BASIC ELECTRICAL ENGINEERING FORMULAS

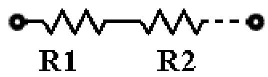
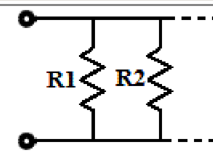
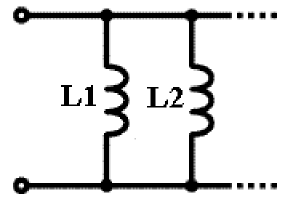
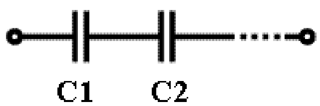
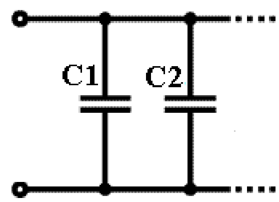
BASIC ELECTRICAL CIRCUIT FORMULAS

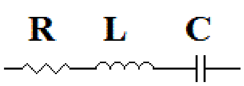
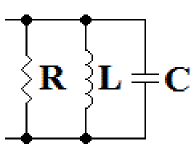
CIRCUIT ELEMENT	IMPEDANCE		VOLT-AMP EQUATIONS		ENERGY (dissipated on R or stored in L, C)
	absolute value	complex form	instantaneous values	RMS values for sinusoidal signals	
RESISTANCE	R	R	v=iR	Vrms=IrmsR	$E=Irms^2R\times t$
INDUCTANCE	2πfL	jωL	v=L×di/dt	Vrms=Irms×2πfL	$E=Li^2/2$
CAPACITANCE	1/(2πfC)	1/jωC	i=C×dv/dt	Vrms=Irms/(2πfC)	$E=Cv^2/2$

Notes:
R- electrical resistance in ohms, L- inductance in henrys, C- capacitance in farads, f - frequency in hertz, t- time in seconds, π≈3.14159;
ω=2πf - angular frequency;
j - imaginary unit ($j^2=-1$)

BASIC ELECTRICAL THEOREMS AND CIRCUIT ANALYSIS LAWS

LAW	DEFINITION	RELATIONSHIP
Ohm's Law modified for AC circuits with sinusoidal signals	Ù=Z×Ì, where Ù and Ì - voltage and current phasors, Z - complex impedance (for resistive circuits: u=R×i)	Lorentz force law, Faraday's law and Drude model
Kirchhoff's Current Law (KCL)	The sum of electric currents which flow into any junction in an electric circuit is equal to the sum of currents which flow out	Conservation of electric charge
Kirchhoff's Voltage Law (KVL)	The sum of the electrical voltages around a closed circuit must be zero	Conservation of energy

EQUATIONS FOR SERIES AND PARALLEL CONNECTIONS				
CIRCUIT ELEMENT	SERIES CONNECTION		PARALLEL CONNECTION	
RESISTANCE		Rseries= R1+R2+...		Rparallel= 1/ (1/R1+1/R2+...)
INDUCTANCE		Lseries= L1+L2+...		Lparallel= 1/(1/L1+1/L2+...)
CAPACITANCE		Cseries= 1/ (1/C1+1/C2+...)		Cparallel= C1+C2+...

RLC IMPEDANCE FORMULAS		
CIRCUIT CONNECTION	COMPLEX FORM	ABSOLUTE VALUE
 Series	Z=R+jωL+1/jωC	$Z = \sqrt{R^2 + (\omega L - \frac{1}{\omega C})^2}$
 Parallel	Z= 1/(1/R+1/jωL+jωC)	$Z = \frac{1}{\sqrt{\frac{1}{R^2} + \left(\omega C - \frac{1}{\omega L}\right)^2}}$

MAGNETIC FIELD UNITS AND EQUATIONS

QUANTITY	SYM-BOL	SI UNIT	SI EQUATION	CGS UNIT	CGS EQUATION	CONVER-SION FACTOR
Magnetic induction	B	tesla (T)	$B=\mu_o(H+M)$	Gauss (G)	$B = H+4\pi M$	$1\ T = 10^4\ G$
Magnetic field strength	H	ampere/ meter (A/m)	$H = NI/lc$ (lc - magnetic path, m)	Oersted (Oe)	$H = 0.4\pi NI/lc$ (lc - magnetic path, cm)	$1\ A/m = 4\ \pi\times10^{-3}$ Oe
Magnetic flux	Φ	weber (Wb)	$\Phi = BAc$ (Ac - area, m^2)	Maxwell (M)	$\Phi = BAc$ (Ac - area, cm^2)	$1\ Wb = 10^8\ M$
Magnetization	M	ampere/ meter (A/m)	$M=m/V$ (m- total magnetic moment, V- volume, m^3)	emu/cm^3	$M=m/V$ (m- total magnetic moment, V- volume, cm^3)	$1\ A/m = 10^{-3}\ emu / cm^3$
Magnetic permeability of vacuum	μ_o	newton/ $ampere^2$	$\mu_o= 4\pi\times10^{-7}$	1	-	$4\pi\times10^{-7}$
Inductance	L	henry	$L=\mu_o\mu N^2Ac/lc$ (N- turns, Ac- area, m^2, lc - magnetic path, m)	henry	$L= =0.4\pi\mu N^2Ac/lc\times \times10^{-8}$ (N- turns, Ac-area, cm^2, lc - magnetic path, cm)	1
Emf (voltage)	V	volt	$V= -Nd\Phi/dt$ (N- turns)	volt	$V= -10^{-8}\times \times N\times d\Phi/dt$ (N- turns)	1

MAXWELL'S EQUATIONS IN FREE SPACE (IN SI UNITS)		
LAW	**DIFFERENTIAL FORM**	**INTEGRAL FORM**
Gauss' law for electricity	$\nabla \cdot \vec{E} = \frac{\rho}{\varepsilon_0} = 4\pi k \rho$	$\oint \vec{E} \cdot d\vec{A} = \frac{q}{\varepsilon_0}$
Gauss' law for magnetism	$\nabla \cdot \vec{B} = 0$	$\oint \vec{B} \cdot d\vec{A} = 0$
Faraday's law of induction	$\nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$	$\oint \vec{E} \cdot d\vec{s} = -\frac{d\Phi_B}{dt}$
Ampere's law	$\nabla \times \vec{B} = \frac{\vec{J}}{\varepsilon_0 c^2} + \frac{1}{c^2}\frac{\partial \vec{E}}{\partial t}$	$\oint \vec{B} \cdot d\vec{s} = \mu_0 i + \frac{1}{c^2}\frac{\partial}{\partial t}\int \vec{E} \cdot d\vec{A}$
NOTES: E - electric field, ρ - charge density, $\varepsilon_0 \approx 8.85\times10^{-12}$ - electric permittivity of free space, π ≈ 3.14159, k - Boltzmann's constant, q - charge, B - magnetic induction, Φ - magnetic flux, J - current density, i - electric current, c ≈ 299 792 458 m/s - the speed of light, $\mu_0 = 4\pi\times10^{-7}$ - magnetic permeability of free space, ▼ - del operator (if **V** is a vector function, then ▼·**V** - divergence of **V**, ▼×**V** - the curl of **V**).		

For more reference info see EE Information Online