

The Network Elements

Basic elements of network are discussed here: 1) Resistance 2) Inductor

1) Resistance:

- ✘ Defined as per Ohm's law: Temperature remaining constant in a uniform cross-section of wire, the potential difference across two points is proportional to current; the constant of proportionality is known as resistance.

$$V=RI;$$

$$=R (dq/dt)$$

- ✘ Linear relation between V&I (slope of straight line is G,-ve for load lines in diodes & transistors).
- ✘ Resistance depends upon:
 - 1) Nature of material
 - 2) Geometry of material
 - 3) Temperature.
- ✘ $R=\rho(l/a)$ and $R=R_0(1+\alpha \Delta t)$.
- ✘ ρ is resistivity ($\Omega\text{-m}$); R_0 is reference temperature (at 0^0 C or 20^0 C); α is temperature coefficient of resistance (can be +ve or -ve).
- ✘ Inverse of resistance is called conductance (G), SI unit Siemens (or mho).
- ✘ In 'resistance' power is dissipated as heat.

2) Inductor:

- ✘ Is linear.
- ✘ $N\phi=LI$.
- ✘ **Faraday's Law:** Voltage (opposing) is induced in a coil for a change in flux,
$$v=-N(d\phi/dt)$$
- ✘ Units of inductance: Henry $\{(V\text{-s})/A\}$.
- ✘ $p=vi=Li(di/dt)$.
- ✘ Energy $W= (1/2) Li^2$.
- ✘ $L= (\mu_0\mu_r N^2 A_f)/l_m$; A_f , flux linking area; l_m , magnetic path length.
- ✘ $mmf= S\phi$; S (amp/weber) is reluctance of magnetic circuit.
- ✘ $S= \{1/(\mu A_f)\}$.
- ✘ $i(t)=(1/L) \int_{-\infty}^t v(t) dt = (1/L) \int_0^t v(t) dt + i(0)$
- ✘ SERIES: $L_{eq}=L_1+L_2$.

*These are some of my personal notes. I am very thankful to Google (www.google.com), NPTEL (<http://nptel.iitm.ac.in/>) and Wikipedia (www.wikipedia.org) (I, however, do not have the exact references). Please confirm everything before you mug up. Let the website moderators know if you find anything controversial.

- ✘ PARALLEL: $L_{eq}=(L_1L_2)/(L_1+L_2)$.
- ✘ When two coils are placed close to each other, NOT all the flux produced by the changing current in 1st coil links the 2nd coil, only a fraction k (such that $k_{max}=1$) links (called *coefficient of coupling*). To bring k near to 1, magnetic core materials are used.

Some Important Inventions

- ✘ Karl Ferdinand Braun, (1850-1918), Germany — Cathode-Ray Tube Oscilloscope.
- ✘ Samuel Hunter Christie, (1784-1865), UK — Wheatstone Bridge.
- ✘ Rudolf **Diesel**, (1858-1913), Germany — **Diesel** Engine.
- ✘ Samuel Morey, (1762-1843), USA — Internal Combustion Engine.
- ✘ J. Robert Oppenheimer , (1904-1967), USA — Father of the Atomic Bomb.
- ✘ Wilhelm Conrad **Roentgen**, (1845-1923), Germany — The X-ray Machine.
- ✘ Edward Teller (Ede Teller), (1908-2003), Hungary — Hydrogen Bomb.
- ✘ Nikola **Tesla**, (1856-1943), Serbian-Croatian-American — Developer of the Tesla Coil and inventor of the induction motor, alternating current polyphase power distribution system, wireless communication, robotics, logic gates, the bladeless turbine, radio, VTOL aircraft, etc.
- ✘ Alessandro **Volta**, (1745-1827), Italy — Battery

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The Laplace Transform of Some Common Identities

| Identity | Laplace Transform | Region |
|-------------------------|-----------------------------|----------------|
| $\sin at$ | $a/(s^2+a^2)$ | $s>0$ |
| $\sin ht$ | $a/(s^2-a^2)$ | $s> a $ |
| $\cos at$ | $s/(s^2+a^2)$ | $s>0$ |
| $\cos ht$ | $s/(s^2-a^2)$ | $s> a $ |
| $\sin at - at\cos at$ | $2a^3/(s^2+a^2)^2$ | |
| t^n | $(n+1)!/s^{(n+1)}$ | $n=0,1,2\dots$ |
| t^n | $T(n+1)/s^{(n+1)}$ | $n>-1$ |
| $t^n f(t)$ | $(-1)^n d^n F(s)/ds^n$ | $n=0,1,2\dots$ |
| $\delta(t-a)$ | e^{-as} | |
| $u(t-a)$ | e^{-as}/s | |
| $(e^{-at} - e^{-bt})/t$ | $\text{Log}\{(s+b)/(s+a)\}$ | |

Points to Remember

- ✘ $\log_b a = (\log_k a) / (\log_k b)$; $k > 0$
- ✘ A **Darlington pair** is two transistors connected together so that the current amplified by the first is further amplified by the second transistor, giving a very high gain.
- ✘ It is difficult to transform direct current from one voltage to another, so they are not used for transmission.

My teacher says that Christmas tree lights are a series circuit. So, when one lamp blew, why didn't they all go out?

Christmas tree lights are not like ordinary lamps! When they blow they automatically short-circuit (they become like a wire link) so the circuit is still complete and the other lamps remain lit. This makes it easy to see the blown lamp.

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Count your Time

What is the voltage to ground at “B”?
Ans: 2.46V

Find the total current through the ammeter.
Ans: 118mA

What is the voltage B to D?
Ans: B is +18.6V w.r.t D

What is the battery voltage?
Ans: 12V

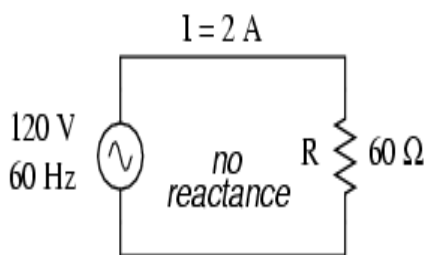
The Cathode Ray Tube (CRT)

- ✘ CRT screen forms the anode.
- ✘ Deflection of beam can be brought about by either magnetic (electromagnets) or electric field.

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- ✘ The screen is covered with a phosphorescent coating (transition metals or rare earth elements which emits *visible light* when excited by the electrons).
- ✘ Source of the electron beam is the electron gun; through thermionic emission.

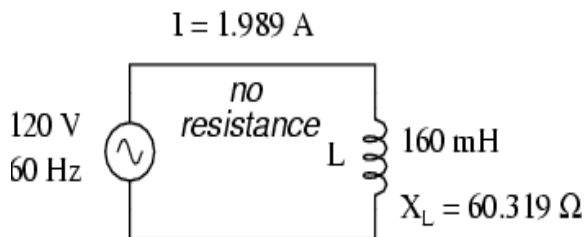
Solved Questions: Find P, Q, S in the figures shown below*:



$P = \text{true power} = I^2 R = 240 \text{ W}$

$Q = \text{reactive power} = I^2 X = 0 \text{ VAR}$

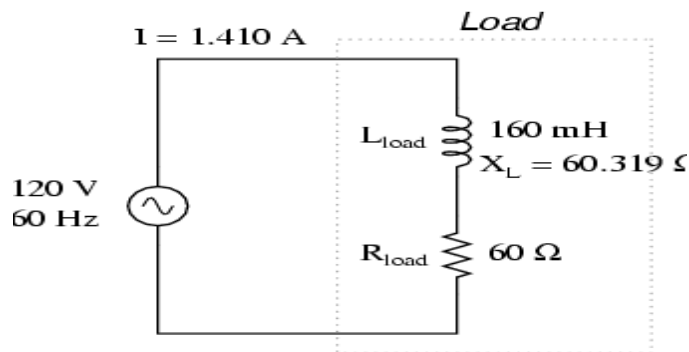
$S = \text{apparent power} = I^2 Z = 240 \text{ VA}$



$P = \text{true power} = I^2 R = 0 \text{ W}$

$Q = \text{reactive power} = I^2 X = 238.73 \text{ VAR}$

$S = \text{apparent power} = I^2 Z = 238.73 \text{ VA}$



$P = \text{true power} = I^2 R = 119.365 \text{ W}$

$Q = \text{reactive power} = I^2 X = 119.998 \text{ VAR}$

$S = \text{apparent power} = I^2 Z = 169.256 \text{ VA}$

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The Electro-magnetic Waves

Decreasing order of Frequency:

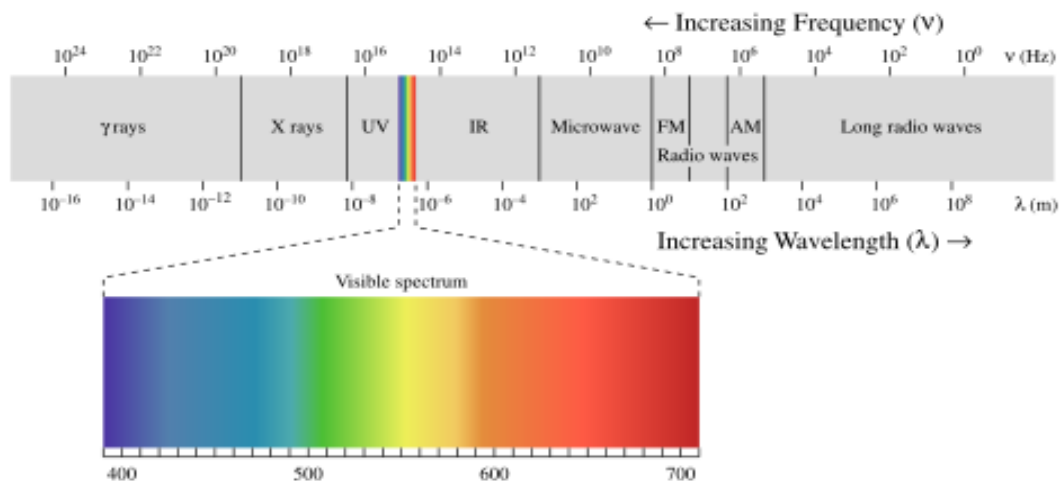
| |
|---------------|
| Gamma rays. |
| X-rays. |
| U-V rays |
| Visible light |
| I-R rays |
| Microwaves |
| Radiowaves |

The Electromagnetic Spectrum

- ✘ Photon acts as transporters of energy.
- ✘ As a photon is absorbed by an atom, it excites an electron, elevating it to a higher energy level. If the energy is great enough, so that the electron jumps to a high enough energy level, it may escape the positive pull of the nucleus and be liberated from the atom in a process called *photoionisation*. Conversely, an electron that descends to a lower energy level in an atom emits a photon of light (equal to the energy difference). Since the energy levels of electrons in atoms are discrete, each element emits and absorbs its own characteristic frequencies.
- ✘ EM radiation with a wavelength between approximately 400 nm and 750 nm is detected by the human eye and perceived as visible light.
- ✘ The distance between two adjacent crests is called the *wavelength*.
- ✘ Hertz is the SI unit of frequency.
- ✘ Speed of wave (v) = frequency x wavelength. ($v=c$ in vacuum or less in other media)
- ✘ As waves cross boundaries between different media, their speed changes but their frequency remains constant.
- ✘ Interference is the superposition of two or more waves resulting in a new wave pattern. If the fields have components in the same direction, they constructively interfere, while opposite directions cause *destructive interference*.
- ✘ The energy in electromagnetic waves is sometimes called *radiant energy*.

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- ✘ In the particle model of EM radiation, a wave consists of discrete packets of energy, or quanta, called *photons*.
- ✘ If radiation having a frequency in the visible region of the EM spectrum reflects off of an object, say, a bowl of fruit, and then strikes our eyes, this results in our visual perception of the scene.
- ✘ When EM radiation impinges upon a conductor, it couples to the conductor, travels along it, and induces an electric current on the surface of that conductor by exciting the electrons of the conducting material (*skin effect*). This effect is used in antennas.
- ✘ EM radiation may also cause certain molecules to absorb energy and thus to heat up; this is exploited in microwave ovens.



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