

SCHEME :K

Name : _____
Roll No.: _____ Year : 20 __20
Exam Seat No. : _____

LABORATORY MANUAL FOR POWER SYSTEM ANALYSIS (316331)



ELECTRICAL ENGINEERING GROUP



**MAHARASHTRA STATE BOARD OF
TECHNICAL EDUCATION, MUMBAI**
(Autonomous)(ISO21001:2018)(ISO/IEC27001:2013)

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To ensure that the Diploma Level Technical Education constantly matches the latest requirements of Technology and industry and includes the all-round personal development of students including social concerns and to become globally competitive, technology led organization.

MISSION:

To provide high quality technical and managerial manpower, information and consultancy services to the industry and community to enable the industry and community to face the challenging technological & environmental challenges.

QUALITY POLICY:

We, at MSBTE are committed to offer the best in class academic services to the students and institutes to enhance the delight of industry and society. This will be achieved through continual improvement in management practices adopted in the process of curriculum design, development, implementation, evaluation and monitoring system along with adequate faculty development programs.

CORE VALUES:**MSBTE believes in the following:**

- Education industry produces live products.
- Market requirements do not wait for curriculum changes.
- Question paper is the reflector of academic standards of education organization.
- Well designed curriculum needs effective implementation too.
- Competency based curriculum is the backbone of need based program.
- Technical skills do need support of life skills.
- Best teachers are the national assets.
- Effective teaching learning process is impossible without learning resources.

A Laboratory Manual

For

POWER SYSTEM ANALYSIS

(316331)

SEMESER - VI

“K-SCHEME”

(EE/EP)



Maharashtra State

Board of Technical Education, Mumbai.

(Autonomous) (ISO: 21001:2018) (ISO/IEC 27001:2013)



**Maharashtra State Board of Technical Education, Mumbai
(Autonomous) (ISO21001:2018) (ISO/IEC 27001:2013)
4th Floor, Government Polytechnic Building, 49, Kherwadi,
Bandra (East), Mumbai – 400051,**



**Maharashtra State
Board of Technical Education, Mumbai.**

Certificate

This is to certify that Mr. / Ms.

Roll No....., of Sixth semester of Diploma in
..... of
Institute.....

..... (Code :.....) has completed the term work
satisfactorily in course **Power System Analysis (316331)** for the academic year
20..... to 20..... as prescribed in the curriculum.

Place:

Enrollment No:

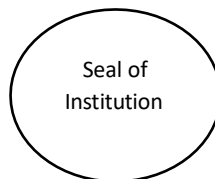
Date:

Exam. Seat No:

Course teacher

Head of the Department

Principal



PREFACE

The primary focus of any engineering laboratory or field work in the technical education system is to develop the industry-relevant competencies and skills essential for emerging professionals. With this objective, MSBTE introduced the innovative ‘K’ Scheme curriculum for engineering diploma programs, emphasizing outcome-based education. Accordingly, substantial time is dedicated to practical and analytical activities. This highlights the crucial importance of laboratory work, making it imperative for every teacher, instructor, and student to understand that each minute spent in the laboratory must be utilized meaningfully to develop the intended outcomes, rather than engaging in routine, non-productive activities.

In alignment with this philosophy, the laboratory exercises in **Power System Analysis** have been carefully designed to act as a vehicle for achieving industry-identified competencies. Power systems form the backbone of electrical engineering, and the analytical skills required to study load flow, system stability, fault analysis, and network modeling cannot be cultivated through traditional lecture-based teaching alone. These essential skills demand hands-on practice supported by simulation tools, software applications, and structured analytical procedures.

This laboratory manual is prepared to assist all stakeholders—students, teachers, and instructors—to achieve the predefined outcomes effectively. Students are expected to thoroughly review the relevant practical one day in advance, understand the associated theoretical concepts, and come prepared for meaningful laboratory engagement. Each practical in this manual begins by identifying the competency, industry-relevant skills, course outcomes, and practical outcomes. This approach enables students to clearly understand the purpose of each activity and the skills they will acquire through systematic procedures, observations, and analysis. The insights gained will help them solve real-world power system challenges as practicing engineers.

The manual also provides guidelines for teachers and instructors to facilitate student-centered learning by arranging and managing the required resources, ensuring that each practical is performed methodically. This will help students master the analytical tools and techniques essential for modern power system planning, operation, and control.

Power System Analysis plays a vital role in developing professional expertise in electrical diploma engineers. Today’s power networks require skilled engineers capable of modeling complex systems, interpreting electrical parameters, analyzing system behavior under various conditions, and ensuring stable and reliable operation. This subject equips students with the ability to perform load flow studies, short-circuit analysis, stability assessments, and per-unit calculations using both manual and software-based methods. Through practical exercises and simulations, students learn to interpret results, identify critical issues, and propose appropriate corrective measures—skills that are indispensable in utility operations, consultancy, power generation, and transmission companies.

Despite our earnest efforts to ensure accuracy and completeness, certain errors may have inadvertently remained, as this is the first edition of the manual. Constructive suggestions for improvement are welcomed and will be sincerely appreciated.

Programme Outcome (POs) to be achieved through Practical

PO 1. Basic & Discipline specific knowledge: Apply knowledge of basic mathematics, sciences and engineering fundamentals and engineering specialization to solve the engineering problems.

PO 2. Problem Analysis: Identify and analyze well defined engineering problems using codified standard methods.

PO 3. Design /Development Solutions: Design solutions for well-defined technical problems and assist with the design of systems components or processes to meet specified needs.

PO 4. Engineering tools experimentation and testing: Apply modern engineering tools and appropriate technique to conduct standard tests and measurements.

PO 5. Engineering practices for society sustainability and environment: Apply appropriate technology in context of society, sustainability, environment and ethical practices.

PO 6. Project Management: Use engineering management principles individually, as a team member or a leader to manage projects and effectively communicate about well-defined engineering activities.

PO 7. Lifelong learning: Ability to analyze individual needs and engage in updating in context of technological changes.

List of Relevant expected psychomotor domain Skills

This Lab manual intends to develop the expected psychomotor domain skills of students. The skills mentioned below will be developed through the experiments performed in this Laboratory.

1. Ability to draw correct power system network diagrams and prepare per-unit system data.
2. Ability to model transmission lines, transformers, and generators for analysis using appropriate parameters.
3. Ability to perform load flow analysis using manual methods and software tools.
4. Ability to conduct short-circuit and fault analysis to determine system currents and voltages under faulted conditions.
5. Ability to record, tabulate, interpret, and analyze system behavior for stability, voltage regulation, and network performance.

Guidelines to teachers

1. Teacher should provide the guideline with demonstration of each practical to the students along with all features involved.
2. Teacher shall explain the relevant prior concepts before starting each practical to ensure conceptual clarity.
3. Involvement of students during the execution of every practical is essential for better understanding.
4. Teacher should ensure that the intended skills and competencies are actually developed in students after completing the practical exercise.
5. Teachers should give students opportunities for hands-on practice after the demonstration to build confidence.
6. It is expected that the teacher explains the skills and competencies to be developed before starting the practical.
7. Additional industry-relevant knowledge and skills may be provided even if they are not explicitly mentioned in the manual.
8. Finally, a practical assignment should be given, and student performance should be assessed to verify whether the outcome matches the instructions given.

Instructions to Students

1. Organize your work in groups effectively and maintain records of all performed tasks and programs.
2. Students shall strive to develop maintenance-related skills as expected by industries.
3. Attempt to develop relevant hands-on skills during the practical sessions to gain technical confidence.
4. Cultivate the habit of generating new ideas, innovations, and related skills that extend beyond the scope of the manual.
5. Refer to technical magazines and literature to stay updated with current advancements in the field.
6. Submit your practical work on or before the scheduled date and time without fail.
7. Be well-prepared and thorough when submitting the write-up of any exercise.
8. Attach or paste extra sheets wherever required to explain diagrams, calculations, or observations clearly.

Practical Course Outcome matrix**Course Outcomes (COs)**

- CO1 - Calculate Inductance and Capacitance for different types of transmission lines.
- CO2 - Use generalized circuit theory principles for calculations of transmission line performance
- CO3 - Estimate the power at sending and receiving ends of transmission line.
- CO4 - Analyze the performance of transmission lines graphically.
- CO5 – Interpret the data required for Load flow studies.

Pr. No.	Title of the Practical	Mapped Course Outcome				
		CO 01	CO 02	CO 03	CO 04	CO 05
01	*Identification of type of conductors and calculate Self GMD.	√	--	--	--	--
02	*Inductance and capacitance for 3 \emptyset transmission line with symmetrical and unsymmetrical spacing.	√	--	--	--	--
03	Inductance and capacitance for 1 \emptyset transmission line without ground effect and with ground effect.	√	--	--	--	--
04	*GCC of given n model of transmission line. by using OC SC test.	--	√	--	--	--
05	GCC of given T model of transmission line by using OC SC test.	--	√	--	--	--
06	*GCC of given π (PI) model of transmission line by using software.	--	√	--	--	--
07	GCC of given T model of transmission line by using software.	--	√	--	--	--
08	π (PI) model Transmission line Efficiency and regulation by Load test.	--	--	√	--	--
09	*T model Transmission line Efficiency and regulation by Load test.	--	--	√	--	--
10	Transmission line Receiving end complex power evaluation by using software.	--	--	√	--	--
11	Transmission line Sending end complex power evaluation by using software.	--	--	√	--	--
12	*Transmission line Receiving end or Sending end complex power evaluation by graphical method.	--	--	--	√	--
13	*Development of Ybus matrix by using software- case 1.	--	--	--	--	√

14	Development of Ybus matrix by using software- case 2.	--	--	--	--	√
15	Determination of effect on SLFE during the maintenance outages for given power system using relevant software.	--	--	--	--	√

Content page**List of Practical's and Formative Assessment sheet.**

Pr. No	Title of the Practical	Page No.	Date of performance	Date of Submission	Assessment marks	Dated sign of teacher	Remarks (if any)
01	*Identification of type of conductors and calculate Self GMD.	1					
02	*Inductance and capacitance for 3 \emptyset transmission line with symmetrical and unsymmetrical spacing.	5					
03	Inductance and capacitance for 1 \emptyset transmission line without ground effect and with ground effect.	10					
04	*GCC of given n model of transmission line. by using OC SC test.	14					
05	GCC of given T model of transmission line by using OC SC test.	22					
06	*GCC of given π (PI) model of transmission line by using software.	28					
07	GCC of given T model of transmission line by using software.	35					
08	π (PI) model Transmission line Efficiency and regulation by Load test.	42					
09	*T model Transmission line Efficiency and regulation by Load test.	48					
10	Transmission line Receiving end complex power evaluation by using software.	55					
11	Transmission line Sending end complex power evaluation by using software.	62					

Pr. No	Title of the Practical	Page No.	Date of performance	Date of Submission	Assessment marks	Dated sign of teacher	Remarks (if any)
12	*Transmission line Receiving end or Sending end complex power evaluation by graphical method.	69					
13	*Development of Ybus matrix by using software- case 1.	77					
14	Development of Ybus matrix by using software- case 2.	84					
15	Determination of effect on SLFE during the maintenance outages for given power system using relevant software.	92					
Total marks :							
<p>Note : Out of above suggestive LLOs</p> <ul style="list-style-type: none"> • '*' Marked Practicals (LLOs) Are mandatory. • Minimum 80% of above list of lab experiment are to be performed. • Judicial mix of LLOs are to be performed to achieve desired outcomes. 							

Practical No.1: Identification of type of Conductors and Calculation of Self GMD

I. Practical Significance-

To understand conductor types and calculate self GMD, which is important for transmission line design.

II. Industry or Employer Expected Outcome-

Students will be able to identify conductors and compute self GMD

III. Course Level Learning Outcome-

CO1: Calculate Inductance and Capacitance for different types of transmission lines.

IV. Laboratory Learning Outcome-

LLO 1.1: Identify type of conductor from sample.

LLO 1.2: Calculate Self GMD.

V. Relevant Affective domain related Outcome

Develops observation skills and accuracy in measurements.

VI. Relevant Theoretical Background

The conductor is the primary component of any transmission line that carries electric current from the source to the load.

Types of Conductors in Transmission Line-

- All Aluminum Conductor (AAC)
- Aluminium Conductor Steel Reinforced (ACSR)
- All Aluminum Alloy Conductor (AAAC)
- Aluminum Conductor Aluminum Alloy Reinforced (ACAR)

Properties of Conductor-

- **Electrical Conductivity:** Copper has the highest conductivity of 96% IACS but is also very expensive. Aluminum has a conductivity of 61% IACS and is widely used due to its cost-effectiveness.
- **Tensile Strength:** Steel-reinforced conductors like ACSR have higher tensile strength to withstand mechanical loads due to the steel core.
- **Weight:** Aluminum weighs nearly 3 times less than copper making it preferable for longer spans.
- **Resistance:** The larger cross-sectional area of aluminum compensates for its lower conductivity in comparison to the copper wire of the same resistance.
- **Corrosion Resistance:** Aluminum forms a protective oxide layer over time whereas copper corrodes easily.

Conductors used in transmission include ACSR, AAAC, AAC, and Copper. Self Geometric Mean Distance (GMD) = $0.7788 \times r$, where r is radius. The self-GMD for the types of stranded conductors used in transmission is calculated differently based on the arrangement of their individual strands. The self-GMD for a stranded conductor depends on the size and shape of the overall conductor,

which changes based on the number and size of the individual strands and layer. GMD is the average of all the distances between the conductors of different phases.

VII. Actual Diagram with equipment specification

Conductor sample with labeled diameter and radius.



VIII. Resources required

Sr. No.	Particulars	Specification	Quantity	Remark
1	Sample Conductor	ACSR / AAAC / AAC	1	
2	Vernier Caliper	0.01 cm accuracy	1	

IX. Precautions to be followed

Handle measuring instruments carefully, avoid parallax error.

X. Procedure

1. Identify conductor sample.
2. Measure diameter with Vernier Caliper.
3. Calculate radius.
4. Compute $GMD = 0.7788 \times r$.
5. Record observations.

XI. Observation Table

Conductor Type	Diameter (cm)	Radius (cm)	Self GMD (cm)

XVI. References/ suggestions for further Reading

Sr.No.	Link	Description
1	Electrical Power Systems	C.L. Wadhwa
2	https://archive.nptel.ac.in/courses/117/105/117105140/	NPTEL Lecture series on power system Analysis

XVII. Suggested Assessment Scheme

Performance Indicators		Weightage (%)
Process related: 15 Marks		60%
1	Identification of basic construction material	30%
2	Recording of Observations	30%
Product related: 10 Marks		40%
1	Interpretation of result	10%
2	Answer to practical related questions.	20%
3	Submission of report in time	10%
Total : 25 Marks		100%

Marks Obtained			Dated Sign of Teacher
Process Related (15)	Product Related (10)	Total (25)	

Practical No.2: Inductance and capacitance for 3 ϕ transmission line with symmetrical and unsymmetrical spacing.

I. Practical Significance-

To calculate and compare the inductance and capacitance per km of a 3-phase transmission line having:

- i) Symmetrical spacing between conductors.
- ii) Unsymmetrical spacing between conductors with regular transposition.

II. Industry or Employer Expected Outcome-

Students will be able to evaluate inductance and capacitance of 3- ϕ lines.

III. Course Level Learning Outcome-

CO1: Calculate Inductance and Capacitance for different types of transmission lines.

IV. Laboratory Learning Outcome-

LLO 2.1: Evaluate inductance for 3- ϕ line.

LLO 2.2: Evaluate capacitance for 3- ϕ line.

V. Relevant Affective domain related Outcome

Enhances analytical skills for line design.

VI. Relevant Theoretical Background

The inductance per phase of a 3-phase transmission line depends on the conductor radius (r) and the geometric mean distance (GMD) between conductors, while the capacitance per phase depends on conductor radius (r) and the geometric mean distance (GMD) between the line and the earth, and also the relative height of the conductors from the ground. Inductance and capacitance are usually calculated for one phase to neutral and then expressed as per unit length, often with formulas like

$$L=2 \times 10^{-7} \ln \frac{GMD}{r_0} \text{ H/m and}$$

$$C = \left(\frac{2\pi \epsilon_0}{\ln} \right) * (H/r) \text{ F/m,}$$

where H is the effective height from the ground.

• Inductance

Formula:

The inductance per phase (L) is calculated using the formula $L=2 \times 10^{-7} \ln \frac{GMD}{r_0}$

- GMD is the geometric mean distance between conductors.
- r_0 is the effective radius of the conductors, typically 0.7788 times the actual conductor radius (r).

Factors affecting inductance:

- The inductance of a transmission line is affected by the conductor size, the spacing between conductors, and the physical arrangement of the conductors.

- **Capacitance**

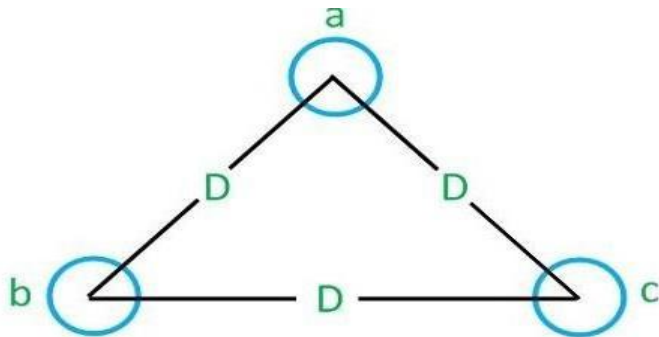
Formula: The capacitance per phase to neutral (C) is given by $C = \left(\frac{2\pi\epsilon_0}{\ln}\right) * (H/r)$ Farads per meter.

- ϵ_0 is the permittivity of free space.
- H is the effective height of the conductors from the ground.
- r is the radius of the conductors.

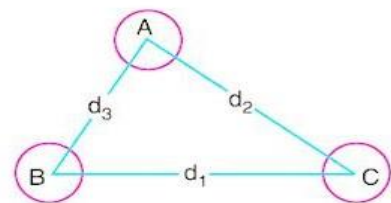
Factors affecting capacitance:

- The capacitance of a transmission line is influenced by the conductor radius and the distance of the conductors from the ground.

VII. Actual Diagram with equipment specification



Symmetrical 3 Phase Line



Unsymmetrical 3 Phase Line

Practical Scenario / Background:

In a 132 kV three-phase overhead transmission system, three conductors are supported on transmission towers. Due to mechanical and structural limitations, the spacing between conductors is not always equal. During a transmission line design study, the layout of one section of the line is found to have the following conductor arrangement (measured between centers of conductors):

- Between conductor **A** and **B**: 2.0 m
- Between conductor **B** and **C**: 2.5 m
- Between conductor **C** and **A**: 4.5 m

Each conductor used is aluminium with a diameter of 1.24 cm.

VIII. Resources Required

Sr. No.	Apparatus	Quantity
1	Calculator / Simulation tool (MATLAB / Manual Calculation)	1
2	Chart showing conductor arrangement	1
3	Measuring instruments / data sheet	1

IX. Procedure

1. Based on the given practical Scenario / Background calculate.
2. Measure or note the distances between each pair of conductors.
3. Calculate the geometric mean distance (GMD) using the formula.
4. Calculate geometric mean radius (GMR) of each conductor.
5. Substitute values into the inductance equation to find L per km per phase.
6. For comparison, assume a symmetrical spacing (say, all conductors 3 m apart) and compute the inductance again.
7. Record both results in the observation table.

X. Observation Table

For Symmetrical

Sr.No	Distance between the conductor (D)			Radius of conductor (r)	Geometric Mean Radius (G _s)	Geometric Mean Distance (G _m)	Inductance per km per phase	Capacitance per km per phase
	A-B	B-C	C-A					
1								
2								

For Unsymmetrical

Sr.No	Distance between the conductor (D)			Radius of conductor (r)	Geometric Mean Radius (G _s)	Geometric Mean Distance (G _m)	Inductance per km per phase	Capacitance per km per phase
	A-B	B-C	C-A					
1								
2								

XI. Result

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XII. Interpretation of results

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XV. References/ suggestions for further Reading

Sr.No.	Link	Description
1	Principle of Power Systems	V.K. Meheta
2	https://archive.nptel.ac.in/content/storage2/courses/108104051/chapter_1/1_6.html	NPTEL course on Power System Analysis

XVI. Suggested Assessment Scheme

Performance Indicators		Weightage (%)
Process related: 15 Marks		60%
1	Identification of basic construction material	30%
2	Recording of Observations	30%
Product related: 10 Marks		40%
1	Interpretation of result	10%
2	Answer to practical related questions.	20%
3	Submission of report in time	10%
Total : 25 Marks		100%

Marks Obtained			Dated Sign of Teacher
Process Related (15)	Product Related (10)	Total (25)	

Practical No.3: Inductance and Capacitance for 1- Φ Transmission Line (With and Without Ground Effect)

I. Practical Significance-

To calculate and compare the inductance and capacitance per km of a single-phase transmission line without and with ground effect.

II. Industry or Employer Expected Outcome-

Students will be able to evaluate the inductance and capacitance of 1- Φ lines and understand the influence of ground effect.

III. Course Level Learning Outcome-

CO1: Calculate Inductance and Capacitance for different types of transmission lines.

IV. Laboratory Learning Outcome-

LLO 3.1: Evaluate inductance of 1- Φ line without and with ground effect.

LLO 3.2: Evaluate capacitance of 1- Φ line without and with ground effect.

V. Relevant Theoretical Background

The inductance and capacitance of a single-phase transmission line depend on the conductor radius (r), the spacing between conductors (D), and the height of conductors above ground (h). In case of ground effect, the image method is used to account for the effect of earth on the electric field distribution.

Formulas

Without Ground Effect:

$$\text{Inductance: } L = \left(\frac{\mu_0}{2\pi} \right) \ln \left(\frac{D}{r} \right) \text{ H/m}$$

$$\text{Capacitance: } C = \left(\frac{2\pi\epsilon_0}{\ln\left(\frac{D}{r}\right)} \right) \text{ F/m}$$

With Ground Effect (using Image Method):

$$\text{Inductance: } L = \left(\frac{\mu_0}{2\pi} \right) \ln \left(\frac{2h}{r} \right) \text{ H/m}$$

$$\text{Capacitance: } C = \left(\frac{2\pi\epsilon_0}{\ln\left(\frac{2h}{r}\right)} \right) \text{ F/m}$$

VI. Resources Required

Apparatus	Quantity
Calculator / Simulation tool (MATLAB / Manual Calculation)	1
Chart showing conductor arrangement	1
Measuring instruments / data sheet	1

VII. Procedure

1. Note the dimensions of the transmission line – distance between conductors (D), height above ground (h), and conductor radius (r).
2. Calculate inductance and capacitance without considering ground effect using given formulas.
3. Repeat the procedure by considering the ground effect using image method formulas.
4. Record the calculated values in the observation table.
5. Compare and interpret the results.

VIII. Observation Table

Sr.No	Distance (D) m	Height (h) m	Radius (r) m	Inductance per km	Capacitance per km
1					
2					
3					
4					

IX. Result

.....

X. Interpretation of results

.....

.....

XIV.References/ suggestions for further Reading

Sr.No.	Link	Description
1	Principle of Power Systems	by V.K. Meheta
2	https://archive.nptel.ac.in/content/storage2/courses/108104051/chapter_1/1_5.html	NPTEL course on Power System Analysis
3	https://archive.nptel.ac.in/content/storage2/courses/108104051/chapter_1/1_13.html	NPTEL course on Power System Analysis

X. Suggested Assessment Scheme

Performance Indicators		Weightage (%)
Process related: 15 Marks		60%
1	Identification of basic construction material	30%
2	Recording of Observations	30%
Product related: 10 Marks		40%
1	Interpretation of result	10%
2	Answer to practical related questions.	20%
3	Submission of report in time	10%
Total : 25 Marks		100%

Marks Obtained			Dated Sign of Teacher
Process Related (15)	Product Related (10)	Total (25)	

Practical No. 4: GCC of given π (PI) model of transmission line by using OC SC test.

I. Practical Significance-

In the power industry, we cannot always test a real, hundreds-of-kilometers-long transmission line. Engineers use scaled-down models (like the Nominal- π model) to predict the behavior of real lines. Determining the ABCD parameters (or GCC) of these models is fundamental for analyzing power flow, voltage regulation, and stability, which are critical for the safe and efficient planning and operation of the power grid.

II. Industry or Employer Expected Outcome-

An industry-ready diploma engineer is expected to model transmission lines and calculate their performance parameters, which is a core competency for roles in system planning, operation, and maintenance within transmission and distribution utilities.

III. Course Level Learning Outcome-

CO2: Use generalized circuit theory principles for calculations of transmission line performance

IV. Laboratory Learning Outcome-

LLO 4.1: Perform OC and SC Test and evaluate Generalized circuit constant (GCC) of given π model of transmission line.

V. Relevant Affective domain related Outcome

- Follow safety precautions meticulously while handling electrical circuits.
- Practice good housekeeping at the workbench.
- Record observations accurately and systematically.

VI. Relevant Theoretical Background

The Nominal- π model is used to represent a medium-length transmission line. Its performance is completely described by its Generalized Circuit Constants (A, B, C, D) in the following equations:

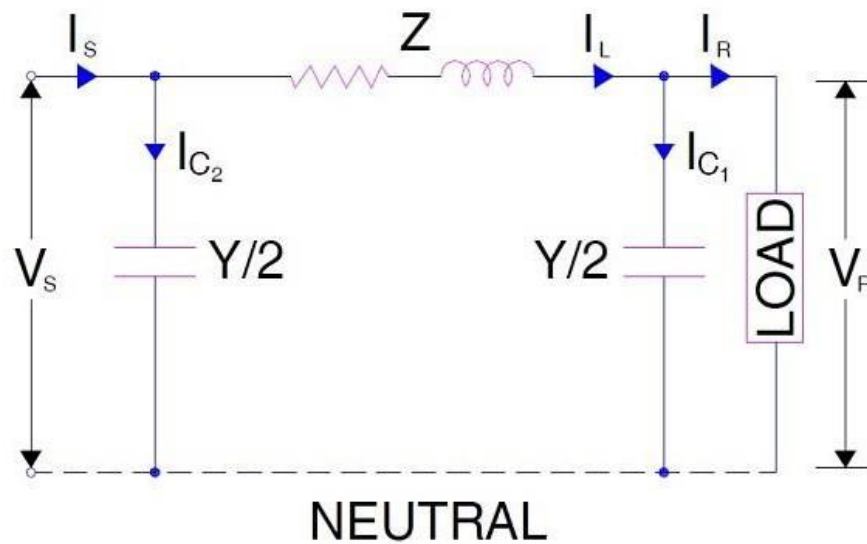
- $V_s = AV_r + B I_r$
- $I_s = C V_r + D I_r$

For a symmetrical and linear two-port network (like the Nominal- π model), the constants have the following relationship: $A=D$

These constants can be found experimentally without knowing the internal R, L, C parameters of the line by performing two simple tests:

1. **Open Circuit Test ($I_r = 0$):** The receiving end is left open. We measure sending end voltage $V_s(oc)$, current $I_s(oc)$, and power $P_s(oc)$.
 - o From this, we calculate: $A=V_s(oc)V_r(oc)$ and $C=I_s(oc)V_r(oc)$
2. **Short Circuit Test ($V_r = 0$):** The receiving end is shorted. We measure sending end voltage $V_s(sc)$, current $I_s(sc)$, and power $P_s(sc)$.
 - o From this, we calculate: $B=V_s(sc)I_r(sc)$ and $A=D$ is already known from the OC test.

VII. π (PI) model of transmission line



VIII. Resources required

Sr. No.	Particulars	Specification	Quantity	Remark
1	Nominal- π Model Trainer Kit	Contains lumped R, L, C components	1	
2	Single Phase Auto Transformer (Variac)	0-270 V, 10 A, 50 Hz	1	
3	AC Ammeter	(0-2.5/5)A MI	2	
4	AC Voltmeter	(0-300)V MI	2	
5	Single Phase Wattmeter	LPF, 5A, 300V	1	
6	Connecting Wires	-	As required	

IX. Precautions to be followed

1. Ensure all the connections are tight and correct before switching ON the supply.
2. The Variac (auto-transformer) should always be started at zero output voltage.
3. Do not touch live terminals. Be especially careful during the short-circuit test.
4. Take readings promptly to avoid overheating of components, especially during the SC test.
5. Check the ratings of meters and the trainer kit to prevent damage due to overloading.

X. Procedure**A. Open Circuit Test (Receiving End Open)**

1. Make the connections as per the circuit diagram.
2. Keep the receiving end open. Ensure the load switch is OFF.
3. Switch ON the AC supply.

4. Gradually increase the Variac voltage to apply a convenient rated voltage (e.g., 230V) at the sending end.
5. Note down all the readings: Sending end voltage $V_s(oc)$, current $I_s(oc)$, power $P_s(oc)$ and receiving end voltage $V_r(oc)$.
6. Gradually decrease the Variac to zero and switch OFF the supply.

B. Short Circuit Test (Receiving End Shorted)

1. Short the receiving end terminals with a thick connecting wire.
2. Switch ON the AC supply.
3. Important: Gradually increase the Variac voltage until the sending end current $I_s(sc)$ reaches its rated value (e.g., 2A). Keep the voltage low as the current will be high.
4. Note down all the readings: Sending end voltage $V_s(sc)$, current $I_s(sc)$, and power $P_s(sc)$.
5. Gradually decrease the Variac to zero and switch OFF the supply.
6. Remove the short circuit from the receiving end.

XI. Observation Table

Open Circuit Test ($I_r = 0$)

Sr.No	Parameter	Symbol	Reading
1	Sending End Voltage	$V_s(oc)$	
2	Sending End Current	$I_s(oc)$	
3	Sending End Power	$P_s(oc)$	
4	Receiving End Voltage	$V_r(oc)$	

Calculations from OC Test:

- $A = V_s(oc)V_r(oc) =$
- Power Factor, $\cos\phi_{oc} = P_s(oc) / V_s(oc) \cdot I_s(oc)$

- $I_s(oc)$ (at receiving end voltage) = $|I_s|Z(-\phi_{oc})$
- $C=I_s(oc) / V_r(oc)$ = (Polar Form)

Short Circuit Test ($V_r = 0$)

Sr.No	Parameter	Symbol	Reading
1	Sending End Voltage	$V_s(sc)$	
2	Sending End Current	$I_s(sc)$	
3	Sending End Power	$P_s(sc)$	

Calculations from SC Test:

- Impedance, $Z= V_s(sc) / I_s(sc)=$
- Power Factor, $\cos\phi_{oc} = P_s (oc) / V_s(oc)\cdot I_s(oc)$
- $Z= R+jX$
- $B=Z$ (Since $I_r=I_s$ in SC test and A is known) = (Polar Form)
- $D=A$ (For a symmetrical network)

XII. Result

The Generalized Circuit Constants for the given Nominal- π model of the transmission line are determined as follows:

- Constant A = _____
- Constant B = _____
- Constant C = _____
- Constant D = _____

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XIII. Interpretation of results

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XIV. Conclusions and Recommendations (if any)

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XV. Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. Why is the sending end voltage kept low during the short-circuit test?
2. What is the physical significance of the 'B' constant in the ABCD parameters?
3. In the OC test, why is the power reading $P_s(oc)$ very small compared to the VA product?
4. What would happen to the value of constant 'A' if the length of the transmission line were increased?

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XVI. References/ suggestions for further Reading

Sr.No.	Link	Description
1	https://archive.nptel.ac.in/content/storage2/courses/108104051/ui/Course_home-2.htm	NPTEL course
2	"Principles of Power System"	V.K. Mehta, Rohit Mehta

XVII. Suggested Assessment Scheme

Performance Indicators		Weightage (%)
Process related: 15 Marks		60%
1	Identification of basic construction material	30%
2	Recording of Observations	30%
Product related: 10 Marks		40%
1	Interpretation of result	10%
2	Answer to practical related questions.	20%
3	Submission of report in time	10%
Total : 25 Marks		100%

Marks Obtained			Dated Sign of Teacher
Process Related (15)	Product Related (10)	Total (25)	

Practical No. 5.: GCC of given T model of transmission line by using OC SC test.

I. Practical Significance

The T-model is another fundamental representation of transmission lines used in power system analysis. Determining its ABCD parameters through experimental tests helps engineers to understand different modeling approaches and select the most appropriate one for specific system studies, ensuring accurate prediction of power system behavior.

II. Industry Expected Outcome

A proficient diploma engineer should be able to model transmission lines using different configurations (π and T models), calculate their performance parameters, and understand the practical implications of each modeling approach in system design and operation.

III. Course Level Learning Outcome-

CO 2: Use generalized circuit theory principles for calculations of transmission line performance.

IV. Laboratory Learning Outcome-

LLO 5.1: Perform OC and SC Test and evaluate Generalized circuit constant (GCC) of given T model of transmission line.

V. Relevant Theoretical Background

The T-model represents a medium-length transmission line with different parameter distribution than the π -model. Its performance is described by Generalized Circuit Constants (A, B, C, D):

$$V_s = AV_r + BI_r$$

$$I_s = CV_r + DI_r$$

For a symmetrical T-network: $A = D$

Theoretical formulas for T-model:

$$A = 1 + YZ/2$$

$$B = Z(1 + YZ/4)$$

$$C = Y$$

$$D = A$$

Experimental determination:

Open Circuit Test ($I_r = 0$):

$A = V_s(oc) / V_r(oc)$

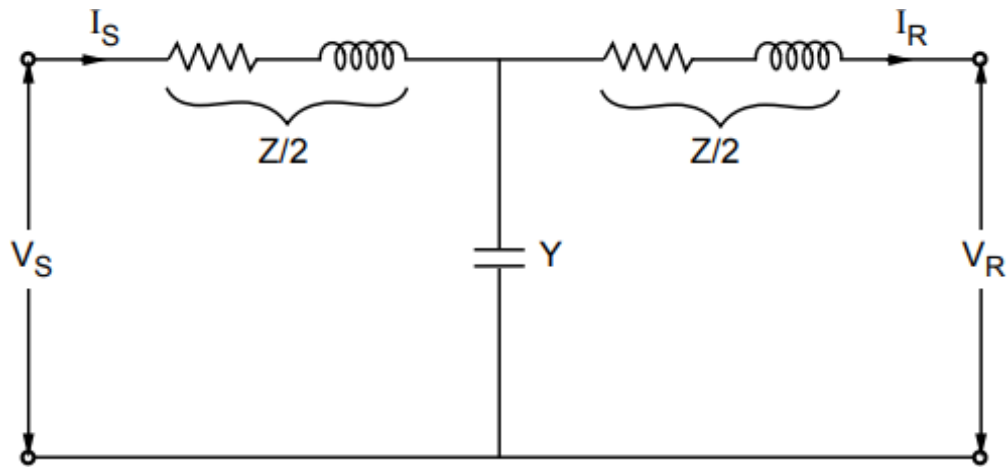
$C = I_s(oc) / V_r(oc)$

Short Circuit Test ($V_r = 0$):

$B = V_s(sc) / I_r(sc)$

$D = A$

VI. Circuit Diagram



VII. Resources Required

Sr. No.	Particulars	Specification	Quantity
1	T-Model Trainer Kit	-	1
2	Auto Transformer	0-270V, 10A	1
3	AC Ammeter	(0-5)A	2
4	AC Voltmeter	(0-300)V	2
5	Wattmeter	LPF, 5A, 300V	1
6	Connecting Wires	-	As required

VIII. Procedure**A. Open Circuit Test:**

1. Make connections as per diagram using T-model kit
2. Keep receiving end OPEN
3. Apply rated voltage (230V) using Variac
4. Record: $V_s(oc)$, $I_s(oc)$, $P_s(oc)$, $V_r(oc)$
5. Reduce voltage to zero

B. Short Circuit Test:

1. Short the receiving end with thick wire
2. Important: Apply low voltage until $I_s(sc)$ reaches rated value (2A)
3. Record: $V_s(sc)$, $I_s(sc)$, $P_s(sc)$
4. Reduce voltage to zero and remove short

IX. Observation Tables**Open Circuit Test ($I_r = 0$)**

Sr.No	Parameter	Symbol	Reading
1	Sending End Voltage	$V_s(oc)$	
2	Sending End Current	$I_s(oc)$	
3	Sending End Power	$P_s(oc)$	
4	Receiving End Voltage	$V_r(oc)$	

Calculations from OC Test:

$$A = V_s(oc) / V_r(oc) =$$

$$C = I_s(oc) / V_r(oc) =$$

Short Circuit Test ($V_r = 0$)

Sr.No	Parameter	Symbol	Reading
1	Sending End Voltage	$V_s(sc)$	
2	Sending End Current	$I_s(sc)$	
3	Sending End Power	$P_s(sc)$	

Calculations from SC Test:

$$B = V_s(sc) / I_s(sc) =$$

$$D = A =$$

X. Result

The Generalized Circuit Constants for the given T-model are:

- Constant A = _____
- Constant B = _____
- Constant C = _____
- Constant D = _____

XI. Practical Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. What is the fundamental structural difference between T-model and π -model?
2. Why are the formulas for constants B and C swapped between π and T models?
3. How does the physical structure of T-model affect current distribution?
4. Which model (π or T) is generally preferred for long transmission lines and why?

XII. References/ suggestions for further Reading

Sr.No.	Link	Description
1	"Principles of Power System"	V.K. Mehta, Rohit Mehta
2	https://archive.nptel.ac.in/content/storage2/courses/108104051/ui/Course_home-2.htm	NPTEL course on Power System Analysis

XIII. Suggested Assessment Scheme

Performance Indicators		Weightage (%)
Process related: 15 Marks		60%
1	Identification of basic construction material	30%
2	Recording of Observations	30%
Product related: 10 Marks		40%
1	Interpretation of result	10%
2	Answer to practical related questions.	20%
3	Submission of report in time	10%
Total : 25 Marks		100%

Marks Obtained			Dated Sign of Teacher
Process Related (15)	Product Related (10)	Total (25)	

Practical No. 6: GCC of given π (PI) model of transmission line by using software.

I. Practical Significance-

In modern power system analysis, software tools are indispensable for solving complex equations and simulating system behavior. Learning to determine transmission line parameters using software like Scilab prepares the engineer for the computational methods used in the industry for system planning, design, and analysis, making the process faster, more accurate, and adaptable to complex scenarios.

II. Industry or Employer Expected Outcome-

An industry-ready diploma engineer is expected to be proficient with computational tools and software to model power system components, analyze their performance, and solve power system problems efficiently.

III. Course Level Learning Outcome-

CO2: Use generalized circuit theory principles for calculations of transmission line performance.

IV. Laboratory Learning Outcome-

LLO 6.1 Determine Generalized circuit constant (GCC) of given π (PI) model of transmission line by using Scilab.

V. Relevant Affective domain related Outcome

- Develop a systematic approach to problem-solving using software.
- Practice ethical use of software and digital resources.
- Document code and results effectively.

VI. Relevant Theoretical Background

The Generalized Circuit Constants (A, B, C, D) for a two-port network are related to its impedance (Z) and admittance (Y) parameters. For a Nominal- π network, the series impedance is $Z=R+j\omega L$ and the total shunt admittance is $Y=j\omega C$, where the admittance is split equally at both ends.

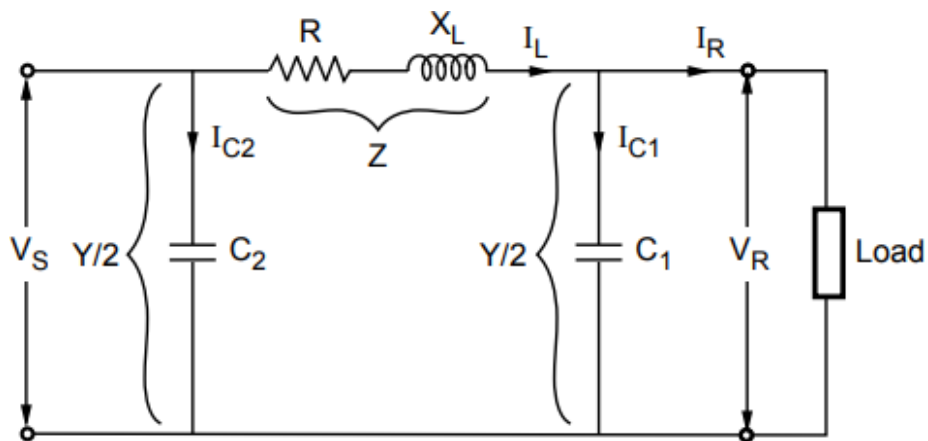
The theoretical formulas for the GCC of a Nominal- π network are:

- $A=1+YZ / 2$

- $B=Z$
- $C=Y(1+YZ/4)$
- $D=A$

In this practical, we will use Scilab, a high-level numerical computational software, to program these formulas. By providing the values of R, L, and C for the given π -model, Scilab will calculate the GCC, demonstrating the application of software in power system computations.

VII. π (PI) model of transmission line-



VIII. Resources required

Sr. No.	Particulars	Specification	Quantity	Remark
1	Computer System	Desktop/Laptop	1	-
2	Scilab Software	Version 5.5.2 or higher	1	Open Source

IX. Precautions to be followed

1. Ensure the Scilab software is properly installed on the computer.
2. Type the code carefully, paying attention to brackets, operators, and semicolons.
3. Use correct variable names and maintain consistency.
4. Verify the input parameters (R, L, C, f) before execution.

X. Procedure

1. Start the Scilab software on your computer.
2. Open a new SciNotes window (the editor) to write your script.
3. Define the known parameters of the given π -model in the script:
 - o Resistance, R (in Ohms)
 - o Inductance, L (in Henries)
 - o Capacitance, C (in Farads)
 - o Supply frequency, f (in Hz)
4. Calculate the angular frequency $\omega=2\pi f$
5. Calculate the series impedance, $Z=R+j*\omega*L$
6. Calculate the total shunt admittance, $Y=j*\omega*C$
7. Write the Scilab code to compute the A, B, C, D constants using the Nominal- π formulas.
8. Execute the script (Ctrl-L in SciNotes or press Execute).
9. Observe the results in the Scilab console.
10. Record the calculated values of the A, B, C, D constants.

XII. Scilab Code: (Space for Scilab/VLAB)

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XII. Observation Table (Student will write the values from Scilab)

Sr.No	Constant	Rectangular Form	Polar Form (Magnitude \angle Angle in Degrees)
1	A		
2	B		
3	C		
4	D		

XIII. Result

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XIV. Interpretation of results

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XV. Conclusions and Recommendations (if any)

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XVII. Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. What is the advantage of using software like Scilab for calculating GCC over manual calculation?
2. In the Scilab code, why is %i used instead of i to represent the complex number?

XVII. References/ suggestions for further Reading

Sr.No	Link	Description
1	"Principles of Power System"	V.K. Mehta, Rohit Mehta
2	https://archive.nptel.ac.in/content/storage2/courses/108104051/ui/Course_home-2.htm	NPTEL course on Power System Analysis

XVIII. Suggested Assessment Scheme

Performance Indicators		Weightage (%)
Process related: 15 Marks		60%
1	Identification of basic construction material	30%
2	Recording of Observations	30%
Product related: 10 Marks		40%
1	Interpretation of result	10%
2	Answer to practical related questions.	20%
3	Submission of report in time	10%
Total : 25 Marks		100%

Marks Obtained			Dated Sign of Teacher
Process Related (15)	Product Related (10)	Total (25)	

Practical No. 7: GCC of given T model of transmission line by using software.

I. Practical Significance-

The T-model is another fundamental representation of transmission lines. Using computational software to determine its parameters is crucial for engineers to compare different modeling approaches and choose the most appropriate one for specific system studies. This skill is directly applicable in power system design software and digital simulators used in the industry.

II. Industry or Employer Expected Outcome-

A proficient diploma engineer should be able to influence computational tools to model and analyze different transmission line configurations, enabling accurate prediction of system behavior under various operating conditions.

III. Course Level Learning Outcome-

CO 2: Use generalized circuit theory principles for calculations of transmission line performance.

IV. Laboratory Learning Outcome-

LLO 7.1 Determine Generalized circuit constant (GCC) of given T model of transmission line by using Scilab.

V. Relevant Affective domain related Outcome

Cultivate precision in translating theoretical models into computational algorithms.

Develop the ability to analyze and compare results from different software-based models.

VI. Relevant Theoretical Background

The T-model is another representation for medium-length transmission lines, where the total series impedance is placed in the middle and the shunt admittance is divided and placed at both ends.

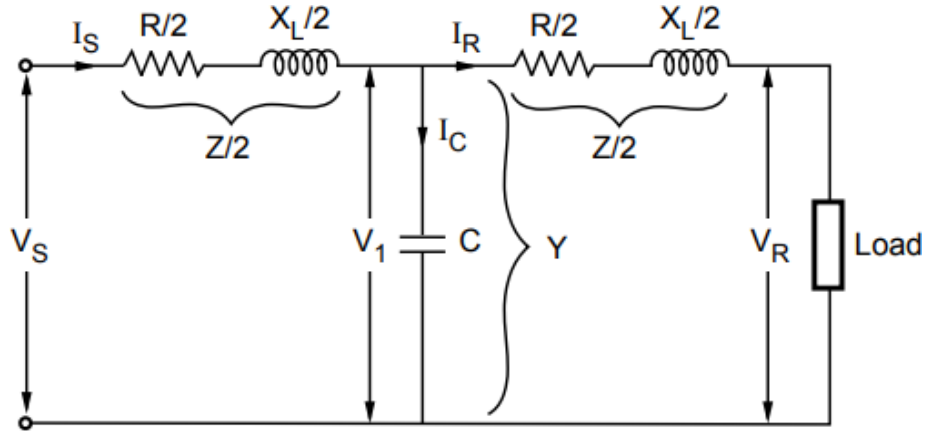
The theoretical formulas for the GCC of a Nominal-T network are:

- $A=1+YZ$
- $B=Z(1+YZ / 4)$
- $C=Y$

- $D=A$

Note that while the formula for 'A' is the same as for the π -model, the formulas for 'B' and 'C' are swapped compared to the π -model. This highlights the difference in the two representations.

VII. T model of transmission line-



VIII. Resources required

Sr. No.	Particulars	Specification	Quantity	Remark
1	Computer System	Desktop/Laptop	1	-
2	Scilab Software	Version 5.5.2 or higher	1	Open Source

IX. Precautions to be followed

1. Double-check the formulas used in the code to ensure they are for the T-model, not the π -model.
2. Verify the input parameters (R , L , C , f) for consistency.
3. Use comments in the code to distinguish it from the π -model program.

X. Procedure

1. Launch the Scilab software.
2. Open a new SciNotes window.
3. Define the known parameters of the given T-model in the script:

XII. Observation Table

Note: Students will run the code and fill the table with the output from the Scilab console.

Sr.No	Constant	Rectangular Form	Polar Form (Magnitude \angle Angle in Degrees)
1	A		
2	B		
3	C		
4	D		

XIII. Result

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XIV. Interpretation of results

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XV. Conclusions and Recommendations (if any)

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XVI. Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

XVII. References/ suggestions for further Reading

Sr.No.	Link	Description
1	https://www.scilab.org/	Official Scilab website
2	https://archive.nptel.ac.in/content/storage2/courses/108104051/ui/Course_home-2.htm	NPTEL course on Power System Analysis
3	"Modern Power System Analysis"	Nagrath I.J. & Kothari D.P.

XVIII. Suggested Assessment Scheme

Performance Indicators		Weightage (%)
Process related: 15 Marks		60%
1	Identification of basic construction material	30%
2	Recording of Observations	30%
Product related: 10 Marks		40%
1	Interpretation of result	10%
2	Answer to practical related questions.	20%
3	Submission of report in time	10%
Total : 25 Marks		100%

Marks Obtained			Dated Sign of Teacher
Process Related (15)	Product Related (10)	Total (25)	

Practical No.8: π (PI) model Transmission line Efficiency and regulation by Load test.

I. Practical Significance

This experiment demonstrates the behaviour of a transmission line under load using the lumped π -model. Students will observe how sending-end and receiving-end powers differ because of line losses, and how voltage regulation varies with load and power factor. Helps understand line performance, losses (I^2R) and the role of power factor correction using an alternative, commonly used model.

II. Industry or Employer Expected Outcome

Use π -transmission lines model for planning and testing. Compute efficiency and voltage regulation for transmission lines under realistic loads.

III. Course Level Learning Outcome

Estimate the power at sending and receiving ends of transmission line.

IV. Laboratory Learning Outcome

LLO Perform Load test on given π (PI) model of transmission line and determine the Efficiency and regulation.

V. Relevant Affective domain related Outcome

Students will demonstrate attention to laboratory safety, careful observation and accurate recording, responsibility for experiment setup, and teamwork during measurement and data analysis.

VI. Relevant Theoretical Background

A transmission line transfers electrical energy from the generating station to the load centre. For studying its performance, the distributed parameters of resistance (R), inductive reactance (X), and shunt capacitance (B) are represented by equivalent circuit models. For medium-length lines (about 80 to 250 km), the parameters are usually lumped into a T-model or a π -model. In this experiment the π -model is used.

In this model:

The total series impedance $Z = R + jX$ is placed in the middle.

The total shunt admittance $Y = jB$ is split into two equal halves, with each half $Y/2$ placed at the sending and receiving ends. The relationship between sending-end and receiving-end quantities is given by the transmission line equations:

$$V_s = A * V_r + B * I_r$$

$$I_s = C * V_r + D * I_r$$

Where A, B, C, D are the transmission line constants for the π -model:

$$A = D = 1 + (Y \cdot Z) / 2$$

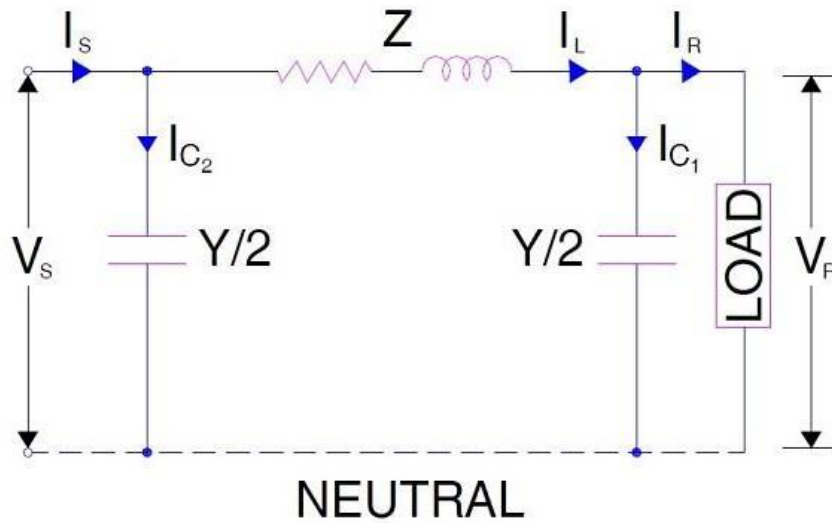
$$B = Z$$

$$C = Y (1 + (Y \cdot Z) / 4)$$

Efficiency: $\% \eta = (P_r / P_s) \times 100$

Voltage Regulation: $\% \text{Reg} = ((V_{nl} - V_r) / V_r) \times 100$

VII. π -model of transmission line-



VIII. Resources required

Sr. No.	Particulars	Specification	Quantity	Remark
1	Transmission line trainer (π -model)	Adjustable R, X, B	1	
2	AC Source / Variac	0–250V, 50Hz	1	
3	Load bank	Variable R & L	1 set	
4	Voltmeter	0–300V	2	
5	Ammeter	0–10A	1	
6	Wattmeter	0–3kW	1	
7	PF Meter	0–1.0 lag/lead	1	

IX. Precautions to be followed

1. Verify wiring and earthing before switching ON.
2. Ensure meters are within rating.
3. Take no-load voltage first.
4. Increase load gradually.
5. Reverse wattmeter connection if reading negative.
6. Switch OFF after each trial.

X. Procedure

1. Inspect all equipment and ensure proper earthing and safety fuses are in place.
2. Connect the π -model transmission line trainer between the sending source (Variac) and the receiving bus according to the schematic.
3. Connect Voltmeters: one at Sending end (V_s) and one at Receiving end (V_r). Connect Ammeter in series with the load. Connect Wattmeter at the sending end to measure P_s . If available, connect a wattmeter at the receiving end to measure P_r .
4. With the load disconnected (open), switch ON the source and set the Variac to the rated line voltage. Record the no-load receiving voltage V_{nl} (measure V_r with no load).
5. Select the first load condition (e.g., resistive load for unity power factor). Close the load and allow the system to stabilize for a few seconds.
6. Record the following measurements: Current I (A), Receiving voltage V_r (V), Sending voltage V_s (V), Sending wattmeter P_s (W), Power factor (pf) or receiving wattmeter P_r (W) if available.
7. Compute receiving-end active power P_r (if not measured) using $P_r = V_r \times I \times \text{pf}$. Compute receiving reactive power $Q_r = V_r \times I \times \sin(\text{acos}(\text{pf}))$.
8. Compute line losses $P_{\text{loss}} = P_s - P_r$.
9. Compute efficiency (%) $\eta (\%) = (P_r / P_s) \times 100$.
10. Compute voltage regulation (%Reg) = $((V_{nl} - V_r) / V_r) \times 100\%$. (State if you prefer denominator V_{nl} instead.)
11. Repeat steps 5 to 10 for different loads and power factors (e.g., unity, 0.8 lag, 0.8 lead) and for increasing load currents until the rated test current or safe limit.
12. After finishing all trials, switch OFF the source, disconnect the load and instruments, and record any observations or anomalies in the report.

XI. Observation Table

Sr.No.	P.F.	I(A)	Vnl(V)	Vr (V)	Vs (V)	Ps (W)	Pr (W)	Ploss (W)	η (%)	% Regulation

XII. Result

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XIII. Interpretation of results

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XIV. Conclusions and Recommendations (if any)

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XV. Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. Differentiate between the T-model and π -model of a medium transmission line.
2. Why is the π -model often preferred over the T-model for power system analysis?
3. Define voltage regulation of a transmission line.

XVI. References/ suggestions for further Reading

Sr.No.	Link	Description
1	https://archive.nptel.ac.in/content/storage2/courses/108104051/ui/Course_home-2.htm	NPTEL course on Power System Analysis
2	https://www.electrical4u.com/transmission-line/	Easy-to-understand notes on models, efficiency, and regulation.
3	https://www.ieee-pes.org/	Access technical papers, standards, and resources on transmission systems.

VII. Suggested Assessment Scheme

Performance Indicators		Weightage (%)
Process related: 15 Marks		60%
1	Identification of basic construction material	30%
2	Recording of Observations	30%
Product related: 10 Marks		40%
1	Interpretation of result	10%
2	Answer to practical related questions.	20%
3	Submission of report in time	10%
Total : 25 Marks		100%

Marks Obtained			Dated Sign of Teacher
Process Related (15)	Product Related (10)	Total (25)	

Practical No.9: T model Transmission line Efficiency and regulation by Load test.

I. Practical Significance- This experiment demonstrates the behaviour of a transmission line under load using the lumped T-model. Students will observe how sending-end and receiving-end powers differ because of line losses, and how voltage regulation varies with load and power factor. It helps to understand line performance, losses (I^2R) and the role of power factor correction.

II. Industry or Employer Expected Outcome-

Compute efficiency and voltage regulation for transmission lines under realistic loads.

III. Course Level Learning Outcome-

CO3: Estimate the power at sending and receiving ends of transmission line.

IV. Laboratory Learning Outcome-

LLO 9.1 Perform Load test on given T model of transmission line and determine the efficiency and regulation.

V. Relevant Affective domain related Outcome

Students will demonstrate attention to laboratory safety, careful observation and accurate recording, responsibility for experiment setup, and teamwork during measurement and data analysis.

VI. Relevant Theoretical Background

A transmission line transfers electrical energy from the generating station to the load centre. For studying its performance, the distributed parameters of resistance (R), inductive reactance (X), and shunt capacitance (B) are represented by equivalent circuit models. For medium-length lines (about 80 to 250 km), the parameters are usually lumped into a T-model or a π -model. In this experiment the T-model is used.

In the T-model the total series impedance (Z) = $R + jX$ is divided equally on both sides of the line, and the total shunt admittance (Y) = jB is placed at the centre of the line.

ABCD parameters of the T-model:

$$A = D = 1 + (YZ / 2)$$

$$B = Z (1 + (YZ / 4))$$

$$C = Y$$

Sending and receiving end voltages and currents are related by:

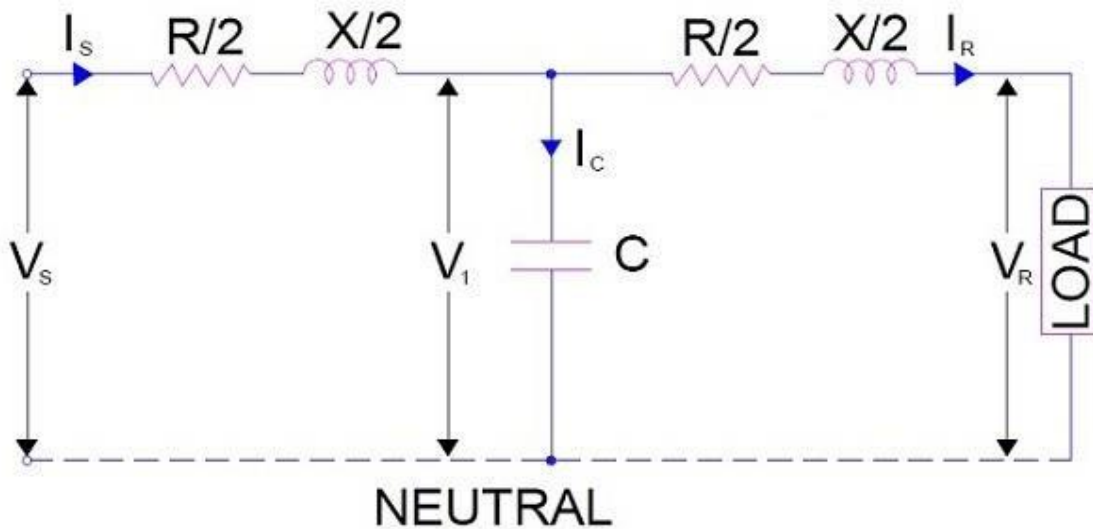
$$V_s = A * V_r + B * I_r$$

$$I_s = C * V_r + D * I_r$$

Efficiency: $\eta = (P_r / P_s) \times 100\%$

Voltage Regulation: $\%Reg = ((V_{nl} - V_r) / V_r) \times 100\%$

VII. T Model of Transmission Line



VIII. Resources required

Sr. No.	Particulars	Specification	Quantity	Remark
1	Transmission line trainer (T-model)	Adjustable R, X, B	1	For simulating short, medium & long transmission line performance
2	AC Source / Variac	0–250V, 50Hz	1	For providing adjustable input supply to the experiment setup
3	Load bank	Variable R & L	1 set	For applying different loading conditions on transmission line
4	Voltmeter	0–300V	2	For measuring sending-end and receiving-end voltages
5	Ammeter	0–10A	1	For measuring line current under various loads

6	Wattmeter	0–3kW	1	For measuring real power and efficiency of transmission line model
7	PF Meter	0–1.0 lag/lead	1	For observing power factor variation with load

IX. Precautions to be followed

1. Verify wiring and earthing before switching ON.
2. Ensure meters are within rating.
3. Take no-load voltage first.
4. Increase load gradually.
5. Reverse wattmeter connection if reading negative.
6. Switch OFF after each trial.

X. Procedure

1. Inspect all equipment and ensure proper earthing and safety fuses are in place.
2. Connect the T-model transmission line trainer kit between the sending source (Variac) and the receiving bus according to the schematic.
3. Connect Voltmeters: one at Sending end (V_s) and one at Receiving end (V_r). Connect Ammeter in series with the load. Connect Wattmeter at the sending end to measure P_s . If available, connect a wattmeter at the receiving end to measure P_r .
4. With the load disconnected (open), switch on the source and set the Variac to the rated line voltage. Record the no-load receiving voltage V_{nl} (measure V_r with no load).
5. Select the first load condition (e.g., resistive load for unity power factor). Close the load and allow the system to stabilize for a few seconds.
6. Record the following measurements: Current I (A), Receiving voltage V_r (V), Sending voltage V_s (V), Sending wattmeter P_s (W), Power factor (pf) or receiving wattmeter P_r (W) if available.
7. Compute receiving-end active power P_r (if not measured) using $P_r = V_r \times I \times \text{pf}$. Compute receiving reactive power $Q_r = V_r \times I \times \sin(\phi)$.
8. Compute line losses $P_{\text{loss}} = P_s - P_r$.
9. Compute efficiency η (%) = $(P_r / P_s) \times 100$.
10. Compute voltage regulation (%Reg) = $((V_{nl} - V_r) / V_r) \times 100\%$. (State if you prefer denominator V_{nl} instead.)

11. Repeat steps 5–10 for different loads and power factors (e.g., unity, 0.8 lag, 0.8 lead) and for increasing load currents until the rated test current or safe limit.
12. After finishing all trials, switch OFF the source, disconnect the load and instruments, and record any observations or anomalies in the report.

XI. Observation Table

Sr.No.	P.F.	I(A)	Vnl(V)	Vr (V)	Vs (V)	Ps (W)	Pr (W)	Ploss (W)	η (%)	% Regulation
1										
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XII. Result

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XIII. Interpretation of results

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XIV. Conclusions and Recommendations (if any)

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XVI. References/ suggestions for further Reading

Sr.No.	Link	Description
1	https://www.youtube.com/watch?v=AZGrQ9rILJM https://www.youtube.com/@IITKanpurNPTEL	Lecture 27: Transmission line models and performance – medium line model,
2	https://www.electrical4u.com/transmission-line/	Easy-to-understand notes on models, efficiency, and regulation.
3	https://www.ieee-pes.org/	Access technical papers, standards, and resources on transmission systems.

XVII. Suggested Assessment Scheme

Performance Indicators		Weightage (%)
Process related: 15 Marks		60%
1	Identification of basic construction material	30%
2	Recording of Observations	30%
Product related: 10 Marks		40%
1	Interpretation of result	10%
2	Answer to practical related questions.	20%
3	Submission of report in time	10%
Total : 25 Marks		100%

Marks Obtained			Dated Sign of Teacher
Process Related (15)	Product Related (10)	Total (25)	

Practical No.10: Transmission line Receiving end complex power evaluation by using software.

I. Practical Significance-

This experiment helps students understand the calculation of real, reactive, and apparent power at the receiving end of a transmission line. It demonstrates how analytical formulas and Scilab simulation can be used to study the effect of power factor and line parameters on system performance. This experiment familiarizes students with Scilab for analyzing power flow in a transmission line. It demonstrates the computation of receiving-end complex power (P, Q) under load conditions using the ABCD parameters. Students learn how software simulation correlates with theoretical calculations in power systems.

II. Industry or Employer Expected Outcome-

- Students will be able to compute real and reactive power at the receiving end of a transmission line.
- Interpret simulation results and verify theoretical calculations.
- Use engineering software tools for power system analysis.

III. Course Level Learning Outcome-

CO3: Estimate the power at sending and receiving ends of transmission line

IV. Laboratory Learning Outcome-

LLO 10.1 Evaluate Receiving end complex power by using Scilab for given transmission line under load condition.

V. Relevant Affective domain related Outcome

- Careful observation of numerical and simulation results.
- Responsible handling of computational tools.
- Teamwork and collaborative problem solving.

VI. Relevant Theoretical Background

For a medium-length line represented by ABCD parameters:

$$V_s = A \cdot V_r + B \cdot I_r,$$

$$I_s = C \cdot V_r + D \cdot I_r$$

For a T-model line:

$$A = D = 1 + (YZ/2),$$

$$B = Z \cdot (1 + YZ/4),$$

$$C = Y$$

where $Z = R + jX$ (series impedance per phase) and $Y = jB$ (shunt admittance per phase).

Receiving-end complex power per phase:

$$S_r = V_r \cdot I_r^* = P_r + jQ_r$$

VII. Resources required

Sr. No.	Particulars	Specification	Quantity	Remark
1	Computer System	Windows / Linux PC with Scilab 6.x	1	Minimum 4GB RAM, 500GB HDD
2	Scilab Software	Open-source numerical tool	1 license per system	Latest version recommended
3	Reference Book	Nagrath & Kothari – Power System Engineering (3rd Ed.)	1	For theory reference and formulas
4	Scientific Calculator and Notebook	For manual verification	1	Calculator with complex number functions

VIII. Precautions to be followed

1. Enter all quantities in per-phase form and proper units.
2. Use correct sign convention: lagging $\rightarrow +Q$, leading $\rightarrow -Q$.
3. Save Scilab code files clearly named and check syntax.
4. Verify that all results are expressed in MW, Mvar, MVA.

IX. Procedure

1. Open Scilab and create a new script.
2. Enter the given data (R, X, Y, V, pf, S).
3. Convert line quantities to per-phase values.
4. Calculate ABCD constants using the above formulas.
5. Assume $V_r \angle 0^\circ$ and $I_r \angle -\phi$.
6. Compute V_s and I_s using $V_s = A \cdot V_r + B \cdot I_r$ and $I_s = C \cdot V_r + D \cdot I_r$.

7. Determine the receiving-end complex power: $S_r = 3 \cdot V_r \cdot I_r^*$.
8. Display P, Q, and |S| using Scilab commands.
9. Repeat for different power-factor values.
10. Record all readings in the observation table.

X. Given Data (for example)

Parameter	Symbol	Value
Line-to-line voltage	VLL	220 kV
Line resistance	R	20 Ω
Line reactance	X	50 Ω
Shunt admittance	Y	$j 4 \times 10^{-4} S$
Apparent Power	S	100 MVA
Frequency	f	50 Hz
Power-factor cases	pf	1.0 (unity), 0.8 lag, 0.8 lead

Computation of ABCD Parameters

$Z = 20 + j50, Y = j0.0004$

$YZ = -0.020 + j0.008$

$A = D = 1 + (YZ/2) = 0.990 + j0.004$

$B = Z \cdot (1 + YZ/4) = 19.80 + j49.79 \Omega$

$C = j0.0004 S$

XI. Scilab Code: (Space for Scilab code)

Note-: Use above data for programing in Scilab

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XII.Observation Table

Sr.No.	Parameter	Theoretical Value	Scilab Output	% Error
1	Ps (MW)			
2	Qs (MVAR)			
3	Ss (MVA)			
4	Efficiency (%)			

XIII. Result

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XVII. References/ suggestions for further Reading

Sr.No.	Link	Description
1	https://www.scilab.org/software/scilab/documentation	Complete Scilab user guide and function reference
2	https://nptel.ac.in/courses/108101038	Video lectures on transmission line modeling and ABCD parameters
3	https://circuitglobe.com/abcd-parameters-of-transmission-line.html	Detailed explanation with examples

XVIII. Suggested Assessment Scheme

Performance Indicators		Weightage (%)
Process related: 15 Marks		60%
1	Identification of basic construction material	30%
2	Recording of Observations	30%
Product related: 10 Marks		40%
1	Interpretation of result	10%
2	Answer to practical related questions.	20%
3	Submission of report in time	10%
Total : 25 Marks		100%

Marks Obtained			Dated Sign of Teacher
Process Related (15)	Product Related (10)	Total (25)	

Practical No.11: Transmission line Sending end complex power evaluation by using software.

I. Practical Significance- This experiment enables students to determine the sending-end real, reactive and apparent power of a medium transmission line using the nominal- π model. It shows how analytical formulas and Scilab simulation help evaluate voltage regulation, efficiency and losses. Students learn to relate theoretical equations of transmission-line parameters with actual software computation.

II. Industry or Employer Expected Outcome-

Students will be able to compute sending-end complex power and transmission losses, compare theoretical and software-based results, and use open-source analytical tools (Scilab) for transmission-line studies.

III. Course Level Learning Outcome-

CO3: Estimate the power at sending and receiving ends of transmission line

IV. Laboratory Learning Outcome-

LLO 11.1 Evaluate Sending end complex power by using Scilab for given transmission line under given condition.

V. Relevant Affective domain related Outcome

- Careful observation of numerical and simulation results.
- Responsible handling of computational tools.
- Teamwork and collaborative problem solving.

VI. Relevant Theoretical Background

For a medium-length (nominal- π) line per phase:

$$V_s = A \cdot V_r + B \cdot I_r,$$

$$I_s = C \cdot V_r + D \cdot I_r$$

$$A = D = 1 + (YZ/2), \quad B = Z, \quad C = Y(1 + YZ/4)$$

where $Z = R + jX$ (series impedance) and $Y = jB$ (shunt admittance).

Three-phase sending-end complex power: $S_s = 3 \cdot V_s \cdot I_s^* = P_s + jQ_s$

VII. Resources required

Sr. No.	Particulars	Specification	Quantity	Remark
1	Computer System	Windows / Linux PC with Scilab 6.x	1	Minimum 4GB RAM, 500GB HDD
2	Scilab Software	Open-source numerical tool	1 license per system	Latest version recommended
3	Reference Book	Nagrath & Kothari – Power System Engineering (3rd Ed.)	1	For theory reference and formulas
4	Scientific Calculator and Notebook	For manual verification	1	Calculator with complex number functions

VIII. Precautions to be followed

1. Enter all quantities in per-phase form and proper units.
2. Use correct sign convention: lagging $\rightarrow +Q$, leading $\rightarrow -Q$.
3. Save Scilab code files clearly named and check syntax.
4. Verify that all results are expressed in MW, Mvar, and MVA.
5. Record simulated and theoretical results properly.

IX. Procedure

1. Open Scilab and create a new script file.
2. Enter the given data (R' , X' , C' , I , V , pf , PR).
3. Convert line quantities to per-phase values.
4. Calculate ABCD constants using nominal- π model.
5. Compute V_r , I_r , V_s , and I_s .
6. Evaluate sending-end complex power: $S_s = 3 \cdot V_s \cdot I_s^*$.
7. Display results (P , Q , $|S|$) using Scilab commands.
8. Record the results in the observation table

XII. Observation Table

Parameter	Theoretical Value	Scilab Output	Error %
P_s (MW)			
Q_s (MVAR)			
S_s (MVA)			
Efficiency (%)			

XIII. Result

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XIV. Interpretation of results

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XV. Conclusions and Recommendations (if any)

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XVI. Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. Define sending-end complex power and explain its components.
2. What is the significance of line efficiency and power factor?
3. How does shunt capacitance affect the sending-end reactive power?

XVII. References/ suggestions for further Reading

Sr.No.	Link	Description
1	https://www.ieee-pes.org/	Research papers and standards on power transmission
2	https://nptel.ac.in/courses/108101038	Video lectures on transmission line modeling and performance
3	https://circuitglobe.com/abcd-parameters-of-transmission-line.html	Theory and examples of transmission parameters

XVIII. Suggested Assessment Scheme

Performance Indicators		Weightage (%)
Process related: 15 Marks		60%
1	Identification of basic construction material	30%
2	Recording of Observations	30%
Product related: 10 Marks		40%
1	Interpretation of result	10%
2	Answer to practical related questions.	20%
3	Submission of report in time	10%
Total : 25 Marks		100%

Marks Obtained			Dated Sign of Teacher
Process Related (15)	Product Related (10)	Total (25)	

Practical No.12: Transmission line Receiving end or Sending end complex power evaluation by graphical method.

I. Practical Significance- The circle diagram is a powerful graphical tool used to visualize the performance of a transmission line under various load conditions. It helps in understanding the relationship between sending-end and receiving-end powers, voltage, current, and power factor. This experiment demonstrates how complex power limits can be determined graphically, which is essential for system planning, stability analysis, and operational control in power systems.

II. Industry or Employer Expected Outcome-

Ability to analyze transmission line performance using graphical methods, interpret circle diagrams for power flow studies, and determine operational limits for real and reactive power transfer in power systems. Estimate the power at sending and receiving ends of transmission line

III. Course Level Learning Outcome-

CO4: Analyze the performance of transmission lines graphically

IV. Laboratory Learning Outcome-

LLO 12.1 Draw Circle Diagram for Receiving end or Sending end for given transmission line under load condition by using scilab

V. Relevant Affective domain related Outcome

Students will demonstrate precision in graphical representation, careful observation of power system relationships, and responsible use of computational tools for power system visualization.

VI. Relevant Theoretical Background

The circle diagram represents the relationship between sending-end and receiving-end quantities in a transmission line. For a lossless line (simplified analysis), the power transfer equation is:

$$P = (|V_s| * |V_r| / X) * \sin(\delta)$$

Where:

P = Real power transferred

|V_s|, |V_r| = Sending-end and receiving-end voltage magnitudes

X = Line reactance

δ = Power angle between voltages

This equation shows that power transfer depends on the product of voltage magnitudes, the line reactance, and the sine of the phase angle.

2. Receiving-End Power Circle Equations:

$$P_r = (|V_s||V_r| / |B|) \cos(\beta - \delta) - (|A||V_r|^2 / |B|) \cos(\beta - \alpha)$$

$$Q_r = (|V_s||V_r| / |B|) \sin(\beta - \delta) - (|A||V_r|^2 / |B|) \sin(\beta - \alpha)$$

Where:

A, B = Transmission line ABCD parameters(Consider nominal Ω model)

α, β = Angles of A and B respectively

VII. Resources required

Sr. No.	Particulars	Specification	Quantity	Remark
1	Computer System	Windows / Linux PC with Scilab 6.x	1	Minimum 4GB RAM, 500GB HDD
2	Scilab Software	Open-source numerical tool	1 license per system	Latest version recommended
3	Reference Book	Nagrath & Kothari – Power System Engineering (3rd Ed.)	1	For theory reference and formulas
4	Scientific Calculator and Notebook	For manual verification	1	Calculator with complex number functions

VIII. Precautions to be followed

1. Use consistent units (p.u. or actual values) throughout calculations
2. Verify ABCD parameters before plotting circle diagrams
3. Ensure proper scaling of P and Q axes for clear visualization
4. Check that circle centers and radii are calculated correctly
5. Label all circles and important points on the diagram
6. Save Scilab code and plots for documentation

IX. Procedure

1. Open Scilab and create a new script file
2. Define the transmission line parameters (R, X, B, length)
3. Calculate ABCD parameters for the transmission line
4. Set sending and receiving end voltage magnitudes
5. Calculate circle center coordinates for receiving end power circle.
6. Generate points for the circle using parametric equations
7. Plot the circle diagram using Scilab's plotting functions
8. Add labels, grid, and legend to the plot
9. Repeat for sending end circle if required
10. Analyze the diagram for power limits and operating regions

X. Given Data(for example)

Parameter	Symbol	Value	Unit
Sending End Voltage	V_s	1.05	p.u.
Receiving End Voltage	V_r	1.00	p.u.
Line Resistance	R	0.1	p.u.
Line Reactance	X	0.8	p.u.
Shunt Admittance	Y	j0.05	p.u.
System Base MVA	Sbase	100	MVA

Calculate the ABCD parameters and plot the Receiving End Circle Diagram using Scilab.

XVII.References/ suggestions for further Reading

Sr.No.	Link	Description
1	https://www.scilab.org/	Official Scilab documentation for plotting functions
2	https://www.youtube.com/watch?v=kGee2B5Pmeg	Receiving end circle diagram
3	https://eee.poriyaan.in/topic/sending-end-power-circle-diagram-12115/	Sending end circle diagram

XVIII.Suggested Assessment Scheme

Performance Indicators		Weightage (%)
Process related: 15 Marks		60%
1	Identification of basic construction material	30%
2	Recording of Observations	30%
Product related: 10 Marks		40%
1	Interpretation of result	10%
2	Answer to practical related questions.	20%
3	Submission of report in time	10%
Total : 25 Marks		100%

Marks Obtained			Dated Sign of Teacher
Process Related (15)	Product Related (10)	Total (25)	

Practical No.13: Development of Ybus matrix by using software- case 1.

I. Practical Significance- This experiment demonstrates the process of forming the bus admittance matrix (Ybus) for a given 3-bus power system network. It helps students understand how individual line reactances contribute to the overall network admittance and how the matrix is used for load flow and fault analysis in power system studies.

II. Industry or Employer Expected Outcome-

Ability to model a power system network using an admittance matrix and perform system analysis such as load flow, short circuit studies, and stability assessment.

III. Course Level Learning Outcome-

CO5: Interpret the data required for Load flow studies

IV. Laboratory Learning Outcome-

LLO 13.1 Use Scilab to develop Ybus matrix for given 3- bus system-1.

V. Relevant Affective domain related Outcome

Students will demonstrate systematic calculation, teamwork during verification, and attention to detail while forming matrices and validating results.

VI. Relevant Theoretical Background

In power system analysis, the bus admittance matrix (Ybus) represents the relationship between bus currents and voltages. It is derived from the line reactances or impedances connecting the buses. The Ybus matrix is symmetric and is fundamental for load flow and fault analysis.

The Y-bus admittance matrix is a square matrix that represents a power system's network admittances, with diagonal elements being the sum of all admittances connected to a bus and off-diagonal elements being the negative of the admittance between two buses.

VII. Resources required

Sr. No.	Particulars	Specification	Quantity	Remark
1	Computer System	Windows / Linux PC with Scilab 6.x	1	Minimum: 4GB RAM, 500GB HDD
2	Scilab Software	Open-source numerical tool	1 license per system	Latest version recommended

3	Reference Book	Nagrath & Kothari – Power System Engineering (3rd Ed.)	1	For theory reference
4	Scientific Calculator and Notebook	For manual verification	1	Complex number functions required

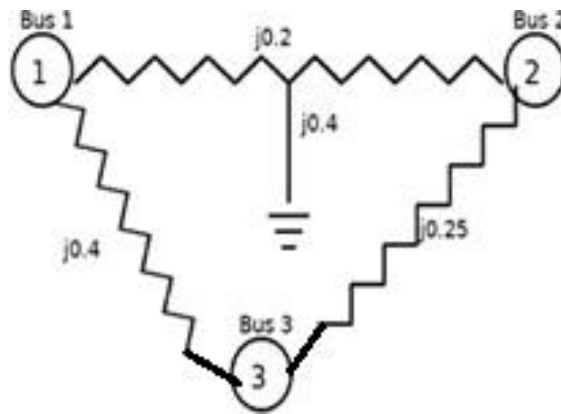
VIII. Precautions to be followed

1. Use correct reactance values while calculating admittance.
2. Enter imaginary values properly in Scilab.
3. Keep the bus numbering sequence correct.
4. Calculate diagonal and off-diagonal elements carefully.
5. Check that the final Y-bus matrix is symmetric.
6. Avoid typing errors in the script.
7. Verify manual calculations before running the program.

IX. Procedure

1. First, open Scilab software on your computer. Create a new script file by clicking on File → New → Script.
2. Write the given reactance values of the 3-bus system as imaginary quantities (since reactance is represented by jX in power systems).
3. Convert each reactance into admittance using the formula $y=1/jX$
4. Identify all buses and their interconnections (Bus-1 with Bus-2, Bus-1 with Bus-3, Bus-2 with Bus-3).
5. Calculate the self-admittance (diagonal elements) for each bus by adding all the admittances connected to that bus.
6. Calculate the mutual admittance (off-diagonal elements) by taking the negative of the branch admittance between the two buses.
7. Combine all values into a 3×3 Y-bus matrix in Scilab.
8. Run the Scilab program by pressing Ctrl + R or clicking Execute → Execute File.
9. Observe the displayed Y-bus matrix and verify that it is symmetric, which confirms correct calculation.
10. Record the results in your observation table and attach the Scilab output..

X. Consider equivalent 3-bus network diagram without ground(for example)



It assume the network is the simple 3-bus triangle with series reactances
 $X_{12}=j0.2$,
 $X_{13}=j0.4$,
 $X_{23}=j0.25$ and **no additional shunt** to ground.

Mathematical formula for Ybus elements:

- Diagonal elements: $Y_{ii}=\sum y_{ik}$ (sum of all admittances connected to bus i)
- Off-diagonal elements: $Y_{ij}=-y_{ij}$

The corresponding branch admittances are:

$$y_{12} = 1/j0.2 = -j5$$

$$y_{13} = 1/j0.4 = -j2.5$$

$$y_{23} = 1/j0.25 = -j4$$

The bus admittance matrix is then constructed as:

Ybus =

$$\begin{bmatrix} -j7.5 & j5 & j2.5 \\ j5 & -j9 & j4 \\ j2.5 & j4 & -j6.5 \end{bmatrix}$$

$$\begin{bmatrix} j5 & -j9 & j4 \end{bmatrix}$$

$$\begin{bmatrix} j2.5 & j4 & -j6.5 \end{bmatrix}$$

XII. Observation Table.

Sr.No.	Element	Manual Calculation	Scilab Output	Verification
1	Y_{11}	$-j7.5$		
2	Y_{12}	$j5$		
3	Y_{13}	$j2.5$		
4	Y_{22}	$-j9$		
5	Y_{23}	$j4$		
6	Y_{33}	$-j6.5$		

XIII. Result

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XIV. Interpretation of results

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XV. Conclusions and Recommendations (if any)

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XVI. Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. What is the significance of the Y-bus matrix in power system analysis?

XVII. References/ suggestions for further Reading

Sr.No.	Link	Description
1	https://help.scilab.org/docs/6.1.1/en_US/matrix.html	Official documentation on matrix handling in Scilab
2	https://www.youtube.com/watch?v=E551B5ep9F0	Power Flow Analysis-Bus Admittance Matrix Power System Analysis
3	https://circuitglobe.com/bus-admittance-matrix.html	Theory and formation rules

XVIII. Suggested Assessment Scheme

Performance Indicators		Weightage (%)
Process related: 15 Marks		60%
1	Identification of basic construction material	30%
2	Recording of Observations	30%
Product related: 10 Marks		40%
1	Interpretation of result	10%
2	Answer to practical related questions.	20%
3	Submission of report in time	10%
Total : 25 Marks		100%

Marks Obtained			Dated Sign of Teacher
Process Related (15)	Product Related (10)	Total (25)	

Practical No.14: Development of Ybus matrix by using software- case 2.

I. Practical Significance- This experiment demonstrates the process of forming the bus admittance matrix (Ybus) for a given 3-bus power system network. This experiment shows students how shunt admittances (line charging) affect the Ybus matrix. Including charging makes the model more realistic and is essential for accurate load flow studies.

II. Industry or Employer Expected Outcome-

Ability to model a power system network using an admittance matrix and perform system analysis such as load flow, short circuit studies, and stability assessment.

III. Course Level Learning Outcome-

CO5: Interpret the data required for Load flow studies

IV. Laboratory Learning Outcome-

LLO 14.1 Use Scilab to develop Ybus matrix for given 3- bus system-2

V. Relevant Affective domain related Outcome

Students will demonstrate systematic calculation, teamwork during verification, and attention to detail while forming matrices and validating results.

VI. Relevant Theoretical Background

In power system analysis, the bus admittance matrix (Ybus) represents the relationship between bus currents and voltages. It is derived from the line reactances or impedances connecting the buses. The Ybus matrix is symmetric and is fundamental for load flow and fault analysis.

The bus admittance matrix (Ybus) is a fundamental tool in power system analysis, providing a complete linear representation of the network. For a more accurate model, especially for medium and long transmission lines, the shunt admittance (primarily capacitance to ground) cannot be neglected. Formation of Ybus with Shunt Elements:

Series Admittance: The admittance of the line connecting two buses i and j is calculated as the inverse of the series impedance: $y_{ij} = 1 / (R_{ij} + jX_{ij})$.

Shunt Admittance: The total shunt admittance of a line (jB) is typically split equally and applied to the two buses at its ends. This accounts for the capacitive charging current of the line

VII. Resources required

Sr. No.	Particulars	Specification	Quantity	Remark
1	Computer System	Windows / Linux PC with Scilab 6.x	1	Minimum: 4GB RAM, 500GB HDD
2	Scilab Software	Open-source numerical tool	1 license per system	Latest version recommended
3	Reference Book	Nagrath & Kothari – Power System Engineering (3rd Ed.)	1	For theory reference
4	Scientific Calculator and Notebook	For manual verification	1	Complex number functions required

VIII. Precautions to be followed

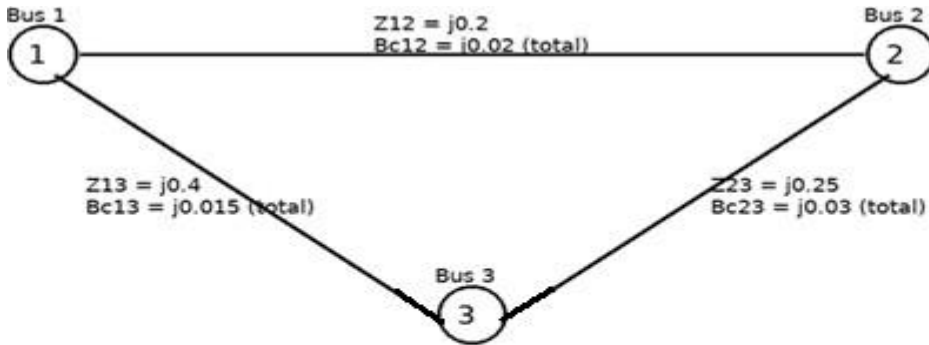
1. Use correct series reactance and shunt charging values while calculating admittances.
2. Enter imaginary values correctly in Scilab.
3. Maintain proper bus numbering (Bus-1, Bus-2, Bus-3).
4. While forming Y-bus, add shunt admittances only to diagonal elements.
5. Off-diagonal terms must be negative of branch admittances.
6. Avoid typing mistakes in the script and verify before running.
7. Cross-check manual calculations before comparing with software output.
8. Ensure the resulting Y-bus matrix is symmetric.

IX. Procedure

1. Open Scilab and create a new script file (File → New → Script).
2. Enter the given series reactance values and shunt charging values of the 3-bus system.
3. Convert each series reactance into series admittance using $y = 1 / jX$.
4. Write shunt charging admittances and add half of each line charging value at the respective buses.
5. Identify all line connections: Bus-1–2, Bus-1–3, Bus-2–3.
6. Calculate off-diagonal elements of Y-bus as the negative of branch admittances.
7. Calculate diagonal elements by adding series admittances connected to the bus and adding respective shunt charging admittances.

8. Form the 3×3 Y-bus matrix using these diagonal and off-diagonal values.
9. Enter this matrix in the Scilab script and execute the program using Ctrl + R.
10. Compare the obtained Y-bus matrix with manual values to confirm correctness.
11. Record the results in the observation table and attach the Scilab output.

X. Consider equivalent 3-bus network diagram without ground: (for example)



(a) One-line diagram (Case 2: with line charging)

Series admittances:

$$Y_{12} = 1/j0.2 = -j5$$

$$Y_{23} = 1/j0.25 = -j4$$

$$Y_{13} = 1/j0.4 = -j2.5$$

Shunt halves at each bus:

$$\text{Bus1: } j(0.01 + 0.0075) = j0.0175$$

$$\text{Bus2: } j(0.01 + 0.015) = j0.025$$

$$\text{Bus3: } j(0.0075 + 0.015) = j0.0225$$

Off-diagonals:

$$Y_{12} = j5,$$

$$Y_{23} = j4,$$

$$Y_{13} = j2.5$$

Diagonals:

$$Y_{11} = -j5 + (-j2.5) + j0.0175 = -j7.4825$$

$$Y_{22} = -j5 + (-j4) + j0.025 = -j8.975$$

$$Y_{33} = -j2.5 + (-j4) + j0.0225 = -j6.4775$$

XII. Observation Table

Sr.No.	Ybus Element	Manual Calculation (p.u.)	Scilab Output (p.u.)	Verification
1	Y_{11}	-j7.4825		
2	Y_{12}	j5		
3	Y_{13}	j2.5		
4	Y_{22}	-j8.975		
5	Y_{23}	j4		
6	Y_{33}	-j6.4775		

XIII. Result

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XIV. Interpretation of results

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XV. Conclusions and Recommendations (if any)

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XVII.References/ suggestions for further Reading

Sr.No.	Link	Description
1	https://help.scilab.org/docs/6.1.1/en_US/matrix.html	Official documentation for handling complex matrices in Scilab.
2	https://www.youtube.com/watch?v=S3AfVjde7bo	Power Systems Understanding Y Bus Matrix
3	https://www.scribd.com/document/548512703/Formation-Of-Y-bus-Matrix	The document describes forming the bus admittance matrix (Y-bus matrix) of a power system network using MATLAB

XVIII.Suggested Assessment Scheme

Performance Indicators		Weightage (%)
Process related: 15 Marks		60%
1	Identification of basic construction material	30%
2	Recording of Observations	30%
Product related: 10 Marks		40%
1	Interpretation of result	10%
2	Answer to practical related questions.	20%
3	Submission of report in time	10%
Total : 25 Marks		100%

Marks Obtained			Dated Sign of Teacher
Process Related (15)	Product Related (10)	Total (25)	

Practical No.15: Determination of effect on SLFE during the maintenance outages for given power system using relevant software.

I. Practical Significance- The Static Load Flow Equations (SLFE) are the fundamental mathematical representation of a power system's steady-state operation. Solving these nonlinear equations is crucial for planning, operation, and contingency analysis. This experiment demonstrates how the solution of the SLFE changes when the system topology is altered due to a maintenance outage, revealing critical information about new line power flows, bus voltages, and system stability.

II. Industry or Employer Expected Outcome-

The industry expects an engineer to be able to model a power system, formulate and solve the SLFE using computational tools, and interpret the results to assess the impact of contingencies, thereby ensuring secure and reliable system operation.

III. Course Level Learning Outcome-

CO5: Interpret the data required for Load flow studies

IV. Laboratory Learning Outcome-

LLO 15.1 Determine the effect on SLFE for given power system using relevant software like VLAB/Scilab.

V. Relevant Affective domain related Outcome

Cultivate a rigorous and analytical approach to power system analysis, demonstrating responsibility and precision in modeling and interpreting computational results.

VI. Relevant Theoretical Background

The Static Load Flow (SLF) refers to the change in real and reactive power flow in transmission lines when the system topology changes, such as during the outage of a line or transformer. This is analyzed using Power Flow (or Load Flow) studies.

- A Power Flow study calculates the voltage magnitude and angle at each bus, and the real and reactive power flows in each line under steady-state conditions.

- When a component is taken out for maintenance (an "N-1 contingency"), the power that was flowing through it must be redistributed through other paths according to Kirchhoff's laws. This redistribution can cause some lines to become overloaded and bus voltages to deviate beyond acceptable limits.
- Software tools like VLAB or SCILAB (with dedicated toolboxes like Powerlib in SCILAB or equivalent) solve the set of non-linear power flow equations using numerical methods like Newton-Raphson or Gauss-Seidel. SLFE (Static Load Flow Equation) is used to estimate the power flow in a transmission line under simplified assumptions:

$$P_{ij} = \delta_i - \delta_j / X_{ij}$$

Where:

- P_{ij} = Power flow from bus i to bus j
- δ_i, δ_j = Bus voltage angles
- X_{ij} = Line reactance

During a maintenance outage, one line is removed. This changes the network topology and power is redistributed through other lines.

This study helps identify:

- Lines that become overloaded
- Changes in bus angles
- System stability concerns

VII. Resources required

Sr. No.	Particulars	Specification	Quantity	Remark
1	Computer System	Windows / Linux PC with Scilab 6.x	1	Minimum: 4GB RAM, 500GB HDD
2	VLAB / SCILAB with Power System Toolbox	Open-source numerical tool	1	Latest version recommended
3	Reference Book	Nagrath & Kothari – Power System Engineering (3rd Ed.)	1	For theory reference
4	Scientific Calculator and Notebook	For manual verification	1	Complex number functions required

VIII. Precautions to be followed

1. Ensure the software is properly installed and licensed (if applicable).
2. Double-check all input parameters (bus data, line data) for accuracy before running the simulation.
3. Save the project file after the base case simulation before proceeding with contingency analysis.
4. Interpret the results carefully, noting the units (per-unit vs. actual values).

IX. Procedure

1. Launch the power system simulation software (e.g., SCILAB/VLAB).
2. Draw the single-line diagram for the 3-bus system.
3. Input the specifications for all buses (type, voltage, load/generation) and transmission lines (resistance, reactance, susceptance).
4. Run the Power Flow analysis for the Base Case (all lines in service). Record the real and reactive power flow in all lines and the voltage at all buses.
5. Simulate the Maintenance Outage Case by disconnecting Line 2-3 from the circuit.
6. Run the Power Flow analysis again for this contingency case.
7. Record the new real and reactive power flows and bus voltages.

1. Given data(for example)

Analyze the following 3-Bus power system:

Bus Data:

Bus	Type	Generation (P, Q)	Load (P, Q)	Voltage Setpoint
1	Slack	-	-	1.06 ∠ 0° pu
2	PQ	-	1.2 + j0.6 pu	-
3	PV	1.0 pu	0.8 + j0.4 pu	1.03 pu

Line Data (Impedance in pu on 100 MVA base):

Line	Resistance (R)	Reactance (X)	Charging (B/2)
1-2	0.02	0.15	0.02
2-3	0.025	0.20	0.025

Line	Base Case P (pu)	Outage Case P (pu)	Change (ΔP)
1-2			
2-3			
1-3			

XII. Result

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XIII. Interpretation of results

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XIV. Conclusions and Recommendations (if any)

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XV. Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. What is the primary purpose of a Slack Bus in a load flow study, and why did its voltage remain unchanged during the outage?

2. Define the term "Shift in Line Flow" (SLF) in your own words, based on what you observed in your experiment.

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XVI. References/ suggestions for further Reading

Sr.No.	Link	Description
1	https://www.vlab.co.in/	Official VLAB portal - Access the power system simulation tool used in this experiment.
2	https://circuitglobe.com/power-system.html	Circuit Globe Power System Articles - Detailed explanations of power system concepts.
3	https://www.ieee.org/	IEEE Xplore Digital Library - Research papers on power system analysis (access through institution).

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