Faculty of Electrical
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English for Electrical Engineering and Computing: A Collection of Texts for Translation – Lower Level

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FOREWORD

This material represents a collection of texts for translation for the English language course at the Faculty of Electrical Engineering – University of Belgrade. It is intended for the subject English Language 1, which is a one-semester course of English for Specific Purposes (ESP), more specifically English for Electrical Engineering and Computing, attended by the first-year students. The collection is intended for English Language 1 pre-examination requirements that include six translation tasks, which are aimed at enhancing students' English language translation skills at lower level. The collection is structured into 50 texts centred on different topics, which cater for diverse needs and leave room for students' interests that differ significantly since the first-year students still attend General Electrical Engineering and Computing modules (including all domains of Electrical Engineering).

The collection reveals borrowings from different authors, various online sources and ESP-tailored textbooks, all of which are listed in the Bibliography. More precisely, *English for Electrical Engineering and Computing: A Collection of Texts for Translation – Lower Level* contains a selection of authentic material based on the text structure from references [1]—[27]. The Collection builds upon the intellectual capital and the theory presented in references [28]—[63], while the texts in the Collection are taken and abridged from references [64]—[222].

I would like to express my gratitude to **Professor Dr. Tijana Parezanović** (**Department of English Language and Literature, Faculty of Foreign Languages, Alfa BK University of Belgrade**) for her genuine interest in the manuscript, her most constructive ideas, her immense expertise, lovely suggestions and her generous help. Nonetheless, the Author is responsible for whatever errors may be found in the textbook. **Professor Dr. Tijana Parezanović** gave her time and patience to improve the overall quality of my ESP and EAP teaching materials.

My boundless thanks go to **Professor Dr. Predrag Pejović** (**Department of Electronics, Faculty of Electrical Engineering, University of Belgrade**) for his genuine interest in the manuscript and his intense and rigorous scrutiny. Academically, I have been the fortunate recipient of Professor Pejović's brilliant knowledge, kindness and support. **Professor Dr. Predrag Pejović**, to whom I owe the immense intellectual debt, is a true visionary and a source of constant intellectual inspiration.

I am greatly in the debt to two scholars and visionaries who initiated me into the study of English for Specific Purposes (ESP), and English for Academic Purposes (EAP) in particular: **Professor Dr. Marija Krivokapić** (**Department of English Language and Literature, Faculty of Philology in Nikšić, University of Montenegro**) and **Professor Dr. Aleksandra Nikčević-Batrićević** (**Department of English Language and Literature, Faculty of Philology in Nikšić, University of Montenegro**).

My gratitude goes to the language-editors – two wonderful colleagues **Professor Dr. Marija Krivokapić** and **Professor Dr. Aleksandra Nikčević-Batrićević** for their genuine interest in the manuscript and more than constructive scrutiny. At the same time, **Professor Dr. Marija Krivokapić** and **Professor Dr. Aleksandra Nikčević-Batrićević** were also my proofreaders who kindly read the manuscript and offered valuable suggestions. Needless to say, it would be a relief to think that half of the joy I feel at the moment goes back to them. At the same time, I hope that this textbook comes up to their expectations.

My thanks go to **Professor Dr. Milan Đurić** (Department of Multimedia Design, Faculty of Computing, University UNION in Belgrade), a digital artist and graphic designer, for his stunning gift cover-design.

In Belgrade, 29th August 2023

Dr Miloš D. Đurić

TEXT 1. WHAT IS ELECTRICITY

There are some inventions that changed human civilization. The first invention was the wheel, the second invention was electricity, the third invention was telecommunications, and the fourth invention was the computer. We will discuss the basic introduction of electricity. Each substance in this universe is made of plenty of atoms and each atom has the same number of negative electrons and positive protons.

As a result, we can say that each neutral substance has the same number of electrons and protons in it. The protons are immovable and strongly attached to the nucleus of the atoms. Electrons are also bounded to atoms and orbiting around the nucleus at different distinct levels. But some of the electrons can move freely or can come out from their orbit due to external influences.

In neutral condition, the number of electrons and protons is the same in any piece of substance. But if somehow the number of electrons in a substance becomes more than the number of protons, the substance becomes negatively charged as the net charge of each electron is negative. If the number of electrons in a substance becomes less than the number of protons, the substance becomes positively charged.

The concentration of free electrons always tries to be uniform. This is the only reason for electricity. Let us explain in detail. If two dissimilarly charged conductive bodies come in contact, the electrons from the body of higher electron concentration will move to the body of lower electron concentration to balance the electron concentration of both bodies. This movement of charge (as electrons are charged particles) is electricity.

The related terms in electricity

Electric Charge: As we told earlier that the number of electrons and number of protons are equal in a neutral body. The amount of negative charge and positive change is also equal in a neutral body since the electric charge of an electron and a proton is numerically equal but their polarity is opposite. But for any reason, the balance of the number of electrons and protons in a body gets distributed the body becomes electrically charged. If the number of electrons more than that of protons the body becomes negatively charged and the amount of charge depends on the number of excess electrons in the body. In the same manner, we can explain the positive change of a body. Here the number of electrons becomes lesser than that of protons. The positivity of the body depends on the difference between protons and electrons in the body.

Electric Current: When charge flows from one point to another to make uniform charge distribution then the rate at which the charge is flowing called electric current. This rate mainly depends on the difference between the charged condition of two points and the conditions of the pathway through which the charge is flowing. The unit of electric current is Ampere and it is nothing but coulomb per second.

Electric Potential: The level of charged condition of a body is known as electric potential. When a body is charged it gets the ability to do some work. Electric potential is the measurement of the ability of a charged body to do work. The current flowing through a conductor is directly proportional to the difference of electric potential between at two ends of the conductor. The electric potential can be visualized as the difference of water level in two water tanks linked with a pipeline. The speed of water flowing from the higher headed tank to lower headed tank depends on the level difference or head difference of the water in the tanks not on the quantity of water stored in the tanks. In the same way, the electric current between two bodies depends on the potential difference between two bodies not on the quantity of charge stored in the bodies.

Electric Field: There is always a force between two nearly placed charged bodies. The force may be either attractive or repulsive depending on the nature of the charge of two bodies. When a charged body enters the nearby zone of another charged body the force is practically experienced. Space surrounds a charged body where another charged body can experience a force is called the electric field of the former body.

These above mentioned four terms are the main parameters of electricity.

How is Electricity Generated

There are three basic ways by which we generally produce electricity.

Electromechanical Process: When a conductor moves in a magnetic field and the conductor cuts the field flux lines electricity is produced in the conductor. Depending on this principle all electrical generators work such as DC generators, alternators, and all kinds of dynamos.

Electrochemical Process: In all types of battery electricity is produced due to chemical reactions. Here chemical energy gets converted to electrical energy.

Solid State Electric Generation: This is the most modern process of electricity generation. Here, free electrons and holes are generated at a PN junction and distribution of charge carriers gets imbalanced across the PN junction when the junction is exposed in the light. These free electrons and holes and their imbalanced distribution across the junction cause electricity in an external circuit. On this principle, PV solar cells work.

Types of Electricity

When electricity produced in the armature of a generator it is always alternating. That means polarity of electricity alters in a periodic interval. In DC generators the produced electricity in armature gets rectified through commutator. In alternators, the AC produced in the armature supplied to the external circuit through slip rings.

When electricity does not change its direction it is called DC electricity. Batteries and solar cells produce DC electricity.

Generation Transmission and Distribution of Electricity

After electricity gets generated in an electrical power plant it gets stepped up by step up transformer for transmitting purpose. The generation of electricity at a low voltage level is practical and economical. But low voltage transmission is not economical. But for electrical transmission, the generated electricity first gets stepped up, and then after transmission it is stepped down by step down transformers for electrical distribution purpose.

The generation of electricity, the transmission of electricity, and the distribution of electricity are normally with three-phase system. Very ultra-high voltage ac transmission is not economical always and that is why DC transmission is sometimes used. The supply system of domestic houses may be a single-phase AC but all commercial, industrial and bigger house supplies are of three phase system.

TEXT 2. HOW TO BECOME A PROGRAMMING EXPERT

How to become a programming expert

The primary requirements for being a good programmer are nothing more than a good memory, an attention to detail, a logical mind and the ability to work through a problem in a methodical manner breaking tasks down into smaller, more manageable pieces.

However, it's not enough just to turn up for a job interview with a logical mind as your sole qualification. An employer will want to see some sort of formal qualification and a proven track record. But if you can show someone an impressive piece of software with your name on it, it will count for a lot more than a string of academic qualifications.

So what specific skills are employers looking for? The Windows market is booming and there's a demand for good C, C++, Delphi, Java and Visual Basic developers. Avoid older languages such as FORTRAN and COBOL unless you want to work as a contract programmer.

For someone starting out, my best advice would be to subscribe to the programming magazines such as Microsoft Systems Journal. Get one or two of the low-cost 'student' editions of C++, Visual Basic and Delphi. Get a decent book on Windows programming. If you decide programming is really for you, spend more money on a training course.

How to become a Computer Consultant

The first key point to realise is that you can't know everything. However you mustn't become an expert in too narrow a field. The second key point is that you must be interested in your subject. The third key point is to differentiate between contract work and consultancy. Good contractors move from job to job every few months. A consultant is different. A consultant often works on very small timescales - a few days here, a week there, but often for a core collection of companies that keep coming back again and again.

There's a lot of work out there for people who know Visual Basic, C++, and so on. And there are lots of people who know it too, so you have to be better than them. Qualifications are important. Microsoft has a raft of exams you can take, as does Novell, and in my experience these are very useful pieces of paper. University degrees are useless. They merely prove you can think, and

How to become an IT Manager

IT managers manage projects, technology and people. Any large organisation will have at least one IT manager responsible for ensuring that everyone who actually needs a PC has one and that it works properly. This means taking responsibility for the maintenance of servers and the installation of new software, and for staffing a help-desk and a support group.

Medium to large companies are also likely to have an IT systems manager. They are responsible for developing and implementing computer software that supports the operations of the business. They're responsible for multiple development projects and oversee the implementation and support of the systems. Companies will have two or three major systems that are probably bought off the shelf and then tailored by an in-house development team.

Here's the road map. After leaving university you get a technical role in a company and spend your evenings and weekends learning the tools of your trade - and getting your current employer to pay for your exams. You don't stay in one company for more than two years. After a couple of hops like that, you may be in a good position to move into a junior consultancy position in one of the larger consultancy companies.

Nearly all IT managers have at least a first degree if not a second one as well. Interestingly, many of them don't have degrees in computing science. In any case, the best qualification for becoming a manager is experience. If your personality is such that you're unlikely to be asked to take responsibility for a small team or a project, then you can forget being an IT manager. You need to be bright, communicative and be able to earn the trust of your teams. Most of this can't be taught, so if you don't have these skills then divert your career elsewhere.

Suppose you're a support engineer. You're stuck in a job you don't like and you want to make a change. One way of making that change is to improve your marketability to potential employers by upgrading your skill-set. If you're going to train yourself up however, whose training should you undertake? If you need certificates, whose certificates should they be? Even if you get those certificates, how certain can you be that your salary will rise as a result? One solution is the range of certifications on offer from Microsoft.

Microsoft offers a large array of certification programmes aimed at anyone from the user of a single program such as Microsoft Word, to someone who wants to become a certified support engineer. There are a myriad of certificates to study for too. If you're the proud holder of any of those qualifications, then you're entitled to call yourself a Microsoft Certified Professional (MCP).

Once you've decided which track you want to take, you should consider just how qualified you already are in terms of experience and knowledge. Will you need to go and take some courses with a training company, or are you the type who can make good use of self-study materials? How much time do you genuinely have to devote towards this? Will your employer pay for your course? Will it grant you leave to go and do the course - assuming you can find one - on either a full-time or part-time basis?

The key question here is experience. This will not only influence the amount of work you'll have to do to get up to speed for the exams, it could also mean the difference between passing or failing the exam.

TEXT 3. A HACKER'S NIGHTMARE

Programmable Chips Secured by Chaos: a complex network of randomly interconnected logic gates creates conditions that could thwart hackers.

Not all chaos is bad. In the case of programmable chips, chaos can be harnessed to create a unique digital identifier. Think of it as a fingerprint—only, instead of distinctive loops and whorls on human skin, this is about the unique physical variations present in silicon chips.

These minute differences, often at an atomic level, vary from chip to chip, even if they are manufactured together. The physical variations can be amplified using a technology called physically unclonable functions (PUFs) to create a signature that is unique to a specific chip.

By putting many PUF cells together, it is possible to create a random number of an arbitrary length. Even though it is random, it is still unique for a particular instance of the chip. More importantly, the identifier does not need to be saved on the chip as it can be generated only when required for authentication and immediately erased. Therefore, PUFs can potentially be used in smart cards and secure IDs, to track goods in supply chains, and for applications where it is vital to know that you are not communicating with an impostor.

Recently, a team of scientists from Ohio State University demonstrated a way to use PUFs in a way that would frustrate even the most patient of hackers.
Current PUFs contain only a limited number of secrets, says Daniel Gauthier, one of the co-authors, in the press release. When this number is in the tens or hundreds of thousands, or even a million, "a hacker with the right technology and enough time can learn all the secrets on the chip." The challenge, therefore, was to find a way to produce an insanely large number of secrets, making it almost impossible for hackers to figure them out, even if they had direct access to the system.

With backgrounds in physics and chaos theory, Gauthier, Charlot and the others approached the problem from a different angle than earlier researchers: "Instead of working with the traditional type of circuit design, we went directly toward what is the most chaotic random thing that you could possibly make," Charlot says. To do so, they constructed a complex network in their PUFs of randomly interconnected logic gates in order to create "deterministic chaos."

In physics, chaos refers to a complex system whose behavior is so unpredictable—because of its great sensitivity to small changes—that it seems random. In this case, the super-sensitivity owed to the tiny variations found in chips. All of the little differences at the atomic level amplify the behavior of the circuit, says Charlot, exponentially increasing the number of secrets, making them all the more difficult to predict. In their study, the researchers tested their system with machine learning attacks, including deep learning-based methods and model-based attacks, which failed to breach the system.

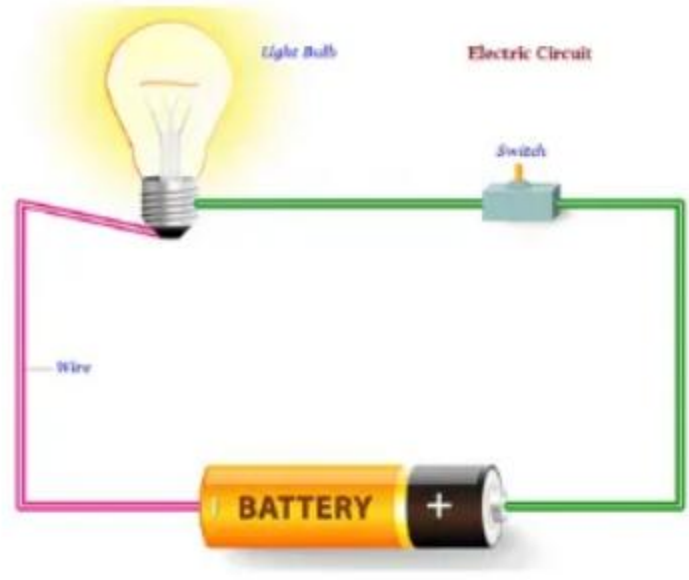
PUFs, however, can be unstable over time and also vulnerable to temperature. Therefore, the key to the process is letting the chaos run just long enough on the chip. “If you let it run too long,” Charlot says, “it’s completely inconsistent…essentially random.” So the researchers found a “sweet spot” in the system. “This is something we had to just measure,” he adds, “but we find that it’s very consistent and reproducible… This is a point in time, where system is simultaneously most unique and most reliable…[which] is right before it becomes completely chaotic.” All of this happens on a time scale of nanoseconds.

Charlot also admits that their system is more sensitive to temperature than other PUFs because it is chaotic, but they have a couple of solutions to mask that. The simplest way, he says, is that you can measure the responses at different temperatures and store them in a database. “It works identically and equally well at every temperature…so one protocol would be you just say what temperature your system is at and then you match it to the database.” This method is in use by several other PUFs. “A more complex [solution] is you can actually identify…some of the logic nodes [that] are more sensitive to temperature…isolate those, and remove them.”

Commercial contracts for the tech are already out. “It’s basically at the industrial stage,” Charlot says. “We know that it works, but there are still a lot of academic questions.” The biggest one being how to calculate the amount of information in systems like this one. “No one’s really calculated entropies this large.” Also, further environmental testing and better error-mitigation strategies are on the anvil.

TEXT 4. ELECTRIC CURRENT, THE THEORY OF ELECTRICITY

What is Electric Current? Electric current is a stream of charged particles—such as electrons or ions—moving through an electrical conductor or space. It is the flow rate of electric charge through a conducting medium with respect to time.
When there is a potential difference between two points in a conductive medium, an electric charge starts flowing from the higher potential point to the lower potential point to balance the charge distribution between the points.
The flow rate of charge with respect of time is known as electric current.



Current Formula
If q Coulomb electric charge gets transferred between these two points in time t sec, then the current can be calculated as

$$i = \frac{q}{t}$$

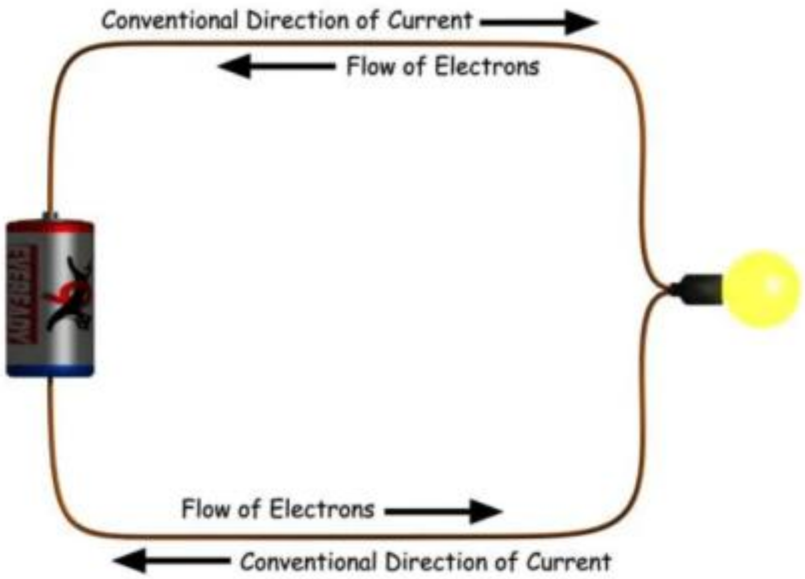
In differential form, the current can be represented as

$$i = \frac{dq}{dt}$$

Units for Current
As the current is the ratio of transferred charge to the time taken for this charge transferring we can say one unit current is such a rate of charge transferring in which one Coulomb charge is transferred from one point to another in one second.
Hence, the unit of current is coulomb/second or amperes (amps) after the great physicist Andrew Marie Ampere. This is the SI unit of electric current.
Theory of Electricity
Current in Metallic Conductor
The main cause of current through a metallic substance is the flow of electrons that is the directional drift of free electrons.

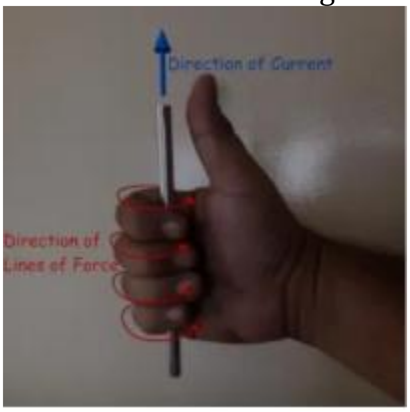
In metal, even at room temperature, there are plenty of free electrons exist inside the metallic crystal structure.
When electric potential between two points in the metal differs the free electrons which were randomly moving at equilibrium potential condition and also the free electrons supplied by the source (if a source is connected between these two points) now get drifted towards higher potential point due to electrostatic attraction.
As each of the electrons has a negative charge of -1.602×10^{-19} coulomb, it can be said that the negative charge gets shifted towards a higher potential point. The rate of flow of this negative charge in respect of time is the current in the metal.

Although the flow of electrons or negative charge is from lower potential point to higher potential point but the conventional direction of current is considered from higher potential to lower potential. Although current is mainly caused by the flow of electrons that is the flow of negative charge but previously it was thought that the electrical current is due to the flow of positive change.



But now it is proved that the current in a metallic conductor is due to flow of electrons or negative charge but the direction of current is still considered as it was accepted previously that is opposite of flow of electrons.
The direction of the current which is considered from a higher potential point to a lower potential point is known as the conventional direction of the current.
When current flows in one direction either in a constant or fluctuating manner, the current is called direct current.
When current flows in either direction in a frequency is called alternating current. The average value of an alternating current is zero.
The alternating current is measured in RMS value. One main parameter of alternating current is frequency.
When current flows through a conductor there will be a magnetic field surrounding the conductor. The direction of the lines of force of the magnetic field can be determined by right-hand grip rule.

If we imagine that we have held the current-carrying conductor with our right hand with the extended thumb along the direction of the current then four fingers of our right hand indicate the direction of lines of force of the magnetic field.



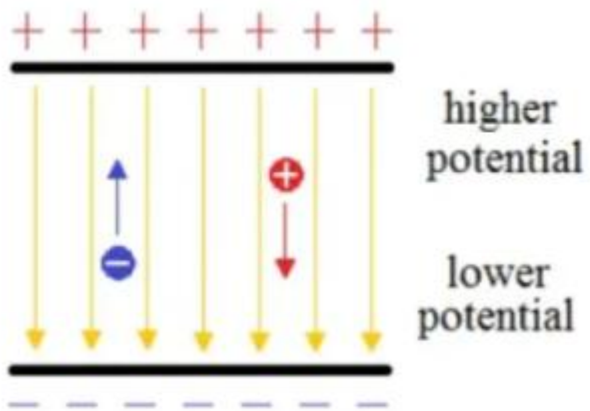
When we make a coil with a conductor and current flows through the coil then due to magnetic effect of each conductor of the coil there will be an overall magnetic field surrounding the coil.
Here we can also determine the direction of the field by the right-hand grip rule. If we hold the current-carrying coil with our four fingers along the direction of current in the turns of the coil then the extended thumb indicates the direction of the magnetic field.
When we place a current carrying conductor or a current carrying coil in a magnetic field, a mechanical force acts on the current carrying conductor or coil.
This mechanical force depends on the current through the conductor or coil.
Depending on the principle of interaction between current and magnetic field one can measure the current. One of the basic instruments to measure the current is pmmc instrument or permanent magnet moving coil instrument.
The pmmc instrument is only able to measure direct current. The alternating current can be measured by moving the iron instrument where the magnetic field created by the current through the instrument coil causes movement of a soft iron piece either by attraction or repulsion force.
This instrument can also measure direct current. Rectifier type instruments are also used to measure alternating current.
Here a bridge rectifier is used to rectify alternating current then it is measured with pmmc instrument. Wherever may be the types of current measuring instrument in one word all current measuring instruments are called ammeter.
An ammeter is always connected in series with the path of which the current to be measured. When a very high current is to be measured we use current transformers to step down current for measuring purposes.
When current flows through a conductor there is a heating effect in the conductor. The loss of power in the conductor is i^2R watts. The loss of energy is i^2Rt joules. This loss of energy is converted to heat. Hence,

$$H = i^2\ R\ t\ Joules$$

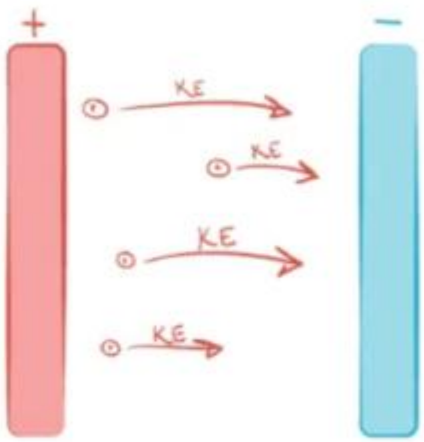
This is known as Joule's Law of Heating.

TEXT 5. ELECTRIC POTENTIAL

Electric potential at a point in an electric field is defined as the amount of work to be done to bring a unit positive electric charge from infinity to that point.
Similarly, the potential difference between two points is defined as the work required to be done for bringing a unit positive charge from one point to other point.
When a body is charged, it can attract an oppositely charged body and can repulse a similar charged body. That means, the charged body has ability of doing work. That ability of doing work of a charged body is defined as electrical potential of that body.



If two electrically charged bodies are connected by a conductor, the electrons starts flowing from lower potential body to higher potential body, that means current starts flowing from higher potential body to lower potential body depending upon the potential difference of the bodies and resistance of the connecting conductor.



So, electric potential of a body is its charged condition which determines whether it will take from or give up electric charge to other body.
Electric potential is graded as electrical level, and difference of two such levels, causes current to flow between them. This level must be measured from a reference zero level. The earth potential is taken as zero level. Electric potential above the earth potential is taken as positive potential and the electric potential below the earth potential is negative.
The unit of electric potential is volt. To bring a unit charge from one point to another, if one joule work is done, then the potential difference between the points is said to be one volt. So, we can say,

$$volt = \frac{joules}{coulomb}$$

If one point has electric potential 5 volt, then we can say to bring one coulomb charge from infinity to that point, 5 joule work has to be done.
If one point has potential 5 volt and another point has potential 8 volt, then 8 – 5 or 3 joules work to be done to move one coulomb from first point to second.

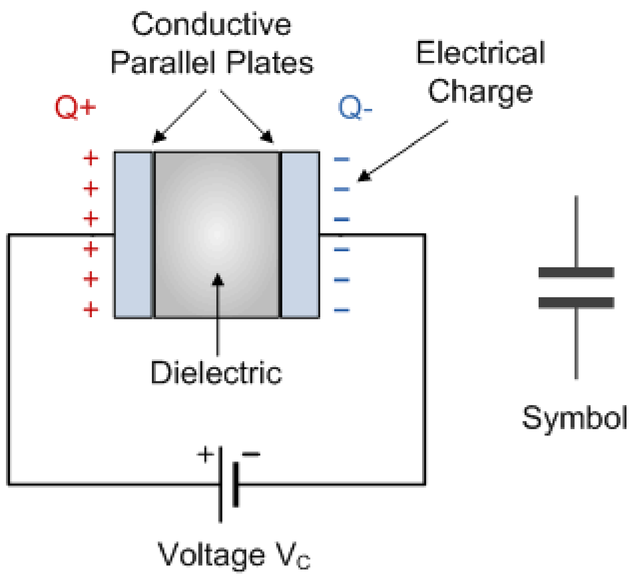
TEXT 6. INTRODUCTION TO CAPACITORS

Capacitors are simple passive device that can store an electrical charge on their plates when connected to a voltage source.
The capacitor is a component which has the ability or “capacity” to store energy in the form of an electrical charge producing a potential difference (*Static Voltage*) across its plates, much like a small rechargeable battery.
There are many different kinds of capacitors available from very small capacitor beads used in resonance circuits to large power factor correction capacitors, but they all do the same thing, they store charge.
In its basic form, a capacitor consists of two or more parallel conductive (metal) plates which are not connected nor touch each other, but are electrically separated either by air or by some form of a good insulating material such as waxed paper, mica, ceramic, plastic or some form of a liquid gel as used in electrolytic capacitors. The insulating layer between capacitors plates is commonly called the Dielectric.

A Typical Capacitor

Due to this insulating layer, DC current cannot flow through the capacitor as it blocks it allowing instead a voltage to be present across the plates in the form of an electrical charge.
The conductive metal plates of a capacitor can be square, circular or rectangular, or they can be of a cylindrical or spherical shape with the general shape, size and construction of a parallel plate capacitor depending on its application and voltage rating.
When used in a direct current or DC circuit, a capacitor charges up to its supply voltage but blocks the flow of current through it because the dielectric of a capacitor is non-conductive and basically an insulator. However, when a capacitor is connected to an alternating current or AC circuit, the flow of the current appears to pass straight through the capacitor with little or no resistance.
There are two types of electrical charge, a positive charge in the form of Protons and a negative charge in the form of Electrons. When a DC voltage is placed across a capacitor, the positive (+ve) charge quickly accumulates on one plate while a corresponding and opposite negative (-ve) charge accumulates on the other plate. For every particle of +ve charge that arrives at one plate a charge of the same sign will depart from the -ve plate. Then the plates remain charge neutral and a potential difference due to this charge is established between the two plates. Once the capacitor reaches its steady state condition an electrical current is unable to flow through the capacitor itself and around the circuit due to the insulating properties of the dielectric used to separate the plates.
The flow of electrons onto the plates is known as the capacitors Charging Current which continues to flow until the voltage across both plates (and hence the capacitor) is equal to the applied voltage Vc. At this point the capacitor is said to be “fully charged” with electrons.
The strength or rate of this charging current is at its maximum value when the plates are fully discharged (initial condition) and slowly reduces in value to zero as the plates charge up to a potential difference across the capacitors plates equal to the source voltage.

The amount of potential difference present across the capacitor depends upon how much charge was deposited onto the plates by the work being done by the source voltage and also by how much capacitance the capacitor has and this is illustrated below.



The parallel plate capacitor is the simplest form of capacitor. It can be constructed using two metal or metallised foil plates at a distance parallel to each other, with its capacitance value in Farads, being fixed by the surface area of the conductive plates and the distance of separation between them. Altering any two of these values alters the value of its capacitance and this forms the basis of operation of the variable capacitors. Also, because capacitors store the energy of the electrons in the form of an electrical charge on the plates the larger the plates and/or smaller their separation the greater will be the charge that the capacitor holds for any given voltage across its plates. In other words, larger plates, smaller distance, more capacitance.

By applying a voltage to a capacitor and measuring the charge on the plates, the ratio of the charge Q to the voltage V will give the capacitance value of the capacitor and is therefore given as: $C = Q/V$ this equation can also be re-arranged to give the familiar formula for the quantity of charge on the plates as: $Q = C \times V$

Although we have said that the charge is stored on the plates of a capacitor, it is more exact to say that the energy within the charge is stored in an “electrostatic field” between the two plates. When an electric current flows into the capacitor, it charges up, so the electrostatic field becomes much stronger as it stores more energy between the plates.

Likewise, as the current flowing out of the capacitor, discharging it, the potential difference between the two plates decreases and the electrostatic field decreases as the energy moves out of the plates.

The property of a capacitor to store charge on its plates in the form of an electrostatic field is called the Capacitance of the capacitor. Not only that, but capacitance is also the property of a capacitor which resists the change of voltage across it.

The Capacitance of a Capacitor

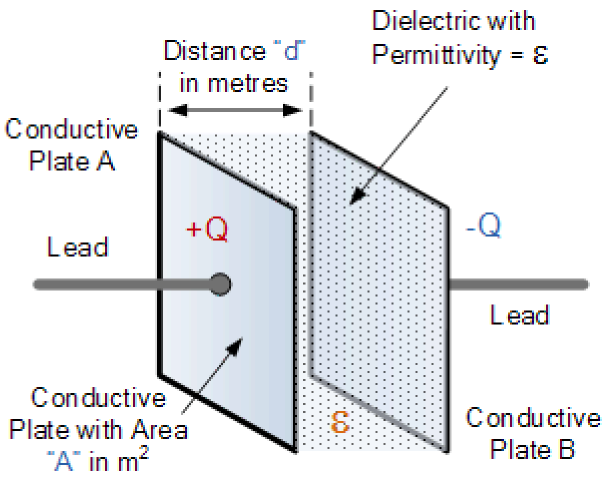
Capacitance is the electrical property of a capacitor and is the measure of a capacitors ability to store an electrical charge onto its two plates with the unit of capacitance being the Farad (abbreviated to F) named after the British physicist Michael Faraday.

Capacitance is defined as being that a capacitor has the capacitance of One Farad when a charge of One Coulomb is stored on the plates by a voltage of One volt. Note that capacitance, C is always positive in value and has no negative units. However, the Farad is a very large unit of measurement to use on its own, so sub-multiples of the Farad are generally used such as micro-farads, nano-farads and pico-farads, for example.
Standard Units of Capacitance
Microfarad (μF) 1μF = 1/1,000,000 = 0.000001 = 10^{-6} F
Nanofarad (nF) 1nF = 1/1,000,000,000 = 0.000000001 = 10^{-9} F
Picofarad (pF) 1pF = 1/1,000,000,000,000 = 0.000000000001 = 10^{-12} F

Then using the information above we can construct a simple table to help us convert between pico-Farad (pF), to nano-Farad (nF), to micro-Farad (μF) and to Farads (F) as shown.

Pico-Farad (pF)	Nano-Farad (nF)	Micro-Farad (μF)	Farads (F)
1,000	1.0	0.001	
10,000	10.0	0.01	
1,000,000	1,000	1.0	
	10,000	10.0	
	100,000	100	
	1,000,000	1,000	0.001
		10,000	0.01
		100,000	0.1
		1,000,000	1.0

Capacitance of a Parallel Plate Capacitor
The capacitance of a parallel plate capacitor is proportional to the area, A in metres^2 of the smallest of the two plates and inversely proportional to the distance or separation, d (i.e. the dielectric thickness) given in metres between these two conductive plates.
The generalised equation for the capacitance of a parallel plate capacitor is given as: $C = \varepsilon(A/d)$ where ε represents the absolute permittivity of the dielectric material being used. The dielectric constant, ε_0 also known as the "permittivity of free space" has the value of the constant 8.84 x 10^{-12} Farads per metre.
To make the maths a little easier, this dielectric constant of free space, ε_0, which can be written as: $1/(4\pi \times 9\times10^9)$, may also have the units of picofarads (pF) per metre as the constant giving: 8.84 for the value of free space. Note though that the resulting capacitance value will be in picofarads and not in farads.
Generally, the conductive plates of a capacitor are separated by some kind of insulating material or gel rather than a perfect vacuum. When calculating the capacitance of a capacitor, we can consider the permittivity of air, and especially of dry air, as being the same value as a vacuum as they are very close.



Capacitance Example No1

A capacitor is constructed from two conductive metal plates 30cm x 50cm which are spaced 6mm apart from each other, and uses dry air as its only dielectric material. Calculate the capacitance of the capacitor.

$$\text{Using:} \quad C = \varepsilon_0 \frac{A}{d}$$

$$\text{where:} \quad \varepsilon_0 = 8.84 \times 10^{-12}$$

$$A = 0.3 \times 0.5\, m^2 \quad \text{and} \quad d = 6 \times 10^{-3}\, m$$

$$C = \frac{8.84 \times 10^{-12} \times (0.3 \times 0.5)}{6 \times 10^{-3}} = 0.221 nF$$

Then the value of the capacitor consisting of two plates separated by air is calculated as 221pF or 0.221nF

The Dielectric of a Capacitor

As well as the overall size of the conductive plates and their distance or spacing apart from each other, another factor which affects the overall capacitance of the device is the type of dielectric material being used.

The conductive plates of a capacitor are generally made of a metal foil or a metal film allowing for the flow of electrons and charge, but the dielectric material used is always an insulator. The various insulating materials used as the dielectric in a capacitor differ in their ability to block or pass an electrical charge.

This dielectric material can be made from a number of insulating materials or combinations of these materials with the most common types used being: air, paper, polyester, polypropylene, Mylar, ceramic, glass, oil, or a variety of other materials.

The factor by which the dielectric material, or insulator, increases the capacitance of the capacitor compared to air is known as the Dielectric Constant, k and a dielectric material with a high dielectric constant is a better insulator than a dielectric material with a lower dielectric constant. Dielectric constant is a dimensionless quantity since it is relative to free space.

The actual permittivity or "complex permittivity" of the dielectric material between the plates is then the product of the permittivity of free space (ε_o) and the relative permittivity (ε_r) of the material being used as the dielectric and is given as:
Complex Permittivity

$$\varepsilon = \varepsilon_0 \times \varepsilon_r$$

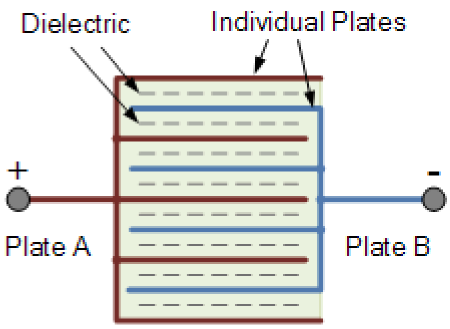
In other words, if we take the permittivity of free space, ε_o as our base level and make it equal to one, when the vacuum of free space is replaced by some other type of insulating material, their permittivity of its dielectric is referenced to the base dielectric of free space giving a multiplication factor known as "relative permittivity", ε_r. So the value of the complex permittivity, ε will always be equal to the relative permittivity times one.
Typical units of dielectric permittivity, ε or dielectric constant for common materials are: Pure Vacuum = 1.0000, Air = 1.0006, Paper = 2.5 to 3.5, Glass = 3 to 10, Mica = 5 to 7, Wood = 3 to 8 and Metal Oxide Powders = 6 to 20 etc. This then gives us a final equation for the capacitance of a capacitor as:

$$\text{Capacitance, C} = \frac{\varepsilon_o \varepsilon_r A}{d} \text{ Farads}$$

One method used to increase the overall capacitance of a capacitor while keeping its size small is to "interleave" more plates together within a single capacitor body. Instead of just one set of parallel plates, a capacitor can have many individual plates connected together thereby increasing the surface area, A of the plates.
For a standard parallel plate capacitor as shown above, the capacitor has two plates, labelled A and B. Therefore as the number of capacitor plates is two, we can say that n = 2, where "n" represents the number of plates.
Then our equation above for a single parallel plate capacitor should really be:

$$\text{Capacitance, C} = \frac{\varepsilon_o \varepsilon_r (n-1) A}{d} \text{ Farads}$$

However, the capacitor may have two parallel plates but only one side of each plate is in contact with the dielectric in the middle as the other side of each plate forms the outside of the capacitor. If we take the two halves of the plates and join them together we effectively only have "one" whole plate in contact with the dielectric.
As for a single parallel plate capacitor, n – 1 = 2 – 1 which equals 1 as C = (ε_o*ε_r x 1 x A)/d is exactly the same as saying: C = (ε_o*ε_r*A)/d which is the standard equation above.
Now suppose we have a capacitor made up of 9 interleaved plates, then n = 9 as shown.
Multi-plate Capacitor



8 mini capacitors in one

Now we have five plates connected to one lead (A) and four plates to the other lead (B). Then BOTH sides of the four plates connected to lead B are in contact with the dielectric, whereas only one side of each of the outer plates connected to A is in contact with the dielectric. Then as above, the useful surface area of each set of plates is only eight and its capacitance is therefore given as:

$$C = \frac{\varepsilon_0 \varepsilon_r (n-1) A}{d} = \frac{\varepsilon_0 \varepsilon_r (9-1) A}{d} = \frac{\varepsilon_0 \varepsilon_r 8A}{d}$$

Modern capacitors can be classified according to the characteristics and properties of their insulating dielectric:

Low Loss, High Stability such as Mica, Low-K Ceramic, Polystyrene.

Medium Loss, Medium Stability such as Paper, Plastic Film, High-K Ceramic.

Polarized Capacitors such as Electrolytic's, Tantalum's.

Voltage Rating of a Capacitor

All capacitors have a maximum voltage rating and when selecting a capacitor consideration must be given to the amount of voltage to be applied across the capacitor. The maximum amount of voltage that can be applied to the capacitor without damage to its dielectric material is generally given in the data sheets as: WV, (working voltage) or as WV DC, (DC working voltage).

If the voltage applied across the capacitor becomes too great, the dielectric will break down (known as electrical breakdown) and arcing will occur between the capacitor plates resulting in a short-circuit. The working voltage of the capacitor depends on the type of dielectric material being used and its thickness.

The DC working voltage of a capacitor is just that, the maximum DC voltage and NOT the maximum AC voltage as a capacitor with a DC voltage rating of 100 volts DC cannot be safely subjected to an alternating voltage of 100 volts. Since an alternating voltage that has an RMS value of 100 volts will have a peak value of over 141 volts! ($\sqrt{2}$ x 100).

Then a capacitor which is required to operate at 100 volts AC should have a working voltage of at least 200 volts. In practice, a capacitor should be selected so that its working voltage either DC or AC should be at least 50 percent greater than the highest effective voltage to be applied to it.

Another factor which affects the operation of a capacitor is Dielectric Leakage. Dielectric leakage occurs in a capacitor as the result of an unwanted leakage current which flows through the dielectric material.

Generally, it is assumed that the resistance of the dielectric is extremely high and a good insulator blocking the flow of DC current through the capacitor (as in a perfect capacitor) from one plate to the other.

However, if the dielectric material becomes damaged due excessive voltage or over temperature, the leakage current through the dielectric will become extremely high resulting in a rapid loss of charge on the plates and an overheating of the capacitor eventually resulting in premature failure of the capacitor. Then never use a capacitor in a circuit with higher voltages than the capacitor is rated for otherwise it may become hot and explode.

Introduction to Capacitors Summary

The amount of electrical charge that a capacitor can store on its plates is known as its Capacitance value and depends upon three main factors.

Surface Area – the surface area, A of the two conductive plates which make up the capacitor, the larger the area the greater the capacitance.

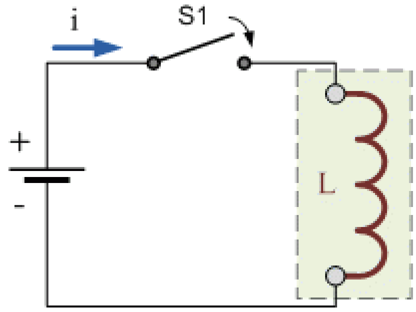
Distance – the distance, d between the two plates, the smaller the distance the greater the capacitance.

Dielectric Material – the type of material which separates the two plates called the "dielectric", the higher the permittivity of the dielectric the greater the capacitance.

We have also seen that a capacitor consists of metal plates that do not touch each other but are separated by a material called a dielectric. The dielectric of a capacitor can be air, or even a vacuum but is generally a non-conducting insulating material, such as waxed paper, glass, mica different types of plastics etc. The dielectric provides the following advantages:
The dielectric constant is the property of the dielectric material and varies from one material to another increasing the capacitance by a factor of k.
The dielectric provides mechanical support between the two plates allowing the plates to be closer together without touching.
Permittivity of the dielectric increases the capacitance.
The dielectric increases the maximum operating voltage compared to air.
Capacitors can be used in many different applications and circuits such as blocking DC current while passing audio signals, pulses, or alternating current, or other time varying wave forms. This ability to block DC currents enables capacitors to be used to smooth the output voltages of power supplies, to remove unwanted spikes from signals that would otherwise tend to cause damage or false triggering of semiconductors or digital components.
Capacitors can also be used to adjust the frequency response of an audio circuit, or to couple together separate amplifier stages that must be protected from the transmission of DC current.
At DC a capacitor has infinite impedance (open -circuit), at very high frequencies a capacitor has zero impedance (short-circuit). All capacitors have a maximum working voltage rating, its WV DC so select a capacitor with a rating at least 50% more than the supply voltage.
There are a large variety of capacitor styles and types, each one having its own particular advantage, disadvantage and characteristics.

TEXT 7. THE INDUCTOR

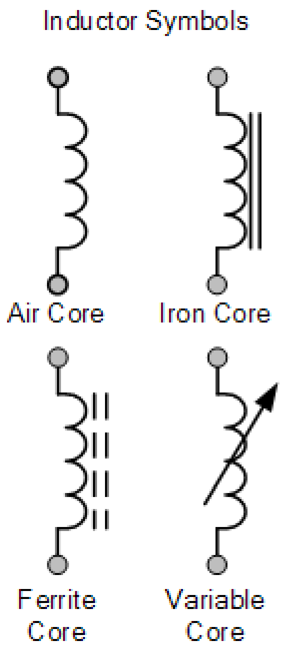
An Inductor is a passive electrical component consisting of a coil of wire which is designed to take advantage of the relationship between magentism and electricity as a result of an electric current passing through the coil

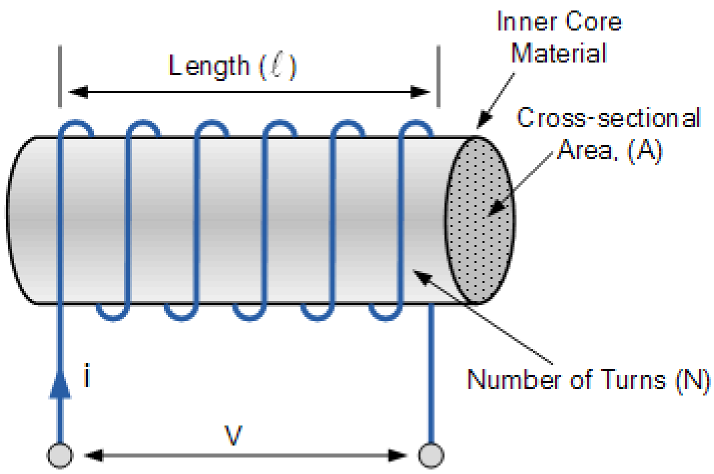


When an electrical current flows through a wire conductor, a magnetic flux is developed around that conductor. This affect produces a relationship between the direction of the magnetic flux, which is circulating around the conductor, and the direction of the current flowing through the same conductor. This results in a relationship between current and magnetic flux direction called, "Fleming's Right Hand Rule".
But there is also another important property relating to a wound coil that also exists, which is that a secondary voltage is induced into the same coil by the movement of the magnetic flux as it opposes or resists any changes in the electrical current flowing it.

A Typical Inductor

In its most basic form, an Inductor is nothing more than a coil of wire wound around a central core. For most coils the current, (i) flowing through the coil produces a magnetic flux, (NΦ) around it that is proportional to this flow of electrical current.
An Inductor, also called a choke, is another passive type electrical component consisting of a coil of wire designed to take advantage of this relationship by inducing a magnetic field in itself or within its core as a result of the current flowing through the wire coil. Forming a wire coil into an inductor results in a much stronger magnetic field than one that would be produced by a simple coil of wire.
Inductors are formed with wire tightly wrapped around a solid central core which can be either a straight cylindrical rod or a continuous loop or ring to concentrate their magnetic flux.
The schematic symbol for a inductor is that of a coil of wire so therefore, a coil of wire can also be called an Inductor. Inductors usually are categorised according to the type of inner core they are wound around, for example, hollow core (free air), solid iron core or soft ferrite core with the different core types being distinguished by adding continuous or dotted parallel lines next to the wire coil as shown below.
Inductor Symbol





The current, i that flows through an inductor produces a magnetic flux that is proportional to it. But unlike a Capacitor which oppose a change of voltage across their plates, an inductor opposes the rate of change of current flowing through it due to the build up of self-induced energy within its magnetic field.
In other words, inductors resist or oppose changes of current but will easily pass a steady state DC current. This ability of an inductor to resist changes in current and which also relates current, i with its magnetic flux linkage, NΦ as a constant of proportionality is called Inductance which is given the symbol L with units of Henry, (H) after Joseph Henry.
Because the Henry is a relatively large unit of inductance in its own right, for the smaller inductors sub-units of the Henry are used to denote its value.

Inductance Prefixes

Prefix	Symbol	Multiplier	Power of Ten
milli	m	1/1,000	10^{-3}
micro	µ	1/1,000,000	10^{-6}
nano	n	1/1,000,000,000	10^{-9}

So, to display the sub-units of the Henry we would use as an example:
1mH = 1 milli-Henry – which is equal to one thousandths (1/1000) of an Henry.
100µH = 100 micro-Henries – which is equal to 100 millionth's (1/1,000,000) of a Henry.
Inductors or coils are very common in electrical circuits and there are many factors which determine the inductance of a coil such as the shape of the coil, the number of turns of the insulated wire, the number of layers of wire, the spacing between the turns, the permeability of the core material, the size or cross-sectional area of the core etc, to name a few.

An inductor coil has a central core area, (A) with a constant number of turns of wire per unit length, (l). So if a coil of N turns is linked by an amount of magnetic flux, Φ then the coil has a flux linkage of NΦ and any current, (i) that flows through the coil will produce an induced magnetic flux in the opposite direction to the flow of current. Then according to Faraday's Law, any change in this magnetic flux linkage produces a self-induced voltage in the single coil of:

$$V_L = N\frac{d\Phi}{dt} = \frac{\mu N^2 A}{\ell}\frac{di}{dt}$$

Where:

N is the number of turns
A is the cross-sectional Area in m^2
Φ is the amount of flux in Webers
μ is the Permeability of the core material
l is the Length of the coil in meters
di/dt is the Currents rate of change in amps/second

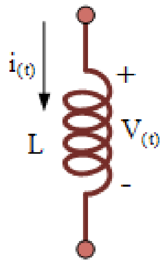
A time varying magnetic field induces a voltage that is proportional to the rate of change of the current producing it with a positive value indicating an increase in emf and a negative value indicating a decrease in emf. The equation relating this self-induced voltage, current and inductance can be found by substituting the $\mu N^2 A / l$ with L denoting the constant of proportionality called the Inductance of the coil.

The relation between the flux in the inductor and the current flowing through the inductor is given as: NΦ = Li. As an inductor consists of a coil of conducting wire, this then reduces the above equation to give the self-induced emf, sometimes called the back emf induced in the coil too:

Back emf Generated by an Inductor

$$V_L(t) = \frac{d\phi}{dt} = \frac{dLi}{dt} = -L\frac{di}{dt}$$

Where: L is the self-inductance and di/dt the rate of current change.



Inductor Coil

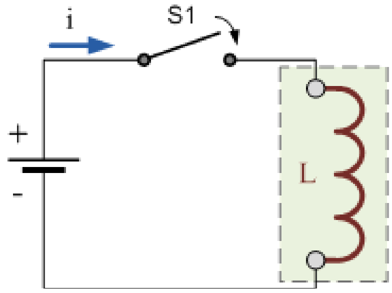
So from this equation we can say that the "Self-induced emf equals Inductance times the rate of current change" and a circuit has an inductance of one Henry will have an emf of one volt induced in the circuit when the current flowing through the circuit changes at a rate of one ampere per second.

One important point to note about the above equation. It only relates the emf produced across the inductor to changes in current because if the flow of inductor current is constant and not changing such as in a steady state DC current, then the induced emf voltage will be zero because the instantaneous rate of current change is zero, di/dt = 0.

With a steady state DC current flowing through the inductor and therefore zero induced voltage across it, the inductor acts as a short circuit equal to a piece of wire, or at the very least a very low value resistance. In other words, the opposition to the flow of current offered by an inductor is very different between AC and DC circuits.

The Time Constant of an Inductor

We now know that the current can not change instantaneously in an inductor because for this to occur, the current would need to change by a finite amount in zero time which would result in the rate of current change being infinite, $di/dt = \infty$, making the induced emf infinite as well and infinite voltages do no exist. However, if the current flowing through an inductor changes very rapidly, such as with the operation of a switch, high voltages can be induced across the inductors coil.



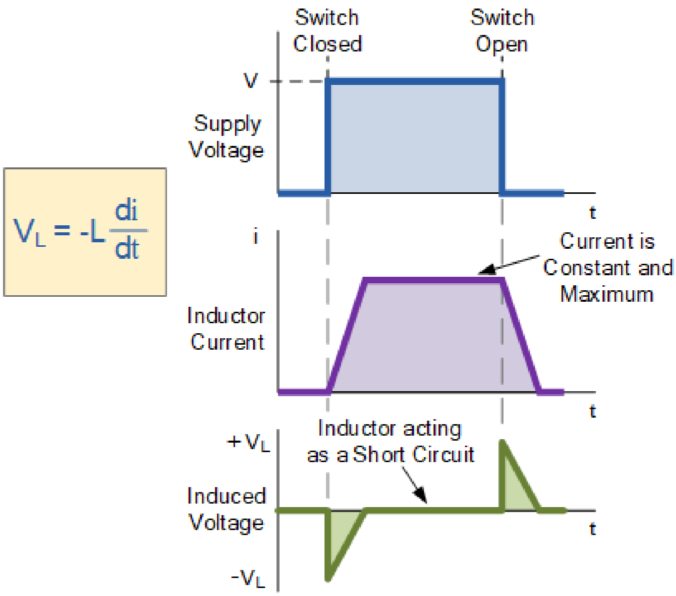
Consider the circuit of a pure inductor on the right. With the switch, (S1) open, no current flows through the inductor coil. As no current flows through the inductor, the rate of change of current (di/dt) in the coil will be zero. If the rate of change of current is zero there is no self-induced back-emf, ($V_L = 0$) within the inductor coil.

If we now close the switch (t = 0), a current will flow through the circuit and slowly rise to its maximum value at a rate determined by the inductance of the inductor. This rate of current flowing through the inductor multiplied by the inductors inductance in Henry's, results in some fixed value self-induced emf being produced across the coil as determined by Faraday's equation above, $V_L = -Ldi/dt$.

This self-induced emf across the inductors coil, (V_L) fights against the applied voltage until the current reaches its maximum value and a steady state condition is reached. The current which now flows through the coil is determined only by the DC or "pure" resistance of the coils windings as the reactance value of the coil has decreased to zero because the rate of change of current (di/dt) is zero in a steady state condition. In other words, in a real coil only the coils DC resistance exists to oppose the flow of current through itself.

Likewise, if switch (S1) is opened, the current flowing through the coil will start to fall but the inductor will again fight against this change and try to keep the current flowing at its previous value by inducing a another voltage in the other direction

Current and Voltage in an Inductor



How much induced voltage will be produced by the inductor depends upon the rate of current change. Lenz's Law stated that: "the direction of an induced emf is such that it will always opposes the change that is causing it". In other words, an induced emf will always OPPOSE the motion or change which started the induced emf in the first place. So with a decreasing current the voltage polarity will be acting as a source and with an increasing current the voltage polarity will be acting as a load. So for the same rate of current change through the coil, either increasing or decreasing the magnitude of the induced emf will be the same.

Inductor Example No1

A steady state direct current of 4 ampere passes through a solenoid coil of 0.5H. What would be the average back emf voltage induced in the coil if the switch in the above circuit was opened for 10mS and the current flowing through the coil dropped to zero ampere.

$$V_L = L\frac{di}{dt} = 0.5\frac{4}{0.01} = 200\,\text{volts}$$

Power in an Inductor

We know that an inductor in a circuit opposes the flow of current, (i) through it because the flow of this current induces an emf that opposes it, Lenz's Law. Then work has to be done by the external battery source in order to keep the current flowing against this induced emf. The instantaneous power used in forcing the current, (i) against this self-induced emf, (V_L) is given from above as:

$$V_{L(t)} = -L\frac{di}{dt}$$

Power in a circuit is given as, P = V*I therefore:

$$P = v.i = \left(L\frac{di}{dt}\right)\times i = \frac{1}{2}L\frac{di^2}{dt} = \frac{d}{dt}\left[\frac{1}{2}Li^2\right]$$

An ideal inductor has no resistance only inductance so R = 0 Ω and therefore no power is dissipated within the coil, so we can say that an ideal inductor has zero power loss.

Energy in an Inductor
When power flows into an inductor, energy is stored in its magnetic field. When the current flowing through the inductor is increasing and di/dt becomes greater than zero, the instantaneous power in the circuit must also be greater than zero, ($P > 0$) ie, positive which means that energy is being stored in the inductor.
Likewise, if the current through the inductor is decreasing and di/dt is less than zero then the instantaneous power must also be less than zero, ($P < 0$) ie, negative which means that the inductor is returning energy back into the circuit. Then by integrating the equation for power above, the total magnetic energy which is always positive, being stored in the inductor is therefore given as:
Energy stored by an Inductor

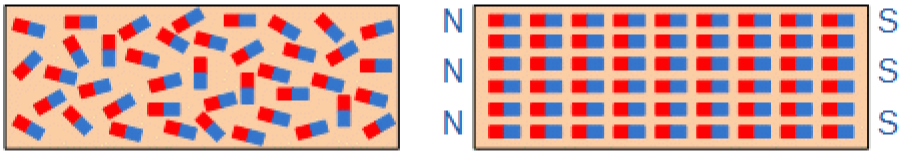
$$W_{(t)} = \frac{1}{2} L i^2_{(t)}$$

Where: W is in joules, L is in Henries and i is in Amperes
The energy is actually being stored within the magnetic field that surrounds the inductor by the current flowing through it. In an ideal inductor that has no resistance or capacitance, as the current increases energy flows into the inductor and is stored there within its magnetic field without loss, it is not released until the current decreases and the magnetic field collapses.
Then in an alternating current, AC circuit an inductor is constantly storing and delivering energy on each and every cycle. If the current flowing through the inductor is constant as in a DC circuit, then there is no change in the stored energy as
$P = Li(di/dt) = 0$.
So inductors can be defined as passive components as they can both stored and deliver energy to the circuit, but they cannot generate energy. An ideal inductor is classed as loss less, meaning that it can store energy indefinitely as no energy is lost.
However, real inductors will always have some resistance associated with the windings of the coil and whenever current flows through a resistance energy is lost in the form of heat due to Ohms Law, ($P = I^2 R$) regardless of whether the current is alternating or constant.
Then the primary use for inductors is in filtering circuits, resonance circuits and for current limiting. An inductor can be used in circuits to block or reshape alternating current or a range of sinusoidal frequencies, and in this role an inductor can be used to "tune" a simple radio receiver or various types of oscillators. It can also protect sensitive equipment from destructive voltage spikes and high inrush currents.

TEXT 8. MAGNETISM

Electromagnetism is the force produced when an electrical current flows through a simple conductor such as a piece of wire or cable.

Magnetic Materials



A small magnetic field is created around the conductor with the direction of this magnetic field with regards to its "North" and "South" poles being determined by the direction of the current flowing through the conductor.

Magnetism plays an important role in Electrical and Electronic Engineering because without it components such as relays, solenoids, inductors, chokes, coils, loudspeakers, motors, generators, transformers, and electricity meters etc, would not work if magnetism did not exist.

Then every coil of wire uses the effect of electromagnetism when an electrical current flows through it. But before we can look at Magnetism and especially Electromagnetism in more detail we need to remember back to our physics classes of how magnets and magnetism works.

The Nature of Magnetism

Magnets can be found in a natural state in the form of a magnetic ore, with the two main types being Magnetite also called "iron oxide", (FE_3O_4) and Lodestone, also called "leading stone". If these two natural magnets are suspended from a piece of string, they will take up a position in-line with the Earth's magnetic field always pointing north.

A good example of this effect is the needle of a compass. For most practical applications these natural occurring magnets can be disregarded as their magnetism is very low and because nowadays, man-made artificial magnets can be produced in many different shapes, sizes and magnetic strengths.

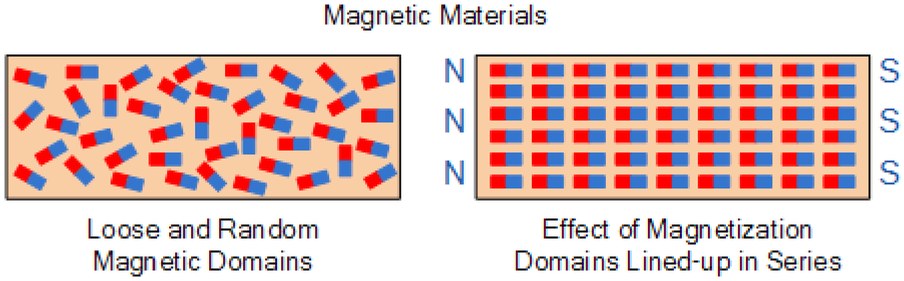
There are basically two forms of magnetism, "Permanent Magnets" and "Temporary Magnets", with the type being used dependant upon its application. There are many different types of materials available to make magnets such as iron, nickel, nickel alloys, chromium and cobalt and in their natural state some of these elements such as nickel and cobalt show very poor magnetic quantities on their own.

However, when mixed or "alloyed" together with other materials such as iron or aluminium peroxide they become very strong magnets producing unusual names such as "alcomax", "hycomax", "alni" and "alnico".

Magnetic material in the non-magnetic state has its molecular structure in the form of loose magnetic chains or individual tiny magnets loosely arranged in a random pattern. The overall effect of this type of arrangement results in zero or very weak magnetism as this haphazard arrangement of each molecular magnet tends to neutralise its neighbour.

When the material is Magnetised this random arrangement of the molecules changes and the tiny unaligned and random molecular magnets become "lined-up" in such a way

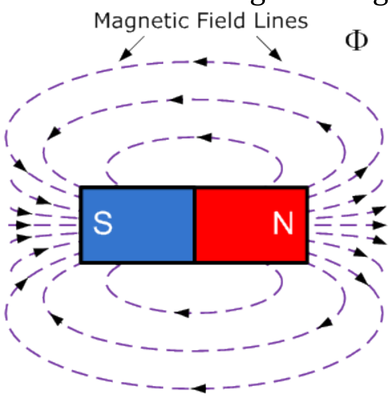
that they produce a series magnetic arrangement. This idea of the molecular alignment of ferromagnetic materials is known as Weber's Theory and is illustrated below.
Magnetic Molecule Alignment of a Piece of Iron and a Magnet



Weber's theory is based on the fact that all atoms have magnetic properties due to the spinning action of the atoms electrons. Groups of atoms join together so that their magnetic fields are all rotating in the same direction. Magnetic materials are composed of groups of tiny magnets at a molecular level around the atoms, and a magnetised material will have most of its tiny magnets lined up in one direction only to produce a north pole in one direction and a south pole in the other direction.
Likewise, a material that has its tiny molecular magnets pointing in all directions will have its molecular magnets neutralised by its neighbouring magnet, thereby neutralising any magnetic effect. These areas of molecular magnets are called "domains".
Any magnetic material will produce a magnetic field itself which depends on the degree of alignment of magnetic domains in the material set up by orbital and spinning electrons. This degree of alignment can be specified by a quantity known as magnetisation, M.
In an unmagnetised material, M = 0, but some of the domains remain aligned over small regions in the material once the magnetic field is removed. The effect of applying a magnetising force to the material is to align some of the domains to produce a non-zero magnetisation value.
Once the magnetising force has been removed, the magnetism within the material will either remain or decay away quiet quickly depending on the magnetic material being used. This ability of a material to retain its magnetism is called Retentivity.
Materials which are required to retain their magnetism will have a fairly high retentivity and as such are used to make permanent magnets, while those materials required to lose their magnetism quickly such as soft iron cores for relays and solenoids will have a very low retentivity.
All magnets, no matter what their shape, have two regions called magnetic poles with the magnetism both in and around a magnetic circuit producing a definite chain of organised and balanced pattern of invisible lines of flux around it. These lines of flux are collectively referred to as the "magnetic field" of the magnet. The shape of this magnetic field is more intense in some parts than others with the area of the magnet that has the greatest magnetism being called "poles". At each end of a magnet is a pole.
These lines of flux (called a vector field) can not be seen by the naked eye, but they can be seen visually by using iron fillings sprinkled onto a sheet of paper or by using a small compass to trace them out. Magnetic poles are always present in pairs, there is always a region of the magnet called the North-pole and there is always an opposite region called the South-pole.
Magnetic fields are always shown visually as lines of force that give a definite pole at each end of the material where the flux lines are more dense and concentrated. The

lines which go to make up a magnetic field showing the direction and intensity are called Lines of Force or more commonly "Magnetic Flux" and are given the Greek symbol, Phi (Φ) as shown below.

Lines of Force from a Bar Magnets Magnetic Field



As shown above, the magnetic field is strongest near to the poles of the magnet were the lines of flux are more closely spaced. The general direction for the magnetic flux flow is from the North (N) to the South (S) pole. In addition, these magnetic lines form closed loops that leave at the north pole of the magnet and enter at the south pole. Magnetic poles are always in pairs.

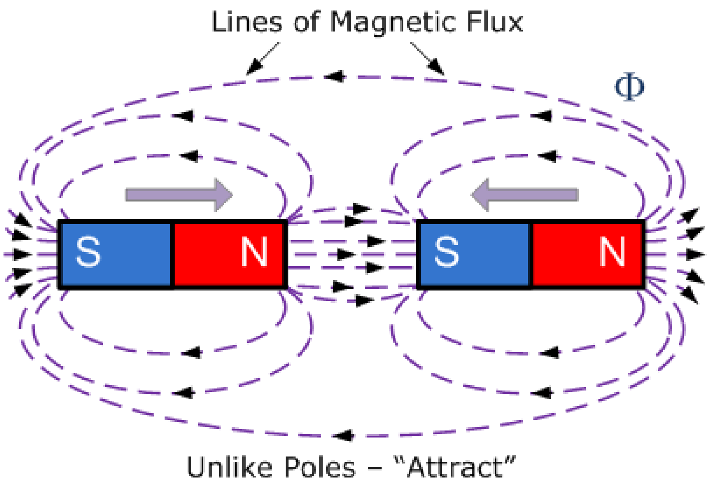
However, magnetic flux does not actually flow from the north to the south pole or flow anywhere for that matter as magnetic flux is a static region around a magnet in which the magnetic force exists. In other words magnetic flux does not flow or move it is just there and is not influenced by gravity. Some important facts emerge when plotting lines of force:

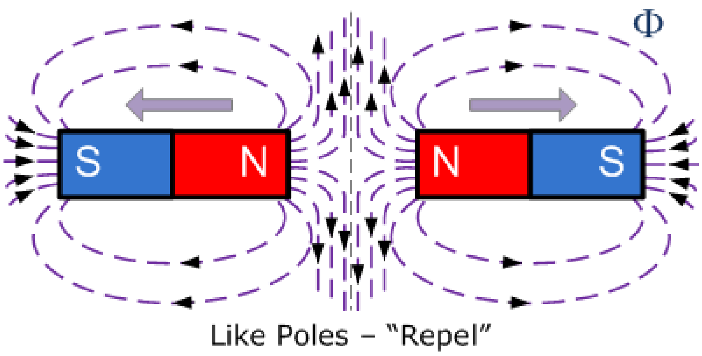
- Lines of force NEVER cross.
- Lines of force are CONTINUOUS.
- Lines of force always form individual CLOSED LOOPS around the magnet.
- Lines of force have a definite DIRECTION from North to South.
- Lines of force that are close together indicate a STRONG magnetic field.
- Lines of force that are farther apart indicate a WEAK magnetic field.

Magnetic forces attract and repel like electric forces and when two lines of force are brought close together the interaction between the two magnetic fields causes one of two things to occur:

- When adjacent poles are the same, (north-north or south-south) they REPEL each other.
- When adjacent poles are not the same, (north-south or south-north) they ATTRACT each other.

This effect is easily remembered by the famous expression that "opposites attract" and this interaction of magnetic fields can be easily demonstrated using iron fillings to show the lines of force around a magnet. The effect upon the magnetic fields of the various combinations of poles as like poles repel and unlike poles attract can be seen below.
Magnetic Field of Like and Unlike Poles





When plotting magnetic field lines with a compass it will be seen that the lines of force are produced in such a way as to give a definite pole at each end of the magnet where the lines of force leave the North pole and re-enter at the South pole. Magnetism can be destroyed by heating or hammering the magnetic material, but cannot be destroyed or isolated by simply breaking the magnet into two pieces.

So if you take a normal bar magnet and break it into two pieces, you do not have two halves of a magnet but instead each broken piece will somehow have its own North pole and a South pole. If you take one of those pieces and break it into two again, each of the smaller pieces will have a North pole and a South pole and so on. No matter how small the pieces of the magnet become, each piece will still have a North pole and a South pole, crazy!

Then in order for us to make use of magnetism in electrical or electronic calculations, it is necessary to define what are the various aspects of magnetism.

The Magnitude of Magnetism

We now know that the lines of force or more commonly the magnetic flux around a magnetic material is given the Greek symbol, Phi, (Φ) with the unit of flux being the Weber, (Wb) after Wilhelm Eduard Weber. But the number of lines of force within a given unit area is called the "Flux Density" and since flux (Φ) is measured in (Wb) and area (A) in metres squared, (m^2), flux density is therefore measured in Webers/Metre^2 or (Wb/m^2) and is given the symbol B.

However, when referring to flux density in magnetism, flux density is given the unit of the Tesla after Nikola Tesla so therefore one Wb/m^2 is equal to one Tesla, $1Wb/m^2 = 1T$.

Flux density is proportional to the lines of force and inversely proportional to area so we can define Flux Density as:

Magnetic Flux Density

$$\text{Magnetic Flux Density, (tesla)} = \frac{\text{Magnetic Flux, (weber)}}{\text{Area, (m2)}}$$

The symbol for magnetic flux density is B and the unit of magnetic flux density is the Tesla, T.

$$B = \frac{\Phi}{A} \quad \text{in Teslas}$$

It is important to remember that all calculations for flux density are done in the same units, e.g., flux in webers, area in m2 and flux density in Teslas.

Magnetism Example No1

The amount of flux present in a round magnetic bar was measured at 0.013 webers. If the material has a diameter of 12cm, calculate the flux density.

The cross sectional area of the magnetic material in m2 is given as:

$$\text{Diameter} = 12\text{cm}$$

$$\therefore \text{Area} = \pi r^2$$

$$A = 3.142 \times 0.06^2 = 0.0113\text{m}^2$$

The magnetic flux is given as 0.013 webers, therefore the flux density can be calculated as:

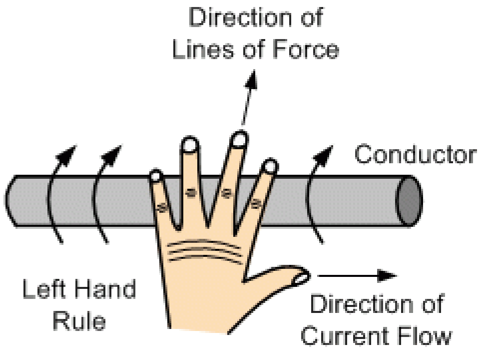
$$B = \frac{\Phi}{A} = \frac{0.013}{0.0113} = 1.15\text{T}$$

So the flux density is calculated as 1.15 Teslas.

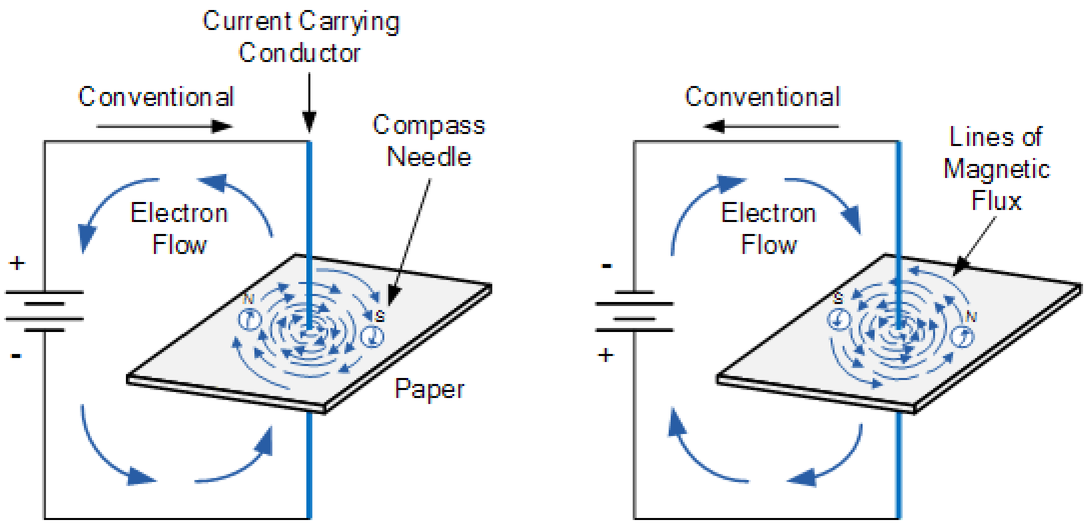
When dealing with magnetism in electrical circuits it must be remembered that one Tesla is the density of a magnetic field such that a conductor carrying 1 ampere at right angles to the magnetic field experiences a force of one Newton-metre length on it.

TEXT 9. ELECTROMAGNETISM

Permanent magnets produce a magnetic field around themselves from their north pole to their south pole.

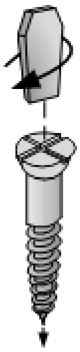


While permanent magnets produce a good and sometimes very strong static magnetic field, in some applications the strength of this magnetic field is still too weak or we need to be able to control the amount of magnetic flux that is present. So in order to produce a much stronger and more controllable magnetic field we need to use electricity.
By using coils of wire wrapped or wound around a soft magnetic material such as an iron core we can produce very strong electromagnets for use in many different types of electrical applications. This use of coils of wire produces a relationship between electricity and magnetism that gives us another form of magnetism called Electromagnetism.
Electromagnetism is produced when an electrical current flows through a simple conductor such as a length of wire or cable, and as current passes along the whole of the conductor then a magnetic field is created along the whole of the conductor. The small magnetic field created around the conductor has a definite direction with both the "North" and "South" poles produced being determined by the direction of the electrical current flowing through the conductor.
Therefore, it is necessary to establish a relationship between current flowing through the conductor and the resultant magnetic field produced around it by this flow of current allowing us to define the relationship that exists between Electricity and Magnetism in the form of Electromagnetism.
We have established that when an electrical current flows through a conductor a circular electromagnetic field is produced around it with the magnetic lines of flux forming complete loops that do not cross around the whole length of the conductor.
The direction of rotation of this magnetic field is governed by the direction of the current flowing through the conductor with the corresponding magnetic field produced being stronger near to the center of the current carrying conductor. This is because the path length of the loops being greater the further away from the conductor resulting in weaker flux lines as shown below.
Magnetic Field around a Conductor



Electromagnetic Field (Clockwise)

Electromagnetic Field (Anticlockwise)

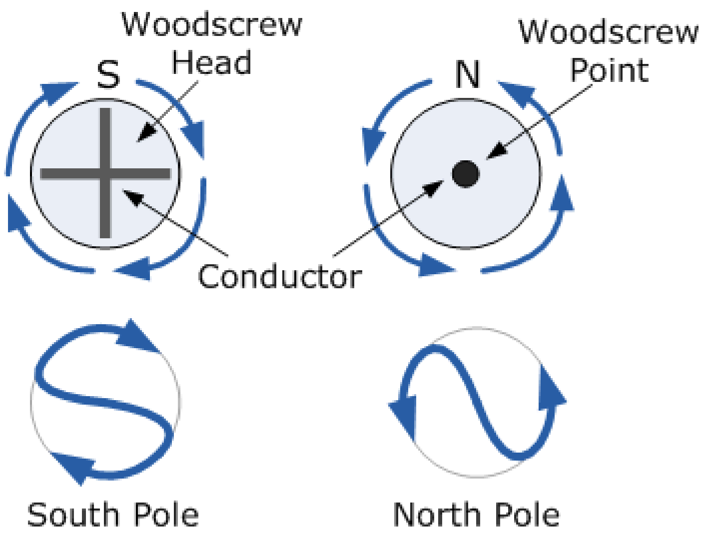


A simple way to determine the direction of the magnetic field around the conductor is to consider screwing an ordinary wood screw into a sheet of paper. As the screw enters the paper the rotational action is CLOCKWISE and the only part of the screw that is visible above the paper is the screw head.

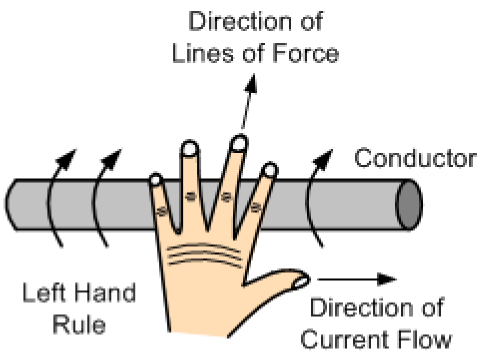
Likewise, the action of removing the screw is the reverse, anticlockwise. As the current enters from the top it therefore leaves the underside of the paper and the only part of the wood screw that is visible from below is the tip or point of the screw and it is this point which is used to indicate current flowing "out of" the paper and towards the observer.

Then the physical action of screwing the wood screw in and out of the paper indicates the direction of the current in the conductor and therefore, the direction of rotation of the electromagnetic field around it as shown below. This concept is known generally as the Right Hand Screw Action.

The Right Hand Screw Action



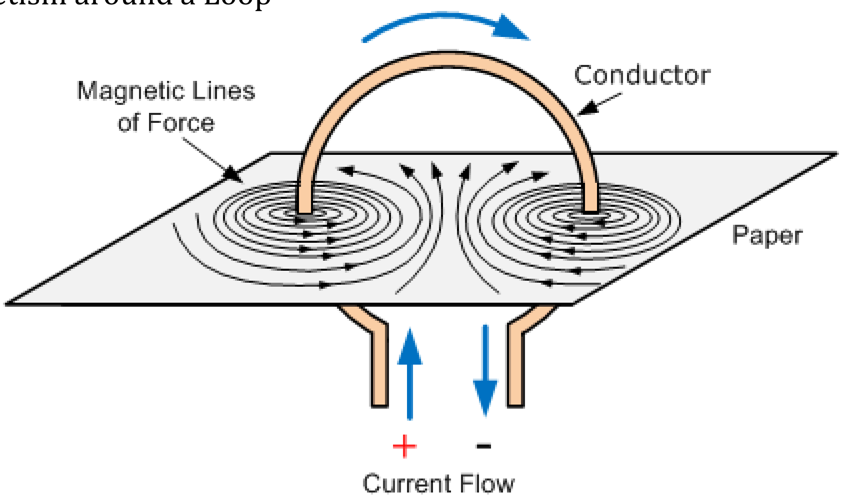
A magnetic field implies the existence of two poles, a north and a south. The polarity of a current carrying conductor can be established by drawing the capital letters S and N and then adding arrow heads to the free end of the letters as shown above giving a visual representation of the magnetic field direction.
Another more familiar concept which determines both the direction of current flow and the resulting direction of the magnetic flux around the conductor is called the "Left Hand Rule".



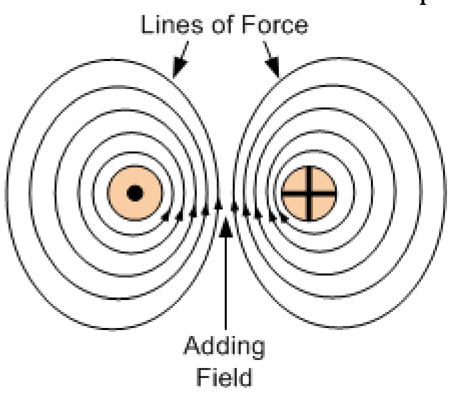
Left Hand Rule of
Electromagnetism

The recognised direction of a magnetic field is from its north pole to its south pole. This direction can be deduced by holding the current carrying conductor in your left hand with the thumb extended pointing in the direction of the *electron flow* from negative to positive.
The position of the fingers laid across and around the conductor will now be pointing in the direction of the generated magnetic lines of force as shown.
If the direction of the electron flowing through the conductor is reversed, the left hand will need to be placed onto the other side of the conductor with the thumb pointing in the new direction of the electron current flow.
Also as the current is reversed the direction of the magnetic field produced around the conductor will also be reversed because as we have said previously, the direction of the magnetic field depends upon the direction of current flow.
This "Left Hand Rule" can also be used to determine the magnetic direction of the poles in an electromagnetic coil. This time, the fingers point in the direction of the electron flow from negative to positive while the extended thumb indicating the direction of the

north pole. There is a variation on this rule called the "right hand rule" which is based on so-called conventional current flow, (positive to negative).
Consider when a single straight piece of wire is bent into the form of a single loop as shown below. Although the electric current is flowing in the same direction through the whole length of the wire conductor, it will be flowing in opposite directions through the paper. This is because the current leaves the paper on one side and enters the paper on the other therefore a clockwise field and an anticlockwise field are produced next to each other across the sheet of paper.
The resulting space between these two conductors becomes an "intensified" magnetic field with the lines of force spreading out in such a way that they assume the form of a bar magnet generating a distinctive north and south pole at the point of intersection.
Electromagnetism around a Loop



Lines of Force around the Loop

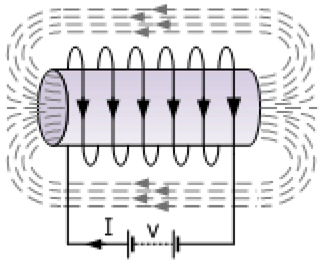


The current flowing through the two parallel conductors of the loop are in opposite directions as the current through the loop exits the left hand side and returns on the right hand side. This results in the magnetic field around each conductor inside the loop being in the "SAME" direction to each other.
The resulting lines of force generated by the current flowing through the loop oppose each other in the space between the two conductors where the two like poles meet thereby deforming the lines of force around each conductor as shown.
However, the distortion of the magnetic flux in between two conductors results in intensity of the magnetic field at the middle junction were the lines of force become closer together. The resulting interaction between the two like fields produces a mechanical force between the two conductors as they try to repel away from each other. In an electrical machine this repelling of these two magnetic fields produces motion.

However, as the conductors cannot move, the two magnetic fields therefore help each other by generating a north and a south pole along this line of interaction. This results in the magnetic field being strongest in the middle between the two conductors. The intensity of the magnetic field around the conductor is proportional to the distance from the conductor and by the amount of current flowing through it.
The magnetic field generated around a straight length of current-carrying wire is very weak even with a high current passing through it. However, if several loops of the wire are wound together along the same axis producing a coil of wire, the resultant magnetic field will become even more concentrated and stronger than that of just a single loop. This produces an electromagnetic coil more commonly called a Solenoid.
Then every length of wire has the effect of electromagnetism around itself when an electrical current flows through it. The direction of the magnetic field depends upon the direction of the flow of current. We can increase the strength of the generated magnetic field by forming the length of wire into a coil.

TEXT 10. ELECTROMAGNETIC INDUCTION

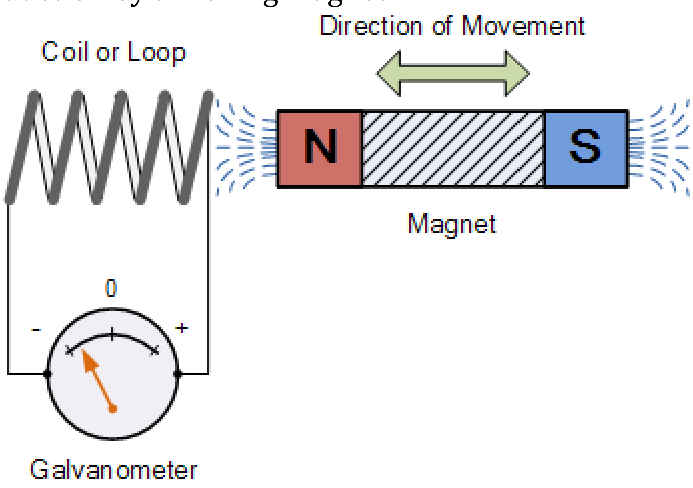
When a DC current passes through a long straight conductor a magnetising force and a static magnetic field is developed around it
If the wire is then wound into a coil, the magnetic field is greatly intensified producing a static magnetic field around itself forming the shape of a bar magnet giving a distinct North and South pole.



Air-core Hollow Coil

The magnetic flux developed around the coil being proportional to the amount of current flowing in the coils windings as shown. If additional layers of wire are wound upon the same coil with the same current flowing through them, the static magnetic field strength would be increased.
Therefore, the magnetic field strength of a coil is determined by the *ampere turns* of the coil. With more turns of wire within the coil, the greater the strength of the static magnetic field around it.
But what if we reversed this idea by disconnecting the electrical current from the coil and instead of a hollow core we placed a bar magnet inside the core of the coil of wire. By moving this bar magnet "in" and "out" of the coil a current would be induced into the coil by the physical movement of the magnetic flux inside it.
Likewise, if we kept the bar magnet stationary and moved the coil back and forth within the magnetic field an electric current would be induced in the coil. Then by either moving the wire or changing the magnetic field we can induce a voltage and current within the coil and this process is known as Electromagnetic Induction and is the basic principle of operation of transformers, motors and generators.
Electromagnetic Induction was first discovered way back in the 1830's by Michael Faraday. Faraday noticed that when he moved a permanent magnet in and out of a coil or a single loop of wire it induced an ElectroMotive Force or emf, in other words a Voltage, and therefore a current was produced.
So what Michael Faraday discovered was a way of producing an electrical current in a circuit by using only the force of a magnetic field and not batteries. This then lead to a very important law linking electricity with magnetism, Faraday's Law of Electromagnetic Induction. So how does this work?.
When the magnet shown below is moved "towards" the coil, the pointer or needle of the Galvanometer, which is basically a very sensitive centre zero'ed moving-coil ammeter, will deflect away from its centre position in one direction only. When the magnet stops moving and is held stationary with regards to the coil the needle of the galvanometer returns back to zero as there is no physical movement of the magnetic field.
Likewise, when the magnet is moved "away" from the coil in the other direction, the needle of the galvanometer deflects in the opposite direction with regards to the first indicating a change in polarity. Then by moving the magnet back and forth towards the

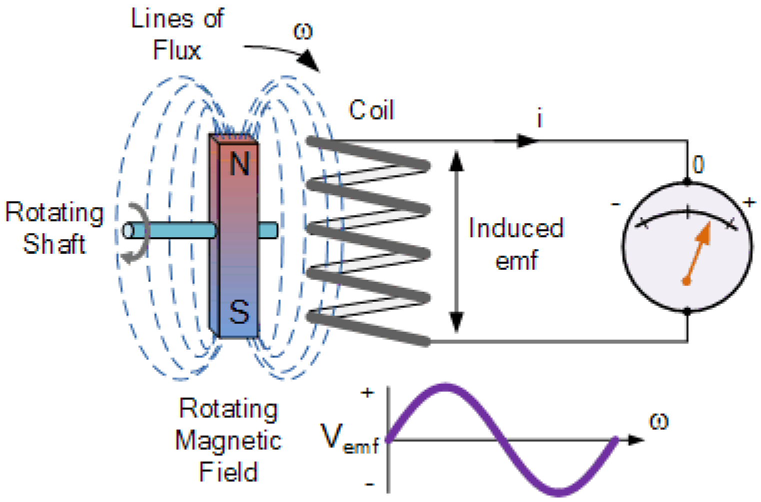
coil the needle of the galvanometer will deflect left or right, positive or negative, relative to the directional motion of the magnet.
Electromagnetic Induction by a Moving Magnet



Likewise, if the magnet is now held stationary and ONLY the coil is moved towards or away from the magnet the needle of the galvanometer will also deflect in either direction. Then the action of moving a coil or loop of wire through a magnetic field induces a voltage in the coil with the magnitude of this induced voltage being proportional to the speed or velocity of the movement.
Then we can see that the faster the movement of the magnetic field the greater will be the induced emf or voltage in the coil, so for Faraday's law to hold true there must be "relative motion" or movement between the coil and the magnetic field and either the magnetic field, the coil or both can move.
Faraday's Law of Induction
From the above description we can say that a relationship exists between an electrical voltage and a changing magnetic field to which Michael Faraday's famous law of electromagnetic induction states: "that a voltage is induced in a circuit whenever relative motion exists between a conductor and a magnetic field and that the magnitude of this voltage is proportional to the rate of change of the flux".
In other words, Electromagnetic Induction is the process of using magnetic fields to produce voltage, and in a closed circuit, a current.
So how much voltage (emf) can be induced into the coil using just magnetism. Well this is determined by the following 3 different factors.
1). Increasing the number of turns of wire in the coil – By increasing the amount of individual conductors cutting through the magnetic field, the amount of induced emf produced will be the sum of all the individual loops of the coil, so if there are 20 turns in the coil there will be 20 times more induced emf than in one piece of wire.
2). Increasing the speed of the relative motion between the coil and the magnet – If the same coil of wire passed through the same magnetic field but its speed or velocity is increased, the wire will cut the lines of flux at a faster rate so more induced emf would be produced.
3). Increasing the strength of the magnetic field – If the same coil of wire is moved at the same speed through a stronger magnetic field, there will be more emf produced because there are more lines of force to cut.
If we were able to move the magnet in the diagram above in and out of the coil at a constant speed and distance without stopping we would generate a continuously

induced voltage that would alternate between one positive polarity and a negative polarity producing an alternating or AC output voltage and this is the basic principle of how an electrical generator works similar to those used in dynamos and car alternators. In small generators such as a bicycle dynamo, a small permanent magnet is rotated by the action of the bicycle wheel inside a fixed coil. Alternatively, an electromagnet powered by a fixed DC voltage can be made to rotate inside a fixed coil, such as in large power generators producing in both cases an alternating current.

Simple Generator using Magnetic Induction



The simple dynamo type generator above consists of a permanent magnet which rotates around a central shaft with a coil of wire placed next to this rotating magnetic field. As the magnet spins, the magnetic field around the top and bottom of the coil constantly changes between a north and a south pole. This rotational movement of the magnetic field results in an alternating emf being induced into the coil as defined by Faraday's law of electromagnetic induction.

The magnitude of the electromagnetic induction is directly proportional to the flux density, β the number of loops giving a total length of the conductor, l in meters and the rate or velocity, v at which the magnetic field changes within the conductor in meters/second or m/s, giving by the motional emf expression:

Faraday's Motional emf Expression

$$\varepsilon = -\beta . \ell . \upsilon \quad \text{volts}$$

If the conductor does not move at right angles (90°) to the magnetic field then the angle θ° will be added to the above expression giving a reduced output as the angle increases:

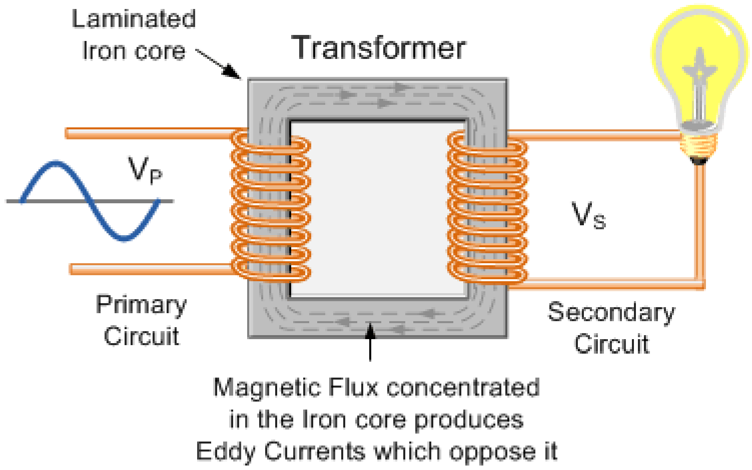
$$\varepsilon = -\beta . \ell . \upsilon \sin\theta \quad \text{volts}$$

Lenz's Law of Electromagnetic Induction

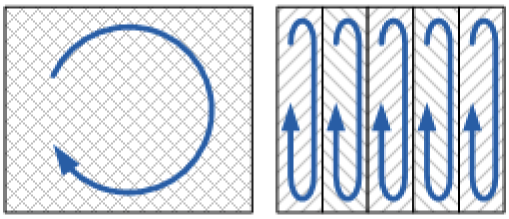
Faraday's Law tells us that inducing a voltage into a conductor can be done by either passing it through a magnetic field, or by moving the magnetic field past the conductor and that if this conductor is part of a closed circuit, an electric current will flow. This voltage is called an induced emf as it has been induced into the conductor by a changing magnetic field due to electromagnetic induction with the negative sign in Faraday's law telling us the direction of the induced current (or polarity of the induced emf).

But a changing magnetic flux produces a varying current through the coil which itself will produce its own magnetic field. This self-induced emf opposes the change that is causing it and the faster the rate of change of current the greater is the opposing emf.

This self-induced emf will, by Lenz's law oppose the change in current in the coil and because of its direction this self-induced emf is generally called a back-emf.
Lenz's Law states that: " the direction of an induced emf is such that it will always opposes the change that is causing it". In other words, an induced current will always OPPOSE the motion or change which started the induced current in the first place and this idea is found in the analysis of Inductance.
Likewise, if the magnetic flux is decreased then the induced emf will oppose this decrease by generating and induced magnetic flux that adds to the original flux.
Lenz's law is one of the basic laws in electromagnetic induction for determining the direction of flow of induced currents and is related to the law of conservation of energy.
According to the law of conservation of energy which states that the total amount of energy in the universe will always remain constant as energy can not be created nor destroyed. Lenz's law is derived from Michael Faraday's law of induction.
One final comment about Lenz's Law regarding electromagnetic induction. We now know that when a relative motion exists between a conductor and a magnetic field, an emf is induced within the conductor.
But the conductor may not actually be part of the coils electrical circuit, but may be the coils iron core or some other metallic part of the system, for example, a transformer.
The induced emf within this metallic part of the system causes a circulating current to flow around it and this type of core current is known as an Eddy Current.
Eddy currents generated by electromagnetic induction circulate around the coils core or any connecting metallic components inside the magnetic field because for the magnetic flux they are acting like a single loop of wire. Eddy currents do not contribute anything towards the usefulness of the system but instead they oppose the flow of the induced current by acting like a negative force generating resistive heating and power loss within the core. However, there are electromagnetic induction furnace applications in which only eddy currents are used to heat and melt ferromagnetic metals.
Eddy Currents Circulating in a Transformer



The changing magnetic flux in the iron core of a transformer above will induce an emf, not only in the primary and secondary windings, but also in the iron core. The iron core is a good conductor, so the currents induced in a solid iron core will be large.
Furthermore, the eddy currents flow in a direction which, by Lenz's law, acts to weaken the flux created by the primary coil. Consequently, the current in the primary coil required to produce a given B field is increased, so the hysteresis curves are fatter along the H axis.



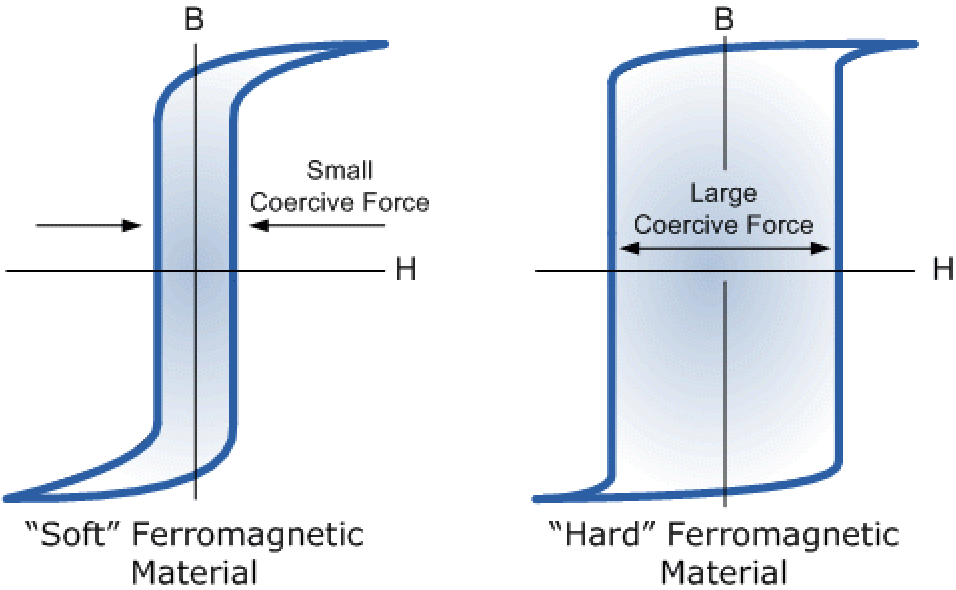
Laminating the Iron Core

Eddy current and hysteresis losses can not be eliminated completely, but they can be greatly reduced. Instead of having a solid iron core as the magnetic core material of the transformer or coil, the magnetic path is “laminated”.

These laminations are very thin strips of insulated (usually with varnish) metal joined together to produce a solid core. The laminations increase the resistance of the iron-core thereby increasing the overall resistance to the flow of the eddy currents, so the induced eddy current power-loss in the core is reduced, and it is for this reason why the magnetic iron circuit of transformers and electrical machines are all laminated.

TEXT 11. MAGNETIC HYSTERESIS

The lag or delay of a magnetic material known commonly as Magnetic Hysteresis, relates to the magnetisation properties of a material by which it firstly becomes magnetised and then de-magnetised.



We know that the magnetic flux generated by an electromagnetic coil is the amount of magnetic field or lines of force produced within a given area and that it is more commonly called "Flux Density". Given the symbol B with the unit of flux density being the Tesla, T.

The magnetic strength of an electromagnet depends upon the number of turns of the coil, the current flowing through the coil or the type of core material being used, and if we increase either the current or the number of turns we can increase the magnetic field strength, symbol H.

Previously, the relative permeability, symbol μ_r was defined as the ratio of the absolute permeability μ and the permeability of free space μ_o (a vacuum) and this was given as a constant. However, the relationship between the flux density, B and the magnetic field strength, H can be defined by the fact that the relative permeability, μ_r is not a constant but a function of the magnetic field intensity thereby giving magnetic flux density as: $B = \mu H$.

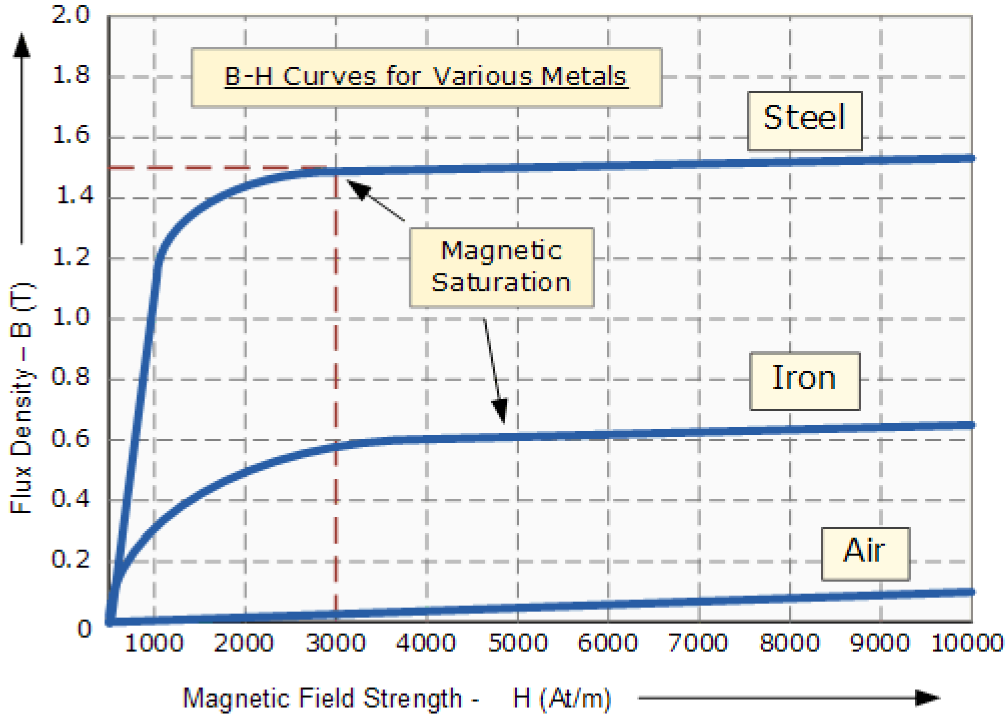
Then the magnetic flux density in the material will be increased by a larger factor as a result of its relative permeability for the material compared to the magnetic flux density in vacuum, $\mu_o H$ and for an air-cored coil this relationship is given as:

$$B = \frac{\Phi}{A} \quad \text{and} \quad \frac{B}{H} = \mu_0$$

So for ferromagnetic materials the ratio of flux density to field strength (B/H) is not constant but varies with flux density. However, for air cored coils or any non-magnetic medium core such as woods or plastics, this ratio can be considered as a constant and this constant is known as μ_o, the permeability of free space, ($\mu_o = 4.\pi.10^{-7}$ H/m).

By plotting values of flux density, (B) against the field strength, (H) we can produce a set of curves called Magnetisation Curves, Magnetic Hysteresis Curves or more commonly B-H Curves for each type of core material used as shown below.

Magnetisation or B-H Curve



The set of magnetisation curves, M above represents an example of the relationship between B and H for soft-iron and steel cores but every type of core material will have its own set of magnetic hysteresis curves. You may notice that the flux density increases in proportion to the field strength until it reaches a certain value were it can not increase any more becoming almost level and constant as the field strength continues to increase.

This is because there is a limit to the amount of flux density that can be generated by the core as all the domains in the iron are perfectly aligned. Any further increase will have no effect on the value of M, and the point on the graph where the flux density reaches its limit is called Magnetic Saturation also known as Saturation of the Core and in our simple example above the saturation point of the steel curve begins at about 3000 ampere-turns per metre.

Saturation occurs because the random haphazard arrangement of the molecule structure within the core material changes as the tiny molecular magnets within the material become "lined-up".

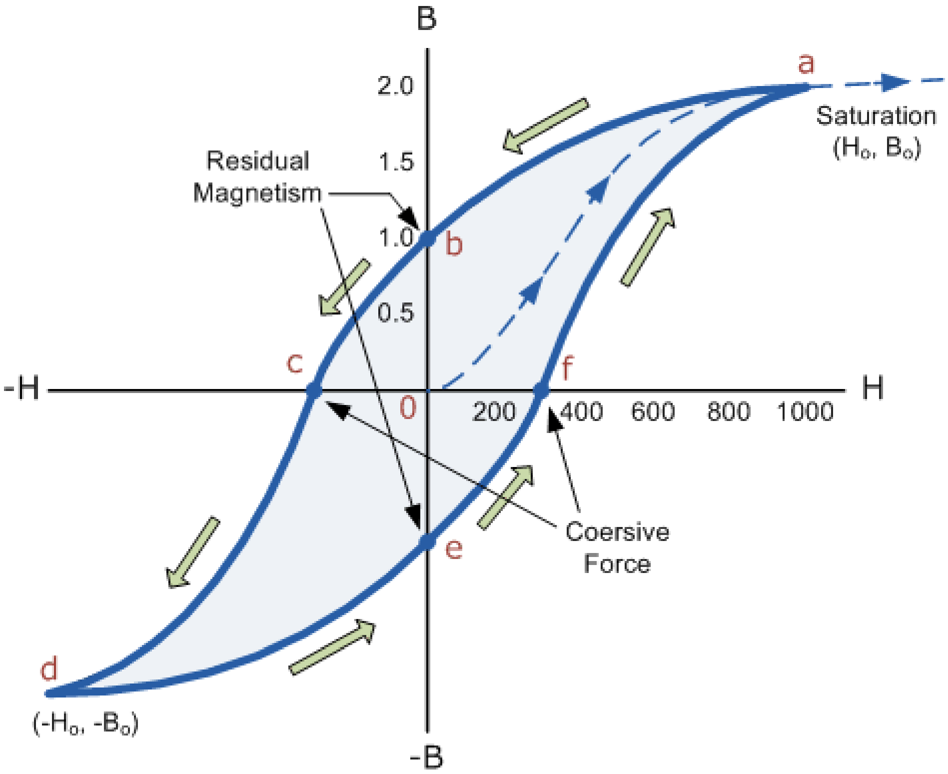
As the magnetic field strength, (H) increases these molecular magnets become more and more aligned until they reach perfect alignment producing maximum flux density and any increase in the magnetic field strength due to an increase in the electrical current flowing through the coil will have little or no effect.

Retentivity

Lets assume that we have an electromagnetic coil with a high field strength due to the current flowing through it, and that the ferromagnetic core material has reached its saturation point, maximum flux density. If we now open a switch and remove the magnetising current flowing through the coil we would expect the magnetic field around the coil to disappear as the magnetic flux reduced to zero.

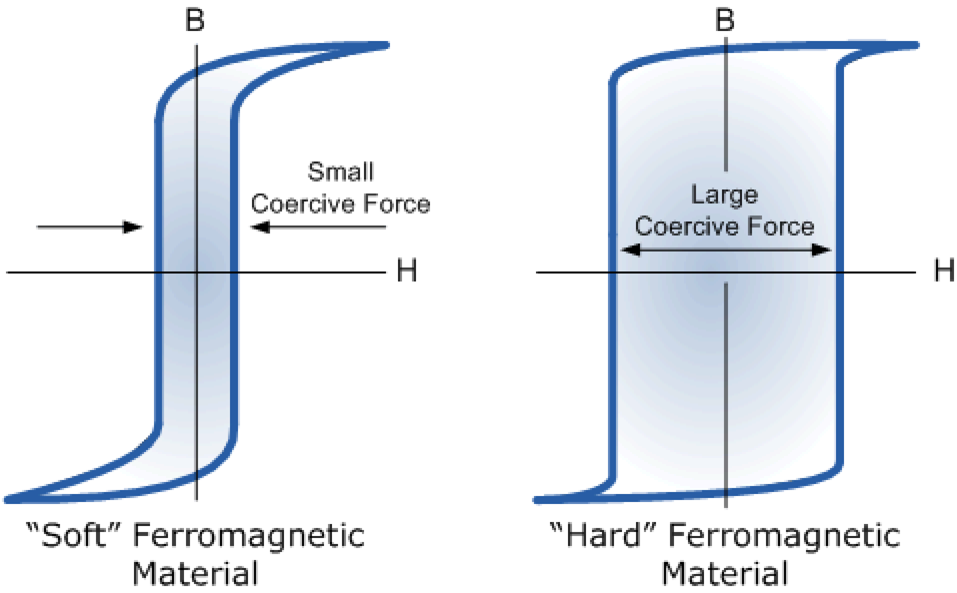
However, the magnetic flux does not completely disappear as the electromagnetic core material still retains some of its magnetism even when the current has stopped flowing in the coil. This ability for a coil to retain some of its magnetism within the core after the

magnetisation process has stopped is called Retentivity or remanence, while the amount of flux density still remaining in the core is called Residual Magnetism, B_R .
The reason for this that some of the tiny molecular magnets do not return to a completely random pattern and still point in the direction of the original magnetising field giving them a sort of "memory". Some ferromagnetic materials have a high retentivity (magnetically hard) making them excellent for producing permanent magnets.
While other ferromagnetic materials have low retentivity (magnetically soft) making them ideal for use in electromagnets, solenoids or relays. One way to reduce this residual flux density to zero is by reversing the direction of the current flowing through the coil, thereby making the value of H, the magnetic field strength negative. This effect is called a Coercive Force, H_C .
If this reverse current is increased further the flux density will also increase in the reverse direction until the ferromagnetic core reaches saturation again but in the reverse direction from before. Reducing the magnetising current, i once again to zero will produce a similar amount of residual magnetism but in the reverse direction.
Then by constantly changing the direction of the magnetising current through the coil from a positive direction to a negative direction, as would be the case in an AC supply, a Magnetic Hysteresis loop of the ferromagnetic core can be produced.
Magnetic Hysteresis Loop



The Magnetic Hysteresis loop above, shows the behaviour of a ferromagnetic core graphically as the relationship between B and H is non-linear. Starting with an unmagnetised core both B and H will be at zero, point 0 on the magnetisation curve.
If the magnetisation current, i is increased in a positive direction to some value the magnetic field strength H increases linearly with i and the flux density B will also increase as shown by the curve from point 0 to point a as it heads towards saturation.

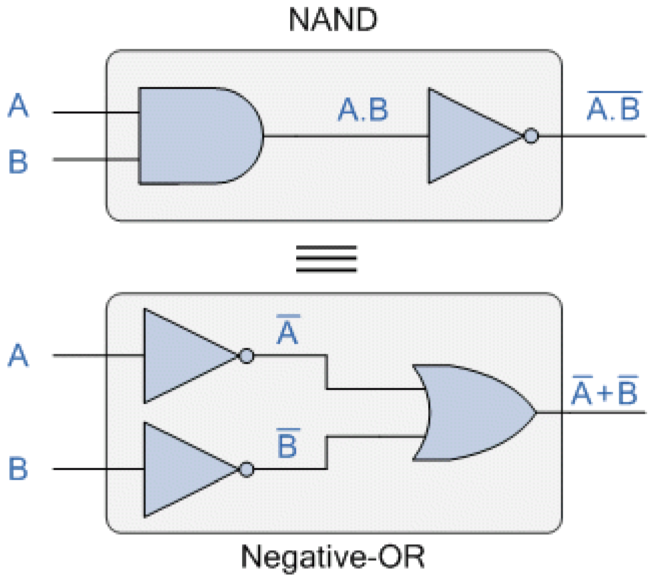
Now if the magnetising current in the coil is reduced to zero, the magnetic field circulating around the core also reduces to zero. However, the coils magnetic flux will not reach zero due to the residual magnetism present within the core and this is shown on the curve from point a to point b.
To reduce the flux density at point b to zero we need to reverse the current flowing through the coil. The magnetising force which must be applied to null the residual flux density is called a "Coercive Force". This coercive force reverses the magnetic field re-arranging the molecular magnets until the core becomes unmagnetised at point c.
An increase in this reverse current causes the core to be magnetised in the opposite direction and increasing this magnetisation current further will cause the core to reach its saturation point but in the opposite direction, point d on the curve.
This point is symmetrical to point b. If the magnetising current is reduced again to zero the residual magnetism present in the core will be equal to the previous value but in reverse at point e.
Again reversing the magnetising current flowing through the coil this time into a positive direction will cause the magnetic flux to reach zero, point f on the curve and as before increasing the magnetisation current further in a positive direction will cause the core to reach saturation at point a.
Then the B-H curve follows the path of a-b-c-d-e-f-a as the magnetising current flowing through the coil alternates between a positive and negative value such as the cycle of an AC voltage. This path is called a Magnetic Hysteresis Loop.
The effect of magnetic hysteresis shows that the magnetisation process of a ferromagnetic core and therefore the flux density depends on which part of the curve the ferromagnetic core is magnetised on as this depends upon the circuits past history giving the core a form of "memory". Then ferromagnetic materials have memory because they remain magnetised after the external magnetic field has been removed.
However, soft ferromagnetic materials such as iron or silicon steel have very narrow magnetic hysteresis loops resulting in very small amounts of residual magnetism making them ideal for use in relays, solenoids and transformers as they can be easily magnetised and demagnetised.
Since a coercive force must be applied to overcome this residual magnetism, work must be done in closing the hysteresis loop with the energy being used being dissipated as heat in the magnetic material. This heat is known as hysteresis loss, the amount of loss depends on the material's value of coercive force.
By adding additive's to the iron metal such as silicon, materials with a very small coercive force can be made that have a very narrow hysteresis loop. Materials with narrow hysteresis loops are easily magnetised and demagnetised and known as soft magnetic materials.
Magnetic Hysteresis Loops for Soft and Hard Materials



Magnetic Hysteresis results in the dissipation of wasted energy in the form of heat with the energy wasted being in proportion to the area of the magnetic hysteresis loop. Hysteresis losses will always be a problem in AC transformers where the current is constantly changing direction and thus the magnetic poles in the core will cause losses because they constantly reverse direction.
Rotating coils in DC machines will also incur hysteresis losses as they are alternately passing north the south magnetic poles. As said previously, the shape of the hysteresis loop depends upon the nature of the iron or steel used and in the case of iron which is subjected to massive reversals of magnetism, for example transformer cores, it is important that the B-H hysteresis loop is as small as possible.

TEXT 12. DEMORGAN'S THEOREM

DeMorgan´s Theorem and Laws can be used to to find the equivalency of the NAND and NOR gates



As we have seen previously, Boolean Algebra uses a set of laws and rules to define the operation of a digital logic circuit with "0's" and "1's" being used to represent a digital input or output condition. Boolean Algebra uses these zeros and ones to create truth tables and mathematical expressions to define the digital operation of a logic AND, OR and NOT (or inversion) operations as well as ways of expressing other logical operations such as the XOR (Exclusive-OR) function.

While George Boole's set of laws and rules allows us to analyse and simplify a digital circuit, there are two laws within his set that are attributed to Augustus DeMorgan (a nineteenth century English mathematician) which views the logical NAND and NOR operations as separate NOT AND and NOT OR functions respectively.

But before we look at DeMorgan's Theory in more detail, let's remind ourselves of the basic logical operations where A and B are logic (or Boolean) input binary variables, and whose values can only be either "0" or "1" producing four possible input combinations, 00, 01, 10, and 11.

Truth Table for Each Logical Operation

Input Variable		**Output Conditions**			
A	B	AND	NAND	OR	NOR
0	0	0	1	0	1
0	1	0	1	1	0
1	0	0	1	1	0
1	1	1	0	1	0

The following table gives a list of the common logic functions and their equivalent Boolean notation where a "." (a dot) means an AND (product) operation, a "+" (plus sign) means an OR (sum) operation, and the complement or inverse of a variable is indicated by a bar over the variable.

Logic Function	Boolean Notation
AND	A.B
OR	A+B
NOT	A
NAND	A .B
NOR	A+B

DeMorgan's Theory

DeMorgan's Theorems are basically two sets of rules or laws developed from the Boolean expressions for AND, OR and NOT using two input variables, A and B. These two rules or theorems allow the input variables to be negated and converted from one form of a Boolean function into an opposite form.

DeMorgan's first theorem states that two (or more) variables NOR´ed together is the same as the two variables inverted (Complement) and AND´ed, while the second theorem states that two (or more) variables NAND´ed together is the same as the two terms inverted (Complement) and OR´ed. That is replace all the OR operators with AND operators, or all the AND operators with an OR operators.

DeMorgan's First Theorem

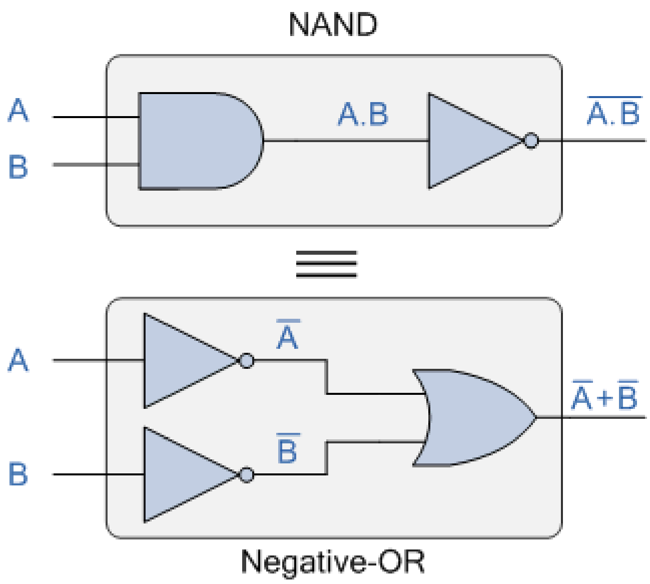
DeMorgan's First theorem proves that when two (or more) input variables are AND'ed and negated, they are equivalent to the OR of the complements of the individual variables. Thus the equivalent of the NAND function will be a negative-OR function, proving that A.B = A+B. We can show this operation using the following table.

Verifying DeMorgan's First Theorem using Truth Table

Inputs		**Truth Table Outputs For Each Term**				
B	A	A.B	A.B	A	B	A + B
0	0	0	1	1	1	1
0	1	0	1	0	1	1
1	0	0	1	1	0	1
1	1	1	0	0	0	0

We can also show that A.B = A+B using logic gates as shown.

DeMorgan's First Law Implementation using Logic Gates



The top logic gate arrangement of: A.B can be implemented using a standard NAND gate with inputs A and B. The lower logic gate arrangement first inverts the two inputs producing A and B. These then become the inputs to the OR gate. Therefore the output from the OR gate becomes: A+B

Then we can see here that a standard OR gate function with inverters (NOT gates) on each of its inputs is equivalent to a NAND gate function. So an individual NAND gate can be represented in this way as the equivalency of a NAND gate is a negative-OR.

DeMorgan's Second Theorem

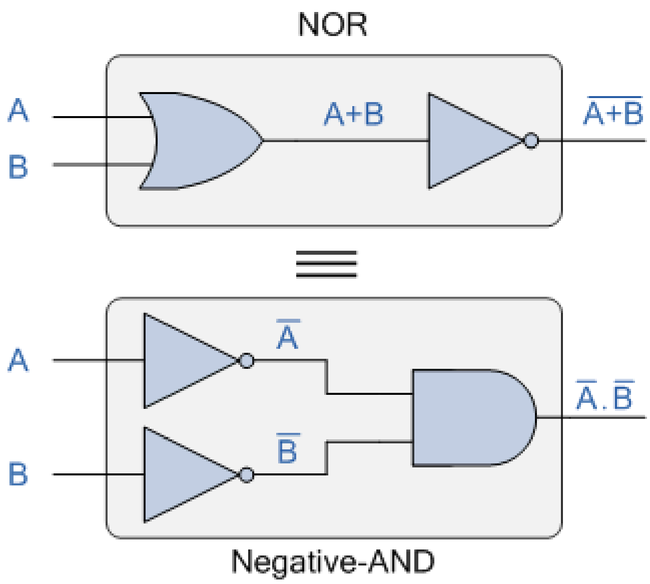
DeMorgan's Second theorem proves that when two (or more) input variables are OR'ed and negated, they are equivalent to the AND of the complements of the individual variables. Thus the equivalent of the NOR function is a negative-AND function proving that A+B = A.B, and again we can show operation this using the following truth table.

Verifying DeMorgan's Second Theorem using Truth Table

Inputs		Truth Table Outputs For Each Term				
B	A	A+B	A+B	A	B	A . B
0	0	0	1	1	1	1
0	1	1	0	0	1	0
1	0	1	0	1	0	0
1	1	1	0	0	0	0

We can also show that A+B = A.B using the following logic gates example.

DeMorgan's Second Law Implementation using Logic Gates



The top logic gate arrangement of: A+B can be implemented using a standard NOR gate function using inputs A and B. The lower logic gate arrangement first inverts the two inputs, thus producing A and B. Thus then become the inputs to the AND gate. Therefore the output from the AND gate becomes: A.B

Then we can see that a standard AND gate function with inverters (NOT gates) on each of its inputs produces an equivalent output condition to a standard NOR gate function, and an individual NOR gate can be represented in this way as the equivalency of a NOR gate is a negative-AND.

Although we have used DeMorgan's theorems with only two input variables A and B, they are equally valid for use with three, four or more input variable expressions, for example:

For a 3-variable input

A.B.C = A+B+C

and also

A+B+C = A.B.C

For a 4-variable input

A.B.C.D = A+B+C+D

and also

A+B+C+D = A.B.C.D

and so on.

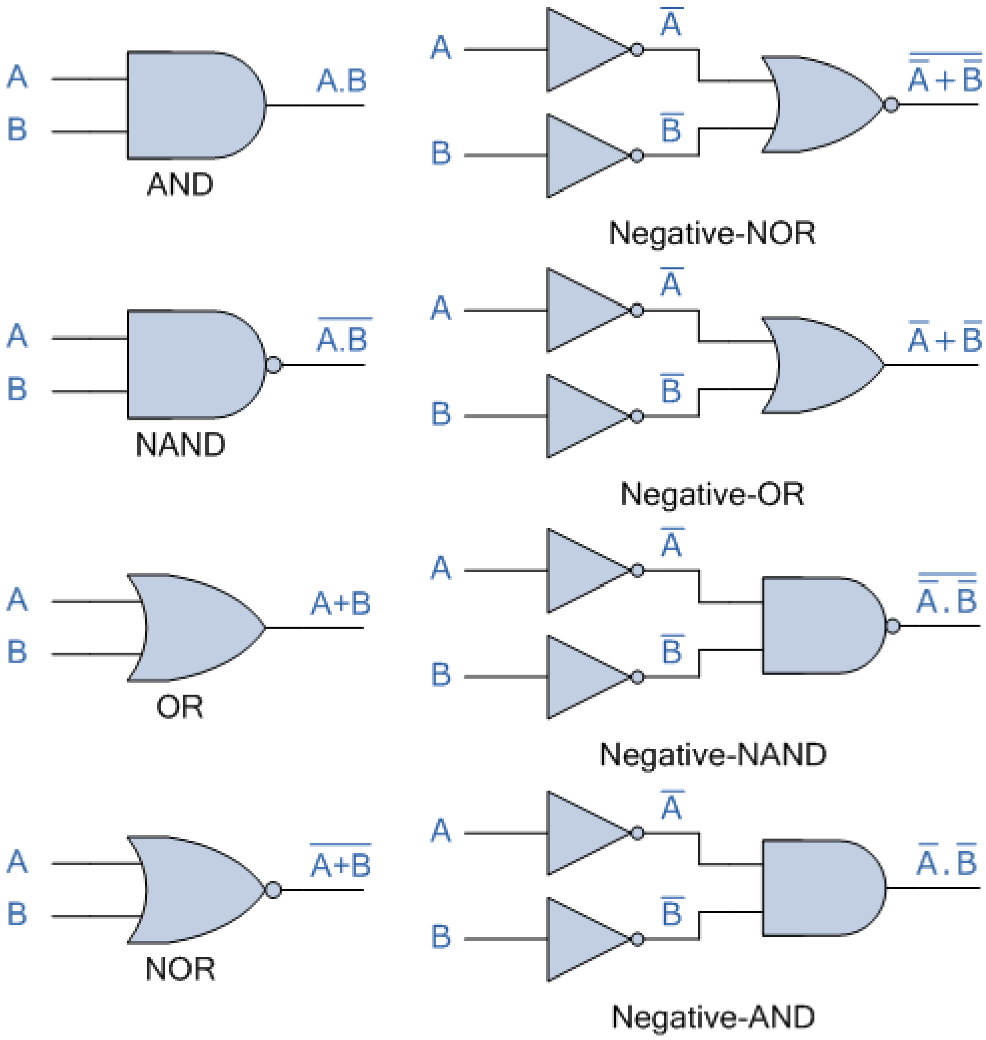
DeMorgan's Equivalent Gates

We have seen here that by using DeMorgan's Theorems we can replace all of the AND (.) operators with an OR (+) and vice versa, and then complements each of the terms or variables in the expression by inverting it, that is 0's to 1's and 1's to 0's before inverting the entire function.

Thus to obtain the DeMorgan equivalent for an AND, NAND, OR or NOR gate, we simply add inverters (NOT-gates) to all inputs and outputs and change an AND symbol to an OR symbol or change an OR symbol to an AND symbol as shown in the following table.

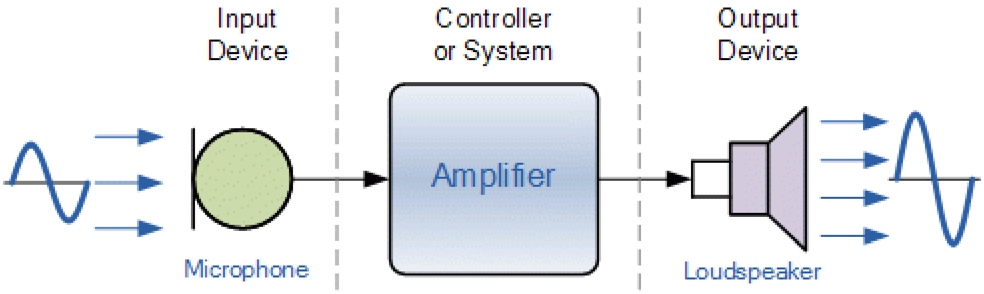
DeMorgan's Equivalent Gates

Standard Logic Gate DeMorgan's Equivalent Gate



A
B
A.B
AND
A
B
$\overline{A.B}$
NAND
A
B
A+B
OR
A
B
$\overline{A+B}$
NOR
A
B
$\overline{A}$
$\overline{B}$
$\overline{\overline{A}+\overline{B}}$
Negative-NOR
A
B
$\overline{A}$
$\overline{B}$
$\overline{A}+\overline{B}$
Negative-OR
A
B
$\overline{A}$
$\overline{B}$
$\overline{\overline{A}.\overline{B}}$
Negative-NAND
A
B
$\overline{A}$
$\overline{B}$
$\overline{A}.\overline{B}$
Negative-AND

Simple stand alone electronic circuits can be made to repeatedly flash a light or play a musical note.



But in order for an electronic circuit or system to perform any useful task or function it needs to be able to communicate with the "real world" whether this is by reading an input signal from an "ON/OFF" switch or by activating some form of output device to illuminate a single light.

In other words, an Electronic System or circuit must be able or capable to "do" something and Sensors and Transducers are the perfect components for doing this.

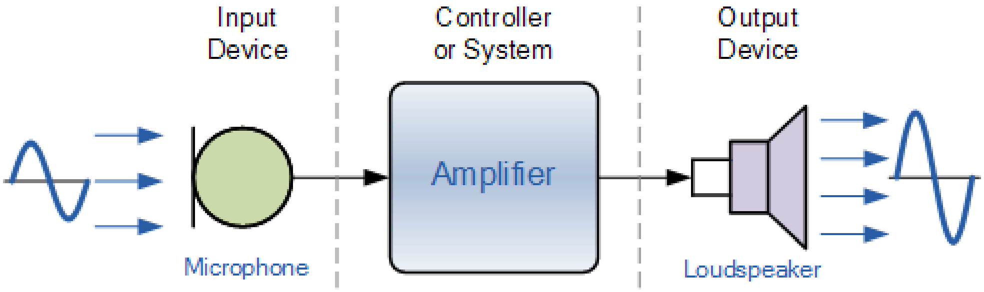
The word "Transducer" is the collective term used for both Sensors which can be used to sense a wide range of different energy forms such as movement, electrical signals, radiant energy, thermal or magnetic energy etc, and Actuators which can be used to switch voltages or currents.

There are many different types of sensors and transducers, both analogue and digital and input and output available to choose from. The type of input or output transducer being used, really depends upon the type of signal or process being "Sensed" or "Controlled" but we can define a sensor and transducers as devices that converts one physical quantity into another.

Devices which perform an "Input" function are commonly called Sensors because they "sense" a physical change in some characteristic that changes in response to some excitation, for example heat or force and covert that into an electrical signal. Devices which perform an "Output" function are generally called Actuators and are used to control some external device, for example movement or sound.

Electrical Transducers are used to convert energy of one kind into energy of another kind, so for example, a microphone (input device) converts sound waves into electrical signals for the amplifier to amplify (a process), and a loudspeaker (output device) converts these electrical signals back into sound waves and an example of this type of simple Input/Output (I/O) system is given below.

Simple Input/Output System using Sound Transducers



There are many different types of sensors and transducers available in the marketplace, and the choice of which one to use really depends upon the quantity being measured or controlled, with the more common types given in the table below:

Common Sensors and Transducers

Quantity being Measured	Input Device (Sensor)	Output Device (Actuator)
Light Level	Light Dependant Resistor (LDR) Photodiode Photo-transistor Solar Cell	Lights & Lamps LED's & Displays Fibre Optics
Temperature	Thermocouple Thermistor Thermostat Resistive Temperature Detectors	Heater Fan
Force/Pressure	Strain Gauge Pressure Switch Load Cells	Lifts & Jacks Electromagnet Vibration
Position	Potentiometer Encoders Reflective/Slotted Opto-switch LVDT	Motor Solenoid Panel Meters
Speed	Tacho-generator Reflective/Slotted Opto-coupler Doppler Effect Sensors	AC and DC Motors Stepper Motor Brake
Sound	Carbon Microphone Piezo-electric Crystal	Bell Buzzer Loudspeaker

Input type transducers or sensors, produce a voltage or signal output response which is proportional to the change in the quantity that they are measuring (the stimulus). The type or amount of the output signal depends upon the type of sensor being used. But generally, all types of sensors can be classed as two kinds, either Passive Sensors or Active Sensors.

Generally, active sensors require an external power supply to operate, called an *excitation signal* which is used by the sensor to produce the output signal. Active sensors are self-generating devices because their own properties change in response to an external effect producing for example, an output voltage of 1 to 10v DC or an output current such as 4 to 20mA DC. Active sensors can also produce signal amplification.

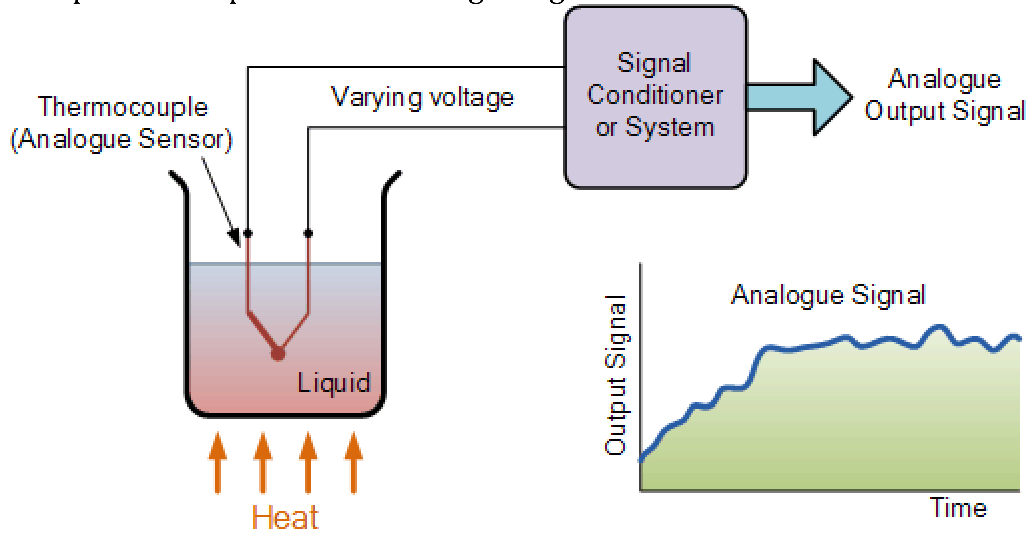
A good example of an active sensor is an LVDT sensor or a strain gauge. Strain gauges are pressure-sensitive resistive bridge networks that are external biased (excitation signal) in such a way as to produce an output voltage in proportion to the amount of force and/or strain being applied to the sensor.

Unlike an active sensor, a passive sensor does not need any additional power source or excitation voltage. Instead a passive sensor generates an output signal in response to some external stimulus. For example, a thermocouple which generates its own voltage output when exposed to heat. Then passive sensors are direct sensors which change their physical properties, such as resistance, capacitance or inductance etc.

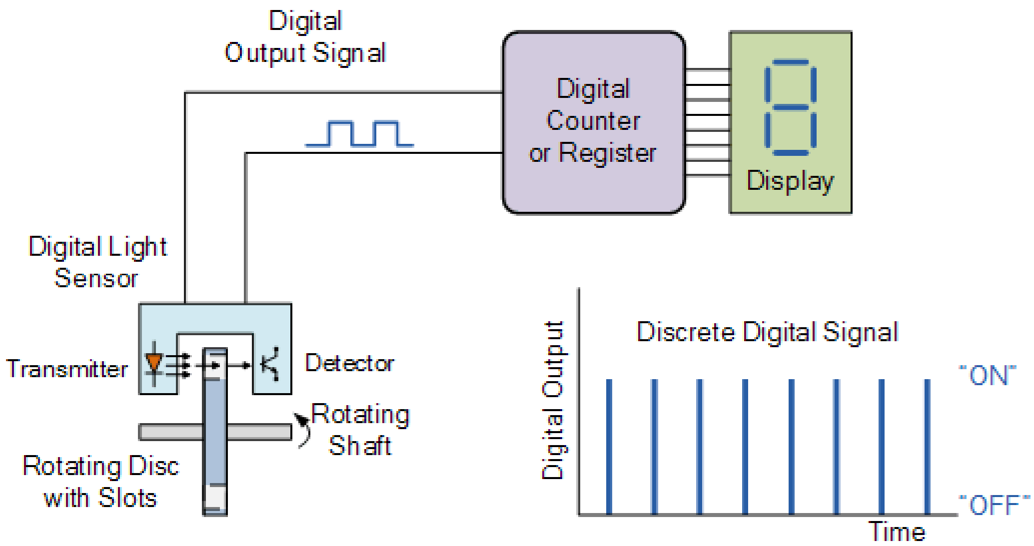
But as well as analogue sensors, Digital Sensors produce a discrete output representing a binary number or digit such as a logic level "0" or a logic level "1".

Analogue and Digital Sensors

Analogue Sensors
Analogue Sensors produce a continuous output signal or voltage which is generally proportional to the quantity being measured. Physical quantities such as Temperature, Speed, Pressure, Displacement, Strain etc are all analogue quantities as they tend to be continuous in nature. For example, the temperature of a liquid can be measured using a thermometer or thermocouple which continuously responds to temperature changes as the liquid is heated up or cooled down.
Thermocouple used to produce an Analogue Signal



Analogue sensors tend to produce output signals that are changing smoothly and continuously over time. These signals tend to be very small in value from a few mico-volts (uV) to several milli-volts (mV), so some form of amplification is required.
Then circuits which measure analogue signals usually have a slow response and/or low accuracy. Also analogue signals can be easily converted into digital type signals for use in micro-controller systems by the use of analogue-to-digital converters, or ADC's.
Digital Sensors
As its name implies, Digital Sensors produce a discrete digital output signals or voltages that are a digital representation of the quantity being measured. Digital sensors produce a Binary output signal in the form of a logic "1" or a logic "0", ("ON" or "OFF"). This means then that a digital signal only produces discrete (non-continuous) values which may be outputted as a single "bit", (serial transmission) or by combining the bits to produce a single "byte" output (parallel transmission).
Light Sensor used to produce an Digital Signal



In our simple example above, the speed of the rotating shaft is measured by using a digital LED/Opto-detector sensor. The disc which is fixed to a rotating shaft (for example, from a motor or robot wheels), has a number of transparent slots within its design. As the disc rotates with the speed of the shaft, each slot passes by the sensor in turn producing an output pulse representing a logic "1" or logic "0" level.

These pulses are sent to a register of counter and finally to an output display to show the speed or revolutions of the shaft. By increasing the number of slots or "windows" within the disc more output pulses can be produced for each revolution of the shaft. The advantage of this is that a greater resolution and accuracy is achieved as fractions of a revolution can be detected. Then this type of sensor arrangement could also be used for positional control with one of the discs slots representing a reference position.

Compared to analogue signals, digital signals or quantities have very high accuracies and can be both measured and "sampled" at a very high clock speed. The accuracy of the digital signal is proportional to the number of bits used to represent the measured quantity. For example, using a processor of 8 bits, will produce an accuracy of 0.390% (1 part in 256). While using a processor of 16 bits gives an accuracy of 0.0015%, (1 part in 65,536) or 260 times more accurate. This accuracy can be maintained as digital quantities are manipulated and processed very rapidly, millions of times faster than analogue signals.

In most cases, sensors and more specifically analogue sensors generally require an external power supply and some form of additional amplification or filtering of the signal in order to produce a suitable electrical signal which is capable of being measured or used. One very good way of achieving both amplification and filtering within a single circuit is to use Operational Amplifiers as seen before.

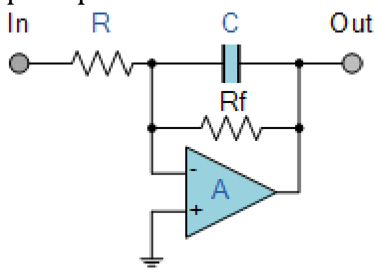
Signal Conditioning of Sensors

Op-amps can be used to provide amplification of signals when connected in either inverting or non-inverting configurations.

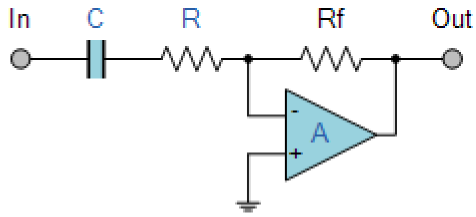
The very small analogue signal voltages produced by a sensor such as a few milli-volts or even pico-volts can be amplified many times over by a simple op-amp circuit to produce a much larger voltage signal of say 5v or 5mA that can then be used as an input signal to a microprocessor or analogue-to-digital based system.

Therefore, to provide any useful signal a sensors output signal has to be amplified with an amplifier that has a voltage gain up to 10,000 and a current gain up to 1,000,000 with the amplification of the signal being linear with the output signal being an exact reproduction of the input, just changed in amplitude.

Then amplification is part of signal conditioning. So when using analogue sensors, generally some form of amplification (Gain), impedance matching, isolation between the input and output or perhaps filtering (frequency selection) may be required before the signal can be used and this is conveniently performed by Operational Amplifiers.
Also, when measuring very small physical changes the output signal of a sensor can become "contaminated" with unwanted signals or voltages that prevent the actual signal required from being measured correctly. These unwanted signals are called "Noise". This Noise or Interference can be either greatly reduced or even eliminated by using signal conditioning or filtering techniques.
By using either a Low Pass, or a High Pass or even Band Pass filter the "bandwidth" of the noise can be reduced to leave just the output signal required. For example, many types of inputs from switches, keyboards or manual controls are not capable of changing state rapidly and so low-pass filter can be used. When the interference is at a particular frequency, for example mains frequency, narrow band reject or Notch filters can be used to produce frequency selective filters.
Typical Op-amp Filters



Low Pass Active Filter

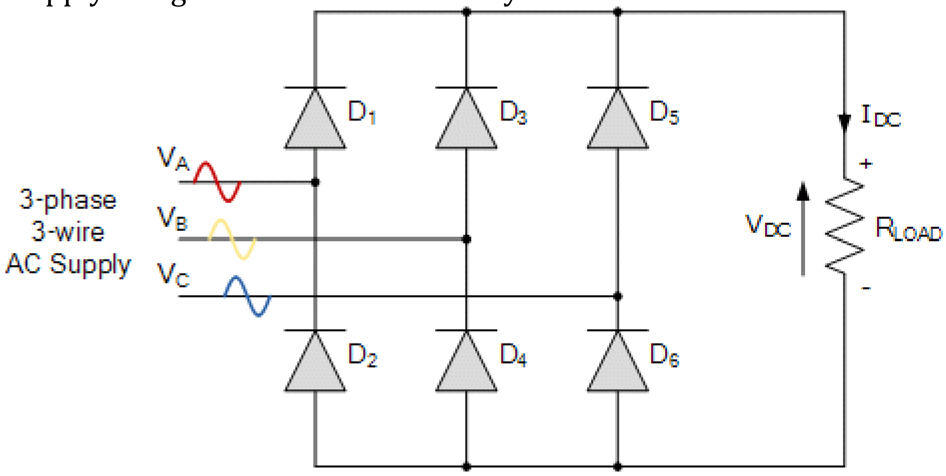


High Pass Active Filter

Were some random noise still remains after filtering it may be necessary to take several samples and then average them to give the final value so increasing the signal-to-noise ratio. Either way, both amplification and filtering play an important role in interfacing both sensors and transducers to microprocessor and electronics based systems in "real world" conditions.

TEXT 14. THREE PHASE RECTIFICATION

3-phase rectification is the process of converting a balanced 3-phase power supply into a fixed DC supply using solid state diodes or thyristors.



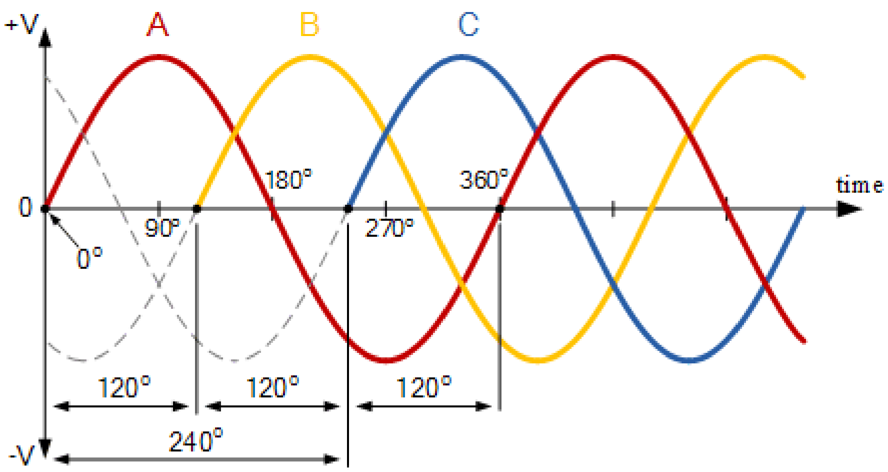
The process of converting an AC input supply into a fixed DC supply is called *Rectification* and the most popular circuits used to perform this rectification process is one that is based on solid-state semiconductor diodes. In fact, rectification of alternating voltages is one of the most popular applications of diodes, as diodes are inexpensive, small and robust allowing us to create numerous types of rectifier circuits using either individually connected diodes or with just a single integrated bridge rectifier module. Single phase supplies such as those in houses and offices are generally 120 Vrms or 240 Vrms phase-to-neutral, also called line-to-neutral (L-N), and nominally of a fixed voltage and frequency producing an alternating voltage or current in the form of a sinusoidal waveform being given the abbreviation of "AC".

Three-phase rectification, also known as poly-phase rectification circuits are similar to the previous single-phase rectifiers, the difference this time is that we are using three, single-phase supplies connected together that have been produced by one single three-phase generator.

The advantage here is that 3-phase rectification circuits can be used to power many industrial applications such as motor control or battery charging which require higher power requirements than a single-phase rectifier circuit is able to supply.

3-phase supplies take this idea one step further by combining together three AC voltages of identical frequency and amplitude with each AC voltage being called a "phase". These three phases are 120 electrical degrees out-of-phase from each other producing a phase sequence, or phase rotation of: $360^o \div 3 = 120^o$ as shown.

Three-phase Waveform



The advantage here is that a three-phase alternating current (AC) supply can be used to provide electrical power directly to balanced loads and rectifiers. Since a 3-phase supply has a fixed voltage and frequency it can be used by a rectification circuit to produce a fixed voltage DC power which can then be filtered resulting in an output DC voltage with less ripple compared to a single-phase rectifying circuit.

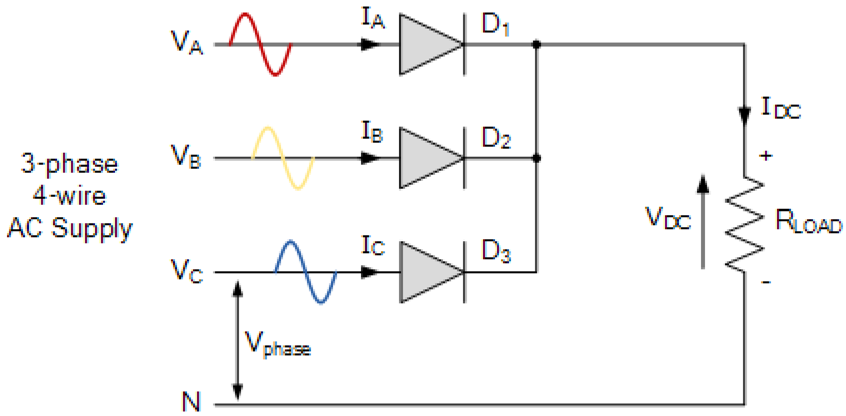
Three-phase Rectification

Having seen that a 3-phase supply is just simply three single-phases combined together, we can use this multi-phase property to create 3-phase rectifier circuits.

As with single-phase rectification, three-phase rectification uses diodes, thyristors, transistors, or converters to create half-wave, full-wave, uncontrolled and fully-controlled rectifier circuits transforming a given three-phase supply into a constant DC output level. In most applications a three-phase rectifier is supplied directly from the mains utility power grid or from a three-phase transformer if different DC output level is required by the connected load.

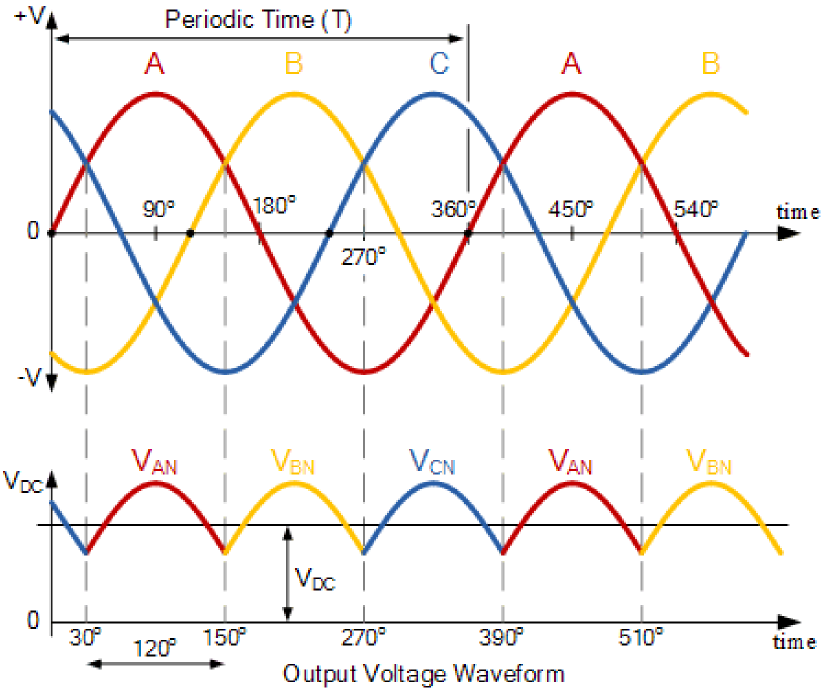
As with the previous single-phase rectifier, the most basic three-phase rectifier circuit is that of an uncontrolled half-wave rectifier circuit which uses three semiconductor diodes, one diode per phase as shown.

Half-wave Three-phase Rectification



So how does this three-phase half-wave rectifier circuit work. The anode of each diode is connected to one phase of the voltage supply with the cathodes of all three diodes connected together to the same positive point, effectively creating a diode-"OR" type arrangement. This common point becomes the positive (+) terminal for the load while the negative (-) terminal of the load is connected to the neutral (N) of the supply. Assuming a phase rotation of Red-Yellow-Blue ($V_A - V_B - V_C$) and the red phase (V_A) starts at 0^o. The first diode to conduct will be diode 1 (D^1) as it will have a more positive

voltage at its anode than diodes D_2 or D_3. Thus diode D_1 conducts for the positive half-cycle of V_A while D_2 and D_3 are in their reverse-biased state. The neutral wire provides a return path for the load current back to the supply.
120 electrical degrees later, diode 2 (D_2) starts to conduct for the positive half-cycle of V_B (yellow phase). Now its anode becomes more positive than diodes D_1 and D_3 which are both "OFF" because they are reversed-biased. Similarly, 120^o later V_C (blue phase) starts to increase turning "ON" diode 3 (D_3) as its anode becomes more positive, thus turning "OFF" diodes D_1 and D_2.
Then we can see that for three-phase rectification, whichever diode has a more positive voltage at its anode compared to the other two diodes it will automatically start to conduct, thereby giving a conduction pattern of: D_1 D_2 D_3 as shown.
Half-wave Three-phase Rectifier Conduction Waveform



From the above waveforms for a resistive load, we can see that for a half-wave rectifier each diode passes current for one third of each cycle, with the output waveform being three times the input frequency of the AC supply. Therefore there are three voltage peaks in a given cycle, so by increasing the number of phases from a single-phase to a three-phase supply, the rectification of the supply is improved, that is the output DC voltage is smoother.
For a three-phase half-wave rectifier, the supply voltages V_A V_B and V_C are balanced but with a phase difference of 120^o giving:
$V_A = V_P*\sin(\omega t - 0^o)$
$V_B = V_P*\sin(\omega t - 120^o)$
$V_C = V_P*\sin(\omega t - 240^o)$
Thus the average DC value of the output voltage waveform from a 3-phase half-wave rectifier is given as:

$$V_{DC} = \frac{3\sqrt{3}}{2\pi} V_P = 0.827 * V_{PEAK}$$

As the voltage supplies peak voltage, V_P is equal to V_{RMS}*1.414, it follows that V_P is equal to V_P/1.414 giving 0.707*V_P, so the average DC output voltage of the rectifier can be expressed in terms of the rms (root-mean-squared) phase voltage giving:

$$V_{DC} = \frac{3\sqrt{3}}{2\pi} \times \frac{V_{PEAK}}{1.414}$$

$$V_{DC} = \frac{0.827}{0.707} V_{RMS} = 1.17 * V_{RMS}$$

3-phase Rectification Example No1

A half-wave 3-phase rectifier is constructed using three individual diodes and a 120VAC 3-phase star connected transformer. If it is required to power a connected load with an impedance of 50Ω, Calculate, a) the average DC voltage output to the load. b) the load current, c) the average current per diode. Assume ideal diodes.

a). The average DC load voltage:

V_{DC} = 1.17*Vrms = 1.17*120 = 140.4 volts

Note that if we were given the peak voltage (V_p) value, then:

V_{DC} would equal 0.827*Vp or 0.827*169.68 = 140.4V.

b). The DC load current:

$I_L = V_{DC}/R_L$ = 140.4/50 = 2.81 amperes

c). The average current per diode:

$I_D = I_L/3$ = 2.81/3 = 0.94 amperes

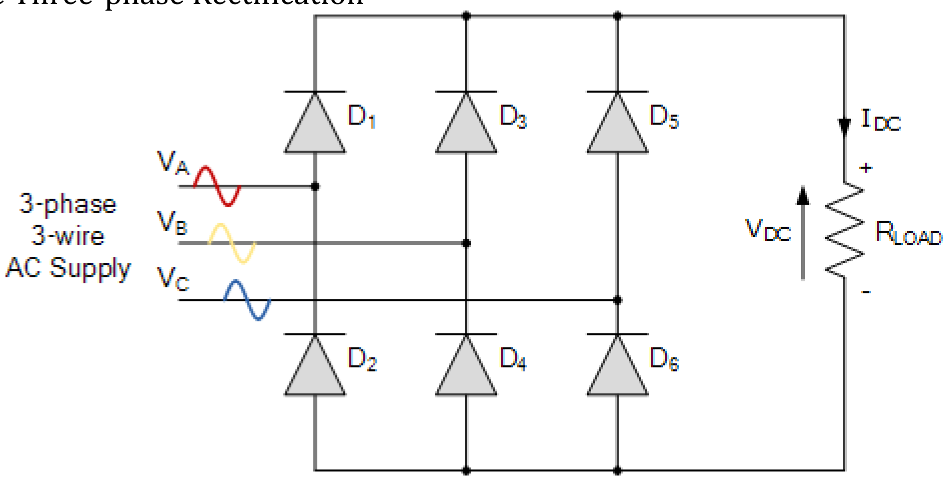
One of the disadvantages of half-wave 3-phase rectification is that it requires a 4-wire supply, that is three phases plus a neutral (N) connection. Also the average DC output voltage is low at a value represented by 0.827*V_P as we have seen. This is because the output ripple content is three times the input frequency. But we can improve on these disadvantages by adding three more diodes to the basic rectifier circuit creating a three-phase full-wave uncontrolled bridge rectifier.

Full-wave Three-phase Rectification

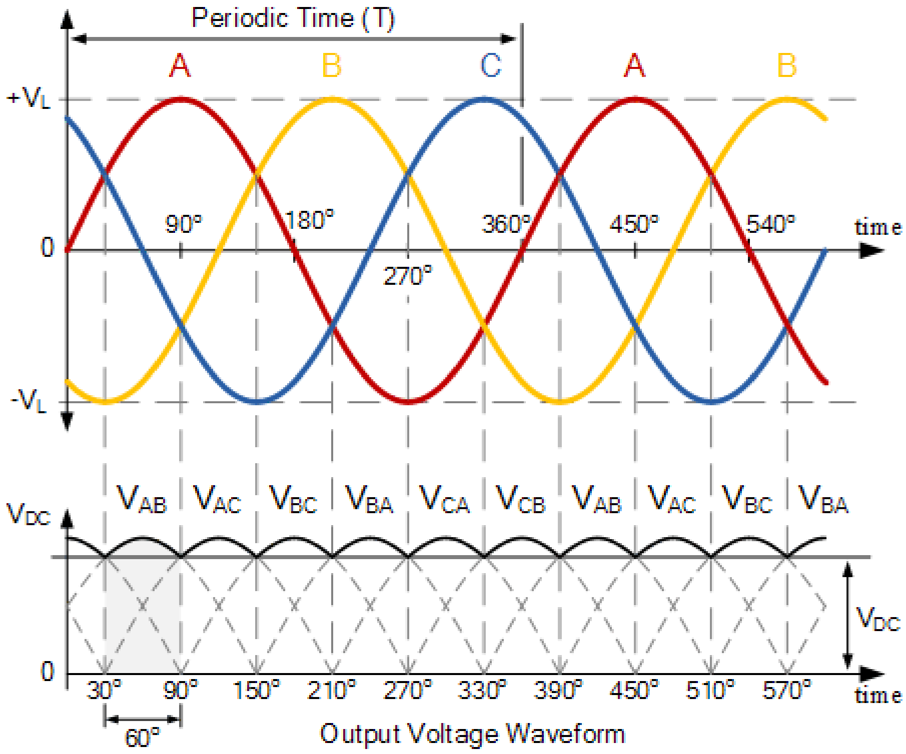
The full-wave three-phase uncontrolled bridge rectifier circuit uses six diodes, two per phase in a similar fashion to the single-phase bridge rectifier. A 3-phase full-wave rectifier is obtained by using two half-wave rectifier circuits. The advantage here is that the circuit produces a lower ripple output than the previous half-wave 3-phase rectifier as it has a frequency of six times the input AC waveform.

Also, the full-wave rectifier can be fed from a balanced 3–phase 3-wire delta connected supply as no fourth neutral (N) wire is required. Consider the full-wave 3-phase rectifier circuit below.

Full-wave Three-phase Rectification



As before, assuming a phase rotation of Red-Yellow-Blue (V_A – V_B – V_C) and the red phase (V_A) starts at 0°. Each phase connects between a pair of diodes as shown. One diode of the conducting pair powers the positive (+) side of load, while the other diode powers the negative (-) side of load.
Diodes D_1 D_3 D_2 and D_4 form a bridge rectifier network between phases A and B, similarly diodes D_3 D_5 D_4 and D_6 between phases B and C and D_5 D_1 D_6 and D_2 between phases C and A.
Thus diodes D_1 D_3 and D_5 feed the positive rail and depending on which one has a more positive voltage at its anode terminal conducts. Likewise, diodes D_2 D_4 and D_6 feed the negative rail and whichever diode has a more negative voltage at its cathode terminal conducts.
Then we can see that for three-phase rectification, the diodes conduct in matching pairs giving a conduction pattern for the load current of: D_{1-2} D_{1-6} D_{3-6} D_{3-6} D_{3-4} D_{5-4} D_{5-2} and D_{1-2} as shown.
Full-wave Three-phase Rectifier Conduction Waveform



In 3-phase power rectifiers, conduction always occurs in the most positive diode and the corresponding most negative diode. Thus as the three phases rotate across the rectifier terminals, conduction is passed from diode to diode. Then each diode conducts for 120° (one-third) in each supply cycle but as it takes two diodes to conduct in pairs, each pair of diodes will conduct for only 60° (one-sixth) of a cycle at any one time as shown above.
Therefore we can correctly say that for a 3-phase rectifier being fed by "3" transformer secondaries, each phase will be separated by 360°/3 thus requiring 2*3 diodes. Note also that unlike the previous half-wave rectifier, there is no common connection between the rectifiers input and output terminals. Therefore it can be fed by a star connected or a delta connected transformer supply.
So the average DC value of the output voltage waveform from a 3-phase full-wave rectifier is given as:

$$V_{DC} = \frac{3\sqrt{3}}{\pi} V_S = 1.65 * V_S$$

Where: V_S is equal to ($V_{L(PEAK)} \div \sqrt{3}$) and where $V_{L(PEAK)}$ is the maximum line-to-line voltage (V_L*1.414).

3-phase Rectification Example No2

A 3-phase full-wave bridge rectifier is required to fed a 150Ω resistive load from a 3-phase 127 volt, 60Hz delta connected supply. Ignoring the voltage drops across the diodes, calculate: 1. the DC output voltage of the rectifier and 2. the load current.

1. the DC output voltage:

The RMS (Root Mean Squared) line voltage is 127 volts. Therefore the line-to-line peak voltage ($V_{L\text{-}L(PEAK)}$) will be:

$$V_{L(PEAK)} = V_{L(RMS)} \times \sqrt{2} = 127 \times 1.414 = 179.6V$$

As the supply is 3-phase, the phase to neutral voltage ($V_{P\text{-}N}$) of any phase will be:

$$V_S = V_{L(PEAK)} \div \sqrt{3} = 179.6 \div 1.732 = 103.7V$$

Note that this is basically the same as saying:

$$V_S = \frac{V_{L(RMS)} \times \sqrt{2}}{\sqrt{3}} = 103.7V$$

Thus the average DC output voltage from the 3-phase full-wave rectifier is given as:

$$V_{DC} = \left[\frac{3\sqrt{3}}{\pi}\right] V_S = 1.654 \times V_S$$

$$\therefore V_{DC} = 1.654 \times 103.7 = 171.5V$$

Again, we can reduce the maths a bit by correctly saying that for a given line-to-line RMS voltage value, in our example 127 volts, the average DC output voltage is:

$$V_{DC} = \frac{3\sqrt{2}}{\pi} V_{L(RMS)} = 1.35 \times 127 = 171.5V$$

2. the rectifiers load current.

The output from the rectifier is feeding a 150Ω resistive load. Then using Ohms law the load current will be:

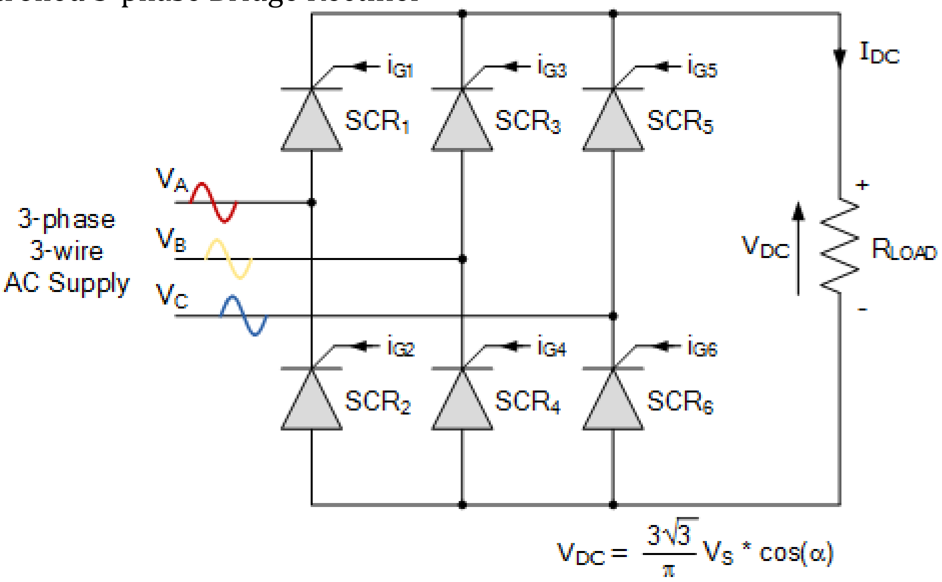
$$I_{LOAD} = V_S \div R_L = 171.5 \div 150 = 1.14 \text{ Amps}$$

Uncontrolled 3-phase rectification uses diodes to provide an average output voltage of a fixed value relative to the value of the input AC voltages. But to vary the output voltage of the rectifier we need to replace the uncontrolled diodes, either some or all of them, with thyristors to create what are called half-controlled or fully-controlled bridge rectifiers.

Thyristors are three terminal semiconductor devices and when a suitable trigger pulse is applied to the the thyristors gate terminal when its Anode–to-Cathode terminal voltage is positive, the device will conduct and pass a load current. So by delaying the timing of the trigger pulse, (firing angle) we can delay the instant in time at which the thyristor would naturally switch "ON" if it were a normal diode and the moment it starts to conduct when the trigger pulse is applied.

Thus with a controlled 3-phase rectification which uses thyristors instead of diodes, we can control the value of the average DC output voltage by controlling the firing angle of

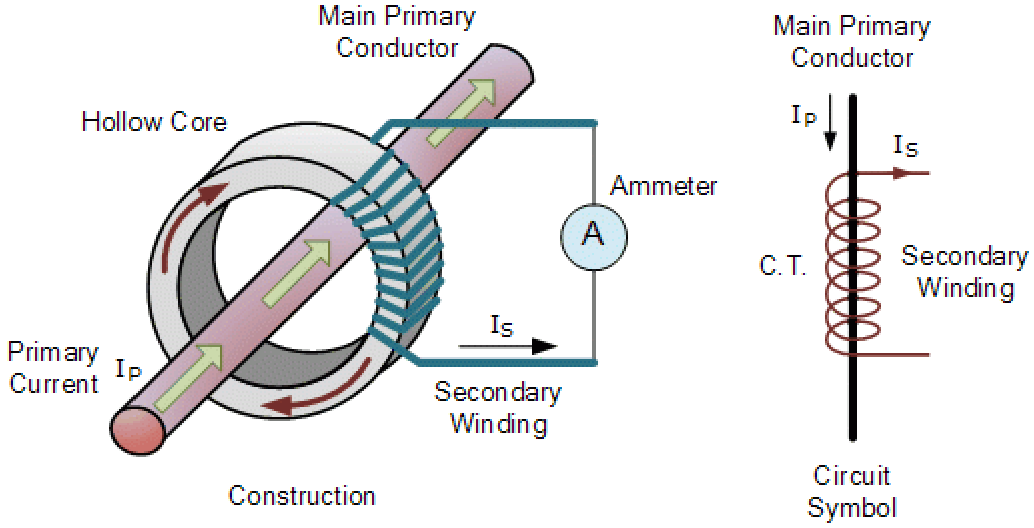
the thyristor pairs and so the rectified output voltage becomes a function of the firing angle, α.
Therefore the only difference to the formula used above for the average output voltage of a 3-phase bridge rectifier is in the cosine angle, *cos(α)* of the firing or triggering pulse. So if the firing angle is zero, (cos(0) = 1), the controlled rectifier performs similar to the previous 3-phase uncontrolled diode rectifier with the average output voltages being the same.
An example of a fully-controlled 3-phase bridge rectifier is given below:
Fully-controlled 3-phase Bridge Rectifier



Three-phase Rectification Summary
Three-phase rectification is the process of converting a 3-phase AC supply into a pulsating DC voltage as rectification converts the input power supply of a sinusoidal voltage and frequency into a fixed voltage DC power. Thus power rectification changes an alternating supply into a unidirectional supply.
But we have also seen that 3-phase half-wave uncontrolled rectifiers, which use one diode per phase, require a star connected supply as a fourth neutral (N) wire to close the circuit from load to source. The 3-phase full-wave bridge rectifier which use two diodes per phase requires just three mains lines, without neutral, such as that provided by a delta connected supply.
Another advantage of a full-wave bridge rectifier is that the load current is well balanced across the bridge improving efficiency (the ratio of output DC power to input power supplied) and reducing the ripple content, both in amplitude and frequency, as compared to the half-wave configuration.
By increasing the number of phases and diodes within the bridge configuration it is possible to obtain a higher average DC output voltage with less ripple amplitude as for example, in 6-phase rectification each diode would conduct for only one-sixth of a cycle.
Also, multi-phase rectifiers produce a higher ripple frequency means less capacitive filtering and a much smoother output voltage. Thus 6, 12, 15 and even 24-phase uncontrolled rectifiers can be designed to improve the ripple factor for various applications.

TEXT 15. THE CURRENT TRANSFORMER

Current Transformers produce an output in proportion to the current flowing through the primary winding as a result of a constant potential on the primary



The Current Transformer (C.T.), is a type of "instrument transformer" that is designed to produce an alternating current in its secondary winding which is proportional to the current being measured in its primary. *Current transformers* reduce high voltage currents to a much lower value and provide a convenient way of safely monitoring the actual electrical current flowing in an AC transmission line using a standard ammeter. The principal of operation of a basic current transformer is slightly different from that of an ordinary voltage transformer.

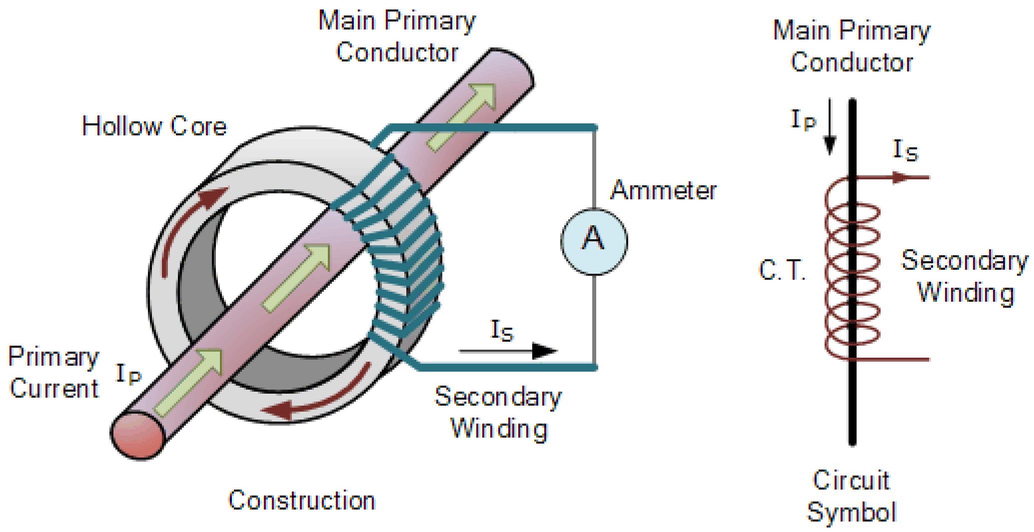
Typical Current Transformer

Unlike the voltage or power transformer looked at previously, the current transformer consists of only one or very few turns as its primary winding. This primary winding can be of either a single flat turn, a coil of heavy duty wire wrapped around the core or just a conductor or bus bar placed through a central hole as shown.

Due to this type of arrangement, the current transformer is often referred too as a "series transformer" as the primary winding, which never has more than a very few turns, is in series with the current carrying conductor supplying a load.

The secondary winding however, may have a large number of coil turns wound on a laminated core of low-loss magnetic material. This core has a large cross-sectional area so that the magnetic flux density created is low using much smaller cross-sectional area

wire, depending upon how much the current must be stepped down as it tries to output a constant current, independent of the connected load.
The secondary winding will supply a current into either a short circuit, in the form of an ammeter, or into a resistive load until the voltage induced in the secondary is big enough to saturate the core or cause failure from excessive voltage breakdown.
Unlike a voltage transformer, the primary current of a current transformer is not dependent of the secondary load current but instead is controlled by an external load.
The secondary current is usually rated at a standard 1 Ampere or 5 Amperes for larger primary current ratings.
There are three basic types of current transformers: wound, toroidal and bar.
Wound Current Transformer – The transformers primary winding is physically connected in series with the conductor that carries the measured current flowing in the circuit. The magnitude of the secondary current is dependent on the turns ratio of the transformer.
Toroidal Current Transformer – These do not contain a primary winding. Instead, the line that carries the current flowing in the network is threaded through a window or hole in the toroidal transformer. Some current transformers have a "split core" which allows it to be opened, installed, and closed, without disconnecting the circuit to which they are attached.
Bar-type Current Transformer – This type of current transformer uses the actual cable or bus-bar of the main circuit as the primary winding, which is equivalent to a single turn. They are fully insulated from the high operating voltage of the system and are usually bolted to the current carrying device.
Current transformers can reduce or "step-down" current levels from thousands of amperes down to a standard output of a known ratio to either 5 Amps or 1 Amp for normal operation. Thus, small and accurate instruments and control devices can be used with CT's because they are insulated away from any high-voltage power lines.
There are a variety of metering applications and uses for current transformers such as with Wattmeter's, power factor meters, watt-hour meters, protective relays, or as trip coils in magnetic circuit breakers, or MCB's.
Current Transformer



Generally current transformers and ammeters are used together as a matched pair in which the design of the current transformer is such as to provide a maximum secondary current corresponding to a full-scale deflection on the ammeter. In most current

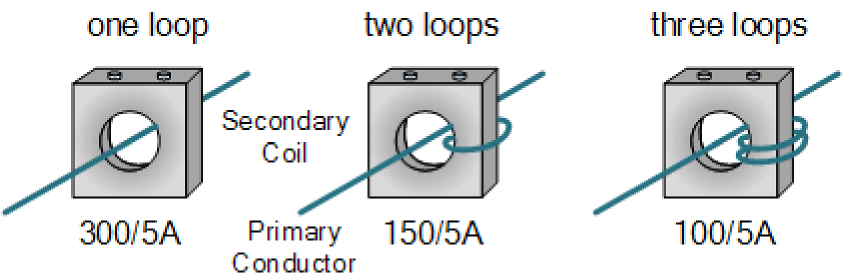
transformers an approximate inverse turns ratio exists between the two currents in the primary and secondary windings. This is why calibration of the CT is generally for a specific type of ammeter.
Most current transformers have a the standard secondary rating of 5 amps with the primary and secondary currents being expressed as a ratio such as 100/5. This means that the primary current is 20 times greater than the secondary current so when 100 amps is flowing in the primary conductor it will result in 5 amps flowing in the secondary winding. A current transformer of say 500/5, will produce 5 amps in the secondary for 500 amps in the primary conductor, 100 times greater.
By increasing the number of secondary windings, Ns, the secondary current can be made much smaller than the current in the primary circuit being measured because as Ns increases, Is goes down by a proportional amount. In other words, the number of turns and the current in the primary and secondary windings are related by an inverse proportion.
A current transformer, like any other transformer, must satisfy the amp-turn equation and:

$$T.R. = n = \frac{N_P}{N_S} = \frac{I_S}{I_P}$$

from which we get:

$$\text{secondary current}, I_S = I_P\left(\frac{N_P}{N_S}\right)$$

The current ratio will sets the turns ratio and as the primary usually consists of one or two turns whilst the secondary can have several hundred turns, the ratio between the primary and secondary can be quite large. For example, assume that the current rating of the primary winding is 100A. The secondary winding has the standard rating of 5A. Then the ratio between the primary and the secondary currents is 100A-to-5A, or 20:1. In other words, the primary current is 20 times greater than the secondary current.
It should be noted however, that a current transformer rated as 100/5 is not the same as one rated as 20/1 or subdivisions of 100/5. This is because the ratio of 100/5 expresses the “input/output current rating” and not the actual ratio of the primary to the secondary currents. Also note that the number of turns and the current in the primary and secondary windings are related by an inverse proportion.
But relatively large changes in a current transformers turns ratio can be achieved by modifying the primary turns through the CT’s window where one primary turn is equal to one pass and more than one pass through the window results in the electrical ratio being modified.
So for example, a current transformer with a relationship of say, 300/5A can be converted to another of 150/5A or even 100/5A by passing the main primary conductor through its interior window two or three times as shown. This allows a higher value current transformer to provide the maximum output current for the ammeter when used on smaller primary current lines.
Current Transformer Primary Turns Ratio



Current Transformer Example No1

A bar-type current transformer which has 1 turn on its primary and 160 turns on its secondary is to be used with a standard range of ammeters that have an internal resistance of 0.2Ω. The ammeter is required to give a full scale deflection when the primary current is 800 Amps. Calculate the maximum secondary current and secondary voltage across the ammeter.

Secondary Current:

$$I_S = I_P\left(\frac{N_P}{N_S}\right) = 800\left(\frac{1}{160}\right) = 5A$$

Voltage across Ammeter:

$$V_S = I_S \times R_A = 5 \times 0.2 = 1.0\ \text{Volts}$$

We can see above that since the secondary of the current transformer is connected across the ammeter, which has a very small resistance, the voltage drop across the secondary winding is only 1.0 volts at full primary current.

However, if the ammeter was removed, the secondary winding effectively becomes open-circuited, and thus the transformer acts as a step-up transformer. This due in part to the very large increase in magnetising flux in the secondary core as the the secondary leakage reactance influences the secondary induced voltage because there is no opposing current in the secondary winding to prevent this.

The results is a very high voltage induced in the secondary winding equal to the ratio of: Vp(Ns/Np) being developed across the secondary winding. So for example, assume our current transformer from above is used on a 480 volt to earth three-phase power line. Therefore:

$$T.R. = n = \frac{V_P}{V_S} = \frac{N_P}{N_S}$$

$$\therefore\ V_S = V_P\left(\frac{N_S}{N_P}\right) = 480\left(\frac{160}{1}\right) = 76{,}800V \text{ or } 76.8kV$$

This high voltage is because the volts per turns ratio is almost constant in the primary and secondary windings and as Vs = Ns*Vp the values of Ns and Vp are high values, so Vs is extremely high.

For this reason a current transformer should never be left open-circuited or operated with no-load attached when the main primary current is flowing through it just as a voltage transformer should never operate into a short circuit. If the ammeter (or load) is

to be removed, a short-circuit should be placed across the secondary terminals first to eliminate the risk of shock.
This high voltage is because when the secondary is open-circuited the iron core of the transformer operates at a high degree of saturation and with nothing to stop it, it produces an abnormally large secondary voltage, and in our simple example above, this was calculated at 76.8kV!. This high secondary voltage could damage the insulation or cause electric shock if the CT's terminals are accidentally touched.
Handheld Current Transformers

There are many specialized types of current transformers now available. A popular and portable type which can be used to measure circuit loading are called "clamp meters" as shown.
Clamp meters open and close around a current carrying conductor and measure its current by determining the magnetic field around it, providing a quick measurement reading usually on a digital display without disconnecting or opening the circuit.
As well as the handheld clamp type CT, split core current transformers are available which has one end removable so that the load conductor or bus bar does not have to be disconnected to install it. These are available for measuring currents from 100 up to 5000 amps, with square window sizes from 1″ to over 12″ (25-to-300mm).
Then to summarise, the Current Transformer, (CT) is a type of instrument transformer used to convert a primary current into a secondary current through a magnetic medium. Its secondary winding then provides a much reduced current which can be used for detecting overcurrent, undercurrent, peak current, or average current conditions.
A current transformers primary coil is always connected in series with the main conductor giving rise to it also being referred to as a series transformer. The nominal secondary current is rated at 1A or 5A for ease of measurement. Construction can be one single primary turn as in Toroidal, Doughnut, or Bar types, or a few wound primary turns, usually for low current ratios.
Current transformers are intended to be used as proportional current devices. Therefore a current transformers secondary winding should never be operated into an open circuit, just as a voltage transformer should never be operated into a short circuit. Very high voltages will result from open circuiting the secondary circuit of an energized current transformer so their terminals must be short-circuited if the ammeter is to be removed or when a CT is not in use before powering up the system.

TEXT 16. ELECTRONIC SYSTEMS

An Electronic System is a physical interconnection of components, or parts, that gathers various amounts of information together

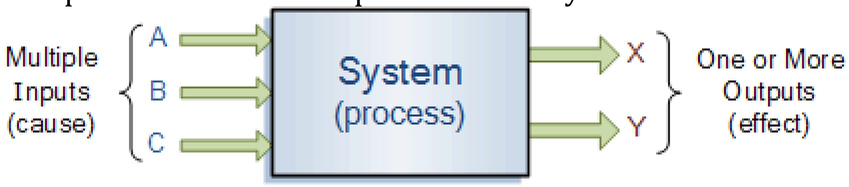
It does this with the aid of input devices such as sensors, that respond in some way to this information and then uses electrical energy in the form of an output action to control a physical process or perform some type of mathematical operation on the signal.

But electronic control systems can also be regarded as a process that transforms one signal into another so as to give the desired system response. Then we can say that a simple electronic system consists of an input, a process, and an output with the input variable to the system and the output variable from the system both being signals.

There are many ways to represent a system, for example: mathematically, descriptively, pictorially or schematically. Electronic systems are generally represented schematically as a series of interconnected blocks and signals with each block having its own set of inputs and outputs.

As a result, even the most complex of electronic control systems can be represented by a combination of simple blocks, with each block containing or representing an individual component or complete sub-system. The representing of an electronic system or process control system as a number of interconnected blocks or boxes is known commonly as "block-diagram representation".

Block Diagram Representation of a Simple Electronic System



Electronic Systems have both *Inputs* and *Outputs* with the output or outputs being produced by *processing* the inputs. Also, the input signal(s) may cause the process to change or may itself cause the operation of the system to change. Therefore the input(s) to a system is the "cause" of the change, while the resulting action that occurs on the systems output due to this cause being present is called the "effect", with the effect being a consequence of the cause.

In other words, an electronic system can be classed as "causal" in nature as there is a direct relationship between its input and its output. Electronic systems analysis and process control theory are generally based upon this Cause and Effect analysis.

So for example in an audio system, a microphone (input device) causes sound waves to be converted into electrical signals for the amplifier to amplify (a process), and a loudspeaker (output device) produces sound waves as an effect of being driven by the amplifiers electrical signals.

But an electronic system need not be a simple or single operation. It can also be an interconnection of several sub-systems all working together within the same overall system.

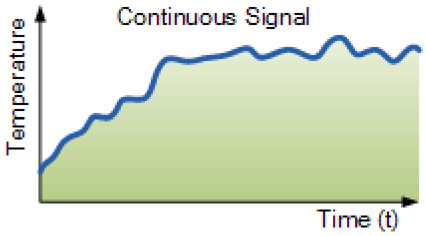
Our audio system could for example, involve the connection of a CD player, or a DVD player, an MP3 player, or a radio receiver all being multiple inputs to the same amplifier which in turn drives one or more sets of stereo or home theatre type surround loudspeakers.

But an electronic system can not just be a collection of inputs and outputs, it must "do something", even if it is just to monitor a switch or to turn "ON" a light. We know that sensors are input devices that detect or turn real world measurements into electronic signals which can then be processed. These electrical signals can be in the form of either voltages or currents within a circuit. The opposite or output device is called an actuator, that converts the processed signal into some operation or action, usually in the form of mechanical movement.

Types of Electronic System

Electronic systems operate on either continuous-time (CT) signals or discrete-time (DT) signals. A continuous-time system is one in which the input signals are defined along a continuum of time, such as an analogue signal which "continues" over time producing a continuous-time signal.

But a continuous-time signal can also vary in magnitude or be periodic in nature with a time period T. As a result, continuous-time electronic systems tend to be purely analogue systems producing a linear operation with both their input and output signals referenced over a set period of time.

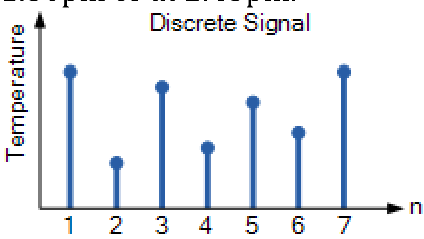


For example, the temperature of a room can be classed as a continuous time signal which can be measured between two values or set points, for example from cold to hot or from Monday to Friday. We can represent a continuous-time signal by using the independent variable for time t, and where x(t) represents the input signal and y(t) represents the output signal over a period of time t.

Generally, most of the signals present in the physical world which we can use tend to be continuous-time signals. For example, voltage, current, temperature, pressure, velocity, etc.

On the other hand, a discrete-time system is one in which the input signals are not continuous but a sequence or a series of signal values defined in "discrete" points of time. This results in a discrete-time output generally represented as a sequence of values or numbers.

Generally a discrete signal is specified only at discrete intervals, values or equally spaced points in time. So for example, the temperature of a room measured at 1pm, at 2pm, at 3pm and again at 4pm without regards for the actual room temperature in between these points at say, 1:30pm or at 2:45pm.



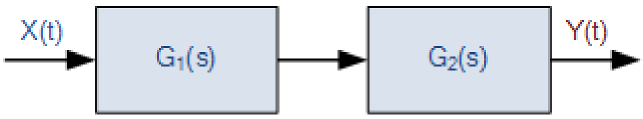
However, a continuous-time signal, x(t) can be represented as a discrete set of signals only at discrete intervals or “moments in time”. Discrete signals are not measured versus time, but instead are plotted at discrete time intervals, where n is the sampling interval. As a result discrete-time signals are usually denoted as x(n) representing the input and y(n) representing the output.
Then we can represent the input and output signals of a system as x and y respectively with the signal, or signals themselves being represented by the variable, t, which usually represents *time* for a continuous system and the variable n, which represents an *integer* value for a discrete system as shown.

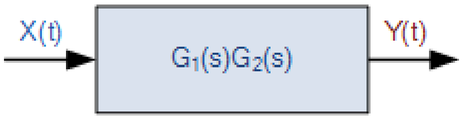
Continuous-time and Discrete-time System

Interconnection of Systems

One of the practical aspects of electronic systems and block-diagram representation is that they can be combined together in either a series or parallel combinations to form much bigger systems. Many larger real systems are built using the interconnection of several sub-systems and by using block diagrams to represent each subsystem, we can build a graphical representation of the whole system being analysed.
When subsystems are combined to form a series circuit, the overall output at y(t) will be equivalent to the multiplication of the input signal x(t) as shown as the subsystems are cascaded together.

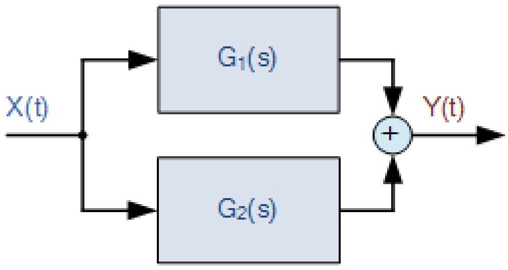
Series Connected System

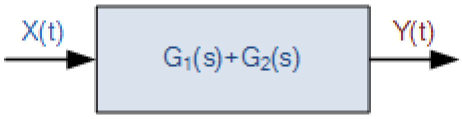




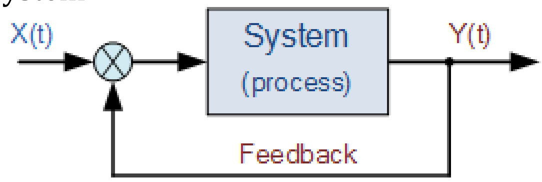
For a series connected continuous-time system, the output signal y(t) of the first subsystem, “A” becomes the input signal of the second subsystem, “B” whose output becomes the input of the third subsystem, “C” and so on through the series chain giving A x B x C, etc.
Then the original input signal is cascaded through a series connected system, so for two series connected subsystems, the equivalent single output will be equal to the multiplication of the systems, ie, $y(t) = G_1(s) \times G_2(s)$. Where G represents the transfer function of the subsystem.
Note that the term “Transfer Function” of a system refers to and is defined as being the mathematical relationship between the systems input and its output, or output/input and hence describes the behaviour of the system.
Also, for a series connected system, the order in which a series operation is performed does not matter with regards to the input and output signals as: $G_1(s) \times G_2(s)$ is the same as $G_2(s) \times G_1(s)$. An example of a simple series connected circuit could be a single microphone feeding an amplifier followed by a speaker.

Parallel Connected Electronic System

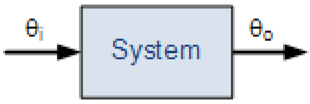




For a parallel connected continuous-time system, each subsystem receives the same input signal, and their individual outputs are summed together to produce an overall output, y(t). Then for two parallel connected subsystems, the equivalent single output will be the sum of the two individual inputs, ie, $y(t) = G_1(s) + G_2(s)$.
An example of a simple parallel connected circuit could be several microphones feeding into a mixing desk which in turn feeds an amplifier and speaker system.
Electronic Feedback Systems
Another important interconnection of systems which is used extensively in control systems, is the "feedback configuration". In feedback systems, a fraction of the output signal is "fed back" and either added to or subtracted from the original input signal. The result is that the output of the system is continually altering or updating its input with the purpose of modifying the response of a system to improve stability. A feedback system is also commonly referred to as a "Closed-loop System" as shown.
Closed-Loop Feedback System



Feedback systems are used a lot in most practical electronic system designs to help stabilise the system and to increase its control. If the feedback loop reduces the value of the original signal, the feedback loop is known as "negative feedback". If the feedback loop adds to the value of the original signal, the feedback loop is known as "positive feedback".
An example of a simple feedback system could be a thermostatically controlled heating system in the home. If the home is too hot, the feedback loop will switch "OFF" the heating system to make it cooler. If the home is too cold, the feedback loop will switch "ON" the heating system to make it warmer. In this instance, the system comprises of the heating system, the air temperature and the thermostatically controlled feedback loop.
Transfer Function of Systems



Any subsystem can be represented as a simple block with an input and output as shown. Generally, the input is designated as: θi and the output as: θo. The ratio of output over input represents the gain, (G) of the subsystem and is therefore defined as: $G = \theta o/\theta i$

In this case, G represents the Transfer Function of the system or subsystem. When discussing electronic systems in terms of their transfer function, the complex operator, s is used, then the equation for the gain is rewritten as: $G(s) = \theta o(s)/\theta i(s)$

Electronic System Summary

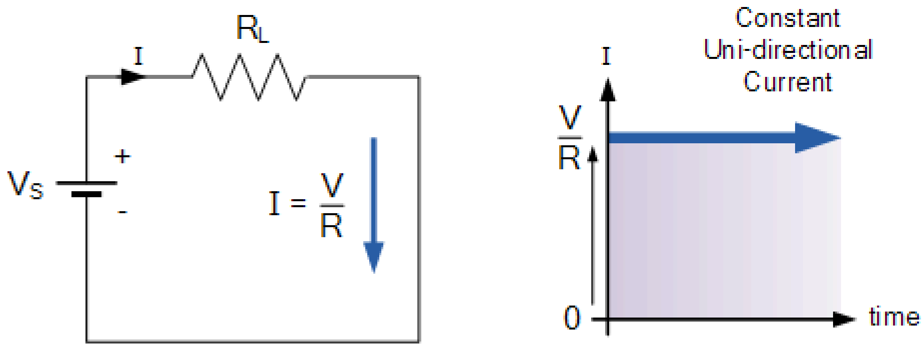
We have seen that a simple Electronic System consists of an input, a process, an output and possibly feedback. Electronic systems can be represented using interconnected block diagrams where the lines between each block or subsystem represents both the flow and direction of a signal through the system.

Block diagrams need not represent a simple single system but can represent very complex systems made from many interconnected subsystems. These subsystems can be connected together in series, parallel or combinations of both depending upon the flow of the signals.

We have also seen that electronic signals and systems can be of continuous-time or discrete-time in nature and may be analogue, digital or both. Feedback loops can be used be used to increase or reduce the performance of a particular system by providing better stability and control. Control is the process of making a system variable adhere to a particular value, called the reference value.

TEXT 17. AC WAVEFORM AND AC CIRCUIT THEORY

AC Sinusoidal Waveforms are created by rotating a coil within a magnetic field and alternating voltages and currents form the basis of AC Theory
Direct Current or D.C. as it is more commonly called, is a form of electrical current or voltage that flows around an electrical circuit in one direction only, making it a "Uni-directional" supply.
Generally, both DC currents and voltages are produced by power supplies, batteries, dynamos and solar cells to name a few. A DC voltage or current has a fixed magnitude (amplitude) and a definite direction associated with it. For example, +12V represents 12 volts in the positive direction, or -5V represents 5 volts in the negative direction.
We also know that DC power supplies do not change their value with regards to time, they are a constant value flowing in a continuous steady state direction. In other words, DC maintains the same value for all times and a constant uni-directional DC supply never changes or becomes negative unless its connections are physically reversed. An example of a simple DC or direct current circuit is shown below.
DC Circuit and Waveform



An alternating function or AC Waveform on the other hand is defined as one that varies in both magnitude and direction in more or less an even manner with respect to time making it a "Bi-directional" waveform. An AC function can represent either a power source or a signal source with the shape of an *AC waveform* generally following that of a mathematical sinusoid being defined as: $A(t) = A_{max}*\sin(2\pi ft)$.
The term AC or to give it its full description of Alternating Current, generally refers to a time-varying waveform with the most common of all being called a Sinusoid better known as a Sinusoidal Waveform. Sinusoidal waveforms are more generally called by their short description as Sine Waves. Sine waves are by far one of the most important types of AC waveform used in electrical engineering.
The shape obtained by plotting the instantaneous ordinate values of either voltage or current against time is called an AC Waveform. An AC waveform is constantly changing its polarity every half cycle alternating between a positive maximum value and a negative maximum value respectively with regards to time with a common example of this being the domestic mains voltage supply we use in our homes.
This means then that the *AC Waveform* is a "time-dependent signal" with the most common type of time-dependant signal being that of the Periodic Waveform. The periodic or AC waveform is the resulting product of a rotating electrical generator. Generally, the shape of any periodic waveform can be generated using a fundamental frequency and superimposing it with harmonic signals of varying frequencies and amplitudes.
Alternating voltages and currents can not be stored in batteries or cells like direct current (DC) can, it is much easier and cheaper to generate these quantities using

alternators or waveform generators when they are needed. The type and shape of an AC waveform depends upon the generator or device producing them, but all AC waveforms consist of a zero voltage line that divides the waveform into two symmetrical halves. The main characteristics of an AC Waveform are defined as:

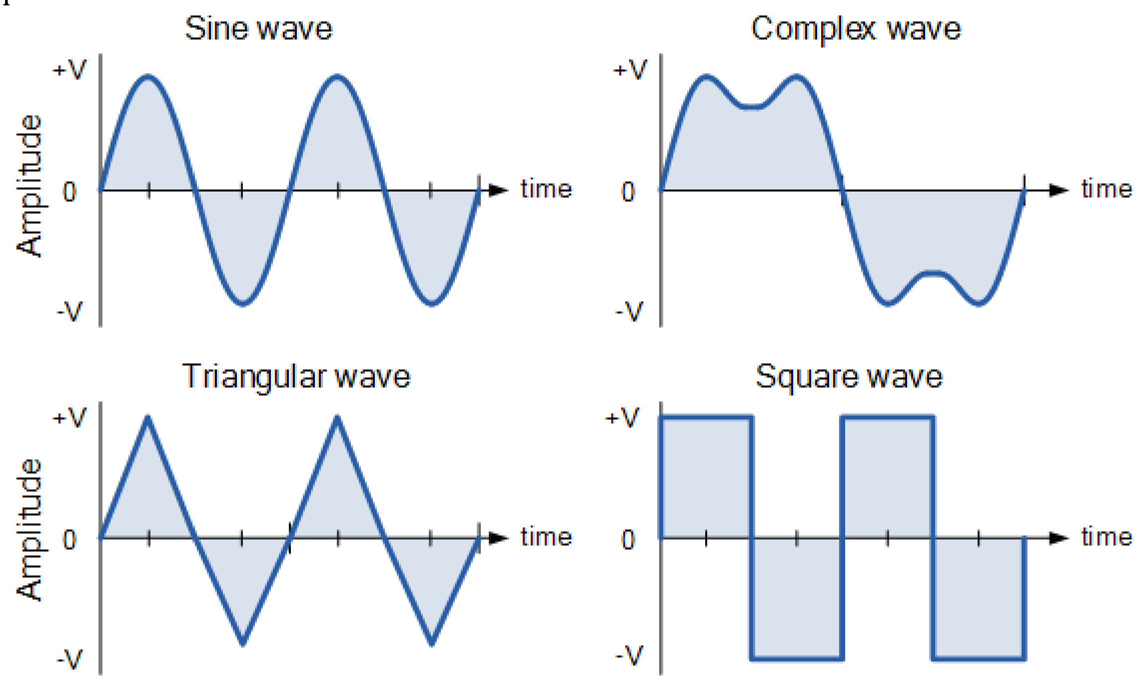
AC Waveform Characteristics

- The Period, (T) is the length of time in seconds that the waveform takes to repeat itself from start to finish. This can also be called the *Periodic Time* of the waveform for sine waves, or the *Pulse Width* for square waves.
- The Frequency, (*ƒ*) is the number of times the waveform repeats itself within a one second time period. Frequency is the reciprocal of the time period, ($f = 1/T$) with the unit of frequency being the *Hertz*, (Hz).
- The Amplitude (A) is the magnitude or intensity of the signal waveform measured in volts or amps.

Generally, for AC waveforms this horizontal base line represents a zero condition of either voltage or current. Any part of an AC type waveform which lies above the horizontal zero axis represents a voltage or current flowing in one direction. Likewise, any part of the waveform which lies below the horizontal zero axis represents a voltage or current flowing in the opposite direction to the first. Generally for sinusoidal AC waveforms the shape of the waveform above the zero axis is the same as the shape below it. However, for most non-power AC signals including audio waveforms this is not always the case.

The most common periodic signal waveforms that are used in Electrical and Electronic Engineering are the *Sinusoidal Waveforms*. However, an alternating AC waveform may not always take the shape of a smooth shape based around the trigonometric sine or cosine function. AC waveforms can also take the shape of either *Complex Waves*, *Square Waves* or *Triangular Waves* and these are shown below.

Types of Periodic Waveform



The time taken for an AC Waveform to complete one full pattern from its positive half to its negative half and back to its zero baseline again is called a Cycle and one complete cycle contains both a positive half-cycle and a negative half-cycle. The time taken by the

waveform to complete one full cycle is called the Periodic Time of the waveform, and is given the symbol "T".
The number of complete cycles that are produced within one second (cycles/second) is called the Frequency, symbol ƒ of the alternating waveform. Frequency is measured in Hertz, (Hz) named after the German physicist Heinrich Hertz.
Then we can see that a relationship exists between cycles (oscillations), periodic time and frequency (cycles per second), so if there are ƒ number of cycles in one second, each individual cycle must take 1/ƒ seconds to complete.
Relationship Between Frequency and Periodic Time

$$\text{Frequency}, (f) = \frac{1}{\text{Periodic Time}} = \frac{1}{T} \quad \text{Hertz}$$

or

$$\text{Periodic Time}, (T) = \frac{1}{\text{Frequency}} = \frac{1}{f} \quad \text{seconds}$$

AC Waveform Example No1
1. What will be the periodic time of a 50Hz waveform and 2. what is the frequency of an AC waveform that has a periodic time of 10mS.
1).

$$\text{Periodic Time}, \ (T) = \frac{1}{f} = \frac{1}{50} = 0.02\text{secs or } 20\text{ms}$$

2).

$$\text{Frequency}, \ (f) = \frac{1}{T} = \frac{1}{10 \times 10^{-3}} = 100\text{Hz}$$

Frequency used to be expressed in "cycles per second" abbreviated to "cps", but today it is more commonly specified in units called "Hertz". For a domestic mains supply the frequency will be either 50Hz or 60Hz depending upon the country and is fixed by the speed of rotation of the generator. But one hertz is a very small unit so prefixes are used that denote the order of magnitude of the waveform at higher frequencies such as kHz, MHz and even GHz.
Definition of Frequency Prefixes

Prefix	Definition	Written as	Periodic Time
Kilo	Thousand	kHz	1ms
Mega	Million	MHz	1us
Giga	Billion	GHz	1ns
Terra	Trillion	THz	1ps

Amplitude of an AC Waveform

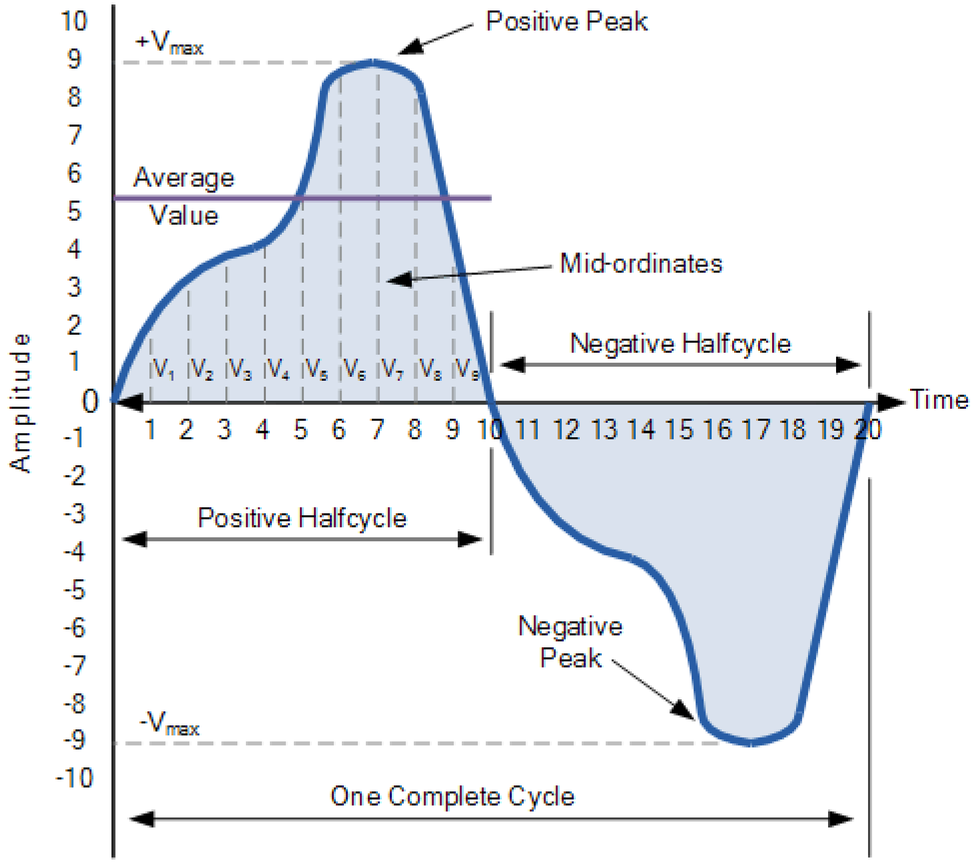
As well as knowing either the periodic time or the frequency of the alternating quantity, another important parameter of the AC waveform is Amplitude, better known as its Maximum or Peak value represented by the terms, V*max* for voltage or I*max* for current. The peak value is the greatest value of either voltage or current that the waveform reaches during each half cycle measured from the zero baseline. Unlike a DC voltage or current which has a steady state that can be measured or calculated using Ohm's Law, an alternating quantity is constantly changing its value over time.

For pure sinusoidal waveforms this peak value will always be the same for both half cycles (+Vm = -Vm) but for non-sinusoidal or complex waveforms the maximum peak value can be very different for each half cycle. Sometimes, alternating waveforms are given a *peak-to-peak*, V*p-p* value and this is simply the distance or the sum in voltage between the maximum peak value, +V*max* and the minimum peak value, -V*max* during one complete cycle.

The Average Value of an AC Waveform

The average or mean value of a continuous DC voltage will always be equal to its maximum peak value as a DC voltage is constant. This average value will only change if the duty cycle of the DC voltage changes. In a pure sine wave if the average value is calculated over the full cycle, the average value would be equal to zero as the positive and negative halves will cancel each other out. So the average or mean value of an AC waveform is calculated or measured over a half cycle only and this is shown below.

Average Value of a Non-sinusoidal Waveform



To find the average value of the waveform we need to calculate the area underneath the waveform using the mid-ordinate rule, trapezoidal rule or the Simpson's rule found commonly in mathematics. The approximate area under any irregular waveform can easily be found by simply using the mid-ordinate rule.

The zero axis base line is divided up into any number of equal parts and in our simple example above this value was nine, (V_1 to V_9). The more ordinate lines that are drawn the more accurate will be the final average or mean value. The average value will be the addition of all the instantaneous values added together and then divided by the total number. This is given as:

Average Value of an AC Waveform

$$V_{average} = \frac{V_1 + V_2 + V_3 + V_4 + \ldots + V_n}{n}$$

Where: n equals the actual number of mid-ordinates used.
For a pure sinusoidal waveform this average or mean value will always be equal to $0.637*V_{max}$ and this relationship also holds true for average values of current.
The RMS Value of an AC Waveform
The average value of an AC waveform that we calculated above as being: $0.637*V_{max}$ is NOT the same value we would use for a DC supply. This is because unlike a DC supply which is constant and and of a fixed value, an AC waveform is constantly changing over time and has no fixed value. Thus the equivalent value for an alternating current system that provides the same amount of electrical power to a load as a DC equivalent circuit is called the "effective value".
The effective value of a sine wave produces the same I^2*R heating effect in a load as we would expect to see if the same load was fed by a constant DC supply. The effective value of a sine wave is more commonly known as the Root Mean Squared or simply RMS value as it is calculated as the square root of the mean (average) of the square of the voltage or current.
That is V_{rms} or I_{rms} is given as the square root of the average of the sum of all the squared mid-ordinate values of the sine wave. The RMS value for any AC waveform can be found from the following modified average value formula as shown.

RMS Value of an AC Waveform

$$V_{RMS} = \sqrt{\frac{V_1^2 + V_2^2 + V_3^2 + V_4^2 + \ldots + V_n^2}{n}}$$

Where: n equals the number of mid-ordinates.
For a pure sinusoidal waveform this effective or R.M.S. value will always be equal too: $1/\sqrt{2}*V_{max}$ which is equal to $0.707*V_{max}$ and this relationship holds true for RMS values of current. The RMS value for a sinusoidal waveform is always greater than the average value except for a rectangular waveform. In this case the heating effect remains constant so the average and the RMS values will be the same.
One final comment about R.M.S. values. Most multimeters, either digital or analogue unless otherwise stated only measure the R.M.S. values of voltage and current and not the average. Therefore when using a multimeter on a direct current system the reading will be equal to I = V/R and for an alternating current system the reading will be equal to Irms = Vrms/R.

Also, except for average power calculations, when calculating RMS or peak voltages, only use V_{RMS} to find I_{RMS} values, or peak voltage, Vp to find peak current, Ip values. Do not mix them together as Average, RMS or Peak values of a sine wave are completely different and your results will definitely be incorrect.

Form Factor and Crest Factor

Although little used these days, both Form Factor and Crest Factor can be used to give information about the actual shape of the AC waveform. Form Factor is the ratio between the average value and the RMS value and is given as.

$$\text{Form Factor} = \frac{\text{R.M.S value}}{\text{Average value}} = \frac{0.707 \times \text{Vmax}}{0.637 \times \text{Vmax}}$$

For a pure sinusoidal waveform the Form Factor will always be equal to 1.11. Crest Factor is the ratio between the R.M.S. value and the Peak value of the waveform and is given as.

$$\text{Crest Factor} = \frac{\text{Peak value}}{\text{R.M.S. value}} = \frac{\text{Vmax}}{0.707 \times \text{Vmax}}$$

For a pure sinusoidal waveform the Crest Factor will always be equal to 1.414.

AC Waveform Example No2

A sinusoidal alternating current of 6 amps is flowing through a resistance of 40Ω. Calculate the average voltage and the peak voltage of the supply.

The R.M.S. Voltage value is calculated as:

$$V_{RMS} = I \times R = 6 \times 40 = 240V$$

The Average Voltage value is calculated as:

$$\text{Form Factor} = \frac{V_{RMS}}{V_{average}}$$

$$\therefore\ V_{average} = \frac{V_{RMS}}{\text{Form Factor}} = \frac{240}{1.11} = 216.2\text{ volts}$$

The Peak Voltage value is calculated as:

$$\text{Peak Voltage} = \text{R.M.S.} \times 1.414$$

$$\therefore\ 240 \times 1.414 = 339.4\text{ volts}$$

The use and calculation of Average, R.M.S, Form factor and Crest Factor can also be use with any type of periodic waveform including Triangular, Square, Sawtoothed or any other irregular or complex voltage/current waveform shape. Conversion between the various sinusoidal values can sometimes be confusing so the following table gives a convenient way of converting one sine wave value to another.

Sinusoidal Waveform Conversion Table

Convert From	Multiply By	Or By	To Get Value
Peak	2	$(\sqrt{2})^2$	Peak-to-Peak
Peak-to-Peak	0.5	1/2	Peak
Peak	0.707	$1/(\sqrt{2})$	RMS
Peak	0.637	$2/\pi$	Average
Average	1.570	$\pi/2$	Peak
Average	1.111	$\pi/(2\sqrt{2})$	RMS
RMS	1.414	$\sqrt{2}$	Peak
RMS	0.901	$(2\sqrt{2})/\pi$	Average

TEXT 18. NEW APPLICATIONS OF THE COMPUTER

Among the most exciting new applications of the computer is the ability to bring together information that exists in a variety of forms. New computer tools, often using combinations of hardware and software, are now providing better ways to bring together information that is stored on other media in the form of graphics, sound, and video. These new programs, known collectively as multimedia applications, bring the other media sources under computer control.

CD-ROM - based Multimedia

One of the problems in dealing with computer-controlled sound and graphics is that the related files require extremely large amounts of storage. One solution is to store graphics, sound, and video files on a high-capacity device such as compact disk (CD). Compact disks can store huge amounts of data and the CD drives can be used to deliver this information to the computer's internal memory as data. Because most of these devices cannot be used to record information, they are known as read-only memory (ROM) devices. Although they are used to store computer data, these devices do not use the same kind of magnetic media generally used by computers to store data. Instead, these devices store information by permanently etching the encoded data into the same kind of plastic disk used to store and play back popular music. Because the stored data is deciphered using a laser-based reading device, there is no physical contact with the disk and no possibility of wear to the disk. Their high capacity and permanence are making CD-ROM disks a common storage and delivery tool for multimedia.

Videodisc

The videodisc player is similar to the compact disk player, but the disks used are somewhat different. While the CD disks are used to store and deliver computer data, videodiscs are used to store and deliver video images. They can be used to deliver high-quality video to a television set by displaying the video images in sequence at the same 30-frames-per-second rate that is used in broadcast television. Many videodisc players can be controlled by computer. And because the video images are stored a single image at a time, one image can be displayed under computer control or a sequence of images can be displayed to create the effect of live video.

Digital Video

Most of the video images we are used to seeing on our home television sets were originally captured using a video camera and stored on video tape. But today, special devices make it possible to store video images in digital form on a computer's magnetic media as computer graphics. By rapidly delivering these digital graphics images to the computer's screen one after the other, we can simulate the kind of video images we see on our television set.

Computer-delivered digital video presents many exciting possibilities. Because the video images are stored on normal computer media as data in separate graphics files, there is unlimited potential for editing the video sequence using computer graphics editing methods. And because the video images can be displayed on the computer's screen as graphics, they can be incorporated into presentations that in the past used only still pictures.

Multimedia Authoring Systems

In order to manage the presentation of information that is stored in dissimilar formats, new multimedia-based authoring systems are being developed. These programs vary considerably in design, but all are capable of incorporating text, graphics, sound, and video into one program. These programs provide special tools to manage these resources and to deliver them to the user interactively.

Virtual Reality

With the emergence of ever more realistic computer graphics, many people have found the computer's monitor to be a limited output device for displaying them. Many found the two-dimensional view of modern, complex colour graphics did not fully convey the potential held by this new form of computerized information. This led to the investigation of ways to present and to interact with more realistic, three-dimensional displays. The result was the development of highly realistic displays that provide users with the feeling that they are fully immersed in the computer image. Collectively, these applications have become known by the title of "virtual reality."

TEXT 19. ADVANTAGES OF COMPUTER DATA PROCESSING

Computer-oriented data processing systems or just computer data processing systems are not designed to imitate manual systems. They should combine the capabilities of both humans and computers. Computer data processing systems can be designed to take advantage of four capabilities of computers.

1. Accuracy. Once data have been entered correctly into the computer component of a data processing system, the need for further manipulation by humans is eliminated, and the possibility of error is reduced. Computers, when properly programmed, are also unlikely to make computational errors. Of course, computer systems remain vulnerable to the entry by humans of invalid data.

2. Ease of communications. Data, once entered, can be transmitted wherever needed by communications networks. These may be either earth or satellite-based systems. A travel reservations system is an example of a data communications network. Reservation clerks throughout the world may make an enquiry about transportation or lodgings and receive an almost instant response. Another example is an office communications system that provides executives with access to a reservoir of date, called a corporate data base, from their personal microcomputer work stations.

3. Capacity of storage. Computers are able to store vast amounts of information, to organize it, and to retrieve it in ways that are far beyond the capabilities of humans. The amount of data that can be stored on devices such as magnetic discs is constantly increasing. All the while, the cost per character of data stored is decreasing.

4. Speed. The speed, at which computer data processing systems can respond, adds to their value. For example, the travel reservations system mentioned above would not be useful if clients had to wait more than a few seconds for a response. The response required might be a fraction of a second.

Thus, an important objective in the design of computer data processing systems is to allow computers to do what they do best and to free humans from routine, error-prone tasks. The most cost-effective computer data processing system is the one that does the job effectively and at the least cost.

The Data Processing cycle

Input data are the original, unchanged data, and their processing includes a few steps. The key is the order of these steps, as it helps you ensure they will become valuable sources of information.

The data processing cycle can be repeated, as input data from one cycle can be stored and used as input data in another process. This is why we're calling it a cycle.

Let's quickly discuss the cycle's steps:

1. Collecting raw data

In this stage, remember that your data sources should be verified and reliable. If you follow the „trash in, trash out" rule and your input data are poor quality, you won't achieve satisfying processing results.

2. Preparing and cleaning data

This includes sorting and filtering original data. You do that to delete redundant or incorrect data. In this stage, you verify whether your raw data has any errors, duplicates, or incorrect values and check their completeness. You should also ensure their format allows you to analyze and process them further. You can learn more about this issue in our article "Data errors. What are the consequences of using poor-quality data?".

3. Entering data

In this step, your raw but prepared and cleaned data are transformed so that the application or machine responsible for further processing can read them. Some examples of data entry include manual data entry, a file upload, or document scans.

4. Processing data

In this stage, your data are subjected to different processing methods and techniques that ensure your desired results. This step depends on your data sources and the reasons for processing them.

5. Data processing results

You can present processed data in a clear, user-friendly form, such as charts, tables, vector files, raster files, or reports. Such data can be further interpreted, stored, and used in the next data processing cycles.

6. Storing and archiving data

The last stage is storing and archiving raw input data and processing results, including all metadata. Store your data correctly to quickly access and use them in the future.

TEXT 20. THE INTERNET

The Internet, a global computer network that embraces millions of users all over the world, began in the United States in 1969 as a military experiment. It was designed to survive a nuclear war. Information sent over the Internet takes the shortest path available from one computer to another. Because of this any two computers on the Internet will be able to stay in touch with each other as long as there is a single route between them. This technology is called packet switching. Owing to this technology, if some computers on the network are knocked out, information will just route around them. One such packet switching network that has already survived a war is the Iraqi computer network that was knocked out during the Gulf War.
Despite the confusing techno-jargon that surrounds it, the Internet is simple: computers talk to one another through a network that uses phone lines, cable, and fiber-optic lines. At present more than 60 million people use the Internet and over five million computers worldwide are linked in. Most of the Internet host computers are in the United States, while the rest are located in more than 100 other countries. Although the number of host computers can be counted fairly accurately, nobody knows exactly how many people use the Internet, there are millions worldwide, and their number is growing by thousands each month. People use the Net for transferring data, playing games, socializing with other computer users, and sending e-mail.
The most popular Internet services are e-mail, reading USENET news, using the World Wide Web, telnet, FTP, information sites and Gopher.

The Internet can be divided into five broad areas:
Electronic mail
E-mail is much faster than traditional or snail mail because once the message is typed out, it arrives in the electronic mailbox of the recipient within minutes or seconds. Anything that can be digitized – pictures, sound, video –can be sent, retrieved and printed at the other end. This is efficient and convenient.
Information sites
This is perhaps the fastest growing area of the Internet as more and more people put their own information pages on line. One thing that computers do very well is processing vast amounts of data very fast, so, by specifying a key word or phrase, the computer can then search around the Net until it finds some matches. These information sites are usually stored on big computers that exist all over the world. The beauty of the Net is that you can access all of them from your home, using your own PC.

The World Wide Web
The World Wide Web usually referred to as WWW or 3W, is a vast network of information databases that feature text, visuals, sound, and video clips. On the WWW you can do such things as go on tour of a museum or art exhibition, see the latest images from outer space, go shopping, and get travel information on hotels and holidays.
USENET News
Usenet is a collection of newsgroups covering any topic. Newsgroups allow users to participate in dialogues and conversations by subscribing, free of charge. Each newsgroup consists of messages and information posted by other users. There are more than 10,000 newsgroups and they are popular with universities and businesses.

Telnet

Telnet programs allow you to use your personal computer to access a powerful mainframe computer. It is a network protocol used on the Internet or local area network connections (LANs). Telnet provides access to a command-line interface on a remote machine. Telnet clients are available for virtually all platforms.

Aside from the complex physical connections that make up its infrastructure, the Internet is facilitated by bi- or multi-lateral commercial contracts (peering agreements), and by technical specifications or protocols that describe how to exchange data over the network. Indeed, the Internet is defined by its interconnections and routing policies.
The complex communications infrastructure of the Internet consists of its hardware components and a system of software layers that control various aspects of the architecture. While the hardware can often be used to support other software systems, it is the design and the rigorous standardization process of the software architecture that characterizes the Internet.
The responsibility for the architectural design of the Internet software systems has been delegated to the Internet Engineering Task Force (IETF). The IETF conducts standard-setting work groups; open to any individual, about the various aspects of Internet architecture. Resulting discussions and final standards are published in Request for Comment (RFC), freely available on the IETF web site. The principal methods of networking that enable the Internet are contained in a series of RFC that constitute the Internet Standards. These standards describe a system known as the Internet Protocol Suite. This is a model architecture that divides methods into a layered system of protocols (e.g., RFC 1122, RFC 1123). The layers correspond to the environment or scope in which their services operate. At the top is the space (Application Layer) of the software application and just below it is the Transport Layer which connects applications on different host via the network (client-server model). The underlying network consists of two layers: the Internet Layer which enables computers to connect to one-another via intermediate (transit) networks and thus is the layer that establishes internetworking, and lastly, at the bottom, is a software layer that provides connectivity between hosts on the same local link, e.g., a local area network (LAN) or a dial-up connection. This model is also known as TCP/IP model of networking. While other models have been developed, such as the Open Systems Interconnection (OSI) model, they are not compatible in the details of description, nor implementation.

TEXT 21. THE LANGUAGE OF E-MAIL

E-mail is the simplest and most immediate function of the Internet for many people. Run through a list of questions that new e-mail users ask most and some snappy answers to them.

What is electronic mail? Electronic mail, or e-mail as it's normally shortened to, is just a message that is composed, sent and read electronically (hence the name). With regular mail you write out your message (letter, postcard, whatever) and drop it off at the post office. The postal service then delivers the message and the recipient reads it. E-mail operates basically the same-way except that everything happens electronically. You compose your message using e-mail software, send it over the lines that connect the Internet's networks and the recipient uses an e-mail program to read the message.

How does e-mail know to get where it's going? Everybody who's connected to the Internet is assigned a unique e-mail address. In a way, this address is a lot like the address of your house or apartment because it tells everyone else your exact location on the Net. So anyone who wants to send you an e-mail message just tells the e-mail program the appropriate address and runs the Send command. The Internet takes over from there and makes sure the missive arrives safety.

What's this netiquette stuff I keep hearing about? The Net is a huge, unwieldy mass with no "powers-that-be" that can dictate content or standards. This is, for the most part, a good thing because it means there's no censorship and no one can wield authority arbitrarily. To prevent this organized chaos from descending into mere anarchy, however, a set of guidelines has been put together over the years. These guidelines are known collectively as netiquette (network etiquette) and they offer suggestions on the correct way to interact with the Internet's denizens. To give you a taste of netiquette, here are some highlights to consider.

- Keep your message brief and to the point and make sure you clear up any spelling slips or grammatical gaffes before shipping it out.
- Make sure the Subject lines of your message are detailed enough so they explain what your message is all about.
- Don't SHOUT by writing your missives entirely in uppercase letters.
- Don't bother other people by sending them test messages. If you must test a program, send a message to yourself.

What's a flame? The vast majority of e-mail correspondence is civil and courteous, but with millions of participants all over the world, it's inevitable that some folks will rub other the wrong way. When this happens, the combatants may exchange emotionally charged, caustic, often obscene messages called flames. When enough of these messages exchanges hands, an out-and-out flame war develops. These usually burn themselves out after a while, and then the participants can get back to more interesting things.

Is e-mail secure? In a word, no. The Net's open architecture allows programmers to write interesting and useful new Internet services, but it also allows unscrupulous snoops to lurk where they don't belong. In particular, the e-mail system has two problems: it's not that hard for someone else to read your e-mail, and it's fairly easy to forge an e-mail address. If security is a must for you, then you'll want to create an industrial strength password for your home directory, use encryption for your most sensitive messages, and use an anonymous remailer when you want to send something incognito.

TEXT 22. COMPUTER NETWORKS

A computer network is a series of connections and associated devices through which computers can communicate with other computers. A computer network consists of two or more computers that are interconnected in order to share resources (such as printers), exchange files, or allow electronic communications. In a computer network the individual stations, called "nodes", may be computers, terminals, or communication units of various kinds. The computers on a network may be linked through cables, telephone lines, radio waves, satellites, or infrared light beams.

In addition to physically connecting computers and communication devices, a network system has the function of establishing a cohesive architecture that allows almost seamless data transmission while using various equipment types. Open System Interconnection (OSI) and IBM's System Network Architecture are two popular architectures used at present.

Local-area networks and wide-area networks are two basic network types.

A local-area network (LAN) is a computer network that covers a local area. It may be a home, office or small group of buildings such as a college or factory. The topology of a network dictates its physical structure. The generally accepted maximum size for a LAN is 1 square km. At present, there are two common wiring technologies for a LAN, Ethernet and Token Ring. A LAN typically includes two or more PCs, printers, CD-ROMs and high-capacity storage devices, called file servers, which enable each computer on the network to access a common set of files. A LAN is controlled by LAN operating system software. LAN users may also have access to other LANs or tap into wide-area networks. LANs with similar architectures are linked by transfer points, called "bridges", and LANs with different architectures use "gateways" to convert data as it passes between systems. A router is used to make the connection between LANs.

A wide-area network (WAN) is a computer network that covers a wide geographical area, involving a large number of computers. Computer networks may link the computers by means of cables, optical fibres, or satellites and modems. Typically, WANs are used to connect LANs together. Many WANs are built for one particular organization and are private, others, built by Internet service providers, provide connections from an organization's LAN to the Internet. WANs are most often built of leased lines. At each end of the leased line, a router is used to connect to the LAN on one side and a hub within the WAN on the other.

The best example of a WAN is the Internet, a collection of networks and gateways linking millions of computer users on every continent. Networks within the Internet are linked by common communication programs and protocols. A protocol is a set of established standards that enable computers to communicate with each other. A number of network protocols such as TCP/IP,X.25, ATM and Frame relay can be used for WANs. By means of the Internet, users can obtain a variety of information browsing via buttons, highlighted text, or sophisticated searching software known as search engines.

TEXT 23. SOFTWARE: THE INSIDE STORY

Computer software determines the types of tasks a computer can help you accomplish. Some software helps you create documents; while other software helps you edit home videos, prepare your tax return or design the floor plan for a new house.
The instructions that tell a computer how to carry out a task are referred to as a computer program. These programs form the software that prepares a computer to do a specific task, such as document production, video editing, graphic design or Web browsing. In popular usage the term “software” refers to one or more computer programs and any additional files that are provided to carry out a specific type of task.
Whether it’s on a CD or downloaded from the Web, today’s software is typically composed of many files. You might be surprised by the number of files that are necessary to make software work. At least one of the files included in a software package contains an executable program designed to be launched, or started, by users. On PCs, these programs are stored in files that typically have .exe file extensions and are referred to as “executable files”. Other files supplied with a software package contain programs that are not designed to be run by users. These “support programs” contain instructions for the computer to use in conjunction with the main user-executable file. A support program can be activated by the main program as needed. Support programs often have file extensions such as .dll and .ocx.
In addition to program files, many software packages also include data files. As you might expect, these files contain any data that is necessary for a task, but not supplied by the user, such as Help documentation. The data files supplied with a software package sport files extensions such as .txt, .bmp, and .hlp.

The use of a main user-executable file plus several support programs and data files offers a great flexibility and efficiency for software developers. Support programs and data files from existing programs can usually be modified by developers for other programs without changing the main executable file. This modular approach can reduce the time required to create and test the main executable file, which usually contains a long and fairly complex program. This modular approach also allows software developers to reuse their support programs in multiple software products and adapt preprogrammed support modules for use in their own software. Modular programming techniques are of interest mainly to people who create computer programs; however these techniques affect the process of installing and uninstalling software. It is important, therefore, to remember that computer software consists of many files that contain user-executable programs, support programs, and data.

Software is categorized as application software or system software. The primary purpose of application software is to help people carry out tasks using a computer. In contrast, the primary purpose of system software – your computer’s operating system, device drivers, programming languages, and utilities – is to help the computer to carry out its basic operating functions.
Computer software or just software is a general term used to describe the role that computer programs, procedures and documentation play in a computer system. The term includes:
· Application software, such as word processors which perform productive tasks for users.

· Firmware, which is software programmed resident to electrically programmable memory devices on board, mainboards or other types of integrated hardware carriers.
· Middleware, which controls and co-ordinates distributed systems.
· System software such as operating systems, which interface with hardware to provide the necessary services for application software.
· Software testing is a domain dependent of development and programming.
· Software testing consists of various methods to test and declare a software product fit before it can be launched for use by either an individual or a group.
· Testware, which is an umbrella term or container term for all utilities and application software that serve in combination for testing a software package but not necessarily may optionally contribute to operational purposes.

As such, testware is not a standing configuration but merely a working environment for application software or subsets thereof.
Software includes things such as websites, programs or video games that are coded by programming languages like C or C++. "Software" is sometimes used in a broader context to mean anything which is not hardware but which is used with hardware, such as film, tapes and records.
Computer software is often regarded as anything but hardware, meaning that the "hard" are the parts that are tangible while the "soft" part is the intangible objects inside the computer. Software encompasses an extremely wide array of products and technologies developed using different techniques like programming languages, scripting languages, microcode, or an FPGA configuration.
The types of software include web pages developed by technologies like HTML, PHP, Perl, JSP, ASP.NET, XML, and desktop applications like Open Office, Microsoft Word developed by technologies like C, C++, Java, or C#.
Software usually runs on underlying software operating systems such as the Linux or Microsoft Windows. Software also includes video games and the logic systems of modern consumer devices such as automobiles, televisions, and toasters.
Computer software is so called to distinguish it from computer hardware, which encompasses the physical interconnections and devices required to store and execute (or run) the software. At the lowest level, software consists of a machine language specific to an individual processor. A machine language consists of groups of binary values signifying processor instructions that change the state of the computer from its preceding state. Software is an ordered sequence of instructions for changing the state of the computer hardware in a particular sequence. It is usually written in high-level programming languages that are easier and more efficient for humans to use (closer to natural language) than machine language. High-level languages are compiled or interpreted into machine language object code. Software may also be written in an assembly language, essentially, a mnemonic representation of a machine language using a natural language alphabet. Assembly language must be assembled into object code via an assembler.
The term "software" was first used in this sense by John W. Tukey in 1958. In computer science and software engineering, computer software is all computer programs. The theory that is the basis for most modern software was first proposed by Alan Turing in his 1935 essay “Computable numbers with an application to the Entscheidungsproblem”.

TEXT 24. TYPES OF GRAPHICS SOFTWARE

Computer graphics are pictures created, changed or processed by computers. There are two categories.
1. **Bitmapped graphics** represent images as bitmaps; they are stored as pixels and can become a bit distorted when they are manipulated. The density of dots, known as the resolution and expressed in dots per inch, determines how sharp the image is.
2. **Vector graphics** represent images as mathematical formulae, so they can be changed or scaled without losing quality. They are ideal for high-resolution output.
There are different types of graphics software.

- Image manipulation programs let you edit your favourite images. For example, you can scan a picture into your PC or transfer a photo from your camera and then add different effects, or filters.
- **Painting and drawing programs**, also called **illustration packages**, offer facilities for freehand drawing, with a wide choice of pens and brushes, colours and patterns. One example is *Windows Paint*.
- **Business graphics programs**, also called **presentation software**, let you create pie charts, bar charts and line graphs of all kinds for slide shows and reports. You can import data from a database or spreadsheet to generate the graphs. (Spreadsheets, or worksheets, are mathematical tables which show figures in rows and columns. A spreadsheet program helps you manage personal and business finances.)
- **Computer-aided design** (**CAD**) is used by engineers and architects to design everything from cars and planes to buildings and furniture. First they make a wireframe, a drawing with edges and contour lines. Then if they want to colour the objects and add texture, they create a surface for the object; this is called 'filling the surface'. Finally, the design is rendered to make the object look realistic. Rendering is a process that adds realism to graphics by using shading, light sources and reflections.
- **Desktop publishing** (**DTP**) is based around a page layout program, which lets you import text from a word processor, clip-art (ready-made pictures) from graphics packages, and images from scanners or cameras, and arrange them all on a page. It is used to design and publish books, newspapers, posters, advertisements, etc.
- **Digital art**, or **computer art**, is done with applets that use mathematical formulae to create beautiful bright shapes called fractals. A fractal is a geometric figure with special properties, e.g. the Koch snowflake or the Mandelbrot set. Fractals can also be used to model real objects like clouds, coastlines or landscapes.
- **Computer animation** uses graphics program (e.g. digital cartooning systems) to create or edit moving pictures. Each image in a sequence of images is called a 'frame'.
- **Geographic information systems** (**GIS**) allow cartographers to create detailed maps.

TEXT 25. COMPUTER GRAPHICS

3D computer graphics are works created by computers and specialized 3D software. In general, the art of 3D modelling is akin to photography, while the art of 2D graphics is analogous to painting. 3D computer graphics relies on the same algorithms that 2D computer graphics does. In computer graphics software this distinction is occasionally blurred. Some 2D applications use 3D techniques to achieve certain effects, e.g., lighting, while some primarily 3D applications make use of 2D visual techniques, i.e., 2D graphics is a subset of 3D graphics.

OpenGL and Direct 3D are two popular APIs for the generation of real-time imagery. Many modern graphics cards provide hardware acceleration based on the APIs that frequently enable to display complex 3D graphics in real-time. However, it is unnecessary to employ any of them to create 3D computer graphics. The process of creating 3D computer graphics can be divided into three basic stages, such as: modelling, scene layout setup and rendering.

The modelling stage can be described as shaping individual objects later used in the scene. There exist a number of modelling techniques, for instance, constructive solid geometry, NURBS modelling, polygonal modelling, subdivision surfaces and implicit surfaces. Modelling may also include editing object surface or material properties (e.g., colour, luminosity, reflection characteristics, transparency or index of refraction), adding textures and others. It may also include various activities related to preparing for animation of a 3D model. Modelling can be performed by means of dedicated programs (e.g., Lightwave Modeller, Rhinoceros 3D, Moray), application components (Shaper, Lofter in 3D Studio) or a scene description language.

Scene layout setup involves arranging virtual objects, lights, cameras and other entities on a scene which will be later used to produce an image or an animation. If it is used for animation, this stage usually makes use of a technique called «key framing». This technique facilitates creation of complicated movements in the scene. Lighting is an important aspect of stage setup. Its effects can contribute greatly to the mood and emotional response, facts which are well-known to photographers and theatre lighting technicians.

Rendering is the final stage of creating the actual 2D image or animation from the prepared scene. Rendering for interactive media, such as, games and simulation, is calculated and displayed in real time, at rates of approximately 20 to 120 frames per second. Animations for non-interactive media, such as, video and film, are rendered much more slowly. For complex scenes rendering time of individual frames may vary from few seconds to an hour or more. Rendered frames are stored on a hard disk and then transferred to other media, such as, motion picture film or optical disk. These frames can be displayed at high frame rates, typically 24, 25 or 30 frames per second, to achieve the illusion of motion. Rendering software may simulate such visual effects as lens flares, depth of field or motion blur.

These are attempts to simulate visual phenomena resulting from the optical characteristics of cameras and human eye. These effects can lend an element of realism to a scene, even if the effect is merely a simulated artefact of a camera.

Techniques have been developed in order to simulate other naturally-occurring effects, for instance, the interaction of light with various forms of matter. Examples of such techniques include particle systems (which can simulate rain, smoke or fire), volumetric sampling (to simulate fog, dust and other spatial atmospheric effects) and a lot of others. Rendering is computationally expensive. Software for rendering is included in 3D software packages, but there are some rendering systems that are used as plug-ins to popular 3D applications.

The output of the rendering software is often used as only one small part of a completed motion-picture scene. Many layers of material may be rendered separately and integrated into the final stage by using special software packages.
NURBS stands for « » and is a mathematical model commonly used in computer graphics for generating and representing curves and surfaces. The development of NURBS (actually the Bezier Curve) began in the 1950s by engineers who needed free form surfaces representation like those that used for car bodies and ship hulls. Prior representations of this kind of surfaces existed only as a single physical model created by the designer.

NURBS is important for computer-aided design, manufacturing, engineering (CAD, CAM, CAE) and is a standard for numerous industries. But there is still a lot of confusion about their advantages and disadvantages for interactive modelling. In general, it is known that editing NURBS curves and surfaces is highly intuitive and predictable. Depending on the type of user interface, editing can be realized via NURBS control points, most obvious and common for Bezier curves, or via higher level tools, such as, spline modelling or hierarchical editing. Higher level tools can be designed to be very powerful and benefit from the ability of NURBS to create and establish continuity of different levels.

TEXT 26. MALWARE: VIRUSES, WORMS, TROJANS, SPYWARE

Malware (malicious software) is software created to damage or alter the computer data or its operations. These are the main types.
· Viruses arc programs that spread by attaching themselves to executable files or documents. When the infected program is run, the virus propagates to other files or programs on the computer. Some viruses are designed to work at a particular time or on a specific date, e.g. on Friday 13th. An email virus spreads by sending a copy of itself to everyone in an email address book.
Worms are self-copying programs that have the capacity to move from one computer to another without human help, by exploiting security flaws in computer networks. Worms are self-contained and don't need to be attached to a document or program the way viruses do.
· Trojan horses are malicious programs disguised as innocent-looking files or embedded within legitimate software. Once they are activated, they may affect the computer in a variety of ways: some are just annoying, others are more ominous, creating a backdoor to the computer which can be used to collect stored data. They don't copy themselves or reproduce by infecting other files.
· Spyware, software designed to collect information from computers for commercial or criminal purposes, is another example of malicious software. It usually comes hidden in fake freeware or shareware applications downloadable from the Internet.
Computer crime encompasses a broad range of illegal activities. It may be divided into two categories: 1) crimes that target computer networks or devices directly (malware, denial-of-service (DoS) attacks and computer viruses) 2) crimes facilitated by computer networks or devices (cyber stalking, fraud and identity theft, phishing scams).
Malicious software (malware) is software designed to infiltrate a computer system without the owner's informed consent. Malware includes computer viruses, worms, Trojan horses, most rootkits, spyware, dishonest adware, and other malicious and unwanted software.

Many early infectious programs were written as experiments or pranks. Hostile intent can be found in programs designed to cause harm or data loss. Many DOS viruses were designed to destroy files on a hard disk, or to corrupt the file system.
However, since the rise of widespread broadband Internet access, malicious software has come to be designed for a profit motive.

Infected "zombie computers" are used to send email spam, to host contraband data such as child pornography, or to engage in distributed denial-of-service attacks.
The best-known types of malware, viruses and worms, are known for the manner in which they spread. A virus requires user intervention to spread, whereas a worm spreads automatically. It can reproduce itself and spreads from one computer to the next over a network. Before Internet access became widespread, viruses spread on personal computers by infecting programs or the executable boot sectors of floppy disks. With the rise of the MS Windows platform in the 1990s it became possible to write infectious code in the macro language of Microsoft Word and similar programs.
For a malicious program to accomplish its goals, it must be able to do so without being shut down, or deleted by the user or administrator of the computer on which it is running. When a malicious program is disguised as something innocuous or desirable, users may install it. This is the technique of the Trojan horse or Trojan. One of the most

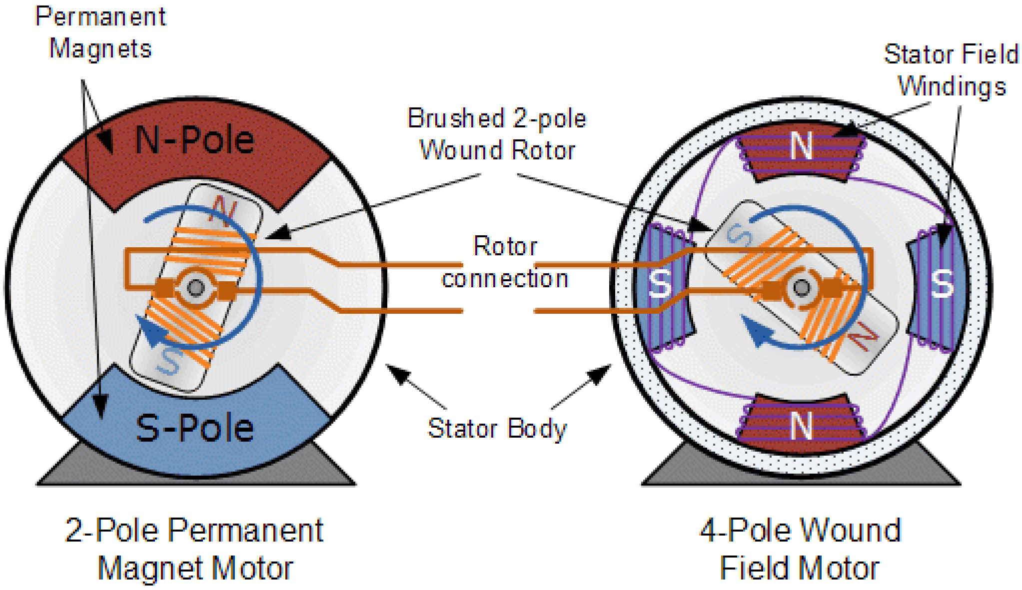
common ways that spyware is distributed is as a Trojan horse, bundled with a piece of desirable software that the user downloads from the Internet. When the user installs the software, the spyware is installed alongside. Spyware authors who attempt to act in a legal fashion may include an end-user license agreement that states the behavior of the spyware in loose terms, which the users are unlikely to read or understand.
Once a malicious program is installed on a system, it is essential that it stay concealed, to avoid detection and disinfection. Techniques known as rootkits allow this concealment, by modifying the host operating system so that the malware is hidden from the user. Rootkits can prevent a malicious process from being visible in the system's list of processes. Some malicious programs contain routines to defend against removal, not merely to hide themselves, but to repel attempts to remove them.
A computer can be a source of evidence. Even though the computer is not directly used for criminal purposes, it is an excellent device for record keeping, particularly given the power to encrypt the data. This evidence can be obtained and decrypted and be of great value to criminal investigators.
As malware attacks become more frequent, attention has begun to shift from viruses and spyware protection, to malware protection, and programs have been developed to specifically combat them. They can provide real time protection against the installation of malware software on a computer by scanning all incoming network data for malware and blocks any threats. They also scan the contents of the windows registry, operating system files, and installed programs on a computer, allowing the user to choose which files to delete or keep.

Computer Crime

It doesn't take any special digital expertise to mastermind some computer crimes. Setting fire to a computer doesn't require the same finesse as writing a stealthy virus, but both can have the same disastrous effect on data. "Old-fashioned" crimes, such as arson, that take a high-tech twist because they involve a computer can be prosecuted under traditional laws.
Traditional laws do not, however, cover the range of possibilities for computer crimes. Suppose a person unlawfully enters a computer facility and steals backup tapes. That person might be prosecuted for breaking and entering. But would common breaking and entering laws apply to a person who uses an off-site terminal to "enter" a computer system without authorization? And what if a person copies a data file without authorization? Has that file really been "stolen" if the original remains on the computer? Many countries have computer crime laws that specifically define computer data and software as personal property. These laws also define as crimes the unauthorized access, use, modification, or disabling of a computer system or data. But laws don't necessarily stop criminals. If they did, we wouldn't have to deal with malicious code and intrusions.
A 1995 high-profile case involved a computer hacker named Kevin Mitnick, who was accused of breaking into dozens of corporate, university, government, and personal computers. Although vilified in the media, Mitnick had the support of many hackers and other people who believed that the prosecution grossly exaggerated the extent of his crimes.
Nonetheless, Mitnick was sentenced to 46 months in prison and ordered to pay restitution in the amount of $4,125 during his three-year period of supervised release.

The prosecution was horrified by such a paltry sum – an amount that was much less than its request for $1,5 million in restitution.
Forbes reporter Adam L. Penenberg took issue with the 46-month sentence imposed by Judge Marianne Pfaelzer and wrote, “This in a country where the average prison term for manslaughter is three years. Mitnick’s crimes were curiously innocuous. He broke into corporate computers, but no evidence indicates that he destroyeddata. Or sold anything he copied. Yes, he pilfered software — but in doing so left it behind. This world of bits is a strange one, in which you can take something and still leave it for its rightful owner. The theft laws designed for payroll sacks and motor vehicles just don’t apply to a hacker.”
The U.S. Patriot Act and the Cyber-Security Enhancement Act carry even stiffer penalties – anywhere from 10 years to life in prison.
Law makers hope that stiff penalties will deter cyber criminals. U. S. Attorney John McKay is quoted as saying, “Let there be no mistake about it, cyber-hacking is a crime. It harms persons, it harms individuals, it harms businesses.
These cases illustrate our culture's ambivalent attitude toward computer hackers. On the one hand, they are viewed as evil cyber terrorists who are set on destroying the glue that binds together the Information Age. From this perspective, hackers are criminals who must be hunted down, forced to make restitution for damages, and prevented from creating further havoc.
From another perspective, hackers are viewed more as Casper the Friendly Ghost in cur complex cyber machines – as moderately bothersome entities whose pranks are tolerated by the computer community, along with software bugs. Seen from this perspective, a hacker's pranks are part of the normal course of study that leads to the highest echelons of computer expertise.

DC Motors are electromechanical devices which use the interaction of magnetic fields and conductors to convert the electrical energy into rotary mechanical energy.

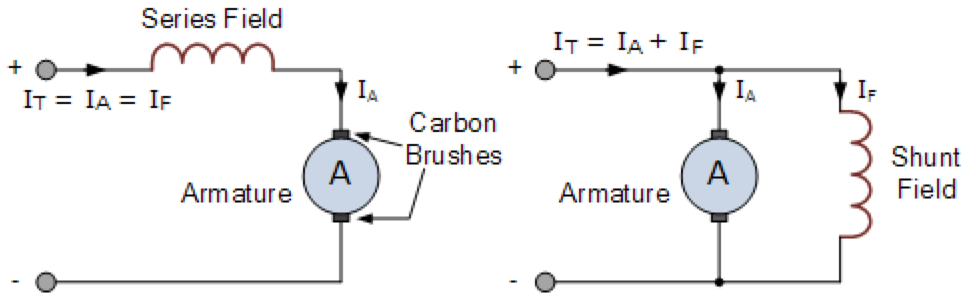


Electrical DC Motors are continuous actuators that convert electrical energy into mechanical energy. The DC motor achieves this by producing a continuous angular rotation that can be used to rotate pumps, fans, compressors, wheels, etc.
As well as conventional rotary DC motors, linear motors are also available which are capable of producing a continuous liner movement. There are basically three types of conventional electrical motor available: AC type Motors, DC type Motors and Stepper Motors.

A Typical Small DC Motor

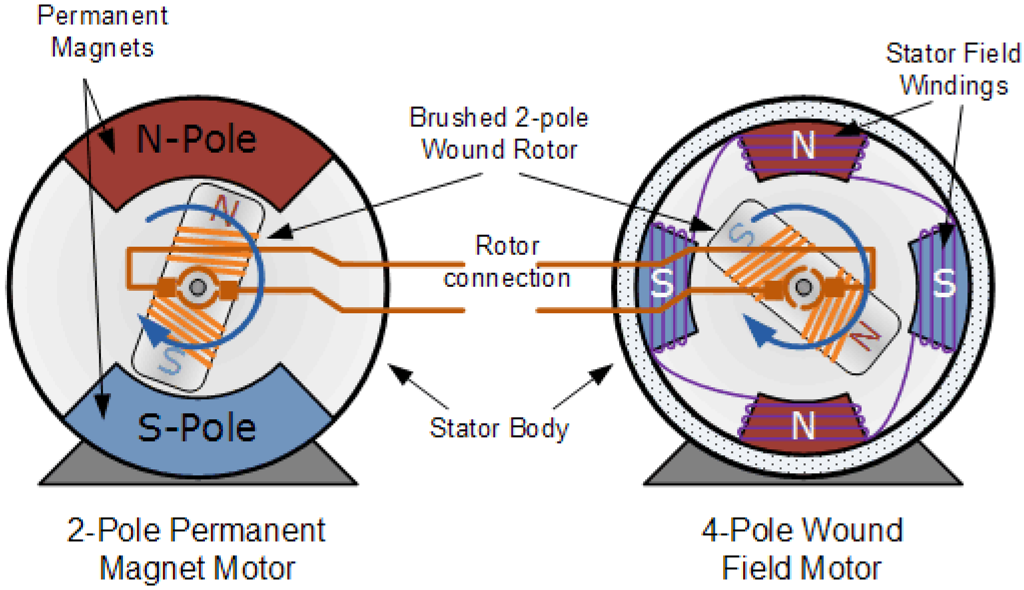
AC Motors are generally used in high power single or multi-phase industrial applications were a constant rotational torque and speed is required to control large loads such as fans or pumps.
The Basic DC Motor
The **DC Motor** or **Direct Current Motor** to give it its full title, is the most commonly used actuator for producing continuous movement and whose speed of rotation can easily be controlled, making them ideal for use in applications were speed control, servo type control, and/or positioning is required. A DC motor consists of two parts, a "Stator" which is the stationary part and a "Rotor" which is the rotating part. The result is that there are basically three types of DC Motor available.

Brushed Motor – This type of motor produces a magnetic field in a wound rotor (the part that rotates) by passing an electrical current through a commutator and carbon brush assembly, hence the term "Brushed". The stators (the stationary part) magnetic field is produced by using either a wound stator field winding or by permanent magnets. Generally brushed DC motors are cheap, small and easily controlled.
Brushless Motor – This type of motor produce a magnetic field in the rotor by using permanent magnets attached to it and commutation is achieved electronically. They are generally smaller but more expensive than conventional brushed type DC motors because they use "Hall effect" switches in the stator to produce the required stator field rotational sequence but they have better torque/speed characteristics, are more efficient and have a longer operating life than equivalent brushed types.
Servo Motor – This type of motor is basically a brushed DC motor with some form of positional feedback control connected to the rotor shaft. They are connected to and controlled by a PWM type controller and are mainly used in positional control systems and radio controlled models.
Normal DC motors have almost linear characteristics with their speed of rotation being determined by the applied DC voltage and their output torque being determined by the current flowing through the motor windings. The speed of rotation of any DC motor can be varied from a few revolutions per minute (rpm) to many thousands of revolutions per minute making them suitable for electronic, automotive or robotic applications. By connecting them to gearboxes or gear-trains their output speed can be decreased while at the same time increasing the torque output of the motor at a high speed.
The "Brushed" DC Motor
A conventional brushed DC Motor consist basically of two parts, the stationary body of the motor called the **Stator** and the inner part which rotates producing the movement called the **Rotor** or **"Armature"** for DC machines.
The motors wound stator is an electromagnet circuit which consists of electrical coils connected together in a circular configuration to produce the required North-pole then a South-pole then a North-pole etc, type stationary magnetic field system for rotation, unlike AC machines whose stator field continually rotates with the applied frequency. The current which flows within these field coils is known as the motor field current.
These electromagnetic coils which form the stator field can be electrically connected in series, parallel or both together (compound) with the motors armature. A series wound DC motor has its stator field windings connected in SERIES with the armature. Likewise, a shunt wound DC motor has its stator field windings connected in PARALLEL with the armature as shown.
Series and Shunt Connected DC Motor



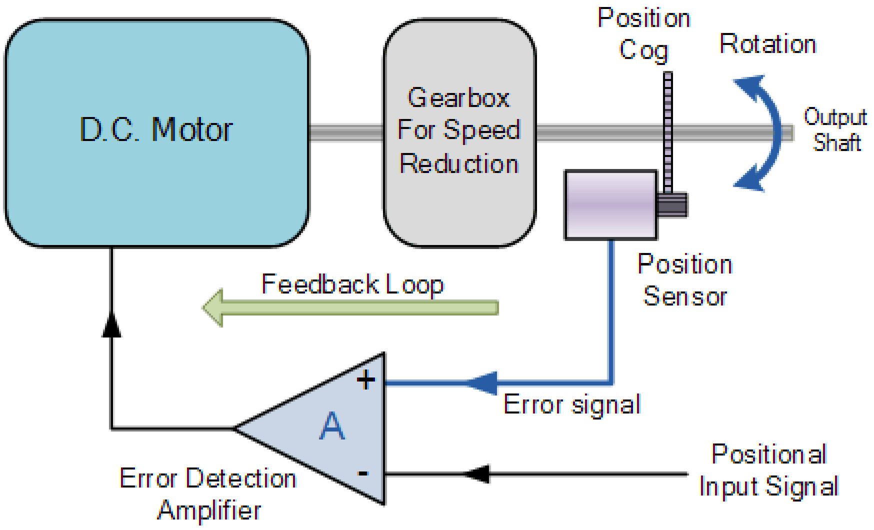
The rotor or armature of a DC machine consists of current carrying conductors connected together at one end to electrically isolated copper segments called the **commutator**. The commutator allows an electrical connection to be made via carbon

brushes (hence the name "Brushed" motor) to an external power supply as the armature rotates.
The magnetic field setup by the rotor tries to align itself with the stationary stator field causing the rotor to rotate on its axis, but can not align itself due to commutation delays. The rotational speed of the motor is dependent on the strength of the rotors magnetic field and the more voltage that is applied to the motor the faster the rotor will rotate. By varying this applied DC voltage the rotational speed of the motor can also be varied.
Conventional (Brushed) DC Motor



The Permanent magnet (PMDC) brushed DC motor is generally much smaller and cheaper than its equivalent wound stator type DC motor cousins as they have no field winding. In permanent magnet DC (PMDC) motors these field coils are replaced with strong rare earth (i.e. Samarium Cobolt, or Neodymium Iron Boron) type magnets which have very high magnetic energy fields.
The use of permanent magnets gives the DC motor a much better linear speed/torque characteristic than the equivalent wound motors because of the permanent and sometimes very strong magnetic field, making them more suitable for use in models, robotics and servos.
Although DC brushed motors are very efficient and cheap, problems associated with the brushed DC motor is that sparking occurs under heavy load conditions between the two surfaces of the commutator and carbon brushes resulting in self generating heat, short life span and electrical noise due to sparking, which can damage any semiconductor switching device such as a MOSFET or transistor. To overcome these disadvantages, **Brushless DC Motors** were developed.
The "Brushless" DC Motor
The brushless DC motor (BDCM) is very similar to a permanent magnet DC motor, but does not have any brushes to replace or wear out due to commutator sparking. Therefore, little heat is generated in the rotor increasing the motors life. The design of the brushless motor eliminates the need for brushes by using a more complex drive circuit were the rotor magnetic field is a permanent magnet which is always in synchronisation with the stator field allows for a more precise speed and torque control.

Then the construction of a brushless DC motor is very similar to the AC motor making it a true synchronous motor but one disadvantage is that it is more expensive than an equivalent "brushed" motor design.
The control of the brushless DC motors is very different from the normal brushed DC motor, in that it this type of motor incorporates some means to detect the rotors angular position (or magnetic poles) required to produce the feedback signals required to control the semiconductor switching devices. The most common position/pole sensor is the "Hall Effect Sensor", but some motors also use optical sensors.
Using Hall effect sensors, the polarity of the electromagnets is switched by the motor control drive circuitry. Then the motor can be easily synchronized to a digital clock signal, providing precise speed control. Brushless DC motors can be constructed to have, an external permanent magnet rotor and an internal electromagnet stator or an internal permanent magnet rotor and an external electromagnet stator.
Advantages of the **Brushless DC Motor** compared to its "brushed" cousin is higher efficiencies, high reliability, low electrical noise, good speed control and more importantly, no brushes or commutator to wear out producing a much higher speed. However their disadvantage is that they are more expensive and more complicated to control.
The DC Servo Motor
DC Servo motors are used in closed loop type applications were the position of the output motor shaft is fed back to the motor control circuit. Typical positional "Feedback" devices include Resolvers, Encoders and Potentiometers as used in radio control models such as aeroplanes and boats etc.
A servo motor generally includes a built-in gearbox for speed reduction and is capable of delivering high torques directly. The output shaft of a servo motor does not rotate freely as do the shafts of DC motors because of the gearbox and feedback devices attached.
DC Servo Motor Block Diagram



A servo motor consists of a DC motor, reduction gearbox, positional feedback device and some form of error correction. The speed or position is controlled in relation to a positional input signal or reference signal applied to the device.

RC Servo Motor

The error detection amplifier looks at this input signal and compares it with the feedback signal from the motors output shaft and determines if the motor output shaft is in an error condition and, if so, the controller makes appropriate corrections either speeding up the motor or slowing it down. This response to the positional feedback device means that the servo motor operates within a “Closed Loop System”.

As well as large industrial applications, servo motors are also used in small remote control models and robotics, with most servo motors being able to rotate up to about 180 degrees in both directions making them ideal for accurate angular positioning. However, these RC type servos are unable to continually rotate at high speed like conventional DC motors unless specially modified.

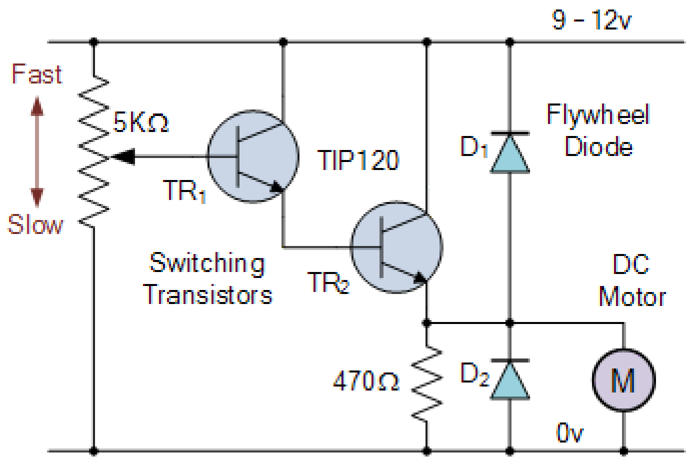
A servo motor consist of several devices in one package, the motor, gearbox, feedback device and error correction for controlling position, direction or speed. They are widely used in robotics and small models as they are easily controlled using just three wires, POWER, GROUND and SIGNAL CONTROL.

DC Motor Switching and Control

Small DC motors can be switched “On” or “Off” by means of switches, relays, transistors or MOSFET circuits with the simplest form of motor control being “Linear” control. This type of circuit uses a bipolar Transistor as a Switch (A Darlington transistor may also be used were a higher current rating is required) to control the motor from a single power supply.

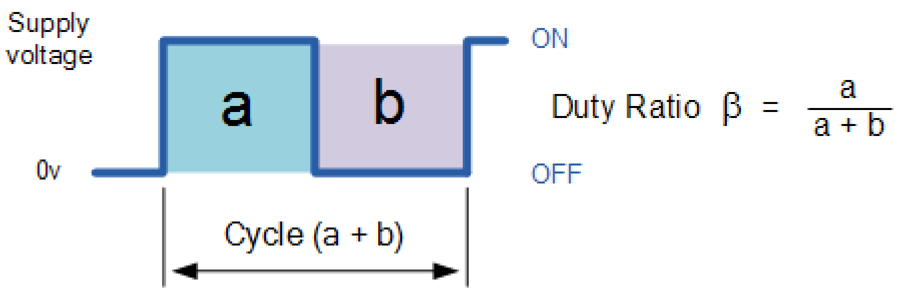
By varying the amount of base current flowing into the transistor the speed of the motor can be controlled for example, if the transistor is turned on “half way”, then only half of the supply voltage goes to the motor. If the transistor is turned “fully ON” (saturated), then all of the supply voltage goes to the motor and it rotates faster. Then for this linear type of control, power is delivered constantly to the motor as shown below.

Motor Speed Control



The simple switching circuit above shows the circuit for a **Uni-directional** (one direction only) motor speed control circuit. As the rotational speed of a DC motor is

proportional to the voltage across its terminals, we can regulate this terminal voltage using a transistor.
The two transistors are connected as a darlington pair to control the main armature current of the motor. A 5kΩ potentiometer is used to control the amount of base drive to the first pilot transistor TR_1, which in turn controls the main switching transistor, TR_2 allowing the motor's DC voltage to be varied from zero to Vcc, in this example 9 to 12 volts.
Optional flywheel diodes are connected across the switching transistor, TR_2 and the motor terminals for protection from any back emf generated by the motor as it rotates. The adjustable potentiometer could be replaced with continuous logic "1" or logic "0" signal applied directly to the input of the circuit to switch the motor "fully-ON" (saturation) or "fully-OFF" (cut-off) respectively from the port of a micro-controller or PIC.
As well as this basic speed control, the same circuit can also be used to control the motors rotational speed. By repeatedly switching the motor current "ON" and "OFF" at a high enough frequency, the speed of the motor can be varied between stand still (0 rpm) and full speed (100%) by varying the mark-space ratio of its supply. This is achieved by varying the proportion of "ON" time (t_{ON}) to the "OFF" time (t_{OFF}) and this can be achieved using a process known as Pulse Width Modulation.
Pulse Width Speed Control
We said previously that the rotational speed of a DC motor is directly proportional to the mean (average) voltage value on its terminals, and the higher this value, up to maximum allowed motor volts, the faster the motor will rotate. In other words more voltage more speed. By varying the ratio between the "ON" (t_{ON}) time and the "OFF" (t_{OFF}) time durations, called the "Duty Ratio", "Mark/Space Ratio" or "Duty Cycle", the average value of the motor voltage and hence its rotational speed can be varied. For simple unipolar drives the duty ratio β is given as:



and the mean DC output voltage fed to the motor is given as: Vmean = β x Vsupply.
Then by varying the width of pulse a, the motor voltage and hence the power applied to the motor can be controlled and this type of control is called **Pulse Width Modulation** or **PWM**.
Another way of controlling the rotational speed of the motor is to vary the frequency (and hence the time period of the controlling voltage) while the "ON" and "OFF" duty ratio times are kept constant. This type of control is called **Pulse Frequency Modulation** or **PFM**.
With pulse frequency modulation, the motor voltage is controlled by applying pulses of variable frequency for example, at a low frequency or with very few pulses the average voltage applied to the motor is low, and therefore the motor speed is slow. At a higher frequency or with many pulses, the average motor terminal voltage is increased and the motor speed will also increase.

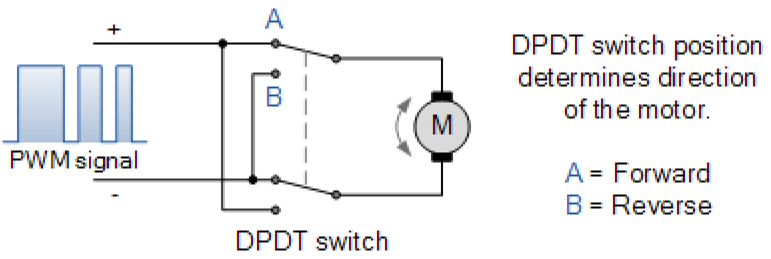
Then, Transistors can be used to control the amount of power applied to a DC motor with the mode of operation being either "Linear" (varying motor voltage), "Pulse Width Modulation" (varying the width of the pulse) or "Pulse Frequency Modulation" (varying the frequency of the pulse).

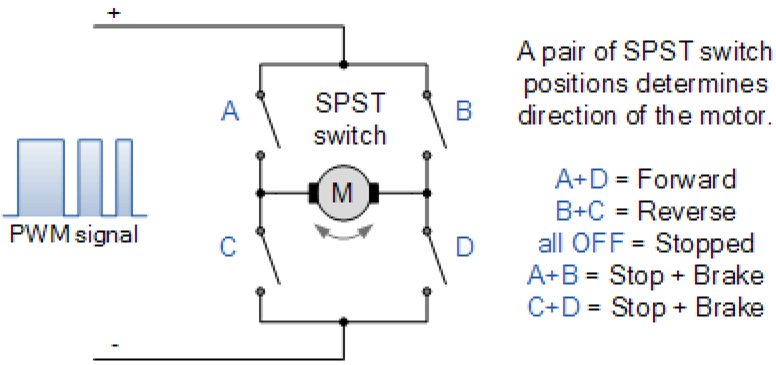
Reversing the Direction of a DC Motor

While controlling the speed of a DC motor with a single transistor has many advantages it also has one main disadvantage, the direction of rotation is always the same, its a "Uni-directional" circuit. In many applications we need to operate the motor in both directions forward and back.

To control the direction of a DC motor, the polarity of the DC power applied to the motor's connections must be reversed allowing its shaft to rotate in the opposite direction. One very simple and cheap way to control the rotational direction of a DC motor is to use different switches arranged in the following manner:

DC Motor Directional Control





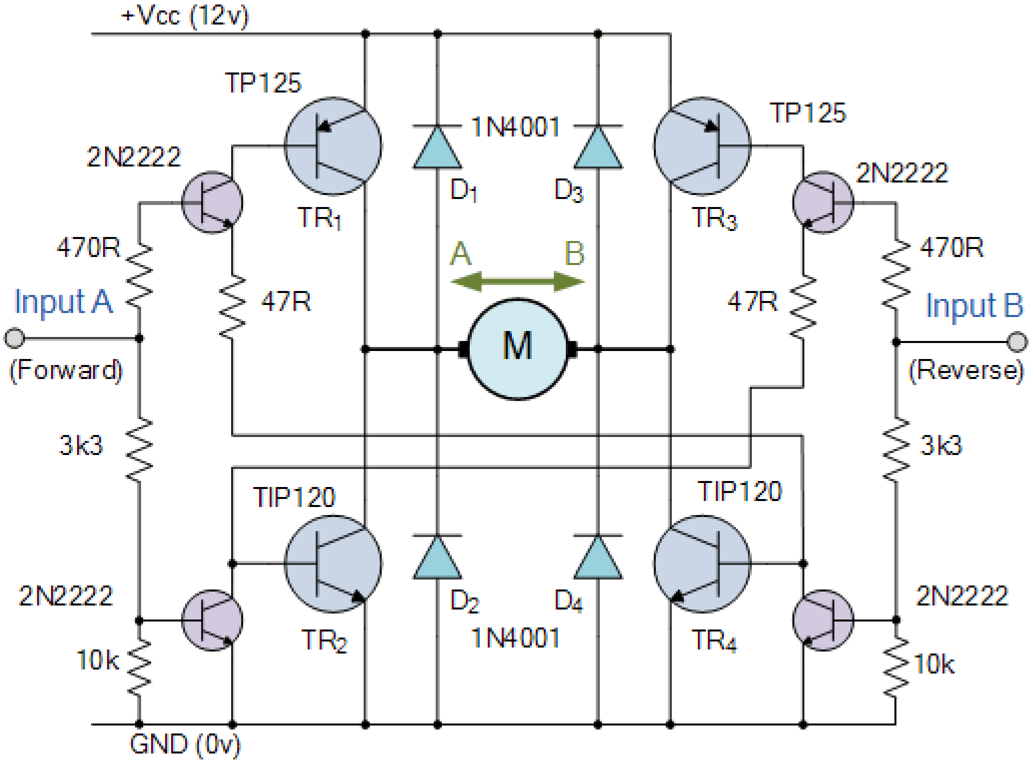
The first circuit uses a single double-pole, double-throw (DPDT) switch to control the polarity of the motors connections. By changing over the contacts the supply to the motors terminals is reversed and the motor reverses direction. The second circuit is slightly more complicated and uses four single-pole, single-throw (SPST) switches arranged in an "H" configuration.

The mechanical switches are arranged in switching pairs and must be operated in a specific combination to operate or stop the DC motor. For example, switch combination A + D controls the forward rotation while switches B + C control the reverse rotation as shown. Switch combinations A + B or C + D shorts out the motor terminals causing it to brake quickly. However, using switches in this manner has its dangers as operating switches A + C or B + D together would short out the power supply.

While the two circuits above would work very well for most small DC motor applications, do we really want to operate different combinations of mechanical switches just to reverse the direction of the motor, NO!. We could change the manual switches for set of Electromechanical Relays and have a single forward-reverse button or switch or even use a solid state CMOS 4066B quad bilateral switch.

But another very good way of achieving bi-directional control of a motor (as well as its speed) is to connect the motor into a **Transistor H-bridge** type circuit arrangement as shown below.

Basic Bi-directional H-bridge Circuit



The **H-bridge circuit** above, is so named because the basic configuration of the four switches, either electro-mechanical relays or transistors resembles that of the letter "H" with the motor positioned on the centre bar. The Transistor or MOSFET H-bridge is probably one of the most commonly used type of bi-directional DC motor control circuits. It uses "complementary transistor pairs" both NPN and PNP in each branch with the transistors being switched together in pairs to control the motor.

Control input A operates the motor in one direction ie, Forward rotation while input B operates the motor in the other direction ie, Reverse rotation. Then by switching the transistors "ON" or "OFF" in their "diagonal pairs" results in directional control of the motor.

For example, when transistor TR1 is "ON" and transistor TR2 is "OFF", point A is connected to the supply voltage (+Vcc) and if transistor TR3 is "OFF" and transistor TR4 is "ON" point B is connected to 0 volts (GND). Then the motor will rotate in one direction corresponding to motor terminal A being positive and motor terminal B being negative.

If the switching states are reversed so that TR1 is "OFF", TR2 is "ON", TR3 is "ON" and TR4 is "OFF", the motor current will now flow in the opposite direction causing the motor to rotate in the opposite direction.

Then, by applying opposite logic levels "1" or "0" to the inputs A and B the motors rotational direction can be controlled as follows.

H-bridge Truth Table

Input A	Input B	Motor Function
TR1 and TR4	TR2 and TR3	

0	0	Motor Stopped (OFF)
1	0	Motor Rotates Forward
0	1	Motor Rotates Reverse
1	1	NOT ALLOWED

It is important that no other combination of inputs are allowed as this may cause the power supply to be shorted out, ie both transistors, TR1 and TR2 switched "ON" at the same time, (fuse = bang!).

As with uni-directional DC motor control as seen above, the rotational speed of the motor can also be controlled using Pulse Width Modulation or PWM. Then by combining H-bridge switching with PWM control, both the direction and the speed of the motor can be accurately controlled.

Commercial off the shelf decoder IC's such as the SN754410 Quad Half H-Bridge IC or the L298N which has 2 H-Bridges are available with all the necessary control and safety logic built in are specially designed for H-bridge bi-directional motor control circuits.

The DC Stepper Motor

Like the DC motor above, **Stepper Motors** are also electromechanical actuators that convert a pulsed digital input signal into a discrete (incremental) mechanical movement are used widely in industrial control applications. A stepper motor is a type of synchronous brushless motor in that it does not have an armature with a commutator and carbon brushes but has a rotor made up of many, some types have hundreds of permanent magnetic teeth and a stator with individual windings.

Stepper Motor

As it name implies, the stepper motor does not rotate in a continuous fashion like a conventional DC motor but moves in discrete "Steps" or "Increments", with the angle of each rotational movement or step dependant upon the number of stator poles and rotor teeth the stepper motor has.

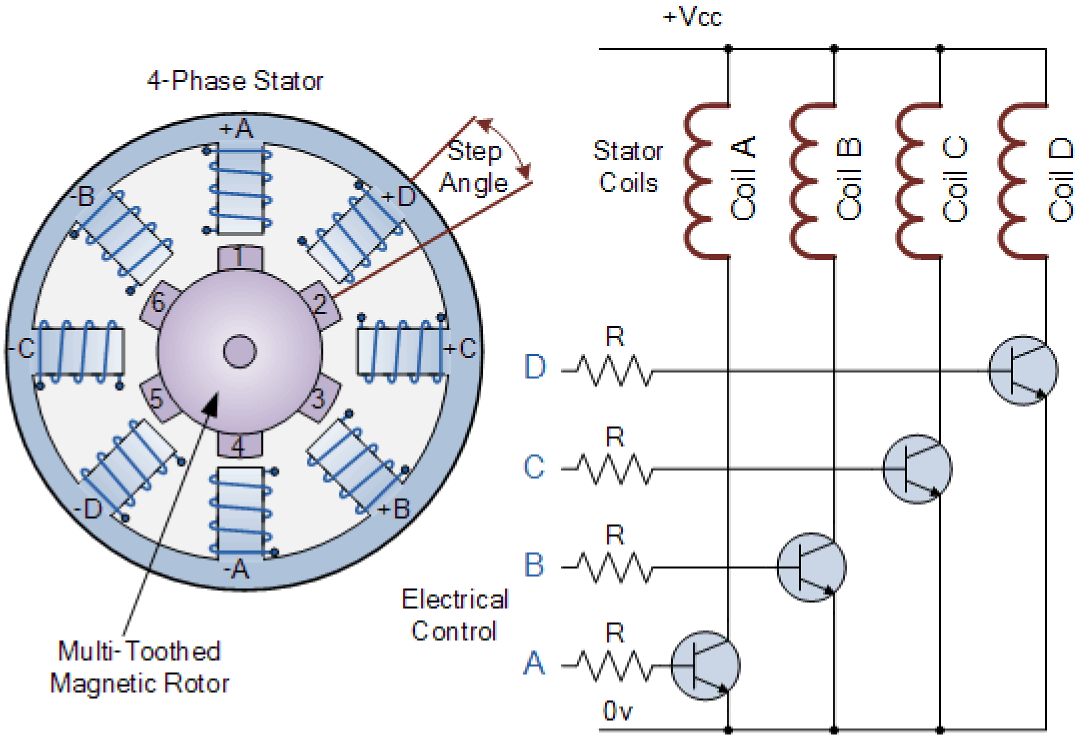
Because of their discrete step operation, stepper motors can easily be rotated a finite fraction of a rotation at a time, such as 1.8, 3.6, 7.5 degrees etc. So for example, lets assume that a stepper motor completes one full revolution (360^o in exactly 100 steps. Then the step angle for the motor is given as 360 degrees/100 steps = 3.6 degrees per step. This value is commonly known as the stepper motors **Step Angle**.

There are three basic types of stepper motor, **Variable Reluctance**, **Permanent Magnet** and **Hybrid** (a sort of combination of both). A **Stepper Motor** is particularly well suited to applications that require accurate positioning and repeatability with a fast response to starting, stopping, reversing and speed control and another key feature of the stepper motor, is its ability to hold the load steady once the require position is achieved.

Generally, stepper motors have an internal rotor with a large number of permanent magnet "teeth" with a number of electromagnet "teeth" mounted on to the stator. The stators electromagnets are polarized and depolarized sequentially, causing the rotor to rotate one "step" at a time.

Modern multi-pole, multi-teeth stepper motors are capable of accuracies of less than 0.9 degs per step (400 Pulses per Revolution) and are mainly used for highly accurate positioning systems like those used for magnetic-heads in floppy/hard disc drives, printers/plotters or robotic applications. The most commonly used stepper motor being the 200 step per revolution stepper motor. It has a 50 teeth rotor, 4-phase stator and a step angle of 1.8 degrees (360 degs/(50×4)).

Stepper Motor Construction and Control



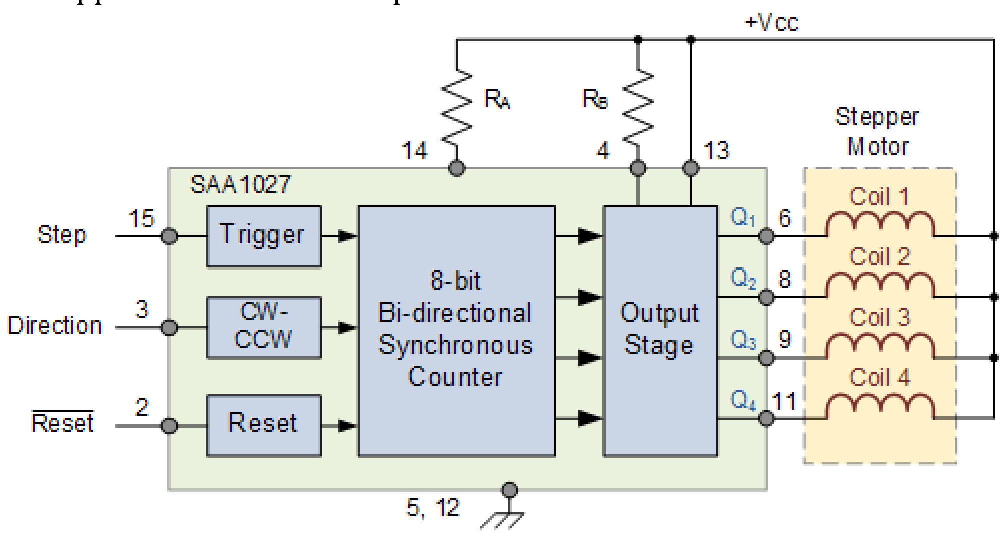
In our simple example of a variable reluctance stepper motor above, the motor consists of a central rotor surrounded by four electromagnetic field coils labelled A, B, C and D. All the coils with the same letter are connected together so that energising, say coils marked A will cause the magnetic rotor to align itself with that set of coils.

By applying power to each set of coils in turn the rotor can be made to rotate or "step" from one position to the next by an angle determined by its step angle construction, and by energising the coils in sequence the rotor will produce a rotary motion.

The stepper motor driver controls both the step angle and speed of the motor by energising the field coils in a set sequence for example, "ADCB, ADCB, ADCB, A…" etc, the rotor will rotate in one direction (forward) and by reversing the pulse sequence to "ABCD, ABCD, ABCD, A…" etc, the rotor will rotate in the opposite direction (reverse).

So in our simple example above, the stepper motor has four coils, making it a 4-phase motor, with the number of poles on the stator being eight (2 x 4) which are spaced at 45 degree intervals. The number of teeth on the rotor is six which are spaced 60 degrees apart.

Then there are 24 (6 teeth x 4 coils) possible positions or "steps" for the rotor to complete one full revolution. Therefore, the step angle above is given as: $360^o/24 = 15^o$.
Obviously, the more rotor teeth and or stator coils would result in more control and a finer step angle. Also by connecting the electrical coils of the motor in different configurations, Full, Half and micro-step angles are possible. However, to achieve micro-stepping, the stepper motor must be driven by a (quasi) sinusoidal current that is expensive to implement.
It is also possible to control the speed of rotation of a stepper motor by altering the time delay between the digital pulses applied to the coils (the frequency), the longer the delay the slower the speed for one complete revolution. By applying a fixed number of pulses to the motor, the motor shaft will rotate through a given angle.
The advantage of using time delayed pulse is that there would be no need for any form of additional feedback because by counting the number of pulses given to the motor the final position of the rotor will be exactly known. This response to a set number of digital input pulses allows the stepper motor to operate in an "Open Loop System" making it both easier and cheaper to control.
For example, lets assume that our stepper motor above has a step angle of 3.6 degs per step. To rotate the motor through an angle of say 216 degrees and then stop again at the require position would only need a total of: 216 degrees/(3.6 degs/step) = 80 pulses applied to the stator coils.
There are many stepper motor controller IC's available which can control the step speed, speed of rotation and motors direction. One such controller IC is the SAA1027 which has all the necessary counter and code conversion built-in, and can automatically drive the 4 fully controlled bridge outputs to the motor in the correct sequence.
The direction of rotation can also be selected along with single step mode or continuous (stepless) rotation in the selected direction, but this puts some burden on the controller. When using an 8-bit digital controller, 256 microsteps per step are also possible
SAA1027 Stepper Motor Control Chip



TEXT 28. JOBS IN COMPUTING

Most ICT-related jobs have developed to meet the need to analyze, design, develop, manage or support computer software, hardware or networks. The primary requirements for being a good programmer are nothing more than a good memory, an attention to detail, a logical mind and the ability to work through a problem in a methodical manner breaking tasks down into smaller, more manageable pieces.

The first key point to realize is that you can't know everything. However you mustn't become an expert in too narrow a field. The second key point is that you must be interested in your subject. The third key point is to differentiate between contract work and consultancy. Good contractors move from job to job every few months. A consultant often works on very small timescales – a few days here, a week there, but often for a core collection of companies that keep coming back again and again.

All the people involved in the different stages of development of a computer project, i.e. analysts, programmers, support specialists, etc. are controlled by a project (or IT) manager.

• **IT managers** manage projects, technology and people. Any large organization will have at least one IT manager responsible for ensuring that everyone who actually needs a PC has one and that it works properly. This means taking responsibility for the maintenance of servers and the installation of new software, and for staffing a help-desk and a support group.

• **Systems Analyst** studies methods of working within an organization to decide how tasks can be done efficiently by computers. He or she takes a detailed analysis of the employer's requirements and work patterns to prepare a report on different options for using information technology.

• **Software Engineer/Designer** produces the programs which control the internal operations of computers, converts the system analyst's specification to a logical series of steps, translates these into the appropriate computer language and often compiles programs from libraries or sub-programs, combining these to make up a complete systems program. Software Engineer designs, tests and improves programs for computer-aided design and manufacture, business applications, computer networks and games.

• **Computer Services Engineering Technician** can be responsible for installation, maintenance or repair of computers and associated equipment. Some technicians carry out routine servicing of large mainframe systems, aiming to avoid breakdowns. Others are called in to identify and repair faults as quickly as possible usually by replacing faulty parts. Work can also involve upgrading machines usually on customer's premises.

• **Network Support Person** maintains the link between PCs and workstations connected in a network. He or she uses telecommunications, software and electronic skills and knowledge of the networking software to locate and correct faults.

• **Computer Salesperson** advises potential customers about available hardware and sells equipment to suit individual requirements, discusses computing needs with the client to ensure that a suitable system can be supplied, organizes the sale and delivery and, if necessary, installation and testing.

• **Application Programmer** writes the programs which enable a computer to carry out particular tasks. He or she may write new programs or adapt existing programs, perhaps altering computer packages to meet the needs of an individual company. Application Programmer also checks programs for faults and does extensive testing.

• **Systems Support Persons** are analyst programmers who are responsible for maintaining, updating and modifying the software used by a company. Some specialize in software which handles the basic operation of the computers. This involves use of machine codes and specialized low-level computer languages. Most handle applications software. They may sort out problems encountered by users. Solving problems may involve amending an area of code in the software, retrieving files and data lost when a system crashes and a basic knowledge of hardware.
• **Hardware Engineer** researches, designs and develops computers, or parts of computers and the computerized element of appliances, machines and vehicles. He or she is also involved in their manufacture, installation and testing. Hardware Engineer may specialize in different areas: research and development, design, manufacturing. He or she has to be aware of cost, efficiency, safety and environmental factors as well as engineering aspect.

There are so many reasons to plop down at the computer and play for hours. For some teens, computer time is a fun way to relax. But for students with strong math skills and technology know-how, computers can lead to successful careers.

Changing technology is one reason computer professionals will continue to be in demand in the future. Short supply is another major factor. David Overbye, director of curriculum at DeVry University, says the dot-com bust has stopped many students from enrolling in computer programs. What kinds of computer careers are available? Hot jobs include video game creator, network security administrator, webmaster and animator.

Animator. Movies, television and Web pages all use high-tech animation. In the long term, Overbye says, animation is a growing industry.

Students interested in a career in animation should be creative and have an eye for design. "It is a more top-level skill," Overbye says. "These are going to be the more artistic types, the people who are good at laying things out."

Computer animators also need to have strong computer skills and "know the tools they are using," Overbye says. Animators can be hired by movie studios, television networks or companies looking for Web designers.

"You're seeing a general trend toward higher (Internet) speeds to the home, so content going on the Web is becoming more dynamic," he says.

Video games Creator. The field of video games and simulation is growing quickly. Computer professionals design video games, military flight simulators and job training programs. Many colleges have created bachelor's degrees in game simulation and programming because of increased need. Simulation tools have become cheaper, so that means more businesses are interested in buying the programs. Taxi cab drivers, for example, could be trained with a simulation program to learn how to drive a route, Overbye says.

Video gaming is also a growing industry in need of professionals to create consoles, handheld systems and computer games.

Overbye says students who are thinking about careers in simulation or game programming should have a strong interest in computers, math and physics. Employers will also expect students to take courses in English, humanities and social sciences to learn communication skills.

Network security administrator. One of the oldest crimes in the world is stealing money, Overbye says. And that crime has gone high-tech as banks and businesses trade money and financial information over networks. Any time you use a credit card at a fast food restaurant, for example, the restaurant network has to send the information to its and your bank. Hackers want to get into the network to steal money, and its security's job to protect the system.

Start a career in network security with a degree in computer information systems. Overbye says students who are considering this degree should have strong math, science and programming skills. They should also be creative types who tend to ask a lot of questions.

Webmaster. Someone has to design all those good-looking Web pages. Web design is a growing field with beginning designers starting at $35,000 a year, says Sung Kang, an assistant professor of graphic design at Iowa State University in Ames.

Creativity and critical thinking are the most important skills for a Web designer. "All the new technology they can learn, but sometimes creatively thinking is very difficult to teach," Kang says.

To become a Web designer, earn a degree in computer programming. Or, study graphic design while taking a few programming courses from the computer science department, Kang says.

TEXT 29. COMPUTER ARCHITECTURE

There are different types of computer of varying size and power, including the following:
Supercomputer (the most powerful type of mainframe)
Mainframe (large, very powerful, multi-user i.e. can be used by many people at the same time, multi-tasking i.e. can run many programs and process different sets of data at the same time)
Minicomputer (smaller than a mainframe, powerful, multi-user, multi-tasking)
Personal computer (PC) (single user)
Desktop computer (suitable size for sitting on an office desk)
Workstation (most powerful type of desktop, used for graphic design, etc.)
Portable (can be carried around, can operate with batteries)
Laptop (large portable, can be rested on user's lap)
Notebook (size of a sheet of notebook paper)
Handheld (can be held in one hand)
Pen-based (main input device is an electronic pen)
PDA (personal digital assistant, has functions such as task lists, diary, address book)
Note that the term PC usually refers to an IBM compatible personal computer i.e. an Apple Mac personal computer is not referred to as a PC. A computer that provides a service on a network e.g. storing files, sharing a printer, is known as a server computer. Server computers usually have a UPS (uninterruptible power supply) attached to them. This is a battery that automatically provides an electricity supply to allow the server to shut itself down properly if the main supply fails.
The processor e.g. Pentium, is the most important part of the computer. It processes the data and controls the computer. Powerful computers used as servers often have more than one processor. There are two main types of memory:
a) RAM (random access memory) holds the program instructions and the data that is being used by the processor,
b) ROM (read only memory) holds the program instructions and settings required to start up the computer.
The combination of the processor and memory is sometimes referred to as the CPU (central processing unit), although sometimes the processor itself is referred to as the CPU. The other parts connected to the CPU are known as peripherals. These can include input devices, output devices, storage devices and communications devices. Input devices include: keyboards, scanners, barcode readers, digital cameras, microphones and video cameras e.g. webcams (small digital video cameras used on the Web). Output devices include: monitors (VDU display screens), printers, plotters, loudspeakers, headphones. Storage devices include: magnetic tape, floppy disks (diskettes), hard disks, CD-ROMs, CD-R disks, CD-RW disks, DVDs and MO disks. A common communications device is a modem (a modulator/demodulator used for converting digital signals to analogue signals and vice versa to allow a computer to be connected to the ordinary telephone system).
A set of connectors used for carrying signals between the different parts of a computer is known as a bus. Data is transferred constantly between the processor and memory along the system bus. Each part of memory has its own memory address and the processor determines where processed data is stored by sending an address signal along an address bus and data along a data bus. This is synchronised by an electronic clock in the CPU that determines the operating speed of the processor. Transferring

data between the processor and RAM can slow up the computer; therefore, some very expensive, extremely fast memory is usually used as a cache to hold the most frequently used data.
In a desktop computer, the CPU (central processing unit) and storage devices (pieces of equipment used for reading from and writing to a storage medium) are normally built inside a system unit which consists of a metal chassis enclosed in a flat desktop or a tower shaped case. Other peripherals are attached to the system unit by cables. Each peripheral uses its own driver card or controller (an expansion card that is plugged into special expansion slots in the system unit). Expansion cards contain the electronics required to communicate with and control the device e.g. video or graphics cards are used for monitors, soundcards are used for audio input/output and NICs (network interface cards) are used for connecting to other computers in a network. Extra memory can also be added to the computer using special memory expansion slots inside the computer. A portable computer that does not have enough space inside to fit expansion cards may use an external device called a port replicator to provide connections for peripherals.
Storage devices in the form of a disk or tape are used to store the programs and data that are not being used. Before a program or data can be used, it must be transferred from the storage device to the main RAM memory. Hard disks consist of a set of magnetic coated metal disks that are vacuum-sealed inside a case to keep out the dust. The magnetic surfaces of the disks are formatted using a read/write head to provide magnetic storage areas. These storage areas form concentric circles called tracks and each track is subdivided into sections called sectors.
The disks are rotated at high speed and read from or written to by the read/write head that moves across the surface of the disks. In server computers, hard disks can be connected together and made to operate as one unit using RAID (a redundant array of inexpensive disks). This can speed up the system and provide a way of recovering data if the system crashes (fails suddenly and completely, usually referring to the failure of a hard disk). There is a variety of optical storage devices that use laser light to read or write to a disk, including: CD-ROMs (compact disk read only memory), CD-R (recordable compact disk), CD-RW (rewritable compact disk), DVD (digital versatile disk - previously known as digital video disk).
An input device called a barcode reader is a special type of scanner for reading barcodes (a set of printed bars of varying thickness that are used to identify a product e.g. used to price items in supermarkets).
When comparing computers, the power of the computer is important. This is mainly determined by the speed and capacity (size) of each part of the computer.
Speed is measured in hertz (Hz) i.e. cycles per second.
Capacity is measured in bytes (B) where 1 byte = 8 bits (binary digits) = 1 character.

TEXT 30. CACHE MEMORY

Most PCs are held back not by the speed of their main processor, but by the time it takes to move data in and out of memory. One of the most important techniques for getting around this bottleneck is the memory cache.

The idea is to use a small number of very fast memory chips as a buffer or cache between main memory and the processor. Whenever the processor needs to read data it looks in this cache area first. If it finds the data in the cache then this counts as a 'cache hit' and the processor need not go through the more laborious process of reading data from the main memory. Only if the data is not in the cache does it need to access main memory, but in the process it copies whatever it finds into the cache so that it is there ready for the next time it is needed. The whole process is controlled by a group of logic circuits called the cache controller.

One of the cache controller's main jobs is to look after 'cache coherency' which means ensuring that any changes written to main memory are reflected within the cache and vice versa. There are several techniques for achieving this, the most obvious being for the processor to write directly to both the cache and main memory at the same time. This is known as a 'write-through' cache and is the safest solution, but also the slowest. The main alternative is the 'write-back' cache which allows the processor to write changes only to the cache and not to main memory. Cache entries that have changed are flagged as 'dirty', telling the cache controller to write their contents back to main memory before using the space to cache new data. A write-back cache speeds up the write process, but does require a more intelligent cache controller.

Most cache controllers move a 'line' of data rather than just a single item each time they need to transfer data between main memory and the cache. This tends to improve the chance of a cache hit as most programs spend their time stepping through instructions stored sequentially in memory, rather than jumping about from one area to another. The amount of data transferred each time is known as the 'line size'.

If there is a cache hit then the processor only needs to access the cache. If there is a miss then it needs to both fetch data from main memory and update the cache, which takes longer. With a standard write-through cache, data has to be written both to main memory and to the cache. With a write-back cache the processor needs only write to the cache, leaving the cache controller to write data back to main memory later on.

HOW A DISK CACHE WORKS

Disk caching works in essentially the same way whether you have a cache on your disk controller or you are using a software-based solution. The CPU requests specific data from the cache. In some cases, the information will already be there and the request can be met without accessing the hard disk.

If the requested information isn't in the cache, the data is read from the disk along with a large chunk of adjacent information. The cache then makes room for the new data by replacing old. Depending on the algorithm that is being applied, this may be the information that has been in the cache the longest or the information that is the least recently used.

The CPU's request can then be met, and the cache already has the adjacent data loaded in anticipation of that information being requested next.

TEXT 31. THE GRAPHICAL USER INTERFACE

The term 'user interface' refers to the standard procedures the user follows to interact with a particular computer. A good user interface is important because when you buy a program you want to use it easily. A few years ago, the way in which users had access to a computer system was quite complex. They had to memorize and type a lot of commands just to see the content of a disk, to copy files or to respond to a single prompt. So, a user interface based on graphics and intuitive tools was designed with a single clear aim: to facilitate interaction with the computer.

Nowadays most computers have a Graphical User Interface (GUI.

A GUI makes use a WIMP environment: Windows, Icons, Menus and Pointer. This type of interface is user-friendly, where system functions are accessed by selecting self-explanatory icons and items from menus.

Windows A window is an area of the computer screen where you can see the contents of a folder, a file, or a program. Some systems allow several windows on the screen at the same time and windows can overlap each other. The window on the top is the one which is «active», the one in use.

Icons are small pictures on the screen. They represent programs, folders, or files. For example, the Recycle Bin icon represents a program for deleting and restoring files. Most systems have a special area of the screen on which icons appear.

Menus give the user a list of choices. You operate the menu by pressing and releasing one or more buttons on the mouse.

The Pointer is the arrow you use to select icons or to choose options from a menu. You move the pointer across the screen with the mouse to use the object selected by the pointer.

A GUI offers graphical icons (graphic images (or intuitive symbols) representing programs, documents, an object or task), and visual indicators (as opposed to text-based interfaces), typed command labels or text navigation to fully represent the information and actions available to a user. A graphical user interface saves a lot of time: you don't need to memorize commands in order to execute an application; you only have to point and click so that its content appears on the screen.

Double-clicking an icon opens a window that lets you work with different tools and menus. A window is a viewing area of the computer screen where you can see the contents of a folder, a file, or a program. Some systems allow several windows on the screen at the same time and windows can overlap each other. The window on the top is the one which is "active", the one in use. By using different windows you can work on several documents or applications simultaneously.

The actions are usually performed through direct manipulation of the graphical elements by the means of a drop-down menu, pop-up menu or pull-down menu (a list of options that appear below a menu bar when you click on an item). The tool for these manipulations is the pointer. The pointer is the arrow, controlled by the mouse, which allows you to move around the screen and choose options from menus. You operate the menu by pressing and releasing one or more buttons on the mouse.

Toolbar buttons are found at the top of a window, they take you to the Home folder and others. The dock is at the bottom of the screen that gives you instant access to the things you use most. When information has to be given to the user or input by the user, a window known as a dialog box is often used. It can contain a variety of elements to gather information from the user including: text boxes, drop-down list boxes, checkboxes and command buttons. A find dialog box is used to gather information from the user about the files they wish to find. All these activities take place on a desktop (the background screen that displays icons, representing programs, files and folders-directories or containers for documents and applications).

Today, the most innovative GUIs are the Macintosh, Microsoft Windows and IBM OS/2 Warp. These three platforms include similar features: a desktop with icons, windows and folders, a printer selector, a file finder, a control panel and various desk accessories. Double-clicking a folder opens a window which contains programs, documents or further nested folders. At any time within a folder, you can launch the desired program or document by double-clicking the icon or you can drag it to another location. The three platforms differ in other areas such as device installation, network connectivity or compatibility with application programs.

Designing the visual composition and temporal behaviour of GUI is an important part of software application programming in the area of human-computer interaction. Its goal is to enhance the efficiency and ease of use for the underlying logical design of a stored program, a design discipline known as usability. Methods of user-centred design are used to ensure that the visual language introduced in the design is well tailored to the tasks. Typically, the user interacts with information by manipulating visual widgets that allow for interactions appropriate to the kind of data they hold.

A GUI may be designed for the requirements of a vertical market as application-specific graphical user interfaces. Examples of application-specific GUIs are:

• Automated teller machines (ATM)
• Point-Of-Sale touch screens at restaurants
• Self-service checkouts used in a retail store
• Airline self-ticketing and check-in
• Information kiosks in a public space, like a train station or a museum
• Monitors or control screens in an embedded industrial application which employ a real time operating system (RTOS).

The latest cell phones and handheld game systems also employ application specific touch screen GUIs. Newer automobiles use GUIs in their navigation systems and touch screen multimedia centres.

TEXT 32. COMPUTER USERS

A computer is a device that processes data according to a set of instructions known as a program. The equipment is known as the hardware and the programs and data are the software. A special set of programs, called an operating system, provides an interface for the user and allows applications programs to communicate with the hardware. Common applications programs include word processors for creating and editing texts, spreadsheets for calculating mathematical formulae and databases for storing data in a way that allows the data to be sorted and searched. Anti-virus programs are used to detect and remove viruses. Some operating systems have graphical (user) interfaces that allow the computer user to select items from menus and to start programs using an input device called a mouse. This is done by pressing a button on the mouse i.e. clicking the mouse. The main device for inputting the data is a typewriter-style keyboard and the output is commonly displayed on a monitor screen that looks like a small television screen.

There is a range of sizes and types of computer. Those designed for use by one person at a time are known as personal computers (PCs). Personal computers include desktop computers and handheld computers that can be carried around by the user. Electronics can be added to desktop computers by plugging in expansion cards (electronic circuit boards that can be plugged into special sockets called expansion slots).

It is also possible to build all the main parts of a computer into one electronic integrated circuit packaged as a single electronic chip i.e. the 'computer on a chip'. This enables computers to be built into other devices including household devices such as washing machines and fridges and to be incorporated into plastic cards i.e. smart cards, which are able to store information such as health records, drivers' licences, bank balances, etc. Devices that include a computer circuit are commonly referred to as smart devices.

A multimedia computer can process different forms of data including text, graphics, audio (sound), animation and video. This enables computer systems to be used for a combination of education and entertainment, sometimes referred to as edutainment.

Unlike most machines, computers do not have a fixed purpose. They are multi-purpose tools. They can be used in a very wide variety of situations and are found in a wide range of systems including security systems, cars and phones. Advanced systems, known as expert systems, enable computers to 'think' like experts. Medical expert systems, for example, can help doctors diagnose an illness and decide on the best treatment. As computer systems are developed, they are becoming more common and are gradually being used for more and more purposes. How they are developed, and for what purposes they are actually used in the future, can be influenced by computer users. A variety of devices known as peripherals can be added externally to a computer. One of the most common peripherals is a printer used for printing the computer output on paper. A digital camera allows photographs to be input to a computer for editing.

Not all computer systems are compatible i.e. they cannot use the same programs and data. Connecting computers together to form a network can provide the 'connectivity' required to enable computers and software to communicate and to share resources. Networks connected together form an internet. The connection of networks throughout the world is known as the Internet or, more simply, the Net. Various communication services are available on the Internet, including email (electronic mail) for sending and receiving text messages and IRC (Internet Relay Chat) which allows users to communicate using text messages in real-time i.e. without any delay, while the users are logged on (connected to a network system account, normally using a password) to the system. An Internet service called FTP (File Transfer Protocol) is used for transferring data or program files between the powerful server computers that provide the network services and the client computers that use these services e.g. downloading music files. Note that copying data from a larger server system to a client is referred to as downloading and copying from the client to the server is known as uploading.

One of the newest and most popular services available on the Internet is the World Wide Web (WWW) which is often simply referred to as the Web. The Web contains interlinked documents called webpages. A set of related webpages stored together on a server computer is called a website. Websites, such as Dogpile and Askjeeves, give the user access to special programs called search engines that are designed to allow the user to find relevant webpages on the Web. An Internet system designed to provide free, interactive access to vast resources for people all over the world is sometimes referred to as an information superhighway.
Services such as these allow people to telecommute (use their computers to stay in touch with the office while they are working at home). Computer users mentioned in this unit include producing greetings cards; using the Microsoft Word word-processing program including features such as clipart (ready-drawn graphic images that can be inserted into documents); communicating on the Internet using email and chat programs including the use of email attachments (other types of files e.g. video files attached to simple email text messages); distance learning and videoconferencing; electronic classrooms or boardrooms; browsing the Web (moving from webpage to webpage using a Web browser program); selling, using a website; painting; scanning pictures; downloading music and creating CD-ROMs. CD-ROMs are storage devices that use laser light for reading and writing data. The most common storage device is a hard disk (a set of aluminium disks coated in a magnetic material and enclosed in a vacuum-sealed case) used for storing the operating system and applications programs as well as the user's data.

TEXT 33. THE DIGITAL AGE. MULTIMEDIA

The Digital Age

We are now living in what some people call the digital age, meaning that computers have become an essential part of our lives. Young people who have grown up with PCs and mobile phones are often called the digital generation. Computers help student to perform mathematical operations and improve their math skills. They are used to access the Internet, to do basic research and to communicate with other students around the world. Teachers use projectors and interactive whiteboards to give presentations and teach science, history or language courses. PC's are also used for administrative purposes – schools use word processors to write letters, and databases to keep records of students and teachers. A school website allows teachers to publish exercises for students to complete online.

Students can also enroll for courses via the website and parents can download official reports. Mobiles let you make voice calls, send texts, email people and download logos, ringtones or games. With a built-in camera you can send pictures and make video calls in face-to-face mode.
New smart phones combine a telephone with web access, video, a games console, an MP3 player, a personal digital assistant (PDA) and a GPS navigation system, all in one.

In banks, computers store information about the money held by each customer and enable staff to access large databases and to carry out financial transactions at high speed. They also control the cashpoints, or ATMs (automatic teller machines), which dispense money to customers by the use of a PIN-protected card. People use a Chip and PIN card to pay for goods and services, instead of using a signature to verify payments, customers are asked to enter a four-digit personal identification number (PIN), the same numbers used at cashpoints; this system makes transactions more secure. With online banking, clients can easily pay bills and transfer money from the comfort of their homes.

Airline pilots use computers to help them control the plane. For example, monitors display data about fuel consumption and weather conditions. In airport control towers, computers are used to manage radar systems and regulate air traffic. On the ground, airlines are connected to travel agencies by computer. Travel agents use computers to find out about the availability of flights, prices, times, stopovers and many other details.

MULTIMEDIA

Multimedia is the term used to refer to a combination of text, graphics, animation, sound and video.
MP3 (MPEG Audio Layer 3) is a standard way of storing compressed, digital audio files (usually music). The name MP3 comes from MPEG (pronounced EM-peg), which stands for the Motion Picture Experts Group, an organisation that develops standards for audio and video compression. MP3 is actually MPEG Audio Layer 3.

MP3 competes with another audio file format called WAV. The key difference is that MP3 files are much smaller than WAV files. An MP3 file can store a minute of sound per megabyte, while a WAV file needs 11 or 12 megabytes to hold the same amount. How does MP3 achieve this compression? CDs and audio files don't reproduce every sound of a performance. Instead, they sample the performance and store a discrete code for each sampled note. A CD or WAV file may sample a song 44,000 times a second, creating a huge mass of information.

By stripping out sounds most people can't hear, MP3 significantly reduces the information stored. For instance, most people can't hear notes above a frequency of 16kHz, so it eliminates them from the mix. Similarly, it eliminates quiet sounds masked by noise at the same frequency. The result is a file that sounds very similar to a CD, but which is much smaller. An MP3 file can contain spoken word performances, such as radio shows or audio books, as well as music. It can provide information about itself in a coded block called a tag. The tag may include the performer's name, a graphic such as an album cover, the song's lyrics, the musical genre, and a URL for more details.
Digital audio is created by sampling sound 44,000 times a second and storing a code number to represent each sound sample. The files are compressed by removing any sounds that are inaudible to the human ear, making them much smaller than files created using other digital audio storage standards, such as WAV. The size of an audio file is commonly measured in megabytes (MB) (millions of bytes). The frequency of a sound is measured in kilohertz (kHz) (thousands of cycles per second). MP3 files have extra code added, called tags, that give the user information about the file e.g. the performer's name, a URL (uniform resource locator i.e. a web address) or a graphic such as an album cover.

Because of their small size, MP3 files are more suitable for transferring across the Internet (the connection of computer networks across the world). Some Internet websites (sets of related pages stored on a Web server on the World Wide Web) are devoted to providing MP3 files for downloading (copying from a server computer to a client computer). The user can create their own music compilations (combinations of files) by listening to each file using a computer program, such as Windows Media Player, and choosing what files to download, They can then use a computer program called an MP3 player to listen to the files and control the sound. MP3 players let the user group songs into play lists and randomize the selections. They also have sound control features such as spectrum analyzers, graphic equalizers, and frequency displays.
A track info button allows the user to see the information stored in the MP3 file tag. Other buttons may take you to a music library where you can organize your MP3 files by performer or genre. The appearance of MP3 players can be changed using programs called skins (or themes). These programs are designed to change the appearance of the most popular players. MP3 players often include a program, called a ripper, that lets the user rip (extract) a song from a CD (compact disk) and convert it to a standard WAV file. Another program called an encoder is used to convert WAV files into MP3 files or vice versa.

Recorder programs are also available that enable the user to create audio CDs using a writable CD-ROM drive. Special MP3 player devices are also available that enable the user to listen to MP3 files without a computer.

MIDI (Musical Instrument Digital Interface) is a standard way of connecting musical instruments, music synthesizers, and computers. A piece of electronics called a MIDI interface board is installed on each device to enable the device to communicate using MIDI standards. As music is being played, it can be displayed on a monitor screen as a musical score, then edited using a computer program that uses all the features of a mixing desk (an electronic device for mixing sounds together), stored and printed. MIDI systems do not store the actual sound. Instead the sound is encoded (stored as MIDI messages) in the form of 8-bit bytes (units of capacity equal to eight binary digits i.e. 1s and 0s) of digital information. A bit is a binary digit i.e. a 1 or a 0, and a byte is a group of 8 bits. The MIDI messages commonly consist of instructions that tell the receiving instrument what note to play, how long and how loud it should be played, including a number that indicates which instrument to play. Each instrument is represented by a different number e.g. 67 is a saxophone.

A DVD-ROM, commonly referred to as a DVD (digital versatile disk - previously known as digital video disk), is a development of CD-ROM (compact disk read only memory). It is an optical storage medium (a storage medium that uses laser light to store data) that provides large amounts of storage space for multimedia files. A DVD-ROM drive (a storage device for reading DVD disks) uses blue laser light (rather than the red laser light used by CD-ROM drives) to read information from the disk. Both sides of the disk can be used for storing files and each side can have two separate storage layers. The data transfer rate of a DVD (the speed at which data can be read from a DVD) is also faster than that of a CD-ROM. The capacity of a DVD is commonly measured in gigabytes (GB) (thousands of millions of bytes).

MPEG is a method of compressing and decompressing video signals. MPEG stands for Motion Picture Experts Group, an organisation that develops standards for audio and video compression.

TEXT 34. APPLICATION SERVICE PROVIDERS

If your hard disk is packed to bursting point, the IT department is far too busy to fix your email problems, and your business can't afford to buy the tools that you'd like to develop the company website, then it's time to think about using an application service provider (ASP). Rather than installing software on each machine or server within your organisation, you rent applications from the ASP, which provides remote access to the software and manages the hardware required to run the applications.

There are a lot of advantages to this approach. The havoc caused by viruses makes the idea of outsourcing your email and office suite services an attractive option. It also gives you more flexibility - you pay for applications as and when you need them, rather than investing in a lot of costly software which you're then tied to for years. Not having to worry about upgrading to the latest version of your office suite or about battling with the complexities of managing an email system, leaves businesses with more time.

Time to focus on what they do best.

However, there are some potential pitfalls. To use applications remotely requires a lot of bandwidth, which is only really available from a broadband connection or a leased line to the ASP itself. It is also important to ensure that the ASP will be able to provide a secure, reliable service which will be available whenever you need it.

Providing applications and storage space for vast numbers of users requires some powerful technology on the part of the ASP. This includes security controls and data storage as well as providing the physical links to customers. For the most part, ASPs don't own the data centres that store the information. Instead, they lease space from data storage specialists. In this way, they can be confident of meeting customers' increasing storage requirements by buying more space as it's needed.

There's a wide variety of applications available for use via ASPs. Office suite applications and e-mail services are two of the most generic applications available through ASPs large, complex business applications such as enterprise resource planning tools like SAP are another popular candidate for delivery through an ASP. Other business services, such as payroll and accounting systems are also available.

This is particularly beneficial to small businesses which are likely to grow quickly and don't want to deal with the problems caused by outgrowing their existing system and having to move to a high-end package. ASPs also offer a means of using specialist tools that would otherwise prove prohibitively expensive. Small businesses have the opportunity to use such tools for short periods of time as and when they need them, rather than having to buy the software as a permanent investment.

One of the major barriers for small businesses which want to make a start in e-commerce is ensuring that they have sufficient resources to cope with sudden large increases in customers. This means not only having adequate storage for all your customers' details, but ensuring that you have the technology in place to handle stock levels, efficient delivery and large volumes of traffic. It's very rare for an e-commerce business to handle all of these elements by itself, making this one of the best-established areas of ASP use.

Being able to respond rapidly to changes in the size of your customer base and the type of product that they want to order from your business, demands more flexibility than traditional software can provide.

TEXT 35. APPLICATIONS PROGRAMS

Software is the word used to refer to programs (sets of computer instructions written in a computer language) and data that is input, processed and output by a computer system. Applications programs are programs that allow the user to do various types of work on a computer e.g. wordprocessors, databases. A set of related applications programs is referred to as a package (or a suite). Common applications programs include:

wordprocessors	**for creating and editing texts**
spreadsheets	for performing calculations using formulas
databases	for storing data so that it can be easily searched and sorted
graphics	for drawing
games	for playing fast action games
accounts	for keeping business accounts
payroll	for calculating salaries
presentation program	for creating multimedia slide shows
email	for sending electronic mail messages
PIM (personal information manager)	for keeping track of appointments, address book, task list, etc.
DTP (desktop publishing program)	for creating publications to be printed by a professional printer
small business tools	for performing various business tasks
website editor	for creating and editing webpages
image editor	for editing graphic images
developer tools	for writing programs to add features to existing applications and creating integrated program systems

Some applications programs, such as wordprocessors, spreadsheets and databases, are commonly referred to as office programs because they are commonly used in a typical office. Office packages (or suites) such as Microsoft Office are sets of interrelated office programs. Different versions of office suites are usually available containing different combinations of programs. Mail merging is a useful feature found in most office suites that combines a database with a wordprocessor document to automatically produce a copy of a standard letter for each record in the database. A variety of computer hardware is used in the doctors' practice in this unit including:

PC	**common name for an IBM compatible personal computer**
network	computers connected together.
file server	a powerful computer that stores and allows users access to data files on a network.
laser printer	a very high quality text and graphics printer that has a photosensitive drum that deposits toner powder on the paper
dot-matrix printer	a low quality printer that prints by hammering pins on the paper to print an image made up of dots. The hammering action means that it can print on special multipart paper where a number of copies are produced at the same time.
CD-ROM	a compact disk read only memory storage device that is cheap to produce and suitable for storing large amounts of data.

For example, the Patient Browser program (GPASS) is a type of database for sorting and searching patient records. To search, you select different option screens by clicking on a tab with a mouse and inputting the search criteria (details of what you are looking for) in text boxes known as criteria boxes. Different button icons can be clicked to perform different operations e.g. the Find button. The default button is the option that is selected automatically.

Tomb Raider is a popular adventure game that has appeared in various versions. The main character is represented by a female animated image, known as Lara Croft. The user follows a storyline in which they have to solve puzzles and control the movements of the main character, sometimes having to react quickly to avoid dangerous obstacles. It is available on well-known games consoles (specialized games computers) called Play Station and Dreamcast manufactured by a company called Sega.
Sim City is a simulation program (a program that simulates real life) in which the user has to develop a city by building roads and 3D (three-dimensional) buildings, setting taxes, etc. They also have to control objects such as simulated cars and people. The user can download (copy from a server computer) additional objects and swap items with other users using a special website.

An ASP (application service provider) rents applications to users i.e. instead of buying software, the user pays for using applications as and when they need them.
The ASP provides the software, manages the hardware and provides storage space, security controls and the physical links to customers. The ASP normally leases storage space for programs and data from data centers (facilities for storing large amounts of information) owned by data storage specialists.

The user is provided with remote access (accesscommunications network) to a wide variety of programs including: generic applications such as e-mail (electronic mail) and office suites, high-end (advanced) packages including large, complex business applications such as enterprise resource planning tools (e.g. SAP), business services, such as payroll and accounting systems, expensive specialist tools and e-commerce resources (electronic commerce - buying and selling on the Internet).
This gives the user more flexibility and saves them having to install and maintain programs, upgrade (install newer versions of programs), deal with viruses (programs that can reproduce themselves and are written with the purpose of causing damage or causing a computer to behave in an unusual way) and manage e-mail systems (electronic mail systems).

Disadvantages of this system include: the need for a broadband (high bandwidth i.e. a connection with a high signal capacity network connection or a leased line (a cable connection that is rented for use in a communications system) and dependence on the ASP to provide a secure, reliable, readily available service.

TEXT 36. COMPUTERS MAKE THE WORLD SMALLER AND SMARTER

The ability of tiny computing devices to control complex operations has transformed the way many tasks are performed, ranging from scientific research to producing consumer products. Tiny "computers on a chip" are used in medical equipment, home appliances, cars and toys. Workers use handheld computing devices to collect data at a customer site, to generate forms, to control inventory, and to serve as desktop organisers.

Not only computing equipment getting smaller, it is getting more sophisticated. Computers are part of many machines and devices that once required continual human supervision and control. Today, computers in security systems result in safer environments, computers in cars improve energy efficiency, and computers in phones provide features such as call forwarding, call monitoring, and call answering.

These smart machines are designed to take over some of the basic tasks previously performed by people; by so doing, they make life a little easier and a little more pleasant. Smart cards store vital information such as health records, drivers' licenses, bank balances, and so on. Smart phones, cars, and appliances with built in computers can be programmed to better meet individual needs. A smart house has a built-in monitoring system that can turn lights on and off, open and close windows, operate the oven, and more.

With small computing devices available for performing smart tasks like cooking dinner, programming the VCR, and controlling the flow of information in an organization, people are able to spend more time doing what they often do best - being creative.

Computers can help people work more creatively.
Multimedia systems are known for their educational and entertainment value, which we call "edutainment".

Multimedia combines text with sound, video, animation, and graphics, which greatly enhances the interaction between user and machine and can make information more interesting and appealing to people.

Expert systems software enables computers to "think" like experts. Medical diagnosis expert systems, for example, can help doctors pinpoint a patient's illness, suggest further tests, and prescribe appropriate drugs.

Connectivity enables computers and software that might otherwise be incompatible to communicate and to share resources. Now that computers are proliferating in many areas and networks are available for people to access data and communicate with others, so personal computers are becoming interpersonal PCs. They have the potential to significantly improve the way we relate to each other.

Many people today telecommute - that is, use their computers to stay in touch with the office while they are working at home. With the proper tools, hospital staff can get a diagnosis from a medical expert hundreds or thousands of miles away. Similarly, the disabled can communicate more effectively with others using computers.

Distance learning and videoconferencing are concepts made possible with the use of an electronic classroom or boardroom accessible to people in remote locations. Vast databases of information are currently available to users of the Internet, all of whom can send mail messages to each other. The information superhighway is designed to significantly expand this interactive connectivity so that people all over the world will have free access to all these resources.

People power is critical to ensuring that hardware, software, and connectivity are effectively integrated in a socially responsible as way. People - computer users and computer professionals - are the ones who will decide which hardware, software, and networks endure and how great an impact they will have on our lives. Ultimately people power so must be exercised to ensure that computers are used not only efficiently but in a socially responsible way.

TEXT 37. SEARCH ENGINES, EMAIL PROTOCOLS

Study these tips for conducting searches using AltaVista.
Don't use simple keywords. Typing in the word football is unlikely to help you to find information on your favourite football team. Unless special operators are included, AltaVista assumes the default operator is OR. If, for example, the search query is American football, AltaVista will look for documents containing either American or football although it will list higher those documents which contain both.
AltaVista is specifically case sensitive. If you specify apple as your search term, AltaVista will return matches for apple, Apple and APPLE. However, if you use Apple or apPle, AltaVista will only match Apple and apPle respectively.

AltaVista supports natural language queries. If you really aren't sure where to start looking, try typing a natural language query in the search box. The question “Where can I find pages about digital cameras?” will find a number of answers but at least it will give you some idea of where to start.

Try using phrase searching. This is where you place quotation marks around your search term, e.g. 'alternative medicine'. This will search for all documents where these two words appear as a phrase.

Attaching a + to a word is a way of narrowing your search. It means that word must be included in your search. For example, if you were looking for information on cancer research, use +cancer +research instead of just cancer.
Attaching a - to a word or using NOT is another way of narrowing your search. This excludes the search item following the word NOT or the - sign. For example, science NOT fiction or science -fiction will exclude sites in which these two words occur together.

Use brackets to group complex searches, for example: (cakes AND recipes) AND (chocolate OR ginger) will find pages including cakes and recipes and either chocolate or ginger or both.
You can refine your search by doing a field search. Put the field, then a colon and then what you are looking for. For example, URL:UK +universities will find only British universities. title: 'English language' will find only sites which contain this phrase in their titles.

AltaVista supports the use of wildcard searches. If you insert a * to the right of a partial word, say hydro*, it will find matches for all words beginning with hydro such as hydrocarbon and hydrofoil. Wildcards can also be used to search for pages containing plurals of the search terms as well as to catch possible spelling variations, for example alumin*m will catch both aluminium (UK) and aluminum (US).

If you are looking for multimedia files then save yourself time by selecting images, audio or video with the radio buttons on AltaVista's search box and then entering your search.

Email protocols

Although the format of a mail message, as transmitted from one machine to another, is rigidly defined, different mail protocols transfer and store messages in slightly different ways. The mail system you're probably used to employs a combination of SMTP and POP3 to send and receive mail respectively. Others may use IMAP4 to retrieve mail, especially where bandwidth is limited or expensive.

SMTP is used to transfer messages between one mail server and another. It's also used by email programs on PCs to send mail to the server. SMTP is very straightforward, providing only facilities to deliver messages to one or more recipients in batch mode. Once a message has been delivered, it can't be recalled or cancelled. It's also deleted from the sending server once it's been delivered. SMTP uses 'push' operation, meaning that the connection is initiated by the sending server rather than the receiver. This makes it unsuitable for delivering messages to desktop PCs, which aren't guaranteed to be switched on at all times.

Web mail systems use some of the same protocols as client/server mail. Some can access an ISP-based POP3 mailbox, allowing you to read your mail anywhere you can find a browser.

TEXT 38. BIPOLAR JUNCTION TRANSISTOR

The Bipolar Junction Transistor is a semiconductor device which can be used for switching or amplification.

Transistors are three terminal active devices made from different semiconductor materials that can act as either an insulator or a conductor by the application of a small signal voltage. The transistor's ability to change between these two states enables it to have two basic functions: "switching" (digital electronics) or "amplification" (analogue electronics). Then bipolar transistors have the ability to operate within three different regions:

Active Region – the transistor operates as an amplifier and $Ic = \beta * Ib$

Saturation – the transistor is "Fully-ON" operating as a switch and Ic = I(saturation)

Cut-off – the transistor is "Fully-OFF" operating as a switch and Ic = 0

A Typical
Bipolar Transistor

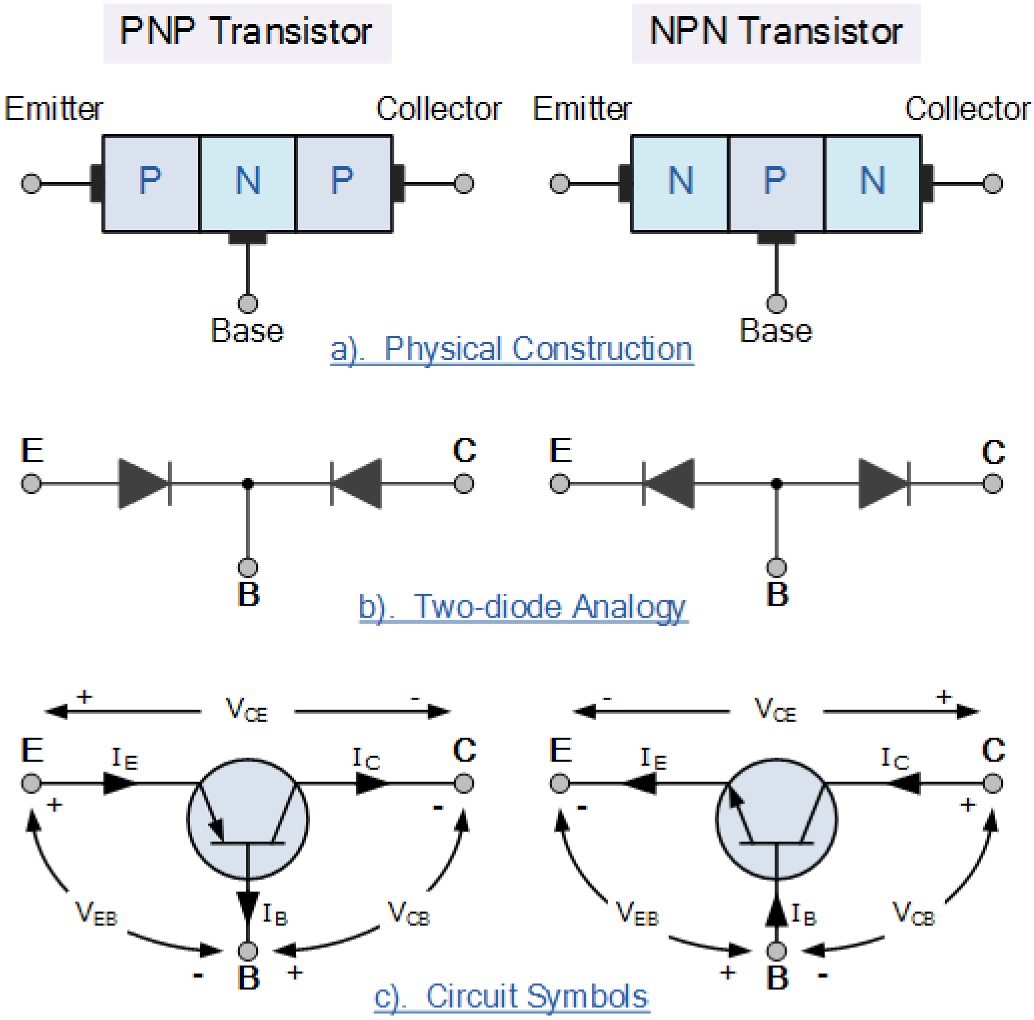
The word Transistor is a combination of the two words Transfer Varistor which describes their mode of operation way back in their early days of electronics development. There are two basic types of bipolar transistor construction, PNP and NPN, which basically describes the physical arrangement of the P-type and N-type semiconductor materials from which they are made.

The **Bipolar Transistor** basic construction consists of two PN-junctions producing three connecting terminals with each terminal being given a name to identify it from the other two. These three terminals are known and labelled as the Emitter (E), the Base (B) and the Collector (C) respectively.

Bipolar Transistors are current regulating devices that control the amount of current flowing through them from the Emitter to the Collector terminals in proportion to the amount of biasing voltage applied to their base terminal, thus acting like a current-controlled switch. As a small current flowing into the base terminal controls a much larger collector current forming the basis of transistor action.

The principle of operation of the two transistor types PNP and NPN, is exactly the same the only difference being in their biasing and the polarity of the power supply for each type.

Bipolar Transistor Construction



The construction and circuit symbols for both the PNP and NPN bipolar transistor are given above with the arrow in the circuit symbol always showing the direction of "conventional current flow" between the base terminal and its emitter terminal. The direction of the arrow always points from the positive P-type region to the negative N-type region for both transistor types, exactly the same as for the standard diode symbol.

Bipolar Transistor Configurations

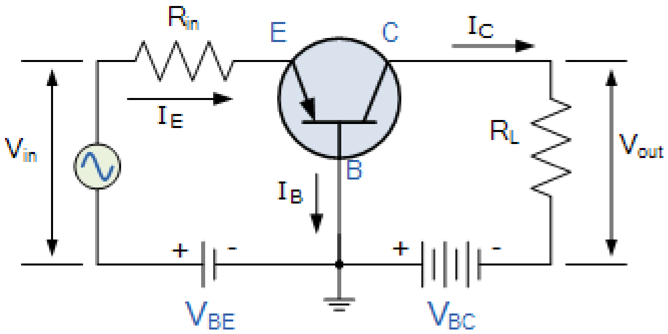
As the **Bipolar Transistor** is a three terminal device, there are basically three possible ways to connect it within an electronic circuit with one terminal being common to both the input and output. Each method of connection responding differently to its input signal within a circuit as the static characteristics of the transistor vary with each circuit arrangement.

Common Base Configuration – has Voltage Gain but no Current Gain.
Common Emitter Configuration – has both Current and Voltage Gain.
Common Collector Configuration – has Current Gain but no Voltage Gain.

The Common Base (CB) Configuration

As its name suggests, in the **Common Base** or grounded base configuration, the BASE connection is common to both the input signal AND the output signal. The input signal is applied between the transistors base and the emitter terminals, while the corresponding output signal is taken from between the base and the collector terminals as shown. The base terminal is grounded or can be connected to some fixed reference voltage point.

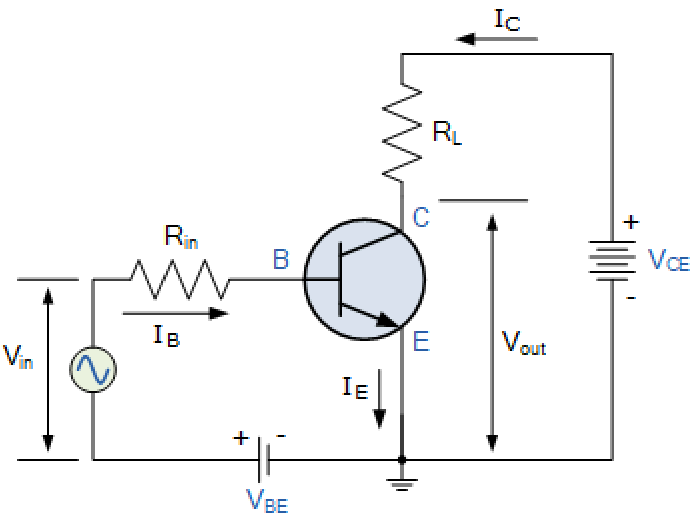
The input current flowing into the emitter is quite large as its the sum of both the base current and collector current respectively therefore, the collector current output is less than the emitter current input resulting in a current gain for this type of circuit of "1" (unity) or less, in other words the common base configuration "attenuates" the input signal.
The Common Base Transistor Circuit



This type of amplifier configuration is a non-inverting voltage amplifier circuit, in that the signal voltages Vin and Vout are "in-phase". This type of transistor arrangement is not very common due to its unusually high voltage gain characteristics. Its input characteristics represent that of a forward biased diode while the output characteristics represent that of an illuminated photo-diode.
Also this type of bipolar transistor configuration has a high ratio of output to input resistance or more importantly "load" resistance (RL) to "input" resistance (Rin) giving it a value of "Resistance Gain". Then the voltage gain (Av) for a common base configuration is therefore given as:
Common Base Voltage Gain

$$A_V = \frac{Vout}{Vin} = \frac{I_C \times R_L}{I_E \times R_{IN}}$$

Where: Ic/Ie is the current gain, alpha (α) and RL/Rin is the resistance gain.
The common base circuit is generally only used in single stage amplifier circuits such as microphone pre-amplifier or radio frequency (Rƒ) amplifiers due to its very good high frequency response.
The Common Emitter (CE) Configuration
In the **Common Emitter** or grounded emitter configuration, the input signal is applied between the base and the emitter, while the output is taken from between the collector and the emitter as shown. This type of configuration is the most commonly used circuit for transistor based amplifiers and which represents the "normal" method of bipolar transistor connection.
The common emitter amplifier configuration produces the highest current and power gain of all the three bipolar transistor configurations. This is mainly because the input impedance is LOW as it is connected to a forward biased PN-junction, while the output impedance is HIGH as it is taken from a reverse biased PN-junction.
The Common Emitter Amplifier Circuit



In this type of configuration, the current flowing out of the transistor must be equal to the currents flowing into the transistor as the emitter current is given as Ie = Ic + Ib. As the load resistance (R_L) is connected in series with the collector, the current gain of the common emitter transistor configuration is quite large as it is the ratio of Ic/Ib. A transistors current gain is given the Greek symbol of Beta, (β).
As the emitter current for a common emitter configuration is defined as Ie = Ic + Ib, the ratio of Ic/Ie is called Alpha, given the Greek symbol of α. Note: that the value of Alpha will always be less than unity.
Since the electrical relationship between these three currents, Ib, Ic and Ie is determined by the physical construction of the transistor itself, any small change in the base current (Ib), will result in a much larger change in the collector current (Ic). Then, small changes in current flowing in the base will thus control the current in the emitter-collector circuit. Typically, Beta has a value between 20 and 200 for most general purpose transistors. So if a transistor has a Beta value of say 100, then one electron will flow from the base terminal for every 100 electrons flowing between the emitter-collector terminal.
By combining the expressions for both Alpha, α and Beta, β the mathematical relationship between these parameters and therefore the current gain of the transistor can be given as:

$$\text{Alpha}, (\alpha) = \frac{I_C}{I_E} \quad \text{and} \quad \text{Beta}, (\beta) = \frac{I_C}{I_B}$$

$$\therefore I_C = \alpha.I_E = \beta.I_B$$

$$\text{as:} \quad \alpha = \frac{\beta}{\beta + 1} \qquad \beta = \frac{\alpha}{1 - \alpha}$$

$$I_E = I_C + I_B$$

Where: “Ic” is the current flowing into the collector terminal, “Ib” is the current flowing into the base terminal and “Ie” is the current flowing out of the emitter terminal.

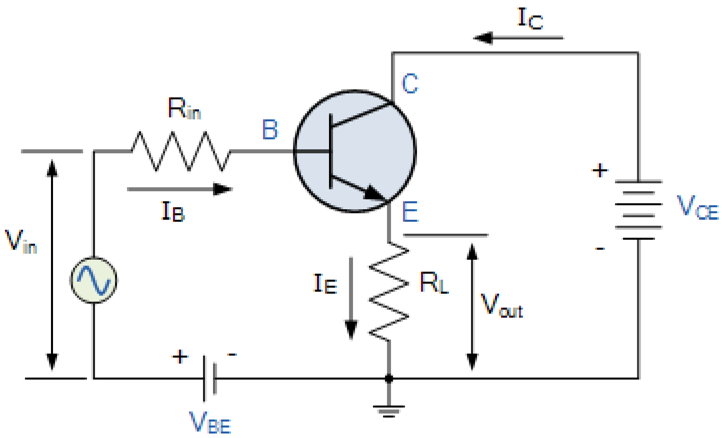
Then, to summarise. This type of bipolar transistor configuration has a greater input impedance, current and power gain than that of the common base configuration but its voltage gain is much lower. The common emitter configuration is an inverting amplifier circuit. This means that the resulting output signal has a 180° phase-shift with regards to the input voltage signal.

The Common Collector (CC) Configuration

In the **Common Collector** or grounded collector configuration, the collector is connected to ground through the supply, thus the collector terminal is common to both the input and the output. The input signal is connected directly to the base terminal, while the output signal is taken from across the emitter load resistor as shown. This type of configuration is commonly known as a **Voltage Follower** or **Emitter Follower** circuit.

The common collector, or emitter follower configuration is very useful for impedance matching applications because of its very high input impedance, in the region of hundreds of thousands of Ohms while having a relatively low output impedance.

The Common Collector Transistor Circuit



The common emitter configuration has a current gain approximately equal to the β value of the transistor itself. However in the common collector configuration, the load resistance is connected in series with the emitter terminal so its current is equal to that of the emitter current.

As the emitter current is the combination of the collector AND the base current combined, the load resistance in this type of transistor configuration also has both the collector current and the input current of the base flowing through it. Then the current gain of the circuit is given as:

The Common Collector Current Gain

$$I_E = I_C + I_B$$

$$A_i = \frac{I_E}{I_B} = \frac{I_C + I_B}{I_B}$$

$$A_i = \frac{I_C}{I_B} + 1$$

$$A_i = \beta + 1$$

This type of bipolar transistor configuration is a non-inverting circuit in that the signal voltages of Vin and Vout are "in-phase". The common collector configuration has a voltage gain of about "1" (unity gain). Thus it can considered as a voltage-buffer since the voltage gain is unity.

The load resistance of the common collector transistor receives both the base and collector currents giving a large current gain (as with the common emitter configuration) therefore, providing good current amplification with very little voltage gain.

Having looked at the three different types of bipolar transistor configurations, we can now summarise the various relationships between the transistors individual DC currents flowing through each leg and its DC current gains given above in the following table.

Relationship between DC Currents and Gains

$$I_E = I_B + I_C \qquad \alpha = \frac{I_C}{I_E} = \frac{\beta}{1+\beta}$$

$$I_C = I_E - I_B$$

$$I_B = I_E - I_C \qquad \beta = \frac{I_C}{I_B} = \frac{\alpha}{1-\alpha}$$

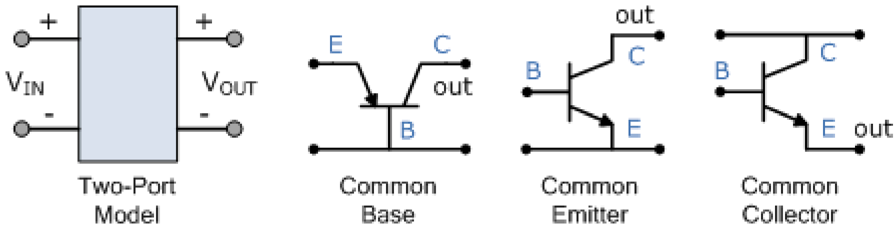
$$I_B = \frac{I_C}{\beta} = \frac{I_E}{1+\beta} = I_E(1-\alpha)$$

$$I_C = \beta.I_B = \alpha.I_E \qquad I_E = \frac{I_C}{\alpha} = I_B(1+\beta)$$

Note that although we have looked at NPN Bipolar Transistor configurations here, PNP transistors are just as valid to use in each configuration as the calculations will all be the same, as for the non-inverting of the amplified signal. The only difference will be in the voltage polarities and current directions.
Bipolar Transistor Summary

Then to summarise, the 134ummariz of the bipolar transistor in each one of the above circuit configurations is very different and produces different circuit characteristics with regards to input impedance, output impedance and gain whether this is voltage gain, current gain or power gain and this is 134ummarized in the table below.

Bipolar Transistor Configurations



with the generalised characteristics of the different transistor configurations given in the following table:

Characteristic	**Common Base**	**Common Emitter**	**Common Collector**
Input Impedance	Low	Medium	High
Output Impedance	Very High	High	Low
Phase Shift	0º	180º	0º
Voltage Gain	High	Medium	Low
Current Gain	Low	Medium	High
Power Gain	Low	Very High	Medium

TEXT 39. THE RISE OF THE WORLD WIDE WEB

By the early 1990s, people were using computers in many different ways. Computers were already installed in most schools, offices, and homes. They were commonly used for writing papers, playing games, financial accounting, and business productivity applications. But very few people used them for communication, research, and shopping the way we do now. A man named Tim Berners-Lee changed all that. In 1990, Lee added an exciting hypertext and multimedia layer to the Internet and called it the World Wide Web. The rest, as they say, is history.

Believe it or not, the Web was not the first attempt at building a worldwide online community. Cutting edge geeks have been using online services such as Compuserve all the way back to the early 1980's. There were thousands of other privately run Bulletin Board Systems (BBS) as well, which served the general interest of curious nerds and researchers from around the world. Perhaps the most ambitious project was the French system Minitel, but it never caught on in the rest of the world and eventually faded into obscurity. Experiences on these BBS were poor by today's standards. There was no graphics or even color. There was no sound except of course the obnoxious beeps and gurgles a modem makes when it initiates a dial-up connection to a server. Bandwidth was also very slow compared to today's speeds. Typical operating speeds were between 300 and 1200 baud. Today, a typical broadband connection is thousands of times faster than this.

The Web was not built for geeks. It was built for everyone. It was built with very high ideals. No single company, government, or organization controls it. It was new and exciting. New ideas and words appeared almost daily. Obscure technical terms became household words overnight. First it was email. Then it was URL and domain name. Then rather quickly came spam, homepage, hyperlink, bookmark, download, upload, cookie, e-commerce, emoticon, ISP, search engine, and so on. Years later we are still making up new words to describe our online world. Now, we "google" for information. We "tweet" what's happening around us to others. The new words never seem to stop!
Just because the web seems so chaotic and unorganized compared to more structured companies and governments, doesn't mean it's total anarchy. In 1994, Tim Berners Lee started the W3C, a worldwide organization dedicated to setting standards for the Web. This group is probably the most respected authority for what should and should not be Web standards. W3C's mission is to lead the Web to its full potential.

As a student of English and Technology, you will hear people use the words 'Internet' and 'World Wide Web' almost interchangeably. They are, of course, not the same thing. So what is the difference between the two? Perhaps a simple answer is that the Internet is the biggest network in the world, and the World Wide Web is a collection of software and protocols on that network. I guess a more simple way to put it is, the World Wide Web is an application that runs on The Internet.

The original backbone of the Internet is based on an old military network called ARPANET which was built by ARPA in the late 1960's. ARPANET was built so information could withstand a nuclear war. The idea was not to have a single point of failure. This means if part of the ARPANET was blown up in a nuclear war, the rest of it will still work! What made ARPANET so successful was its packet-switching technology, invented by Lawrence Roberts. The idea is that "packets" of information have a "from" address and a "to" address. How they get from point "a" to point "b" depends on what roads are open to them. Packet switching is a very elegant thing. Without it, the Internet would simply not work.

People view the World Wide Web through a software application called a web browser or simply a "browser" for short. Some popular examples of web browsers include Microsoft Internet Explorer, Google Chrome, Mozilla Firefox, and Apple Safari. Browsers allow people to search, view, and even add and edit data on the World Wide Web.
The Web is not supposed to be a passive experience. Creating new pages for the Web is getting easier all the time. Web editing software is specially designed to work with hypertext languages such as HTML, which is the original specification for the Web. Web editing software normally allows for the WYSIWYG creation of text, images, and hyperlinks between related documents. With web applications such as wikis, MySpace and Facebook, a typical user can create his or her first online presence in a matter of hours.

In the year 1999, the Internet suffered its first financial crash. Many companies selling products and services on the Web were not living up to sales expectations. This was known as the Dot Com Bubble. There were many reasons why this happened, but perhaps the two most important reasons were a combination of slow connection speeds and too much optimism. Very few people had fast internet connections and many people thought the Internet was "just a passing fad". But we know now that the Internet is not a fad. So what happened? Web 2.0 happened!

What is Web 2.0? It's very hard to say. It's just a phrase to describe a transition from the pre-existing state of 'Web 1.0', which was slow, static, and unusable, to a new, 'second web', which was faster, more dynamic, and more usable for the average person. How did these things happen? Broadband modems enabled sites like video-streaming YouTube to become possible. Better design and development practices enabled social media sites like MySpace and then Facebook to attract hundreds of millions of users. Finally, search engine technology improved on sites like Google where people could actually find the information they were looking for.

What will be the future of the Web? Easy. More speed and more power. In the future, digital distribution on the Internet is likely to replace all other forms of media distribution including CDs, DVDs, and even radio and television broadcasts.
I personally feel lucky to be alive in the age of the Web. It is one of the coolest things ever invented. It is unlikely that such another wonderful and major revolutionary invention will occur in our lifetime. But I can still dream about the Next Big Thing. And who knows? Maybe **you** will invent it.

TEXT 40. WORD PROCESSING FACILITIES START UP

Writing letters, memos or reports are the ways most people use computers. They manipulate words and a text on a screen – primarily to print at some later time and store for safe keeping. Computers alleviate much of the tedium associated with typing, proofing and manipulating words. Because computers can store and recall information so readily, documents need not be retyped from scratch just to make corrections or changes. The real strength of word processing lies in this ability to store, retrieve and change information. Typing is still necessary (at least, for now) to put the information into the computer initially, but once in, the need to retype only applies to new information.

Word processing is more than just typing, however. Features such as Search and Replace allow users to find a particular phrase or word no matter where it is in a body of text. This becomes more useful as the amount of text grows.

Word processors usually include different ways to view the text. Some include a view that displays the text with editor's marks that show hidden characters or commands (spaces, returns, paragraph endings, applied styles, etc.) Many word processors include the ability to show exactly how the text will appear on paper when printed. This is called WYSIWIG (What You See Is What You Get, pronounced "wizzy-wig"). WYSIWIG shows bold, italic, underline and other style characteristics on the screen so that the user can clearly see what he or she is typing. Another feature is the correct display of different typefaces and format characteristics (margins, indents, super- and sub-scripted characters, etc.). This allows user to plan the document more accurately and reduces the frustration of printing something that doesn't look right. Many word processors now have so many features that they approach the capabilities of layout applications for desktop publishing. They can import graphics, format multiple columns of text, run text around graphics, etc.

Two important features offered by word processors are automatic hyphenation and mail merging. Automatic hyphenation is the splitting of a word between two lines so that the text will fit better on the page.

The word processor constantly monitors words typed and when it reaches the end of a line, if a word is too long to fit, it checks that word in a hyphenation dictionary. This dictionary contains a list of words with the preferred places to split it. If one of these cases fits part of the word at the end of the line, the word processor splits the word, adds a hyphen at the end and places the rest on the next line. This happens extremely fast and gives text a more polished and professional look.

Mail merge applications are largely responsible for the explosion of 'personalized' mail. Form letters with designated spaces for names and addresses are stored as documents with links to lists of names and addresses of potential buyers or clients. By designating what information goes into which blank space, a computer can process a huge amount of correspondence substituting the 'personal' information into a form letter. The final document appears to be typed specifically to the person addressed.

Many word processors can also generate tables of numbers or figures, sophisticated indices and comprehensive tables of contents.

TEXT 41. THE WORLD WIDE WEB

The World Wide Web began in 1989 as a project by high-energy physics researchers in Switzerland to distribute research Internet to fellow physicists. Since then, the Web has rapidly moved into the forefront of Internet technologies. More people use the Web on the Internet than all other technologies on the Net combined. To most of the general public, the Web is synonymous with the Internet itself and is, in fact, thought by many to have played the dominant role in moving the Internet from an academic research tool to a household word.

The Web is an abstract (imaginary) space of information. On the Web, you find documents, sounds, videos, and information. On the Web connections are hypertext links. The Web uses a writing technology called hypertext. A hypertext is a group of unlinked files. Hypertext is a key concept for understanding today's Web, but the idea of hypertext originated much earlier than the Web or even the Internet. Two of the most important elements of the Web-Hypertext Transfer Protocol (HTTP) and Hypertext Markup Language (HTML) – contain "hypertext" in their names.

HTTP is a protocol that works with TCP/IP (Transmission Control Protocol/Internet Protocol) to get Web resources to your desktop. A web resource can be defined as any chunk of data that has a URL, such as an HTML document, a graphic, or a sound file. HTTP includes commands called "methods" that help your browser communicate with web servers. GET is the most frequently used HTTP method. The GET method is typically used to retrieve the text and graphics files necessary for displaying a Web page. This method can also be used to pass a search query to a file server. HTTP transports your browser's requests for a Web resource to a Web server. Next, it transports the Web server's response back to your browser.

HTML is a set of specifications for creating HTML documents that a browser can display as a Web page. HTML is called a markup language because authors mark up their documents by inserting special instructions, called HTML tags that specify how the document should appear when displayed on a computer screen or printed.

On today's Web, many aspects of hypertext have become a reality. A typical Web page is based on a document stored in a file and identified by a unique address called a URL (Uniform Resource Locator). To access any one of these documents, you can type its URL. You can also click an underline word or phrase called a hypertext link (or simply a "link") to access related Web pages.

HTTP and HTML are two of the major ingredients that define the Web. If you add URLs, browsers, and Web servers to this recipe, you'll have a pretty complete menu of the basic technologies that make the Web work.

A web server stores data from Web pages that form a Web site. One way to store data for a Web page is as a file called an HTML document – a plain text, document with embedded HTML tags. Some of these tags specify how the document is to be displayed when viewed in a browser. Other tags contain links to related document, graphics, sound, and video files that are stored on Web servers. As an alternative to HTML documents, Web servers can store Web page data in other types of files, such as databases. Data from product databases, college course schedules, and music catalogues can be assembled into HTML format "on the fly" in response to Web requests.

To surf the Web, you use Web client software called a browser. When you type a URL into the browser's Address box, you are requesting HTML data for a specific Web page. Your browser creates a request for the data by using the HTTP "GET" command.

A Web server is configured to include HTTP software. This software is always running when the server is “up” and ready to fulfill requests. One of the server’s ports is dedicated to listening for HTTP requests. When a request arrives, the server software analyzes it and takes whatever action is necessary to fulfill it.

The computer that runs Web software might have other software running on it as well. For example, a computer might operate as a Web server, as an e-mail server, and as an FTP (File Transfer Protocol) server all at the same time! To efficiently handle these diverse duties, a computer devotes one port to HTTP requests, one port to handling e-mail, and another port to FTP requests.

A browser is a software program that on your computer and helps you access Web pages. Technically, a browser is the client half of the client/server software that facilitates communication between a personal computer and a Web server. The browser is installed on your computer, and Web server software is installed on servers connected to the Internet.

Your browser plays two key roles. First, it uses HTTP to send messages to a Web server – usually a request for a specific HTML document from Web server, your browser interprets the HTML tags to display requested Web page. Today’s popular browsers are Internet Explorer, Mozilla Firefox, Opera, Google Chrome.

A Web site is a group of related Web pages. The Web site is the master address, and the individual Web pages are like subdirectories to that root directory. Many businesses are creating Web sites for their customers to use. These sites may include price list, information about products, and comparisons of product features with those of competing products. Many sites even allow customers to order products over the Web. Because your site is representing you on the Web, you will want the site to look impressive. For a professional-looking site, you may want to hire a firm that creates Web sites. Such firms employ HTML experts as well as graphic designers and marketing specialists.

TEXT 42. STEPS IN COMPUTER PROGRAM DEVELOPMENT

Although the programmer is responsible for writing the computer program, the system analyst must communicate the computer program requirements to the programmer. The function of each program was defined for the programmer when functions were allocated during system design. Detailed data flow diagrams (DFD) are prepared for each program from the decomposed DFDs created during the design phase. These DFDs define the function of each program.

In program planning, the logic to be used to solve the problem is developed. Algorithms, computer program logic flowcharts, and structure charts are useful tools for program planning. Algorithms are sets of rules or instructions used to accomplish tasks. They may be stated as formulas, decision tables, or narratives.

The next step, writing, or coding, a program, is the actual writing of computer instructions. These instructions will be translated to machine code and followed by the computer; they should follow the steps of the program logic plan.
Several programming languages, particularly COBOL, PL/I, and RPG, are commonly used to solve business problems. In addition to these traditional languages, organizations using database management systems may choose to generate programs using the query language of the DBMS.

These query languages are part of a package of programming tools known as fourth-generation languages. Each language has its advantages and disadvantages. Most computer installations have a standard language used by their programmers. Programmers usually are not given a choice of language unless some special circumstances exist.

Testing and debugging a program involve:

- translating the coded program into machine language, a process called compilation;
- testing the translated program with sample data and checking the result.

If the results of testing are not correct, the program is said to have "bugs". Debugging is the process of correcting computer programs to obtain correct results.
The last step is to complete the documentation for the program. The documentation must include a statement of the purpose of the program, a description of the solution logic, a listing of the program instructions, and sample outputs from the completed programs. Information provided to the programmer by the analyst, such as descriptions of program inputs, outputs, and files, should be included. Instructions to operators explaining how the program is to be used must be written before the program documentation is completed.

TEXT 43. PROCEDURAL PROGRAMMING

The traditional approach to programming uses a procedural paradigm (sometimes called "imperative paradigm") to conceptualize the solution to a problem as a sequence of steps. A program written in a procedural language typically consists of self-contained instructions in a sequence that indicates how a task is to be performed or a problem is to be solved.

A programming language that supports the procedural paradigm is called a procedural language. Procedural languages are well suited for problems that can be easily solved with a linear, or step–by-step, algorithm. Programs created with procedural languages have a starting point and an ending point.

The flow of execution from the beginning to the end of the program is essentially linear – that is, the computer begins at the first instruction and carries out the prescribed series of instructions until it reaches the end of the program.

An algorithm is a set of steps for carrying out a task that can be written down and implemented. An algorithm for a computer program is a set of steps that explains how to begin with known information specified in a problem statement and how to manipulate that information to arrive a solution. In a later phase of the software development process, the algorithm is coded into instructions written in a programming language so that a computer can implement it.

To design an algorithm, you might begin by recording the steps you take to solve the problem manually. The computer also needs the initial information, so the part of your algorithm must specify how the computer gets it. Next, your algorithm should also specify how to manipulate this information and, finally, how the computer decides what to display as the solution.

You can express an algorithm in several different ways, including structured English, pseudocode, and flowcharts. These tools are not programming languages, and they cannot be processed by a computer. Their purpose is to give you a way to document your ideas for program design.

Structured English is a subset of the English language with a limited selection of sentence structures that reflects processing activities. Another way to express an algorithm is with pseudocode. Pseudocode is a notational system for algorithms that has been described as a mixture of English and your favorite programming language.

A third way to express an algorithm is to use a flowchart. A flowchart is a graphical representation of the way a computer should progress from one instruction to the next when it performs a task.

Before finalizing the algorithm for a computer program, you should perform a walkthrough to verify that your algorithm works. To perform a walkthrough for a simple program, you can use a calculator, paper, and pencil to step through a sample problem using realistic "test" data.

For more complex programs, a walkthrough might consist of a verbal presentation to a group of programmers who can help identify logical errors in the algorithm and suggest ways to make the algorithm more efficient.

The algorithm specifies the order in which program instructions are performed by the computer. Unless you do otherwise, sequential execution is the normal pattern of program execution. During sequential execution, the computer performs each instruction in the order it appears – the first instruction in the program is executed first, then the second instruction, and so on, to the last instruction in the program.

Some algorithms specify that a program must execute instructions in an order different from the sequence in which they are listed, skip some instructions under certain circumstances, or repeat instructions. Control structures are instructions that specify the sequence in which program is executed. Most programming languages have three types of control structures: sequence controls, selection controls, and repetition controls.
A sequence control structure changes the order in which instructions are carried out by directing the computer to execute an instruction elsewhere in the program. A sequence control structure directs the computer to the statements they contain, but when these statements have been executed, the computer neatly returns to the main program.
A selection control structure, also referred to as a "decision structure" or "branch", tells a computer what to do, based on whether a condition is true or false. A simple example of a selection control structure is the IF…THEN…ELSE command.
A repetition control structure directs the computer to repeat one or more instructions until certain condition is met. The section of code that repeats is usually referred to as a loop or "iteration". Some of the most frequently used repetition commands are FOR…NEXT, DO…WHILE, DO…UNTIL, and WHILE…WEND (which means "while ends").

All the first programming languages were procedural. The first widely used standardized computer language, FORTRAN, with its procedural paradigm set the pattern for other popular procedural languages, such as COBOL, APL, ALGOL, PL/1, PASCAL, C, ADA, and BASIC.
The procedural approach is best suited for problems that can be solved by following a step-by-step algorithm. It has been widely used for transaction processing, which is characterized by the use of a single algorithm applied to many different sets of data. For example, in banking industry, the algorithm for calculating checking account balances is the same, regardless of the amounts deposited and withdrawn. Many problems in math and science also lend themselves to the procedural approach.
The procedural approach and procedural languages tend to produce programs that run quickly and use system resources efficiently. It is a classic approach understood by many programmers, software engineers, and system analysts. The procedural paradigm is quite flexible and powerful, which allows programmers to apply it to many types of problems.

The downside of the procedural paradigm is that it does not fit gracefully with certain types of problems – those that are unstructured or those with very complex algorithms. The procedural paradigm has also been criticized because it forces programmers to view problems as a series of steps, whereas some problems might better be visualized as interacting objects or as interrelated words, concepts, and ideas.

TEXT 44. USER APPLICATION OPERATING SYSTEM HARDWARE

This is a structure showing where Operating System is located on generally used software systems on desktops. Practical computer systems divide software systems into three major classes: system software, programming software and application software, although the distinction is arbitrary, and often blurred.
System software
System software helps run the computer hardware and computer system. It includes a combination of the following:
· device drivers;
· operating systems;
· servers;
· utilities;
· windowing systems.
The purpose of systems software is to unburden the applications programmer from the often complex details of the particular computer being used, including such accessories as communications devices, printers, device readers, displays and keyboards, and also to partition the computer's resources such as memory and processor time in a safe and stable manner. Examples are- Windows XP, Linux, and Mac OS X.
Programming software
Programming software usually provides tools to assist a programmer in writing computer programs, and software using different programming languages in a more convenient way. The tools include:
· compilers
· debuggers
· interpreters
· linkers
· text editors
An Integrated development environment (IDE) is a single application that attempts to manage all these functions.
Application software
Application software allows end users to accomplish one or more specific (not directly computer development related) tasks. Typical applications include:
· industrial automation
· business software
· computer games
· quantum chemistry and solid state physics software
· telecommunications (i.e., the internet and everything that flows on it)
· databases
· educational software
· medical software
· military software
· molecular modeling software
· image editing
· spreadsheet
· Word processing
· Decision making software
Application software exists for and has impacted a wide variety of topics.

TEXT 45. IT CERTIFICATION

Certification refers to the confirmation of certain characteristics of an object, person, or organization. This confirmation is often, but not always, provided by some form of external review, education, or assessment.
One of the most common types of certification in modern society is professional certification, where a person is certified as being able to competently complete a job or task, usually by the passing of an examination.
There are two general types of professional certification: some are valid for a lifetime, once the exam is passed. Others have to be recertified again after a certain period of time. Also, certifications can differ within a profession by the level or specific area of expertise they refer to. For example, in the IT Industry there are different certifications available for software tester, project manager, and developer. Similarly, the Joint Commission on Allied Health Personnel in Ophthalmology offers three certifications in the same profession, but with increasing complexity.
Certification does not refer to the state of legally being able to practice or work in a profession. That is licensure. Usually, licensure is administered by a governmental entity for public protection purposes and a professional association administers certification. Licensure and certification are similar in that they both require the demonstration of a certain level of knowledge or ability.
Another common type of certification in modern society is product certification. This refers to processes intended to determine if a product meets minimum standards, similar to quality assurance.
In first-party certification, an individual or organization providing the good or service offers assurance that it meets certain claims. In second-party certification, an association to which the individual or organization belongs provides the assurance. Third-party certification involves an independent assessment declaring that specified requirements pertaining to a product, person, process or management system have been met.
For software testing the certifications can be grouped into exam-based and education-based. Exam-based certifications:
For this there is the need to pass an exam, which can also be learned by self-study: e.g. for International Software Testing Qualifications Board Certified Tester by the International Software Testing Qualifications Board or Certified Software Tester by QAI or Certified Software Quality Engineer by American Society for Quality. Education-based certifications are the instructor-led sessions, where each course has to be passed, e.g. Certified Software Test Professional or Certified Software Test Professional by International Institute for Software Testing.

Types of certification

· Academic degree
· Professional certification
· Product certification and certification marks
· Cyber security certification
· Digital signatures in public-key cryptography
· Music recording sales certification, such as "Gold" or "Platinum"
· Film certification, also known as Motion picture rating system
· Professional certification (computer technology)
· Laboratory Certification and audits

Network+
Network+ exam by Comptia is designed specifically for the IT professional who have more than nine months experience in the computer network administration. The code of the Network+ exam is N10-003 and it was first introduced in 1997. Till the mid of May 2005, according to Comptia's announcement, more than 150,000 were Network+ exam certified. Network+ is an entry level exam and it paves the way for the IT professionals in their quest for the more advance certifications like MCSE, CCNA, CCNP etc. There are not prerequisites for this certification. Comptia recommends that you must have the A+ certifications.
Network+ certification is well suited and designed for the network administrators. The topics covered in this exam are media and topologies, standards, protocols, network support and implementations. The Network+ certification shows the candidate's knowledge of the basic networking fundamentals. Like other Comptia's certifications, the Network+ certification will not be expired once it is achieved.
Security+
Security+ certification is designed for the IT professionals who have 2 years of experience in the network or systems administration and having the main focus on the security. The code of this exam is SY0101 and it was introduced by Comptia in 2002. Security+ is an entry level test for the most advanced tests like ISC2, CISSP and the SANS. As well as it can also be used as the basis for the some Microsoft certifications. Security+ certification is well suited for the network and security administrators and professionals.
The common topics included in this exam are designing security for a network, security infrastructure, cryptography, authentication, access control, internal and external network attacks and the dealing with the company's security.
Security+ certifications shows the candidates knowledge of these things and it prepares the candidate to such level that he/she competes with the security breaches and finds some good alternative ways that are helpful in reducing the cost of a security breach. Once this certification is achieved it will never expire just like the other certifications of Comptia.
Microsoft MCSE
Microsoft Certified Systems Engineer (MCSE) is designed for the professionals who are some requirements of analyzing the business, designing, making infrastructure, and implementing the securities at certain levels. MCSE is based on the Microsoft Windows 2000 platform and Windows NT platform (though many of the NT exams have been obsolete now). The Windows 2003 server has been merged into the MCSE exam.
MCSE certification does not retire but the newer versions are released by the Microsoft after few years. So the candidate has to be upgraded himself/herself with these latest exams. There are no specific requirements for the MCSE certifications. Those candidates who have one year experience in managing a computer network, network or desktop operating systems, will be considered suitable for this exam. Job descriptions and roles including after achieving the MCSE are Systems engineer, Network Engineer, Network Consultant, and Systems Analyst.
There is a 7 exams pass requirement for this certification and the candidates how are holding the MCSE 2000, are required to give 2-upgrade exams. By passing these exams you can achieve Windows Server 2000 MCSE exam.
Cisco CCNA
Cisco CCNA certification (Cisco Certified Network Associates) is an introductory level exam. The CCNA exam by Cisco systems was designed for the candidates who can

install, configure and do administrator of the LAN (Local Area Network) or WAN (Wide Area Network) networks. CCNA is a prerequisite for the some higher level certifications like CCNP and CCDP. The CCNA exam is valid for the three years. In 2003, Cisco has introduced the two paths of the CCNA exam (INTRO and ICND). Job role for the individuals who are CCNA certified are network administration, system administration and network consultant etc.

CCNP

CCNP (Cisco Certified Network Professional) exam is designed for the candidates who can install, configure and troubleshoot a LAN/WAN network of 100 to 500 computers. The CCNP certification has its prerequisites such as CCNP certification. The topics included in this certification are converged networks, security, VPN, quality of service and broadband technologies like VOIP, DSL, Cable net etc. There is a four, three and two exams path to the CCNP. The CCNP exam is valid for the three years. The job role for a CCNP certified is Network administration, LAN administration,WAN administrator and Network consultant.

ISC2 CISSP

CISSP (Certified Information Systems Security Professional) is introduced by ISC2. The ISC2 is a not profit organization and it manages the CISSP exams. A CISSP exam is designed for the candidates who are having minimum four years of experience in the field of Information systems. A bachelor and a Master degree separately, can be a substitute of the one required years for this exam. Also, some lower level certifications like SSCP (Systems Security Certified Practitioner) is also recommended before the CISSP exam.

The CISSP exam is aimed for the IT professionals who want to be Information security professionals, systems security professionals and network security professionals.

TEXT 46. TODAY'S MOST DESIRED INFORMATION TECHNOLOGY SKILLS

In today's economy, many companies seeking information technology professionals have raised the bar for what they expect out of their IT department. As information technology has ventured far away from the conventional personal computer and single programmer and entered the realm of technology integration, those in the IT field have been forced to follow suit with these expectations.

Employers are now in search of business prospects specializing in both information and communications technologies – professionals who not only possess technical expertise, but can also offer basic business skills including management, graphic design and communications. As the health of the economy improves, business are investing in an onslaught of applications, technical projects and infrastructures that necessitate highly skilled and qualified IT programmers and project managers.

Unfortunately, IT professionals are not only up against a competitive market, but are also faced with an increasing number of companies cutting down on IT staff and introducing new technologies that will automate operations and decrease costs, according to Computerworld.com. Therefore, it is best for IT professionals out on the job market to possess skills in the following:

1. Technical Support: The ability to migrate a company to the most up-to-date software and maintain a thorough understanding of how it works for any troubleshooting that may arise.

2. Application Development and Programming: In an ever changing environment, it is necessary for IT professionals to process applications expertise for the introduction of new products and innovations.

3. Security and Risk Management: Regulatory compliance needs and an increasing demand for tools with implemented security features are driving demand for valuable security skills. It is expected IT staff should be experts in encryption, data loss prevention, compliance and auditing, Web content filtering, e-discovery support, and threat and vulnerability evaluation.

4. Network Administration: With an increased usage in video and VoIP, companies will require network, voice and radio experts to manage upgrades and oversee compliance with federal mandates. IT professionals should be familiar with server, storage and networking in order to efficiently solve issues.

5. Project Management: This comes into play for the oversight of Web and mobile initiatives and rollouts of newer products. Therefore, IT professionals must stay up to date on emerging technologies and applications so the company they work for can benefit, as well. According to a poll by Monster.com, more than half of those planning to make new hires this year will seek out candidates with project management skills.

6. Business Intelligence: Technology experts should be able to take knowledge of computer-based technologies and apply them to the identification, extraction and analysis of business data for contribution to a company's profitability.
7. **United Communications:** With several areas of the enterprise integrating with unified communications solutions, it's important for IT staff to understand these technologies as a value to the company and recommend new ways of doing business that provide a competitive advantage to the company. IT professionals should be familiar with today's integrations with e-mail, instant messaging and conferencing capabilities.
8. **Mobile Devices/Applications:** IT professionals should have basic knowledge of the tools used to migrate applications, data and configuration settings to mobile devices and smartphones. With much of Internet searching and daily communications moving to smartphones, and companies requiring employees to use a separate phone for business purposes, this opens up a whole new arena for opportunities in the IT market.
9. **Data Center:** Storage experience, as well as data center expertise, is in high demand in today's IT world, according to Computerworld.com. Individuals should have analytical skills for choosing the most cost-friendly and appropriate storage-area network for the company.
10. **Social Media:** This isn't completely necessary, but it may appeal largely to organizations looking to effectively get its message and news out to the world, as well as connect with other partners and companies in the industry.

TEXT 47. NETWORK COMMUNICATIONS

The application layer is the only part of a communications process that a user sees, and even then, the user doesn't see most of the work that the application does to prepare a message for sending over a network. The layer converts a message's data from human-readable form into bits and attaches a header identifying the sending and receiving computers.

The presentation layer ensures that the message is transmitted in a language that the receiving computer can interpret (often ASCII). This layer translates the language, if necessary, and then compresses and perhaps encrypts the data. It adds another header specifying the language as well as the compression and encryption schemes.

The session layer opens communications and has the job of keeping straight the communications among all nodes on the network. It sets boundaries (called bracketing) for the beginning and end of the message, and establishes whether the messages will be sent half-duplex, with each computer taking turns sending and receiving, or full-duplex, with both computers sending and receiving at the same time. The details of these decisions are placed into a session header.

The transport layer protects the data being sent. It subdivides the data into segments, creates checksum tests - mathematical sums based on the contents of data - that can be used later to determine if the data was scrambled. It can also make backup copies of the data. The transport header identifies each segment's checksum and its position in the message.

The network layer selects a route for the message. It forms data into packets, counts them, and adds a header containing the sequence of packets and the address of the receiving computer.

The data-link layer supervises the transmission. It confirms the checksum, then addresses and duplicates the packets. This layer keeps a copy of each packet until it receives confirmation from the next point along the route that the packet has arrived undamaged.

The physical layer encodes the packets into the medium that will carry them - such as an analogue signal, if the message is going across a telephone line - and sends the packets along that medium.
An intermediate node calculates and verifies the checksum for each packet. It may also reroute the message to avoid congestion on the network.
At the receiving node, the layered process that sent the message on its way is reversed. The physical layer reconverts the message into bits. The data-link layer recalculates the checksum, confirms arrival, and logs in the packets. The network layer recounts incoming packets for security and billing purposes. The transport layer recalculates the checksum and reassembles the message segments. The session layer holds the parts of the message until the message is complete and sends it to the next layer. The presentation layer expands and decrypts the message. The application layer converts the bits into readable characters, and directs the data to the correct application.

TEXT 48. PUTTING A NEW TWIST ON OPTICAL COMMUNICATIONS

If the lacklustre speed of your Internet connection is getting you down, help could soon arrive from the orbital angular momentum of light. That is because an international team of researchers has developed a prototype system that uses this previously unexploited property of electromagnetic radiation to boost the amount of information that can be transmitted using a given amount of bandwidth. Although the test transmission was done across just a few metres in a vacuum, the technology developed in this proof-of-principle application could find wider application in optical telecommunications.

The rate at which data can be transmitted using electromagnetic radiation is normally limited by how much of the electromagnetic frequency spectrum is used – a quantity referred to as the bandwidth of the system. However, electromagnetic radiation has other degrees of freedom in addition to frequency and researchers are keen to use these to develop multiplexing schemes that boost the amount of data that can be sent over a link. For example, photons have an intrinsic spin angular momentum that manifests itself in the polarization of light. This property has already been used to increase data transmission rates – one stream of data is transmitted using photons with vertical polarization, for example, and another stream using photons with horizontal polarization.

It turns out that light can also carry orbital angular momentum. This is a result of the phase fronts of the waves rotating relative to their direction of propagation to create a pattern resembling a corkscrew. Whereas spin angular momentum can take only two values, orbital angular momentum can, in principle, take an infinite number of values. This could, in theory, allow a large number of data channels to be created using a finite amount of bandwidth.

This orbital angular momentum was first considered as a possible means of quantum communication in 2001 by the Austrian quantum physicist Anton Zeilinger. The idea that classical information could also be encoded in the orbital-angular-momentum states of photons was then demonstrated in 2004 by Miles Padgett and colleagues at the University of Glasgow in the UK. However, while Padgett's group proved that the principle could work, there was much to be done to produce a practical system.

The challenge has been taken up by Alan Willner and team at the University of Southern California, who, together with colleagues elsewhere in the US and in Israel, are the first to use orbital-angular-momentum states for multiplexing. Each data stream is encoded in the usual way using a series of on/off laser pulses. Then, separate streams of data are given a different orbital angular momentum before the beams are combined and transmitted. Finally, the different streams are separated in a process called «demultiplexing».

The different orbital-angular-momentum states are orthogonal, which means that there is no «crosstalk» between the beams. As a bonus, since quantum mechanics allows you to know both the orbital and the spin angular momentum of a photon at the same time, the researchers managed to perform both polarization multiplexing and orbital-angular-momentum multiplexing on their beams of light. This doubled the number of states available and allowed the transmission to reach terabit speeds.

«What impresses me most about the research is that it goes beyond a proof of principle to the point where the researchers' results show meaningful amounts of speed», comments Padgett. «It's not just 'let me prove the basic physics – they're also putting in place lots of the supporting technology that would be needed in practice to build a runnable system».

TEXT 49. ELECTROMAGNETIC GENERATION OF POWER

Electricity. Electricity is one of the basic forms of energy. Electricity is associated with electric charge, a property of certain elementary particles such as electrons and protons, two of the basic particles that make up the atoms of all ordinary matter. Electric charges can be stationary, as in static electricity, or moving, as in an electric current.
Electrical activity takes place constantly everywhere in the universe. Electrical forces hold molecules together. The nervous systems of animals work by means of weak electric signals transmitted between neurons (nerve cells). Electricity is generated, transmitted, and converted into heat, light, motion, and other forms of energy through natural processes, as well as by devices built by people.
Electricity can be generated in many ways and from many different sources. It can be sent over long distances. Electricity can also be converted into other forms of energy, and it can be stored. Electricity takes a part in nearly every aspect of modern technology. Electricity provides light, heat, and mechanical power. It makes telephones, computers, televisions, and countless other necessities and luxuries possible.

Electric current. An electric current is a movement of charge. When two objects with different charges touch and redistribute their charges, an electric current flows from one object to the other. If two objects are connected by a material that lets charge flow easily, such as a copper wire, then an electric current flows from one object to the other through the wire. Current that flows in one direction only is called direct current. Current that flows back and forth, reversing direction again and again, is called alternating current. Direct current, which is used in most battery-powered devices, is easier to understand than alternating current. A flow of direct current starts from a battery or generator, passes through resistances, meters, motors and so on and finally returns to its starting point. A direct current is used in the electrical system of an automobile and an airplane, in the tram, telegraph, telephone, in industry, etc. Alternating current is used in most devices that are plugged in to electrical outlets in buildings. Other properties that are used to quantify and compare electric currents are the voltage (also called electromotive force) and the resistance of the conductor to the passage of the current. The amount of current, voltage, and resistance in any circuit are all related through an equation called Ohm's law.
Conductors are materials that allow an electric current to flow through them easily. Most metals are good conductors. A good conductor is one that has low resistance. Silver is the best conductor and copper is the second best. Electric wires are usually made of copper, which is less expensive than silver.

Substances that do not allow electric current to flow through them are called insulators, nonconductors. A good insulator has a very high resistance. Rubber, glass, and air are common insulators. Electricians wear rubber gloves so that electric current will not pass from electrical equipment to their bodies. There are several different devices that can supply the voltage necessary to generate an electric current. The two most common sources are generators and electrolytic cells.

Electric circuits. This illustration shows the electric circuit used in a simple flashlight. Current, provided by a battery, flows through a wire, into a bulb, and through another wire back to the battery. As the current flows through a tiny wire inside the bulb (the filament), it heats and glows.

All electric circuit is a pathway through which the electric current can flow. A simple circuit consists of a power source, two conducting wires, each one attached to a terminal of the source and a device through which electricity can flow. This device is called a load and it's attached to the wires. If all the parts are properly connected, the current flows and the bulb lights up.
There can be a switch on one of the connecting wires. A flashlight is an example of such a circuit. When the switch is open, the connection is broken, electric current cannot flow through the circuit, and the bulb does not light. When the switch is closed, current flows and the bulb lights.
The bulb filament may burn out if too much electric current flows through it. To prevent this a fuse or circuit breaker may be placed in the circuit. When too much current flows through the fuse, a wire in the fuse heats up and melts, thereby breaking the circuit and stopping the flow of current.
The part of an electric circuit other than the source of electric current is called the load. The load includes all devises placed in the circuit, such as lights, electro motors, heaters or speakers. It also includes the connecting wires, as well as switches, fuses, and other devices. The load forms a continuous conducting path between the terminals of the current source.
There are two basic ways in which the parts of a circuit are arranged. One arrangement is called a series circuit, and the other is called a parallel circuit.

Measuring electric current

Electric current is measured in units called amperes (amp). If 1 coulomb of charge flows past each point of a wire every second, the wire is carrying a current of 1 amp. If 2 coulombs flow past each point in a second, the current is 2 amp.
Voltage.When the two terminals of a battery are connected by a conductor, an electric current flows through the conductor. One terminal continuously sends electrons into the conductor, while the other continuously receives electrons from it. The current flow is caused by the voltage, or potential difference, between the terminals. The more terminals are giving up and receiving electrons, the higher the voltage. Voltage is measured in units called volts. Another name for a voltage produced by a source of electric current is electromotive force.
Resistance.A conductor allows an electric current to flow through it, but it does not permit the current to flow with perfect freedom. Collisions between the electrons and the atoms of the conductor interfere with the flow of electrons. This phenomenon is known as resistance. Resistance is measured in units called ohms. The symbol for ohms is the Greek letter omega, Ω.
The resistance of a piece of wire depends on its length, and its cross-sectional area, or thickness. The longer the wire is, the greater its resistance. If one wire is twice as long as a wire of identical diameter and material, the longer wire offers twice as much resistance as the shorter one. A thicker wire, however, has less resistance, because a thick wire offers more room for an electric current to pass through than a thin wire does. Scientists describe this relationship between resistance, length, and area by saying that resistance is proportional to length and inversely proportional to cross-sectional area.
Usually, the higher the temperature of a wire, the greater its resistance. The resistance of some materials drops to zero at very low temperatures. This phenomenon is known as superconductivity.

Ohm's Law.The relationship between current, voltage, and resistance is given by Ohm's law. This law states that the amount of current passing through a conductor is directly proportional to the voltage across the conductor and inversely proportional to the resistance of the conductor. Ohm's law can be expressed as an equation, $V = IR$, where V is the difference in volts between two locations (called the potential difference), I is the amount of current in amperes that is flowing between these two points, and R is the resistance in ohms of the conductor between the two locations of interest. If any two of the quantities are known, the third can be calculated.
Under normal conditions, resistance is constant in conductors made of metal. If the voltage is raised to 220 in the example above, then R is still 11. The current I will be doubled, however, since $I = V/R = 220/11 = 20$ amp.

Electromagnetic generation of power

Electrical energy can be produced through a number of methods. Common methods include the use of light, pressure, heat, chemical and electromagnetic induction. Of this processes, electromagnetic induction is most responsible for the generation of the majority of the electrical power used by humans. Virtually all mechanical devices (generators and alternators) that produce electrical power employ the process of electromagnetic induction. The use of light, pressure, heat, and chemical sources for electrical power is found on aircraft but produce a minimal amount of all the electrical power consumed during a typical flight.
Electromagnetic induction is the process of producing a voltage (EMF) by moving a magnetic field in relationship to a conductor. As shown in figure, when a conductor is moved through a magnetic field, an EMF is produced in conductor. If a complete circuit is connected to the conductor, the voltage also produces a current flow.
It is the relative motion between a conductor and a magnetic field that caused current to flow in conductor. Either the conductor or magnet can be moving or stationary. When a magnet and its field are moved through a coiled conductor, a DC voltage with a specific polarity is produced. The polarity of this voltage depends on the direction in which the magnet is moved and position of the north and south pole of magnetic field.
Transformers
One of the great advantage in the use of the alternating current is ease with which the voltage may be changed by means of a relatively simple device known transformers. Although there are many different types of transformers, and a great variety of different applications, the principles of action are the same in each case.
The basic arrangement consists of a laminated iron core forming a closed magnetic circuit on which two separate windings are mounted. One winding, called primary, is connected to the AC supply, and other winding, the secondary, produces a voltage which can have any desired value.
Transformers provide us with a means of stepping up or down an AV voltage. For step-up transformer the secondary voltage will be greater than the primary. For step-down transformer the secondary voltage will be less than the primary. The amount of voltage is proportional to the number of turns in coil and to the rate at which the magnetic field varies. With a normal AC supply connected to the primary, the field changes at a uniform rate throughout each cycle and a voltage appears in secondary.

Rectifier. Rectifier is an electronic device for converting alternating current from the mains into direct current, necessary for computer circuits. All rectifiers operate on the principle of one-way conductivity of a rectifying diode. One-way conductivity means

that the rectifying diode conduct current in one direction and does not conduct current in the opposite direction.
All rectifiers consist of three main parts:
(1) Power transformer, which is connected to the mains,
(2)Rectifying diode,
(3)Load.

There are two main types of rectifiers. The first type is called half-wave rectifier, the second type is called full-wave rectifier. In a half-wave rectifier the secondary winding of the power transformer does not have any center tap and the frequency of pulsations at the output is fifty cycles per second. In a full-wave rectifier the secondary winding of the power transformer has a centre tap, which is grounded, and there are two rectifying diodes. The pulsations frequency at a full-wave rectifier is one hundred cycles per second, which is much easier to filter out.

During the first half-cycle of the AC voltage, the electromotive force (EMF), developed in the secondary winding of the power transformer, drives the current from the ground to the rectifying diode. In this direction the diode conducts and the current flows through the load. During the second half-cycle the electromotive force changes for the opposite and drives the current from the diode to the ground. In this direction the diode does not conduct and no current flows through the load.

The frame of reference, used for plotting the functional dependence of current from time is called the rectangular frame of reference. It consists of the origin and two axis- the axis of the variable (horizontal) and the axis of the function (vertical).
Transistors

The transistor is a semiconductor devise for the amplification of electric signals. The transistor of the greatest importance at present is the junction triode. This transistor contains three district regions of semiconductor, each heaving an ohmic lead. A junction transistor can be regarded as composed of two p-n junctions separated by a thin base region. The left hand junction is called the emitter, the right hand side- the collector. The p-n emitter-base junction is forward biased while the p-n collector-base junction is reverse-biased.

The emitter acts as an injecting contact and injects electrons into the base region under the influence of very small emitter signal. There they diffuse until are caught by the collector field. The collector circuit has a much higher impedance and voltage level then those of the emitter circuit. The transfer of charge from the low-impedance emitter to the higher-impedance collector circuit yields power amplification. There are two types of transistors based upon their structure, the n-p-n and the p-n-p. Their modes of action are similar; the roles of electrons and holes are interchanged in these two arrangements.

Amplifier. Amplifier is an electronic device for stepping up power of the signal. All amplifiers operate on the principle of controlling very large amount of output powerby very small amounts of input power, applied to the control electrode. Amplification factor of an amplifier is calculated as the ratio of its output power to input power. There are two main types of amplifiers: 1) Vacuum tube amplifiers, and 2) Transistor, or solid state, amplifier.

Vacuum tube amplifier consists of plate, control grid, cathode. Control grid controls current flowing through the tube. Cathode emits electrons. Filament heats the cathode, enabling the process of electronic emission. By their nature vacuum tubes are high voltage devices because voltages are high, but current are low.

Transistor amplifier consists of collector, base and emitter. Base controls current flowing through the transistor. Emitter emits electrons. Collector collects electrons, arriving from emitter. By their nature transistors are current device because currents are high, but voltages are low.

TEXT 50. DEEP BLUE AND BLUE GENE

Deep Blue

On May 11, 1997, an IBM computer called IBM ® Deep Blue ® beat the world chess champion after a six-game match: two wins for IBM, one for the champion and three draws. The match lasted several days and received massive media coverage around the world. It was the classic plot line of man vs. machine. Behind the contest, however, was important computer science, pushing forward the ability of computers to handle the kinds of complex calculations needed to help discover new medical drugs; do the broad financial modeling needed to identify trends and do risk analysis; handle large database searches; and perform massive calculations needed in many fields of science.

Since the emergence of artificial intelligence and the first computers in the late 1940s, computer scientists compared the performance of these "giant brains" with human minds, and gravitated to chess as a way of testing the calculating abilities of computers. The game is a collection of challenging problems for minds and machines, but has simple rules, and so is perfect for such experiments.

Over the years, many computers took on many chess masters, and the computers lost.

IBM computer scientists had been interested in chess computing since the early 1950s. In 1985, a graduate student at Carnegie Mellon University, Feng-hsiung Hsu, began working on his dissertation project: a chess playing machine he called ChipTest. A classmate of his, Murray Campbell, worked on the project, too, and in 1989, both were hired to work at IBM Research. There, they continued their work with the help of other computer scientists, including Joe Hoane, Jerry Brody and C. J. Tan. The team named the project Deep Blue. The human chess champion won in 1996 against an earlier version of Deep Blue; the 1997 match was billed as a "rematch."

The champion and computer met at the Equitable Center in New York, with cameras running, press in attendance and millions watching the outcome. The odds of Deep Blue winning were not certain, but the science was solid. The IBMers knew their machine could explore up to 200 million possible chess positions per second. The chess grandmaster won the first game, Deep Blue took the next one, and the two players drew the three following games. Game 6 ended the match with a crushing defeat of the champion by Deep Blue.

The match's outcome made headlines worldwide, and helped a broad audience better understand high-powered computing. The 1997 match took place not on a standard stage, but rather in a small television studio. The audience watched the match on television screens in a basement theater in the building, several floors below where the match was actually held. The theater seated about 500 people, and was sold out for each of the six games. The media attention given to Deep Blue resulted in more than three billion impressions around the world.

Deep Blue had an impact on computing in many different industries. It was programmed to solve the complex, strategic game of chess, so it enabled researchers to explore and understand the limits of massively parallel processing. This research gave developers insight into ways they could design a computer to tackle complex problems in other fields, using deep knowledge to analyze a higher number of possible solutions. The architecture used in Deep Blue was applied to financial modeling, including marketplace trends and risk analysis; data mining—uncovering hidden relationships

and patterns in large databases; and molecular dynamics, a valuable tool for helping to discover and develop new drugs.
Ultimately, Deep Blue was retired to the Smithsonian Museum in Washington, DC, but IBM went on to build new kinds of massively parallel computers such as IBM Blue Gene ®. The Deep Blue project inspired a more recent grand challenge at IBM: building a computer that could beat the champions at a more complicated game, *Jeopardy!*.
Over three nights in February 2011, this machine—named Watson—took on two of the all-time most successful human players of the game and beat them in front of millions of television viewers. The technology in Watson was a substantial step forward from Deep Blue and earlier machines because it had software that could process and reason about natural language, then rely on the massive supply of information poured into it in the months before the competition. Watson demonstrated that a whole new generation of human - machine interactions will be possible.

In 1999, IBM developed the Deep Computing Institute built on its experience with Deep Blue. The institute aimed to explore and solve large, complex technological problems through deep computing—using large-scale advanced computational methods applied to large data sets. Deep computing provides business decision makers with the ability to analyze and develop solutions to these very difficult problems.

The power inside the machine
The Deep Blue computer was a 32-node IBM RS/6000® SP high-performance computer, which used IBM POWER2 Super Chip processors, the single-chip implementation of the POWER2 processor. Each node employed a single microchannel card containing eight dedicated VLSI chess processors, for a total of 256 processors working in tandem. The Deep Blue programming code was written in C and ran under the IBM AIX® operating system.
Data mining
Deep computing has been applied to many areas, including data mining. Most business enterprises around the world have accumulated massive databases containing valuable information about their customers, sales, competitors and products. Deep computing can be used to help discover hidden relationships and patterns in large databases using the tremendous speed and capacity of massively parallel supercomputers. This can give business leaders information to help them make the right decisions to improve efficiencies, increase revenue and build customer loyalty.
Financial modeling
Financial risk assessment is another area that can be assisted by deep computing. A wide variety of statistical methods can be used to help assess portfolio risk and predict future equity values. Typically, these modeling applications require a rapid assessment of value and risk associated with a large number of stocks and portfolios—similar to the assessments which must be made in a chess game. Because the evaluations are largely independent of each other, parallel processing is uniquely qualified for the job. Deep computing can enable users to visualize and capitalize on trends to help offer a significant advantage in the marketplace.
Molecular dynamics
Molecular dynamics is used within the pharmaceutical industry to discover and develop new drugs. Analyzing compound interactions on a molecular level requires massive amounts of processing and computational power. By creating a special purpose chip that can specifically address the complexities of molecular dynamics, a system can be

designed that can quickly and efficiently analyze the interactions between atoms and molecules pertinent to the design of pharmaceutical compounds. Deep computing can help cut the development time for drugs dramatically and reduce costs substantially.

Blue Gene

Over the past 100 years, high-end IBM machines have consistently ranked among the most powerful on the planet. When IBM ® Blue Gene ® was unveiled in 2004, it was both the most powerful supercomputer and the most efficient, consuming only a fraction of the energy and floor space of any other supercomputer.

Blue Gene – a super computer
The introduction of Blue Gene ushered in a new era of high-performance computing, continuing a long IBM tradition. Developed and manufactured in collaboration with the US Department of Energy's Lawrence Livermore National Laboratory in California, Blue Gene was originally built to help biologists observe the invisible processes of protein folding and gene development. Hence the name.

From an engineering standpoint, the guiding principle was simple but innovative: do more with less. When a small team of IBM engineers and scientists began developing the prototype for the Blue Gene ®/L in 1999, they were looking to make a radical departure from how supercomputers were being designed at the time. For decades, supercomputers had defined the state-of-the-art in high-performance computing and communications; but if their architecture stayed the same, the machines would soon require football field-sized buildings to house them. Worse, they would use enough electricity in one year to power a mid-size town, and they would require yet more power to prevent them from overheating.
Enter Blue Gene and a US$100 million, five-year development effort by IBM. Designed to harness thousands of low-power, cooler-running processors, the first IBM Blue Gene/L was built at the IBM lab in Rochester, Minnesota. On September 29, 2004, the new machine surpassed NEC's Earth Simulator as the fastest computer in the world.
Whereas IBM's previous champ, IBM Deep Blue ®, had 32 processors and could calculate about 200 million potential chess moves per second in its historic six-game victory over a chess grand master in 1997, Blue Gene/L used 131,000 processors to routinely handle 280 trillion operations every second. A single scientist with a calculator would have to work nonstop for 177,000 years to perform the operations that Blue Gene could do in one second. The Blue Gene/L was also noteworthy for its choice of operating system, Linux ®, and its support for the development of open source applications.
Perhaps more important than its speed was the way Blue Gene/L revolutionized the economics of supercomputing, due to its small size and power efficiency. Each Blue Gene rack contained 1024 dual-processor nodes in a footprint that dramatically reduced floor space. The processors were engineered to be so tiny that 32 of them fit on a single microchip.
Blue Gene/L was a landmark in supercomputing, but its real work had only begun. IBM researchers then began to explore the wide range of applications that would run on the system. The computer's speed and expandability enabled universities, governments and commercial research labs to address a wide range of problems that had simply been too

complex to tackle. And leaders could also make more informed decisions—not just in life sciences, but also in astronomy, climate, drug development, cosmology and many other fields.
In September 2009, United States President Barack Obama recognized IBM and the Blue Gene family of supercomputers with the National Medal of Technology and Innovation, the country's most prestigious award given to leading innovators for technological achievement. And the influence of the Blue Gene/L energy-efficient design and computing model can be seen today across the information technology industry.
Blue Gene systems have helped map the human genome, investigated medical therapies, simulated radioactive decay, replicated brain power, flown airplanes, pinpointed tumors, predicted climate trends and identified fossil fuels. Much more progress lies ahead. When Blue Gene ®/P, the family's second generation, was unveiled in 2007, it nearly tripled the performance of Blue Gene/L, immediately becoming the most energy-efficient and space-saving computing package built, at that point in time.
On February 8, 2011, IBM announced the 10-petaflop Blue Gene/Q supercomputer "Mira," in collaboration with the US Department of Energy's (DOE) Argonne National Laboratory located near Chicago, Illinois. Mira was designed to enable significant advances in designing ultra-efficient electric car batteries, understanding global climate change, exploring the evolution of our universe and more. IBM continues to explore the cutting edge of high-performance computing as part of its ongoing quest to change the way research and science can be done.
Today, 17 of the top 20 most energy-efficient supercomputers in the world are built on IBM high-performance computing technology, according to the latest supercomputing "Green500 List," including the Blue Gene/Q, which was named the "Greenest Supercomputer in the World" by Green500.org in November 2010. And other Blue Gene machines, with similar architectures, have held many of the top spots on successive TOP500 lists of the world's fastest computers.
In the past, increases in the performance and speed of a supercomputer meant increases in space requirements and energy consumption as well. Then came the IBM ® Blue Gene/L ® supercomputer, a compact machine that offered unprecedented performance in an energy efficient design.

Technicians at Lawrence Livermore National Laboratory in California install the world's most powerful computer, an IBM Blue Gene/L supercomputer.
Since its introduction in 2004, the Blue Gene line of supercomputers has become pervasive, impacting numerous industries and diverse projects. Its speed and expandability have enabled business and science to address a wide range of complex problems and make more informed decisions—not just in the life sciences, but also in astronomy, climate, simulations, modeling and many other areas. Blue Gene systems have helped map the human genome, investigated medical therapies, simulated radioactive decay, replicated brain power, flown airplanes, pinpointed tumors, predicted climate trends and identified fossil fuels—all for less time and money than would have been required to physically complete these tasks.

In 2004, the IBM ® Blue Gene ® computer became the fastest supercomputer in the world, delivering unprecedented performance in a compact, low-power design. Using Linux ® software and embedded system-on-a-chip (SoC) technology, the Blue Gene supercomputer radically reduced the size and cost of highly scalable systems, while dramatically increasing performance. Five years later, the Blue Gene project was awarded the National Medal of Technology and Innovation by US President Barack Obama.

The IBM Blue Gene/L computer was developed through a collaboration with Lawrence Livermore National Laboratory (LLNL) located in Livermore, California. When the Blue Gene/L supercomputer was announced in 2004, it had a theoretical peak performance of 360 TFLOPS (one trillion floating-point operations per second) and scored over 280 TFLOPS sustained on the Linpack benchmark. On September 29, 2004, it surpassed NEC's Earth Simulator as the fastest computer in the world.

After an upgrade in 2007, the performance of the Blue Gene/L computer increased to 478 TFLOPS sustained and 596 TFLOPS peak. In that same year, Blue Gene/P, the second generation of the Blue Gene supercomputer, was unveiled. It nearly tripled the performance of the Blue Gene/L computer, and became the most energy-efficient and space-saving computing package ever built.

Then, in February 2011, IBM's announced the next-generation Blue Gene supercomputer, nicknamed "Mira," for the Argonne National Laboratory located outside of Chicago, Illinois. Mira is an unprecedented 10-petaflop Blue Gene/Q supercomputer, and is expected to be operational in 2012, and made available to scientists from industry, academia and government research facilities around the world.

The Blue Gene design uses many small, low-power embedded chips, each connected through five specialized networks inside the system. For example, a Blue Gene system with 65,000 nodes, are interconnected as a 64 x 32 x 32 three-dimensional torus, making it easy to build large systems. The design is modular, composed of "racks" that can be added as requirements grow.

In addition to speed and scalability, Blue Gene supercomputers delivered breakthroughs in energy efficiency. With the creation of Blue Gene computers, IBM dramatically shrank the physical size and energy needs of a computing system whose processing speed would have required a dedicated power plant capable of generating power to thousands of homes.

The influence of the Blue Gene supercomputer's energy-efficient design and computing model can be seen throughout the IT industry. Today, 17 of the top 20 most energy-efficient supercomputers in the world are built on IBM high-performance computing technology, including the Blue Gene/Q, which was named the "Greenest Supercomputer in the World," according to the November 2010 Supercomputing "Green500 List" announced by Green500.org.

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