Mymensingh Polytechnic Institute
Estd. 1963

Welcome to my Presentation
Presented
by

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NETWORKS, FILTERS & TRANSMISSION LINES

NETWORKS, FILTERS & TRANSMISSION LINES

মানবন্টন

T	P	C
2	1	3

TC 40

Mid Eax 20

TF 60

PC 25

PF 25

Full mark 150

f~wgKv

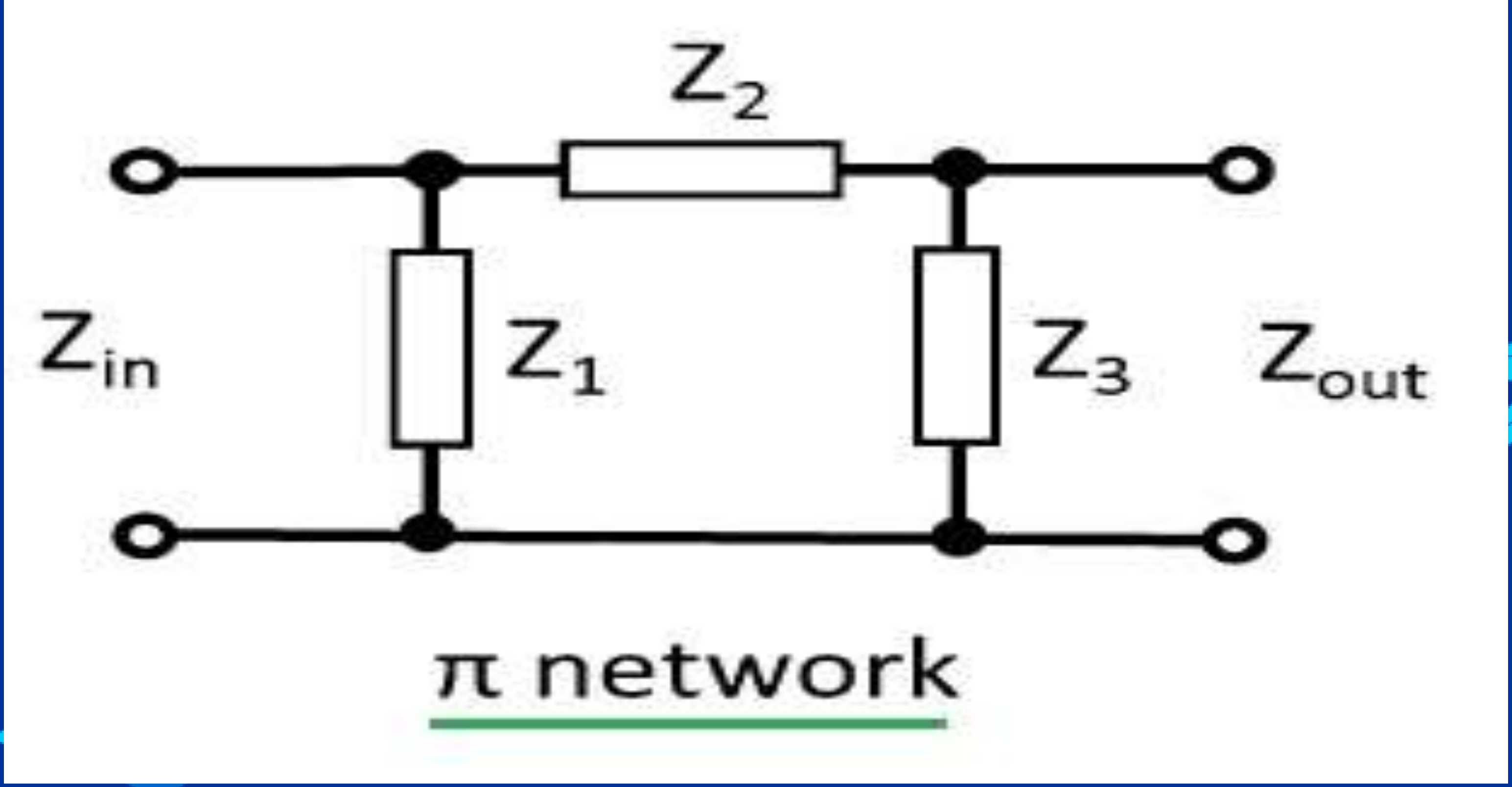
‰e`y¨wZK Dcv`vbmg~n †hgb †iwR÷i, BÛv±i, K¨vcvwmUi, B‡jKUªwbK wUDe, †mwgKÛv±i wWfvBm, UªvÝdg©vi Ges †fv‡ëR Drm mg~‡ni †h‡Kvb cÖKvi B›UviKv‡bKkb‡K †bUIqvK© ejv nq| Ab¨vb¨ mvwK©‡Ui mv‡_ ms‡hvM Kivi Rb¨ †bUIqv‡K©i `yB ev Z‡ZvwaK Uvwg©bvj _v‡K| †h †bUIqv‡K©i GK †Rvov Uvwg©bvj _v‡K Zv‡K `yB Uvwg©bvj ev GK †cvU© †bUIqvK© e‡j| Avevi †h †bUIqv‡K©i `yB †Rvov Uvwg©bvj _v‡K Zv‡K Pvi Uvwg©bvj ev `yB †cvU© †bUIqvK© e‡j| †iwR÷i, BÛv±i ev K¨vcvwmU‡ii wmwiR, c¨vivjvj ev wmwiR-c¨vivjvj ms‡hvM n‡jv `yB Uvwg©bvj †bUIqv‡K©i D`vnib hv 1 (K) I (L) bs wP‡Î †`Lv‡bv n‡q‡Q| GKwU UªvÝdg©v‡ii `yÕwU BbcyU Uvwg©bvj I `yÕwU AvDUcyU Uvwg©bvj _v‡K| ZvB UªvÝdg©vi Pvi Uvwg©bvj †bUIqv‡K©i D`vnib hv 1 (M) bs wP‡Î †`Lv‡bv n‡q‡Q| Abyifcfv‡e Ggwcødvqvi, †iKwUdvqvi, GwUby‡qUi, wdëvi BZ¨vw` cÖ‡Z¨‡Ki `yÕwU BbcyU Uvwg©bvj I `yÕwU AvDUcyU Uvwg©bvj Av‡Q weavq Giv Pvi Uvwg©bvj †bUIqvK©| 1 (N) bs

Pvi Uvwg©bvj †bUIqv‡K©i êwkó¨

- **1.1 †bUIqv‡K©i msMv** (Define network)
- **1.2 GKwUf Gwj‡g›U, c¨vwmf Gwj‡g›U, wjwbqvi I bb-wjwbqvi Gwj‡g›U, BDwb‡jUv‡ij I evB‡jUv‡ij Gwj‡g‡›Ui msMv** (Define the terms active element, passive element, linear & non linear element, Unilateral & Bilateral elements)
- **1.3 †bUIqv‡K©i †kªbxweb¨vm** (Classification of networks)
- **1.4 wm‡gwUªK¨vj I Gwm‡gwUªK¨vj †bUIqv‡K©i msMv** (Defination of symmetrical & asymmetrical networks)
- **1.5 wmwi‡R mshy³ GKwU mvavib Pvi Uvwg©bvj wm‡gwUªK¨vj †bUIqv‡K©i K¨v‡i±vwiw÷Km Bw¤úW¨vÝ, †cÖvcv‡Mkb Kb÷¨v›U, GwUby‡qkb Kb÷¨v›U I †dR Kb÷¨v›U** (Characteristics impedance, propagation constant, attenuation constant & phase constant of general four terminal symmetrical networks connected in series)
- **1.6 wmwi‡R mshy³ GKwU mvavib Pvi Uvwg©bvj Gwm‡gwUªK¨vj †bUIqv‡K©i BUv‡iwUf Bw¤úW¨vÝ, B‡gR Bw¤úW¨vÝ, B‡gR UªvÝdvi Kb÷¨v›U, BUv‡iwUf UªvÝdvi Kb÷¨v›U I Bbmvikb jm** (Iterative impedance, image impedance, image transfer constant, iterative transfer constant & insertion loss of general four terminal asymmetrical networks connected in series)-

1.1 †bUIqv‡K©i msMv (Define network)

 ‰e`y¨wZK Dcv`vbmg~n †hgb †iwR÷i, BÛv±i, K¨vcvwmUi, B‡jKUªwbK wUDe, †mwgKÛv±i wWfvBm, UªvÝdg©vi Ges †fv‡ëR Drm mg~‡ni †h‡Kvb cÖKvi B›UviKv‡bKkb‡K †bUIqvK© ejv nq|



1.2 GKwUf Gwj‡g›U, c¨vwmf Gwj‡g›U, wjwbqvi I bb-wjwbqvi Gwj‡g›U, BDwb‡jUv‡ij I evB‡jUv‡ij Gwj‡g›Ui msMv (Define the terms active element, passive element, linear & non linear element, Unilateral & Bilateral elements)

GKwUf Gwj‡g›U- ‡bUIqv‡K© e¨eüZ ‡h mKj Gwj‡g›Umg~n wb‡RB BGgGd Drm wn‡m‡e e¨eüZ n‡Z cv‡i Zv‡`i‡K GKwUf Gwj‡g›U e‡j| ‡hgb ‡mwgKÛv±i wWfvBm ev B‡jKUªwbK wUDe|

c¨vwmf Gwj‡g›U- ‡bUIqv‡K© e¨eüZ ‡h mKj Gwj‡g›Umg~n wb‡R BGgGd Drm wn‡m‡e e¨eüZ n‡Z cv‡i bv Ges G‡`i cwiPvjbvi Rb¨ evwn¨K ‡mv‡m©i cÖ‡qvRb nq Zv‡`i‡K c¨vwmf Gwj‡g›U e‡j| ‡hgb ‡iwR÷i, BÛv±i, K¨vcvwmUi, _vwg©÷i, LDR,VDR BZ¨vw`|

wjwbqvi Gwj‡g›U- ‡bUIqv‡K© e¨eüZ ‡h mKj Gwj‡g›Umg~‡ni wfZi w`‡q cÖevwnZ Kv‡i›U cÖ‡qvMK…Z ‡fv‡ë‡Ri mv‡\_ mgvbycvwZK nv‡i ev mij‰iwLKfv‡e (linear) cwieZ©b nq Zv‡`i‡K wjwbqvi Gwj‡g›U e‡j| ‡hgb ‡iwR÷i, BÛv±i, K¨vcvwmUi|

bb-wjwbqvi Gwj‡g›U- ‡bUIqv‡K© e¨eüZ ‡h mKj Gwj‡g›Umg~‡ni wfZi w`‡q cÖevwnZ Kv‡i›U cÖ‡qvMK…Z ‡fv‡ë‡Ri mv‡\_ mgvbycvwZK nv‡i ev mij‰iwLKfv‡e (linear) cwieZ©b nq bv Zv‡`i‡K bb-wjwbqvi Gwj‡g›U e‡j| ‡hgb ‡mwgKÛv±i WvqW, UªvbwR÷i, _vwg©÷i, LDR,VDR BZ¨vw`|

1.3 †bUIqv‡K©i †kªbxweb¨vm (Classification of networks)

†bUIqv‡K©i †kªbxweb¨v‡mi mgq wewfbœ welq we‡ePbv Kiv nq| †hgb-

1| †bUIqv‡K© e¨eüZ Dcv`v‡bi êwkó¨,

2| †bUIqv‡K© e¨eüZ Dcv`v‡bi wmMbvj Drcv`b ¶gZv,

3| †bUIqv‡K© e¨eüZ Dcv`v‡bi wfZi w`‡q cÖevwnZ Kv‡i‡›Ui †cvjvwiwU,

4| ‡bUIqv‡K©i B‡jKwUªK¨vj êwkó¨,

5| †bUIqv‡K©i Bw¤úW¨vÝ cwigv‡ci c×wZ,

6| †bUIqv‡K©i Dcv`vb mg~‡ni êwkó¨,

7| GKvwaK †bUIqvK© ms‡hvM c×wZ BZ¨vw`|

1.4 wm‡gwUªK¨vj I Gwm‡gwUªK¨vj †bUIqv‡K©i msMv (Defination of symmetrical & asymmetrical networks)

wm‡gwUªK¨vj (symmetrical) †bUIqvK© - ‡h †bUIqv‡K©i BbcyU I AvDUcyU Uvwg©bvj mg~n ci¯úi cwiewZ©Z n‡j Gi B‡jKwUªK¨vj êwk‡ó¨i †Kvb cwieZ©b nq bv Zv‡K wm‡gwUªK¨vj †bUIqvK© e‡j| †hgb GKwU UªvÝdg©v‡ii cÖvBgvwi I †m‡KÛvwi‡Z hw` mgvb msL¨K cu¨vP _v‡K Z‡e Gi cÖvBgvwi I †m‡KÛvwi‡Z †fv‡ëR I Bw¤úW¨vÝ mgvb n‡e| ZvB hw` Gi BbcyU I AvDUcyU Uvwg©bvj mg~n ci¯úi cwiewZ©Z Kiv nq Z‡e Gi B‡jKwUªK¨vj êwk‡ó¨i †Kvb cwieZ©b n‡e bv|

1.5 wmwi‡R mshy³ GKwU mvavib Pvi Uvwg©bvj wm‡gwUªK¨vj †bUIqv‡K©i K¨v‡i±vwiw÷Km BwcwWÝ, †cÖvcv‡Mkb Kb÷¨v›U, GwUby‡qkb Kb÷¨v›U I †dR Kb÷¨v›U (Characteristics impedance, propagation constant, attenuation constant & phase constant of general four terminal symmetrical networks connected in series)

wm‡gwUªK¨vj †bUIqv‡K©i c¨vivwgUvi¸‡jv n‡jv- K¨v‡i±vwiw÷Km BwcwWÝ, †cÖvcv‡Mkb Kb÷¨v›U, GwUby‡qkb Kb÷¨v›U I †dR Kb÷¨v›U| wb‡gœ G‡`i eb©bv †`qv n‡jv-

1.6 wmwi‡R mshy³ GKwU mvavib Pvi Uvwg©bvj Gwm‡gwUªK¨vj †bUIqv‡K©i BUv‡iwUf Bw¤úW¨vÝ, B‡gR Bw¤úW¨vÝ, B‡gR UªvÝdvi Kb÷¨v›U, BUv‡iwUf UªvÝdvi Kb÷¨v›U I Bbmvikb jm (Iterative impedance, image impedance, image transfer constant, iterative transfer constant & insertion loss of general four terminal asymmetrical networks connected in series)

Gwm‡gwUªK¨vj †bUIqv‡K©i BbcyU I AvDUcyU Uvwg©bv‡ji Bw¤úW¨vÝ mgvb bq e‡j G‡`i êwkó¨ LyeB RwUj| Gwm‡gwUªK¨vj †bUIqv‡K©i c¨vivwgUvi¸‡jv n‡jv- BUv‡iwUf Bw¤úW¨vÝ, B‡gR Bw¤úW¨vÝ, B‡gR UªvÝdvi Kb÷¨v›U, BUv‡iwUf UªvÝdvi Kb÷¨v›U| wb‡gœ G‡`i eb©bv

f~wgKv

G Aa¨v‡qi gyL¨ Av‡jvP¨ welq n‡jv wKQz we‡kl ai‡bi †bUIqv‡K©i êwkó¨, icvšZi, Zzjbv, mgZvKib BZ¨vw`| we‡kl ai‡bi †bUIqvK©¸‡jv n‡jv- wiKv‡i›U †bUIqvK©, e¨v‡jÝW I Avb-e¨v‡jÝW †bUIqvK©, †jwUm †bUIqvK©, j¨vWvi †bUIqvK© BZ¨vw`| GQvovI Pvi Uvwg©bvj †bUIqvK©‡K eb©bv Kivi Rb¨ wewfbœ iK‡gi c¨vivwgUvi †hgb Z- c¨vivwgUvi, Y- c¨vivwgUvi, H- c¨vivwgUvi BZ¨vw` m¤ú‡K© Av‡jvKcvZ Kiv n‡q‡Q|

2.1 wiKv‡i›U †bUIqv‡K©i msÁv (Definition of Recurrent network)

GKvwaK †bUIqvK© ci¯úi mshy³ n‡q †h †bUIqvK© ‰Zwi nq Zv‡K wiKv‡i›U †bUIqvK© e‡j| Avi GKwU GKK †bUIqvK©‡K bb-wiKv‡i›U †bUIqvK© e‡j|

GKwU `xN© jvBb we‡ePbv Kiv n‡jv hvi cÖwZ GKK ‰`‡N©¨i cwievwn‡Z wbgœwjwLZ c¨vivwgUvimg~n we`¨gvb- (K) †iwR÷¨vÝ (R), (L) BÛvKU¨vÝ (L), (M) jvBb KÛv±‡ii g‡a¨ K¨vcvwmU¨vÝ (C) Ges (N) jvBb KÛv±‡ii g‡a¨ wj‡KR KÛv±¨vÝ (G)| 2.1 bs wP‡Î wiKv‡i›U †bUIqv‡K©i ms‡hvM †`Lv‡bv n‡jv|

2.2 e¨v‡jÝW Ges Avbe¨v‡jÝW j¨vWvi †bUIqv‡K©i cv_©K¨ (Distinguish between balancd & unbalanced ladder network)

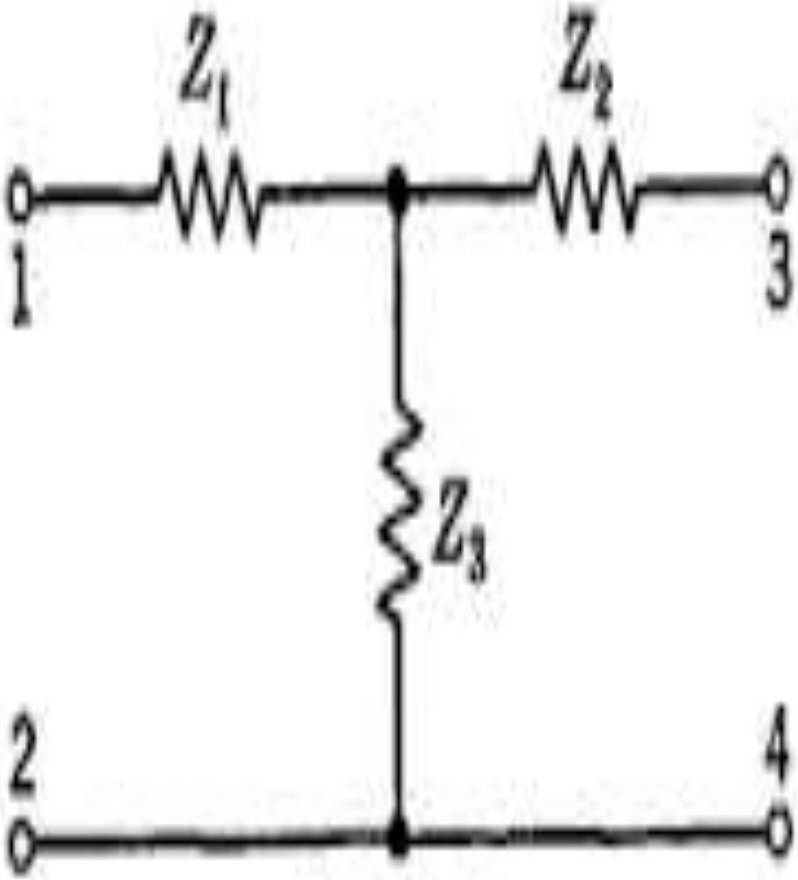
`yB ev Z‡ZwaK wm‡gwUªK¨vj ev Gwm‡gwUªK¨vj ev †bUIqvK©‡K ci¯ú‡ii mv‡_ wmwi‡R ms‡hvM Ki‡j †h †bUIqv‡K©i m„wó nq Zv‡K j¨vWvi †bUIqvK© e‡j| j¨vWvi †bUIqvK© `yB ai‡bi n‡Z cv‡i| h_v-
(K) e¨v‡jÝW j¨vWvi †bUIqvK© Ges (L) Avbe¨v‡jÝW j¨vWvi †bUIqvK©|

‡h mKj †bUIqv‡K©i ‡h‡Kvb GKwU BbcyU Uvwg©bvj I MÖvD‡Ûi ga¨Kvi Bw¤úW¨vÝ Ges Aci GKwU BbcyU Uvwg©bvj I MÖvD‡Ûi ga¨Kvi Bw¤úW¨vÝ mgvb nq A_ev ‡h‡Kvb GKwU AvDUcyU Uvwg©bvj I MÖvD‡Ûi ga¨Kvi Bw¤úW¨vÝ Ges Aci GKwU AvDUcyU Uvwg©bvj I MÖvD‡Ûi ga¨Kvi Bw¤úW¨vÝ mgvb nq Zv‡K e¨v‡jÝW j¨vWvi †bUIqvK© e‡j|

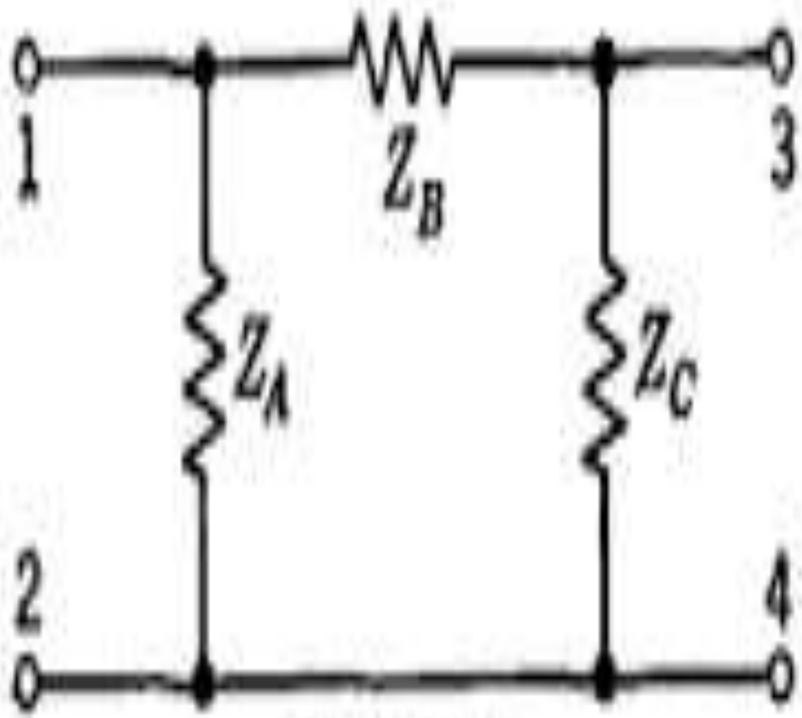
2.3 †jwUm †bUIqv‡K©i A_© (Meaning of Lattice network)

‡jwUm †bUIqvK© GKwU we‡kl ai‡bi †bUIqvK© I ‡jwUm †bUIqvK© `yÕvU wmwiR evû I `yÕwU kv›U evû mgš^‡q MwVZ| cÖwZwU wmwiR evûi Bw¤úW¨vÝ , d‡j †gvU wmwiR Bw¤úW¨v‡Ýi gvb | Avevi cÖwZwU kv›U evûi Bw¤úW¨vÝ $2Z_2$, d‡j †gvU kv›U Bw¤úW¨v‡Ýi gvb Z_2| Gi AvDUcyU Uvwg©bvj I‡cb ev kU© Ae¯'vq Bbcy‡U †h Bw¤úW¨vÝ cvIqv hvq Abyiƒ‡c BbcyU Uvwg©bvj I‡cb ev kU© Ae¯'vq AvDUcy‡U †mB Bw¤úW¨vÝ cvIqv hvq| ZvB ‡jwUm †bUIqvK© GKwU wm‡gwUªK¨vj †bUIqvK©|

2.4 e¨v‡jÝW Ges Avbe¨v‡jÝW j¨vWvi †bUIqvK©‡K T, π I L †mKk‡b ifcvš—i (Drawing of balancd & unbalanced ladder network as T, π & L sections)



T section



π section

e¨v‡jÝW Ges Avbe¨v‡jÝW j¨vWvi †bUIqvK©‡K T, π I L †mKk‡b ifcvš—i (Drawing of balancd & unbalanced ladder network as T, π & L sections)

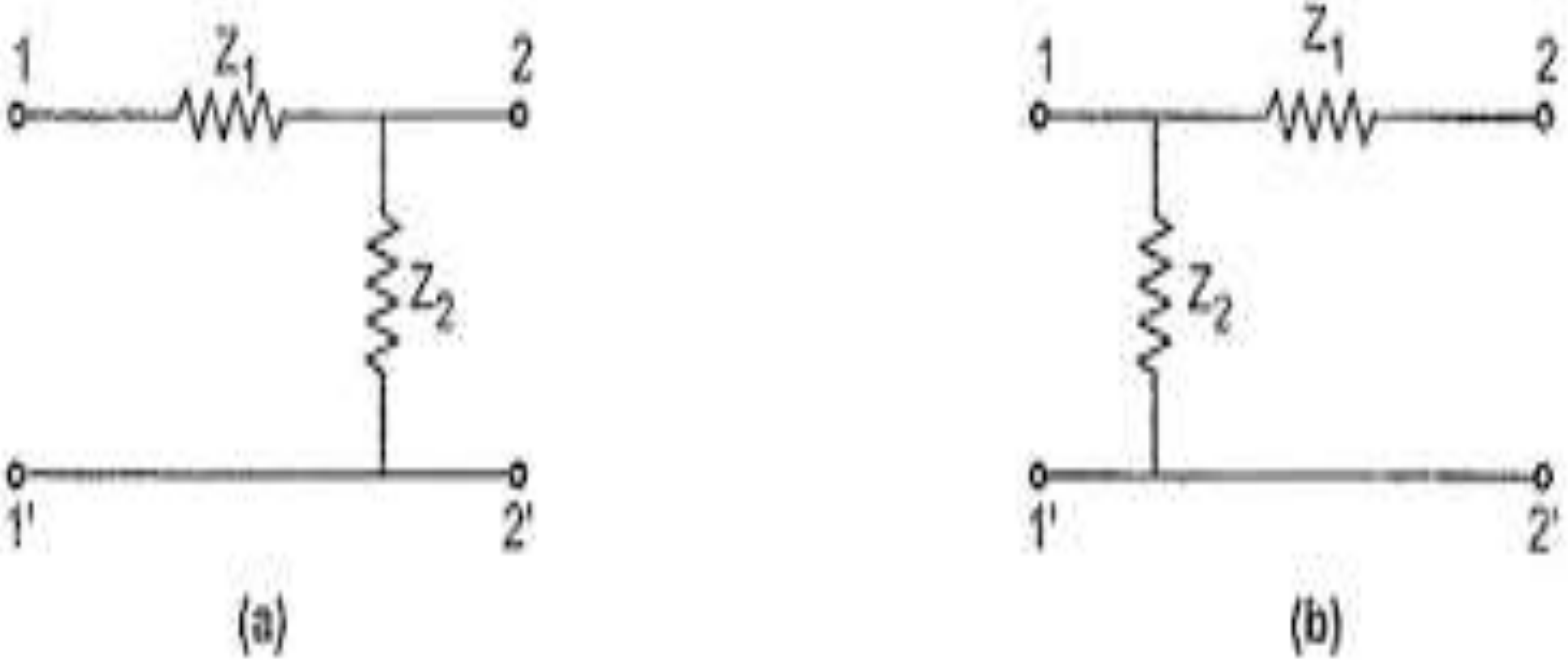


Fig. L sections

2.5 e¨v‡jÝW Ges Avbe¨v‡jÝW †mKk‡bi g‡a¨ mgZvKib (Equivalence between balancd & unbalanced sections)

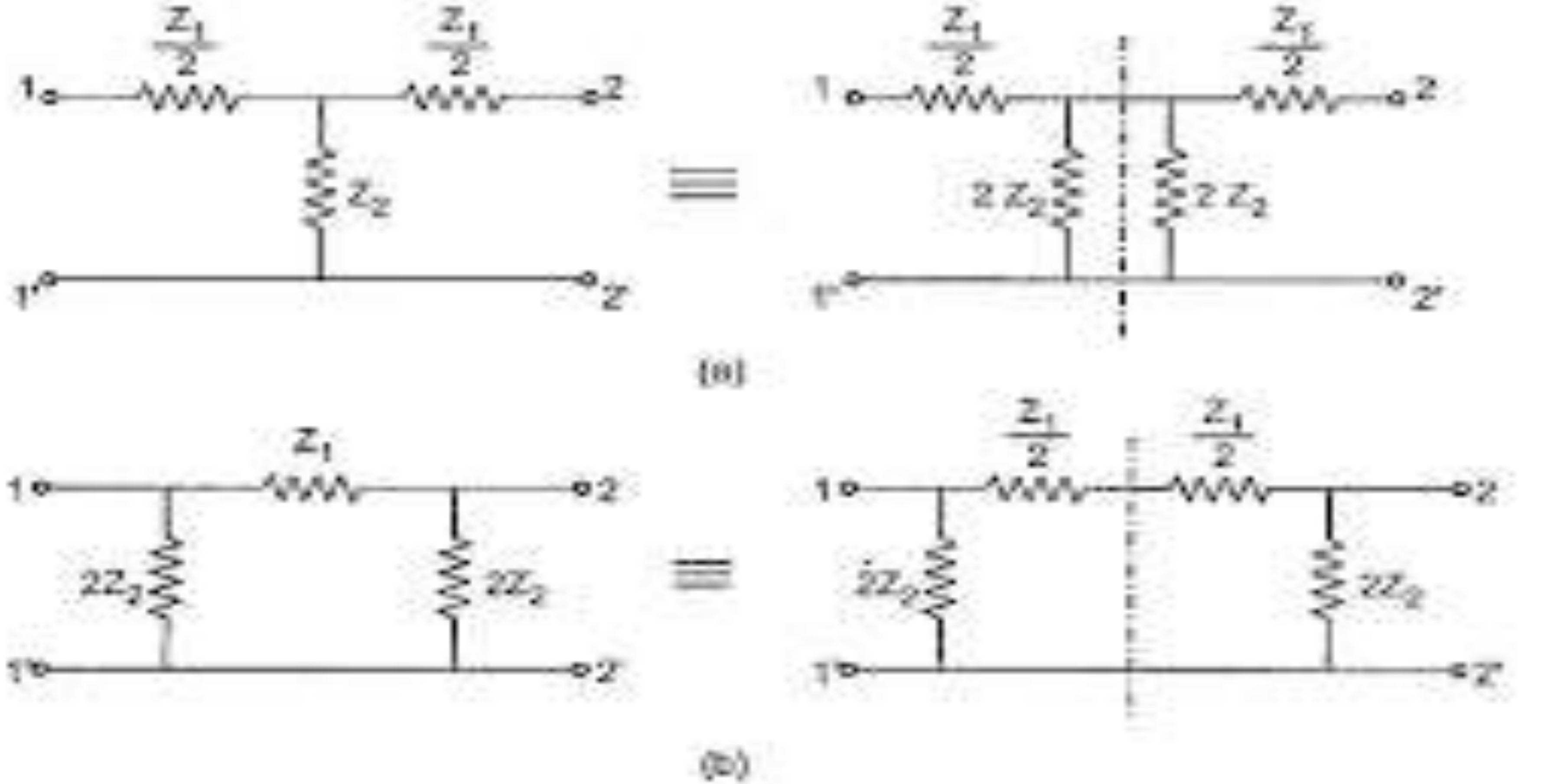
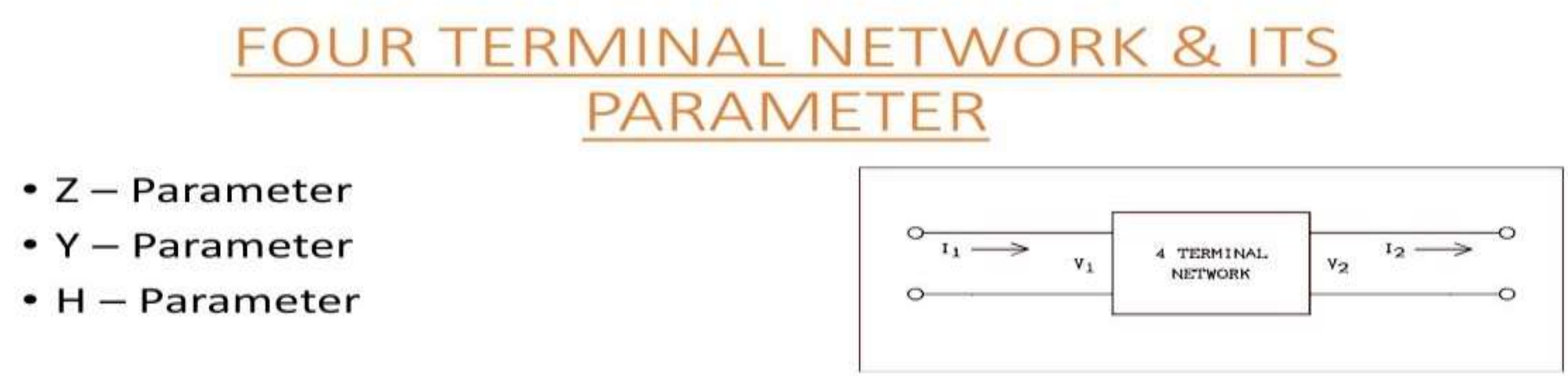


Fig. 8.24 Symmetrical T and π networks composed of two identical half sections

2.6 Pvi Uvwg©bvj †bUIqv‡K©i c¨vivwgUvimg~n
(Parameters of four terminal networks)

GKwU Pvi Uvwg©bvj †bUIqvK©‡K BbcyU I AvDUcyU ‡cv‡U©i Kv‡i›U I †fv‡ë‡Ri gva¨‡g Dc¯’vcb Kiv hvq|

Pvi Uvwg©bvj †bUIqv‡K©i BbcyU I AvDUcyU ‡cv‡U©i Kv‡i›U I †fv‡ëR



$$V_1 = Z_{11}I_1 + Z_{12}I_2$$

$$V_2 = Z_{21}I_1 + Z_{22}I_2$$

$$I_1 = Y_{11}V_1 + Y_{12}V_2$$

$$I_2 = Y_{21}V_1 + Y_{22}V_2$$

f~wgKv

G Aa¨v‡q wewfbœ cÖKvi ‡bUIqvK© ‡hgb T, π, L I nvd ‡mKkb BZ¨vw` m¤ú‡K© Av‡jvPbv Kiv n‡q‡Q| G me ‡bUIqv‡K©i K¨v‡i±vwiw÷Km Bw¤úW¨vÝ, ‡cÖvcv‡Mkb Kb÷¨v›U, GwUby‡qkb Kb÷¨v›U, ‡dR Kb÷¨v›U, BUv‡iwUf Bw¤úW¨vÝ, B‡gR Bw¤úW¨vÝ BZ¨vw` m¤ú‡K©I Av‡jvPbv Kiv n‡q‡Q|

T, π, L I nvd †mKkb †bUIqv‡K©i êwkó¨
(Features T, π, L & Half section Networks)

- **3.1 jv¤úW Bw¤úW¨v‡Ýi gva¨‡g wm‡gwUªK¨vj T I π †mKkb †bUIqv‡K©i K¨v‡i±vwiw÷K Bw¤úW¨vÝ wbb©q (Deduction of Characteristic impedance interms of lumped impedance of symmetrical T & π section networks)**
- **3.2 I‡cb mvwK©U Bw¤úW¨vÝ I kU© mvwK©U Bw¤úW¨v‡Ýi gva¨‡g wm‡gwUªK¨vj T I π †mKkb †bUIqv‡K©i K¨v‡i±vwiw÷K Bw¤úW¨vÝ wbb©q (Deduction of Characteristic impedance interms of open circuit impedance & short circuit impedance of symmetrical T & π section networks)**
- **3.3 wm‡gwUªK¨vj T I π †mKkb †bUIqv‡K©i ‡cÖvcv‡Mkb Kb÷¨v›U wbb©q (Deduction of propagation constant of symmetrical T & π section networks)**
- **3.4 wm‡gwUªK¨vj T I π †mKkb †bUIqvK©‡K nvd †mKkb †bUIqv‡K© iƒcvš—i (Identify symmetrical T & π section into half section networks)**
- **3.5 nvd †mKkb †bUIqv‡K©i BUv‡iwUf, B‡gR, I‡cb mvwK©U I kU© mvwK©U Bw¤úW¨vÝ wbb©q (Deduction of Iterative, Image, Open circuit & Short circuit Impedance of half section networks)**
- **3.6 e¨v‡jÝW I Avbe¨v‡jÝW L †mKkb †bUIqvK© (Balanced & unbalanced L section network)**
- **3.8 T †bUIqvK©‡K ÷vi Ges π †bUIqvK©‡K ‡gk †bUIqv‡K© iƒcvš—i**

3.1 jv¤úW Bw¤úW¨v‡Ýi gva¨‡g wm‡gwUªK¨vj T I π ‡mKkb ‡bUIqv‡K©i K¨v‡i±vwiw÷K Bw¤úW¨vÝ wbb©q (Deduction of Characteristic impedance interms of lumped impedance of symmetrical T & π section networks)

wm‡gwUªK¨vj T ‡bUIqvK© - wm‡gwUªK¨vj T ‡bUIqvK© LyeB ¸iyZ¡c~b© GKUv ‡bUIqvK© hv e¨envwiK ‡¶‡Î e¨eüZ nq| G‡Z GKwU wmwiR Bw¤úW¨vÝ‡K mgvb `yBfv‡M fvM K‡i GKwU kv›U Bw¤úW¨v‡Ýi `yB cv‡k¦© ms‡hvM Kiv nq| d‡j ‡bUIqvK©wU Bs‡iwR A¶i T Gi gZ ‡`Lvq e‡j G‡K T ‡bUIqvK© e‡j hv ‡`Lv‡bv n‡jv|

wm‡gwUªK¨vj T ‡bUIqvK©

wm‡gwUªK Vj T
†bUIqvK©

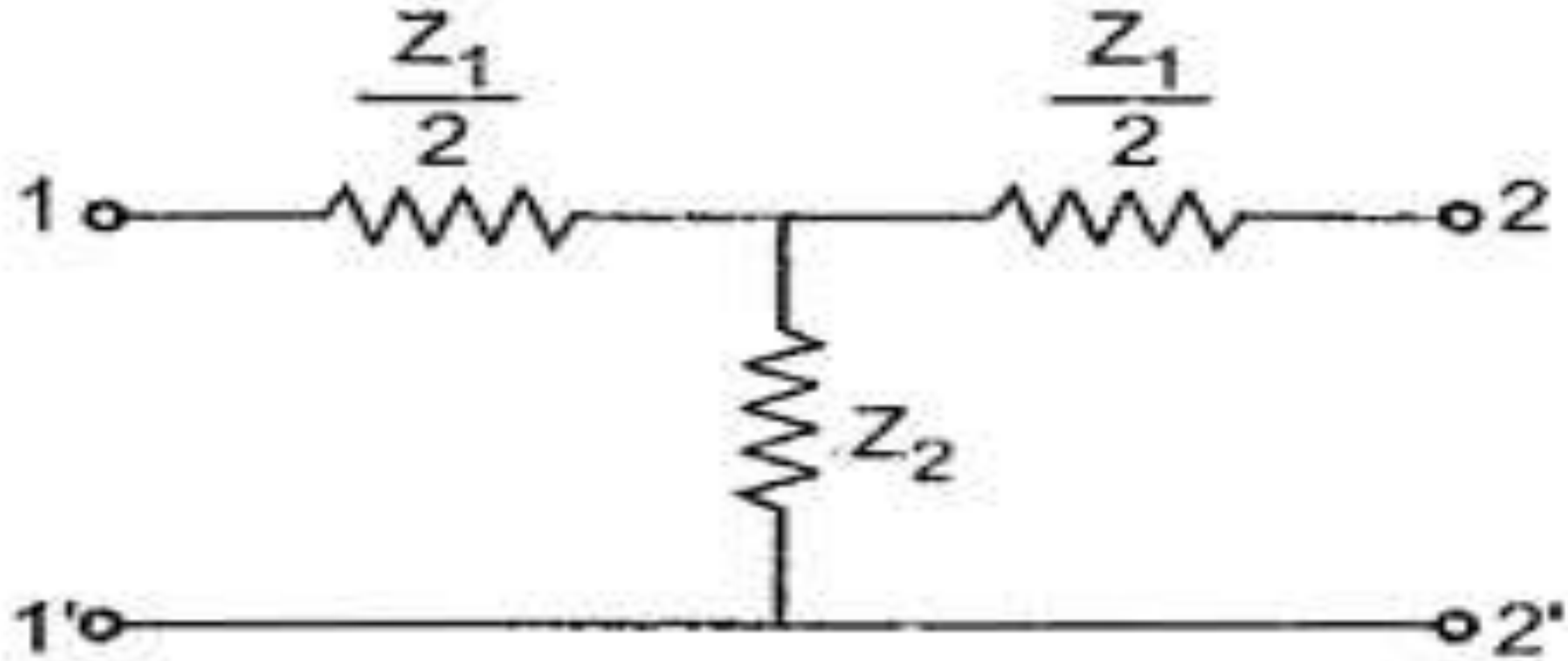


Fig. Symmetrical T network

wm+gwU«K Vj I
†bUIqvK©

$$\therefore \quad Z_{1N} = Z_0 = \frac{Z_1}{2} + \left[Z_2 \parallel \left(\frac{Z_1}{2} + Z_0 \right) \right]$$

$$\therefore \quad Z_0 = \frac{Z_1}{2} + \frac{Z_2 \left(\frac{Z_1}{2} + Z_0 \right)}{Z_2 + \frac{Z_1}{2} + Z_0}$$

$$\therefore \quad Z_0 \left(Z_2 + \frac{Z_1}{2} + Z_0 \right) = \frac{Z_1}{2} \left(Z_2 + \frac{Z_1}{2} + Z_0 \right) + \frac{Z_1 Z_2}{2} + Z_2 Z_0$$

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

$$\therefore \quad Z_0^2 = \frac{Z_1^2}{4} + Z_1 Z_2 \qquad \ldots (1)$$

$$\therefore \quad Z_0 = \sqrt{\frac{Z_1^2}{4} + Z_1 Z_2} \qquad \ldots (2)$$

3.2 I‡cb mvwK©U Bw¤úW¨vÝ I kU© mvwK©U Bw¤úW¨v‡Ýi gva¨‡g wm‡gwUªK¨vj T I π ‡mKkb ‡bUIqv‡K©i K¨v‡i±vwiw÷K Bw¤úW¨vÝ wbb©q (Deduction of Characteristic impedance interms of open circuit impedance & short circuit impedance of symmetrical T & π section networks)

wm‡gwUªK¨vj T ‡bUIqvK© - wm‡gwUªK¨vj T ‡bUIqv‡K©i AvDUcyU Uvwg©bvj ‡Lvjv Ae¯'vq BbcyU Uvwg©bv‡j ‡h Bw¤úW¨vÝ cvIqv hvq Zv‡K Gi I‡cb mvwK©U Bw¤úW¨vÝ (Z_{OC}) e‡j| G ai‡bi ms‡hvM e¨e¯'v wP‡Î ‡`Lv‡bv n‡jv| Avevi wm‡gwUªK¨vj T ‡bUIqv‡K©i AvDUcyU Uvwg©bvj kU© Ae¯'vq BbcyU Uvwg©bv‡j ‡h Bw¤úW¨vÝ cvIqv hvq Zv‡K Gi kU© mvwK©U Bw¤úW¨vÝ ($Z_{SC}$) e‡j| G ai‡bi ms‡hvM e¨e¯'v wP‡Î ‡`Lv‡bv n‡jv| wm‡gwUªK¨vj T ‡bUIqvK© Gi (K) I‡cb mvwK©U, (L) kU© mvwK©U

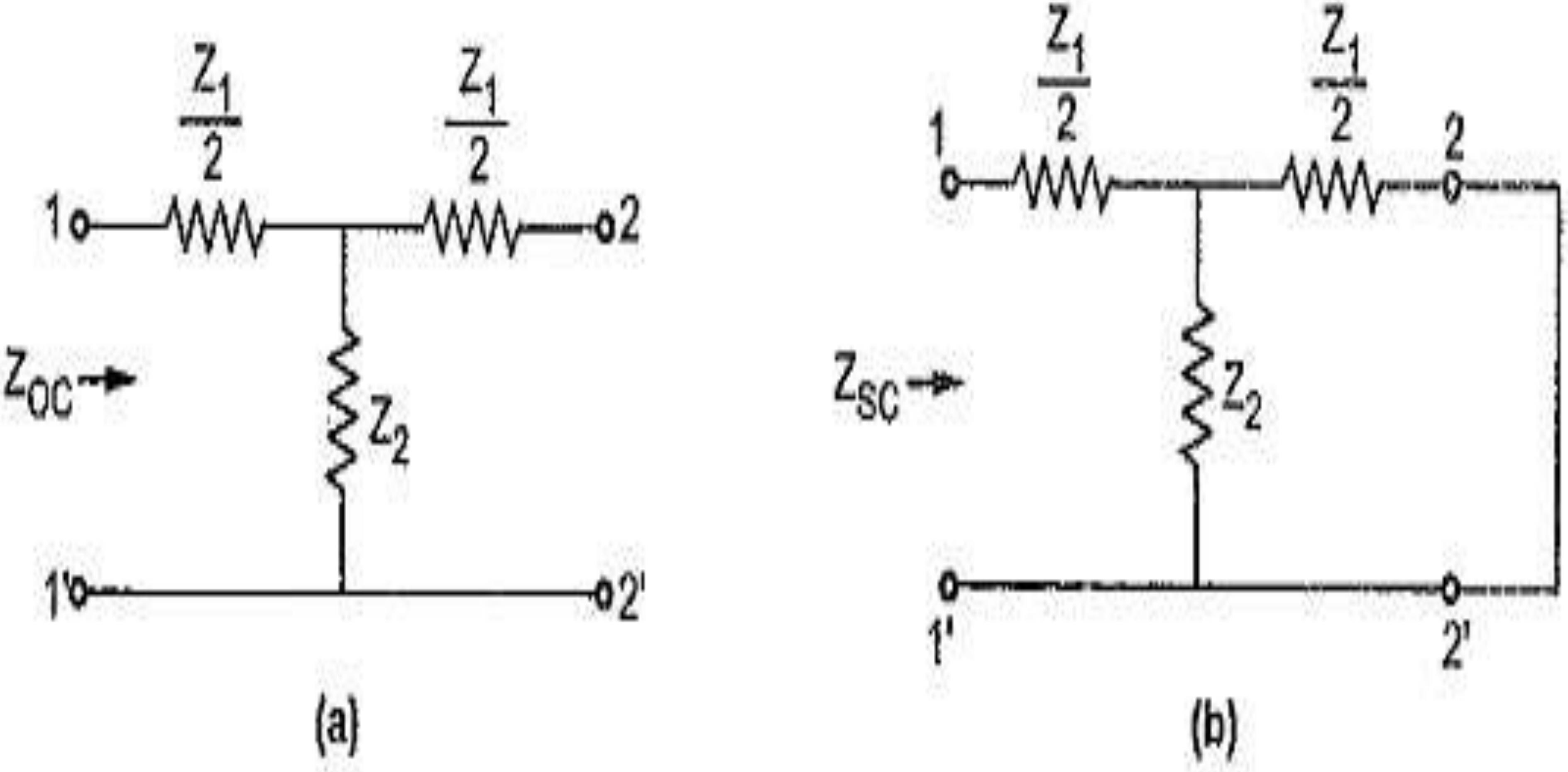


Fig. Open and short circuit impedances of symmetrical T network

Consider Fig. 8 a)

$$Z_{1OC} = Z_{2OC} = Z_{OC} = \frac{Z_1}{2} + Z_2 \qquad \dots (3)$$

Consider Fig.)

$$Z_{1SC} = Z_{2SC} = Z_{SC} = \frac{Z_1}{2} + \left[\frac{Z_1}{2} || Z_2\right]$$

$$Z_{SC} = \frac{Z_1}{2} + \frac{\frac{Z_1 Z_2}{2}}{\frac{Z_1}{2} + Z_2}$$

$$Z_{SC} = \frac{\frac{Z_1^2}{4} + \frac{Z_1 Z_2}{2} + \frac{Z_1 Z_2}{2}}{\left(\frac{Z_1}{2} + Z_2\right)} \qquad \dots (4)$$

Multiplying equations (3) and (4), we can write

•

$$Z_{OC} \cdot Z_{SC} = \left(\frac{Z_1}{2} + Z_2\right)\left[\frac{\frac{Z_1^2}{4} + Z_1 Z_2}{\left(\frac{Z_1}{2} + Z_2\right)}\right] = \frac{Z_1^2}{4} + Z_1 Z_2$$

$$Z_{OC} Z_{SC} = Z_0^2$$

$$Z_0 = \sqrt{Z_{OC} \cdot Z_{SC}} \qquad \dots (5)$$

3.3 wm‡gwUªK¨vj T I π †mKkb †bUIqv‡K©i ‡cÖvcv‡Mkb Kb÷¨v›U wbb©q (Deduction of propagation constant of symmetrical T & π section networks)

wm‡gwUªK¨vj T †bUIqvK© – wm‡gwUªK¨vj T †bUIqv‡K©i ‡cÖvcv‡Mkb Kb÷¨v›U wbb©‡qi Rb¨ Gi BbcyU Uvwg©bv‡ji g‡a¨ GKUv †fv‡ëR †mvm© E_g ms‡hvM Kiv nq hvi B›Uvibvj Bw¤úW¨vÝ $Z_g = Z_0$ Ges AvDUcyU Uvwg©bv‡ji g‡a¨ K¨v‡i±vwiw÷Km Bw¤úW¨vÝ (Z_0) ms‡hvM Kiv nq| G e¨e¯’v 3.3.1 bs wP‡Î †`Lv‡bv n‡jv| ‡bUIqvK©wUi †cÖib I MÖnb cÖv‡šZi Kv‡i›U h_vµ‡g I_S I I_R aiv n‡jv|

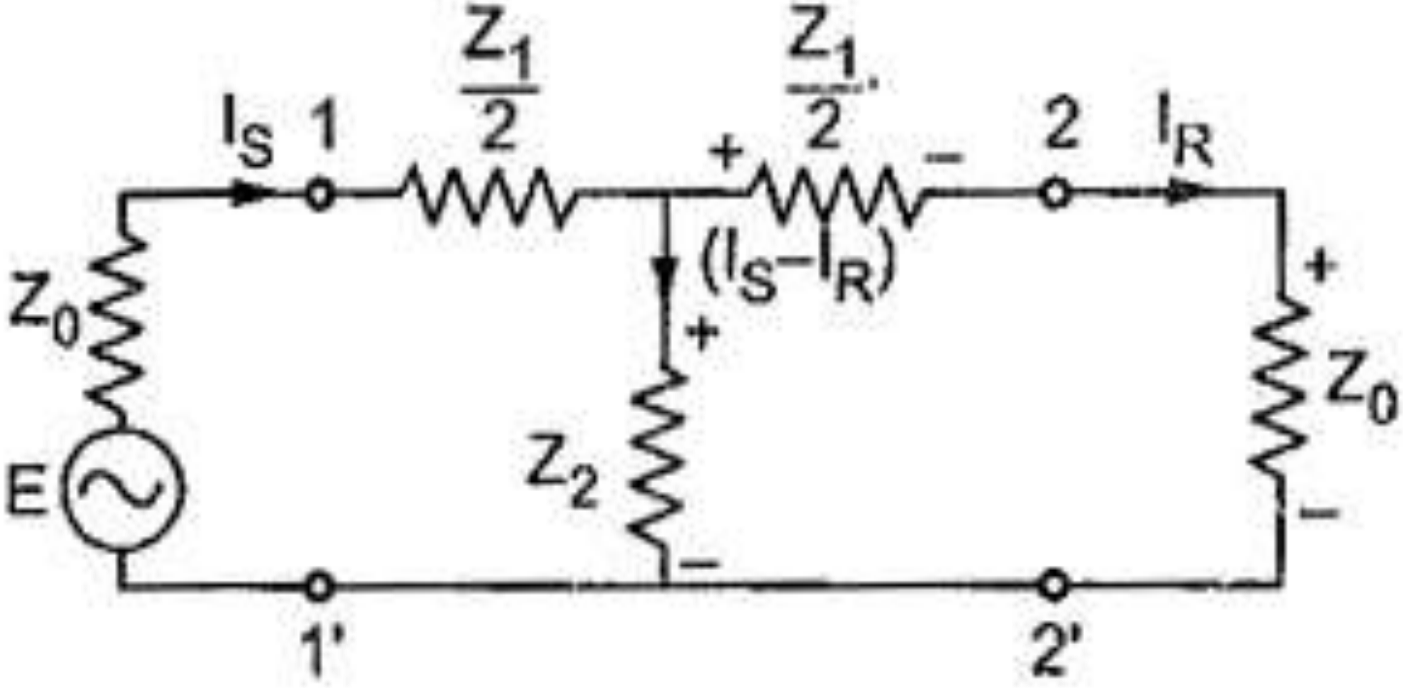


Fig. Correctly terminated symmetrical T network

Applying KVL to the outer loop,

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

$$(Z_2)\, I_S = \left(Z_2 + \frac{Z_1}{2} + Z_0\right) I_R$$

Hence

$$e^{\gamma} = \frac{I_S}{I_R} = \frac{Z_2 + \frac{Z_1}{2} + Z_0}{Z_2}$$

$$e^{\gamma} = 1 + \frac{Z_1}{2Z_2} + \frac{Z_0}{Z_2} \quad \ldots (1)$$

The propagation constant of T section is therefore given by

$$\gamma = ln\left[1+\frac{Z_1}{2Z_2}+\frac{Z_0}{Z_2}\right] \qquad \dots (2)$$

Putting value of Z_0 in equation (1), we can write

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

$$e^{\gamma} = 1+\frac{Z_1}{2Z_2}+\sqrt{\frac{Z_1^2}{4Z_2^2}+\frac{Z_1}{Z_2}} \qquad \dots (3)$$

From above equation we can write

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

$$e^{-\gamma} = 1+\frac{Z_1}{2Z_2}-\sqrt{\frac{Z_1^2}{4Z_2}+\frac{Z_1}{Z_2}} \quad \ldots (4)$$

Adding equations (3) and (4), we get

$$e^{\gamma}+e^{-\gamma} = 2\left(1+\frac{Z_1}{2Z_2}\right)$$

$$\frac{e^{\gamma}+e^{-\gamma}}{2} = \left(1+\frac{Z_1}{2Z_2}\right)$$

$$\cosh\gamma = 1+\frac{Z_1}{2Z_2} \quad \ldots (5)$$

Subtracting equation (4) from (3), we get,

$$e^{\gamma} - e^{-\gamma} = 2\sqrt{\frac{Z_1^2}{4Z_2^2} + \frac{Z_1}{Z_2}} = \frac{2}{Z_2}\sqrt{\frac{Z_1^2}{4} + Z_1 Z_2} = 2\,\frac{Z_0}{Z_2}$$

$$\frac{e^{\gamma} - e^{-\gamma}}{2} = \frac{Z_0}{Z_2}$$

$$\sinh\gamma = \frac{Z_0}{Z_2} \qquad \ldots (6)$$

Dividing equation (6) by (5) we get,

$$\tanh\gamma = \frac{\sinh\gamma}{\cosh\gamma}$$

$$\tanh\gamma = \frac{\dfrac{Z_0}{Z_2}}{\left(1+\dfrac{Z_1}{2Z_2}\right)}$$

$$\tanh\gamma = \frac{Z_0}{\left(\dfrac{Z_1}{2}+Z_2\right)} = \frac{\sqrt{Z_{OC}\cdot Z_{SC}}}{Z_{OC}} = \sqrt{\frac{Z_{SC}}{Z_{OC}}} \qquad \ldots (7)$$

Series and shunt arm impedances in terms of characteristic impedance (Z_0) and propagation constant (γ)

Consider equation (5),

$$\cosh \gamma = 1 + \frac{Z_1}{2Z_2}$$

$$\cosh \gamma - 1 = \frac{Z_1}{2Z_2}$$

$$2 \sinh^2 \frac{\gamma}{2} = \frac{Z_1}{2Z_2}$$

$$\sinh^2 \frac{\gamma}{2} = \frac{Z_1}{4Z_2}$$

$$\sinh \frac{\gamma}{2} = \sqrt{\frac{Z_1}{4Z_2}} \qquad \ldots (8)$$

Consider equation (6),

$$\sinh \gamma = \frac{Z_0}{Z_2}$$

$$2\sinh\frac{\gamma}{2}\cosh\frac{\gamma}{2} = \frac{Z_0}{Z_2}$$

$$\cosh\frac{\gamma}{2} = \frac{Z_0}{2Z_2\sinh\frac{\gamma}{2}}$$

$$\cosh\frac{\gamma}{2} = \frac{Z_0}{2Z_2}\cdot\sqrt{\frac{4Z_2}{Z_1}} = \frac{Z_0}{\sqrt{Z_1 Z_2}} \qquad \ldots (9)$$

Dividing equation (8) and (9),

$$\tanh\frac{\gamma}{2} = \frac{\sinh\frac{\gamma}{2}}{\cosh\frac{\gamma}{2}}$$

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

Thus each series arm impedance, in terms of the characteristic impedance and propagation constant is given by

$$Z_2 = \frac{Z_0}{\sinh \gamma} \quad \text{... (11)}$$

Similarly, shunt arm impedance in terms of the characteristic impedance and propagation constant is given from equation (6) as

$$\frac{Z_1}{2} = Z_0 \cdot \tanh \frac{\gamma}{2} \quad \text{... (10)}$$

Hence T network with components expressed in terms of characteristic impedance and propagation constant is as shown in the

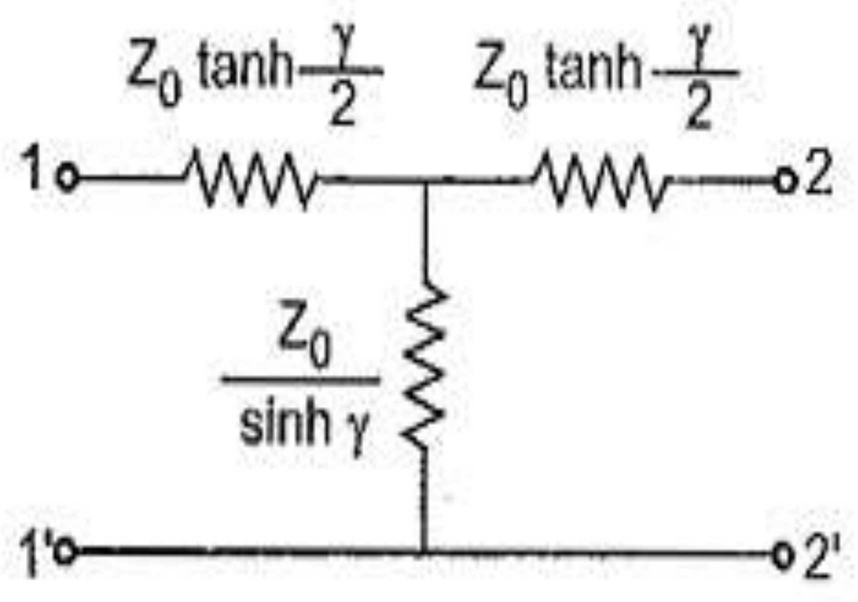


Fig. Symmetrical T network impedances in terms of Z_{0T} and γ_T

THANKS