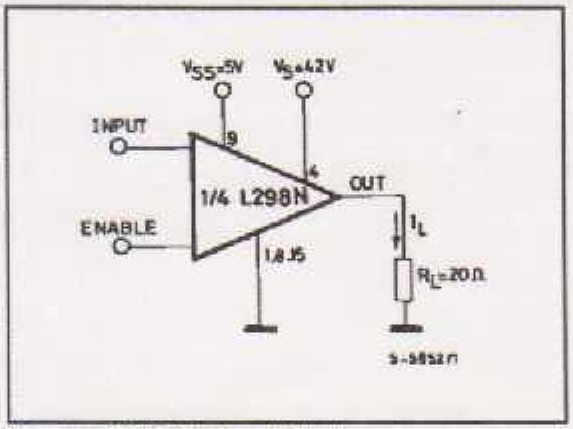


Figure 2 : Switching Times Test Circuits.



Note : For INPUT Switching, set EN = H
For ENABLE Switching set IN = H

Figure 3 : Source Current Delay Times vs. Input or Enable Switching.

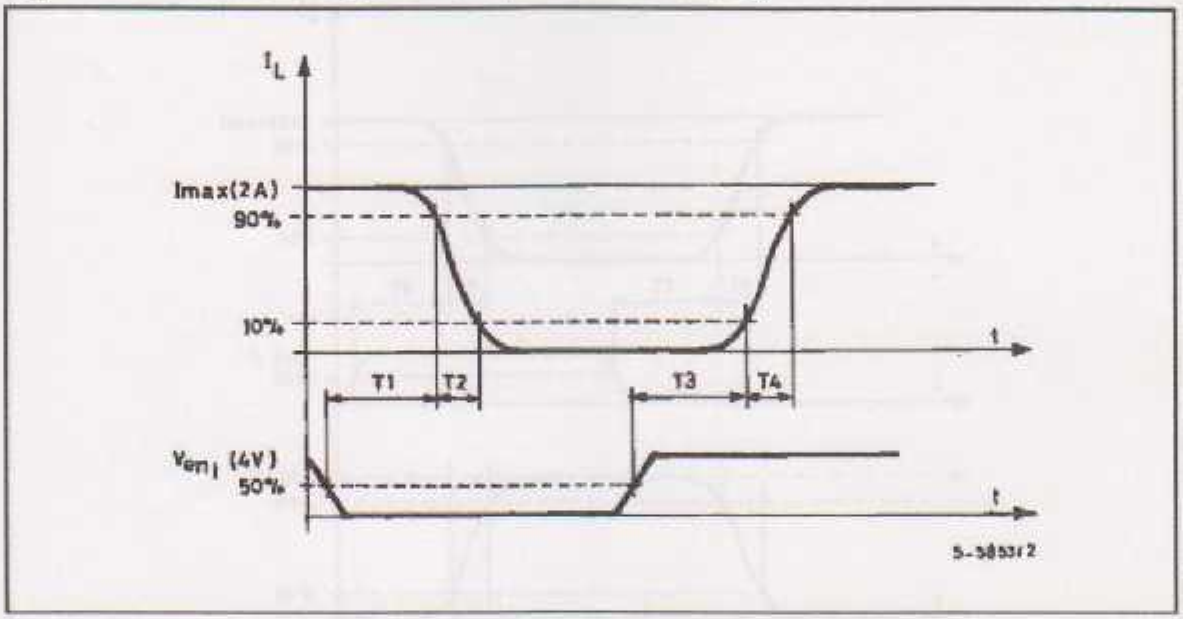
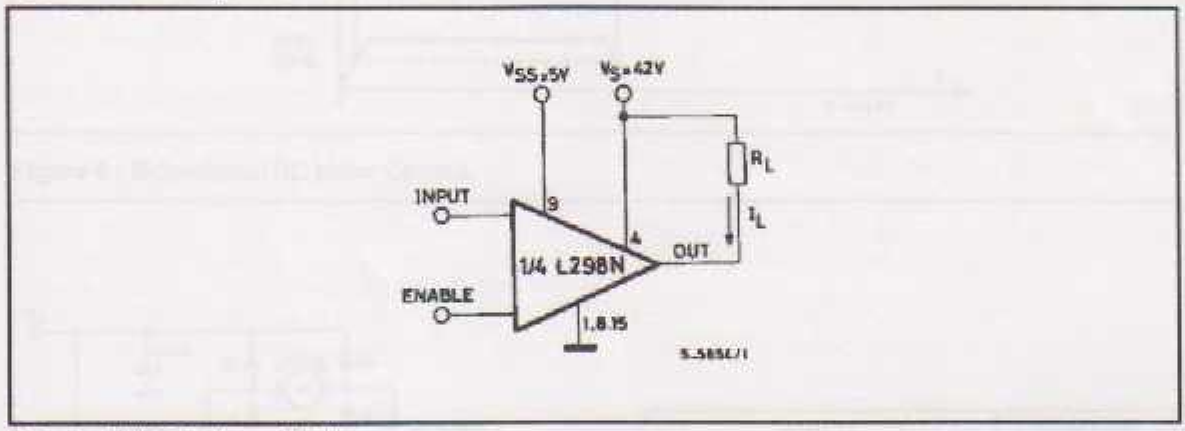


Figure 4 : Switching Times Test Circuits.



Note : For INPUT Switching, set EN = H
For ENABLE Switching, set IN = L

Figure 5 : Sink Current Delay Times vs. Input 0 V Enable Switching.

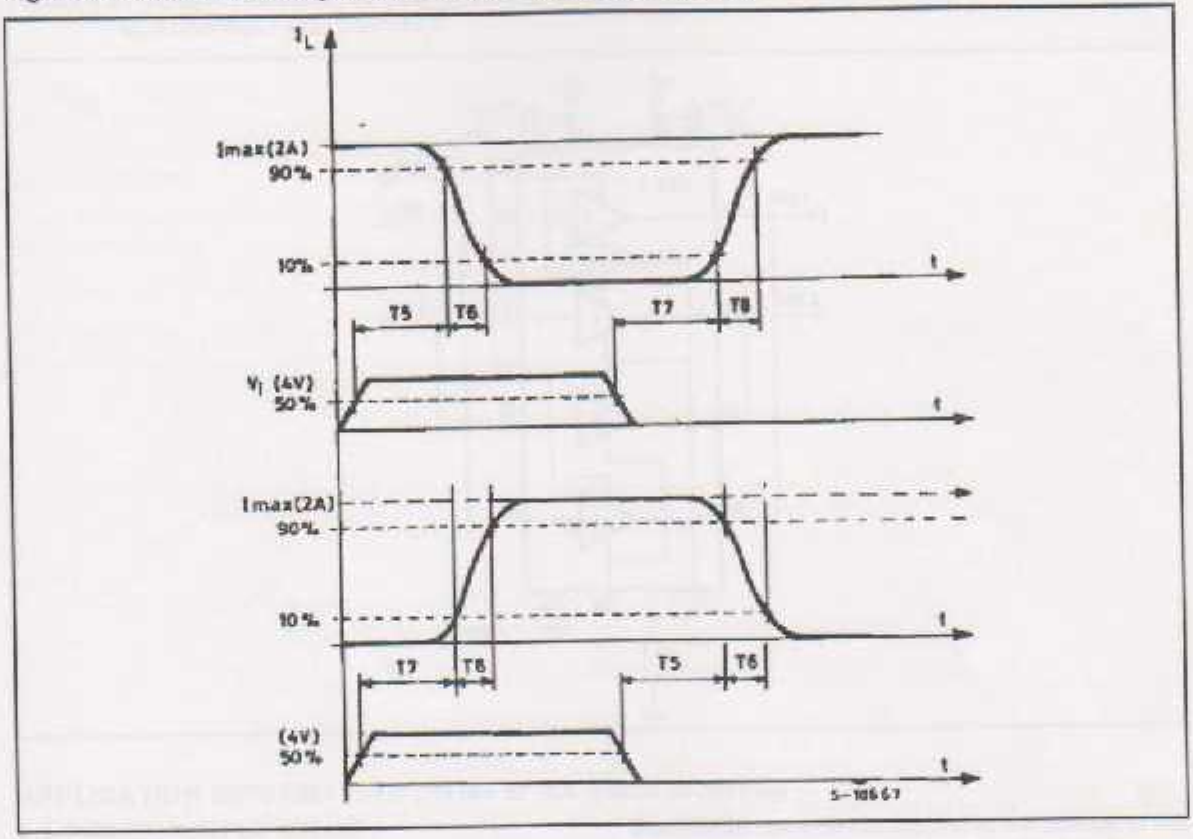
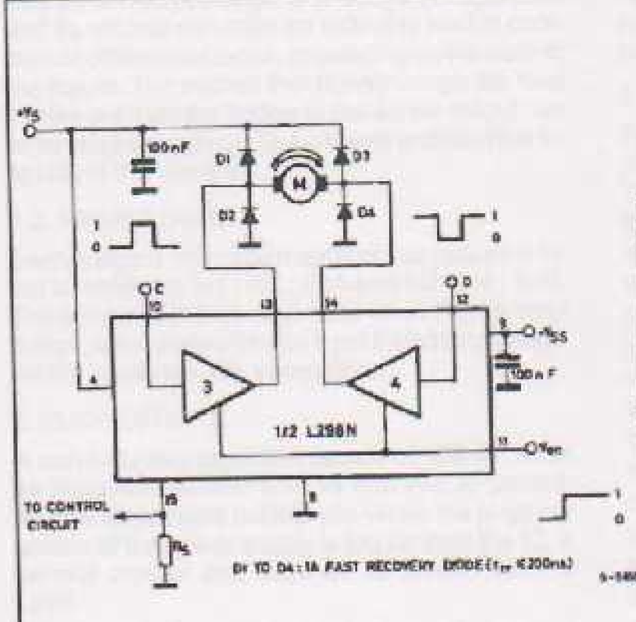


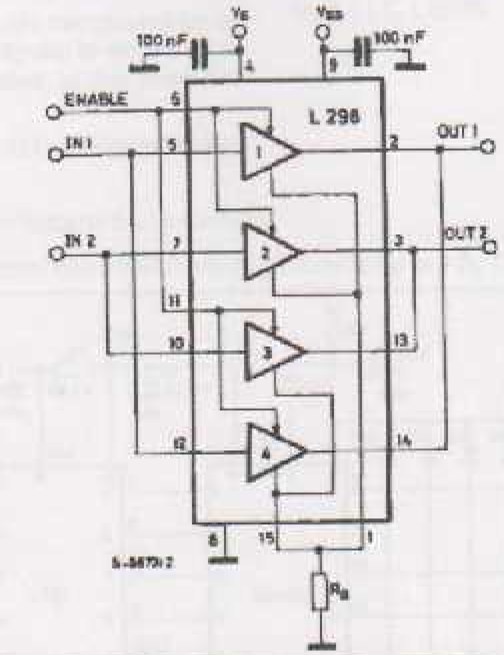
Figure 6 : Bidirectional DC Motor Control.



Inputs		Function
V_{en} = H	C = H ; D = L	Forward
	C = L ; D = H	Reverse
	C = D	Fast Motor Stop
V_{en} = L	C = X ; D = X	Free Running Motor Stop

L = Low H = High X = Don't care

Figure 7 : For higher currents, outputs can be paralleled. Take care to parallel channel 1 with channel 4 and channel 2 with channel 3.



APPLICATION INFORMATION (Refer to the block diagram)

1.1. POWER OUTPUT STAGE

The L298 integrates two power output stages (A ; B). The power output stage is a bridge configuration and its outputs can drive an inductive load in common or differenzial mode, depending on the state of the inputs. The current that flows through the load comes out from the bridge at the sense output : an external resistor (R_{SA} ; R_{SB}.) allows to detect the intensity of this current.

1.2. INPUT STAGE

Each bridge is driven by means of four gates the input of which are In1 ; In2 ; EnA and In3 ; In4 ; EnB. The In inputs set the bridge state when The En input is high ; a low state of the En input inhibits the bridge. All the inputs are TTL compatible.

2. SUGGESTIONS

A non inductive capacitor, usually of 100 nF, must be foreseen between both Vs and Vss, to ground, as near as possible to GND pin. When the large capacitor of the power supply is too far from the IC, a second smaller one must be foreseen near the L298.

The sense resistor, not of a wire wound type, must be grounded near the negative pole of Vs that must be near the GND pin of the I.C.

Each input must be connected to the source of the driving signals by means of a very short path.

Turn-On and Turn-Off : Before to Turn-ON the Supply Voltage and before to Turn it OFF, the Enable input must be driven to the Low state.

3. APPLICATIONS

Fig 6 shows a bidirectional DC motor control Schematic Diagram for which only one bridge is needed. The external bridge of diodes D1 to D4 is made by four fast recovery elements ($t_{rr} \leq 200$ nsec) that must be chosen of a VF as low as possible at the worst case of the load current.

The sense output voltage can be used to control the current amplitude by chopping the inputs, or to provide overcurrent protection by switching low the enable input.

The brake function (Fast motor stop) requires that the Absolute Maximum Rating of 2 Amps must never be overcome.

When the repetitive peak current needed from the load is higher than 2 Amps, a paralleled configuration can be chosen (See Fig.7).

An external bridge of diodes are required when inductive loads are driven and when the inputs of the IC are chopped; Shottky diodes would be preferred.

This solution can drive until 3 Amps In DC operation and until 3.5 Amps of a repetitive peak current.

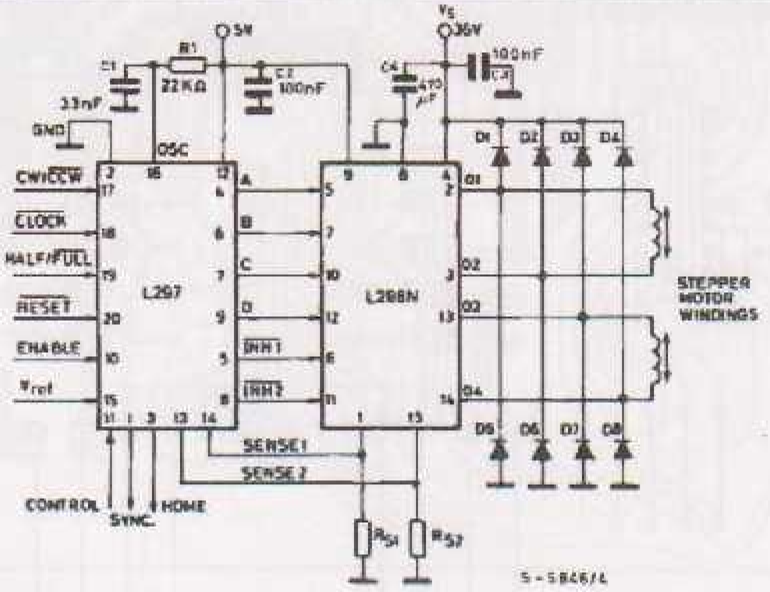
On Fig 8 It is shown the driving of a two phase bipolar stepper motor ; the needed signals to drive the inputs of the L298 are generated, in this example, from the IC L297.

Fig 9 shows an example of P.C.B. designed for the application of Fig 8.

Fig 10 shows a second two phase bipolar stepper motor control circuit where the current is controlled by the I.C. L6506.

Figure 8 : Two Phase Bipolar Stepper Motor Circuit.

This circuit drives bipolar stepper motors with winding currents up to 2 A. The diodes are fast 2 A types.



$R_{S1} = R_{S2} = 0.5\,\Omega$

D1 to D8 = 2 A Fast diodes $\{$ $V_F \leq 1.2$ V @ I = 2 A; trr $\leq$ 200 ns

Figure 9 : Suggested Printed Circuit Board Layout for the Circuit of fig. 8 (1:1 scale).

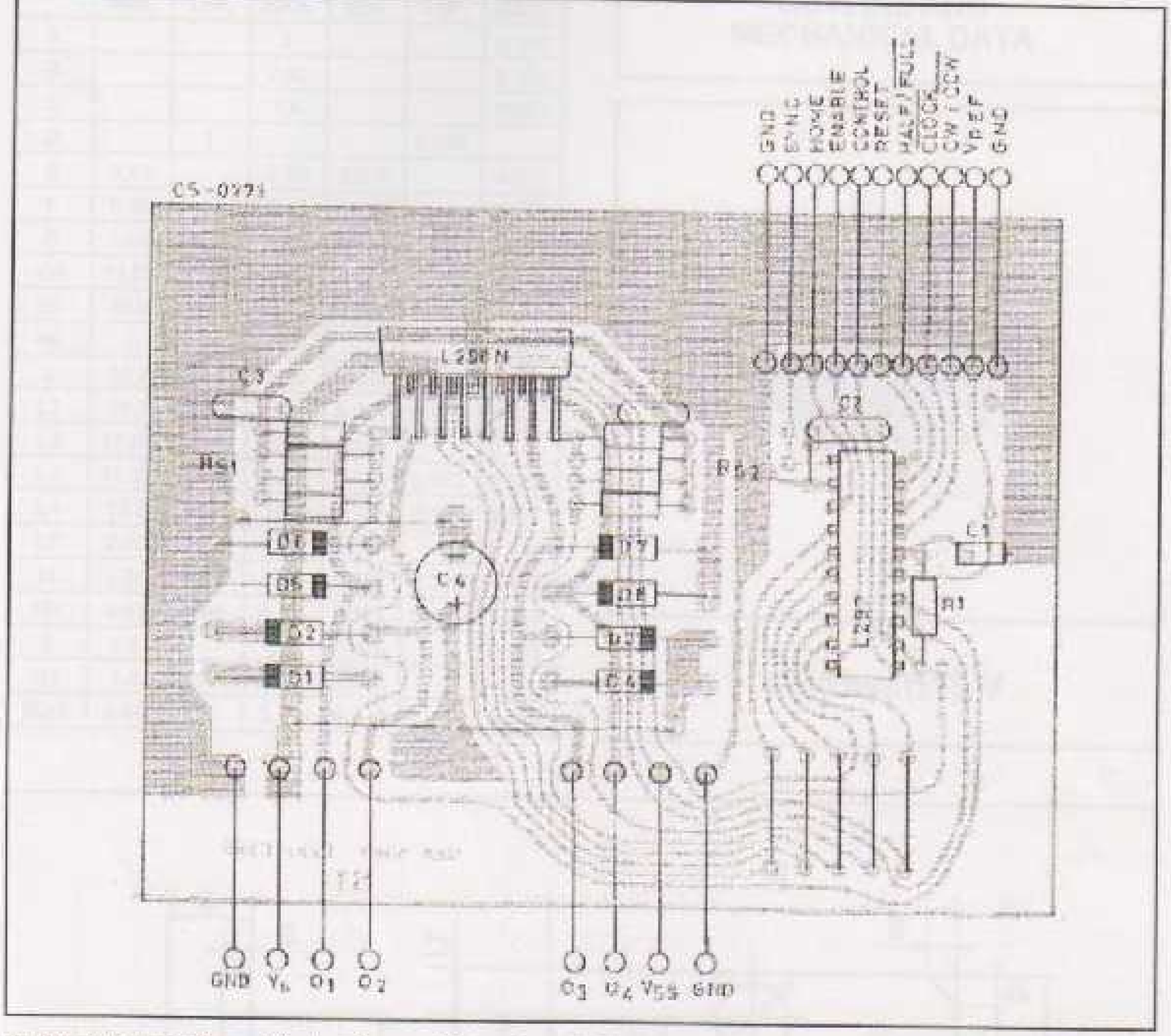
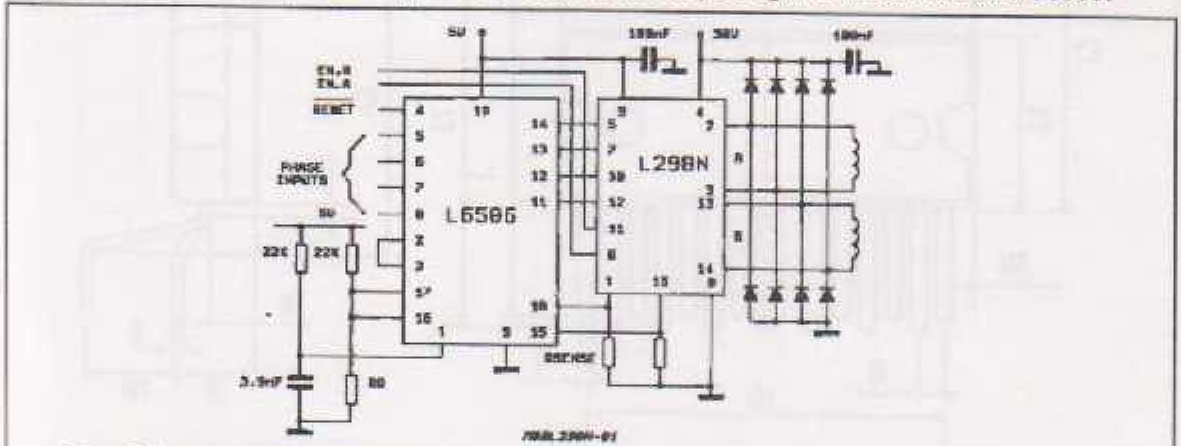


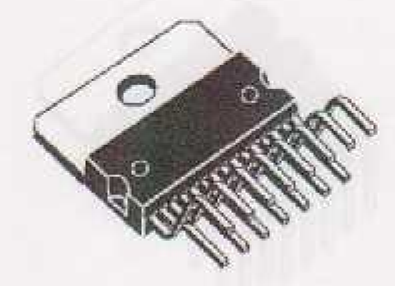
Figure 10 : Two Phase Bipolar Stepper Motor Control Circuit by Using the Current Controller L6506.



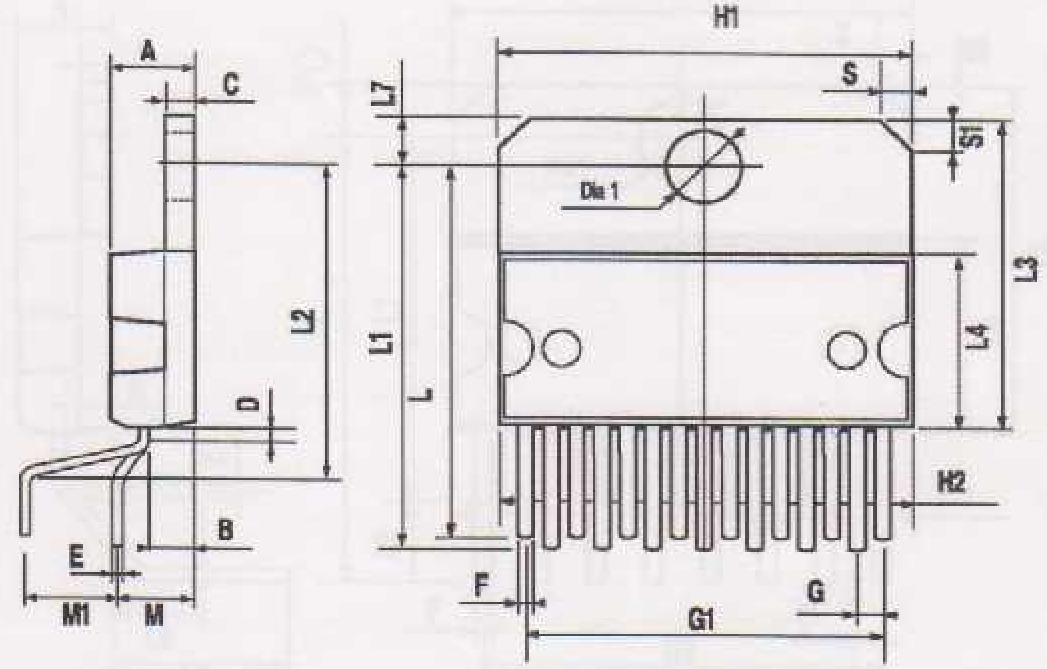
R_R and R_{sense} depend from the load current

DIM.	mm			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A			5			0.197
B			2.65			0.104
C			1.6			0.063
D		1			0.039	
E	0.49		0.55	0.019		0.022
F	0.66		0.75	0.026		0.030
G	1.02	1.27	1.52	0.040	0.050	0.060
G1	17.53	17.78	18.03	0.690	0.700	0.710
H1	19.6			0.772		
H2			20.2			0.795
L	21.9	22.2	22.5	0.862	0.874	0.886
L1	21.7	22.1	22.5	0.854	0.870	0.886
L2	17.65		18.1	0.695		0.713
L3	17.25	17.5	17.75	0.679	0.689	0.699
L4	10.3	10.7	10.9	0.406	0.421	0.429
L7	2.65		2.9	0.104		0.114
M	4.25	4.55	4.85	0.167	0.179	0.191
M1	4.63	5.08	5.53	0.182	0.200	0.218
S	1.9		2.6	0.075		0.102
S1	1.9		2.6	0.075		0.102
Dia1	3.65		3.85	0.144		0.152

OUTLINE AND MECHANICAL DATA

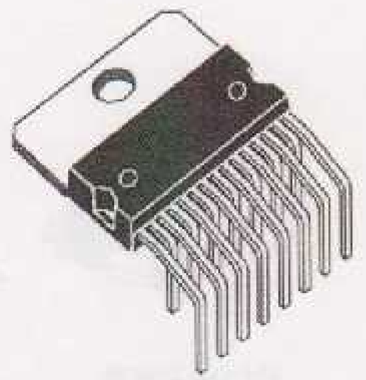


Multiwatt15 V

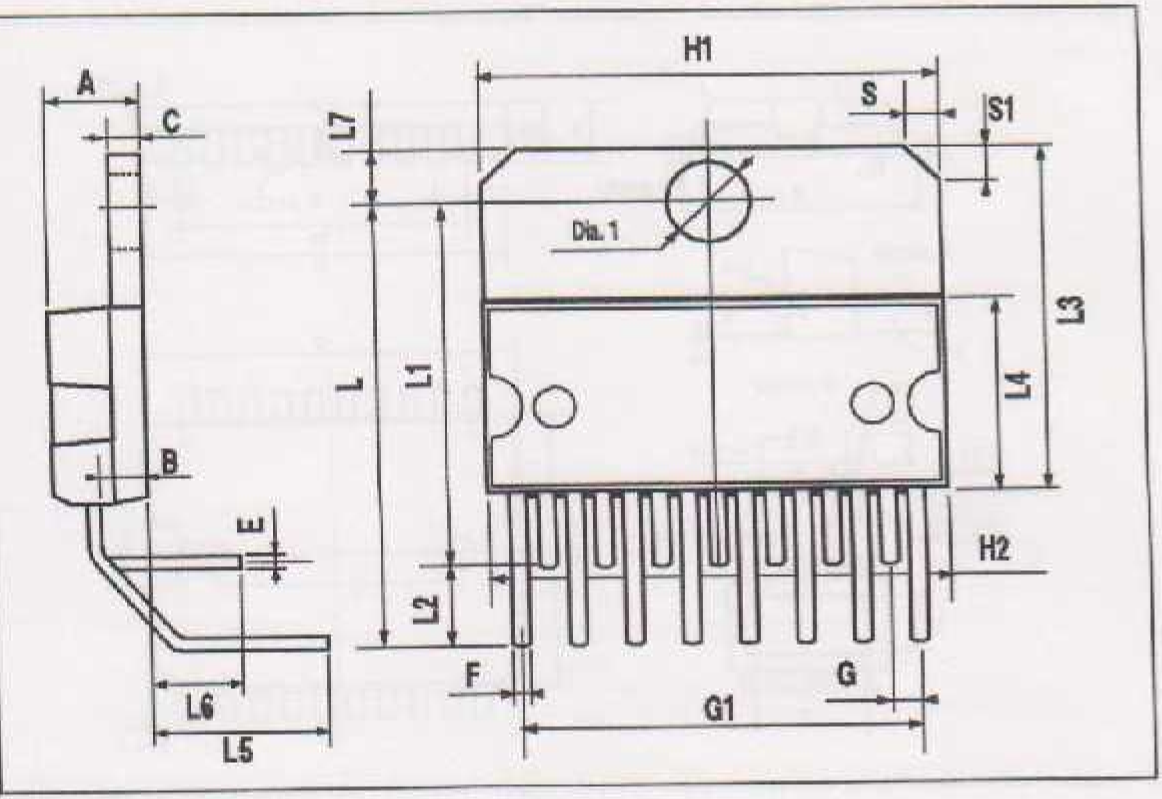


DIM.	mm			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A			5			0.197
B			2.65			0.104
C			1.6			0.063
E	0.49		0.55	0.019		0.022
F	0.66		0.75	0.026		0.030
G	1.14	1.27	1.4	0.045	0.050	0.055
G1	17.57	17.78	17.91	0.692	0.700	0.705
H1	19.6			0.772		
H2			20.2			0.795
L		20.57			0.810	
L1		18.03			0.710	
L2		2.54			0.100	
L3	17.25	17.5	17.75	0.679	0.689	0.699
L4	10.3	10.7	10.9	0.406	0.421	0.429
L5		5.28			0.208	
L6		2.38			0.094	
L7	2.65		2.9	0.104		0.114
S	1.9		2.6	0.075		0.102
S1	1.9		2.6	0.075		0.102
Dia1	3.65		3.85	0.144		0.152

OUTLINE AND MECHANICAL DATA



Multiwatt15 H



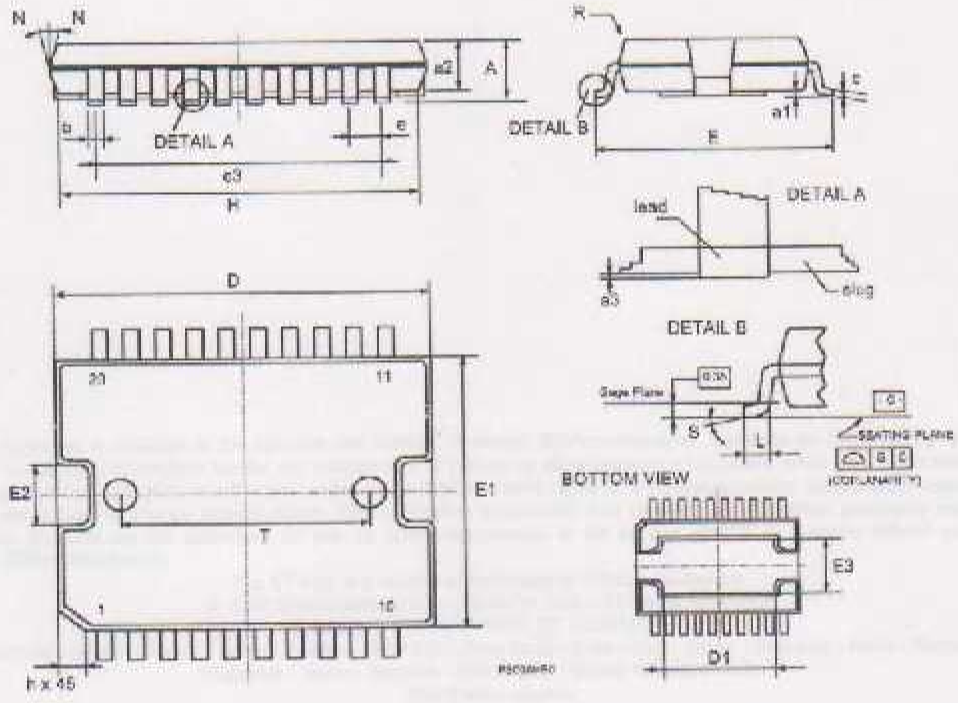
DIM.	mm			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A			3.6			0.142
a1	0.1		0.3	0.004		0.012
a2			3.3			0.130
a3	0		0.1	0.000		0.004
b	0.4		0.53	0.016		0.021
c	0.23		0.32	0.009		0.013
D (1)	15.8		16	0.622		0.630
D1	9.4		9.8	0.370		0.386
E	13.9		14.5	0.547		0.570
e		1.27			0.050	
e3		11.43			0.450	
E1 (1)	10.9		11.1	0.429		0.437
E2			2.9			0.114
E3	5.8		6.2	0.228		0.244
G	0		0.1	0.000		0.004
H	15.5		15.9	0.610		0.626
h			1.1			0.043
L	0.8		1.1	0.031		0.043
N	10° (max.)					
S	8° (max.)					
T		10			0.394	

(1) "D and F" do not include mold flash or protrusions.
- Mold flash or protrusions shall not exceed 0.15 mm (0.006").
- Critical dimensions: "E", "G" and "a3"

OUTLINE AND MECHANICAL DATA

JEDEC MO-166

PowerSO20



1.3 MP Digital Eyepiece Camera for Microscope Model MEM1300 DCM130 MD130

Specifications

eyepiece camera for microscope

DESCRIPTION

MEM1300 (1.3 megapixel) is professionally designed for microscope, which is usually to be connected to either microscope eyepiece tube or the trinocular c-mount. MEM1300 captures stills photos of 1280*1024 pixel and video clips of 640*480 pixel. The special design of IC Board enables MEM1300 offer true color and bright image, and with a advanced imaging software you can create excellent microscopy reports by setting density, contrast, saturation, sharpness and exposing time. MEM1300 keeps the balance between resolution and transmitting rate. It is hard to process a big image file on net, so more resolution is not always better.

SPECIFICATIONS

Sensor Parameter	1/2" 1.3 Mega Pixels CMOS
Max Resolution	1280*1024
USB Device	USB 2.0, 480 MB /s
Frame Rate	16 f/s @ 1280*1024
Preview Model	1280*1024, 640*480, 320*240
Pixels Size	5.2μm *5.2μm
Sensitivity	1.8 V/lux-sec@550nm
Spectrum response	400nm—1000nm
Shutter Type	ERS(electronic rolling shutter)
White Balance	Auto
Accessories	One adapter of Dia.30 mm for stereo microscope
USB cable length	1.5M
Operating System	Windows--XP2,Vista
Basic PC*	Pentium4 2.0GHz or more
	512MB RAM or more
	USB 2.0 Port
	17 Monitor or more big

References

[1] Paracer S & Ahmadjian V, Symbiosis: An Introduction to Biological Associations, 2nd edn (New York: Oxford University Press, 2000), p 10

[2] http://www.news-medical.net/health/Pathology-What-is-Pathology.aspx

[3] http://www.medicalnewstoday.com/info/cancer-oncology/

[4] Paustian T, Roberts G (2009). "Beijerinck and Winogradsky Initiate the Field of Environmental Microbiology". Through the Microscope: A Look at All Things Small (3rd ed.)

[5] Morita S (2006). Roadmap of Scanning Probe Microscopy. NanoScience and Technology. Berlin: Springer.
http://www.britannica.com/EBchecked/topic/468443polycythemia

[6] http://pathwiki.pbworks.com/w/page/14674010/HemaSlide5

[7] Stepher J. Chapman, Electric Machinery Fundamentals, McGraw Hill Collage, August 1998.

[8] Laughton M.A. and Warne D.F., Editors. Electrical engineer's reference book. 16th ed. Newnes, 2003. Page 19-4.

[9] Arduino Mega 2560, Arduino – Homepage, Sviluppo Basilicata http://arduino.cc/en/Main/ArduinoBoardMega2560

[10] http://www.ebay.com/itm/12V-DC-60RPM-Powerful-High-Torque-Gear-Box-Motor-/360816460849#Nav01

[11] Limit Switches Posted by Joshua in Safety February 27th, 2012 http://www.cnc4everyone.com/safety/limit-switches/,

[12] Geared DC Motors & Encoders, Amironic, http://www.amironic.co.il/Products_next.asp?ID=21

[13] GSM Difinition http://searchmobilecomputing.techtarget.com/definition/GSM

[14]The principle of the GSM

http://answers.wikia.com/wiki/What_is_the_working_principle_of_GSM

[15]The principle of the GSM (picture)

http://www.clear.rice.edu/elec301/Projects01/cdma/compare.html

[16]GSM Network Areas

http://www.wisegeek.com/what-is-a-gsm-network.htm

[17]Definition of Third Generation (3G) GSM Modem:

http://www.techopedia.com/definition/2918/third-generation-wireless-3g

[18]SIM Card

http://en.wikipedia.org/wiki/Subscriber_identity_module

[19]Protocols and configurations

http://en.wikipedia.org/wiki/Dynamic_Host_Configuration_Protocol