ATME College of Engineering

Department of EEE Emitting Elite Energy

Course: Power System Simulation Lab
Ex-1: : Computation of Efficiency & Voltage Regulation for TLs

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Outline of Class

- Experiment – 1: Computation of Efficiency & Voltage Regulation for TLs

Experiment-1

Formation for symmetric π /T configuration for Verification of $AD-BC$=1, Determination of Efficiency and Regulation.

SL No.	Experiment	PO	CO
1	Formation for symmetric π /T configuration for Verification of $AD-BC$=1, Determination of Efficiency and Regulation.	PO1,PO2,PO3,PO5, PO7,PO9,PO10,PO12	CO 1

Experiment-1

Formation for symmetric π /T configuration for Verification of $AD-BC=1$, Determination of Efficiency and Regulation.

Objective:
To calculate efficiency and voltage regulation for power system network.
Generic Skills / Outcomes:
On completion of the experiment the student will understand the regulation ranges and efficiency for network under different topology.

Experiment-1

Formation for symmetric π /T configuration for Verification of $AD-BC=1$, Determination of Efficiency and Regulation.

Classification of overhead transmission lines.

Short transmission lines.

Medium transmission lines.

Long Transmission Lines

Theory

- A transmission line has three constants R, L and C distributed uniformly along the whole length of the line.
- The resistance and inductance from the series impedance.
- The capacitance existing between conductors for 1- phase line or from a conductor to neutral for 3- phase line forms a shunt path through the length of the line.
- Therefore, capacitance effects introduce complications in transmission line calculations.

Theory

Depending upon the manner in which capacitance is taken into account, the overhead transmission lines are classified as.

Sl. No.	Line	Length	Voltage	Parameter
1	Short	50 Miles 80 KM	11 & 33 KV	R,L
2	Medium	50-100 Miles 80-160 KM	66 & 132 KV	R, L & C
3	Long	Above 100 Miles Above 160KM	Above 132 KV	R, L & C

Theory

Voltage Regulation : When a transmission line is carrying current, there is a voltage drop in the line due to resistance and inductance of the line. The result is the receiving end voltage (Vr) of the line is generally less than the sending end voltage (Vs).

This voltage drop (Vs-Vr) in the line is expressed as a percentage of receiving end voltage Vr and is called voltage regulation.

- Mathematically:-

$$\%\text{age voltage regulation} = \frac{V_s - V_r}{V_r} * 100$$

Theory

Transmission Efficiency: The power obtained at the receiving end of a transmission line is generally less than the sending end power due to losses in the line resistance.

The ratio of receiving end power to the sending end power of a transmission line is known as the transmission efficiency of the line.

%age Transmission efficiency:-

$$\frac{\text{Receiving end power}}{\text{Sending end power}}$$

Theory

Let I = load current

R = loop resistance *i.e.*, resistance of both conductors

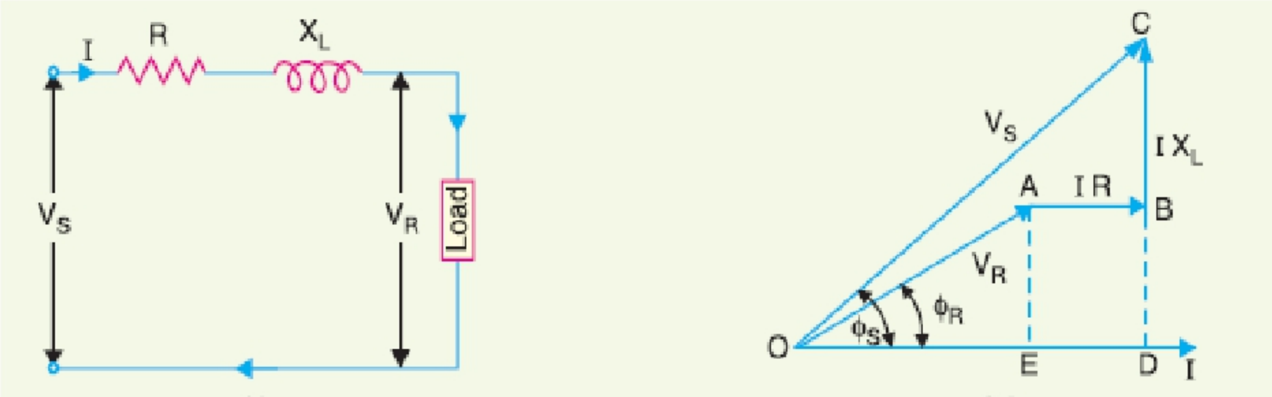
X_L = loop reactance

V_R = receiving end voltage

$\cos \phi_R$ = receiving end power factor (lagging)

V_S = sending end voltage

$\cos \phi_S$ = sending end power factor



(i) (ii)

Theory

$$(OC)^2 = (OD)^2 + (DC)^2$$

or

$$V_S^2 = (OE + ED)^2 + (DB + BC)^2$$

$$= (V_R \cos \phi_R + IR)^2 + (V_R \sin \phi_R + IX_L)^2$$

$$\therefore \quad V_S = \sqrt{(V_R \cos \phi_R + IR)^2 + (V_R \sin \phi_R + IX_L)^2}$$

(*i*) %age Voltage regulation $= \dfrac{V_S - V_R}{V_R} \times 100$

(*ii*) Sending end *p.f.*, $\cos \phi_S = \dfrac{OD}{OC} = \dfrac{V_R \cos \phi_R + IR}{V_S}$

(*iii*) Power delivered $= V_R I_R \cos \phi_R$

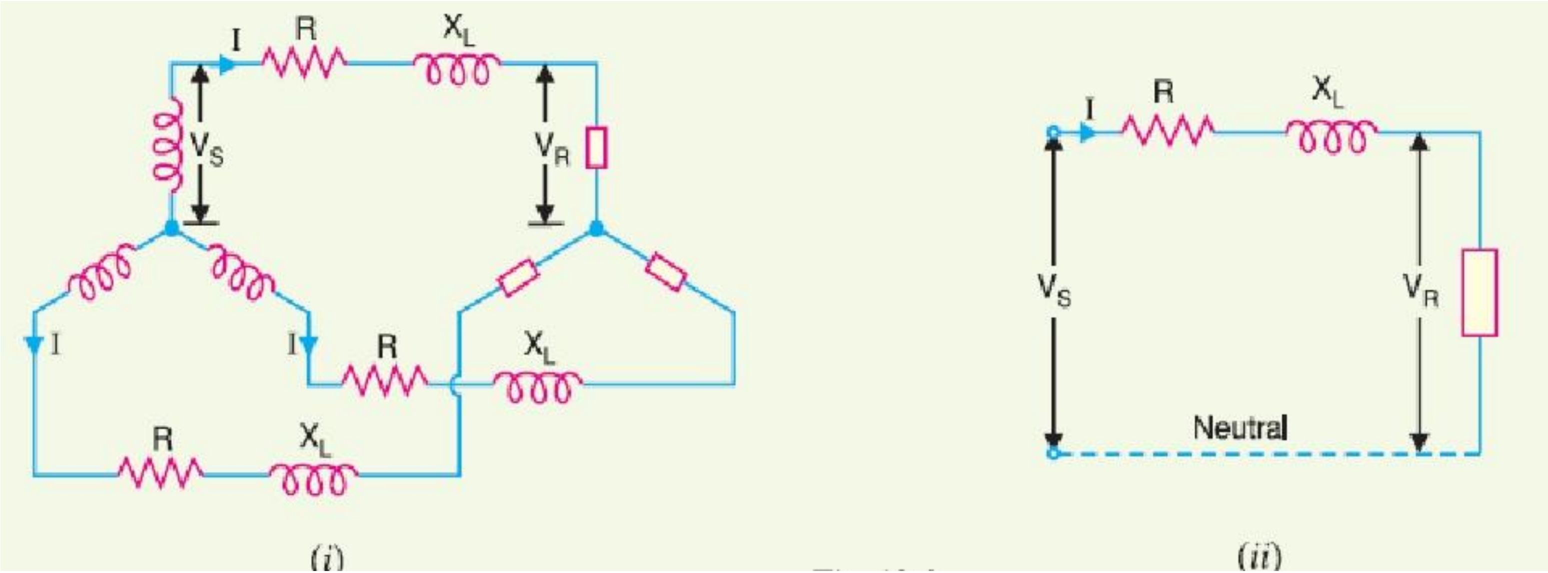
Line losses $= I^2 R$

Power sent out $= V_R I_R \cos \phi_R + I^2 R$

%age Transmission efficiency $= \dfrac{\text{Power delivered}}{\text{Power sent out}} \times 100$

$$= \frac{V_R I_R \cos \phi_R}{V_R I_R \cos \phi_R + I^2 R} \times 100$$

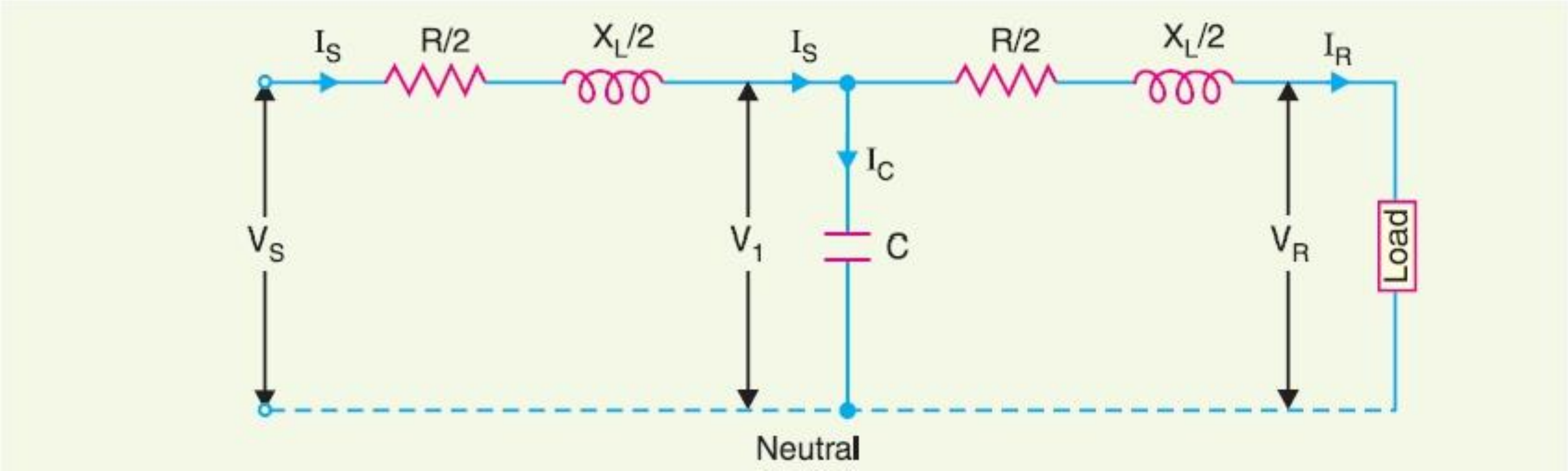
Theory



Shows a Y-connected generator supplying a balanced Y-connected load through a transmission line.

Each conductor has a resistance of R_{Ω} and inductive reactance of $X_{l\Omega}$.

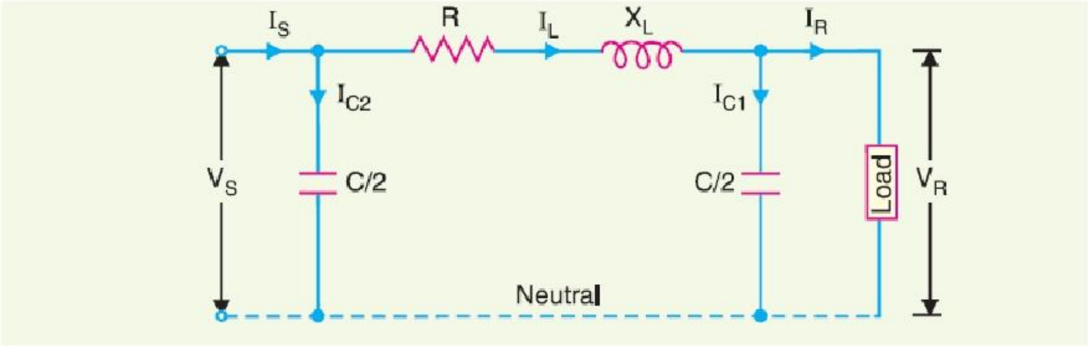
Nominal T network



In this method, the whole line capacitance is assumed to be concentrated at the middle point of the line and half the line resistance and reactance are lumped on its either side as shown in fig.

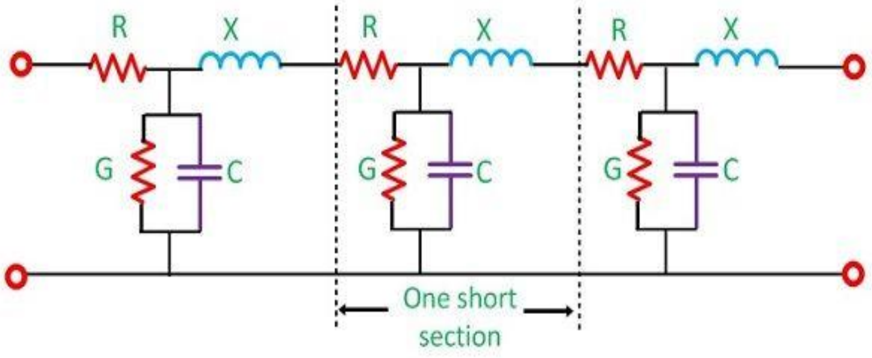
Nominal pi network

Nominal π method

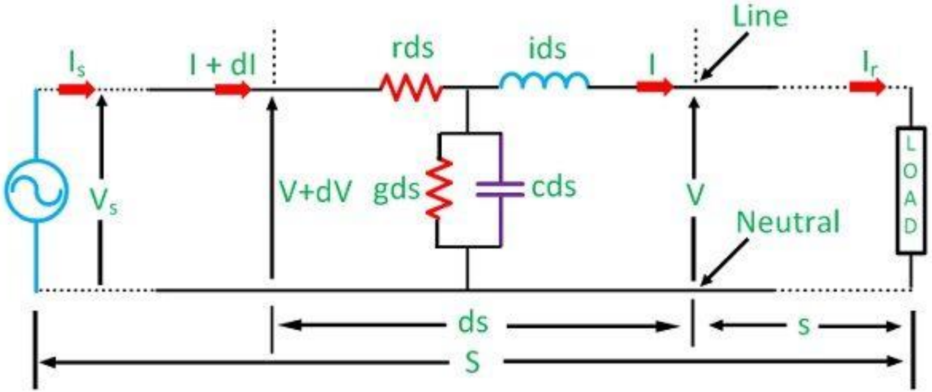


In this method, the capacitance of each conductor is divided into two halves; one half being lumped at the sending end and the other half at the receiving end as shown in fig.

Long Transmission Lines



Long transmission lines showing distributed parameters.



Incremental length of the transmission lines.

Circuit Globe

Long Transmission Lines

Where, r – resistance per unit length, per phase
l – inductance per unit length, per phase
c – capacitance per unit length, per phase
x – inductive reactance per unit length, per phase
z – series impedance per unit length, per phase
g – shunt leakage conductance, per phase to neutral per unit length
b – shunt leakage susceptance, per phase to neutral per unit length
y – shunt admittance per unit length, per phase to neutral.

For constant supply let,
V – voltage at a distance 's' from the load end
V + dV – voltage at a distance (s+ds) from the load end
I – current at a distance 's' from the load end
I + dI – current at a distance (s+ds) from the load end.

Long Transmission Lines

The difference in the voltage between the ends of the assumed sections of length ds is dV. This difference is caused by the series impedance of the line.

$$dV = Iz\,ds$$

$$\frac{dV}{ds} = Iz --------- equ(1)$$

$$\frac{d^2V}{ds^2} = z\frac{dI}{ds}$$

From equation (2)

$$\frac{d^2V}{ds^2} = zVy --------- equ(3)$$

$$dI = Vy\,ds$$

$$\frac{dI}{ds} = Vy --------- equ(2)$$

$$\frac{d^2I}{ds^2} = y\frac{dI}{ds}$$

From equation (1)

$$\frac{d^2I}{ds^2} = yIz --------- equ(4)$$

Long Transmission Lines

$$I = \frac{\sqrt{zy}}{z}(C_1 e^{\gamma s} - C_2 e^{-\gamma s})$$

$$I = \frac{\sqrt{y}}{\sqrt{z}}(C_1 e^{\gamma s} - C_2 e^{-\gamma s}) --------- equ(8)$$

$$I = \frac{1}{2}\left(I_r + \frac{V_r}{z_0}\right)e^{\gamma s} + \frac{1}{2}(I_r - \frac{V_r}{z_0})e^{-\gamma s}$$

$$I = \frac{V_r}{z_0}\left[\frac{e^{\gamma s} - e^{-\gamma s}}{2}\right] + I_r \frac{[e^{\gamma s} + e^{-\gamma s}]}{2} ------ equ(14)$$

$$V = \frac{1}{2}(V_r + z_0 I_{r)} e^{\gamma s} + \frac{1}{2}(V_r - z_0 I_r)e^{-\gamma s}$$

$$V = V_r\left[\frac{e^{\gamma s} + e^{-\gamma s}}{2}\right] + z_0 I_r \left[\frac{e^{\gamma s} + e^{-\gamma s}}{2}\right] ------ equ(13)$$

$$sinh\theta = \left[\frac{e^{\gamma s} - e^{-\gamma s}}{2}\right]$$

$$cosh\theta = \left[\frac{e^{\gamma s} + e^{-\gamma s}}{2}\right]$$

$$A = cosh\gamma S$$

$$B = z_0 sinh\gamma S$$

$$C = \frac{1}{z_o} sinh\gamma S$$

$$D = cosh\gamma S$$

$$V = V_r cosh\gamma s + z_0 I_r sinh\gamma s$$

$$I = I_r cosh\gamma s + \frac{V_r}{Z_0} sinh\gamma s$$

$$V_s = V_r cosh\gamma S + z_0 I_r sinh\gamma S ----(15)$$

$$I_s = I_r cosh\gamma S + \frac{V_r}{Z_0} sinh\gamma S ----(16)$$

Program Code

```
%ABCD of eqt. PI Network
z=0.2+0.408i;y=0+3.14e-6i;
k1=input('\n Enter 1-for short line 2-for medium line 3-for long line   ');
switch k1
case 1,
    length=40;
    Z=z*length;Y=y*length;
    A=1;B=Z;C=0;D=1;
case 2,
    length=140;
    Z=z*length;Y=y*length;
    A=1+Y*Z/2;
    B=Z;
    C=Y*(1+Y*Z/4);
    D=A;
```

Program Code

```
case 3,
    length=300;
    zc=sqrt(z/y);
    gam=sqrt(z*y)*length;
    A=cosh(gam);
    D=A;
    B=zc*sinh(gam);
    C=1/zc*sinh(gam);
    fprintf('\n The equvalent PI cicuit constants:');
    zeq=z*length*sinh(gam)/gam;
    yeq=y*length/2*tanh(gam/2)/(gam/2);
    fprintf('\n     Zeq  = %15.4f %+15.4fi',real(zeq),imag(zeq));
    fprintf('\n     Yeq/2= %15.4f %+15.4fi',real(yeq),imag(yeq));
otherwise
    disp('wrong choice of tr.line');
end
```

Program Code

```
fprintf('\nA,B,C and D constants : \n');
fprintf('---------------------------------------');
fprintf('\nA = %15.4f %+15.4fi',real(A),imag(A));
fprintf('\nB = %15.4f %+15.4fi',real(B),imag(B));
fprintf('\nC = %15.4f %+15.4fi',real(C),imag(C));
fprintf('\nD = %15.4f %+15.4fi',real(D),imag(D));
fprintf('\n The product AD-BC=%f',A*D-B*C);
k2=input('\n Enter 1 - To read Vr, Ir and compute Vs , Is \n      2 - To read Vs, Is and compute Vr, Ir    ');
switch k2,
case 1,
    %vr=input('enter Vr/phase  ');
    %ir=input('enter Ir/phase  ');
    vr=132+0.0i;
    ir=174.96-131.22i;
    vr=vr*1e3/sqrt(3);
    vs=(A*vr+B*ir)/1e3;
```

Program Code

```
is=C*vr+D*ir;
    fprintf('\nSending end Voltage/ph=%f %+fi KV',real(vs),imag(vs));
    fprintf('\nSending end Current/ph=%f %+fi AMP',real(is),imag(is));
    vs=vs*1e3;
case 2,
    %vs=input('enter Vs/phase    ');
    %is=input('enter Is/phase    ');
    vs=132+0.0i;
    is=174.96-131.22i;
    vs=vs*1e3/sqrt(3.0);
    vr=(A*vs-B*is)/1e3;
    ir=-C*vs+D*is;
    fprintf('\nReceiving end Voltage/ph=%f %+fi KV',real(vr),imag(vr));
    fprintf('\nReceiving end Current/ph=%f %+fi AMP',real(ir),imag(ir));
    vr=vr*1e3;
```

Program Code

```
otherwise
    disp('wrong choice');
end
rec_pow=3*real(vr*conj(ir))/1e6;
%rec_pow=3*abs(vr)*abs(ir)*cos(angle(vr)-angle(ir))/1e6;
send_pow=3*real(vs*conj(is))/1e6;
%send_pow=3*abs(vs)*abs(is)*cos(angle(vs)-angle(is))/1e6;
eff=rec_pow/send_pow*100;
reg=(abs(vs)/abs(A)-abs(vr))/abs(vr)*100;
fprintf('\n Receiving end power=%.2f KVA',rec_pow);
fprintf('\n Sending end power=%.2f KVA',send_pow);
fprintf('\n Efficiency=%.2f %%',eff);
fprintf('\n Voltage Regulation=%.2f%%',reg);
```

Program Code

```
Results:
Enter 1-for short line 2-for medium line 3-for long line   1
 A,B,C and D constants :
---------------------------------------
A =          1.0000        +0.0000i
B =          8.0000       +16.3200i
C =          0.0000        +0.0000i
D =          1.0000        +0.0000i
 The product AD-BC=1.000000
 Enter 1 - To read Vr, Ir and compute Vs , Is
      2 - To read Vs, Is and compute Vr, Ir    1

Sending end Voltage/ph=79.751426 +1.805587i KV
Sending end Current/ph=174.960000 -131.220000i AMP
 Receiving end power=40.00 KVA
 Sending end power=41.15 KVA
 Efficiency=97.21 %
 Voltage Regulation=4.67%>>
```

Program Code

Program code for Nominal T network

```
case 2,
    length=140;
    Z=z*length;Y=y*length;
    A=1+Y*Z/2;
    B=Z*(1+Y*Z/4);
    C=Y;
    D=(1+Y*Z/2);

case 2,
    length=140;
    Z=z*length;Y=y*length;
    A=1+Y*Z/2;
    B=Z;
    C=Y*(1+Y*Z/4);
    D=A;
```

Thank You