LAW & Formulae

1. Ohm's Law in point of field theory → $\boxed{J = \sigma . E}$ Ohm's Law

2. Coulomb's Law → (F)
Force of attraction between two charge $F = K\frac{q_1 q_2}{r^2}$

$$\boxed{F = \frac{1}{4\pi\epsilon_0\epsilon_r} \cdot \frac{q_1 q_2}{r^2}}$$ Coulomb's Law

3. Lifting Power of magnet

$\boxed{P = \frac{B^2 A}{2\mu_0}}$ N/m² $\boxed{P = \frac{B^2 A}{9.81 \times 2\mu_0}}$ kg-wt

P = Pulling force, A = Pole area in m², B = Flux Density,

4. Energy stored in magnetic field → $\boxed{E = \frac{1}{2} L I^2}$

5. Energy stored in electric field → $\boxed{E = \frac{1}{2} C V^2}$

6. Energy stored in ~~seri~~ series aiding coil

$$\boxed{E = \frac{1}{2} L_1 I_1^2 + \frac{1}{2} L_2 I_2^2 + M I^2}$$

7. Energy stored in series opposing coil

$$\boxed{E = \frac{1}{2} L_1 I_1^2 + \frac{1}{2} L_2 I_2^2 - M I^2}$$

8. Rate of change of stored energy, $\boxed{\frac{dE}{dt} = \frac{1}{2} I^2 \cdot \frac{dL}{dt}}$

9. Gauss's Theorem $\boxed{\int \vec{E} \cdot \vec{ds} = \frac{q}{\epsilon_0}}$

10. $\boxed{Q \sim \text{factor} = \frac{Z}{R}}$ ← $Q = \frac{1}{\cos\phi}$

11. $\boxed{Q \text{ factor} = \frac{f_0}{BW}}$ $\boxed{\text{Dissipation factor} = \frac{1}{Q}}$

12. $\boxed{Q_L = \frac{X_L}{R}}$ $\boxed{Q_C = \frac{X_C}{R}}$

13. Current in charging ckt in one time Const. = 63.2%

14. Mutual Inductance $\boxed{M = K\sqrt{L_1 L_2}}$ K = Coupling Co-eff^n K ≤ 1

When K=1, entire flux links with both coil.

CONSTANT

Faraday's Constant → 96500 Coulomb.

Absolute Permeability (μ_0) → $4\pi \times 10^{-7}$ H/m

Absolute Permittivity (ϵ_0) → 8.854×10^{-12} F/m

Electrostatic Constant $\left(\frac{1}{4\pi\epsilon_0}\right)$ → 9×10^{9} $N\text{-}m^2/C^2$

Electro chemical Eqv. of Silver → 0.001118 gm/C
(Z) Copper → 0.00032 gm/C

Standard emf of a cell → 1.09 V

Fusing factor of HRC fuse → 1.1

Breadth factor / Spread factor / Winding factor / Distribution factor → 0.96

Pitch factor → 0.966.

Voltage drop at conducting SCR → 1.5 V

Current carrying capacity of copper bus-bar → $1.2 A/mm^2$

Impulse Ratio of Rod Gap → 1.2 to 1.5

Mechanical Eqv. of Heat → 4.18 J/Cal

Voltage of a fully charged cell → 2.1 volt.

Dielectric St. of Air → 30 kV/cm (max), 21.3 kV/cm (rms)

Ratio of lead : tin (in fuse wire) → 40:60 (Pb:Sn)

D.E. Strength of Air → 3 kV/mm.

Melting Point of Al → 660°C
" " " Cu → 1085°C
" " " Fe → 1580°C
" " " Ag → 960°C
" " " W → 3400°C

1 Culomb charge = 6.28×10^{16} electron charge / 6.24×10^{18} electron

Capacitance of an isolated sphere of rad. 'r', charge 'Q' → $4\pi\epsilon_0\epsilon_r R$

1 KWh = 864 KCal

1 Cal = 4.2 J
1 J = 0.24 Cal

1 AMU = 1.67×10^{-27} kg.

D.E. Strength of SF_6 = 2.5 times of Air.

B.D. Voltage of Paper Cap → > 10 KV

D.E. Const. of Air → 1
" " Mica → 3 to 8

Joul's Mech. eqv. of heat = 4186 J/Kcal

UNIT

1. Electric field Intensity → Newton/Volt.
2. Electrostatic Const → Newton - m^2/C^2 $\left(\frac{1}{4\pi\epsilon_0}\right)$
3. Electric Intensity → Newton/C or V/m
4. ECE → gm/C.
5. 1 wb = 10^8 lines.
6. Susceptibility → No unit.
7. Quantity of Electricity → Coulomb.
8. Electric flux → Coulomb.
9. Heat energy → Joule.
10. Hysterisis loss (W_h) = $\eta B_m^{1.6} f v$ watt → volume
    Eddy Current loss (W_e) = $K B_m^2 f^2 t^2 v^2$ → thickness
11. $\boxed{1 \text{ BHP} = 745.7 \text{ watt}}$
    1 Metric HP = 735.5 watt
12. ϵ_r of vacuum ⇒ 8.854×10^{-12} F/m
13. Time constant for R-C ckt ⇒ $\boxed{\tau = RC}$
    " " " R-L " ⇒ $\boxed{\tau = \frac{L}{R}}$
14. Intrinsic impedance of free space - 377 Ω
15. 1 Farad = 9×10^{11} esu
16. $\frac{1}{4\pi\epsilon_0} = 9 \times 10^9$ (17.) 1 C = 3×10^9 esu.
17. 1 BThU = 1053 J
    1 CHU = 1896 J
    1 kwh = ~~3600~~ 3.6×10^6 J

Ion → Charged Particle
Atom → Neutral as a whole
Constantum = Cu - 60% Ni - 40%

Resistivity chart
1. Carbon (Graphene)
2. Silver
3. Copper
4. Gold
5. Calcium
6. Zn
7. Li
8. Fe
9. Pt
10. Tin
11. Pb.

Dielectric strength (at 20°C)

		const.
Asbestos →	42 kV/mm.	3-5
Air →	3 kV/mm	1
Mica →	50 - 200 kV/mm	3-8
Rubber →	40 kV/mm	2-4
PVC →	~~500~~ 700 kV/mm	
Paper		1.5-3
Vacuum →	∞ kV/mm	

15. Torque in synch watt (T) $\boxed{T = \frac{P}{(1-S)}}$

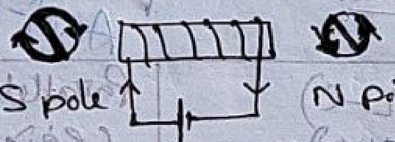
P = Gross o/p power
S = slip.

16. M/C η $\boxed{\begin{array}{l}\text{Variable loss = Const. Loss}\\ \text{Copper loss = Iron loss.}\end{array}}$

17. Max Power developed Condition for DC Motor $\boxed{E_b = \frac{V}{2}}$

18. $\boxed{\theta(\text{mech}) = \frac{\theta(\text{elect})}{\text{Pole Pair.}}}$ No. of twigs = no. of node − 1

19. $\boxed{L = B - N + 1}$ L = Link B = Branch N = Node

Sl. No.	Rule	Application	Sl. No.	Rule	Application.
1.	End Rule	Polarity of Electromagnet.  S pole N pole	2.	1st law of Illu.n	Inverse sq. law $\boxed{E \propto \frac{1}{r^2}}$
				2nd law of Illu.n	Lambert's Cosine Law $\boxed{E = \frac{I\cos\theta}{r^2}}$
3.	Conservation of Charge	KCL	4.	Conservation of Energy	KVL
5.	Kelvin's Law	Economic size of Conductor.	6.	P.V. Action	Solar Cell
7.	Smith Chart. (Circular)	Zin of T/m line at any distance from load. (Matching ckt)	8.	MILMAN Effect.	C connected between i/p & o/p. of an amplifier affects its HF response
9.	Ampere Right Hand Rule	Direction of mag. field in a current carrying conductor.	10.	Faraday's law of electrolysis 1st law.	$\boxed{m \propto Q}$ $\boxed{m = Z \cdot I \cdot t.}$ (Z = e.c. eqv)
				2nd law	$\boxed{m \propto E}$ m = KE

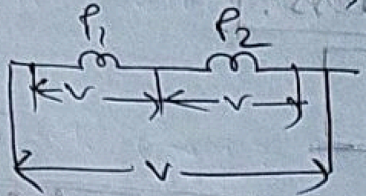
Bilateral →	R, L, C
Unilateral →	Diodes, T/s, Elect. Capa
Active →	V, I, source, MOSFET, Diode, T/s, FET.
Passive →	R, L, C
Linear →	R, L, C
Non linear →	Diodes, T/s.

20. For Even function $f(t)$ condition → $\boxed{f(t) = f(-t)}$ Even

For Odd function $f(t)$ condition → $\boxed{-f(t) = f(-t)}$ Odd

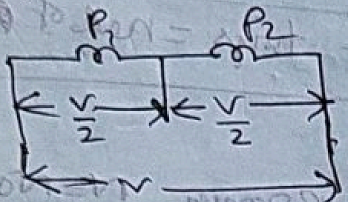
21. Same watt, Same voltage, 2 lamp in series (P_1 & P_2)

(I)



Total Power, $\boxed{P = \frac{P_1 \times P_2}{P_1 + P_2}}$ now $P_1 = \frac{1}{4} P$

(II)



Total Power, $\boxed{P = P_1 + P_2}$

Diff^n wattage $P_1 \neq P_2$ Brig. $P_1 > P_2$

$P_1 < P_2$

~~Series RLC~~ → Acceptor ckt.

~~Parallel~~ " → ~~Rejector ckt~~

Anti-Resonant ckt

22. Leakage in Electrical Machine -

$\boxed{\text{Leakage factor} = \frac{\text{Total flux}}{\text{Useful flux}}}$

23. Series & Parallel Resonance.

Item	Series (R-L-C) (Acceptor ckt)	Parallel (R-L & C) (Rejector ckt)
Z at Resonance	Minimum (= R)	Maximum ($= \frac{L}{CR}$)
Current	Maximum	Minimum
Effective Z	R	$\frac{L}{CR}$
p.f at Resonance	Unity	Unity
Magnify →	Voltage	Current
Resonant freq (f_0) →	$f_0 = \frac{1}{2\pi\sqrt{LC}}$	$f_0 = \frac{1}{2\pi}\sqrt{\frac{1}{LC} - \frac{R^2}{L^2}}$
Magnification (Q_0)	$\frac{X_L}{R}$	$\frac{X_L}{R}$

24. $\boxed{\text{Electrical Degree} = 180° \times \text{No. of Pole}}$

25. Gauss's Law: "The total electric flux through any closed surface surrounding charges is equal to the amount of charge enclosed."

$$\boxed{\phi_E = \oint \vec{E} \cdot d\vec{A} = \frac{q_{in}}{\varepsilon_0}}$$

Biot - Savart Law:-

$\boxed{B = \frac{\mu_0 I}{2R}}$ $\boxed{|dB| = \left(\frac{\mu_0}{4\pi}\right)\left(\frac{I\,dl\,\sin\theta}{r^2}\right)}$ $\mu_0 = 4\pi\times10^{-7}$ H/m

Ampere's Circuital Work Law :- " The mmf around a closed path is equal to the current enclosed by the path."

$$\boxed{\oint \vec{H}.d\vec{s} = I}$$

H = Mag. field strength
S = Enclosed path
I = Current.

Biot- Savart Law → Magnetostatics.
Coulomb's Law → Electrostatics.

$\boxed{B = \frac{\mu_0 I\,dl\,\sin\theta}{4\pi r^2}}$

$\boxed{F = \frac{q_1 q_2}{4\pi\varepsilon_0 r^2}}$

⊛ $\mu_0 = 4\pi\times10^{-7}$ H/m

⊛ $\varepsilon_0 = 8.854\times10^{-12}$ F/m

I → CGS unit = Biot
Charge → " " = franklin

MAGNETIC CKT.

Sl. No.		Unit (CGS)	Unit (SI)	Analogy	Relation
1.	Mag. Flux (ϕ)	Maxwell	Weber (Wb) Maxwell (cgs)	Current (I)	1 Wb = 10^5 lines of forces; 1 Wb = 10^8 Maxwell
2.	Flux Density (B)	Gauss (Gs) or Maxwell/cm^2	Wb/m^2 or Tesla	Current Density (J)	$\boxed{B = \frac{\phi}{A}}$ $\boxed{B = \mu H}$
3.	~~Field~~ Strength Flux (F)	Dyne	Newton (N)		$\boxed{F = mH}$ m = pole st. in wb. H = fld. st. in N/wb.
4.	MMF (NI)	Gilbert	Amp-turn. ~~Gilbert (cgs)~~	Voltage (V)	$\boxed{MMF = \phi\times S = \text{Amp-turn}}$ $\boxed{MMF = H\times l}$ H = Mag. force, l = length of mag. ckt.
5.	Reluctance (S)		AT/Wb.	Resistance (R)	$\boxed{S = \frac{l}{\mu_0\mu_r a}}$
6.	Magnetising Force (H)	Oersted	AT/m ~~oersted~~ N/Wb		$\boxed{H = \frac{MMF}{l}}$ F = m H (force, wb.)
7.	Permeability (μ)		H/m.	Conductivity (ρ)	$\boxed{\mu = \frac{B}{H}}$ $\mu_0 = 4\pi\times10^{-7}$ H/m $\boxed{\mu = \mu_0\times\mu_r}$
8.	Permeance		Wb/AT	Conductance (G)	Permeance $= \frac{1}{S}$

$$\boxed{\text{Leakage factor} = \frac{\text{Total flux}}{\text{Useful flux}}}$$

Electrochemical Equi: Mass of substance liberated from an electrolyte by one coulomb of electricity.

Inst. Power =

$$P_i = \frac{V_m I_m}{2}\left[\cos\theta - \cos(2\omega t + \theta)\right]$$

$$= V_m I_m\left[\sin(\omega t + \theta_v)\sin(\omega t + \theta_i)\right]$$

~~Purely inductive ckt.~~

$\cos(A-B) - \cos(A+B) = 2\sin A\sin B$

~~$P_i = V_m I_m \cos 2\omega t$~~

Sl. No.	Particle	Symbol	Mass	Charge	Mass	Charge
1.	Electron	e^-	0	-1	9.11×10^{-31} kg (1/1800 AMU)	(−) 1.6×10^{-19} C
2.	Proton	p^+	1 AMU	$+1$	1.67×10^{-27} kg	(+) 1.6×10^{-19} C
3.	Neutron	n^0	1 AMU	0	1.67×10^{-27} kg	0

2 Capacitor in series. $X_e = \frac{X_{C_1} X_{C_2}}{X_{C_1} + X_{C_2}}$

Inside a ~~cha~~ conducting sphere Potential is const.

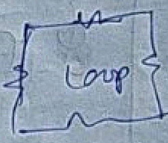
1 HP → 4500 kg water lifted in ~~2~~ 1 min

Solar cells are photo diode

Ripple factor ~~of~~ of capacitor filter may be decreased by increasing C.

$$\boxed{\text{Dielect. Const} = \frac{\text{Permittivity of Dielect.}}{\text{Permittivity of Vacuum.}}}$$

KCL applied for both linear & non-lin. n/w.
A closed path made by several branches of network
~~Kaor~~ $\rightarrow$ Loop.



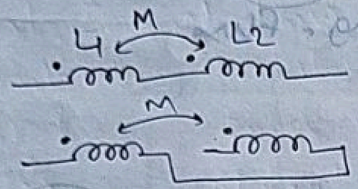
KCL — Conservation of Charge
KVL — " " Energy
Lenz Law — " " energy

Inductor stores energy in magnetic field.
Form factor of DC $\rightarrow$ Unity.

Susceptance $(B) = \dfrac{X}{Z^2}$

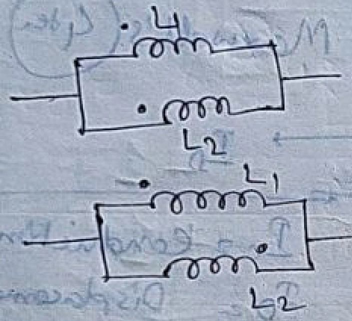
At PTC temp $\uparrow$ $\rightarrow$ R $\uparrow$ non linearly.

#



$\boxed{L = L_1 + L_2 + 2M}$ Mutual field assist. (cum. coupled)

$\boxed{L = L_1 + L_2 - 2M}$ Mutual field oppose (Diff^n coupled)



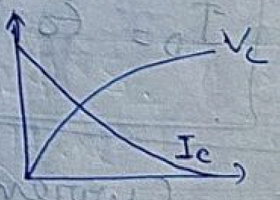
$\boxed{L = \dfrac{L_1 L_2 - M^2}{L_1 + L_2 - 2M}}$ Mutual field assist.

$\boxed{L = \dfrac{L_1 L_2 - M^2}{L_1 + L_2 + 2M}}$ Mutual field oppose

$A \times B = (6 + j8)(3 - j4)$
$= 18 - \cancel{j24} + \cancel{j24} - j^2 32$ $\quad [j^2 = -1]$
$= 18 + 32$
$= 50 + j0$

$\dfrac{A}{B} = \dfrac{6 + j8}{3 - j4} \times \dfrac{(3 + j4)}{(3 + j4)} =$

R-C Transient-



Charging current $\boxed{i_c = I_0 e^{-t/\lambda}}$

Charging voltage, $\boxed{V_c = V\left(1 - e^{-t/\lambda}\right)}$

$\boxed{I_0 = \dfrac{V}{R}}$

Discharging current $\boxed{i_d = (-)\, I_0 e^{-t/\lambda}}$

Discharging voltage $\boxed{V_d = V e^{-t/\lambda}}$

Time const. $\boxed{\lambda = RC}$

$\boxed{\dfrac{1}{\lambda} = \text{Damping Coeff.}}$

Gauss's Law in Electrostatics →

$$\boxed{\oint \vec{E}\cdot d\vec{s} = \frac{q}{\epsilon_0}}$$

Maxwell's 1st eq^n
$\vec{E}$ = Elect. Field

Gauss's law in Magnetism →

$$\boxed{\oint \vec{B}\cdot d\vec{s} = 0}$$

Maxwell's 2nd eq^n
$\vec{B}$ = Mag. Field.

Faraday's law of e.m. induction →

$$\boxed{\oint \vec{B}\cdot d\vec{l} = -\frac{d\phi_B}{dt}}$$

Maxwell's 3rd eq^n
ϕ_B = Mag. flux

Ampere-Maxwell's Circuital law.

$$\boxed{\oint \vec{B}\cdot d\vec{l} = \mu_0\left(I_c + \underbrace{\epsilon_0\frac{d\phi_E}{dt}}_{I_D}\right)}$$

Maxwell's 4th eq^n

ϵ_0 = Elect. flux.

⊛ Ampere's Circuital law

$$\boxed{\oint \vec{B}\cdot d\vec{l} = \mu_0 I}$$

I_c = Conduction Current
I_D = Displacement "
$I = (I_c + I_D)$

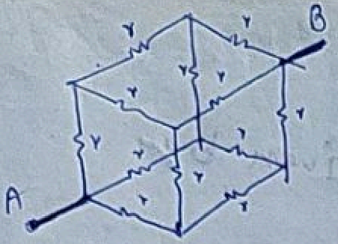
⊛ Velocity of electromagnetic wave in free space

$$\boxed{c = \frac{1}{\sqrt{\mu_0 \cdot \epsilon_0}}} = 3\times10^8 \text{ m/s}$$

$$\boxed{I_D = \epsilon_0\frac{d\phi_E}{dt}} \quad \boxed{E = -\frac{d\phi_B}{dt}}$$

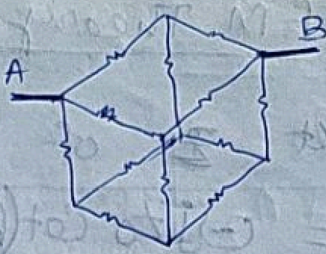
⊛ Current source → dual → Voltage Source
→ " → Twig
Link
Mesh → " → Node

Superposition Th → Linear   Substitution → Linear
Thevenin's " → "
Norton's " → "
Max P.T. " → Bilateral
Tellegen's " → All (Sum of power delivered in any branch = zero)



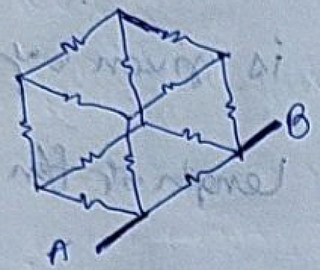
$\boxed{R_{AB} = \frac{5r}{6}}$

opposite



$\boxed{R_{AB} = \frac{3r}{4}}$

(diagonal)



$\boxed{R_{AB} = \frac{7r}{12}}$

(One edge)

Y to $\Delta \Rightarrow 3R$

Δ to $Y \Rightarrow \frac{R}{3}$

GRAPH THEORY

TREE - Contains all nodes but donot form any Close path or loop

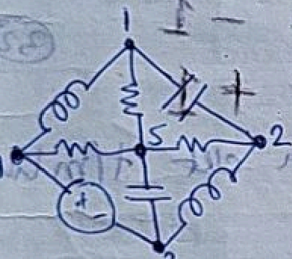
BRANCH -

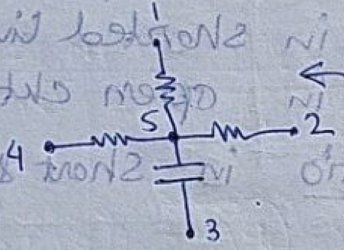
NODE - Junction of branch

LINK -

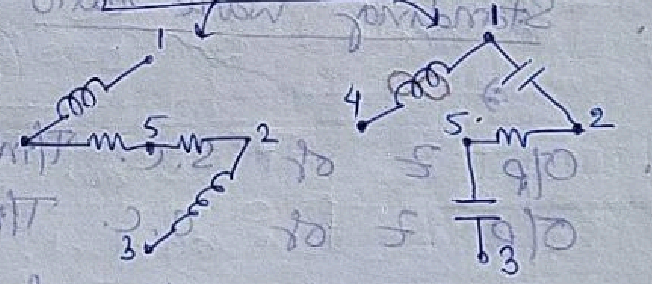
TWIG - Branches of tree is called Twigs, $\boxed{\text{Twig} = \text{Node} - 1}$

COTREE -





Contains all Nodes but
No branch
So it is TREE



1, 2, 3, 4, 5 → Node

1-2, 2-3, 3-4, 4-1 → Branch

1-5, 5-2, 5-4, 5-3 → Twig
1-4, 4-5, 5-2, 2-3 → "
4-1, 1-2, 2-5, 5-3 → "

R-L Transient

Charging Current = $\boxed{i_L = i_0 \left(1 - e^{-t/\lambda}\right)}$

Charging voltage = $\boxed{V_L = V e^{-t/\lambda}}$

Time Const. $\boxed{\lambda = \frac{L}{R}}$

$\boxed{i_0 = \frac{V}{R}}$

Discharging Current = $\boxed{i_L = i_0 \cdot e^{-t/\lambda}}$

Discharging Voltage = $\boxed{V_L = (-)V \cdot e^{-t/\lambda}}$

$\frac{1}{\lambda}$ = Damping Co-eff.

EM Theory.

1. The open ckt Z of T/m line is given by

$$\boxed{Z_{oc} = (-)jZ_0 \cot(\beta L)}$$

2. The short ckt Z of T/m line is given by

$$\boxed{Z_{sc} = jZ_0 \tan(\beta L)}$$ L = Length of T/m line

3. The characteristic impedance (Z_0) is given by

(50 Ω or 75 Ω) SI or

$$\boxed{Z_0 = \sqrt{Z_{oc} \cdot Z_{sc}}}$$ $$\boxed{Z_0 = \sqrt{Z_L \cdot Z_{i/p}}}$$

4. Characteristic Z (Z_0) ; L = Ind / unit length of line
or Surge Impedance ~~loading~~ C = Cap / unit length

$$\boxed{Z_0 = \sqrt{\frac{L}{C}}}$$ $$\boxed{Z_0 = \sqrt{X_L \cdot X_C}}$$

5. voltage Reflection Co-eff^n in shorted line = −1
6. voltage Reflection Co-eff^n in open ckt^n = +1
7. Standing wave ratio in short & open ckt T/m line
→ ∞
8. O/P Z of S.C. T/m line = 0
O/P Z of O.C. T/m line = ∞
9. For max power transfer theorem to be applied to the T/m line, Reflection co-eff^n has to be → zero
10. Transmission Co-eff^n, $$\boxed{T = \frac{Z_L}{Z_0}}$$ $$\boxed{T = \frac{E_t}{E_i}}$$
11. Standing wave for O.C. voltage & S.C. current are same. Phase Diff^n − λ/8
12. Standing wave for O.C. Current & S.C. voltage are same. Phase Diff^n − λ/8
13. S.W.R for max. power ~~of~~ transfer in T/m line
1:1

14. S.W. occurs due to → Z mismatch.

15. $SW.R = \frac{V_{max}}{V_{min}}$ $\frac{\text{antinode}}{\text{node}}$

$SWR = \frac{Z_L}{Z_0}$ Z_L = Load Z, Z_0 = Chan. Z.

16. Relation between Reflection Co-effⁿ & SW.R

$S = \frac{1+R}{1-R}$

$SWR = \frac{\text{Transmitted Wave}}{\text{Reflected Wave}}$

17. Range of SWR → $1 < S < \infty$

18. Maximum Z of T/m line

$Z_{max} = S \times Z_0$ S = SWR, Z_0 = Chan. Z.

19. Minimum Z of T/m line

$Z_{min} = \frac{Z_0}{S}$

20. Current Reflection Co-effⁿ at any point of line = (−) voltage Reflection Co-effⁿ at any point of line.

21. Relation between T/m Coeffⁿ & Reflection Coeffⁿ

$T + R = 1$ (*)

22. Reflection Co-effⁿ, $R = \frac{E_r}{E_i}$ (*) [E_r = Reflected Amp. E_i = Incident Amp.]

23. Reflection Co-effⁿ (in terms of Intrinsic Z)

$R = \frac{\eta_2 - \eta_1}{\eta_2 + \eta_1}$

24. Reflection Coeffⁿ (in terms of permittivity ε)

$R = \frac{\sqrt{\epsilon_2} - \sqrt{\epsilon_1}}{\sqrt{\epsilon_2} + \sqrt{\epsilon_1}}$

Propagation velocity v_p of ~~ideal~~ Normal value $\frac{1}{\sqrt{LC}}$

$v = \frac{\omega}{\beta} = \frac{2\pi f}{\beta}$

Phase const.

25. Transmission Coeff^{n} (in terms of intrinsic Z)

$$\boxed{T = \frac{2\eta_2}{\eta_1 + \eta_2}}$$

26. T/m Coeff^{n} (in terms of permittivity, ϵ_0)

$$\boxed{T = \frac{2\sqrt{\epsilon_2}}{\sqrt{\epsilon_1}+\sqrt{\epsilon_2}}}$$

27. In matched line T/m Coeff^{n} → 1
In matched line Reflection Coeff → 0
(max Power transferred from transmitter to receiver)

28. ~~Reflection Power~~, ~~R~~ Reflection Co-eff^{n} (in terms of power)

$$\boxed{R = \sqrt{\frac{P_{reflected}}{P_{incident}}}}$$

29. Transmitted ~~Po~~ Co-eff^{n} (in terms of power)

$$\boxed{T = \sqrt{\frac{P_{transmitted}}{P_{incident}}}}$$

30. Relation between R & T (in terms of power)

$$\boxed{R^2 + T^2 = 1}$$

31. VSWR (Voltage Standing wave Ratio)

Reflection coeff. (Γ) $\boxed{(R) = \frac{Z_L - Z_0}{Z_L + Z_0}}$ Z_L = load Z, Z_0 = Char Z

32. Normal value of (R) = $\boxed{-1 \leq R \leq +1}$

(−1 means − 100% Reflection & 180° out of phase
+1 means − 100% " & 0° "
0 " 0% " all power t/m to load)

33. T/m voltage = Incident voltage + Reflected voltage
T/m Current = Incident Current + Reflected Current.

34. for matched line

$\boxed{Z_{i/p} = Z_0}$ Z_0 = Char Imp.

35. Avarage Power in E.M. wave is given by →

$\boxed{\text{Poynting vector} = \text{Electric field} \times \text{Magnetic field}}$
↑ cross product.

36. for ∞ T/m line $\boxed{Z_{i/p} = Z_0}$

37. Best T/m Length $\boxed{L = \lambda/8}$

38. T/m line length = Wavelength, $\boxed{Z_{i/p} = Z_L}$
↳ when condition holds good

39. Char Impedance or Surge Impedance for long T/m line –

$\boxed{Z_S = \sqrt{\frac{Z}{Y}}}$ $\boxed{\gamma = \sqrt{YZ}}$ $\boxed{\gamma = \alpha + j\beta}$

Z = Series Impedance / p.u. Length / per phase.
Y = Shunt Admittance p.u. Length /per phase.
γ = Propagation Const.

40. ∞ line → no ~~[illegible]~~ reflected wave

41.

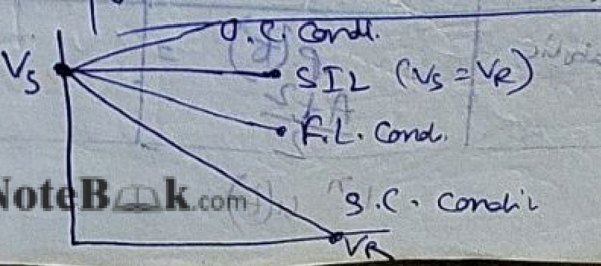
	Z_0 or Z_S	phase Angle
Overhead line →	400 Ω,	0 – −15° (ϕ)
Underground line →	40 Ω	

42. Surge Impedance Loading (SIL) [Power]

Power delivered by a line to a purely Resistive load equal in value to the surge impedance.

$\boxed{SIL = V_R^2 \sqrt{\frac{C}{L}}}$ (V_R = Reciving end voltage)

$\boxed{SIL = \frac{V_R^2}{Z_S}}$ $\boxed{\text{unit} \to \text{Watt or MW}}$



SIL for long T/m line = 100 Ω

Reflection co-eff. of simplest standing wave = 1

$t e^{-at} u(t)$ $\qquad \frac{1}{(s+a)^2}$

$\frac{d^n}{dt^n} x(t)$ $\qquad s^n X(s) - s^{n-1} x(0) - s^{n-2} x'(0)$

$\int x(t)\, dt$ $\qquad \frac{X(s)}{s} + \frac{x(0^-)}{s} + \dots$

$e^{-at} \sin at$ $\qquad \frac{a}{(s+a)^2 + a^2}$

$e^{-at} \cos at$ $\qquad \frac{(s+a)}{(s+a)^2 + a^2}$

Laplace Transform,

Sl. No.	Name	f(t)	f(s)	Waveform
1.	Impulse	$f(t) = \begin{cases} 1 & t=0 \\ 0 & t>0 \end{cases}$ $\delta(t)$	1	
2.	Step.	$L(1) =$ $u(t)$	$\frac{1}{s}$	
3.	Ramp	$L(t) =$ $r(t)$	$\frac{1}{s^2}$	
4.	Exponential	$L(e^{at}) =$	$\frac{1}{s-a}$	
5.	Sine	$L(\sin at) =$	$\frac{a}{s^2+a^2}$	
6.	Cosine	$L(\cos at) =$	$\frac{s}{s^2+a^2}$	
7.		$L(\sinh at) =$	$\frac{a}{s^2-a^2}$	
8.		$L(\cosh at) =$	$\frac{s}{s^2-a^2}$	
9.		$L(e^{-at}) =$	$\frac{1}{s+a}$	
10.	Parabolic	$p(t) = \frac{At^2}{2}$	$\frac{1}{s^3}$	p(t)

$t^n u(t)$ $\qquad \frac{n!}{s^{n+1}}$

Co-eff of Reflection & Refraction (T/m)

$V_{Refraction} = \frac{2Z_L}{Z_L + Z_0}$ $\quad$ $i_{Refraction} = \frac{2Z_0}{Z_L + Z_0}$

$V_{Reflection} = \frac{Z_L - Z_0}{Z_L + Z_0}$ $\quad$ $i_{Reflection} = \frac{Z_0 - Z_L}{Z_L + Z_0}$

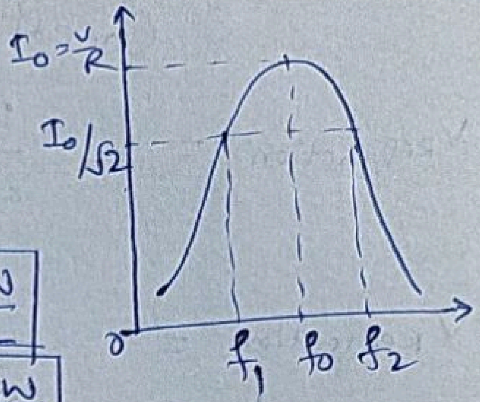
$$\boxed{i_{Reflection} = (-)\, V_{Reflection}}$$

Z_L = Load Impedance $\quad$ Z_0 = Characteristics Impedance

	OPEN CKT LINE	SHORT CKT LINE	FLAT LINE (Matched line)
	$Z_L = \infty$	$Z_L = 0$	$Z_L = Z_0$
$V_{Refraction}$	2	0	1
$V_{Reflection}$	1	-1	0
$i_{Refraction}$	0	2	1
$i_{Reflection}$	-1	1	0

Parameter	Condition of Reciprocity.	Condition of Symmetry.
Z	$Z_{12} = Z_{21}$	$Z_{11} = Z_{22}$
Y	$Y_{12} = Y_{21}$	$Y_{11} = Y_{22}$
T (ABCD)	$AD = BC + 1$	$A = D$
h	$h_{12} = -h_{21}$	$h_{11}h_{22} - h_{12}h_{21} = 1$

1. $\boxed{Q \text{ factor} = \frac{1}{R}\sqrt{\frac{L}{C}}} = \frac{\text{Energy stored}}{\text{Energy lost.}}$



2. $\boxed{\text{Band width} = \frac{f_0}{Q}}$ · $\boxed{BW = f_2 - f_1}$
3. Lower Half Power Frequency $\boxed{(f_1) = f_0 - \frac{BW}{2}}$
4. Upper Half Power Frequency $\boxed{(f_2) = f_0 + \frac{BW}{2}}$
5. Maximum power at resonance at $-3dB$.
6. At Half Power Point,

   (i) Current $= I_0/\sqrt{2}$

   (ii) Impedance $= \sqrt{2}R = \sqrt{2}Z$

   (iii) $P_1 = P_2 = P_0/2$

   (iv) Ckt Phase Angle $\theta = \pm 45°$

   (v) $Q = \tan\theta = \tan 45° = 1$

7. Voltage Magnification $= \frac{X_L}{R} = \frac{X_C}{R}$
8. $\boxed{\text{Selectivity} = \frac{f_0}{f_2 - f_1}} \boxed{= \frac{f_0}{BW}}$

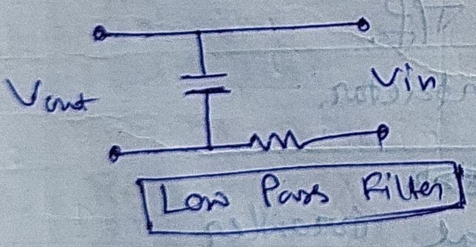
Current through Inductor → Exponential Growth
" " Capacitor → " Decay

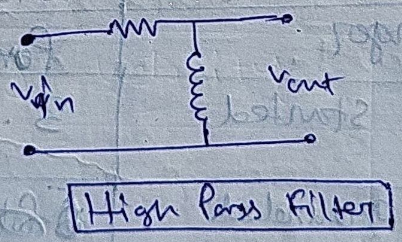
Series element in Band Pass filter → Series Comb. of L & C
Series element " Band Stop " → Parallel " " L & C

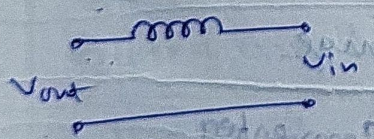
Shunt element " Band Pass filter → Parallel " " L & C
Shunt element " Band Stop " → Series " " L & C

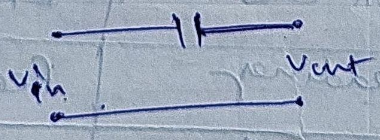
Series element of High Pass filter → Capacitor.
Series element of Low Pass Filter → Inductor.

Shunt element of High Pass filter → Inductor.
Shunt element of Low pass filter → Capacitor.









$f \downarrow \; X_L \downarrow$ $\qquad$ $f \uparrow \; X_C \downarrow$

Maximum Allowable gate Power dissipation (P_{gm})

$$\boxed{P_{gm} = \frac{P_{avg}}{D}}$$

$P_{avg} = P_{gm} \times D$

P_{avg} = Average gate power dissipation

D = Duty cycle.

HARMONICS

What?

Harmonics are defined as an unwanted higher freq^n component that is an integer multiple of fund. freq^n.

$$\text{Amplitude}_{\text{harmonics}} < \text{Amp.}_{\text{fund.}}$$

Source?

Inductor, Rectifier, Elect. Ballast in fl. tube, Sw. H/f., discharge lighting, highly inductive load.

Due to most powerful switching ckt. like SCR, Power T/s, VFD, ~~VF~~ VVVFD.

Effect?

Power quality problem, pulsating torque in motor, heating problem in equipment. (↑ Iron loss)

Time Harmonics:- Gen. by Non sinusoidal varying source

Space Harmonics:- Gen. by non sin. distribution of coil in m/c & slotting.

1st Harmonics (fund.) $(f) = v_1 = V_m \sin(\omega t)$

2nd " $(2f) = v_2 = V_{2m} \sin(2\omega t)$

3rd " $(3f) = v_3 = V_{3m} \sin(3\omega t)$

Total value of complex waveform (fund + har)

$$\boxed{V_{Total} = v_1 + v_2 + v_3 + \dots + v_n} \qquad \boxed{f_n = n \cdot f_1}$$

Types:	Rotate	Example
+ve seq. Harmonics:-	Forward with fund. freq.	4th, 7th, 10th, 13th
-ve seq. Harmonics:-	Reverse	2nd, 5th, 8th, 11th ..
zero seq. Harmonics:-	Not Rotate	3rd, 6th, 9th, 12th .. (Triplens^n)

seq.

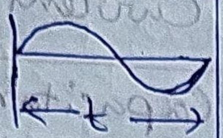
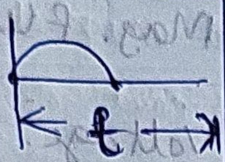
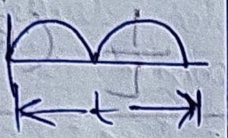
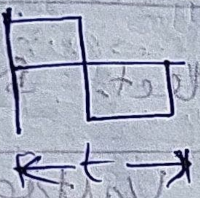
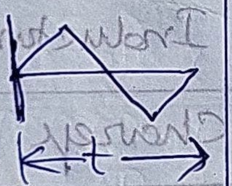
+ve → overheating of cond.

-ve " → Opposite phasor rotation, Weaken Rot. mag. fld, Reduce Mech. o/p

zero → Add arithmetically in common neutral current

↳ $\boxed{I_N = 3 I_{ph}}$ less efficient, overheat

Diff. Wave form.

Sl. No.	Wave form	Phasor	RMS value	Average Value	Form factor ($\frac{RMS}{Avg}$)	Peak Factor ($\frac{Max}{RMS}$)
1.	Sine wave		$\frac{I_m}{\sqrt{2}}$	$\frac{2I_m}{\pi}$	1.11	1.41
2.	Half wave Rectified Sine wave		$\frac{I_m}{2}$	$\frac{I_m}{\pi}$	1.57	2.0
3.	Full wave Rectified Sine wave		$\frac{I_m}{\sqrt{2}}$	$\frac{2I_m}{\pi}$	1.11	1.41
4.	Rectangular wave (Square wave)		I_m	I_m		1
5.	Triangular wave		$\frac{I_m}{\sqrt{3}}$	$\frac{I_m}{2}$	1.16	1.73

Z_{11} = Input Driving Point Impedance

Z_{22} = Output " "

Z_{12} = Reverse Transfer "

Z_{21} = Forward " "