Basic Network Theory Concepts - GATE Study Material in PDF

Network Theory has a wide array of applications in many disciplines. Some of the engineering streams it has relevance in includes EE, EC, CS, etc. Besides *Gate* 2018, this GATE Study Material, is also useful for IES, BARC, DRDO, BSNL & other exams. Let's look at the Basic Concepts of Network Theory which explains the basics of Network Theory and help you understand its application though solved examples. Hope this free GATE Study Material is useful to you. You can check earlier study material here:

Types of Matrices

Properties of Matrices

Rank of a Matrix and Its Properties

Solution of a System of Linear Equations

Eigen Values & Eigen Vectors

Linear Algebra Revision Test 1

Basic Network Theory Concepts

Charge

Electric charge is the physical property of matter that causes it to experience a force when placed in an electromagnetic field.

Unit: Coulomb(C)

Note:

i. Like Charges are repelled to each other whereas opposite charges are attracted towards each other.

ii. An object is negatively charged if it has an excess of electrons, and is otherwise positively charged.

Charge of an electron $q = -\ 1.6 \times 10^{-19}$ Coulomb ($\leftarrow$ unit)

Charge of a proton $= +\ 1.6 \times 10^{-19}$ Coulomb

Current

Electric current (i)is defined as the rate of flow of electric charges in a conductor. In electric circuits this charge is often carried by moving electrons in a wire.

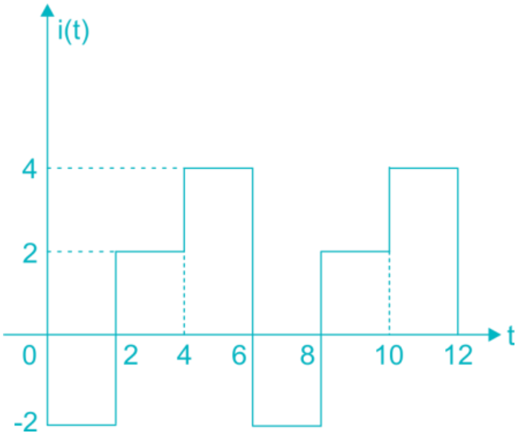
Units: Ampere (A)

Note:

Mathematically, $i(t) = \frac{dq(t)}{dt}$ (or) $q(t) = \int_{t_0}^{t} i(t)\, dt$

Example:

For the below figure, calculate the total charge.



Solution:

$Q = \int idt$

$Q_{Total} = \int_0^{12} Idt = 2\int_0^{6}(-2 \times 2 + 2 \times 2 + 4 \times 2) = \ 16\ C$

Voltage

Voltage (or)electric potential difference (or)electric pressure or electric tension

is the difference in electric potential energy between two points per unit electric charge.

The voltage between two points is equal to the work done per unit of charge.

Units: Volts (V)

Note: Voltage does not exist at a point by itself, it is measured always w. r. t.

Some reference point.

$v(t) = \frac{dW}{dQ}$

Power

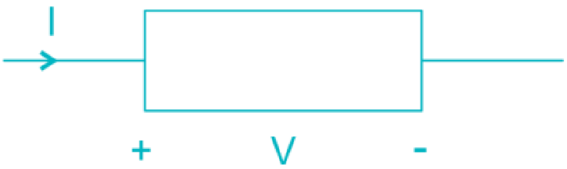
The rate of performing work per unit time is known as power and also it is equivalent to the amount of energy consumed per unit time.

$$P(t) = \frac{dW}{dt} = \frac{dW}{dQ}\frac{dQ}{dt} = v(t)i(t)$$

Unit: Watt (W)

Sign Convention for Power Calculation:

For Power Absorbing:



For Power delivering:

Example:

Find the time at which maximum power is delivered to a load, whose voltage across it is given as $v(t) = 50\ e^{-5t}$ V and current through it is $i(t) = 5 - 5\ e^{-5t}$A.

Solution:

$$P(t) = v(t)\ i(t) = 50\ e^{-5t}\ (5 - 5e^{-5t})$$

$= 250\,e^{-5t} - 250\,e^{-10t}$

For maximum power transfer we have $\frac{dp(t)}{dt} = 0$

$-5 \times 250\,e^{-5t} - 2500\,e^{-10t} = 0$

$\Rightarrow e^{5t} = 2$

$t = \frac{\ln 2}{5} = 0.138 \text{ sec} = 138 \text{ ms}$

Energy

Energy is defined as the ability to perform a work.

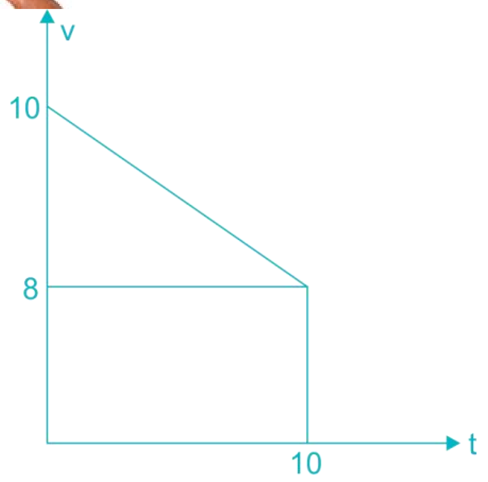
$w(t) = \int_{t_0}^{t} P(t)\,dt$

Unit: watt − sec (or) Joules

Note: 1kWh $= 3.6 \times 10^6$ Joules (Kilo Watt Hour = kWh)

Example:

A fully charge i − pod is for 20 minute music play. During music play the characteristics of voltage is shown in figure. During music play current deliver by battery is constant at 4A. Find energy of battery during music play.



Solution:

Energy, E $= \int P \times dt$

$= \int_0^{10} V.I.dt = 4 \times [\frac{1}{2} \times 2 \times 10 \times 60 + 8 \times 10 \times 60]$

Now, Energy $= 5400 \times 4 = 21600\ J = 21.6\ kJ$

Ohm’s Law

At a particular temperature Ohm’s law states that the current through a conductor between two points is directly proportional to the voltage across the two points.

i.e. $I \propto V \Rightarrow I = \frac{V}{R}$

$\therefore V = IR$, where R is the resistance of the conductor.

Resistor

The electrical resistance of an electrical conductor is a measure of the difficulty to pass an electric current through that conductor.

Unit: Ohms (Ω)

The Ohm's Law Relation: $V = IR$

Note: The inverse quantity of resistance is electrical conductance.

Unit of conductance: mho

Inductor

It is the property of an electrical conductor by which a change in current through it induces an electromotive force in both the conductor itself.

Unit: Henry (H)

The Ohm's Law Relation: Flux, $\phi = LI$

Note:

$v = L.\frac{di}{dt}$

$i = \frac{1}{L}\int_{-\infty}^{t} v.dt$

Capacitance

Capacitance is the ability of a body to store an electrical charge. A material with a large capacitance holds more electric charge at a given voltage, than one with low capacitance.

Unit: Farad (F)

The Ohm's Law Relation: Charge, $Q = CV$

Note:

$i = C.\frac{dv}{dt}$

$v = \frac{1}{C}\int_{-\infty}^{t} i.dt$

Circuit Elements

i. Active Elements:

These elements deliver power to the network.

Ex: Op – Amps, generators and independent source

ii. Passive Elements:

Capacity of only receiving power.

Ex: Resistor, Inductor and Capacitor

iii. Bilateral Elements:

V – I relationship is same for current in either direction.

Ex: Resistor, Inductor and Capacitor

iv. Unilateral Elements:

V – I relationship is different for current in two directions.

Ex: Diode

v. Linear Elements:

Linear relationship between V and I.

For these elements graph should passes through the origin.

Ex: R, L and C.

vi. Non – Linear Elements –

Non – linear relationship between V and I

Ex: Diode

vii. Lumped elements:

Separable elements with very small in size as compared to the wavelength of the signal.

No phase variation.

Ex: R, L and C.

viii. Distributed Element:

Not electrically separable and distributed over entire length of the circuit.

Size is larger than the wavelength of the signal.

Phase variations are exists.

Ex: Transmission Lines.