DRONACHARYA
Group of Institutions

POWER SYSTEM

LABORATORY MANUAL

B.Tech. 5 Semester

Subject Code: KEE-551

Session: 2023-24, Odd Semester

DRONACHARYA GROUP OF INSTITUTIONS
DEPARTMENT OF EEE
#27 KNOWLEDGE PARK 3

GREATER NOIDA

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List of Experiments mapped with COs

| S. No.	Name of the Experiment	Course Outcome
1	Determination of ABCD parameters of a 400 kV, 300 km transmission line	CO 1
2	To study and compare the performance of a ring and radial distribution systems	CO 1
3	Determination of power angle characteristics of a transmission line	CO 2
4	Improvement of voltage profile at a load bus using a shunt capacitor	CO 2
5	To verify the Ferranti effect in a transmission line	CO 3
6	Study of Surge Impedance Loading of a transmission Line	CO 2
7	To draw the P V characteristics of a transmission line	CO 4
8	To study the characteristics of a series compensated transmission line	CO 2
9	To study operation of oil testing set.	CO 4
10	To obtain formation of Y-bus and perform load flow analysis	CO 3

LAB EXPERIMENTS

Experiment 1

AIM Determination of ABCD parameters of a 400 kV, 300 km transmission line.

SIMULINK BLOCKS REQUIRED:

1. AC voltage source single phase-50 Hz, 326.598 kV peak
2. Series RL element (R=1.85 Ohms, L=0.0486735H)-6 Nos.
3. Capacitors (C=0.2996 μF)-12 Nos.
4. RMS block-3Nos.
5. Display block-3Nos.
6. Voltage and current measurement blocks
7. Powergui

Note: Line considered is a 400 kV, 300 km transmission line. Each pi section represents a length of 50 km. Six such pi sections are cascaded to represent a physical line length of 300 km.

CIRCUIT DIAGRAM:
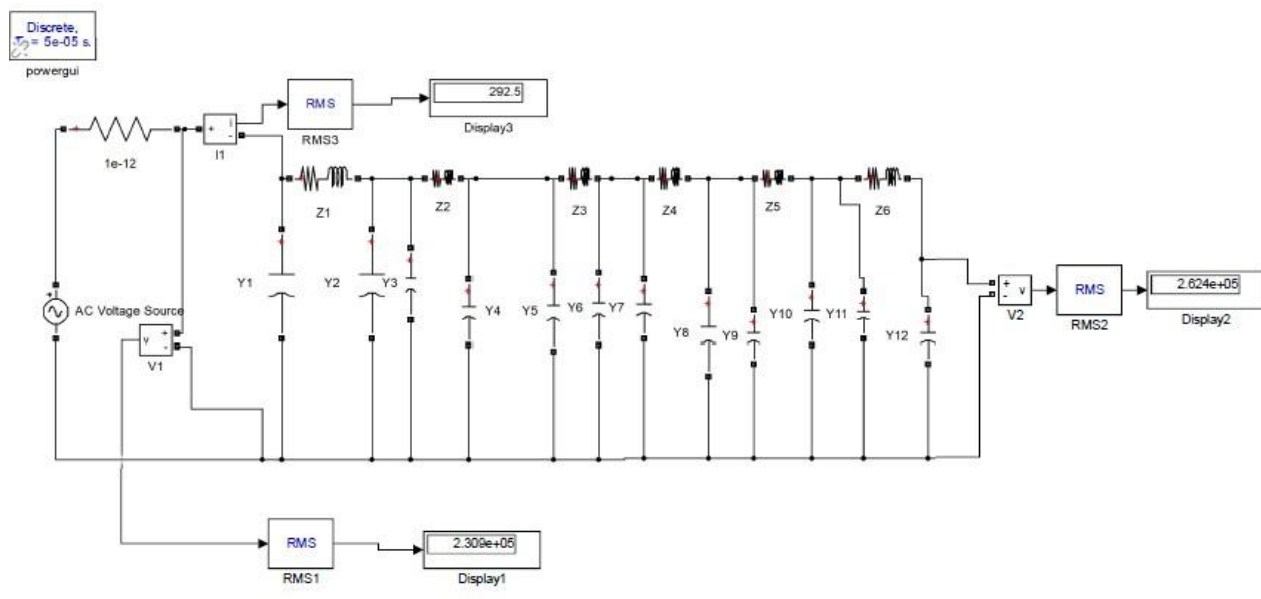
Fig.1 Open circuit
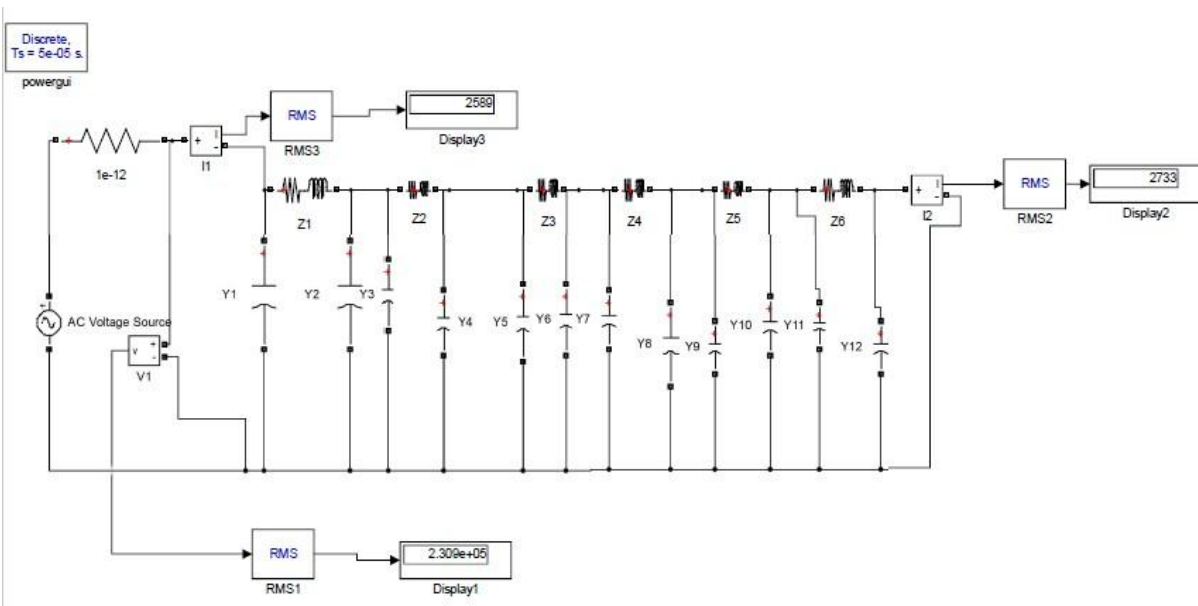
Fig.2 Short Circuit

PROCEDURE:
Short Circuit
1. In Simulink, build the circuit as shown in Fig1. Make sure that in the RMS block, the fundamental frequency is set to 50 HZ, initial RMS value is set to 0, and sampling time is same as that used in the 'powergui' block.
2. Run the simulation and measure the sending end current and voltage, and the receiving end voltage.

Open circuit:
1. In Simulink, build the circuit as shown in Fig1. Make sure that in the RMS block, the fundamental frequency is set to 50 HZ, initial RMS value is set to 0, and sampling time is same as that used in the 'powergui' block.
2. **Run the simulation and measure the sending and receiving end currents and the sending end current.**
3. Repeat same by interchanging the secondary end & receiving end.

OBSERVATION TABLE:

	SENDING END		RECEIVING END	
	V_s (V)	I_s (A)	V_s (V)	I_s (A)
OPEN				
SHORT				

CALCULATION

$$A = \frac{V_S}{V_R}\bigg|_{I_R=0} \qquad B = \frac{V_S}{I_R}\bigg|_{V_R=0} \qquad C = \frac{I_S}{V_R}\bigg|_{I_R=0} \qquad D = \frac{I_S}{I_R}\bigg|_{V_R=0}$$

**RESULT-** ABCD Parameters of transmission line has been calculated.

Experiment -2

AIM: To study and compare the performance of a ring and radial distributionsystems.

SIMULINK BLOCKS REQUIRED:

1. Single phase 325.27 V peak, 50 Hz AC power supply
2. RL element representing distribution lines (Z1=Z3=0.5+j0.26 Ohms, Z2=0.25+j0.13 Ohms)
3. R element representing loads (R=50 Ohms)
4. Voltage and Current measurement blocks
5. RMS block
6. Display block
7. Powergui

CIRCUIT DIAGRAM

Model of 500 m long feeder is divided into three sections of 200m, 100m, and 200m. Feeder is designed for a maximum load of 12A.
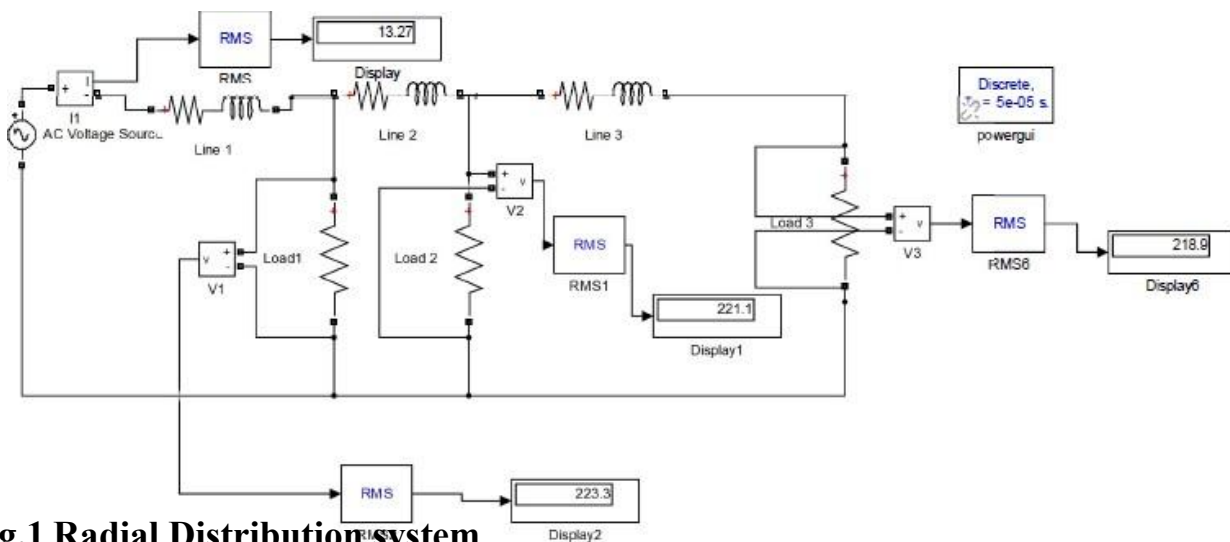
Fig.1 Radial Distribution system
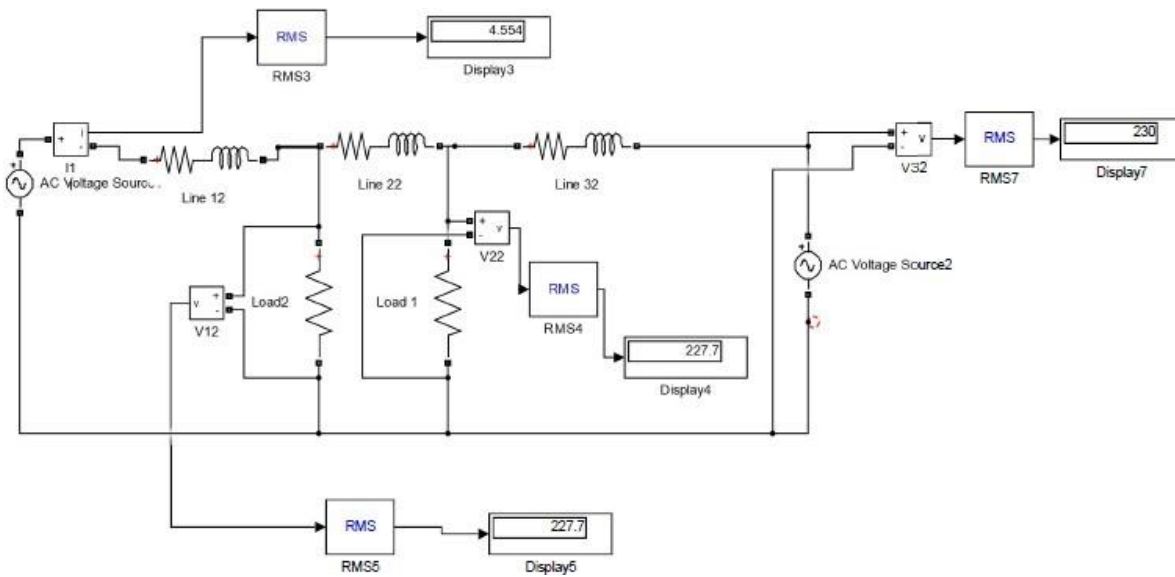
Fig. 2 Ring main distribution system

PROCEDURE:

Radial System

1. Build the SIMULINK model as shown in the figure 1.
2. Make sure that in the RMS block, the fundamental frequency is set to 50 HZ, initial RMS value is set to 0, and sampling time is same as that used in the 'powergui' block.
3. Run the simulation model. Note down the readings of the ammeter (input side) and the three voltages.

Ring Mains System

1. Build the SIMULINK model as shown in the figure 2.
2. Make sure that in the RMS block, the fundamental frequency is set to 50 HZ, initial RMS value is set to 0, and sampling time is same as that used in the 'powergui' block.
3. Run the simulation model. Note down the readings of the ammeter and the three voltages.

OBSERVATION TABLE:

For radial type AC distribution system:

S.No.	Vs (V)	Is (A)	Va (V)	% Voltage Drop	Vb (V)	% Voltage Drop	Vc (V)	% Voltage Drop

For ring type AC distribution system:

S.No.	Vs (V)	Is (A)	Va (V)	Vb (V)	% Voltage Drop

RESULT:

Experiment 3

AIM Determination of power angle characteristics of a transmission line.

SIMULINK BLOCKS REQUIRED

1. Series RL element (R=2.96 Ohms, L=77.8776 mH) representing a short transmission line of 400 kV, 80 km-1No.
2. Controlled voltage sources -2Nos.
3. Sine Wave function (Set 50 Hz, single phase, 326.598 kV peak rating)-2Nos.
4. Current and voltage measurement blocks
5. Power measurement blocks
6. Displays
7. RMS calculation block
8. Powergui

CIRCUIT DIAGRAM
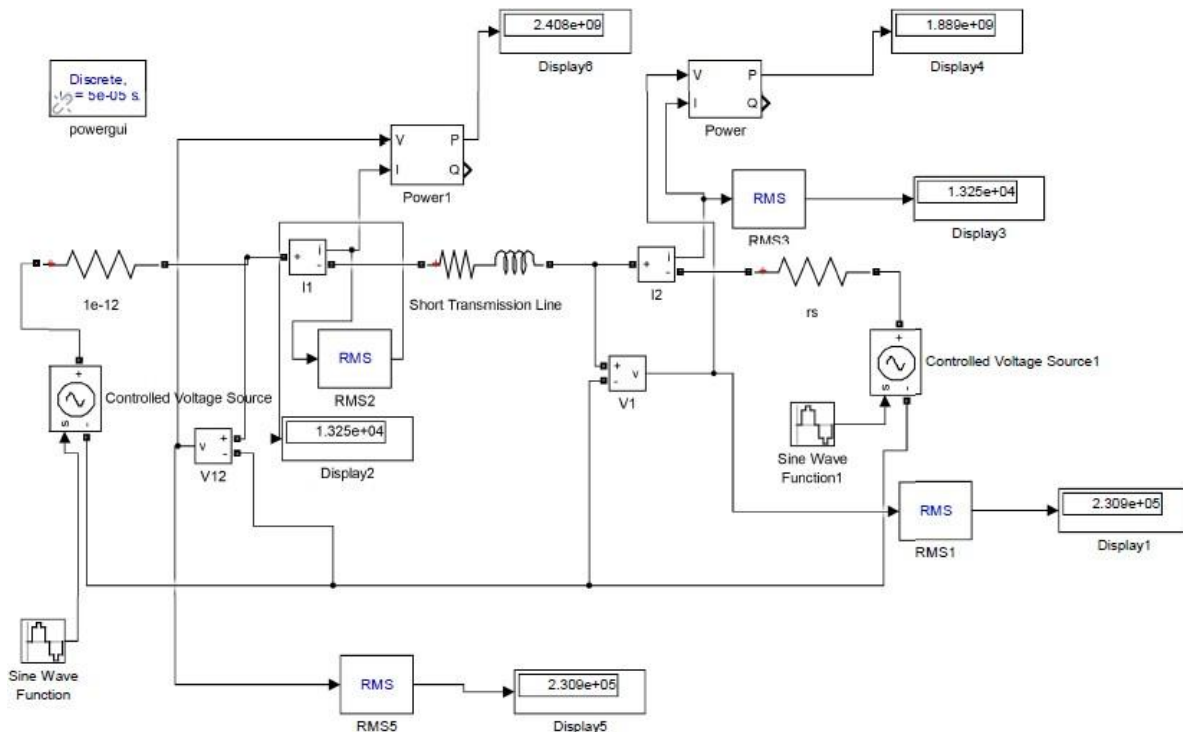
Fig: Circuit Diagram of Power Angle Characteristics

PROCEDURE:

1. Build the SIMULINK model according to the diagram.
2. Set the sending end (Vs) and receiving end (Vr) voltages at 326.598 kilovolts (constant) peak.
3. Now start varying the phase angle (δ) of the sending end voltage (Vs) (change in the sine wave function) in the steps of 10⁰ and note the readings of power blocks and current measurement blocks after running the model.
4. Vary the phase angle of the sending end voltage (change in the sine wave function) once in leading direction from 0-70⁰, and then in lagging direction for same range to see the change in direction of power flow from sending end to receiving end and vice versa.
5. Tabulate the reading & draw the power angle characteristic (P Vs   ).

OBSERVATION TABLE:

(i)   Sending end voltage (lagging) receiving end voltage

S.NO	δ (DEG.)	I_S	W_S
1.	0		
2.	10		
3.	20		
4.	30		
5.	40		
6.	50		
7.	60		
8.	70		

(ii) Sending end voltage (Leading) Receiving end Voltage

S.NO	δ (DEG.)	I_r	W_r
1.	0		
2.	10		
3.	20		
4.	30		
5.	40		

## RESULT:

Plotted the curve between power and Power Angle.

Experiment 4

AIM Improvement of voltage profile at a load bus using a shunt capacitor.

SIMULINK BLOCKS REQUIRED

1. AC voltage source, single phase, 50 Hz
2. Pi section transmission line (R=0.037 Ohms/km, L=0.97347 mH/km, C=11.984 nF/km, total length= 300 km, 6 sections of 50 km each, rated line to line voltage is 400 kV, per phase rating is 230.94 kV)
3. R element representing a load (R=114 Ohms)-1 No.
4. C element for a shunt capacitor- 1No. (C=22.223 μF)
5. Single phase breaker-1No
6. Breaker control block-1No
7. Voltage and current measurement blocks
8. RMS calculation blocks
9. Display block
10. Powergui block

CIRCUIT DIAGRAM
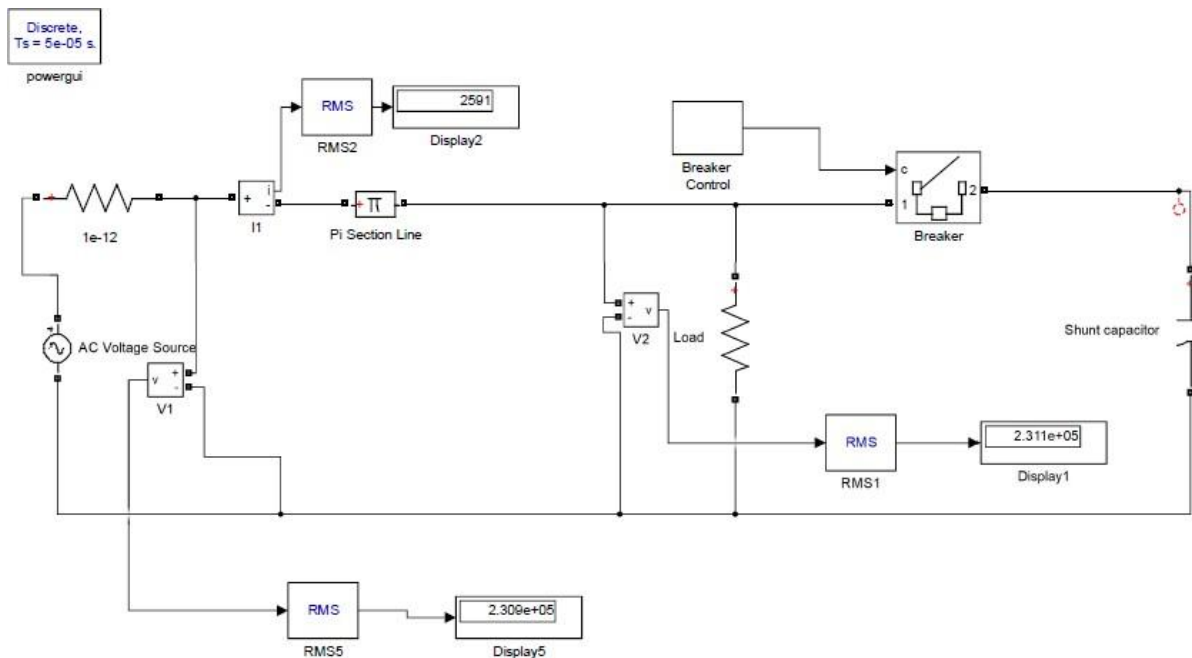
Fig. Circuit diagram

PROCEDURE

1. Build a SIMULINK model as shown in Circuit diagram.
2. Set the value of the ac voltage source to 326.598 kV peak & note down the input and output voltage. The load resistance is taken as 114 Ohms. Take the compensating shunt capacitor value to be 22.223 µF.
3. After about 4 seconds of simulation run time, the breaker will close contacts connecting the shunt capacitance.
4. Note down change in output voltage.
5. Repeat same for other value of voltages.
6. Calculate the Voltage regulation of line with Capacitor and without capacitor.

OBSERVATION TABLE:

S.No.	Vs	Without Capacitor		With Capacitor	
		I_L	V_R	I_L	V_R

RESULT

Voltage profile of transmission line with and without shunt capacitor has been plotted.

Experiment 5

AIM To verify the Ferranti effect in a transmission line.

SIMULINK BLOCKS REQUIRED-

1. AC Voltage source, single-phase, 50 Hz, 326.598 kV peak
2. Series RL element (R=1.85 Ohms, L=0.0486735H)-6 Nos.
3. Capacitors (C=0.2996 µF)-12 Nos.
4. Voltage measurement blocks
5. RMS Calculator block
6. Displays
7. Powergui

> Note: We have considered a 400 kV, 300 km transmission line. Each pi section represents a 50 km length. Six such pi sections are cascaded to represent a physical line length of 300 km.
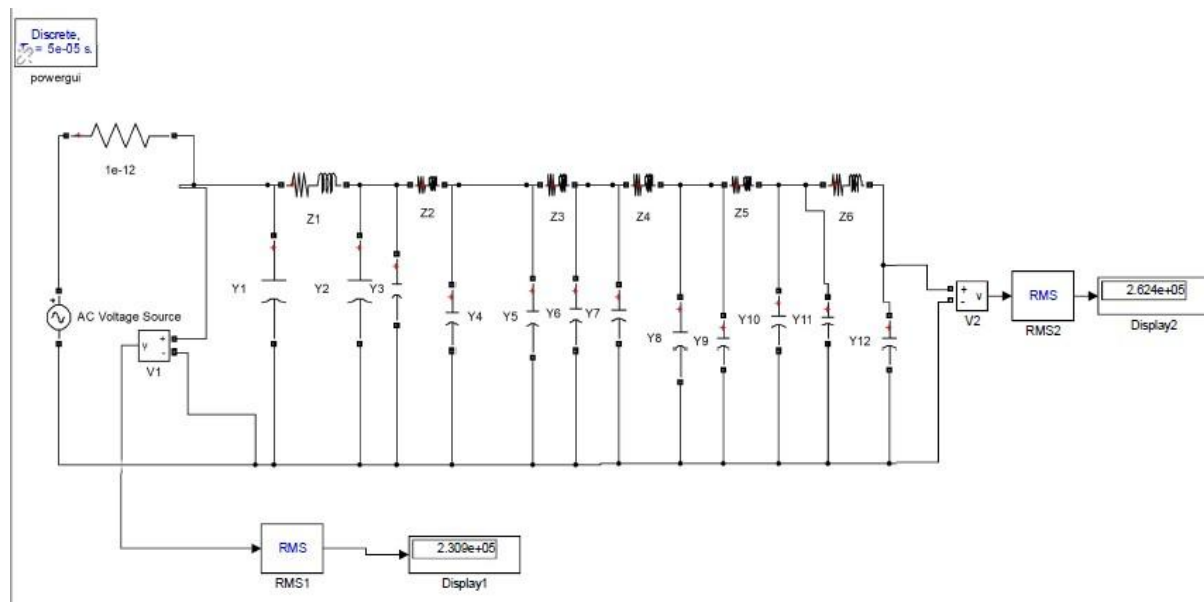
CIRCUIT DIAGRAM

Fig. Circuit diagram

PROCEDURE

1. Build a SIMULINK model as shown in the circuit diagram.
2. Set a voltage in the AC source.
3. Run the simulation and note down the input and output voltage.
4. Measure voltages at the end of different pi sections of the line (to represent voltages at different points in the line).
5. Draw the graph between V_R and distance.
6. Repeat same for other values of voltages.

OBSERVATION TABLE

S.NO.	STEP/DISTANCE	SENDING END VOLTAGE(V_S)	RECEIVING END VOLTAGE(V_R)
1.			
2.			
3.			

RESULT: Ferranti effect has been plotted and observed the graph between receiving end voltage and distance.

Experiment 6

**AIM** Study of Surge Impedance Loading of a transmission Line

SIMULINK BLOCKS REQUIRED

1. AC voltage source, 1 phase, 50 Hz, 326.598 kV peak
2. Current, power and voltage measurement blocks
3. RMS calculation blocks
4. Display units
5. Pi section transmission line (R=0.037 Ohms/km, L=0.97347 mH/km, C=0.11984 nF/km, total length=300 km, 6 sections of 50 km each, rated line to line voltage is 400 kV, per phase rating is 230.94 kV)
6. R element representing a purely resistive load
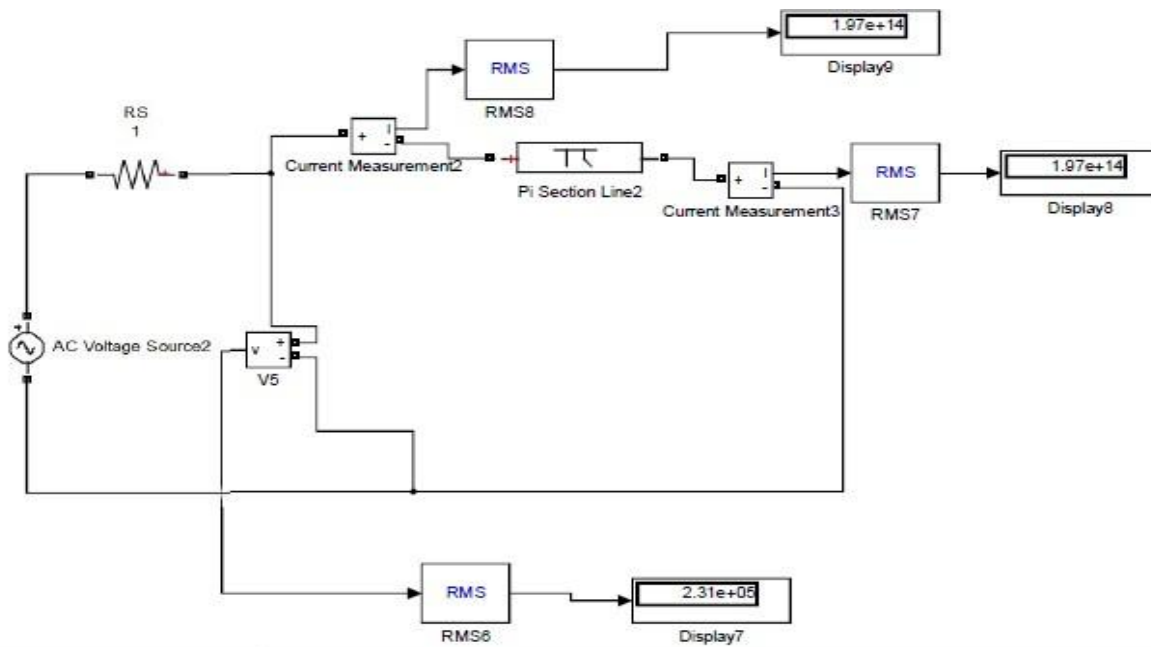7. Powergui block

CIRCUIT DIAGRAM
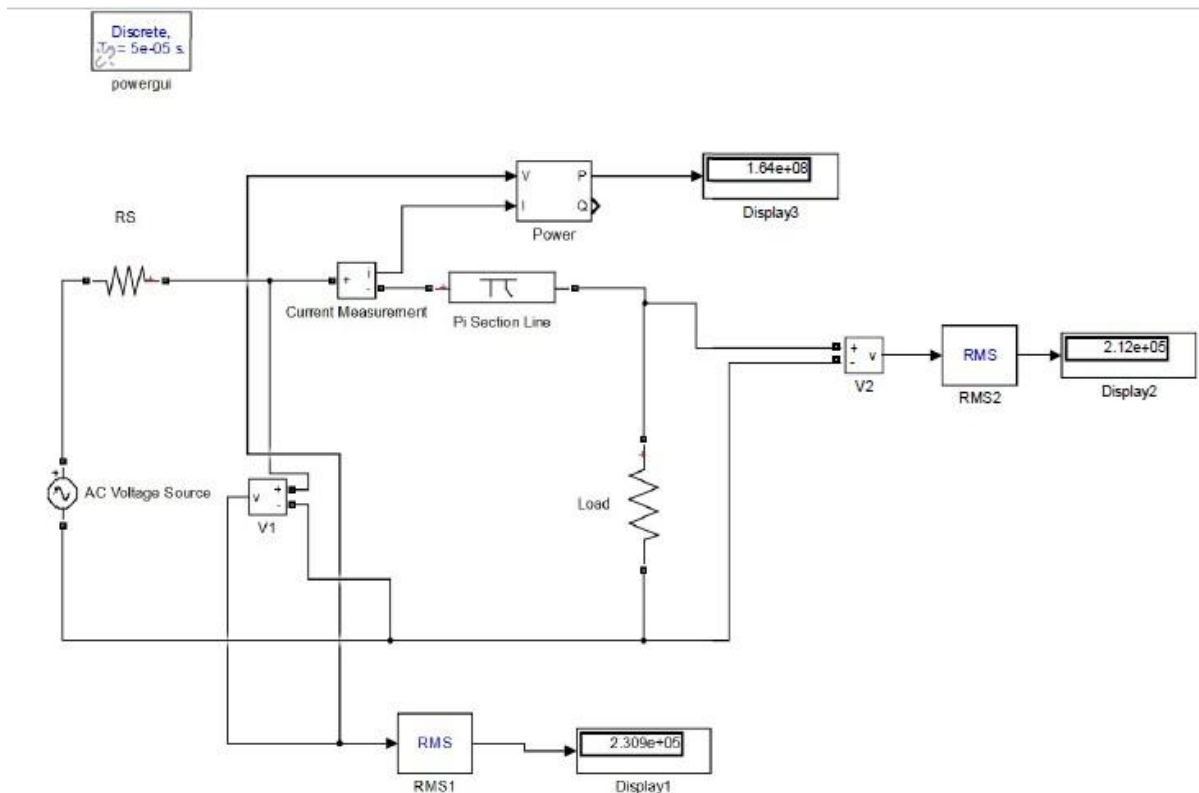
Fig.1 Finding the surge impedance loading
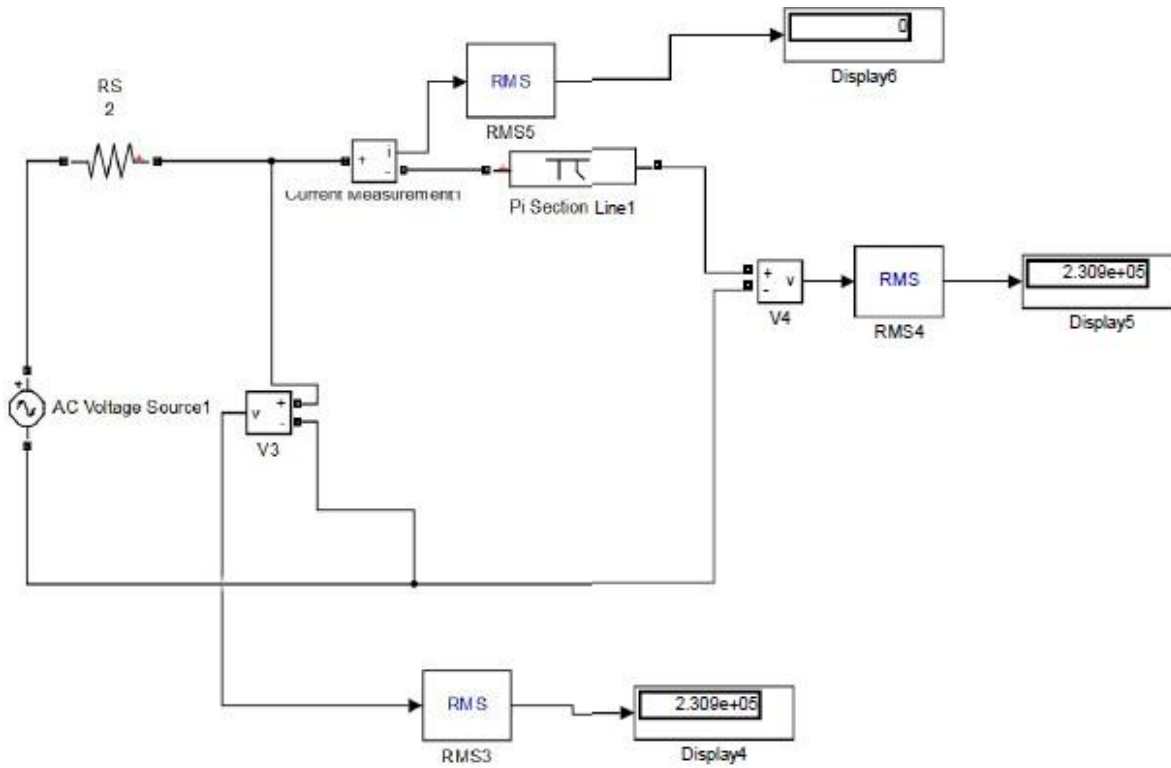
Fig.2 Open circuit measurements

Fig.3 Short circuit measurements

PROCEDURE

1. Build the SIMULINK model as shown in Fig.1.
2. Set the voltage of sending end (in the AC voltage source) to required level, i.e., 326.598 kV peak.
3. Run the simulation by applying load. In different simulation runs, keep on changing the load in suitable steps until the KW of the sending end increases to a certain limit, remains constant and then decreases.
4. Note down the value of maximum KW rating or loading. This value gives the SIL of the line.
5. Remove the load.
6. Build the SIMULINK model given in Fig.2. Note the receiving end is open circuited using a voltage measurement block. To find SIL, run the simulation and note down sending end voltage (   ) and current (   ).
7. Build the SIMULINK model given in Fig.3. Note the receiving end is short circuited using a current measurement block. Run the simulation and note down sending end voltage (   ) and current (   ).
8. Find impedance in open circuit and short circuit condition.

CALCULATION

$Zoc = Voc/Ioc$; $Zsc = Vsc/Isc$

Find core or natural impedance, Zc or $Zn = \sqrt{ZocZsc}$

Surge impedance loading, $P = V^2/Z_c$ in kW

OBSERVATION TABLE-

S.No	V_S	V_R	LOAD POWER

	SENDING END		RECEIVING END	
	V_s (V)	I_s (A)	V_s (V)	I_s (A)
OPEN				
SHORT				

RESLULT:

Surge impedance of line =

Surge impedance loading of line =

Experiment 7

AIM To draw the P V characteristics of a transmission line.

SIMULINK BLOCKS REQUIRED

1. AC voltage source, 1 phase, 50 Hz, 326.598 kV peak
2. Current, power and voltage measurement blocks
3. RMS calculation blocks
4. Display units
5. Pi section transmission line (R=0.037 Ohms/km, L=0.97347 mH/km, C=0.11984 nF/km, total length=300 kms, 6 sections of 50 km each, rated line to line voltage is 400 kV, per phase rating is 230.94 kV)
6. R element representing a purely resistive load
7. Powergui block
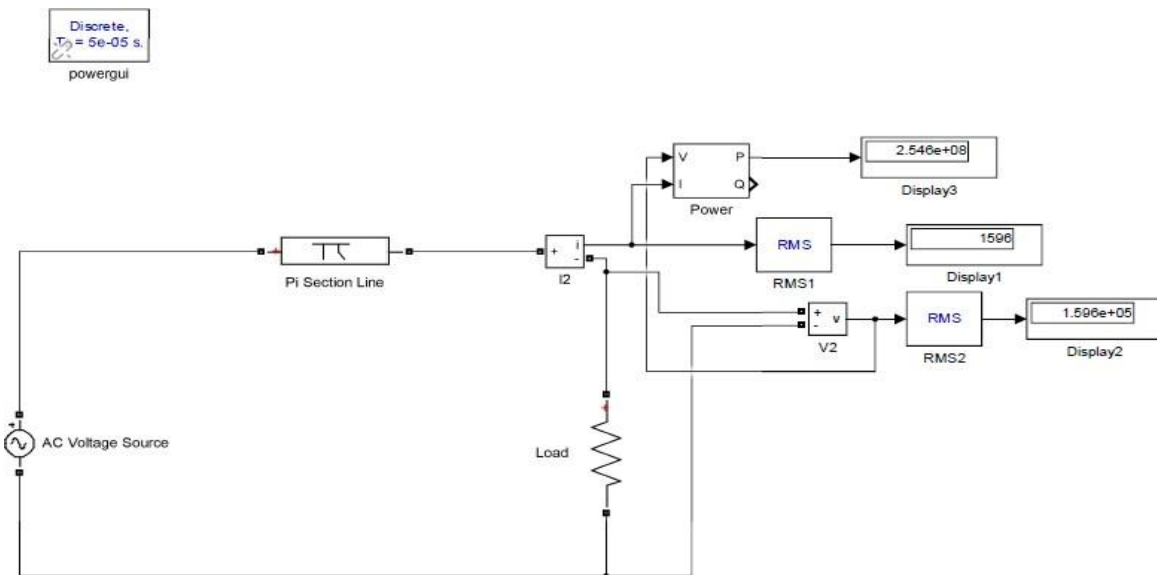
CIRCUIT DIAGRAM

Fig. Circuit connection

PROCEDURE

1. Build a SIMULINK model as per Circuit diagram.
2. Set the load resistance to 100 Ohms.
3. Adjust the input voltage to 326.598 kV peak and run the simulation.
4. Note the readings in table.
5. Now decrease the load resistance and note the readings.
6. Continue taking readings by decreasing resistance till you get the critical point and voltage drops beyond critical value.
7. Plot graph between power and voltage.

OBSERVATION TABLE

S.NO	POWER (P)	LOAD(V_L)	CURRENT(I)
1.			
2.			
3.			
4.			
5.			

**RESULT:** Power angle characteristics of a transmission line is plotted.

Experiment 8

AIM To study the characteristics of a series compensated transmission line.

SIMULINK BLOCKS REQUIRED-

1. AC voltage source, 1 phase, 50 Hz, 326.598 kV peak
2. Current, power and voltage measurement blocks
3. RMS calculation blocks
4. Display units
5. Pi section transmission line (R=0.037 Ohms/km, L=0.97347 mH/km, C=0.11984 nF/km, total length=300 kms, 6 sections of 50 km each, rated line to line voltage is 400 kV, per phase rating is 230.94 kV)
6. R element representing a purely resistive load
7. C element representing the series capacitor
8. Powergui block

CIRCUIT DIAGRAM
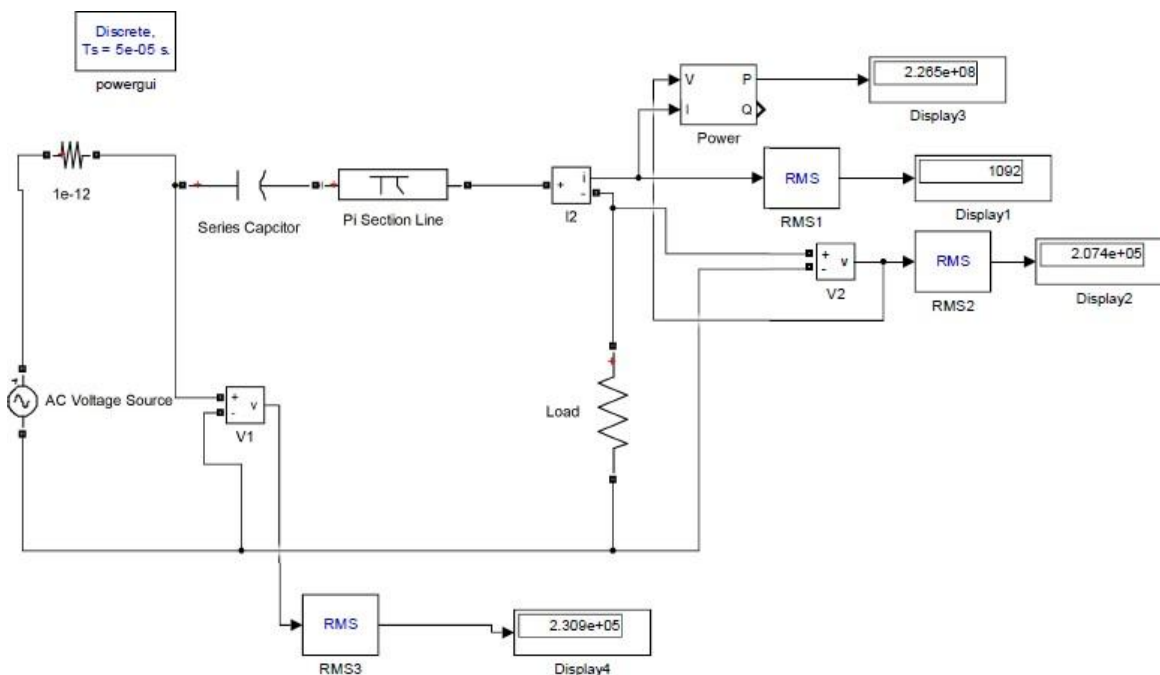
Fig. Circuit diagram

PROCEDURE-

1. Build a SIMULINK model as shown in Circuit diagram.
2. Set the load resistance to 190 Ohms.
3. Run the simulation without connecting a series capacitor. Note down the power, current, and voltages.
4. Connect a series capacitor so as to provide approximately 10 % compensation, simulate and note down the readings.
5. Increase the degree of compensation in steps of 10 %, simulate and tabulate the results for each scenario. Go up to 50 % compensation.
6. Calculate voltage increase at receiving end.
7. Plot graph Compensation vs voltage, power.

OBSERVATION TABLE

S.NO	LOAD	V_S	I	V_R	P
1.	NO CAPACITOR				
2.	C1				
3.	C2				
4.	C3				

RESULT: Plot of power transferred with various levels of compensation is plotted.

EXPERIMENT NO. 9

AIM: To study operation of oil testing set.

APPARATUS USED: Oil Testing Set

THEORY: When a sample of oil is subjected to dielectric stress in a gap between two spheres the materials of higher conductivity and higher spheres capacity are drawn into the intense field between the spheres and causes a distortion of the field resulting in local high density and disruption begins at these points. When testing transformer oil it is found often that one or more discharge occur across the gap at comparatively low voltages due to the presence of water particles but that the voltage can be raised to a very much higher value before complete rupture occurs. If particles of higher dielectric constant than the oil are drawn into the intense field, they will cause excessive local stress which may result in dissociation or ionization of oil and the gases of ionization may bridge the gap and causes complete rupture. In standard specifications for 'Insulating Oil' the method of applying the testing voltage (which must be alternating or approximately sine waveform of frequency between 25 and 100 Hz and with a peak factor of $\sqrt{2}$ +5% has been laid down. The test has to be carried out under standard conditions. The minimum dimensions of the test cell, diameter of the electrode and the distance between them are specified.

PROCEDURE: When testing oils the set is operated according to a particular method (in compliance with the regulations) i.e. with a fixed spark gap and variable testing voltage. The voltage should be increased gradually under continues observation of the measuring until the breakdown occurs. To test oils of high quality the distance between electrodes should be adjusted to 2 mm. The equipment permit 310 KV/cm to be measured. For testing oils of medium quality or inferior quality the spark gap should be adjusted to 4 mm by means of a distance gauge. The insulating material oil testing cup is equipped normally with two calotte-shaped electrodes of 36 mm dia, radius of each sphere is 25 mm. The oil testing cup is kept as small as possible to do with minimum quantity of oil. Suitable safety contacts are provided to put the set out of operation as soon as the top lid is opened in order to insert or remove the test cup, thus eliminating HT danger.

The set is disconnected automatically as soon as the puncture occurs. No oil tests are possible as long as the lid of the rear of the cabinet is open.

CIRCUIT DIAGRAM:
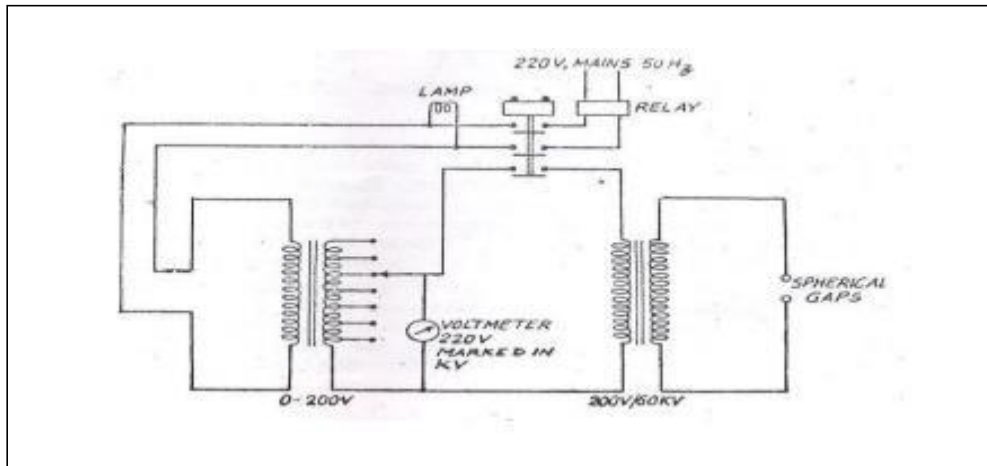
RESULT:

Distance between electrodes =_____Breakdown voltage = _____

EXPERIMENT NO. 10

AIM: To obtain formation of Y-bus and perform load flow analysis

```
%   From To  R   X
z = [0   1   0   1.0
     0   2   0   0.8
     1   2   0   0.4
     1   3   0   0.2
     2   3   0   0.2
     3   4   0   0.08];
Y = ybus(z)                    % bus admittance matrix
Ibus = [-j*1.1; -j*1.25; 0; 0]; % vector of injected bus currents
Zbus = inv(Y)                  % bus impedance matrix
Vbus = Zbus*Ibus
```

This lab manual has been updated by

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Crosschecked By
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Please spare some time to provide your valuable feedback.