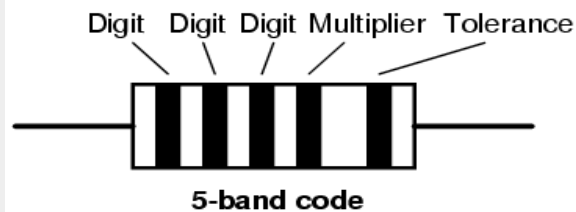


Color	Digit	Multiplier	Tolerance (%)
Black	0	10 ⁰ (1)	
Brown	1	10 ¹	1
Red	2	10 ²	2
Orange	3	10 ³	
Yellow	4	10 ⁴	
Green	5	10 ⁵	0.5
Blue	6	10 ⁶	0.25
Violet	7	10 ⁷	0.1
Grey	8	10 ⁸	
White	9	10 ⁹	
Gold		10 ⁻¹	5
Silver		10 ⁻²	10
(none)			20

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



Example.1



A resistor colored Yellow-Violet-Orange-Gold would be 47 kΩ with a tolerance of +/- 5%.

Example.2



Electric Power

Electric Power

Electric power is the rate of energy consumption in an electrical circuit.
The electric power is measured in units of watts.

- Electric power definition
- Electric power calculation
- Power of AC circuits
- Power factor
- Power calculator

Electric power definition

The electric power P is equal to the energy consumption E divided by the consumption time t :

$$P = \frac{E}{t}$$

P is the electric power in watt (W).

E is the energy consumption in joule (J).

t is the time in seconds (s).

Example

Find the electric power of an electrical circuit that consumes 120 joules for 20 seconds.

Solution:

$$E = 120\text{J}$$

$$t = 20\text{s}$$

$$P = E / t = 120\text{J} / 20\text{s} = 6\text{W}$$

Electric power calculation

$$P = V \cdot I$$

or

$$P = I^2 \cdot R$$

or

$$P = V^2 / R$$

P is the electric power in watt (W).

V is the voltage in volts (V).

I is the current in amps (A).

R is the resistance in ohms (Ω).

Power of AC circuits

The formulas are for single phase AC power.

For 3 phase AC power:

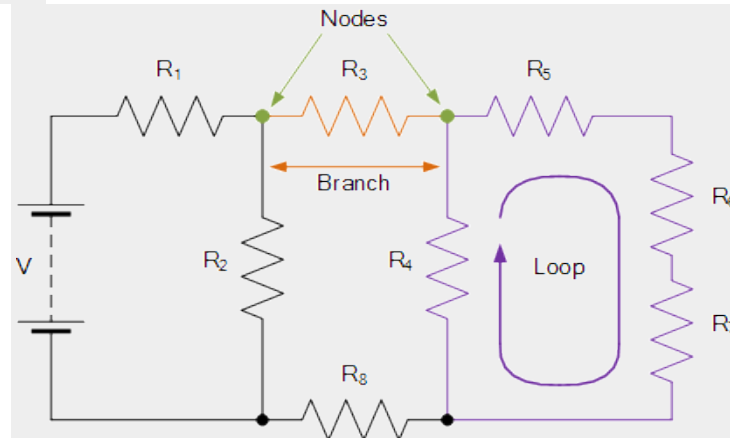
When line to line voltage (VL-L) is used in the formula, multiply the single phase power by square root of 3 ($\sqrt{3}=1.73$).

When line to zero voltage (VL-0) is used in the formula, multiply the single phase power by 3.

Note that: Components are said to be connected in Series if the same current flows through component.

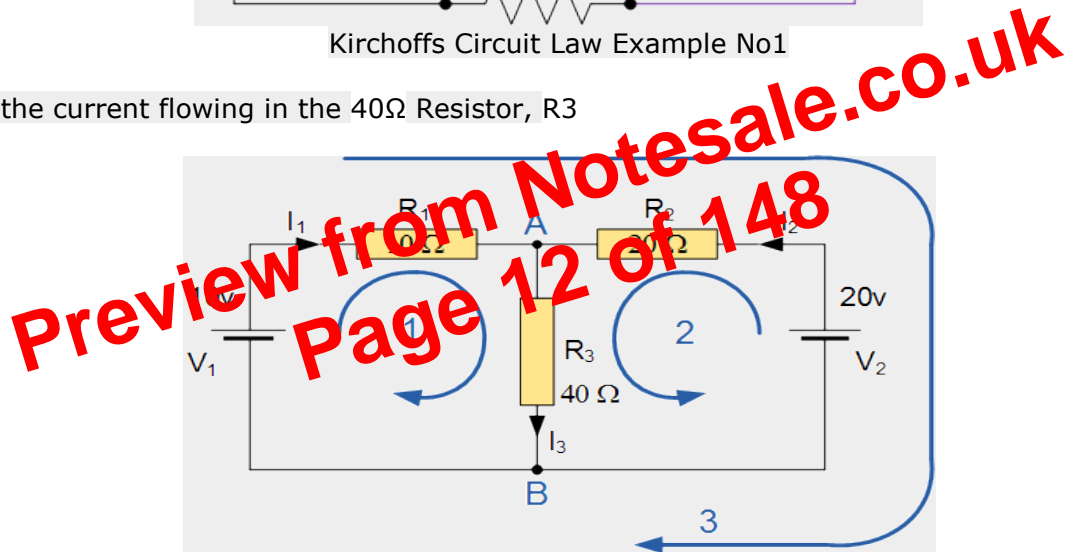
Components are said to be connected in Parallel if the same voltage is applied across them.

A Typical DC Circuit



Kirchoffs Circuit Law Example No1

Find the current flowing in the 40Ω Resistor, R_3



The circuit has 3 branches, 2 nodes (A and B) and 2 independent loops. Using Kirchoffs Current Law, KCL the equations are given as;

At node A : $I_1 + I_2 = I_3$

At node B : $I_3 = I_1 + I_2$

Using Kirchoffs Voltage Law, KVL the equations are given as;

Loop 1 is given as : $10 = R_1 \times I_1 + R_3 \times I_3 = 10I_1 + 40I_3$

Loop 2 is given as : $20 = R_2 \times I_2 + R_3 \times I_3 = 20I_2 + 40I_3$

Loop 3 is given as : $10 - 20 = 10I_1 - 20I_2$

As I_3 is the sum of $I_1 + I_2$ we can rewrite the equations as;

Eq. No 1 : $10 = 10I_1 + 40(I_1 + I_2) = 50I_1 + 40I_2$

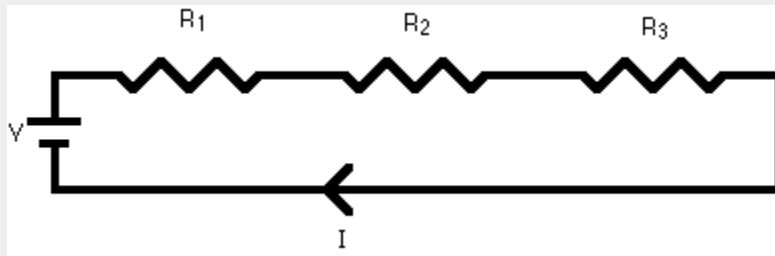
Eq. No 2 : $20 = 20I_2 + 40(I_1 + I_2) = 40I_1 + 60I_2$

Resistors in Series

Series circuits

A series circuit is a circuit in which resistors are arranged in a chain, so the current has only one path to take. The current is the same through each resistor. The total resistance of the circuit is found by simply adding up the resistance values of the individual resistors:

Equivalent resistance of resistors in series : $R = R_1 + R_2 + R_3 + \dots$



A series circuit is shown in the diagram above. The current flows through each resistor in turn. If the values of the three resistors are:

$R_1 = 8\ \Omega$, $R_2 = 8\ \Omega$, and $R_3 = 4\ \Omega$, the total resistance is $8 + 8 + 4 = 20\ \Omega$.

With a 10 V battery, by $V = IR$ the total current in the circuit is:

$I = V/R = 10/20 = 0.5\ \text{A}$. The current through each resistor would be 0.5 A.

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Diode

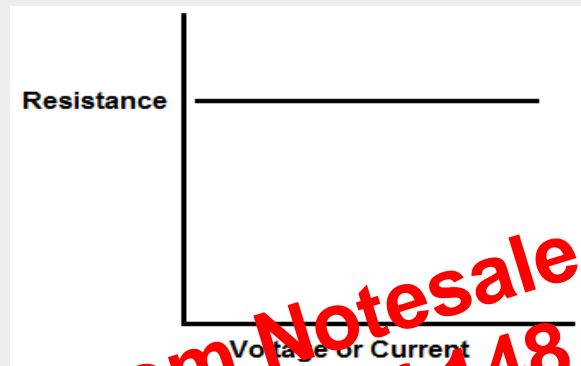
Diode resistance is the resistance which a diode offers in a circuit.

Just like a resistor or any other load in a circuit, a diode offers resistance in a circuit.

Unlike resistors, though, diodes are not linear devices. This means that the resistance of diodes does not vary directly and proportional to the amount of voltage and current applied to them. It changes parabolically.

Below is a graph of the resistance of a resistor or any other linear load:

Resistor Resistance Graph



As you can see from the graph of a resistor, the resistance is constant. It does not vary when either voltage or current is changed in a circuit. When you have a 10K Ω resistor in a circuit, it will offer 10K Ω resistance in the circuit regardless of the voltage or current of the circuit.

The resistance can be calculated by the formula, $R=V/I$.

Diodes, however, do not work like this. Diodes are not linear devices; they are nonlinear. Since diodes are semiconductor devices doped with impurities, they do not function like linear devices. Their resistance changes based on the voltage and current that falls across them. Resistance is not constant.

And diode resistance does not change in a linear sense, but in a parabolic sense.

Below is a graph of diode resistance:

Diode Resistance Graph

Chapter – 3. Electromagnet Magnetism

Magnetic Circuit

Magnetic circuit, closed path to which a magnetic field, represented as lines of magnetic flux, is confined. In contrast to an electric circuit through which electric charge flows, nothing actually flows in a magnetic circuit.

In a ring-shaped electromagnet with a small air gap, the magnetic field or flux is almost entirely confined to the metal core and the air gap, which together form the magnetic circuit. In an electric motor, the magnetic field is largely confined to the magnetic pole pieces, the rotor, the air gaps between the rotor and the pole pieces, and the metal frame. Each magnetic field line makes a complete unbroken loop. All the lines together constitute the total flux. If the flux is divided, so that part of it is confined to a portion of the device and part to another, the magnetic circuit is called parallel. If all the flux is confined to a single closed loop, as in a ring-shaped electromagnet, the circuit is called a series magnetic circuit.



In analogy to an electric circuit in which the current, the electromotive force (voltage), and the resistance are related by Ohm's law (current equals electromotive force divided by resistance), a similar relation has been developed to describe a magnetic circuit.

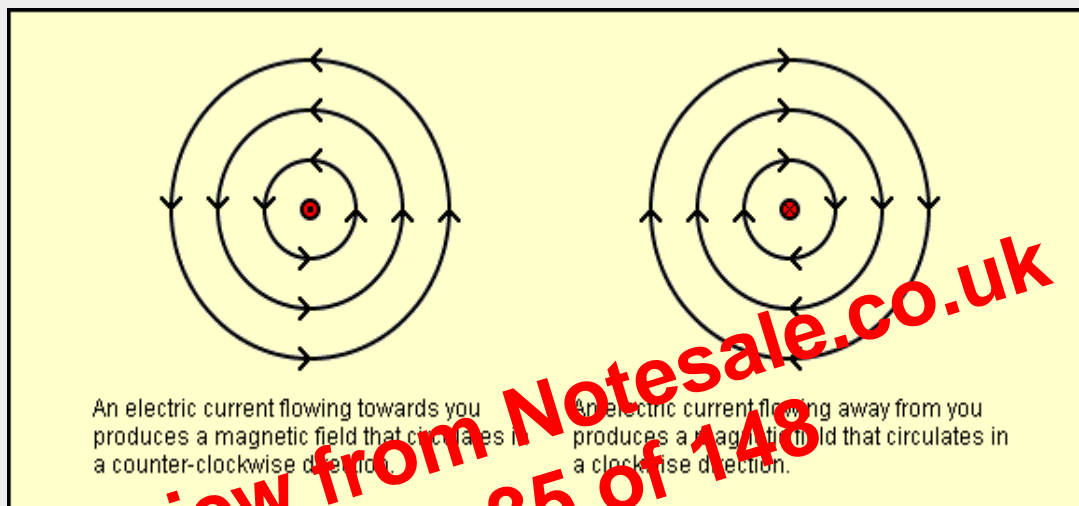
The magnetic flux is analogous to the electric current. The magnetomotive force, mmf, is analogous to the electromotive force and may be considered the factor that sets up the flux. The mmf is equivalent to a number of turns of wire carrying an electric current and has units of ampere-turns. If either the current through a coil (as in an electromagnet) or the number of turns of wire in the coil is increased, the mmf is greater; and if the rest of the magnetic circuit remains the same, the magnetic flux increases proportionally.

The reluctance of a magnetic circuit is analogous to the resistance of an electric circuit. Reluctance depends on the geometrical and material properties of the circuit that offer opposition to the presence of magnetic flux. Reluctance of a given part of a magnetic circuit is proportional to its length and inversely proportional to its cross-sectional area and a magnetic property of the given material called its permeability. Iron, for example, has an extremely high permeability as compared to air so that it has a comparatively small reluctance, or it offers relatively little opposition to the presence of magnetic flux. In a series magnetic circuit, the total reluctance equals the sum of the individual reluctances encountered around the closed flux path. In a magnetic circuit, in summary, the magnetic flux is quantitatively equal to the magnetomotive force divided by the reluctance.

Electromagnet

An electromagnet is a magnet that runs on electricity. Unlike a permanent magnet, the strength of an electromagnet can easily be changed by changing the amount of electric current that flows through it. The poles of an electromagnet can even be reversed by reversing the flow of electricity.

An electromagnet works because an electric current produces a magnetic field. The magnetic field produced by an electric current forms circles around the electric current, as shown in the diagram below:



If a wire carrying an electric current is formed into a series of loops, the magnetic field can be concentrated within the loops. The magnetic field can be strengthened even more by wrapping the wire around a core. The atoms of certain materials, such as iron, nickel and cobalt, each behave like tiny magnets. Normally, the atoms in something like a lump of iron point in random directions and the individual magnetic fields tend to cancel each other out. However, the magnetic field produced by the wire wrapped around the core can force some of the atoms within the core to point in one direction. All of their little magnetic fields add together, creating a stronger magnetic field.

As the current flowing around the core increases, the number of aligned atoms increases and the stronger the magnetic field becomes. At least, up to a point. Sooner or later, all of the atoms that can be aligned will be aligned. At this point, the magnet is said to be saturated and increasing the electric current flowing around the core no longer affects the magnetization of the core itself.

Figure 2: Effective Area of the Wire Loop at Different Rotational Angles

The Rate of Change of Φ , $d\Phi / dt$, is the largest at the zero points of the Waveform and is the smallest at the peaks of the Waveform, therefore the Induced E_{emf} is maximum at the zero points and minimum at the peaks, Figure 3. The Induced E_{emf} output by the Generator is an AC Voltage and its Waveform is shown in Figure 4.

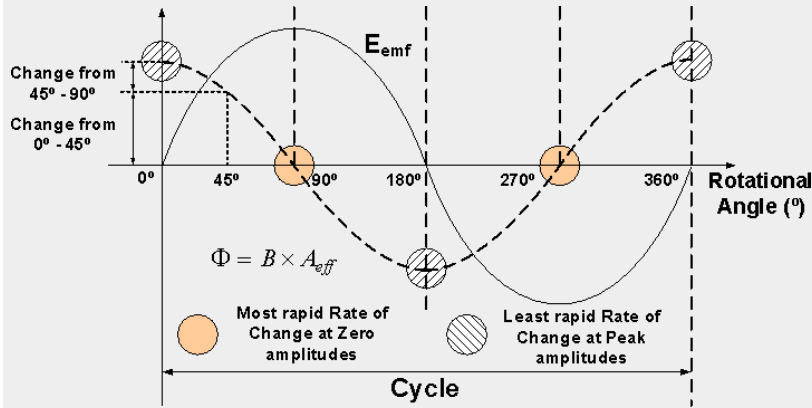
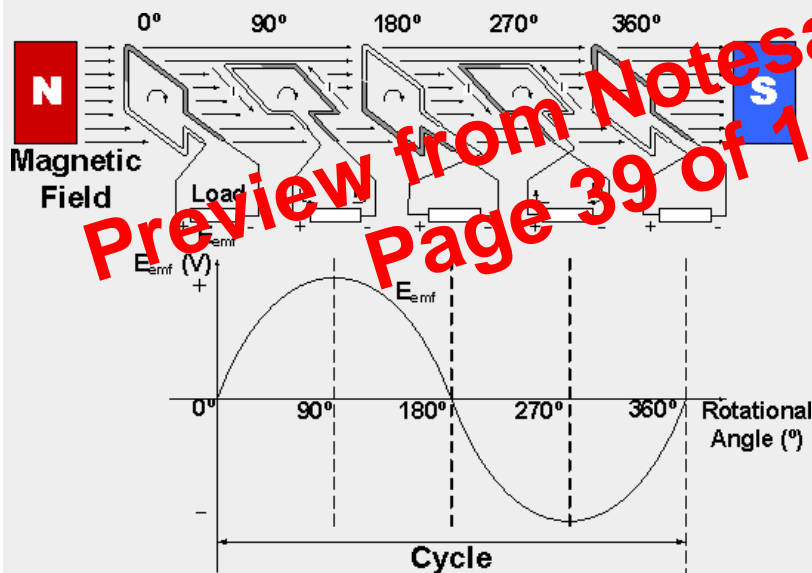


Figure 3: Different Rates of Change of the Magnetic Flux at Various Rotational Angles



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Transformer Principle

One of the main reasons that we use alternating AC voltages and currents in our homes and workplaces is that AC supplies can be easily generated at a convenient voltage, transformed (hence the name transformer) into much higher voltages and then distributed around the country using a national grid of pylons and cables over very long distances.

The reason for transforming the voltage to a much higher level is that higher distribution voltages implies lower currents for the same power and therefore lower I^2R losses along the networked grid of cables. These higher AC transmission voltages and currents can then be reduced to a much lower, safer and usable voltage level where it can be used to supply electrical equipment in our homes and workplaces, and all this is possible thanks to the basic Voltage Transformer.



A Typical Voltage Transformer

The voltage transformer can be thought of as an electrical component rather than an electronic component. A transformer basically is very simple static (or stationary) electro-magnetic passive electrical device that works on the principle of Faraday's law of induction by converting electrical energy from one value to another.

The transformer does this by linking together two or more electrical circuits using a common oscillating magnetic circuit which is produced by the transformer itself. A transformer operates on the principals of 'electromagnetic induction', in the form of Mutual Induction.

Mutual induction is the process by which a coil of wire magnetically induces a voltage into another coil located in close proximity to it. Then we can say that transformers work in the 'magnetic domain', and transformers get their name from the fact that they 'transform' one voltage or current level into another.

Transformers are capable of either increasing or decreasing the voltage and current levels of their supply, without modifying its frequency, or the amount of Electrical Power being transferred from one winding to another via the magnetic circuit.

A single phase voltage transformer basically consists of two electrical coils of wire, one called the 'Primary Winding' and another called the 'Secondary Winding'. For this tutorial we will define the 'primary' side of the transformer as the side that usually takes power, and the 'secondary' as the side that usually delivers power. In a single-phase voltage transformer the primary is usually the side with the higher voltage.

on its secondary winding with respect to the primary, it is called a Step-up transformer. When it is used to decrease the voltage on the secondary winding with respect to the primary it is called a Step-down transformer.

However, a third condition exists in which a transformer produces the same voltage on its secondary as is applied to its primary winding. In other words, its output is identical with respect to voltage, current and power transferred. This type of transformer is called an Impedance Transformer and is mainly used for impedance matching or the isolation of adjoining electrical circuits.

The difference in voltage between the primary and the secondary windings is achieved by changing the number of coil turns in the primary winding (N_P) compared to the number of coil turns on the secondary winding (N_S).

As the transformer is basically a linear device, a ratio now exists between the number of turns of the primary coil divided by the number of turns of the secondary coil. This ratio, called the ratio of transformation, more commonly known as a transformers turns ratio, (TR). This turns ratio value dictates the operation of the transformer and the corresponding voltage available on the secondary winding.

It is necessary to know the ratio of the number of turns of wire on the primary winding compared to the secondary winding. The turns ratio, which has no units, compares the two windings in order and is written with a colon, such as 3:1 (3-to-1). This means in this example, that if there are 3 volts on the primary winding there will be 1 volt on the secondary winding, 3 volts-to-1 volt. Then we can see that if the ratio between the number of turns changes the resulting voltages must also change by the same ratio, and this is true.

Transformers are all about ratios. The ratio of the primary to the secondary, the ratio of the input to the output, and the turns ratio of any given transformer will be the same as its voltage ratio. In other words for a transformer turns ratio = voltage ratio. The actual number of turns per wire on any winding is generally not important, just the turns ratio and this relationship is given as:

A Transformers Turns Ratio

$$\frac{N_P}{N_S} = \frac{V_P}{V_S} = n = \text{Turns Ratio}$$

Assuming an ideal transformer and the phase angles: $\Phi_P \equiv \Phi_S$

Note that the order of the numbers when expressing a transformers turns ratio value is very important as the turns ratio 3:1 expresses a very different transformer relationship and output voltage than one in which the turns ratio is given as: 1:3.

Transformer Basics Example No1

A voltage transformer has 1500 turns of wire on its primary coil and 500 turns of wire for its secondary coil. What will be the turns ratio (TR) of the transformer.

$$T.R. = \frac{N_P}{N_S} = \frac{\#Pri. Coils}{\#Sec. Coils} = \frac{1500}{500} = \frac{3}{1} = 3:1$$

$$E_{\text{rms}} = \frac{N\omega}{\sqrt{2}} \Phi_{\text{max}}$$

$$\Phi_{\text{max}} = \frac{E_{\text{rms}}}{N\omega} \times \sqrt{2} = \frac{2200}{480 \times 2\pi \times 50} \times \sqrt{2}$$

$$\therefore \Phi_{\text{max}} = 0.0206 \text{ Wb or } 20.6 \text{ mWb}$$

b). The cross-sectional area of the core.

$$\Phi_{\text{max}} = \beta \times A$$

$$\therefore A = \frac{\Phi_{\text{max}}}{\beta} = \frac{0.0206}{1.1} = 0.0187 \text{ m}^2$$

c). The secondary induced emf.

$$\therefore V_s = \frac{V_p N_s}{N_p} = \frac{2200 \times 90}{480} = 412.5 \text{ Volts}$$

Electrical Power in a Transformer

Another one of the transformer basics parameters is its power rating. Transformers are rated in Volt-amperes, (VA), or in larger units of Kilo Volt-amperes, (kVA). In an ideal transformer (ignoring any losses), the power available in the secondary winding will be the same as the power in the primary winding, they are constant wattage devices and do not change the power only the voltage to current ratio. Thus, in an ideal transformer the Power Ratio is equal to one (unity) as the voltage, V multiplied by the current, I will remain constant.

That is the electric power at one voltage/current level on the primary is transformed into electric power, at the same frequency, to the same voltage/current level on the secondary side. Although the transformer can step-up (or step-down) voltage, it cannot step-up power. Thus, when a transformer steps-up a voltage, it steps-down the current and vice-versa, so that the output power is always at the same value as the input power. Then we can say that primary power equals secondary power, (PP = PS).

Power in a Transformer

$$\text{Power}_{\text{Primary}} = \text{Power}_{\text{Secondary}}$$

$$P_{(\text{PRIM})} = P_{(\text{SEC})} = V_P I_P \cos\theta_P = V_S I_S \cos\theta_S$$

Where: Φ_P is the primary phase angle and Φ_S is the secondary phase angle.

Note that since power loss is proportional to the square of the current being transmitted, that is: I^2R , increasing the voltage, let's say doubling (2) the voltage would decrease the current by the same amount, (2) while delivering the same amount of power to the load and therefore reducing losses by factor of 4. If the voltage was increased by a factor of 10, the current would decrease by the same factor reducing overall losses by factor of 100.

Transformer Basics Efficiency

A transformer does not require any moving parts to transfer energy. This means that there are no friction or windage losses associated with other electrical machines. However, transformers do suffer from other types of losses called 'copper losses' and 'iron losses' but generally these are quite small.

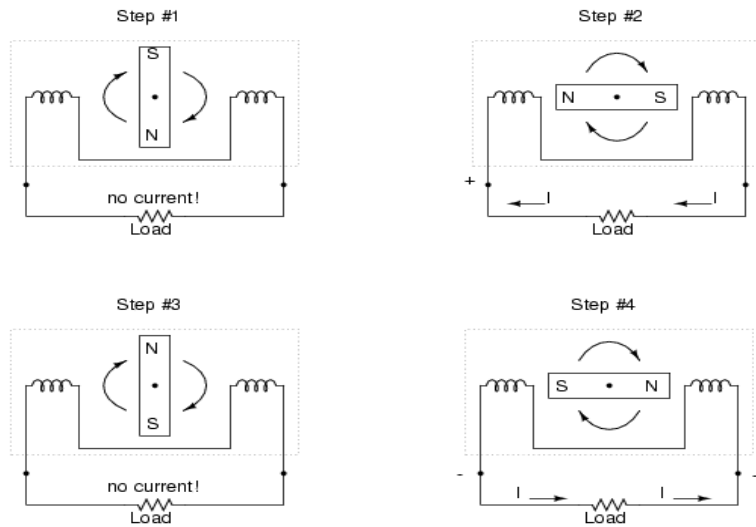
Copper losses, also known as I^2R loss is the electrical power which is lost in heat as a result of circulating the currents around the transformer's copper windings, hence the name. Copper losses represents the greatest loss in the operation of a transformer. The actual watts of power lost can be determined (in each winding) by squaring the amperes and multiplying by the resistance in ohms of the winding (I^2R).

Iron losses, also known as hysteresis is the lagging of the magnetic molecules within the core, in response to the alternating magnetic flux. This lagging (or out-of-phase) condition is due to the fact that it requires power to reverse magnetic molecules; they do not reverse until the flux has attained sufficient force to reverse them.

Their reversal results in friction, and friction produces heat in the core which is a form of power loss. Hysteresis within the transformer can be reduced by making the core from special steel alloys.

The intensity of power loss in a transformer determines its efficiency. The efficiency of a transformer is reflected in power (wattage) loss between the primary (input) and secondary (output) windings. Then the resulting efficiency of a transformer is equal to the ratio of the power output of the secondary winding, P_S to the power input of the primary winding, P_P and is therefore high.

An ideal transformer is 100% efficient because it delivers all the energy it receives. Real transformers on the other hand are not 100% efficient and at full load, the efficiency of a transformer is between 94% to 96% which is quite good. For a transformer operating with a constant voltage and frequency with a very high capacity, the efficiency may be as high as 98%. The efficiency, η of a transformer is given as:

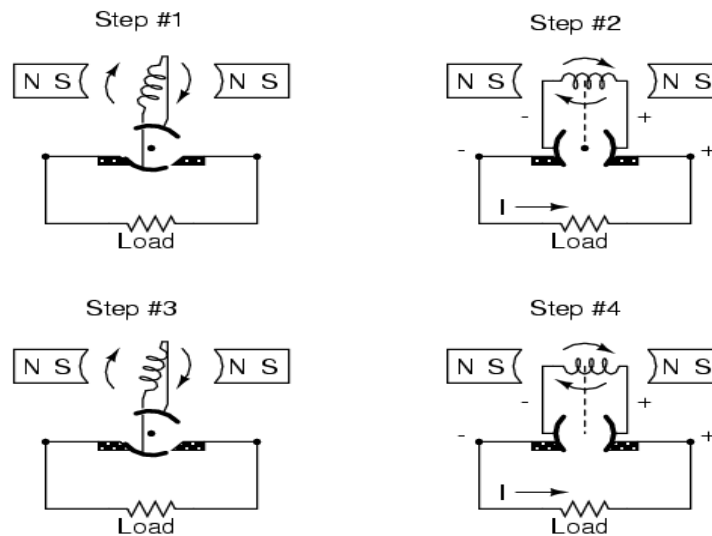


Alternator operation

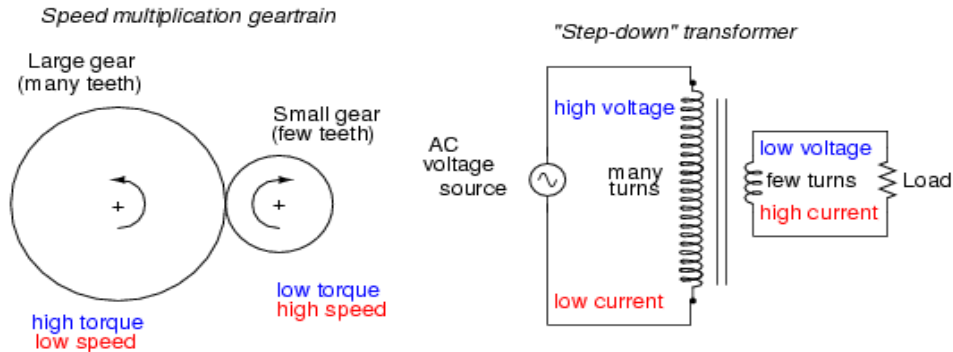
Notice how the polarity of the voltage across the wire coils reverses as the opposite poles of the rotating magnet pass by. Connected to a load, this reversing voltage polarity will create a reversing current direction in the circuit. The faster the alternator's shaft is turned, the faster the magnet will spin, resulting in an alternating voltage and current that switches directions more often in a given amount of time.

While DC generators work on the same general principle of electromagnetic induction, their construction is not as simple as their AC counterparts. With a DC generator, the coil of wire is mounted in the shaft where the magnet is on the AC alternator, and electrical connections are made to this spinning coil via stationary carbon 'brushes' contacting copper strips on the rotating shaft. All this is necessary to switch the coil's changing output polarity to the external circuit so the external circuit sees a constant polarity:

Figure below

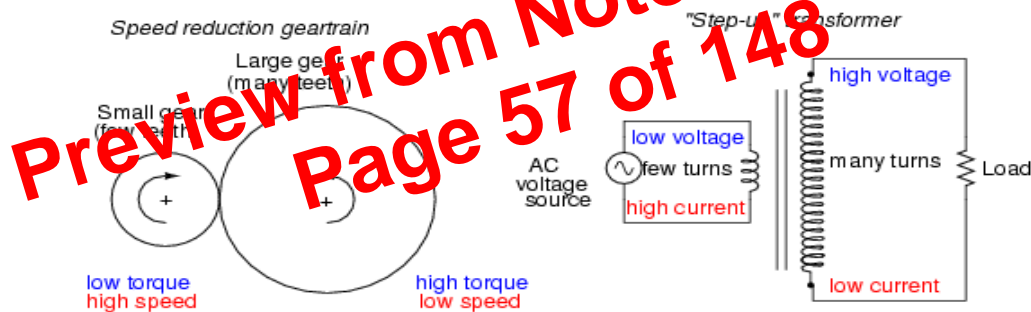


the ratio of primary to secondary turns. This relationship has a very close mechanical analogy, using torque and speed to represent voltage and current, respectively: Figure below



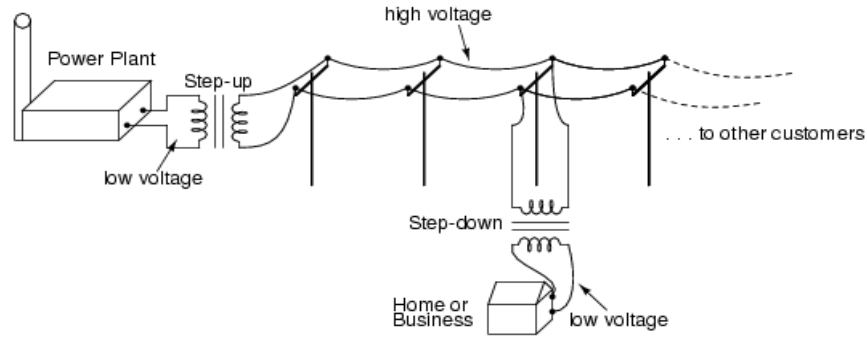
Speed multiplication gear train steps torque down and speed up. Step-down transformer steps voltage down and current up.

If the winding ratio is reversed so that the primary coil has less turns than the secondary coil, the transformer steps up the voltage from the source level to a higher level at the load: Figure below



Speed reduction gear train steps torque up and speed down. Step-up transformer steps voltage up and current down.

The transformer's ability to step AC voltage up or down with ease gives AC an advantage unmatched by DC in the realm of power distribution in figure below. When transmitting electrical power over long distances, it is far more efficient to do so with stepped-up voltages and stepped-down currents (smaller-diameter wire with less resistive power losses), then step the voltage back down and the current back up for industry, business, or consumer use.



Transformers enable efficient long distance high voltage transmission of electric energy.

Transformer technology has made long-range electric power distribution practical. Without the ability to efficiently step voltage up and down, it would be cost-prohibitive to construct power systems for anything but close-range (within a few miles at most) use.

As useful as transformers are, they only work with AC, not DC. Because the phenomenon of mutual inductance relies on changing magnetic fields, and direct current (DC) can only produce steady magnetic fields, transformers simply will not work with direct current. Of course, direct current may be interrupted (pulsed) through the primary winding of a transformer to create a changing magnetic field (as is done in automotive ignition systems to produce high-voltage spark plug power from a low-voltage DC battery), but pulsed DC is not that different from AC. Perhaps more than any other reason, this is why AC finds such widespread application in power systems.

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Chapter – 5. Circuit Analysis

Circuit Analysis

Solving a set of equations that represents a circuit is straightforward, if not always easy. However, developing that set of equations is not so easy. The two commonly taught methods for forming a set of equations are the node voltage (or nodal) method and the loop-current (or mesh) method. I will briefly describe each of these, and mention their benefits and disadvantages. I will end with a discussion of a third method, Modified Nodal Analysis, that has some unique benefits. Among its benefits is the fact that it lends itself to algorithmic solution -- the ultimate goal of these pages is to describe how to use a program for generating a set of equations representing the circuit that can be solved symbolically. If you are only interested in using that program you may go directly to the page describing SyCiSi.

Circuits discussed herein are simple resistive circuits with independent voltage and current sources. Dependent sources can be added in a straightforward way, but are not considered here.

Node Voltage Method

To apply the node voltage method to a circuit with n nodes (with m voltage sources), perform the following steps.

Select a reference node (usually ground).

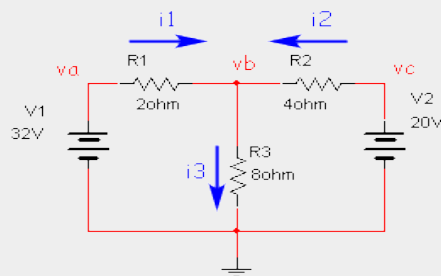
Name the remaining $n-1$ nodes and label a current through each passive element and each current source.

Apply Kirchoff's current law to each node not connected to a voltage source.

Solve the system of $n-1-m$ unknown voltages.

Example 1

Consider the circuit shown below



Steps 1 and 2 have already been applied. To apply step 3:

The construction of the rotor of the single phase induction motor is similar to the squirrel cage three phase induction motor. The rotor is cylindrical in shape and has slots all over its periphery. The slots are not made parallel to each other but are bit skewed as the skewing prevents magnetic locking of stator and rotor teeth and makes the working of induction motor more smooth and quieter. The squirrel cage rotor consists of aluminium, brass or copper bars. These aluminium or copper bars are called rotor conductors and are placed in the slots on the periphery of the rotor. The rotor conductors are permanently shorted by the copper or aluminium rings called the end rings. In order to provide mechanical strength these rotor conductor are braced to the end ring and hence form a complete closed circuit resembling like a cage and hence got its name as "squirrel cage induction motor". As the bars are permanently shorted by end rings, the rotor electrical resistance is very small and it is not possible to add external resistance as the bars are permanently shorted. The absence of slip ring and brushes make the construction of single phase induction motor very simple and robust.

Working Principle of Single Phase Induction Motor

NOTE: We know that for the working of any electrical motor whether its ac or dc motor, we require two fluxes as, the interact of these two fluxes produced the required torque, which is desired parameter for any motor to rotate.

When single phase ac supply is given to the stator winding of single phase induction motor, the alternating current starts flowing through the stator or main winding. This alternating current produces an alternating flux called main flux. This main flux also links with the rotor conductors and induce the rotor conductors. According to the Faraday's law of electromagnetic induction, emf gets induced in the rotor. As the rotor circuit is closed one so, the current starts flowing in the rotor. This current is called the rotor current. This rotor current produces its own flux called rotor flux. Since this flux is produced due to induction principle so, the motor working on this principle got its name as induction motor. Now there are two fluxes one is main flux and another is called rotor flux. These two fluxes produce the desired torque which is required by the motor to rotate.

Why Single Phase Induction Motor is not Self Starting?

According to double field revolving theory, any alternating quantity can be resolved into two components, each component have magnitude equal to the half of the maximum magnitude of the alternating quantity and both these component rotates in opposite direction to each other. For example - a flux, ϕ_m can be resolved into two components

$$\frac{\phi_m}{2} \text{ and } -\frac{\phi_m}{2}$$

Each of these components rotates in opposite direction i. e if one $\phi_m / 2$ is rotating in clockwise direction then the other $\phi_m / 2$ rotates in anticlockwise direction.

Example of Star-Delta Starter:

A Star-Delta starter is generally used to reduce start current of the motor. An example is given to know about the star-delta starter.

From the circuit, we used a supply of 440volts to start a motor. And here we used a set of relays to shift motor connections from star to delta with a time delay. In this, we explained the working by using lamp instead of motor for easy understanding. Throughout star operation the lamps might glow faint showing the supply voltage over the coils are 440volts. During delta operation after the timer works the lights might glow with full intensity showing full supply voltage of 440volts. The 555 timer performs the monostable operation, the output of which is sustained to a relay for updating the mains supply from 3-phase star-to-delta.

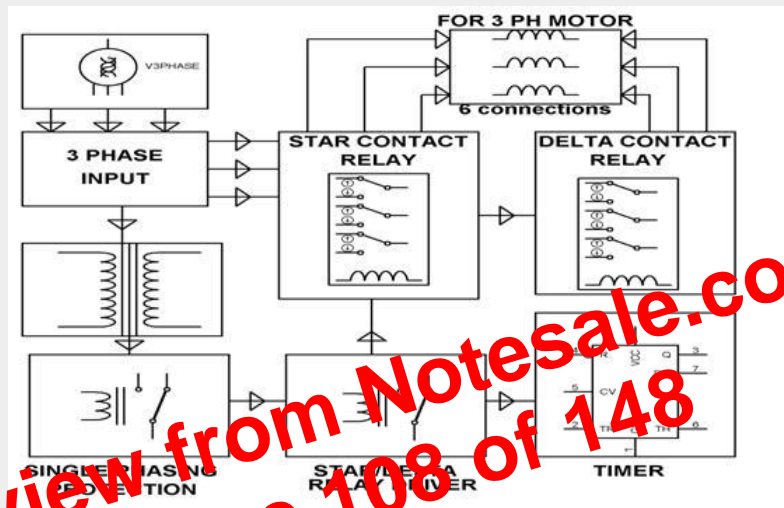
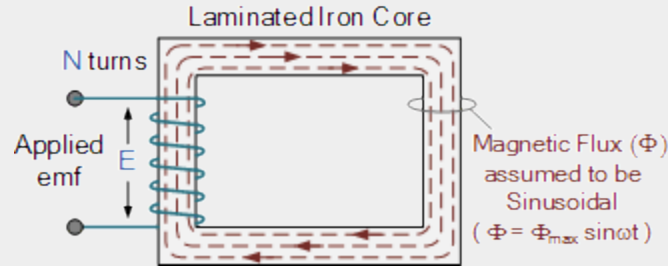


Photo Credit:

- Motor starting period Vs Steady state running period by myelectrical
- Star Delta Motor Control Power Circuit by s1.hubimg
- Induction motor winding terminals connected in star and Delta Configuration by myelectrical
- Full load current in Open Transition and closed transition by electricneutron

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As the magnetic lines of force setup by this electromagnet expand outward from the coil the soft iron core forms a path for and concentrates the magnetic flux. This magnetic flux links the turns of both windings as it increases and decreases in opposite directions under the influence of the AC supply.

However, the strength of the magnetic field induced into the soft iron core depends upon the amount of current and the number of turns in the winding. When current is reduced, the magnetic field strength reduces.

When the magnetic lines of flux flow around the core, they pass through the turns of the secondary winding, causing a voltage to be induced into the secondary coil. The amount of voltage induced will be determined by: $N \cdot d\Phi/dt$ (Faraday's Law), where N is the number of coil turns. Also this induced voltage has the same frequency as the primary winding voltage.

Then we can see that the same voltage is induced in each coil turn of both windings because the same magnetic flux links the turns in both the windings together. As a result, the total induced voltage in each winding is directly proportional to the number of turns in that winding. However, the peak magnitude of the output voltage available on the secondary winding will be reduced if the magnetic losses of the core are high.

If we want the primary coil to produce a stronger magnetic field to overcome the cores magnetic losses, we can either send a larger current through the coil, or keep the same current flowing, and instead increase the number of coil turns (NP) of the winding. The product of amperes times turns is called the 'ampere-turns', which determines the magnetising force of the coil.

So assuming we have a transformer with a single turn in the primary, and only one turn in the secondary. If one volt is applied to the one turn of the primary coil, assuming no losses, enough current must flow and enough magnetic flux generated to induce one volt in the single turn of the secondary. That is, each winding supports the same number of volts per turn.

As the magnetic flux varies sinusoidally, $\Phi = \Phi_{max} \sin \omega t$, then the basic relationship between induced emf, (E) in a coil winding of N turns is given by:

emf = turns x rate of change

materials of which the core is composed of; also gets linked with this flux and an emf is induced.

But this magnetic flux does not contribute anything towards the externally connected load or the output power and is dissipated in the form of heat energy. So such losses are called Eddy Current losses and are mathematically expressed as:

$$P_e = K_e f^2 K_f^2 B_m^2$$

Where;

- K_e = Constant of Eddy Current
- K_f^2 = Form Constant
- B_m = Strength of Magnetic Field

Hysteresis Loss

Hysteresis loss is defined as the electrical energy which is required to realign the domains of the ferromagnetic material which is present in the core of the transformer.

These domains lose their alignment when an alternating current is supplied to the primary windings of the transformer and the emf is induced in the ferromagnetic material of the core which disturbs the alignment of the domains and afterwards they do not realign properly. For their proper realignment, some external energy supply, usually in the form of current is required. This extra energy is known as Hysteresis loss.

Mathematically, they can be defined as;

$$P_h = K_h B_m^{1.6} fV$$

These are the different kinds of losses happened to occur in transformer and an electrical engineer must take care of their losses and try to reduce them as low as possible.

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As we know that the commercial or typical efficiency of a transformer is the ratio of Output and Input in watts

Efficiency = Output (in Watts)/Input (in Watts)

But there are number of transformers whose performance can't be monitored according the above general efficiency.

Those distribution transformers which supply electrical energy to lighting and other general circuits, their primary energize for 24 hours, but the secondary windings does not energize all the time. In other words, Secondary windings only energize at the night time when they supply electrical energy to lighting circuits. I.e. secondary windings supply eclectic power for very small load or no load for maximum time in 24 hours. It means that core loss occurs for 24 hours regularly but copper loss occurs only when transformer is on loaded.

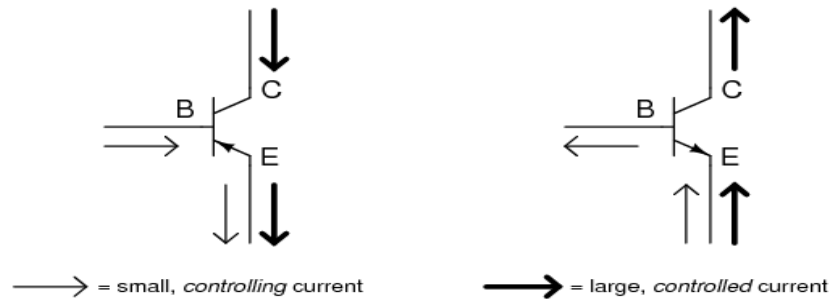
Therefore it realizes the necessity to design a transformer in which the core loss should be low. As copper loss depends on load, therefore, they should be neglected. In this type of transformers, we can track their performance only by all day efficiency. All day efficiency may be also called "Operational efficiency". On the base of usable energy, we estimate the all day efficiency for a specific time (During the 24 hours =one day). And we can find it by the following formula.

All Day Efficiency = Output (in kWh)/Input (in kWh)

To understand about the all day efficiency, we must know about the load cycle i.e. how much load is connected, and for how much time (in 24 hours).

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to the standards of semiconductor symbology, the arrow always points against the direction of electron flow. (Figure below)



Small Base-Emitter current controls large Collector-Emitter current flowing against emitter arrow.

Bipolar transistors are called bipolar because the main flow of electrons through them takes place in two types of semiconductor material: P and N, as the main current goes from emitter to collector (or vice versa). In other words, two types of charge carriers'electrons and holes'comprise this main current through the transistor.

As you can see, the controlling current and the controlled current always mesh together through the emitter wire, and their electrons always flow against the direction of the transistor's arrow. This is the first and foremost rule in the use of transistors: all currents must be going in the proper direction for the device to work as a current regulator. The small, controlling current is usually referred to simply as the base current because it is the only current that goes through the base wire of the transistor. Conversely, the large, controlled current is referred to as the collector current because it is the only current that goes through the collector wire. The emitter current is the sum of the base and collector currents, in compliance with Kirchhoff's Current Law.

No current through the base of the transistor, shuts it off like an open switch and prevents current through the collector. A base current, turns the transistor on like a closed switch and allows a proportional amount of current through the collector. Collector current is primarily limited by the base current, regardless of the amount of voltage available to push it. The next section will explore in more detail the use of bipolar transistors as switching elements.