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basic of electrical engineering

engineering:-a science by which the properties of matter and the sources of energy in nature are made useful to man.

Circuit :- an interconnection of simple electrical devices in which there is at least one closed path in which current may flow.

Analysis:- a (mathematical) study of a Cineplex entity and the interrelation ship of its parts.

Thus we might be inclined to decide that (engineering circuit analysis) is a mathematical study of same useful interconnection of simple electrical devices in which there is at least one closed current path.

This definition is essentially correct although we cannot understand it fully until we clarify what is meant by current and electrical devices, a task which we shall undertake shortly.

The international system of units:- SI sys

The International system of units, known as in every language, derives all the units in the various technologies from the following sex units:-

No	quantity	unit	symbol
1-	length (l)	meter	(m)
2-	mass (m)	kilogram	(kg)
3-	time (t)	second	(s)
4-	electric current (I)	ampere	(a)
5-	temperature (o)	Kelvin	(k) or (c)
6-	luminous intensity ( )	candela	(cad)de

the meter is the length equal to (1650763.73) w lengths of the orange line in the spectrum of in it nationally- specified krypton – 86 discharge lamp. The kilogram is the mass of a platinum –iridium dear preserved at the international bureau of we and measures at Sevres, near Paris. The second is the interval occupied by 9192631 cycles of radiation corresponding to the Tran of the ceasium-133 a tom. The Kelvin is 1—273.16 of the thermodynamic temperature of triple point of water .on the Celsius the temperature of the triple point of water 0.01c hence , 0c = 273.15 k the candela is defined abbreviation ;cd ; the new unit of luminous intensity ,termed the candle by international conference of weights and measure .the luminous intensity of a lamp is defined as the light radiating capacity of a source in a given direction , exposed in candelas cd .

definitions of other derived SI units :-

-the Newton (N) is the force which, when applied to a mass of (1kg) gives it an acceleration of ($1m/s^2$).

-the Pascal (pa) is the stress of pressure equal to ($1N/m^2$).

-the joule (j) is the work done when a force of (1n) is exerted through a distance of (1m) in the direction other force.

-the watt (W) is the power equal to (1j/s).

-the hertz (z) is the unit of frequency, namely the number of cycles per second.

-the lumen (lm) is the luminous flux emitted within unit solid angle by a point source having a uniform intensity of I candela.

-the lux (lx) is a illumination of ($1lm/m^2$).

Unit of force

The SI unit of force is the Newton (n) namely the which , when applied to a mass of 1kg, gives it an a relation of ($1m/s^2$)
Hence the force(f) required to give a mass (m) an acceleration(a) is
F { Newton's} = m { kilograms } x a (meter/ second)

Weight:-

The weight of a body is the gravitational exerted by the earth on the body. Owing to the variation the radius of the earth , the gravitational force on given mass , at sea level , is different at different latitudes. The weight of a (1kg) mass at sea level the London area is practically (9.81n) for most purposes we can assume:-
The weigh of a body 9.81m Newton's.

Where: m- is the mass of the body in kilograms.

Example-1:-

A force of (50) is applied to amass of 200 kg find the acceleration .
Solution ; substituting in expression f= m* a, we have:- 50(n)=200(kg)*a
$A=0.25m/s^2$

Example-2:-

A steel block has a mass of 80kg. calculate the weight of the block at sea level in the vicinity of London?

Solution:-

Since the weight of a 1kg mass=9.81n
Weight of the steel block= 80[kg]*9.81[n/kg]=784.8N

Note:-

This expression can alternatively be stated thus:- weigh of block $\simeq$80 [kg] *9.81[m/s^2]=784.8(N)
When the body under consideration is stationary (n / kg) is better since it emphasize the relationship between mass and weight ; namely that a mass a1 kg has a weight of approximately (9 . 81) .

Unit of work or energy:-

The international system of energy is the joule(1818-1889).
The joule is the work done when a force of (1n) acts through a distance of (1m) in the direction of the force hence ,if a force (f) acts through distance (d)in its own direction :-
Work done =f [Newton]*d [met/sec]
= f*d [joules] →(d=l المسافة)
if a body having mass (m) , in kilogram , is moving with velocity(v) in (meters /sec)
kinetic energy = 1/2 m v^2 joule
if a body having mass (m) , in kilograms ,is lifted vercally through height (h) , in metres . and if (g) is the gravitational acceleration ; in meters/ second ^{2} ; in that

potential energy acquired by body = work done in the body

= m g h (joules) = 9 . 81 mh

specific heat capacity:-

different substances a absorb different amounts of heat to raise the temperature of a given mass of the substance by one degree. The heat required to raise the temperature of (1kg) of a substance by (1 degree) is termed the –specific –that capacity of that substance hence, if (c) represents the specific heat capacity of a substance in joules per kilogram Kelvin, the heat required to rais the temperature of (m) kilograms of the substance by (t) degrees:
=m c t (joules)
the following table gives the approximate values of the specific heat capacity of some well-known subs-lances for a temperature range between oc̊ and 100c̊

substance	specific heat capacity
water	4190 j/kg.k
copper	390 j/kg.k
iron	500 j/kg.k
aluminum	

unit of power:-

since power is the rate of doing work , it follows the SI unit of power is the joule/second or watt (after the Scottish engineer, James watt, 1736-1819). In practice ,the watt is often found to be in convenient small and so the kilowatt is frequently used.
Similarly when we are dealing with a large of energy, it is convenient to express the latter In kilo watt hours rather than in joules .

1 kw.h =1000watt hours =1000·3600 watt. Sec =3600000 joules
if t – is the torque ,in Newton.metres ,
acting about an axis of rotation , and if (n) is the speed in revolutions / second ,
power = torque in Newton meters . speed in radian
= t.2. 3.14.n joules /second or watts =wt watt .
where w – ungula velocity in radians /second

conversion factors:-

table:- common conversion factors, in equation and ratio form:-

1 inch	= 2.54 centimeters	$\frac{2.54\ cm}{1\ in.}$
1 foot	= 0.3048 meter	$\frac{0.3048m}{1\ ft}$
1 mile	=1.609 kilometers	$\frac{1.609km}{1m}$
1 gallon	=3.785 liters	$\frac{3.7851}{1gal.}$
1 ounce	=28.35 grams	$\frac{28.35g}{1oz}$
1paound (mass)	=0.4536 kilograms	$\frac{0.4536kg}{1ibm}$

mechanical quantities

in electrical engineering we need to use certain mechanical quantities , the units of these quantities being defined in terms of the units of length , mass and time ,namely the miter , the kilogram, and the second as follows.

Force:- symbol-f-

The Newton (n) is that force which gives a mass of an acceleration of 1m/s²
The relationship between these factors is :-

F=ma (Newtons) ,(N)

Where m-mass, and a-acceleration

Energy or work :-symbol-w-

The joule (j) is the work done when a force of acts through a distance of (1m) in the direction work done = w=Fd (joules)
where d-distance.

thermal energy (Q)

the energy gained or lost by a mass of (m) kilogram of substance when its temperature is changed by (θ) Kelvin (k) is ; $Q = m c \delta \theta$) joules ; where ; c – the specific heat capacity of the substance .

torque :

is the turning moment produced by a force about an axis or center of rotation and is the product of the force (f) which is at right angle to the radius of rotation (R) ,
when (f) is in newtons (N) and (R) is in meters (m) : { $T = F R$ } n m

:

power:-

is the rate of doing work and the unit of power is the watt (w) , which is the joule/second .

$$p=\frac{Fd}{t} \quad \text{(w or j/s)}$$

$$=\text{force} * \text{velocity} = fv$$

Relationship in an electrical circuit :-

1-electrical quantity :- {Q=It} coulombs (c) .
2-electrical potential :- {E=IR} volts [v]- ohms low.
3-electrical energy :- {w=EIt} joules or watt seconds.
4- 1kwh =1000*60 =3.6*10 j or 3.6 mj.

$$1kwh= \frac{joules}{3.6}$$

the kwh is often called a unit of electrical energy
4-electrical power :-is the rate of doing work.

$$p=\frac{EIt \text{ joules}}{t \text{ seconds}}=EI \text{ watt or j/sec.}$$

using the above several other important relation ships can be deduced .for example if we substitute equation (E=IR) in to equation (p=EI) we have :-

{$p=EI=(IR)I=I^2 R$} w

also , substituting (I=E/R) in to equation (p=EI)
gives :-

{$p=EI=E*E/R=E^2/r$ w

substituting equation ($p=EI=I^2R$) and equation

{$p=EI=E^2/r$}

in to equation (w=EIt) , gives :-

$$w=I^2rt \quad \text{joules}$$

$$=\frac{E^2t}{R} \quad \text{joules}$$

Example : an electrical circuit has a resistance of 200 Aum and is energized by a 250v supply. Calculate the current drawn from the supply : the power dissipated by the circuit , the electrical energy consumed in 1 hour :

solution

$I = E/R = 250 / 200 = 1.25$ A

P= E 1 = 250 ⋅ 1.25 =312.5 w

Resistance:- metric units (In SI units)

In SI units ,the resistively would be measured in :-

p-(ohm-----------meters), the area in square meters, and the length in meters .

$R=\rho l/A$, $\rho=R A/L= \Omega\, m^2/m=(\Omega.m)$

$A=(d/2)^2.3.14$

Where ,d- diameter of circular wire.

Example:-

Determine the resistance of a 100ft of copper telephone wire if the diameter is 0.0126 in?

Solution:-

Unit conversions:

L= 100ft (12in/1ft)(2.54cm)=3048cm

D=0.0126 (2.54cm/1)=0.032cm

Therefore:

$A=(d/2)^2.3.14=(3.1416)(0.032)^2/4 =8.04*10/10000\ cm^2$

$$R=L/A\ \rho= \frac{3048}{8.04*10} * 1.724*10/1000000$$

conductance : (G)

by finding reciprocal of the resistance of a material by we have a measure of how well material will conduct electricity . the quantity is called conductance ; has the symbol (G) ; and is measured in siemens (s) . in equation from ;conductance is : $G =1/R$ (siemens) (s) in equation from the conductance is determine by { $G = A / \rho L$ }

series circuits

two types of current are readily available to the consumer today . one is direct current (dc) , in which ideally the flow of charge (current) does not change in magnitude or direction . a circuit consists of any number of elements joined at terminal points ; providing at lest one chased path through which charge can flow . in general ,to find the total resistance of (N) resistor in series ,the following equation is applied ;

$R_T =R_1+R_2+R_3+\ldots\ldots R_n$ once the total resistance is known, the current can be determined from:

$I=\frac{E}{R_t}$, $I=I_1+I_2+I_3+\text{------}+I_n$ and the voltage across each element can be determine from

$V_1=IR_1$, $V_2=IR_2$, $V_3=IR_3$,-------, $V_n=IR_n$

Temperature coefficient of resistance:-

$$\alpha_1=\frac{(R_2-R_1)}{(\theta_2-\theta_1)R_1}$$

temper atur coefficient of resistance referred to θ1 :and has the symbol (α).
And α2,referred to θ2 is:-

$$\alpha_2 = \frac{(R2 - R1)}{(\theta 2 - \theta 1)R2}$$

the values of resistors used in many electronic circuit are color –coded according to an international noted .in the case of metals ,R2 is always greater than R1 and we say that the temperature coefficient of resistance has a positive value . in insulators ,electrolytes and many semiconductors ,the value of R2 is less than that of R1 ,so that the graph slopes from left to right and the temperature coefficient has a negative value . the temperature coefficient of resistance referred to (0c) is temperature coefficient of resistance where :

α_0= R1 –R_0/Q1R_0] rearranging this equation yields R1 = R_0 (1 + α_0 Q1) similarly :

R2 =R0 (1 + α_0 Q2)

Hence $R1/R2 = \frac{1 + \alpha_0 Q1}{1 + \alpha_0 Q2}$

example : the resistance of a coil at 20 c was 20 hum. What current would it draw from a (10 v) supply when operating in cold room at 0c . the temperature coefficient of resistance being 0.0043 per c referred to 0c ?
from equation : R1 = R0 (1 +α_0 Q 1) , R0 =R1/ (1+ α_0 Q1) = 20 /1+ (0.0043 .20) =18.42 hum , I= E/R0 = 10/18.42 =0.543 A

variation of Resistively with temperature : not only resistance but specific resistance of resistivity of metallic conductors also increases with rise in temperature

ρ1 = resistively at t1 c ; ρ2 =resistivity at t2 c

ρ2 = ρ1 (1 + α1 (t2 – t1)

coulomb ; the unit of charge ; one coulomb is the total charge possessed by

6,25 . 1018 electron

electrical charge : the two types of charge are positive charge and negative charge

charge (Q) = number of electron / 6.25 .10 18 electrons
voltage the difference in potential energy per charge is the potential difference or voltage .v = w/ Q , where (w) is expressed in joules and (Q) is in coulom
:current , current in a conductive material is determined by the number of electrons (amount of charge Q that flow past a point in a unit of time . I = Q / t , where I – is a current in amperes , Q – is the charge of electrons in coulomb , t – is the time in second

power (p)

p=w(energy)/t(time)   p=dw/dt   p=w/t=q/t*v=I*v   (w)
p=I*(IR)={I^2R}   (w)
p=(V/R) v={V^2/R}   (w)
a unite called horse power is used in some times to in 1(hp)=746w
ex :what is the power delivered b by a 6V battery if the charge flows at the rate of 48c/min I=Q/t = 48/60 =0.8A
p=I.v=0.8.6=4.8w

coulomb law : f = kQ1Q2/r^2 (Newton) , where f- is attraction or repulsion force(N) , k-a constant =9. 1000000000 N.M/c , Q 1 or Q2 – the charge r- is the distance between two charge .

example :
determine the energy expended moving charge of 50 mc through a potential difference of 6v , w =Q . v = (50 . 1/1000000) (6v) =300Mj . **efficincy** : conservation of energy requires that energy in put = (energy out put) + (energy loss)
dividing both sides of the relation ship by gives
w in/t= w out/t + w loss/t , pin = pout + p lost the efficiency (η) = power out put/ power in put. 100 ٪

ENERgy _the energy determined by W = P t , w – energy in watt second (w. s) or (J) , t – time in second (s) , p – power in (w)
w.s – this unite very small , so watt hours , or k watt hours is used
k.w.h = power (w)/ 1000 . time (h)
example: a motor is rated to deliver 2hp . if it runs on 110 v and is 90٪ efficiency . how many watts . does it draw from the power line . what is the in put current . if the motor is only 70 ٪ efficiency .
solution p out = 2 . * 746 =1492 watt . efficiency = p out/ pin =90=1492/pin * 100
p in =149200/90 = 1657.7 w , p in =v in * current , current = 1657.7/110 =15.07 A
efficiency=p out/p in pin= 2131.4 w current =p in/ v in = 2131.4/ 110 = 19.3 A .

series and parallel circuit ; resistance in series :
when some conductors having resistance R1 R2 R 3 and R4 ……etc , are joined end – on- end , they are said to be connected in series . being a series circuit it should be remembered that

1- current is the same through all the four conductors
2- but voltage drop across each is different due to its different resistance and is given by ohms law 3- sum of the four voltage drop is equal to the voltage applied across the four conductors .

. RT =R1+R2+R3+R4 , RT:equivalent resistance
VT= v1+v2+v3+v4
IT =I1=I2=I3=I4

Resistance in parallel : vt=v1=v2=v3=v4

It=I1+I2+I3+I4 ; 1/Rt = 1/R1+1/R2 +1/R3+1/R4

G=G1+G2+G3+G4 ,three resistance as joined are side to be connected in parallel . in this case (p . d)power dissipation across all resistances is the same , current in each resistor is different and is given by ohms law , the total current is the sum of the three separate current . now =

I = I1+I2 + I 3 = V /R1 + V / R2 + V/R3 , where (v) is the applied voltage ,R= equivalent resistance of the parallel combination , V/R = V/R1+V/R2 +V/R3

Also G = G1 + G2 + G 3 , G – conductance , the main characteristics of a parallel circuit are 1) same voltage acts across all parts of the circuit 2) different resistors have their individual current , 3) branch current are additive 4) conductance are additive 5) power are additive .

Kerchiefs laws 1) current law (k c l) : in any electrical network , the algebraic sum of the current meeting at a point (or junction) is zero

Σ I = 0 2) kerchiefs voltage law (k v L) : the algebraic sum of the products of currents and resistances in each of the conductors in any closed path (or mesh) in a network plus the algebraic sum of the electro motive force in the path is zero

Σ V = 0

Voltage divider rule

Since in a series circuit same current flows through each of the given resistors . voltage drop varies directly with its resistance , if the 24 –v battery connected across a series combination of three resistors (R1,R2 ,R3,)

RT = R1+R2+R3 , according to voltage divider rule , various voltage drops are

V1=VR1/RT V2=VR2/RT V3=VR3/RT

Total conductance (GT) and resistance

If the three conductance are connected in parallel ,

VTP=V1=V2=V3 ,when vtp- parallel total voltage , 1/RTp =1/R1 +1/R2+1/R3

ITP = V/RTP (ohm law) , in general IX=ITP .RTP/ RX (current divider rule)

Thevenin theorem :it provides a mathematical technique for replacing a given network as viewed from two out put terminals , by a single voltage source with a series resistance . it makes the solution of complicated networks (particularly electronic networks) quite quick and easy . if the electric circuit consist of the 1) source voltage 2) internal resistance® 3) in series joined R1 ,R2 4) load resist (RL) 5) two terminals (A,B). suppose it is required to find current flowing through load resistance we will proceed as under 1) remove RL from the circuit terminals A and B . obviously, the

terminals have become open – circuited. 2) calculate the open – circuit voltage(Voc) which appears across terminals A and B when they are open t.e . when RL is removed as seen Voc= drop across (R2) = I R2 : where I – is the circuit current when A and B are open. I= source voltage / R1+R2+internal resistance
Voc=IR2=ER2/R1+R2+r when internal resistance behind the circuit consists of two parallel paths : one containing R2 and the other containing (R1+internal resistance{r} , The equivalent resistance R=R2//(R1+r) =R2(R1+r)/ R2+(R1+r) this resistance is also called Thevenin resistance(Rt) , voltage source called thevenin source whose electro Motive force (e.m.f) equals (voc) or Vth) and whose internal resistance equals Rth orRi. Current flowing through load resistance (RL) is given by
I= Vth / Rth + RL or I= Voc/ Ri + RL

<u>N ORTON THEOREM</u> *
;
this theorem is an alternative to the thevenins theorem . in fact , it is the dual of the thevenin theorem . where as thevenin theorem reduces a two – terminal active network of linear resistance and generators to an equivalent constant –voltage source and series resistance, Norton theorem reptaces the network by an equivalent constant current source and a parallel resistance. This theorem may be stated as follows:-
1-Any two- terminal active network containing voltage sources and resistance when viewed from the out put terminals is equivalent to aconstant- current source and a parallel resistance.the constant current is equal to the current which would flow in a short circuit placed across the terminal and parallel resistance is the resistance of the viewed from theopen-circuited terminals after all voltage and current sources have been removed and replaced by their intermal resistance.

<u>NRRTON THEOREM AND GENERAL USEFUL</u>: V=I(short circuit sc) . Ri

Current open circuit(Isc) = E1/R2+ E2/R2= E1G1+E2G2 , where G1 and G2 are branch conductances. 1/Ri= 1/R1+ 1/ R2 +1/R3 =G1+ G2 +G3

Ri =1/ G1 + G2 +G3

Voltage in terminal = current short circuit ҳ Ri = EG1+EG2/ G1+G2+G3