(N.F.TL)

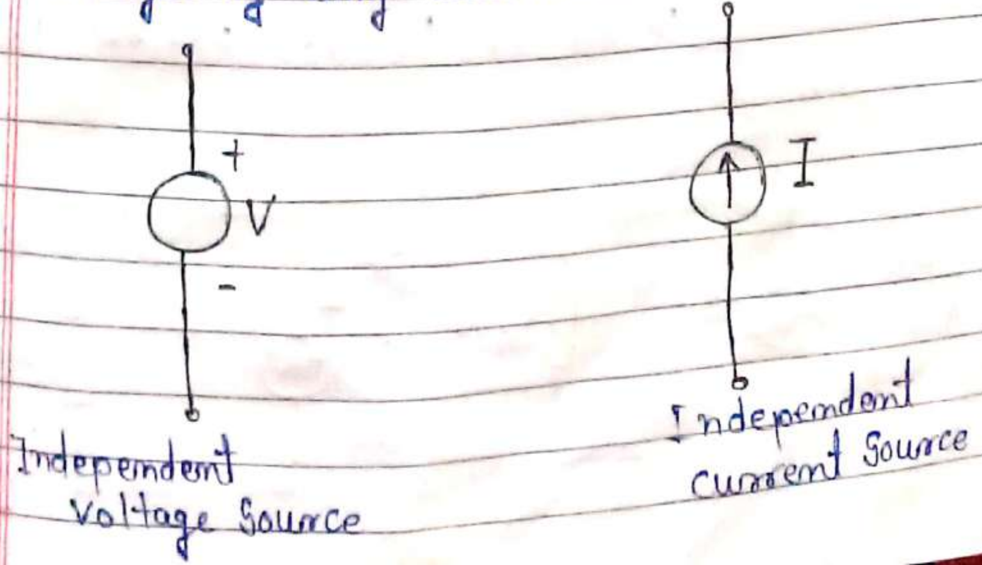
Circuit Theory (परिपथ के सिद्धान्त)

Elements of Network: Electrical Network is a Interconnection of different electrical elements such as Resistors, Inductors, Capacitor voltage source and current source.

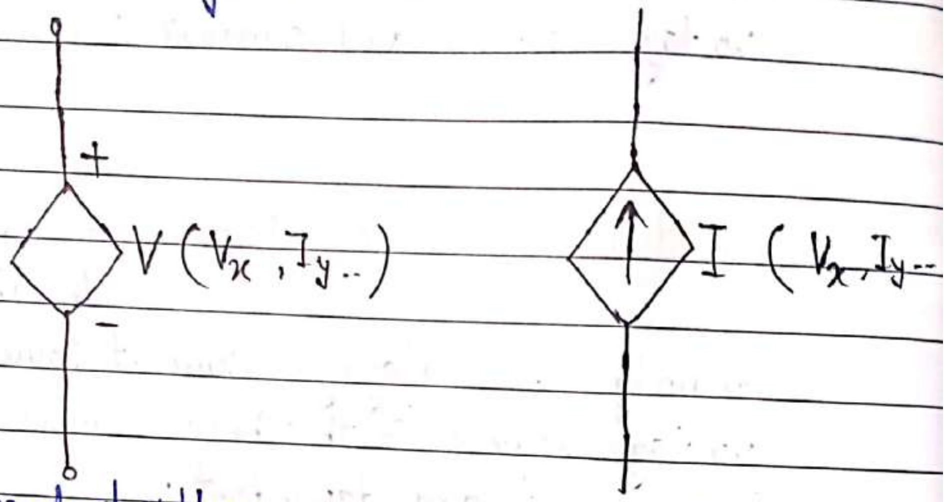
"Independent and Dependent sources": Sources can be divided in mainly two category Current source and voltage source. Both these sources can be independent and dependent.

"Independent Source" → Independent voltage source is one in which voltage always Remains constant and it is not affected by any other variations.

Similarly in Independent current source current always Remains same and it is not changed by any variations in connected Network.



"Dependent Source" → Dependent voltage or current source depends upon a particular elements of the circuit for its voltage and current.

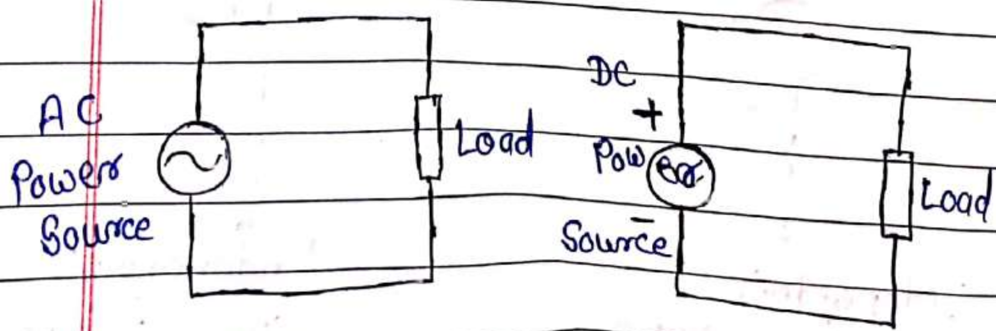


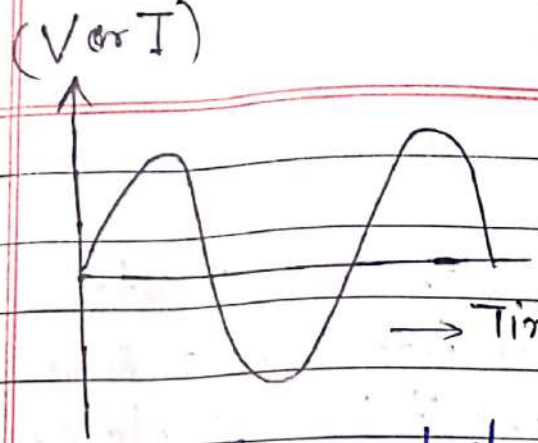
Dependent voltage Source

Dependent current source

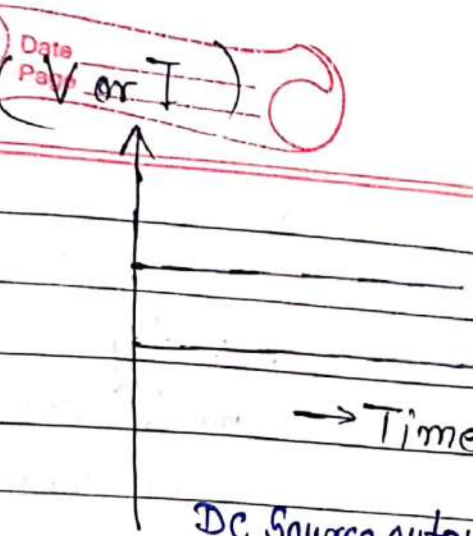
"Electric Power Sources" → For the operation of Electronic and electrical equipment we need electrical power.

Those equipments whoes supply electrical Power are called Electric Power Sources.





Ac Source output



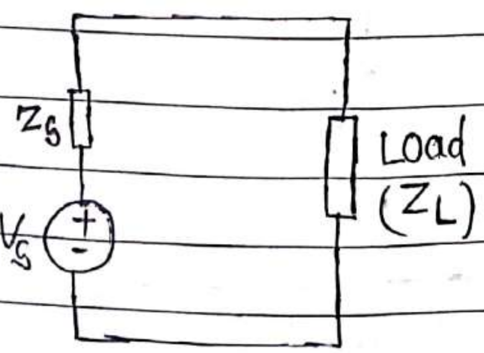
DC Source output

Ac Source output changes uniformly in positive and negative half cycle w.r.t time.

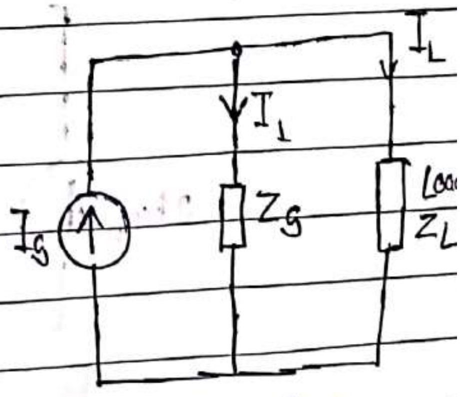
DC Source o/p Remains Constant w.r.t time.

"Internal Resistance of Source" → Every Source i.e voltage source or current Source have its internal Resistance.

Internal Resistance is mainly due to Resistance of electrolyte, coil Resistance or due to o/p impedence.



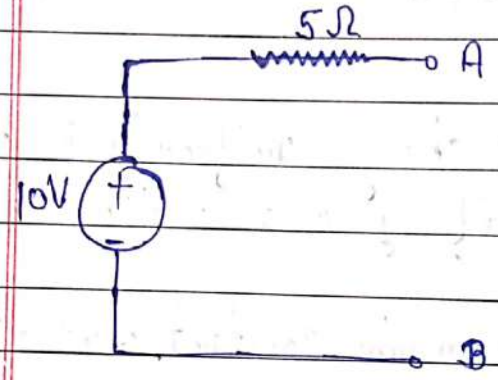
Votage Source



Current Source

"Conversion of Voltage Source into current Source" →

A voltage Source with Series Resistance can be converted into current Source. we can understand it by a Simple example

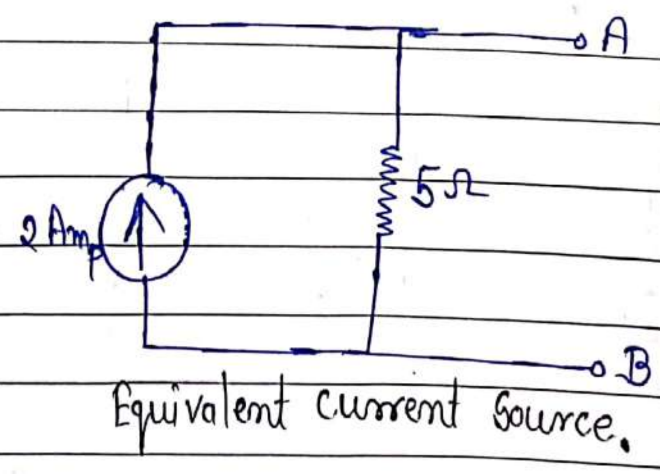


So we have
Source voltage $V_s = 10V$
Internal Resistance $R_{in} = 5Ω$

As per ohms law $I = \frac{V}{R}$

So in this case $I = \frac{10}{5} = 2$ Amp

and the Resistance 5Ω will be in parallel.

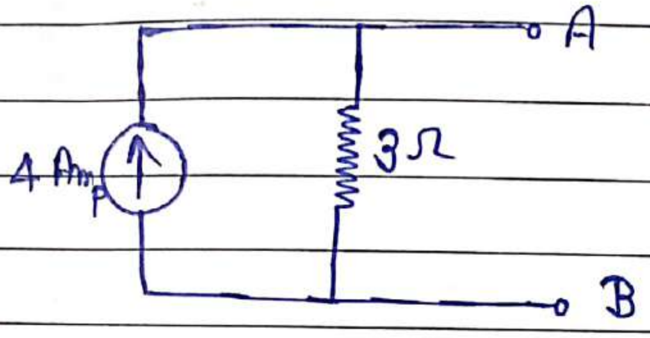


Equivalent current Source.

"Conversion of current Source into voltage Source" →

A current Source having Shunt (Parallel) Resistance can be converted into voltage Source.
we can understand it by simple example

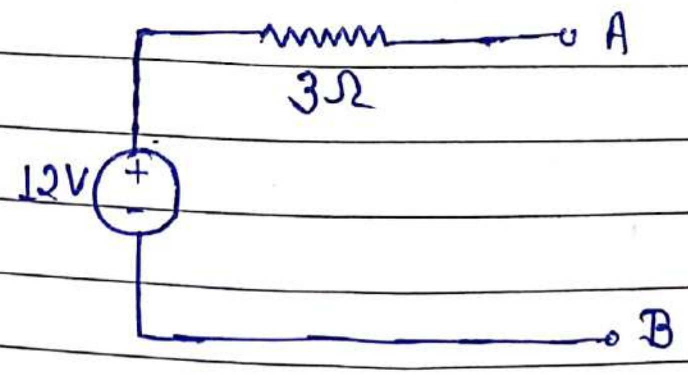
Suppose we have a current Source



ओम के नियम के अनुसार $V = I \cdot R$

$$V = 4 \times 3 = 12 \text{ Volt}$$

समान्तर क्रम वाला Resistance , Series में आ जायेगा

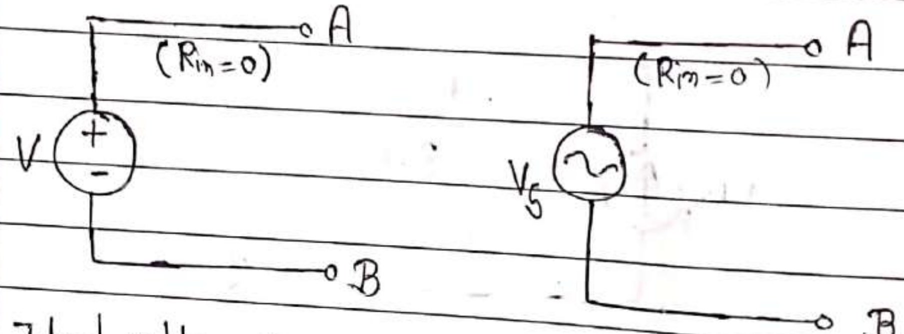


Date ______
Page ______

Ideal Voltage Source (आदर्श वोल्टेज सोर्स) →

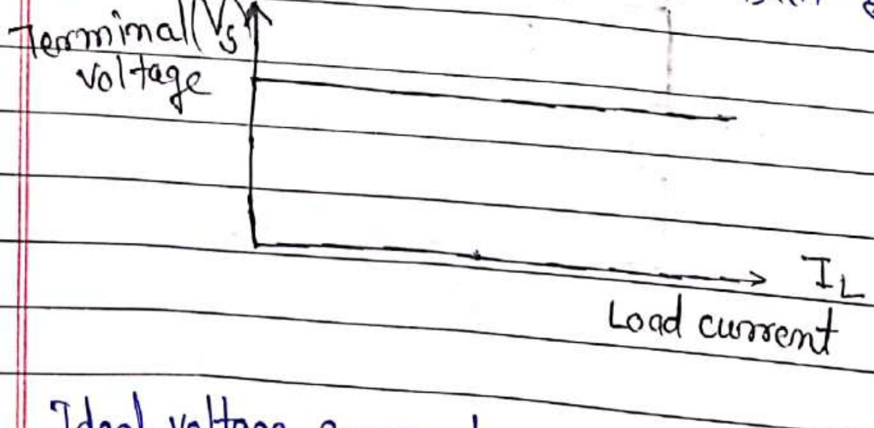
For a Ideal voltage Source Terminal Voltage always Remains constant irrespective of Load Resistance (Z_L)

आदर्श वोल्टेज सोर्स में टर्मिनल वोल्टेज लोड Resistance (Z_L) की Value के सापेक्ष Constant रहता है,



Ideal voltage Source (DC) — Ideal AC Voltage Source

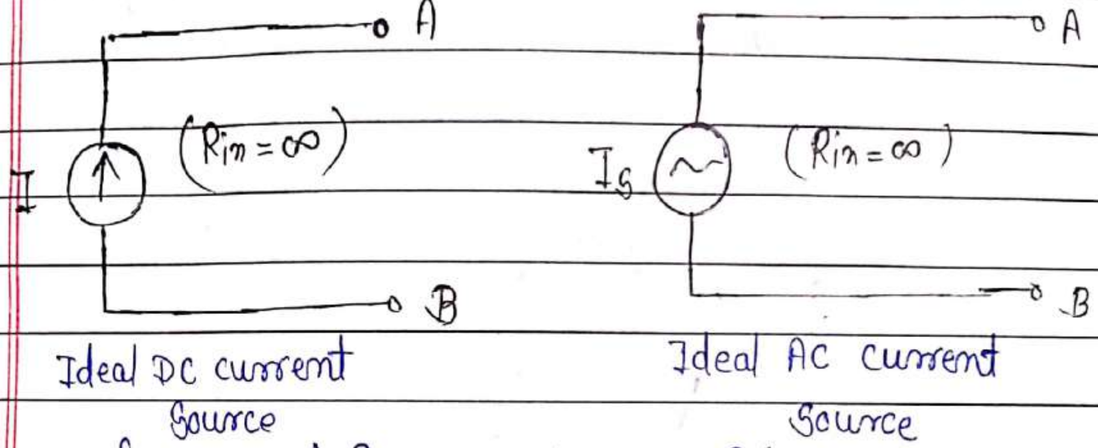
आदर्श वोल्टेज सोर्स का आंतरिक प्रतिरोध शून्य होता है, जिसके कारण टर्मिनल वोल्टेज धारा के मान पर निर्भर नहीं करता है,



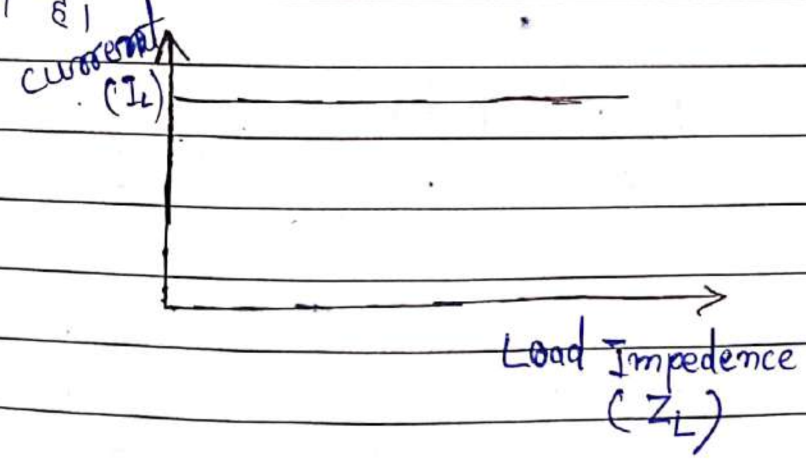
Ideal voltage source have zero Internal Resistance.

Ideal Current Source (आदर्श धारा सोर्स) → For a Ideal current source current always Remains constant irrespective of Load Resistance (Z_L).

आदर्श धारा सोर्स में धारा का मान सदैव समान रहता है, तथा इसका मान लोड Resistance पर निर्भर नहीं करता है।



आदर्श धारा सोर्स का आंतरिक प्रतिरोध अनन्त होता है।



Ideal current Source have infinite internal Resistance.

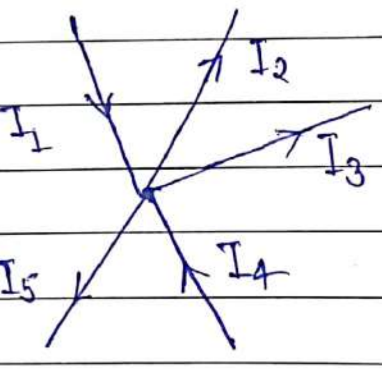
Kirchhoff's Current Law किरचाफ का धारा नियम ⇒

It is one of the fundamental law used for circuit analysis.

This law states that Total current entering a circuit junction is exactly equal to total current leaving the same junction.

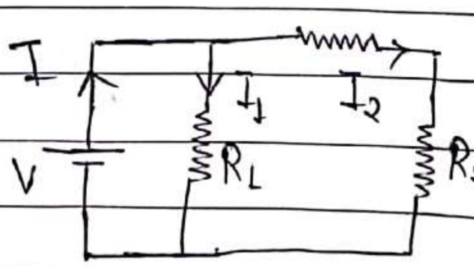
In other words the algebraic sum of all the currents entering and leaving a junction must be equal to zero.

किसी भी सन्धि पर मिलने वाली समस्त धाराओं का बीजगणितीय योग शून्य होता है।



$$\sum I = 0$$

$$I_1 + I_4 = I_2 + I_3 + I_5$$

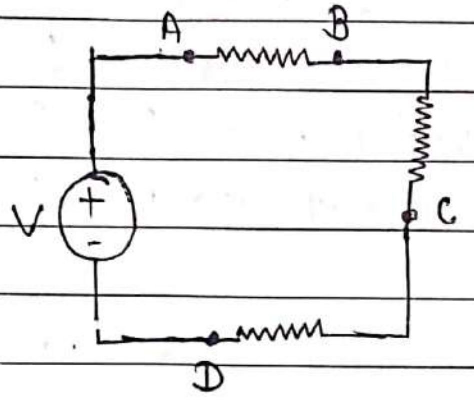


In this circuit as per KCL $I = I_1 + I_2$

Kirchhoff's Voltage Law किरचॉफ का वोल्टेज नियम" →

KVL States that in any closed loop network the total voltage around the loop is equal to the sum of all the voltage drops within the same loop.

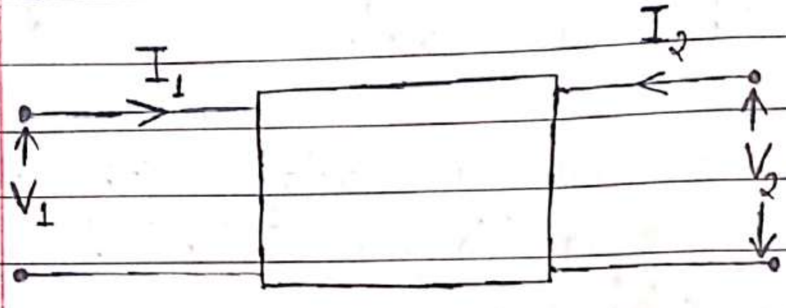
In other words the algebraic sum of all voltages within the loop must be equal to zero. This is called conservation of energy.



As per KVL $$V + V_{AB} + V_{BC} + V_{CD} = 0$$

Date
Page

"Two port Network" ⇒ A two port network is an electrical network with two pairs of terminals to connect to external circuits.



V_1 = Voltage Across port 1
I_1 = Current into Port 1
V_2 = Voltage Across Port 2
I_2 = current into port 2

For Analysis of Two port network we uses different parameters namely

(1) Impedance Parameters (Z Parameters)
(2) Admittance Parameters (Y Parameters)
(3) Hybrid Parameters (H Parameters)
(4) ABCD Parameters

"Z Parameters" ⇒ A two port network can be described by Z Parameters as

$$V_1 = Z_{11} I_1 + Z_{12} I_2$$
$$V_2 = Z_{21} I_1 + Z_{22} I_2$$

in matrix this can be written as

$$\begin{bmatrix} V_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} Z_{11} & Z_{12} \\ Z_{21} & Z_{22} \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix}$$

The Z Parameter can be found as

$$Z_{11} = \frac{V_1}{I_1}\bigg|_{I_2=0} \qquad Z_{12} = \frac{V_1}{I_2}\bigg|_{I_1=0}$$

$$Z_{21} = \frac{V_2}{I_1}\bigg|_{I_2=0} \qquad Z_{22} = \frac{V_2}{I_2}\bigg|_{I_1=0}$$

Z Parameters को open circuit Parameters भी कहते हैं, तथा इनका मात्रक ओम (Ω) होता है।

"Y Parameters" ⇒ A Two port network can be described by Y Parameters.

$$I_1 = y_{11} V_1 + y_{12} V_2$$
$$I_2 = y_{21} V_1 + y_{22} V_2$$

In matrix form it can be written as

$$\begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} y_{11} & y_{12} \\ y_{21} & y_{22} \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \end{bmatrix}$$

The Y Parameters can be found as

$$y_{11} = \frac{I_1}{V_1}\bigg|_{V_2=0} \qquad y_{12} = \frac{I_1}{V_2}\bigg|_{V_1=0}$$

$$y_{21} = \frac{I_2}{V_1}\bigg|_{V_2=0} \qquad y_{22} = \frac{I_2}{V_2}\bigg|_{V_1=0}$$

Y Parameters को Short circuit Parameters भी कहते है, इनका मात्रक mho (℧) होता है।

"H Parameters" → A Two port network can be described by hybrid Parameters.

$$V_1 = h_{11} I_1 + h_{12} V_2$$
$$I_2 = h_{21} I_1 + h_{22} V_2$$

In matrix form it can be written as

$$\begin{bmatrix} V_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{bmatrix} \begin{bmatrix} I_1 \\ V_2 \end{bmatrix}$$

The H Parameters can be found as

$$h_{11} = \frac{V_1}{I_1}\bigg|_{V_2=0} \qquad h_{12} = \frac{V_1}{V_2}\bigg|_{I_1=0}$$

Date
Page

$$h_{21} = \frac{I_2}{I_1}\bigg|_{V_2=0} \qquad h_{22} = \frac{I_2}{V_2}\bigg|_{I_1=0}$$

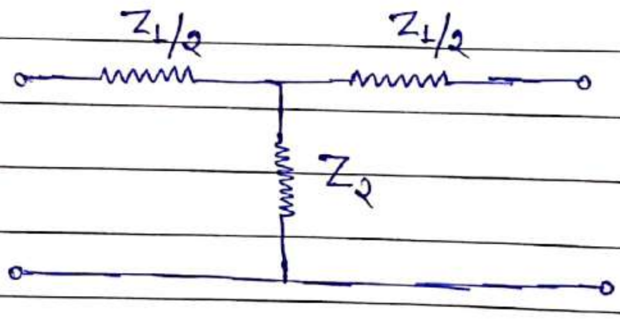
H Parameters में h_{11} की गणना Ω में h_{22} की गणना mho($\mho$) में तथा h_{12} तथा h_{21} विमाहीन होते हैं।

"Symmetrical Network" :⇒ A Two port network is called a symmetrical network if its input and output port can be interchanged without affecting its parameter

Symmetrical networks can be divided into two types

(1) Symmetrical T network
(2) Symmetrical π network

Symmetrical T network :→

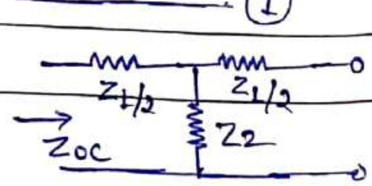


ट्रान्समिशन लाइन में Symmetrical T network का प्रयोग किया जाता है।

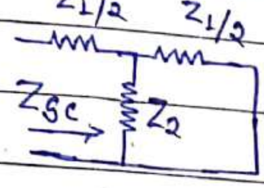
In Symmetrical T network
Series arm impedence − $Z_1/2 + \frac{Z_1}{2} = Z_1$
Shunt arm impedence − Z_2

open circuit impedence

$$Z_{oc} = \frac{Z_1}{2} + Z_2 \quad \text{———} \quad (1)$$



Short circuit impedence



$$Z_{sc} = \left(\frac{Z_1}{2} \parallel Z_2\right) + Z_1/2$$

$$Z_{sc} = \frac{Z_1^2/4 + \frac{Z_1 Z_2}{2} + \frac{Z_1 Z_2}{2}}{(Z_1/2 + Z_2)}$$

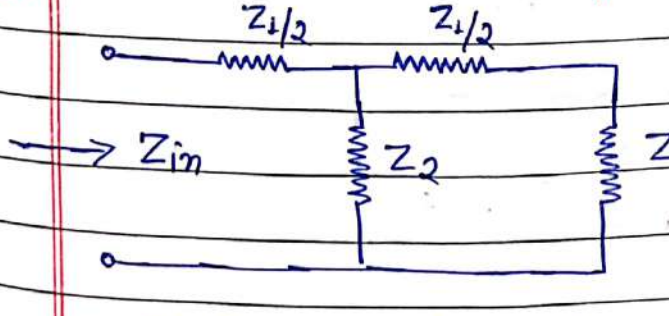
In symmetrical network we derive two electrical properties

1. characteristic Impedence (Z_0)
2. Propagation Constant (γ)

"Characteristic Impedence" → In a Symmetrical T network characteristic impedence can be determin by two ways

1. Using Series and Shunt arm impedence
2. Using open and Short ckt impedence.

"Using Series and Shunt arm impedence" →



By the property of Symmetrical network

$$\boxed{Z_{in} = Z_0}$$ when network is terminated in Z_0.

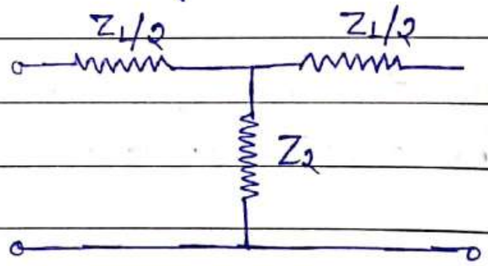
$$Z_{in} = Z_0 = \frac{Z_1}{2} + \left[Z_2 \parallel \left(\frac{Z_1}{2} + Z_0 \right) \right]$$

By Solving this

$$Z_0 = \sqrt{\frac{Z_1^2}{4} + Z_1 \cdot Z_2}$$

"Using open and Short circuit Parameters" →

As we know in Symmetrical T network



$$Z_{oc} = Z_1/2 + Z_2$$

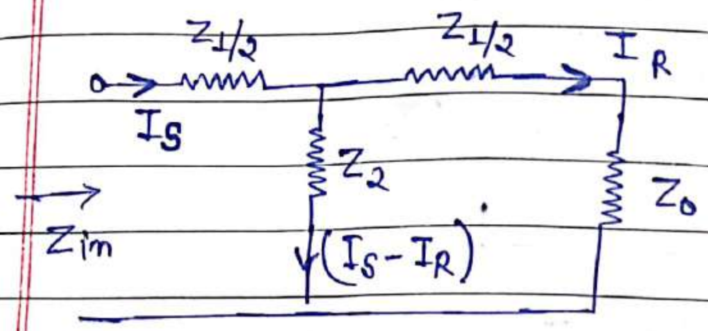
$$Z_{sc} = \frac{Z_1^2 + Z_1 Z_2}{(Z_1/2 + Z_2)}$$

$$Z_0 = \sqrt{(Z_{oc} \cdot Z_{sc})}$$

$$Z_0 = \sqrt{\frac{Z_1^2}{4} + Z_1 Z_2}$$

Scanned with CamScanner

Propagation Constant (γ) ⇒ For a Symmetrical T network



Propagation constant $e^{\gamma} = \frac{I_S}{I_R}$

In symmetrical network $Z_{in} = Z_0$

$$\gamma = \log_e \frac{I_S}{I_R}$$

Applying KCL to loop

$$\frac{Z_1}{2} \cdot I_R + Z_0 I_R - Z_2 (I_S - I_R) = 0$$

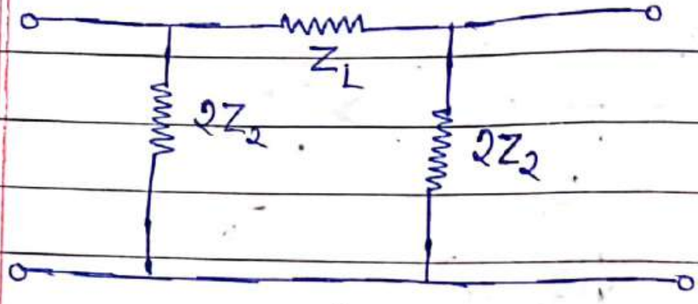
By solving

$$\frac{I_S}{I_R} = \frac{Z_1}{2Z_2} + \frac{Z_0}{Z_2} + 1$$

$$\frac{I_S}{I_R} = \frac{Z_1}{2Z_2} + \sqrt{\frac{Z_1^2}{4Z_2^2} + \frac{Z_1}{Z_2}} + 1$$

$$\boxed{\gamma = \frac{Z_1}{2Z_2} + \sqrt{\frac{Z_1^2}{4Z_2^2} + \frac{Z_1}{Z_2}} + 1}$$

"Symmetrical Pi (π) network" →



In Symmetrical π network

Total Series arm impedence → Z_1

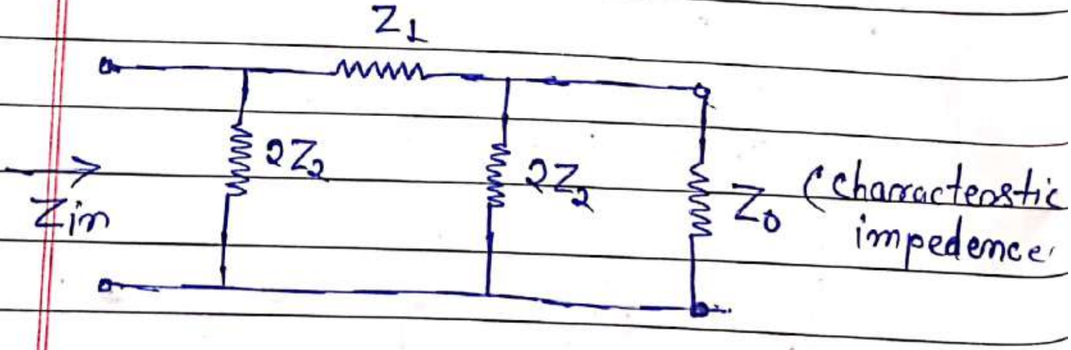
Total Shunt arm impedence $= (2Z_2 \parallel 2Z_2) = Z_2$

For symmetrical network we have two properties

1. characteristic impedence (Z_0)
2. Propagation constant (γ)

"Characteristic impedence" →

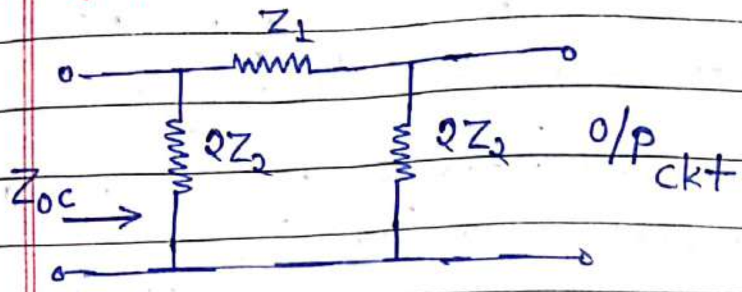
By using Series and Shunt arm impedence



$$Z_{in} = Z_0 = \left[(Z_0 \parallel 2Z_2) + Z_1\right] \parallel 2Z_2$$

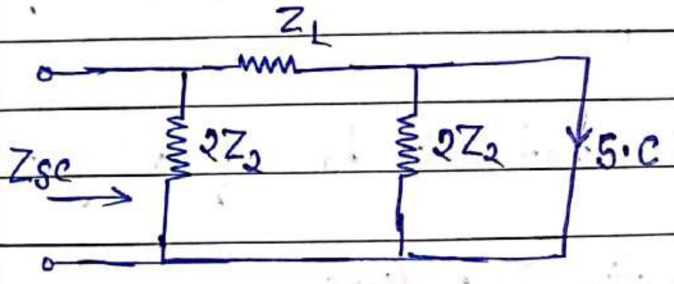
$$Z_0 = \sqrt{\frac{Z_1^2 Z_2^2}{Z_1^2/4 + Z_1 Z_2}}$$

"By using open ckt and Short ckt impedence"



$$Z_{oc} = (Z_1 + 2Z_2) \parallel (2Z_2)$$

$$Z_{oc} = \frac{2Z_2(Z_1 + 2Z_2)}{4Z_2 + Z_1} \quad \text{——— (1)}$$



$$Z_{sc} = (2Z_2) \parallel Z_1 = \frac{2Z_1 Z_2}{Z_1 + 2Z_2}$$

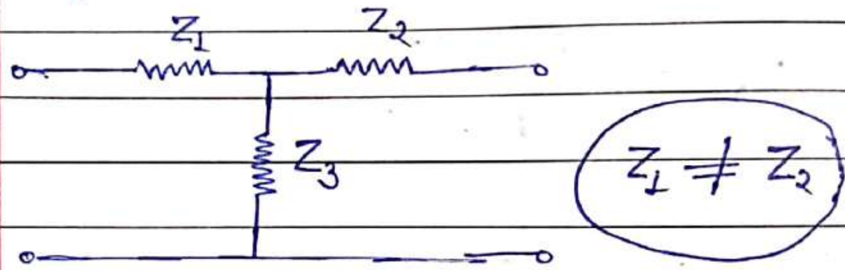
$$Z_0 = \sqrt{Z_{oc} \times Z_{sc}}$$

$$\boxed{Z_0 = \sqrt{\frac{Z_1^2 \cdot Z_2^2}{Z_1^2/4 + Z_1 Z_2}}}$$

"Asymmetrical Networks" → Asymmetrical networks are those in which input and output Ports can not be interchanged

Asymmetrical नेटवर्क में Series arm impedance की value अलग-अलग होती है।
ये नेटवर्क मुख्यतः दो प्रकार के होते हैं

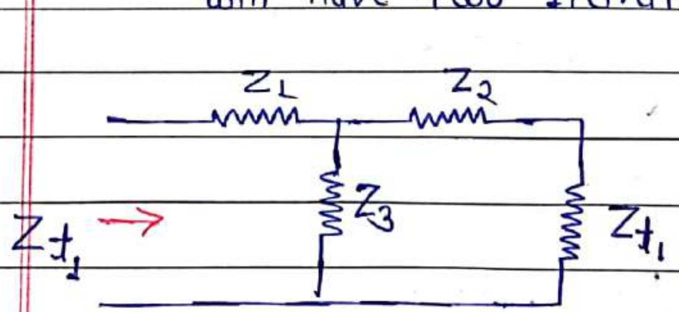
"Asymmetrical T network" →



Asymmetrical networks have following properties

(1) Iterative Impedence
(2) Image Impedence

Iterative Impedence :→ Asymmetrical T network will have two Iterative impedences



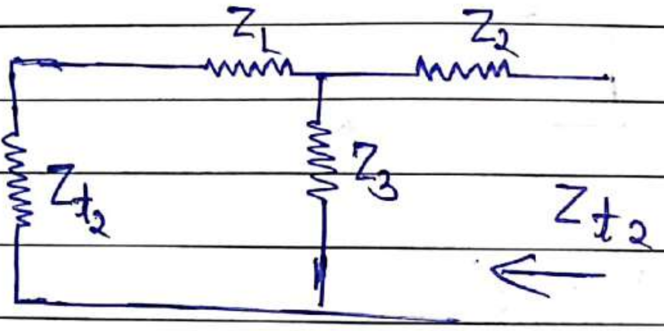
For calculating iterative impedence Z_{t_1} at Port 1 we need to add same Z_{t_1} at the output.

$$Z_{t_1} = (Z_2 + Z_{t_1}) \parallel Z_3 + Z_1$$

By solving this

$$Z_{t_1} = \frac{1}{2}\left[(Z_1 - Z_2) \pm \sqrt{(Z_1 - Z_2)^2 + 4(Z_1 Z_2 + Z_1 Z_3 + Z_2 Z_3)}\right]$$

Similary for calculating iterative impedence at Port 2 we need to add same resistance value at Port 1.



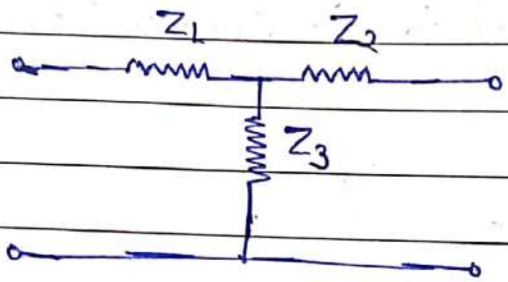
$$Z_{t_2} = (Z_1 + Z_{t_2}) \parallel Z_3 + Z_2$$

$$Z_{t_2} = \frac{1}{2}\left[(Z_2 - Z_1) \pm \sqrt{(Z_2 - Z_1)^2 + 4(Z_1 Z_2 + Z_2 Z_3 + Z_1 Z_3)}\right]$$

Image Impedence for Symmetrical T network

For calculating image impedence we have two image impedence input port impedence and output image impedence.

$$Z_{i_1} = \sqrt{(Z_{oc_1} \cdot Z_{sc_1})} \quad \text{and} \quad Z_{i_2} = \sqrt{(Z_{oc_2} Z_{sc_2})}$$



$$Z_{oc_1} = (Z_1 + Z_3)$$

$$Z_{sc_1} = Z_1 + \frac{Z_2 \cdot Z_3}{Z_2 + Z_3}$$

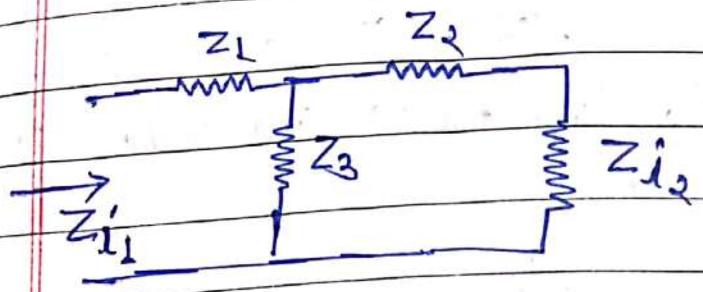
$$Z_{i_1} = \sqrt{(Z_1 + Z_3) \cdot \left(\frac{Z_1 Z_2 + Z_1 Z_3 + Z_2 Z_3}{Z_2 + Z_3}\right)}$$

Similarly

$$Z_{i_2} = \sqrt{Z_{oc_2} \times Z_{sc_2}}$$

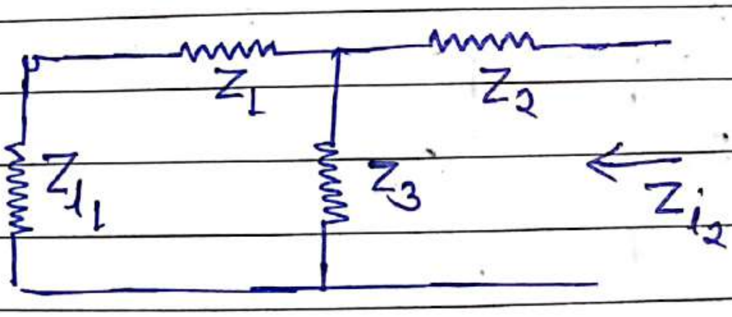
$$Z_{i_2} = \sqrt{(Z_2 + Z_3) \cdot \frac{(Z_1 Z_2 + Z_2 Z_3 + Z_1 Z_3)}{Z_1 + Z_3}}$$

In Second method To calculate image impedence at Port 1



$$Z_{i_1} = (Z_2 + Z_{i_2}) \parallel Z_3 + Z_2$$

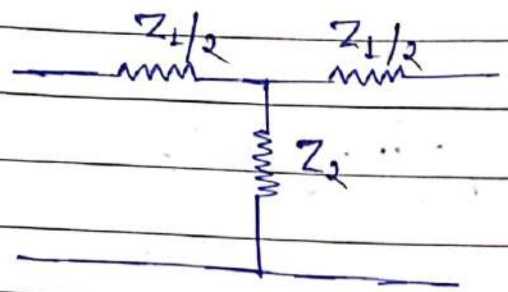
"Image impedence of Port 2" →

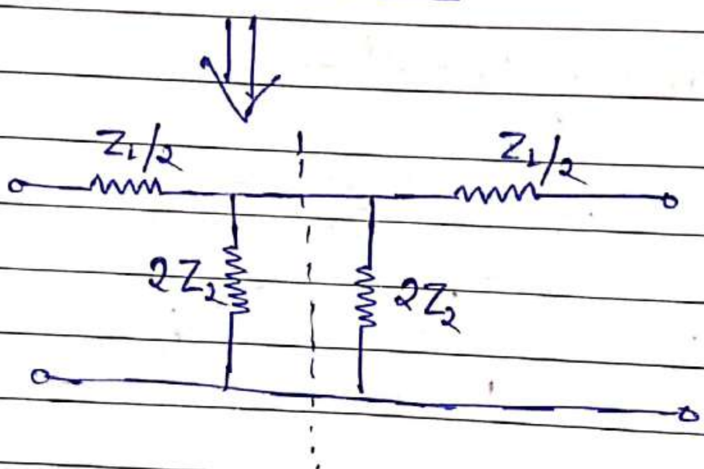


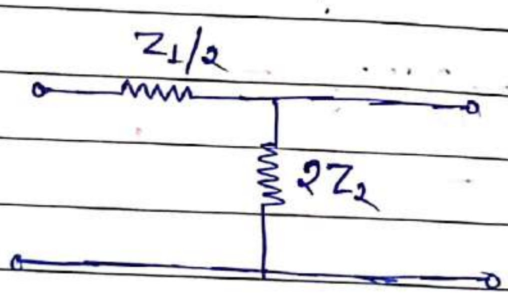
$$Z_{i_2} = (Z_1 + Z_{i_1}) \parallel Z_3 + Z_2$$

Half Section T network :→ Half Section are used for impedence matching.

If we split a 'T' or π symmetric network into two parts its called Half Section network







"This Half Section is Asymmetrical network so we need to calculate Iterative and Image Impedence

For Half T Section

$$Z_{OC_1} = Z_1/2 + 2Z_2$$

$$Z_{SC_1} = Z_1/2$$

"Attenuators"

Date ______
Page ______

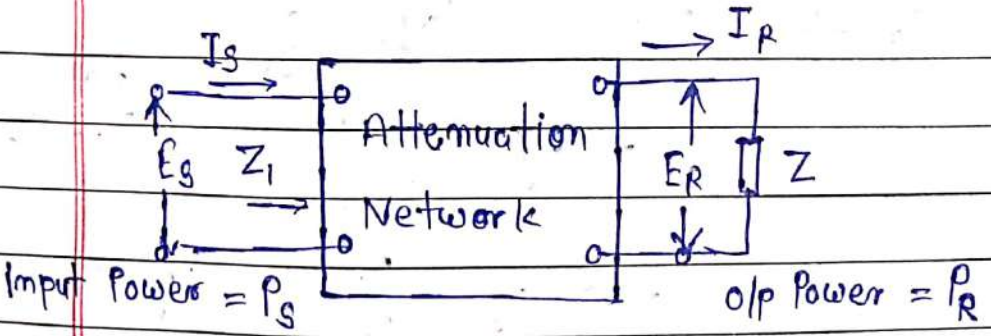
In Transmission equipments at various stages voltage and current need to be attenuate. For this Attenuators are designed.

while designing Attenuators these conditioned need to be fullfilled.

(1) → नेटवर्क द्वारा Desired Attenuation उपलब्ध होना चाहिये
(2) ÷ नेटवर्क द्वारा उचित इनपुट प्रतिबाधा मिलनी चाहिये,
(3) → इसके द्वारा उचित आउटपुट प्रतिबाधा मिलनी चाहिये,

डेसीबल तथा नेपर" → Attenuation is generally measured in Decibel.

In transmission line or any electrical network loss of the power is called Attenuation. It can also measured in Neper.



If in a two port network P_S is input Power and P_R is the output Power.

$$\text{Attenuation in Decibels} = 10 \log_{10} \left| \frac{P_S}{P_R} \right|$$

Date
Page

यदि नेटवर्क में I_S इनपुट धारा तथा I_R आउटपुट धारा

Nepers में Attenuation $= \log_e \left| \frac{I_S}{I_R} \right|$

Attenuation in (db) $= 10 \log_{10} \left| \frac{P_S}{P_R} \right|$

$= 10 \log_{10} \left| \frac{I_S^2 R_1}{I_R^2 R_2} \right|$

$= 10 \log_{10} \left| \frac{I_S}{I_R} \right|^2$ if $(R_1 = R_2)$

$= 20 \log_{10} \left| \frac{I_S}{I_R} \right|$

$= 20 \log_{10} \left| \frac{E_S}{E_R} \right|$

Attenuation in Nepers $= \log_e \left| \frac{I_S}{I_R} \right|$

$= \log_e \left| \frac{E_S}{E_R} \right|$ यदि $(Z_1 = Z_2)$

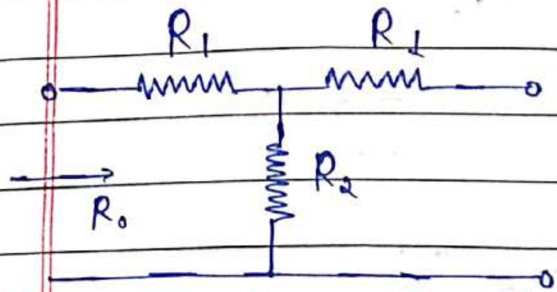
$= \frac{1}{2} \log_e \left| \frac{P_S}{P_R} \right|$ if $(R_1 = R_2)$

So db Attenuation $= 20 \log_{10} \left| \frac{I_S}{I_R} \right|$

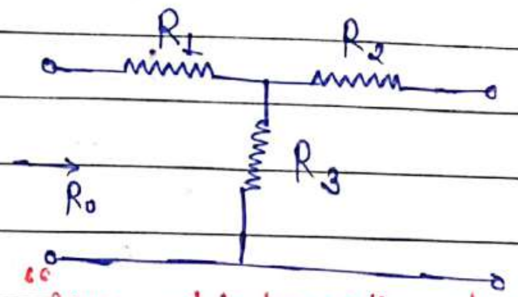
$= 20 \log_e \left| \frac{I_S}{I_R} \right| \times \log_{10} e$

Attenuation (Db) = 8.686 × neper में Attenuation

"Classification of Attenuators" :→ Attenuators can be classified into two categories · Symmetrical and Asymmetrical



"Symmetrical T - Attenuators"



"Asymmetrical T Attenuators"

"Symmetrical T Section Attenuators" :→ ये वे Source तथा Load के मध्य संयोजित प्रतिरोधी नेटवर्क होते हैं, इनमें इनपुट तथा आउटपुट प्रतिरोध बराबर होते हैं, ($R_1 = R_2$)

For designing Symmetrical T Attenuator

$$R_1 = R_0 \left(\frac{N-1}{N+1} \right)$$

R_0 is अभिलाक्षणिक प्रतिबाधा है।

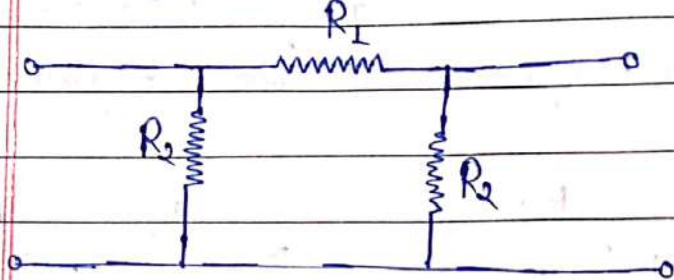
$$R_2 = R_0 \left(\frac{2N}{N^2-1} \right)$$

जहां $N = \frac{R_1 + R_2 + R_0}{R_2}$

तथा $N = \text{antilog}_{10} \left(\frac{D}{20} \right)$

where 'D' is Decibel. Attenuation

"Symmetrical π Section Attenuators" →



In Symmetrical π Attenuator

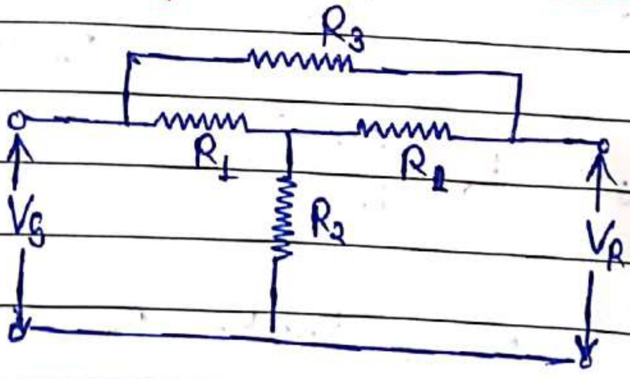
$$N = \text{antilog}_{10}\left(D/20\right)$$

$$R_1 = \frac{R_0 (N^2 - 1)}{2N}$$

$$R_2 = \left(\frac{N+1}{N-1}\right) R_0$$

जहाँ R_0 characterstic impedence है।

"Symmetrical Bridged T-type Attenuator" →



In this ckt Impedences are choosen as

$$R_3 R_2 = R_1^2 = R_0^2$$

Date ______
Page ______

Formulas for designing

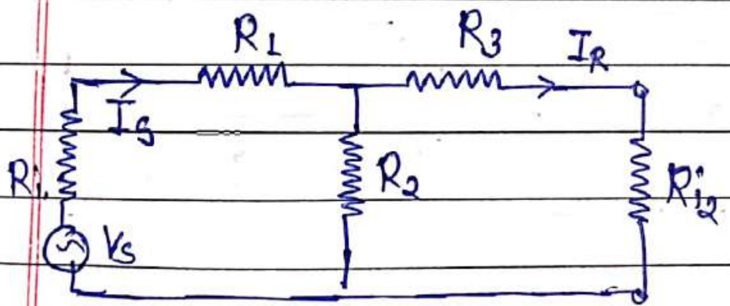
$$R_1 = R_0$$

$$R_2 = \frac{R_0}{N-1}$$

$$R_3 = R_0 (N-1)$$

"Asymmetrical T type Attenuator" - In asymmetrical T type attenuator input and o/p impedences are different.

$$(R_1 \neq R_2)$$



$$N = \sqrt{\left(\frac{P_S}{P_R}\right)} = \sqrt{\frac{I_S^2 R_{i_1}}{I_R^2 R_{i2}}}$$

Formulas for designing

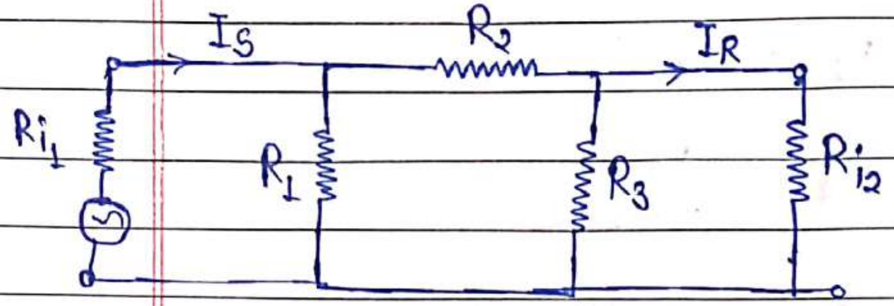
$$R_1 = R_{i_1}\left(\frac{N^2+1}{N^2-1}\right) - 2\sqrt{R_{i_1} R_{i2}}\left(\frac{N}{N^2-1}\right)$$

$$R_2 = 2\sqrt{R_1 R_0}\left(\frac{N}{N^2-1}\right)$$

$$R_3 = R_{i2}\left(\frac{N^2+1}{N^2-1}\right) - 2\sqrt{R_{i_1} R_{i2}}\left(\frac{N}{N^2-1}\right)$$

Date
Page

"Asymmetrical π-type Attenuator" →



For designing π type attenuator we have following formulas :–

$$R_1 = R_{i_1}\left(\frac{N^2-1}{N^2-2NS+1}\right)$$

$$R_2 = \frac{\sqrt{R_{i_1}R_{i_2}}}{2}\left(\frac{N^2-1}{N}\right)$$

and

$$R_3 = R_{i_2}\left(\frac{N^2-1}{N^2-2N/S+1}\right)$$

Scanned with CamScanner