Formulae for Module 3

Electrical symbols and units

Quantity	***Symbol***	***Unit***	***Abbreviated units***
Angle	ϕ	radian or degree	Rad or °
Capacitance	C	Farad	F
Charge	Q	Coulomb	C
Conductance	G	Siemen	S
Current	I	Ampere	A
Energy	J	Joule	J
Flux	Φ	Weber	Wb
Flux density	B	Tesla	T
Frequency	f	Hertz	Hz
Impedance	Z	Ohm	Ω
Inductance	L	Henry	H
Power	P	Watt	W
Reactance	X	Ohm	Ω
Resistance	R	Ohm	Ω
Time	t	second	s
Voltage	V	Volt	V

Charge, current and voltage

$Q = I \times t$

Ohm's Law

$V = I \times R$ and $I = V / R$ and $R = V / I$

Similarly if *resistance* is replaced by *reactance* or *impedance*:

$V = I \times X$ and $I = V / X$ and $X = V / I$
$V = I \times Z$ and $I = V / Z$ and $Z = V / I$

Power and energy

$P = I \times V$ and $P = V^2 / R$ and $P = I^2 R$
$J = P \times t$ and since $P = I \times V$ so $J = I\, V\, t$

Resistors in series

$R_T = R_1 + R_2 + R_3$

Resistors in parallel

$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$ but where there are *only two* resistors $R_T = \frac{R_1 \times R_2}{R_1 + R_2}$

Capacitance

$C = \frac{\varepsilon A}{d}$ where ε is the *permittivity* of the dielectric and $\varepsilon = \varepsilon_0 \varepsilon_r$

Capacitance, charge and voltage

$Q = C V$

Inductance

$L = n^2 \frac{\mu A}{l}$ where μ is the *permeability* of the magnetic medium and $\mu = \mu_0 \mu_r$

Energy stored in a capacitor

$J = ½ C V^2$

Energy stored in an inductor

$J = ½ L I^2$

Inductors in series

$L_T = L_1 + L_2 + L_3$

Inductors in parallel

$\frac{1}{L_T} = \frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3}$ but where there are *only* two inductors $L_T = \frac{L_1 \times L_2}{L_1 + L_2}$

Capacitors in series

$\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$ but where there are *only* two capacitors $C_T = \frac{C_1 \times C_2}{C_1 + C_2}$

Capacitors in parallel

$C_T = C_1 + C_2 + C_3$

Induced e.m.f. in an inductor

$e = -L \frac{di}{dt}$ where $\frac{di}{dt}$ is the *rate of change of current with time*

Current in a capacitor

$i = C \frac{dv}{dt}$ where $\frac{dv}{dt}$ is the *rate of change of voltage with time*

Sine wave voltage

$v = V_{max} \sin(\omega t)$ or $v = V_{max} \sin(2 \pi f t)$ because $\omega = 2 \pi f$

$f = 1 / T$ where T is the periodic time

For a *sine wave*, to convert:
RMS to **peak** multiply by **1.414**
Peak to **RMS** multiply by **0.707**
Peak to **average** multiply by **0.636**
Peak to **peak-peak** multiply by **2**

Capacitive reactance

$$X_C = \frac{V_C}{I_C} = \frac{1}{2\pi f C}$$

Inductive reactance

$$X_L = \frac{V_L}{I_L} = 2\pi f L$$

Resistance and reactance in series

$$Z = \sqrt{\left(R^2 + X^2\right)} \quad \text{and} \quad \phi = \arctan\left(\frac{X}{R}\right)$$

Resonance

$$X_L = X_C \quad \text{thus} \quad \omega L = \frac{1}{\omega C} \quad \text{or} \quad 2\pi f_o L = \frac{1}{2\pi f_o C}$$

$$f_o = \frac{1}{2\pi\sqrt{LC}}$$

Power factor

Power factor = True power/Apparent power = Watts / Volt-amperes = W / VA

True power = $V \times (I \times \cos \phi) = V I \cos \phi$ Power factor = $\cos \phi = R / Z$

Reactive power = $V \times (I \times \sin \phi) = V I \sin \phi$

Motors and generators

$F = B I l$

$f = p n / 60$ where p is the number of pole *pairs* and n is the speed in r.p.m.

Three phase

Star connection $V_L = 1.732 \times V_P$ and $I_L = I_P$ note that $1.732 = \sqrt{3}$

Delta connection $V_L = V_P$ and $I_L = 1.732 \times I_P$

Power in a three phase load $P = 3 \times V_P I_P \cos\phi = 1.732 \times V_L I_L \cos\phi$