Experiment 2 **Performance of Transmission Line** Reg No:-20BEE0298

Name:-Bishal Saha

Date:-15-08-2021

**Aim:-**

To calculate the percentage regulation and Efficiency of a transmission line by manual calculation and verify using Matlab /M-File code.

**Question:-**

A balance 3-phase of 25MVA is supplied at 132kV and 0.8 lag by a transmission line. The series impedence is 0.11+0.389i and admittance is 0.03*10^-4i,the total length of the transmission line is 250 .Calculate % Regulation and Efficiency using Nominal T,Nominal pi and Long Transmission line method.Also verify your results using Matlab and compare them by tabulation.

**Software required:-**

MATLAB

**Theory**

Voltage Regulation:-

It is the Percentage of change in voltage at the Receiving end when load is varied.

%Reg=((Vro-Vrl)/Vrl) *100 = ((|vs|-|Vr|)/|Vr|)*100

Transmission line Efficiency

It is the Percentage ratio of receiving end Power to Sending end Power.

$V_S = AV_R + BI_R$

$I_S = CV_R + DI_R$

| | A | B | C | D |
|---|---|---|---|---|
| Short TL | 1 | Z | 0 | 1 |
| Nominal T | $\left(1+\frac{YZ}{2}\right)$ | $Z\left(1+\frac{YZ}{4}\right)$ | Y | $\left(1+\frac{YZ}{2}\right)$ |
| Nominal π | $\left(1+\frac{YZ}{2}\right)$ | Z | $Y\left(1+\frac{YZ}{4}\right)$ | $\left(1+\frac{YZ}{2}\right)$ |
| Long TL | $\cosh\sqrt{YZ}$ | $\sqrt{\frac{Z}{Y}}\sinh\sqrt{YZ}$ | $\sqrt{\frac{Y}{Z}}\sinh\sqrt{YZ}$ | $\cosh\sqrt{YZ}$ |

**Manual Calculation**

20BEE0298

Given

$V_{RL} = 132e^3$ V, $S_R = 25$ MVA

$P_R = 25e^6 * 0.8$ W

$\cos\phi_R = 0.8$ lag

$Z = 0.11 + 0.389i$

$Y = 0.3e{-}4i$

$L = 250$

$Z = Z \times 250$ , $Y = Y \times 250$

$Z = 27.5 + 97.25i$ , $Y = 75 \times 10^{-4}i$

Nominal T.

$V_S = AV_R + BI_R$

$I_S = CV_R + DI_R$

$$A = 1 + \frac{YZ}{2}$$

$$= 1 + \frac{(75 \times 10^{-4}i)(27.5 + 97.25i)}{2}$$

$$= 0.96 + 0.010$$

$$B = Z + \frac{YZ^2}{4}$$

$$= (27.5 + 97.25i) + \frac{(75 \times 10^{-4}i)(27.5 + 97.25i)^2}{4}$$

$$= 26.49 + 95.61i$$

$C = Y = 0.3e^{-4i}$

$D = A = 0.96 + 0.010$

$$V_{RP} = \frac{132 \times 10^3}{\sqrt{3}} = 76.21 \times 10^3 = V_R = 76.21 \times 10^3 \angle 0° \text{ V}$$

$P_R = 3 V_{RP} I_{RP} \cos\phi_R$

$$\therefore I_{RP} = \frac{P_R}{3 V_{RP} \cos\phi_R} = \frac{25 \times 10^6 \times 0.8}{3 \times 76.21 \times 10^3 \times 0.8} = 109.34 \text{ A.}$$

$= I_{mp}(\cos\phi_R - j\sin\phi_R)$

$= 109.34(0.8 - j0.6)$

$\vec{I_p} = 87.47 - 65.604j$ A

$V_S = AV_R + BI_R$

$= (0.96 + 0.010)(76.21\times10^3\angle0^\circ) + (26.49 + 95.61i)(87.47 - 65.604j)$

$= 8.17\times10^4 + 7.499\times10^3 i$ V

$V_{sp} = 82035\angle5.18$ V

$I_S = CV_R + DI_R$

$= (7.5\times10^{-4}i)(76.21\times10^3\angle0^\circ) + (0.96 + 0.010)(87.47 - 65.604j)$

$= 84.62 - 4.94i$ A

$I_{sp} = 84.76\angle -3.34$ A

$\cos\phi_s = \cos[\log(V_S + I_S)]$

$= \cos[8.63]$

$\cos\phi_s = 0.99$

$P_S = 3V_{sp} I_{sp}\cos\phi_s$

$= 3\times 82035\times 84.76\times 0.9 = 2.102\times10^7$ W

% Regulation $= \dfrac{|V_{SP}| - |V_{RP}|}{|V_{RP}|}\times100$

$= \dfrac{82035 - 76210}{76210}\times100$

$= 7.64$ 8.06

% Efficiency $= \dfrac{P_R}{P_S}\times100 = \dfrac{2.10\times10^7}{25\times10^6} = \dfrac{25\times10^6\times0.8}{2.102\times10^7}\times100$

$= 95.141$

For Nominal Pi.

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$V_S = AV_R + BI_R$

$I_S = CV_R + DI_R$

$A = \left[1 + \frac{YZ}{2}\right] = 0.96 + 0.010$

$B = Z = 27.5 + 97.25i$

$C = Y\left[1 + \frac{YZ}{4}\right] = -3.867e^{-6} + 7.3632e^{-04}i$

$D = \left[1 + \frac{YZ}{2}\right] = 0.963 + 0.0103i$

$V_{rph} = \frac{132 \times 10^3}{\sqrt{3}} = 76.21 \times 10^3 = V_R = 76.21 \times 10^3 \angle 0^\circ$ V

$P_R = 3 V_{rph} I_{rp} \cos\phi_R$

$\therefore I_{rp} = \frac{P_R}{3 V_{rp} \cos\phi_R} = \frac{25 \times 10^6 \times 0.8}{3 \times 76.21 \times 10^3 \times 0.8} = 109.34$ A

$\vec{I} = I_{rp}(\cos\phi_R - j\sin\phi_R)$

$= 109.34(0.8 - j0.6)$ A

$\vec{I} = 87.47 - 65.604j$ A

$V_S = AV_R + BI_R$

$= (0.96 + 0.010)(76.21 \times 10^3 \angle 0^\circ) + (27.5 + 97.25i)(109.34(0.8 - j0.6))$

$= 82216.64 + 7488.81j$ V

$V_{sp} = 82557 \angle 5.20$ V

$I_S = CV_R + DI_R$

$= (-3.867e-6 + 7.3632e-4i)(76.21 \times 10^3 \angle 0^\circ) + (0.963 + 0.0103i) \times (87.47 - 65.604j)$

$= 84.66 - j6.196$ A

$= 84.895 \angle -4.186$ A

$\cos\phi_S = \cos[\text{ang}(V_S + I_S)]$

$= \cos[9.30]$

$= 0.99$

$P_S = 3 V_{sp} I_{sp} \cos\phi_s$

$= 3 \times 82557 \times 84.89 \times 0.99$

$P_S = 2.1023e^7 \text{ W}$

$\%$ Regulation $= \dfrac{|V_{sp}| - |V_{RP}|}{|V_{RP}|}$

$= \dfrac{82557 - 76210}{76210} \times 100$

$= 8.32$

$\%$ Efficiency $= \dfrac{P_n}{P_s} \times 100$

$= \dfrac{25 \times 10^6 \times 0.8}{2.1023e^7} \times 100$

$= 95.13\%$

For Long Transmission

20BEE029

$A = \cosh\sqrt{YZ}$

$= \cosh\sqrt{(27.5+97.25i)(7.5\times10^{-4}i)}$

$= 0.963 + 0.012i$

$B = \sqrt{\frac{Z}{Y}}\sinh\sqrt{YZ}$

$= \sqrt{\frac{27.5+97.2i}{7.5\times10^{-4}i}}\sinh\sqrt{(7.5\times10^{-4}i)(27.5+97.25i)}$

$= 26.835 + 96.165i$

$C = \sqrt{\frac{Y}{Z}}\sinh\sqrt{YZ}$

$= -2.559\times10^{-4} + 7.409\times10^{-4}i$

$D = \cosh\sqrt{YZ}$

$= 0.963 + 0.012i$

$V_{rp} = \frac{132\times10^3}{\sqrt{3}} = 76.21\times10^3 = V_R = 76.21\times10^3\angle0°\ V.$

$P_R = 3V_{rp}I_{rp}\cos\phi_R$

$I_{rp} = \frac{P_R}{3V_{rp}\cos\phi_R} = \frac{25\times10^6\times0.8}{3\times76.21\times10^3\times0.8}$

$= 109.34A$

$\vec{I} = I_{rp}(\cos\phi_R - j\sin\phi_R)$

$= 109.34(0.8 - j0.6)\ A$

$\vec{I_R} = 87.47 - 65.604j\ A\ A$

$V_S = AV_R + BI_R$

$= (0.963 + 0.010i)(76.21\times10^3\angle0°) + (26.83 + 96.16i)(87.47 - 65.604j)$

$= 8.210\times10^4 + 7.428\times10^3 i\ V$

$V_{sp} = 8.2438\times10^4\angle5.1696\ V$

$I_S = CV_R + DI_{12}$

$= (-2.5594 \times 10^{-6} + 7.4091 \times 10^{-4}i)(76.21 \times 10^3 \angle 0^\circ) + (0.963 + 0.01026i)(87.47 - 65.604j)$

$= 84.7783 - 5.8723i$ A

$I_{sp} = 84.98 \angle -3.96$ A

$\cos\phi_s = \cos[\angle(V_{st} I_s)]$

$= \cos[5.16 + 3.96]$

$= \cos[9.12]$

~~$\cos\phi_s = 0.99$~~

$\cos\phi_s = 0.99$

$P_s = 3 V_{sp} I_{sp} \cos\phi_s$

$= 3 \times 8.2438 \times 10^4 \times 84.98 \times 0.9$

$= 2.1023 \times 10^7$ W

% Regulation $= \frac{|V_{SP}| - |V_{RP}|}{|V_{RP}|} \times 100$

$= \frac{8.2438 \times 10^4 - 76210}{76210} \times 100$

$= 8.172$

% Efficiency $= \frac{P_L}{P_S} \times 100 = \frac{25 \times 10^6 \times 0.8}{2.1023 \times 10^7}$

$= 95.181$

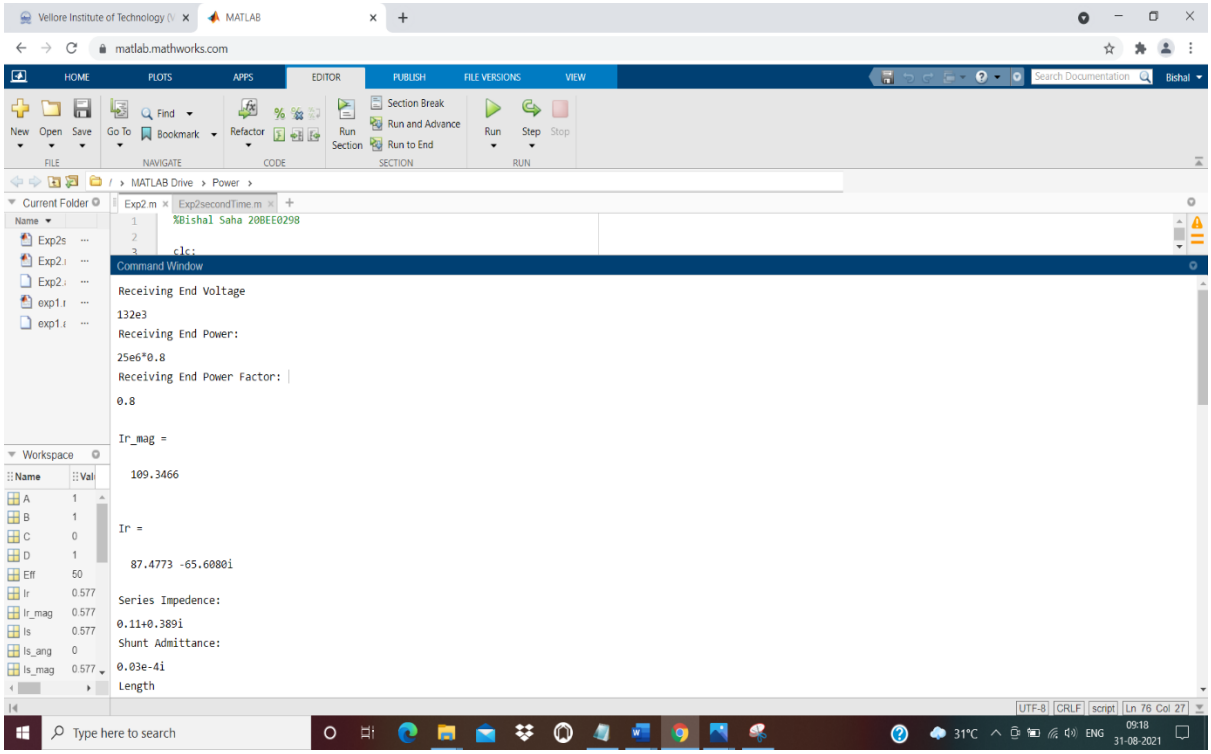
**Program**

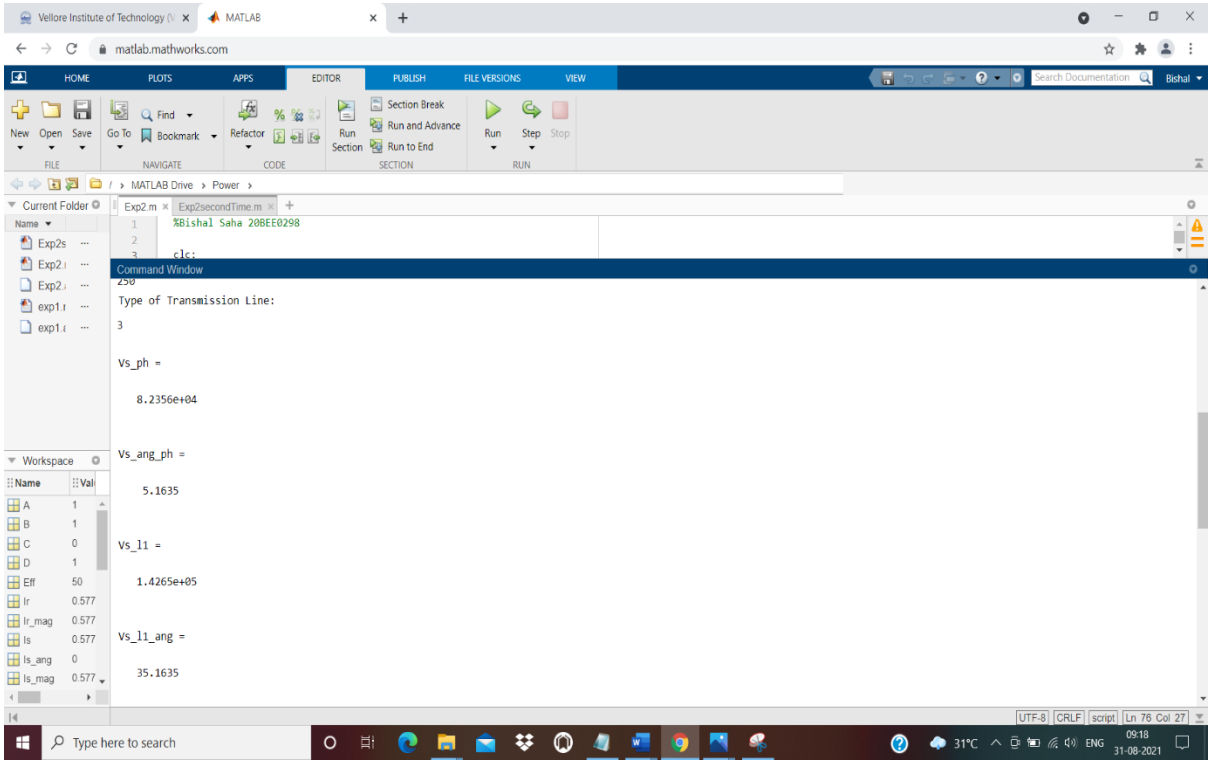
```
%Bishal Saha 20BEE0298

clc;
Vr_l1=input("Receiving End Voltage");
Vr=Vr_l1/sqrt(3);

Pr=input("Receiving End Power: ");
Pf=input("Receiving End Power Factor: ");

Ir_mag=Pr/(sqrt(3)*Vr_l1*Pf)
Ir=Ir_mag*(Pf-1i*(sin(acos(Pf))))

z=input("Series Impedence: ");
y=input("Shunt Admittance: ");

L=input("Length");
Type=input("Type of Transmission Line: ");

%short=1;End Condenser Method=2;Nomimal T=3;Nominal pi=4;Long=5

Z=z*L; Y=y*L;

if (Type==1)
    A=1;
    B=Z;
    C=0;
    D=A;
    Vs=Vr*A+Ir*B;
    Is=Vr*C+Ir*D;

elseif (Type==2)
    A=(1+(Y*Z));
    B=Z;
    C=Y;
    D=1;
    Vs=Vr*A+Ir*B;
    Is=Vr*C+Ir*D;

elseif (Type==3)
    A=(1+(Y*Z/2));
    B=Z*(1+(Y*Z/4));
    C=Y;
    D=A;
    Vs=Vr*A+Ir*B;
    Is=Vr*C+Ir*D;

elseif (Type==4)
    A=(1+(Y*Z/2));
    B=Z;
    C=Y*(1+(Y*Z/4));
    D=A;
    Vs=Vr*A+Ir*B;
    Is=Vr*C+Ir*D;

elseif (Type==5)
    A=cosh(sqrt(Y*Z));
    B=sqrt(Z/Y)*sinh(sqrt(Z*Y));
```

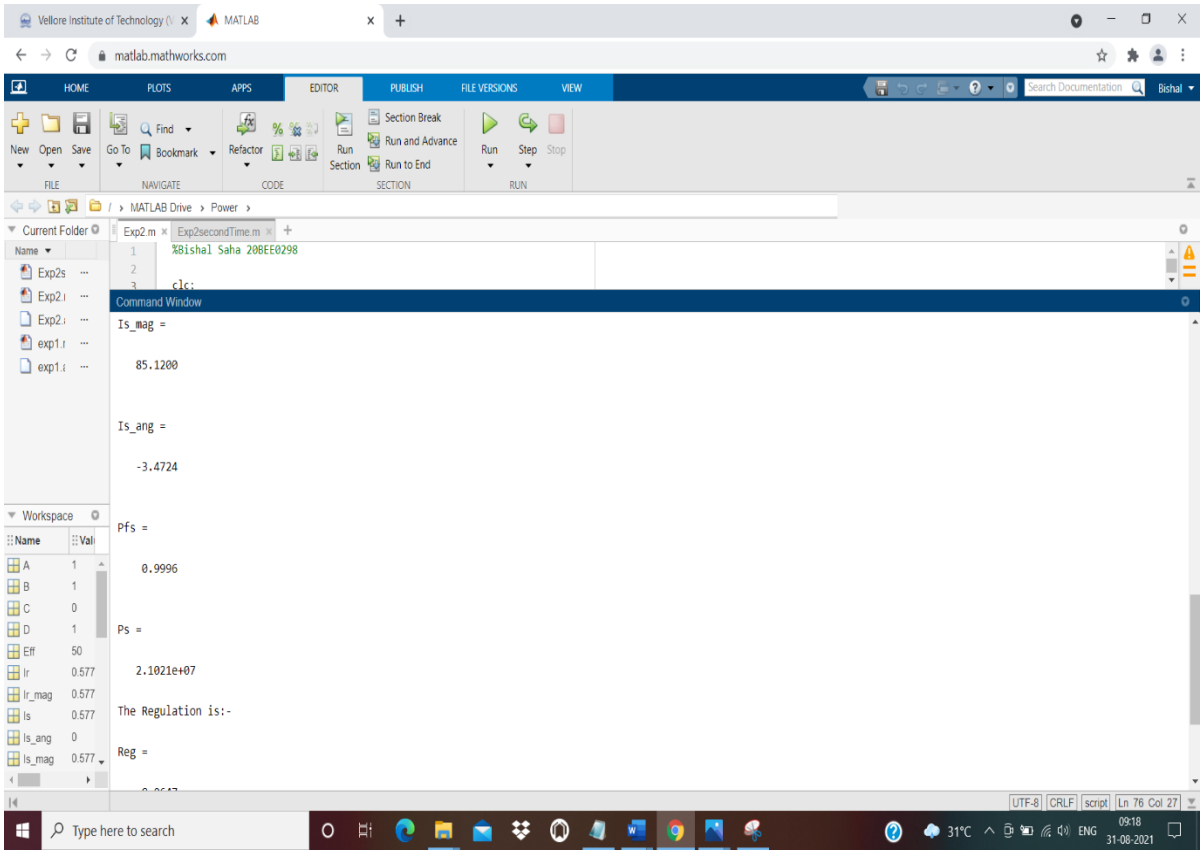
```
    C=sqrt(Y/Z)*sinh(sqrt(Z*Y));
    D=A;
    Vs=Vr*A+Ir*B;
    Is=Vr*C+Ir*D;
end

Vs_ph=abs(Vs)
Vs_ang_ph=rad2deg(angle(Vs))
Vs_l1=abs(Vs)*sqrt(3)
Vs_l1_ang=rad2deg(angle(Vs))+30

Is_mag=abs(Is)
Is_ang=rad2deg(angle(Is))

Pfs=cos(angle(Vs)+angle(Is))
Ps=sqrt(3)*Vs_l1*Is_mag*Pfs
disp("The Regulation is:- ")
Reg=(abs(Vs)-abs(Vr))*100/abs(Vr)
disp("The Efficienct is:- ")
Eff=Pr*100/Ps
```

## Program Output

### Nominal T

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CODE
SECTION
RUN
MATLAB Drive › Power ›
Current Folder
Exp2.m
Exp2secondTime.m
%Bishal Saha 20BEE0298
clc;
Command Window
Is_mag =
85.1200
Is_ang =
-3.4724
Pfs =
0.9996
Ps =
2.1021e+07
The Regulation is:-
Reg =
Workspace
Name
A 1
B 1
C 0
D 1
Eff 50
Ir 0.577
Ir_mag 0.577
Is 0.577
Is_ang 0
Is_mag 0.577
UTF-8
CRLF
script
Ln 76 Col 27
Type here to search
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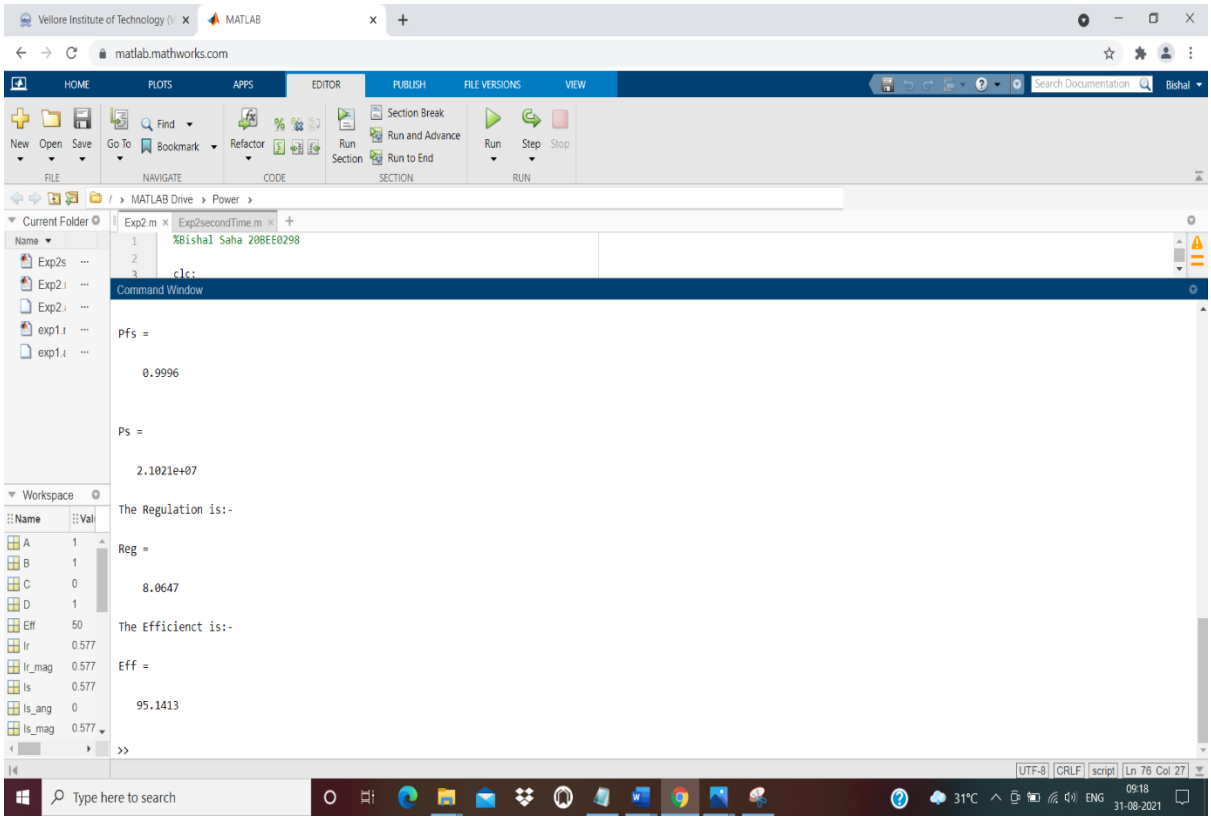
31-08-2021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Section Break
Run and Advance
Run to End
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Step
Stop
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CODE
SECTION
RUN
MATLAB Drive › Power ›
Current Folder
Exp2.m
Exp2secondTime.m
%Bishal Saha 20BEE0298
clc;
Command Window
Pfs =
0.9996
Ps =
2.1021e+07
The Regulation is:-
Reg =
8.0647
The Efficienct is:-
Eff =
95.1413
>>
Workspace
Name
A 1
B 1
C 0
D 1
Eff 50
Ir 0.577
Ir_mag 0.577
Is 0.577
Is_ang 0
Is_mag 0.577
UTF-8
CRLF
script
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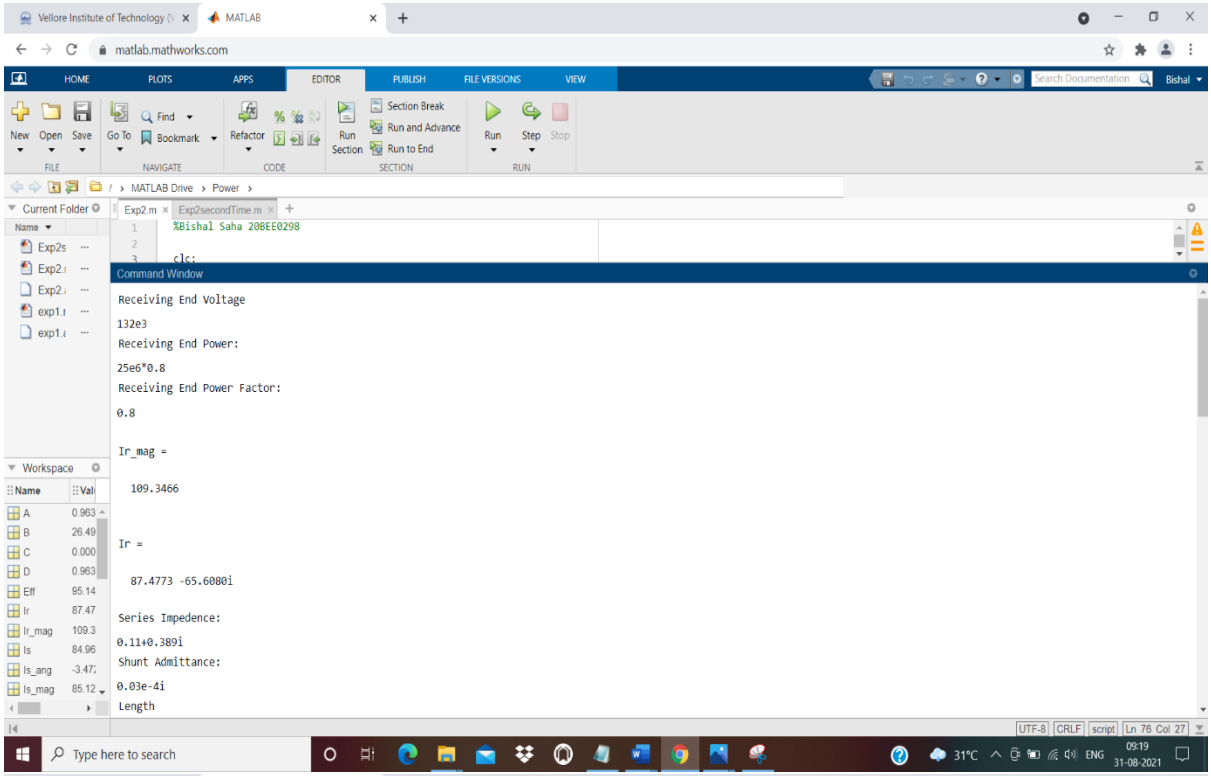
## Nominal Pi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Run Section
Section Break
Run and Advance
Run to End
Run
Step
Stop
FILE
NAVIGATE
CODE
SECTION
RUN
MATLAB Drive › Power
Current Folder
Exp2.m
Exp2secondTime.m
%Bishal Saha 20BEE0298
clc;
Command Window
Receiving End Voltage
132e3
Receiving End Power:
25e6*0.8
Receiving End Power Factor:
0.8
Ir_mag =
109.3466
Ir =
87.4773 -65.6080i
Series Impedence:
0.11+0.389i
Shunt Admittance:
0.03e-4i
Length
Workspace
Name
A 0.963
B 26.49
C 0.000
D 0.963
Eff 95.14
Ir 87.47
Ir_mag 109.3
Is 84.96
Is_ang -3.47
Is_mag 85.12
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script
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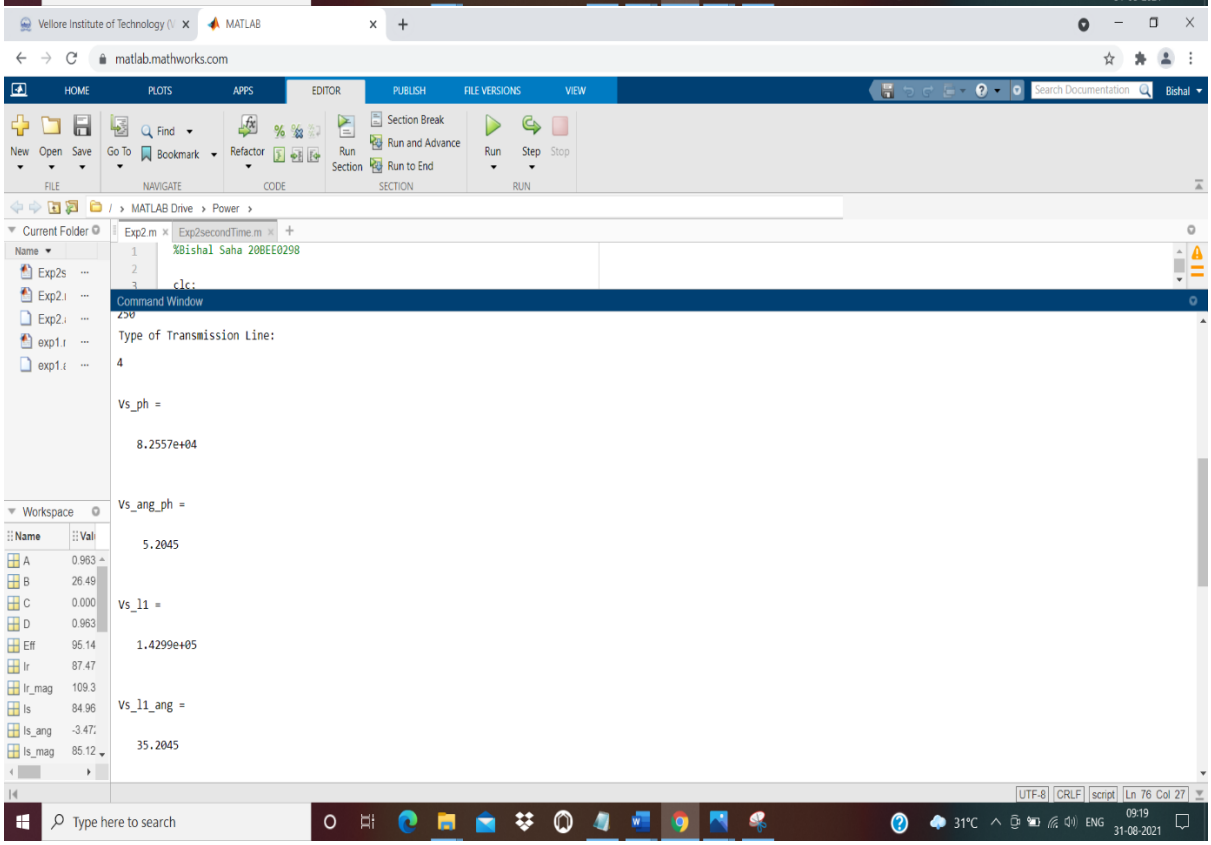
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Section Break
Run and Advance
Run to End
Run
Step
Stop
FILE
NAVIGATE
CODE
SECTION
RUN
MATLAB Drive › Power
Current Folder
Exp2.m
Exp2secondTime.m
%Bishal Saha 20BEE0298
clc;
Command Window
250
Type of Transmission Line:
4
Vs_ph =
8.2557e+04
Vs_ang_ph =
5.2045
Vs_l1 =
1.4299e+05
Vs_l1_ang =
35.2045
Workspace
Name
A 0.963
B 26.49
C 0.000
D 0.963
Eff 95.14
Ir 87.47
Ir_mag 109.3
Is 84.96
Is_ang -3.47
Is_mag 85.12
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script
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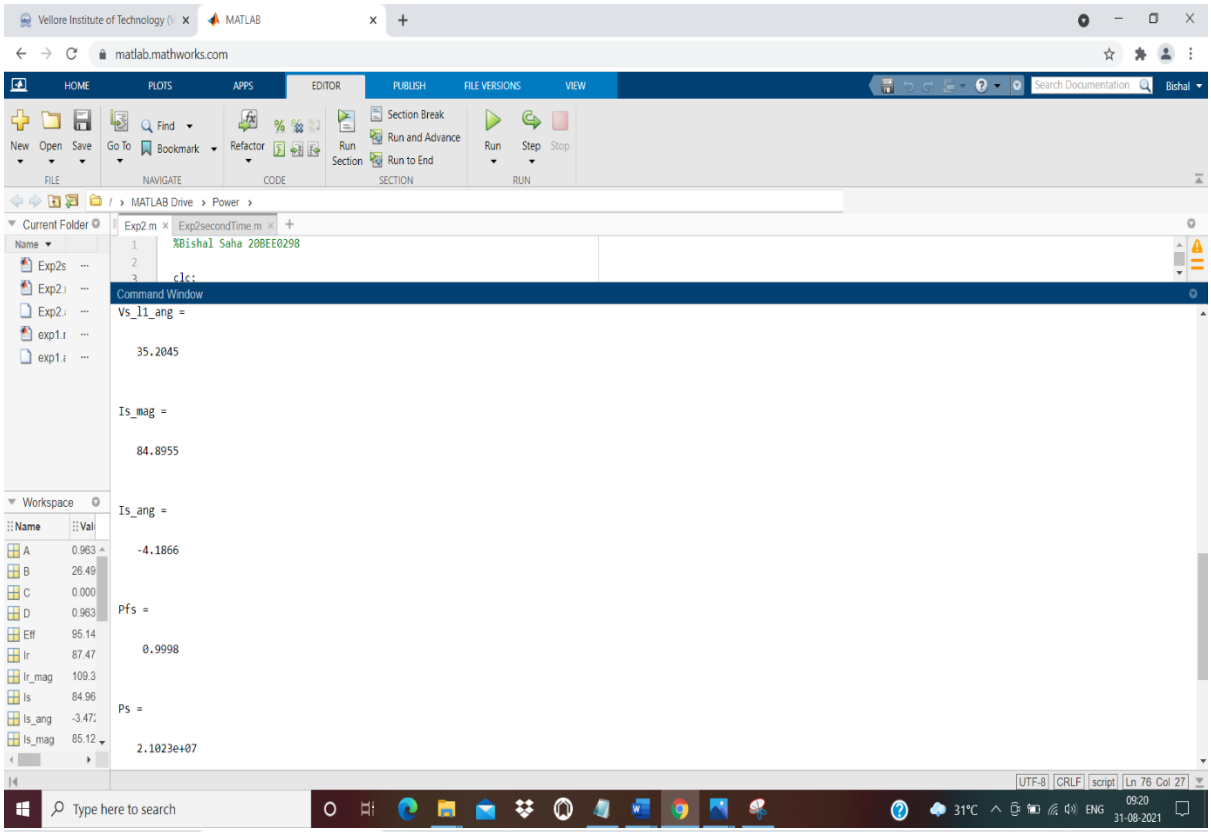
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CODE
SECTION
RUN
MATLAB Drive › Power ›
Current Folder
Exp2.m
Exp2secondTime.m
%Bishal Saha 20BEE0298
clc;
Command Window
Vs_ll_ang =
35.2045
Is_mag =
84.8955
Is_ang =
-4.1866
Pfs =
0.9998
Ps =
2.1023e+07
Workspace
Name
Val
A 0.963
B 26.49
C 0.000
D 0.963
Eff 95.14
Ir 87.47
Ir_mag 109.3
Is 84.96
Is_ang -3.47
Is_mag 85.12
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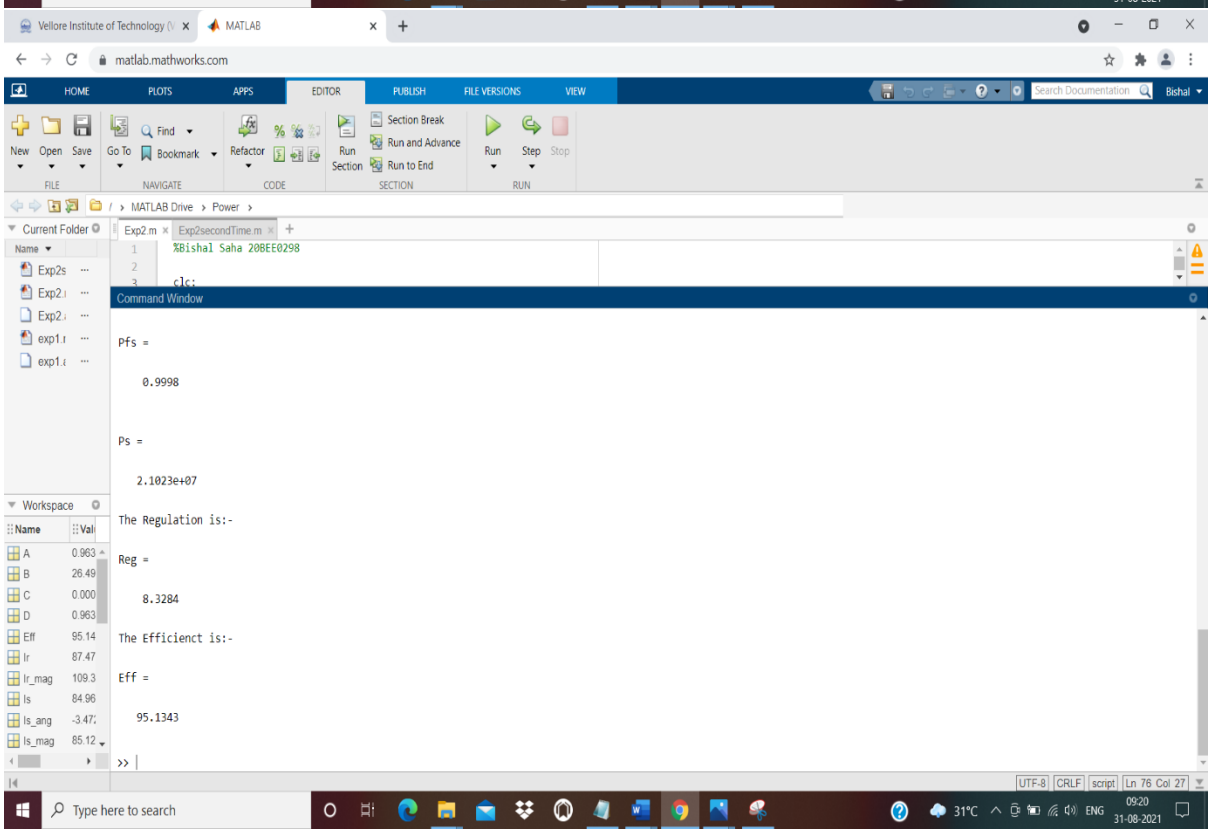
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Run to End
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FILE
NAVIGATE
CODE
SECTION
RUN
MATLAB Drive › Power ›
Current Folder
Exp2.m
Exp2secondTime.m
%Bishal Saha 20BEE0298
clc;
Command Window
Pfs =
0.9998
Ps =
2.1023e+07
The Regulation is:-
Reg =
8.3284
The Efficienct is:-
Eff =
95.1343
>>
Workspace
Name
Val
A 0.963
B 26.49
C 0.000
D 0.963
Eff 95.14
Ir 87.47
Ir_mag 109.3
Is 84.96
Is_ang -3.47
Is_mag 85.12
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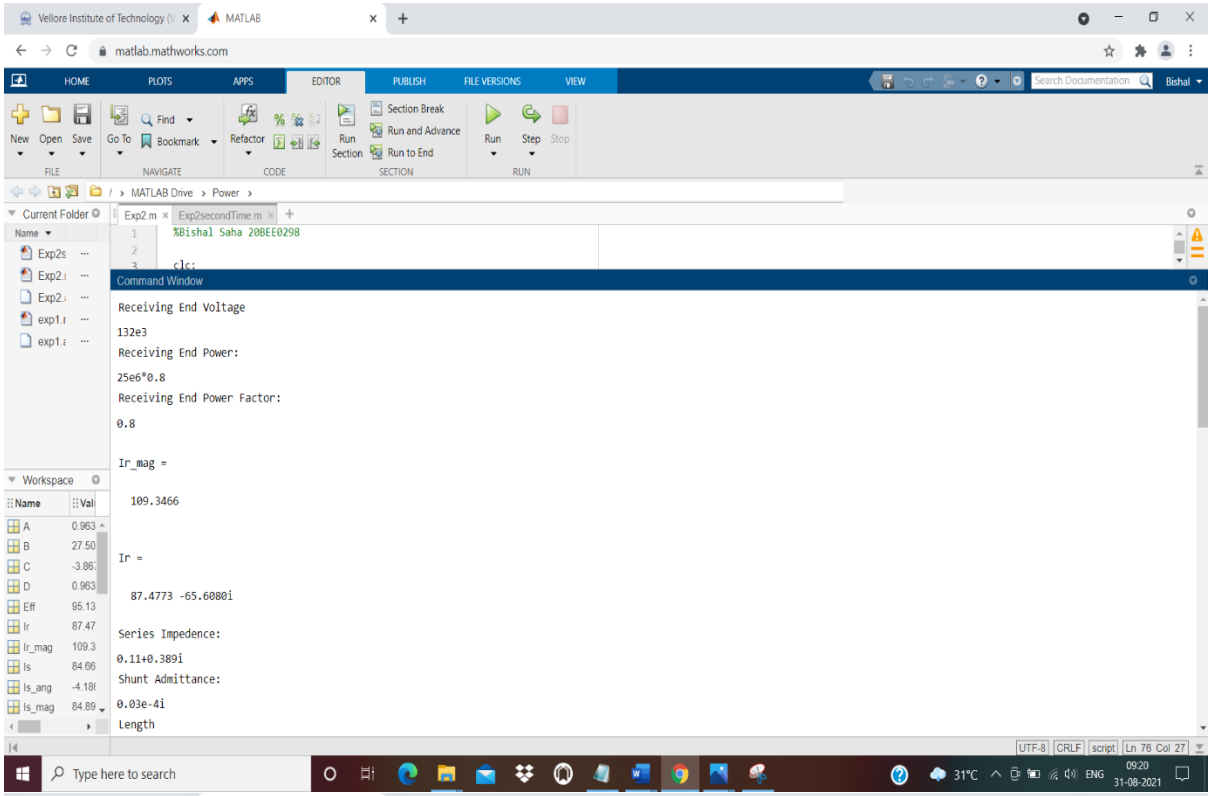
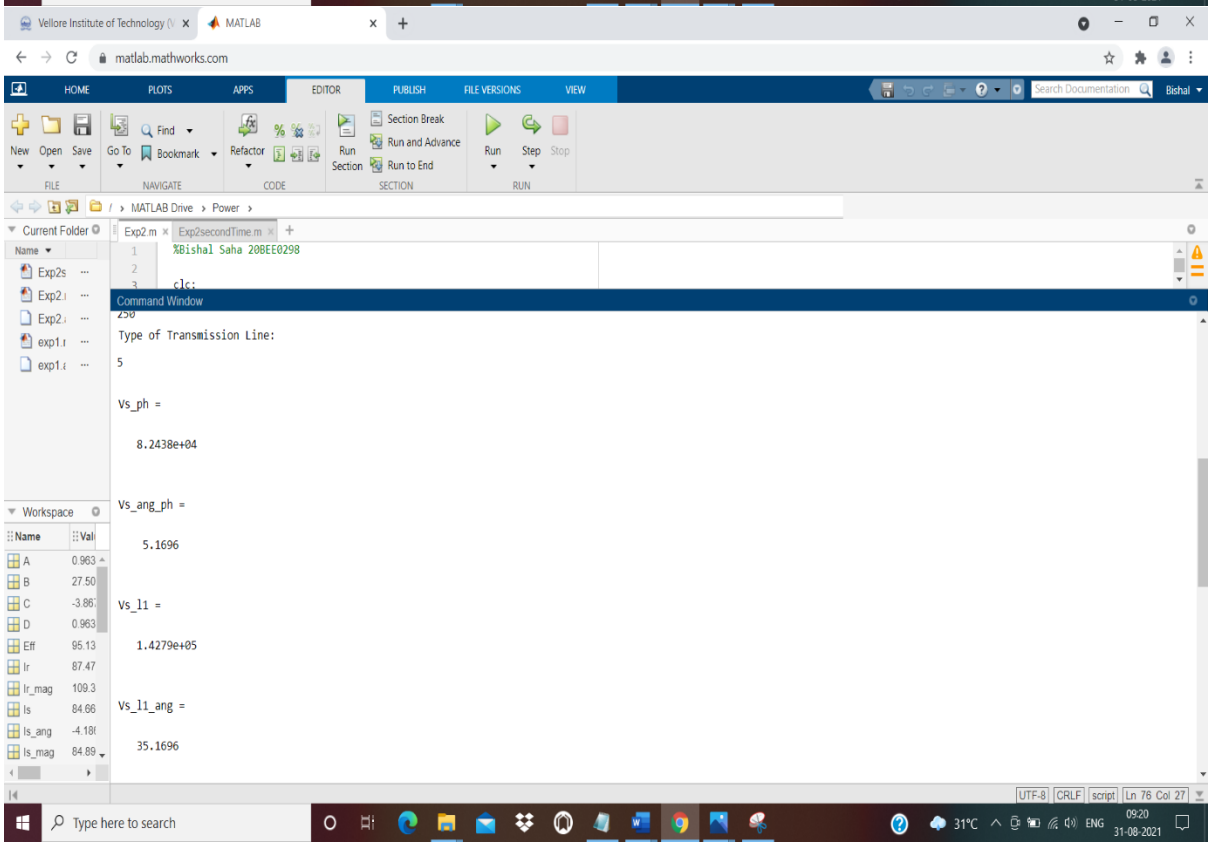
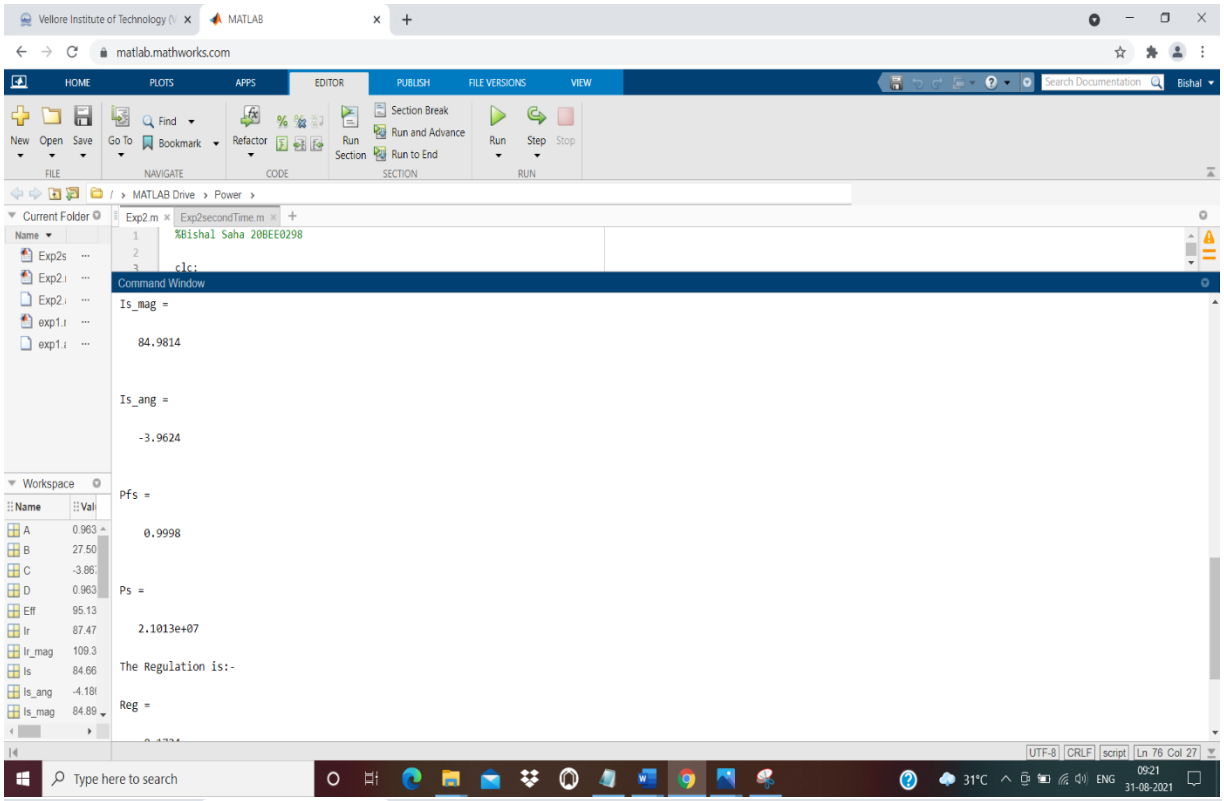
## Long Transmission Line

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Section Break
Run and Advance
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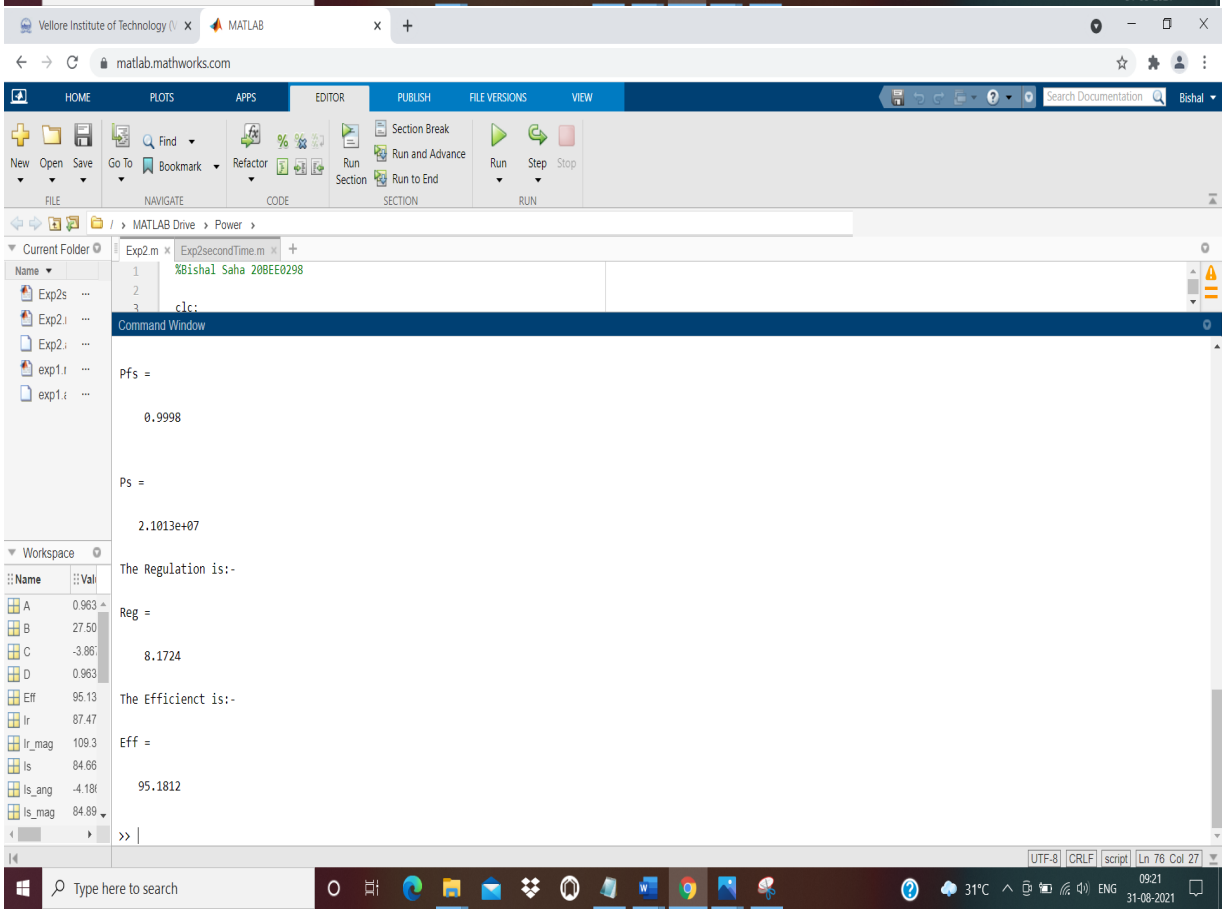
CODE
SECTION
RUN
MATLAB Drive › Power ›
Current Folder
Name
Exp2s
Exp2.
Exp2.
exp1.
exp1.
Exp2.m
Exp2secondTime.m
1 %Bishal Saha 20BEE0298
2
3 clc;
Command Window
Is_mag =
84.9814
Is_ang =
-3.9624
Pfs =
0.9998
Ps =
2.1013e+07
The Regulation is:-
Reg =
Workspace
Name
Val
A 0.963
B 27.50
C -3.86
D 0.963
Eff 95.13
Ir 87.47
Ir_mag 109.3
Is 84.66
Is_ang -4.18
Is_mag 84.89
UTF-8
CRLF
script
Ln 76 Col 27
Type here to search
31°C
ENG
09:21
31-08-2021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MATLAB Drive › Power ›
Current Folder
Name
Exp2s
Exp2.
Exp2.
exp1.
exp1.
Exp2.m
Exp2secondTime.m
1 %Bishal Saha 20BEE0298
2
3 clc;
Command Window
Pfs =
0.9998
Ps =
2.1013e+07
The Regulation is:-
Reg =
8.1724
The Efficienct is:-
Eff =
95.1812
>>
Workspace
Name
Val
A 0.963
B 27.50
C -3.86
D 0.963
Eff 95.13
Ir 87.47
Ir_mag 109.3
Is 84.66
Is_ang -4.18
Is_mag 84.89
UTF-8
CRLF
script
Ln 76 Col 27
Type here to search
31°C
ENG
09:21
31-08-2021

**Tabulation**

| Parameters | Manual Calculation | Matlab Result |
|---|---|---|
| Nominal T | % Regulation=8.06<br>%Efficiency=95.141 | % Regulation=8.064<br>%Efficiency=95.141 |
| Nominal Pi | % Regulation=8.32<br>%Efficiency=95.13 | % Regulation=8.32<br>%Efficiency=95.134 |
| Long Transmission | % Regulation=8.172<br>%Efficiency=95.181 | % Regulation=8.172<br>%Efficiency=95.181 |

**Result and Observation**

Hence with Proper calculation and after verifying the results from Matlab we came to know the %Regulation of different configuration is in the order Long TL > Nominal Pi >Nominal T.

Also the % Efficiency of different configuration is in the order of Long TL >Nominal T >Nominal pi.

Hence the result is verified using MATLAB also.