Experiment no: 2 **Date:** 3/10/16

Aim: 1. To find out the efficiency and regulation of a medium transmission line.

2. To find out the generalized constant of a medium transmission line.

THEORY:

Modeling of Medium Transmission Line:

The transmission line having its effective length more than 80 km but less than 160 km and the line voltage will be in between(21-100 KV), is generally referred to as a medium transmission line. Due to the line length being considerably high,In this case the shunt capacitance can be assumed to be lumped at the middle of the line or half of the shunt capacitance may be considered to be lumped each end of the line.The most commonly used methods for solution of medium transmission lines are: End condenser method, Nominal-T and Nominal- π respectively.

1. End Condenser Method:

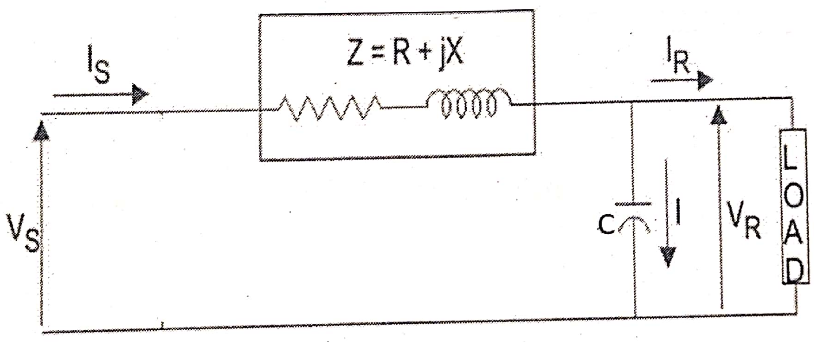

Fig: 1 End Condenser Method

In this method, the capacitance of the line is lumped or concentrated at the receiving or load end as shown in Fig 1. This method of localizing the line capacitance at the load end overestimates the effects of capacitance. In Fig 1. One phase of the 3 –phase transmission line is shown as it is more convenient to work in phase instead of line-to-line values.

I_R	=	load current per phase
R	=	loop resistance i.e., resistance of both conductors
X_L	=	inductive reactance per phase
V_R	=	receiving end voltage
V_S	=	sending end voltage
$Cos\Phi r$	=	receiving end power factor (lagging)

By taking V_R as a referencefrom the phasor diagram,

We have, $V_R = V_R + j0$

Load Current $I_R = j\, I_R(\cos \emptyset_R - j \sin \emptyset_R)$

Capacitive current $I_C = jB_C\, V_R$

The sending end current (I_s) is the phasor sum of load current I_R and capacitive current Ic i,e

$$I_s = I_R + I_C \quad (1)$$

$$W_r = V_R I_R \cos \emptyset_R$$

$$Z = (R + jX_L)$$

$Y = j\, B_{Cc}$ neglecting conductance (G=0)

$$I_C = V_R Y$$

$$V_S = V_R + I_S Z \quad (2)$$

$$W_S = V_S\, I_S \cos \emptyset_s$$

$$\text{Line losses} = I_S^2\, R = W_S - W_R$$

$$\text{\% voltage transmission efficiency} = \left(\frac{Powerdeliveredatreceivingend}{Powersentfromthesendingend}\right) * 100$$

$$\text{\% Voltage regulation} = \left(\frac{(V_{R\,(noload)} - V_{R\,(load)})}{V_{R\,(noload)}}\right) * 100$$

Eq 1 and 2 can be rewrite as

$$V_S = V_R + Z(I_R + I_C)$$

$$V_S = V_R + Z\, Y\, V_R + ZI_R \quad (3)$$

$$V_S = V_R(1 + ZY) + ZI_R$$

And $I_S = YV_R + I_R$

Than the obtain constants are

A = 1+YZ; B =Z; C =Y; D= 1

2. Nominal T Representation of a Medium Transmission Line

In this method the whole capacitance is assumed to be connected at the middle point of the line and half the line resistance and reactance are lumped on its either side as shown in Fig 2.

From the Fig 2

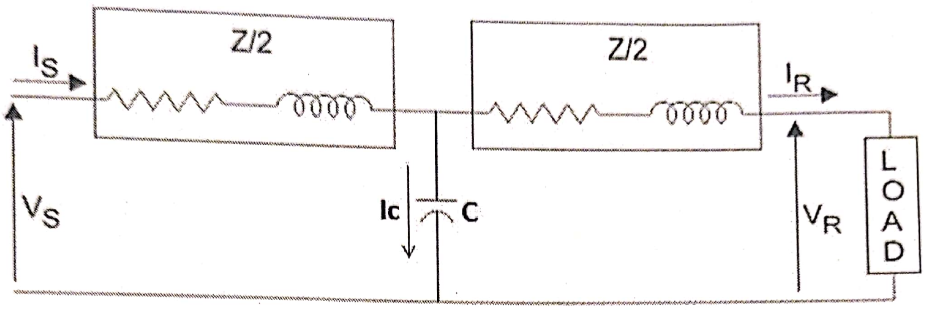

Fig 2. Normal T Method

$$Z = \left(\frac{R}{2} + j\,\frac{X}{2}\right).$$

$$V_C = V_R + I_R\left(\frac{Z}{2}\right)$$

$$I_S = I_R + I_C$$

$$I_S = I_R + Y\,V_C = I_R + Y\,(V_R + I_R\left(\frac{Z}{2}\right))$$

$$I_S = YV_R + I_R\left(1 + \left(\frac{YZ}{2}\right)\right) \qquad (1)$$

$$V_S = V_C + I_S\left(\frac{Z}{2}\right)$$

After substituting V_c and I_s in the above equation and solving

$$V_S = V_R(1 + YZ/2)) + I_R Z(1 + YZ/2) \qquad (2)$$

Compare 1 and 2

A=$(1 + YZ/2)$; B = $(1 + YZ/4)$; C = Y; D =$(1 + YZ/2)$

3 Nominal Π Representation of a Medium Transmission Line

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 2. It is obvious that capacitance at the sending end has no effect on the line drop.

However, its charging current must be added to line current in order to obtain the total sending end current.

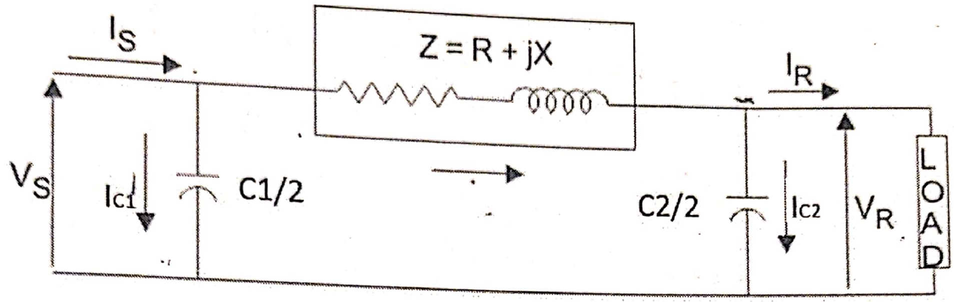

Fig 2. Normal Π Method

I_r	=	load current per phase
R	=	loop resistance i.e., resistance of both conductors
X_L	=	inductive reactance per phase
V_R	=	receiving end voltage
V_S	=	sending end voltage
CosΦr	=	receiving end power factor (lagging)

From the Fig:

$$\boldsymbol{Z = (R + jX)}$$

$$\frac{Y}{2} = j\,\frac{B_C}{2}$$

$$I_{C2} = \left(\frac{Y}{2}\right) V_R$$

$$I = I_{C2} + I_R$$

$$I_S = I + I_{C1} \,\&\, I_{C1} = \left(\frac{Y}{2}\right) V_S$$

$$I_S = \left(\frac{Y}{2}\right) V_R + I_R + \left(\frac{Y}{2}\right) V_S$$

$$V_S = V_R + IZ$$

$$V_S = V_R + Z\left(\left(\frac{Y}{2}\right) V_R + I_R\right) \qquad (1)$$

And $\quad I_S = I_R\left(1+\left(\frac{YZ}{2}\right)\right) + V_R\left(1+\left(\frac{YZ}{2}\right)Y\right) \quad (2)$

Compare 1 and 2 we get

$A = 1+(\frac{YZ}{2})$; $B = Z$; $C = Y(1+(\frac{YZ}{2}))$; $D = 1+(\frac{YZ}{2})$

PROCEDURE:

1) Connect 230V, 1phase, Ac supply at the input terminals of the panel through auto transformer.
2) Do not connect load bank at the output terminals of the panel.
3) Switch on the supply and note down the values of sending end and receiving end voltages.
4) Now, Connect Load bank at the output terminals of the panel.
5) Now using different Methods connect the short transmission kit and gradually increase the load by making the switches of the load bank ON and take different readings and tabulate then in table.
6) Compute $Cos\Theta_r$, V_s, $W_sCos\Theta_s$(from calculated value of Ws) efficiency and regulation.
7) Draw vector diagram to scale and confirm observed values.

OBSERVATION TABLE:

Table 1: FERRANTI EFFECT

Sr No	Vs	Vr
1	203	205
2	170	171.5

Table 2: NOMINAL T METHOD: $V_{NL} = 205.3\,V$

Sr No	Vc1	Vc2	Vr	Vs		Ir	Is	Wr	CosΘr	Ws		CosΘs	%η Efficiency		% Regulation	
				Obs	Cal					Obs	Cal		Obs	Cal	Obs	Cal
1	187	187	171.5	201.5	184.07	0.56	0.56	70	0.7288	86	72.244	0.7919	87.5	96.22	17.5	10.25
2	191	191	171.5	201.5	193.7	0.48	0.48	65	0.7544	75	66.988	~~0.6988~~ 0.8451	86.67	97.03	12.25	7.91

Table 3: NOMINAL PI METHOD $V_{NL} = 206.1\,V$

Sr No	Vc1	Vc2	Vr	Vs		Ir	Is	Wr	CosΘr	Ws		CosΘs	%η Efficiency		% Regulation	
				Obs	Cal					Obs	Cal		Obs	Cal	Obs	Cal
1	203	172.5	172.5	203	190.26	0.54	0.54	70	0.7246	82	72.4	0.7952	85.36	96.26	17.68	10.29
2	203	179.8	179.8	203	194.75	0.49	0.48	65	0.7378	78	69.66	0.8293	83.33	96.82	12.9	8.31

TABLE 4: END CONDENSER METHOD: $V_{NL} = 204.1\,V$

Sr No	Vc1	Vc2	Vr	Vs		Ir	Is	Wr	CosΘr	Ws		CosΘs	%η Efficiency		% Regulation	
				Obs	Cal					Obs	Cal		Obs	Cal	Obs	Cal
1	–	170	170	201.5	187.6	0.56	0.6	70	0.7353	80	72.75	0.7382	87.5	96.21	18.53	10.37
2	–	174.5	174.5	201.5	188.7	0.5	0.54	70	0.8023	80	72.202	0.8150	87.5	96.94	15.47	8.13

Conclusion:

From this experiment we learned different model of medium transmission line and determined its efficiency and different performance parameters. We also studied the effect of load p.f on different char. of medium transmission line

Calculations:

Nominal T- method $\quad Z = 10 + j40, \quad C = 2\times10^{-6}F$

$$\cos\phi_r = \frac{W_r}{V_r I_r} = \frac{70}{171.5\times0.56} = 0.7288$$

$$\phi_r = 43.2088^\circ$$

$\rightarrow \vec{I_r} = 0.56\angle-43.2088$

$$\vec{V_c} = \vec{V_R} + (\vec{I_r})(\vec{Z}/2)$$

$$= 171.5\angle0 + (0.56\angle-43.2088)(5+j20)$$

$$\vec{V_c} = 181.316\angle1.974^\circ$$

$$\vec{I_c} = j V_c (2\pi f C)$$

$$= j(181.316\angle1.974)(2\times3.14\times50\times2\times10^{-6})$$

$$\vec{I_c} = 0.114\angle91.974^\circ$$

$$\vec{I_s} = \vec{I_c} + \vec{I_R}$$

$$= 0.114\angle91.974^\circ + 0.56\angle-43.2088$$

$$I_s = 0.485\angle-33.698$$

$$\vec{V_s} = \vec{V_c} + \vec{I_s}(\vec{Z}/2)$$

$$\vec{V_s} = 189.07\angle3.937$$

$$W_{s(cal)} = W_r + I_R^2 R + I_s^2 R$$

$$= 70 + (0.56)^2(5) + (0.45)^2(5)$$

$$W_{s\,cal} = 72.744\,W$$

$\rightarrow \%\eta_{obs} = \frac{W_r}{W_{s\,obs}}\times100 = \frac{70}{80}\times100 = 87.5\%$

$\rightarrow \%\eta_{cal} = \frac{W_r}{W_{s\,cal}}\times100 = \frac{70}{72.744}\times100 = 96.228\%$

$$\% V.R_{obs} = \frac{V_{s\,obs} - V_r}{V_r} \times 100 = \frac{201.5 - 171.5}{171.5} \times 100 = 17.5\%$$

$$\% VR_{cal} = \frac{V_{s\,cal} - V_r}{V_r} \times 100 = \frac{189.07 - 171.5}{171.5} \times 100 = 10.28\%$$

② Nominal π - Method

$$Z = 10 + j40 \quad , \quad C = 2\mu F$$

$$\rightarrow \cos\phi_r = \frac{W_r}{V_r I_r} = \frac{70}{172.5 \times 0.56} = 0.7246$$

$$\phi_r = 43.56°$$

$$\rightarrow \vec{I_{c_2}} = j\, V_R \left(\frac{\omega C}{2}\right)$$

$$= j\; 172.5 \left(2 \times \pi \times 90 \times \frac{2}{2} \times 10^{-6}\right)$$

$$= 0.05419 \angle 90°$$

$$\vec{I_R} = 0.56 \angle -43.56$$

$$\vec{I} = \vec{I_R} + \vec{I_{c_2}}$$

$$= 0.524 \angle -39.263$$

$$\vec{I_s} = \vec{I} + \vec{I_{c_1}}$$

$$= 0.524 \angle -39.263 + j V_s \left(\frac{\omega c}{2}\right)$$

$$= 0.488 \angle -33.434$$

$$\vec{V_s} = \vec{V_R} + \vec{I}\vec{Z}$$

$$= 172.5 + (0.524 \angle -39.263)(10 + j40)$$

$$= 190.26 \angle 3.89$$

$$\phi_s = 3.89 + 33.434$$

$$\phi_s = 37.324$$

$$\cos\phi_s = 0.7952$$

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$\rightarrow W_{s\,cal} = W_r + \text{losses}$

$= 70 + I^2R$

$= 70 + (0.524)^2(10)$

$= 72.745\ W$

$\rightarrow \%\eta_{obj} = \dfrac{W_r}{W_{s\,obj}} = \dfrac{70}{82} \times 100 = 85.36\%$

$\rightarrow \%\eta_{cal} = \dfrac{W_r}{W_{s\,cal}} = \dfrac{70}{72.745} \times 100 = 96.226\%$

$\rightarrow \%VR_{obj} = \dfrac{V_{s\,obj} - V_r}{V_r} \times 100 = \dfrac{203 - 172.5}{172.5} \times 100 = 17.68\%$

$\rightarrow \%VR_{cal} = \dfrac{V_{s\,cal} - V_r}{V_r} \times 100 = \dfrac{190.26 - 172.5}{172.5} = 10.29\%$

End Condenser Method:

$\rightarrow \cos\phi_r = \dfrac{W_r}{V_r I_r} = \dfrac{70}{170 \times 0.56} = 0.7353$

$\phi_r = 42.6679^\circ$

$\rightarrow \vec{I_r} = 0.56 \angle -42.6679$

$\vec{I_c} = jV_r(2\pi f C)$

$= j170(2 \times \pi \times 50 \times 1 \times 10^{-6})$

$= 0.0534 \angle 90^\circ$

$\vec{I_s} = \vec{I_r} + \vec{I_c}$

$= 0.525 \angle -38.38$

$\vec{V_s} = \vec{V_R} + \vec{V_s}\,\vec{Z}$

$= 170 + (0.525 \angle -38.38)(10 + j40)$

$= 187.628 \angle +4.037$

$\rightarrow \phi_s = 4.037 + 38.38$

$= 42.417$

$\cos\phi_s = 0.7382$

$W_s\ cal = W_R + I_s^2 R$

$= 70 + (0.525)^2 (10)$

$= 72.756\ W$

$\rightarrow \%\ \eta_{obs} = \frac{70}{80} \times 100 = 87.5\%$

$\rightarrow \%\ \eta_{cal} = \frac{70}{72.756} \times 100 = 96.21\%$

$\rightarrow VR_{obs} = \frac{201.5 - 170}{170} \times 100 = 18.53\%$

$\rightarrow VR_{cal} = \frac{187.628 - 170}{170} \times 100 = 10.37\%$