ATME COLLEGE OF ENGINEERING

13th KM Stone, Bannur Road, Mysore - 570028

DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGINEERING

(ACADEMIC YEAR 2024-25)

LABORATORY MANUAL

Course: Power System Analysis I- IPCC Lab

Code: BEE601

Semester: VI

Prepared by,

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INSTITUTIONAL MISSION AND VISION

VISION:

- Development of academically excellent, culturally vibrant, socially responsible and globally competent human resources.

MISSION:

- To keep pace with advancements in knowledge and make the students competitive and capable at the global level.
- To create an environment for the students to acquire the right physical, intellectual, emotional and moral foundations and shine as torchbearers of tomorrow's society.
- To strive to attain ever-higher benchmarks of educational excellence.

DEPARTMENT MISSION AND VISION

VISION:

- To create Electrical and Electronics Engineers who excel to be technically competent and fulfill the cultural and social aspirations of the society.

MISSION:

- To provide knowledge to students that builds a strong foundation in the basic principles of electrical engineering, problem solving abilities, analytical skills, soft skills and communication skills for their overall development.
- To offer outcome based technical education.
- To encourage faculty in training & development and to offer consultancy through research & industry interaction

PROGRAMME OUTCOMES AND PROGRAMME EDUCATIONAL OBJECTIVES

Program outcomes (POs)

Engineering Graduates will be able to:

PO1. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2. **Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO6. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11. **Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Educational Objectives (PEOs)

PEO1: To produce competent and ethical Electrical and Electronics Engineers who will exhibit the necessary technical and managerial skills to perform their duties in society.

PEO2: To make Graduates continuously acquire and enhance their technical and socio-economic skills.

PEO3: To aspire Graduates on R&D activities leading to offering solutions and excel in various career paths.

PEO4: To produce quality engineers who have the capability to work in teams and contribute to real time projects.

PROGRAM SPECIFIC OUTCOMES (PSOs)

Graduates will develop the abilities to:

PSO1: Apply the concepts of Electrical & Electronics Engineering to evaluate the performance of power systems and also to control industrial drives using power electronics.

PSO2: Demonstrate the concepts of process control for Industrial Automation, design models for environmental and social concerns and also exhibit continuous self- learning.

Power System Analysis I -IPCC Laboratory

Course Objective

1. To introduce the per unit system and explain its advantages and computation.
2. To explain the concept of one line diagram and its implementation in problems.
3. To explain the necessity and conduction of short circuit analysis.
4. To explain analysis of three phase symmetrical faults on synchronous machine and simple power systems.
5. To discuss selection of circuit breaker.
6. To explain symmetrical components, their advantages and the calculation of symmetrical components of voltages and currents in un-balanced three phase circuits.
7. To explain the concept of sequence impedance and its analysis in three phase unbalanced circuits.
8. To explain the concept of sequence networks and sequence impedances of an unloaded synchronous generator, transformers and transmission lines.
9. To explain the analysis of synchronous machine and simple power systems for different unsymmetrical faults using symmetrical components.
10. To discuss the dynamics of synchronous machine and derive the power angle equation for a synchronous machine.
11. Discuss stability and types of stability for a power system and the equal area criterion
12. for the evaluation of stability of a simple system.

Course Outcomes:

At the end of the course the student will be able to:

1. Model the power system components & construct per unit impedance diagram of power system. [L2]
2. Analyze three phase symmetrical faults on power system [L4].
3. Compute unbalanced phasors in terms of sequence components and vice versa, also develop sequence networks [L3].
4. Analyze various unsymmetrical faults on power system [L4].
5. Examine dynamics of synchronous machine and determine the power system stability. [L3]

Power System Analysis I-IPCC Laboratory

Course Code	BEE601	CIE Marks	50
Hours/Week	4 Hours Theory + 3 Hours Lab slot	SEE Marks	50
Total Hours	50 Hours Theory + 10 Lab Slots	Exam Hours	3

SL No.	Experiment	PO	CO
1	Write a program to draw power angle curves for salient and non-salient pole synchronous machines, reluctance power, excitation, EMF, and regulation.	PO1, PO2, PO5, PO6	CO5
2	Write a program to calculate Sag of a transmission line for i) Poles at equal height ii) Poles at unequal height.	PO1, PO5, PO7	CO1
3	Write a program to determine the efficiency, Regulation, ABCD parameters for short and long transmission line and verify AD-BC=1.	PO2, PO3, PO5, PO6	CO1
4	Write a program to determine the efficiency, Regulation, and ABCD parameters for medium transmission line for i) Π-configuration ii) T- Configuration and verify AD-BC=1.	PO2, PO3, PO5, PO6	CO1
5	Write a program to calculate sequence components of line voltages given the unbalanced phase voltages.	PO3, PO5, PO8	CO3
6	Write a program to calculate the sequence components of line currents, given the unbalanced phase currents in a three-phase i) 3-wire system ii) 4-wire system.	PO3, PO5, PO8	CO3
7	Determination of fault currents and voltages in a single transmission line for i) Single Line to Ground Fault ii) Line to Line Fault iii) Double Line to Ground Fault Using suitable simulating software package.	PO4, PO5, PO9	CO4
8	Determination of fault currents and voltages in a single transmission line for Three-phase Fault Using suitable simulating software package.	PO4, PO5, PO9	CO2
9	Write a program to obtain critical disruptive voltage for various atmospheric and conductor conditions.	PO1, PO5, PO7	CO1
10	Write a program to evaluate transient stability of single machine connected to infinite bus.	PO5, PO5, PO10	CO5

TEXT BOOKS:

1. Modern Power System, D. P. Kothari, McGraw Hill, 4th Edition, 2011.

List of Reference Books:

1. Elements of Power System, William D. Stevenson Jr, McGraw Hill, 4th Edition, 1982.
2. Power System Analysis and Design, J. Duncan Gloveretal, Cengage, 4th Edition, 2008.
3. Power System Analysis, Hadi Sadat, McGraw Hill,1stEdition,2002.

SL No.	Cycle of Experiments
Cycle-I	
1	Write a program to draw power angle curves for salient and non-salient pole synchronous machines, reluctance power, excitation, EMF, and regulation.
2	Write a program to calculate Sag of a transmission line for i) Poles at equal height ii) Poles at unequal height.
3	Write a program to determine the efficiency, Regulation, ABCD parameters for short and long transmission line and verify AD-BC=1.
4	Write a program to determine the efficiency, Regulation, and ABCD parameters for medium transmission line for i) Π- configuration ii) T-Configuration and verify AD-BC=1.
5	Write a program to obtain critical disruptive voltage for various atmospheric and conductor conditions.
Cycle-II	
6	Write a program to calculate sequence components of line voltages given the unbalanced phase voltages.
7	Write a program to calculate the sequence components of line currents, given the unbalanced phase currents in a three-phase i) 3-wire system ii) 4-wire system.
8	Determination of fault currents and voltages in a single transmission line for i) Single Line to Ground Fault ii) Line to Line Fault iii) Double Line to Ground Fault Using suitable simulating software package.
9	Determination of fault currents and voltages in a single transmission line for Three-phase Fault Using suitable simulating software package.
10	Write a program to evaluate transient stability of single machine connected to infinite bus.

Experiment No.1

Power Angle Diagrams

Write a program to draw power angle curves for salient and non-salient pole synchronous machines, reluctance power, excitation, EMF, and regulation.

Problem

A 34.64 kV, 60 MVA synchronous generator has a direct axis reactance of 13.5 ohms and quadrature axis reactance of 9.333 ohms is operating at 0.8 p.f. Determine the excitation e.m.f, regulation, reluctance power and also plot the power angle diagram.

a. **Program For Salient pole Synchronous machine:**

```
clc
clear
%Power Angle diagram for salient pole synchronous machines
%Power angle curve
P=input('Power in MW =');
pf=input('Power Factor =');
Vt=input('Line to Line Voltage in kV =');
Xd=input('Xd in Ohms =');
Xq=input('Xq in Ohms =');
Vtph=Vt*1000/sqrt(3);            % Per phase Voltage
pf_a=acos(pf);
Q=P*tan(pf_a);
I=(P-j*Q)*1000000/(3*Vtph);            % Current in Amps
delta=0:1:180;
delta_rad=delta*(pi/180);
if Xd~=Xq
   %Salient Pole Synchronous Motor
   Eq=Vtph+(j*I*Xq);
   Id_mag=abs(I)*sin(angle(Eq)-angle(I));
   Ef_mag=abs(Eq)+((Xd-Xq)*Id_mag);
   Exitation_emf=Ef_mag
   Reg=(Ef_mag-abs(Vtph))*100/abs(Vtph)
   PP=Ef_mag*Vtph*sin(delta_rad)/Xd;
   Reluct_Power=Vtph^2*(Xd-Xq)*sin(2*delta_rad)/(2*Xd*Xq);
   Net_Reluct_Power=3*Reluct_Power/1000000;
   Power_sal=PP+Reluct_Power;

   Net_Power_sal=3*Power_sal/1000000;
   plot(delta,Net_Reluct_Power,'K');
```

```
    hold on
    plot(delta,Net_Power_sal,'r');
    xlabel('\Delta(deg) -------- >');
    ylabel('Three Phase Power(pu)-------- >');
    title('Plot:Power Angle Curve for Salient Synchronous M/c');
    legend('Reluct Power','Salient Power');
end
grid;
```

Input:

1. Power in MW
2. Power factor
3. Line to Line Voltage level in kV
4. X_d in ohms
5. X_q in ohms

Output:

1. Exitation e.m.f in kV
2. Regulation in %
3. Plot of Delta v/s Reluctance Power for Salient pole & Non salient pole m/cs.

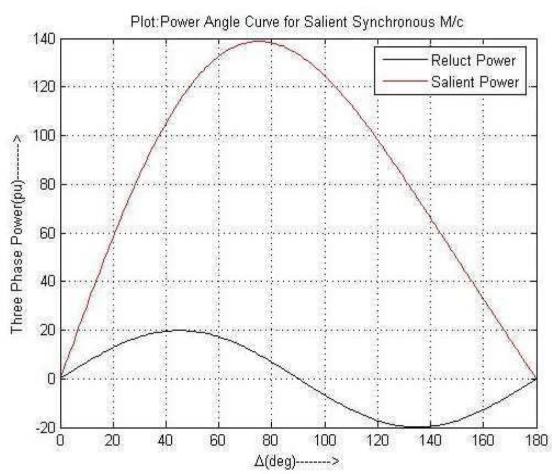
Input Data: from the keyboard: (Salient Pole)

P = 48	Power in MW
Pf = 0.8	Power Factor
V = 34.64	Line to Line Voltage in kV
X_d = 13.5	X_d in ohm
X_q = 9.33	X_q in ohm

Output:

Excitation EMF = 30000 Volts/ phase

Regulation = 50.0024 %



b. Program For Non-Salient pole Synchronous machine:

```
clc
clear
%Power Angle diagram for non-salient pole synchronous machines
%Power angle curve
P=input('Power in MW =');
pf=input('Power Factor =');
Vt=input('Line to Line Voltage in kV =');
Xd=input('Xd in Ohms =');
Xq=input('Xq in Ohms =');
Vtph=Vt*1000/sqrt(3);                    % Per phase Voltage
pf_a=acos(pf);
Q=P*tan(pf_a);
I=(P-j*Q)*1000000/(3*Vtph);              % Current in Amps
delta=0:1:180;
delta_rad=delta*(pi/180);
  if Xd==Xq
     %Non-Salient Pole Synchronous Motor
     Ef=Vtph+(j*I*Xd);
     Exitation_emf=abs(Ef)
     Reg=(abs(Ef)-abs(Vtph))*100/abs(Vtph)
     Power_non=abs(Ef)*Vtph*sin(delta_rad)/Xd;
     Net_Power=3*Power_non/1000000;
     plot(delta,Net_Power);
     xlabel('\Delta(deg) -------- >');
     ylabel('Three Phase Power(MW) -------- >');
     title('Plot:Power Angle Curve for Non-Salient Synchronous M/c');
     legend('Non-Salient Power');
  end
  grid;
```

INPUT REQUIRED AND OUTPUT EXPECTED:

Input:

1. Power in MW
2. Power factor
3. Line to Line Voltage level in kV
4. X_d in ohms
5. X_q in ohms

Output:

1. Excitation e.m.f in kV
2. Regulation in %
3. Plot of Delta v/s Reluctance Power for Salient pole & Non salient pole m/cs

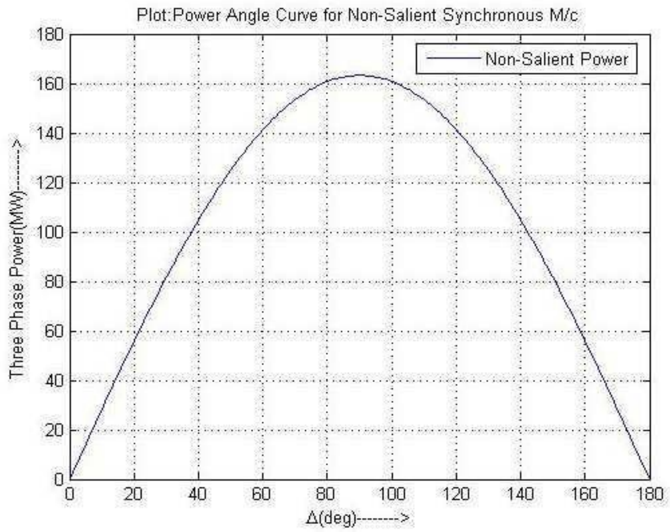
Input Data: from the keyboard: (Non-Salient Pole)

P = 48	Power in MW
Pf = 0.8	Power Factor
V = 34.64	Line to Line Voltage in kV
$X_d = 10$	X_d in ohm
$X_q = 10$	X_q in ohm

Output:

Excitation EMF = 27203 Volts/ phase

Regulation = 36.01 %



Experiment No.2

Sag Calculation for Transmission Lines

Write a program to calculate Sag of a transmission line for:

i) **Poles at equal height**

ii) **Poles at unequal height**

Problem

A transmission line is suspended between two poles. Calculate the sag in the conductor for the following two cases:

i) When both poles are at equal height.

ii) When the poles are at unequal height.

Given Data:

Weight of the conductor per unit length: w = 0.8 N/m

Span length between poles: L = 200 m

Tension in the conductor: T = 3000 N

Height difference between poles: h = 10 m

Program:

```
% Given Data
w = 0.8;     % Weight of conductor per unit length (N/m)
L = 200;     % Span length (m)
T = 3000;    % Tension in conductor (N)
h = 10;      % Height difference between poles (m)

disp('Sag Calculation for Transmission Lines')

disp('1. Sag for Poles at Equal Height:')
S_equal = (w * L^2) / (8 * T);
disp(['Sag (S) = ', num2str(S_equal), ' meters'])

disp('2. Sag for Poles at Unequal Height:')
L1 = L/2 * (1 + (2*h/L));
L2 = L - L1;
S1 = (w * L1^2) / (2 * T);
S2 = (w * L2^2) / (2 * T);
disp(['Sag from lower support (S1) = ', num2str(S1), ' meters'])
disp(['Sag from higher support (S2) = ', num2str(S2), ' meters'])
```

Expected Output:

```
Sag Calculation for Transmission Lines
1. Sag for Poles at Equal Height:
Sag (S) = 1.3333 meters
2. Sag for Poles at Unequal Height:
Sag from lower support (S1) = 1.6133 meters
Sag from higher support (S2) = 1.08 meters
Sag Calculation for Transmission Lines
1. Sag for Poles at Equal Height:
Sag (S) = 1.3333 meters
2. Sag for Poles at Unequal Height:
Sag from lower support (S1) = 1.6133 meters
Sag from higher support (S2) = 1.08 meters
```

Experiment No. 3

Determination of Efficiency and Regulation of Short and Long Transmission Line

Write a program to determine the efficiency, Regulation, ABCD parameters for short and long transmission line and verify AD-BC=1.

<u>Problem</u>

A 3-phase transmission line has:
Series impedance z=0.2+0.408i per km, shunt admittance y=0+3.14*10^{-6}i per km.
Length: 40 km for short line and 300 km for long line.
Find ABCD parameters, sending/receiving voltages & currents, efficiency, and voltage regulation for given Vr=132 kV, Ir=174.96-131.22i A

Program:

```
z=0.2+0.408i;y=0+3.14e-6i;
k1=input('\n Enter 1-for short line 2- for long line   ');
switch k1
case 1,
   length=40;
   Z=z*length;Y=y*length;
   A=1;B=Z;C=0;D=1;
case 2,
   length=300;
   zc=sqrt(z/y);
   gam=sqrt(z*y)*length;
   A=cosh(gam);
   D=A;
   B=zc*sinh(gam);
   C=1/zc*sinh(gam);
   fprintf('\n The equvalent PI cicuit constants:');
   zeq=z*length*sinh(gam)/gam;
   yeq=y*length/2*tanh(gam/2)/(gam/2);
   fprintf('\n     Zeq  = %15.4f %+15.4fi',real(zeq),imag(zeq));
   fprintf('\n     Yeq/2= %15.4f %+15.4fi',real(yeq),imag(yeq));
otherwise
   disp('wrong choice of tr.line');
end
fprintf('\nA,B,C and D constants : \n');
fprintf('----------------------------------------');
fprintf('\nA = %15.4f %+15.4fi',real(A),imag(A));
fprintf('\nB = %15.4f %+15.4fi',real(B),imag(B));
fprintf('\nC = %15.4f %+15.4fi',real(C),imag(C));
fprintf('\nD = %15.4f %+15.4fi',real(D),imag(D));
fprintf('\n The product AD-BC=%f',A*D-B*C);
k2=input('\n Enter 1 - To read Vr, Ir and compute Vs , Is \n      2 - To read Vs, Is and compute
Vr, Ir    ');
switch k2,
```

```
case 1,
   %vr=input('enter Vr/phase  ');
   %ir=input('enter Ir/phase  ');
   vr=132+0.0i;
   ir=174.96-131.22i;
   vr=vr*1e3/sqrt(3);
   vs=(A*vr+B*ir)/1e3;
   is=C*vr+D*ir;
   fprintf('\nSending end Voltage/ph=%f %+fi KV',real(vs),imag(vs));
   fprintf('\nSending end Current/ph=%f %+fi AMP',real(is),imag(is));
   vs=vs*1e3;


case 2,
   %vs=input('enter Vs/phase    ');
   %is=input('enter Is/phase    ');
   vs=132+0.0i;
   is=174.96-131.22i;
   vs=vs*1e3/sqrt(3.0);
   vr=(D*vs-B*is)/1e3;
   ir=-C*vs+D*is;
   fprintf('\nReceiving end Voltage/ph=%f %+fi KV',real(vr),imag(vr));
   fprintf('\nReceiving end Current/ph=%f %+fi AMP',real(ir),imag(ir));
   vr=vr*1e3;
otherwise
   disp('wrong choice');
end
rec_pow=3*real(vr*conj(ir))/1e6;
%rec_pow=3*abs(vr)*abs(ir)*cos(angle(vr)-angle(ir))/1e6;
send_pow=3*real(vs*conj(is))/1e6;
%send_pow=3*abs(vs)*abs(is)*cos(angle(vs)-angle(is))/1e6;
eff=rec_pow/send_pow*100;
reg=(abs(vs)/abs(A)-abs(vr))/abs(vr)*100;
fprintf('\n Receiving end power=%.2f KVA',rec_pow);
fprintf('\n Sending end power=%.2f KVA',send_pow);
fprintf('\n Efficiency=%.2f %%',eff);
fprintf('\n Voltage Regulation=%.2f%%',reg);
```

Expected Output

```
 Enter 1-for short line 2- for long line   1

A,B,C and D constants :
----------------------------------------
A =          1.0000        +0.0000i
B =          8.0000       +16.3200i
C =          0.0000        +0.0000i
D =          1.0000        +0.0000i
 The product AD-BC=1.000000
 Enter 1 - To read Vr, Ir and compute Vs , Is
      2 - To read Vs, Is and compute Vr, Ir    1

Sending end Voltage/ph=79.751426 +1.805587i KV
Sending end Current/ph=174.960000 -131.220000i AMP
 Receiving end power=40.00 KVA
 Sending end power=41.15 KVA
 Efficiency=97.21 %
 Voltage Regulation=4.67%>> 2


 Enter 1-for short line 2- for long line   2

 The equivalent PI cicuit constants:
     Zeq  =         57.7123       +120.6169i
     Yeq/2=          0.0000         +0.0005i
A,B,C and D constants :
----------------------------------------
A =          0.9428         +0.0277i
B =         57.7123       +120.6169i
C =         -0.0000         +0.0009i
D =          0.9428         +0.0277i
 The product AD-BC=1.000000
 Enter 1 - To read Vr, Ir and compute Vs , Is
      2 - To read Vs, Is and compute Vr, Ir    1

Sending end Voltage/ph=97.773395 +15.642655i KV
Sending end Current/ph=167.915908 -48.443896i AMP
 Receiving end power=40.00 KVA
 Sending end power=46.98 KVA
 Efficiency=85.15 %
 Voltage Regulation=37.75%>>
```

Experiment No. 4

Determination of Efficiency and Regulation of Medium Transmission Line

Write a program to determine the efficiency, Regulation and ABCD parameters for medium transmission line for i) Π- configuration ii) T- Configuration and verify AD-BC=1.

Problem

A 3-phase transmission line has:
Series impedance z=0.2+0.408i per km, shunt admittance y=0+3.14*10^{-6}i per km.
Length: 140 km for Medium transmission line.
Find ABCD parameters, sending/receiving voltages & currents, efficiency, and voltage regulation for given Vr=132 kV, Ir=174.96-131.22i A. Solve for Π- configuration and T-Configuration.

Program:

```
clc
clear
length=140;
z=0.2+0.408i;y=0+3.14e-6i;
k1=input('\n Enter 1-for Pi network 2-for T network ');
switch k1,case 1,
Z=z*length;
Y=y*length;
A=1+Y*Z/2;
B=Z;
C=Y*(1+Y*Z/4);
D=A;
case 2,
 Z=z*length;
 Y=y*length;
 A=1+Y*Z/2;
 B=Z*(1+Y*Z/4);
C=Y;
D=(1+Y*Z/2);
end
fprintf('\nA,B,C and D constants : \n');
fprintf('   ');
fprintf('\nA = %15.4f %+15.4fi',real(A),imag(A));
fprintf('\nB = %15.4f %+15.4fi',real(B),imag(B));
fprintf('\nC = %15.4f %+15.4fi',real(C),imag(C));
fprintf('\nD = %15.4f %+15.4fi',real(D),imag(D));
fprintf('\n The product AD-BC=%f',A*D-B*C);
k2=input('\n Enter 1 - To read Vr, Ir and compute Vs , Is \n    2 - To read Vs, Is and compute Vr, Ir   ');
switch k2, case 1,
%vr=input('enter Vr/phase ');
%ir=input('enter Ir/phase ');
vr=132+0.0i;
ir=174.96-131.22i;
vr=vr*1e3/sqrt(3);
vs=(A*vr+B*ir)/1e3;
```

```
is=C*vr+D*ir;
fprintf('\nSending end Voltage/ph=%f %+fi KV',real(vs),imag(vs));
fprintf('\nSending end Current/ph=%f %+fi AMP',real(is),imag(is));
vs=vs*1e3;

case 2,
%vs=input('enter Vs/phase   ');
%is=input('enter Is/phase   ');
vs=132+0.0i;
is=174.96-131.22i;
vs=vs*1e3/sqrt(3.0);
vr=(D*vs-B*is)/1e3;
ir=-C*vs+D*is;
fprintf('\nReceiving end Voltage/ph=%f %+fi KV',real(vr),imag(vr));
fprintf('\nReceiving end Current/ph=%f %+fi AMP',real(ir),imag(ir));
vr=vr*1e3;
otherwise
disp('wrong choice');
end
rec_pow=3*real(vr*conj(ir))/1e6;
%rec_pow=3*abs(vr)*abs(ir)*cos(angle(vr)-angle(ir))/1e6;
send_pow=3*real(vs*conj(is))/1e6;
%send_pow=3*abs(vs)*abs(is)*cos(angle(vs)-angle(is))/1e6;
eff=rec_pow/send_pow*100;
reg=(abs(vs)/abs(A)-abs(vr))/abs(vr)*100;
fprintf('\n Receiving end power=%.2f KVA',rec_pow);
fprintf('\n Sending end power=%.2f KVA',send_pow);
fprintf('\n Efficiency=%.2f %%',eff);
fprintf('\n Voltage Regulation=%.2f%%',reg);
```

Expected output:

```
 Enter 1-for Pi network 2-for T network 1

A,B,C and D constants :

A =          0.9874         +0.0062i
B =         28.0000        +57.1200i
C =         -0.0000         +0.0004i
D =          0.9874         +0.0062i
 The product AD-BC=1.000000
 Enter 1 - To read Vr, Ir and compute Vs , Is
    2 - To read Vs, Is and compute Vr, Ir   1

Sending end Voltage/ph=87.647584 +6.788583i KV
Sending end Current/ph=173.467869 -95.204051i AMP
 Receiving end power=40.00 KVA
 Sending end power=43.67 KVA
 Efficiency=91.59 %
 Voltage Regulation=16.82%>>
```

```
 Enter 1-for Pi network 2-for T network 2

A,B,C and D constants :

A =          0.9874         +0.0062i
B =         27.6485        +56.8476i
C =          0.0000         +0.0004i
D =          0.9874         +0.0062i
 The product AD-BC=1.000000
 Enter 1 - To read Vr, Ir and compute Vs , Is
    2 - To read Vs, Is and compute Vr, Ir   2

Receiving end Voltage/ph=62.956502 -5.848995i KV
Receiving end Current/ph=173.570962 -161.997782i AMP
 Receiving end power=35.62 KVA
 Sending end power=40.00 KVA
 Efficiency=89.06 %
 Voltage Regulation=22.06%>>
```

Experiment No. 5

Determination of Critical Disruptive Voltage for Various Atmospheric and Conductor Conditions

Write a program to obtain critical disruptive voltage for various atmospheric and conductor conditions

Problem: Determine the critical disruptive voltage for different atmospheric and conductor conditions. Consider the following cases.

Case 1:

Conductor radius: r = 0.01 m

Conductor spacing: D = 2 m

Dielectric strength of air: g_0 = 30 kV/cm = 3 MV/m

Surface irregularity factor: m_0 = 0.92

Air density correction factor: δ = 0.95

Case 2:

- **Conductor radius: r = 0.015 m**
- **Conductor spacing: D = 3 m**
- **Dielectric strength of air: g_0 = 28 kV/cm = 2.8 MV/m**
- **Surface irregularity factor: m_0 = 0.90**
- **Air density correction factor: δ = 0.98**

1. **Calculate the logarithmic term ln(D/r) for each case.**
2. **Compute the critical disruptive voltage V_d for each case.**
3. **Write and execute a MATLAB program to compute V_d for different conditions.**

Program:

```
clc;
  clear;
  % Define cases
  cases = [0.01, 2, 3e6, 0.92, 0.95;  % Case 1: r, D, g0, m0, delta
         0.015, 3, 2.8e6, 0.90, 0.98]; % Case 2
  for i = 1:size(cases, 1)
     r = cases(i, 1);
     D = cases(i, 2);
     g0 = cases(i, 3);
     m0 = cases(i, 4);
     delta = cases(i, 5);

     % Compute logarithmic term
     log_term = log(D/r);

     % Compute critical disruptive voltage
     Vd = g0 * m0 * delta * r * log_term;


     % Display Results
     fprintf('Case %d - Critical Disruptive Voltage: %.2f kV\n', i, Vd/1e3);
  end
```

Expected Result:

```
Case 1 - Critical Disruptive Voltage: 138.92 kV
Case 2 - Critical Disruptive Voltage: 196.27 kV
```

Experiment No.6

Write a program to calculate sequence components of line voltages given the unbalanced phase voltages.

Problem:

Calculate sequence components of line voltages given the unbalanced phase voltages.

Given unbalanced phase voltages:

Va = 230∠0°
Vb = 200∠120°
Vc = 210∠-120°

Step 1: Convert Polar to Rectangular Form

Va = 230 + j0
Vb = 200(-0.5 + j0.866) = -100 + j173.2
Vc = 210(-0.5 - j0.866) = -105 - j181.7

Step 2: Apply the Transformation Matrix

Performing the matrix multiplication step by step, we get:

[V_{a0}] = (1/3) * [1 1 1] [230]
[V_{a1}] [1 a a^2] [-100+j173.2]
[Va2] [1 a^2 a] [-105-j181.7]

Calculating each component:

V_{a0} = (230 - 100 - 105 + j(0 + 173.2 - 181.7)) / 3
= (25 - j8.5) / 3
= 8.33 - j2.83

V_{a1} = (230 + (-100 * (-0.5 + j0.866)) + (-105 * (-0.5 - j0.866))) / 3
= (230 + (50 - j86.6) + (52.5 + j90.8)) / 3
= (332.5 + j4.2) / 3
= 110.83 + j1.4

V_{a2} = (230 + (-100 * (-0.5 - j0.866)) + (-105 * (-0.5 + j0.866))) / 3
= (230 + (50 + j86.6) + (52.5 - j90.8)) / 3
= (332.5 - j4.2) / 3
= 110.83 - j1.4

MATLAB Code:

```
clc;
va = 200+0i;
vb = -84.52-181.26i;
vc = -51.764+193.18i;
a=-0.5+0.866i;
va0=1/3*(va+vb+vc);
```

```
va1=1/3*(va+(a*vb)+((a^2)*vc));
va2=1/3*(va+((a^2)*vb)+(a*vc));
% Display Results
disp('Zero Sequence Voltage:'), disp(va0)
disp('Positive Sequence Voltage:'), disp(va1)
disp('Negative Sequence Voltage:'), disp(va2)
```

Result

```
Zero Sequence Voltage:
  21.2387 + 3.9733i

Positive Sequence Voltage:
  1.9747e+002 -1.1439e+001i

Negative Sequence Voltage:
 -18.7089 + 7.4662i
```

Experiment No.7

Write a program to calculate the sequence components of line currents, given the unbalanced phase currents in a three-phase i) 3-wire system ii) 4-wire system.

Problem

In a 3hase system supplying power to a star load, the line currents when the neutral of the supply is not connected to the neutral of the load are Ia=20∠0° A, Ib =20∠-100° A. When the neutrals are connected, the current through the neutral wire is 12∠-30°, determine the line currents under this situation, also find the sequence components of currents for
i)3-wire system ii) 4-wire system.

MATLAB Code:

```
clc
% Given unbalanced phase currents
Ia = 20 +0i;
Ib = -3.473-19.696i;

% case(1): When neutral is not connected
%In=0;
%Ia+Ib+Ic=In=0;
Ic = -(Ia+Ib);

%case(2): When neutral is connected
In=10.39-6i;
Ia0=In/3; %In=3*Ia0

% New value of line currents when neutral is connected
Iaa=Ia0+Ia;
Ibb=Ia0+Ib;
Icc=Ia0+Ic;

%Sequence components-3 wire system
a=-0.5+0.866i;
Ia0=1/3*(Ia+Ib+Ic);
Ia1=1/3*(Ia+(a*Ib)+((a^2)*Ic));
Ia2=1/3*(Ia+((a^2)*Ib)+(a*Ic));

%Sequence components-4 wire system
Ia00=1/3*(Iaa+Ibb+Icc);
Ia11=1/3*(Iaa+(a*Ibb)+((a^2)*Icc));
Ia22=1/3*(Iaa+((a^2)*Ibb)+(a*Icc));

disp ('Line currents when neutral is connected_4 wire system')
disp ('-----------------------------------------------------------')
disp('current through phase-a:'), disp(Iaa)
disp(' current through phase-b:'), disp(Ibb)
disp(' current through phase-c:'), disp(Icc)
```

```
disp ('Sequence components of currents_3 wire system')
disp ('---------------------------------------------')
disp('Zero Sequence current:'), disp(Ia0)
disp('Positive Sequence current:'), disp(Ia1)
disp('Negative Sequence current:'), disp(Ia2)


disp ('Sequence components of currents_4 wire system')
disp ('--------------------------------------------')
disp('Zero Sequence current:'), disp(Ia00)
disp('Positive Sequence current:'), disp(Ia11)
disp('Negative Sequence current:'), disp(Ia22)
```

```
Line currents when neutral is connected_4 wire system
-------------------------------------------------------------
current through phase-a:
  23.4633 - 2.0000i

 current through phase-b:
  -0.0097 -21.6960i

 current through phase-c:
 -13.0637 +17.6960i

Sequence components of currents_3 wire system
----------------------------------------------
Zero Sequence current:
     0

Positive Sequence current:
  21.3709 + 3.7685i

Negative Sequence current:
  -1.3712 - 3.7685i

Sequence components of currents_4 wire system
---------------------------------------------
Zero Sequence current:
   3.4633 - 2.0000i

Positive Sequence current:
  21.3710 + 3.7685i

Negative Sequence current:
  -1.3712 - 3.7686i
```

Experiment No. 8

Determination of fault currents and voltages in a single transmission line for i) Single Line to Ground Fault ii) Line to Line Fault iii) Double Line to Ground Fault Using suitable simulating software package.

Problem:

A three phase generator with an open circuit voltage of 400V is subjected yo an LG fault through a fault impedance of j2Ω. Determine the fault current if Z1= j4 Ω, Z2= j2 Ω, Z0=j1 Ω. Also find the fault current for LL and LLG fault.

```
clc;
clear;
% Line-to-line voltage
V_ll = 400; % V
V_ph = V_ll / sqrt(3); % Line-to-neutral voltage (magnitude)
Ea = V_ph; % phasor form (angle 0)

% Sequence impedances
Z1 = 0+4i; % Positive sequence impedance
Z2 = 0+2i; % Negative sequence impedance
Z0 = 0+1i; % Zero sequence impedance
Zf = 0+2i; % Fault impedance

%% 1. LG Fault
I_lg = Ea / (Z1 + Z2 + Z0 + 3*Zf);
If_lg = 3 * abs(I_lg);

%% 2. LL Fault
I_ll = Ea / (Z1 + Z2 + Zf);
If_ll = sqrt(3) * abs(I_ll);

%% 3. LLG Fault
% I_a1 calculation
numerator = Z2 * (Z0 + 3*Zf);
denominator = Z2 + Z0 + 3*Zf;
Z_parallel = numerator / denominator;
I_a1 = Ea / (Z1 + Z_parallel);

% I_a0 using current division
I_a0 = -I_a1 * (Z2 / (Z2 + Z0 + 3*Zf));
If_llg = 3 * abs(I_a0);

%% Display results
fprintf('Fault Current Results:\n');
fprintf('----------------------\n');
fprintf('LG Fault Current  = %.2f A\n', If_lg);
fprintf('LL Fault Current  = %.2f A\n', If_ll);
fprintf('LLG Fault Current = %.2f A\n', If_llg);
```

Result:

```
Fault Current Results:
----------------------
LG Fault Current  = 53.29 A
LL Fault Current  = 50.00 A
LLG Fault Current = 27.71 A
```

Experiment No. 9

Determination of fault currents and voltages in a single transmission line for Three-phase Fault Using suitable simulating software package.

WAP to calculate the 3phase symmetrical fault current and voltage at fault location for given data
System voltage: 220 kV
Transmission line impedance: Z_t = 0.02 + j0.15 p.u.
Thevenin impedance at the bus: Z_s = 0.05 + j0.20 p.u.
Pre-fault voltage: 1.0 p.u.

MATLAB Code:

```
clc;
clear;

% Given Data
Zs = 0.05 + 1j*0.20;  % Thevenin equivalent impedance
Zt = 0.02 + 1j*0.15;  % Transmission line impedance
E = 1.0;              % Pre-fault voltage in p.u.

% Compute equivalent impedance
Zeq = Zs + Zt;

% Compute fault current
If = E / Zeq;

% Compute voltage at fault location
Vf = E - If * Zt;

% Display Results with Correct Formatting
fprintf('Fault Current (p.u.): %.4f < %.2f degrees\n', abs(If), angle(If)*180/pi);
fprintf('Fault Voltage at Fault Location (p.u.): %.4f < %.2f degrees\n', abs(Vf), angle(Vf)*180/pi);
```

Expected result:

```
Fault Current (p.u.): 2.8017 < -78.69 degrees
Fault Voltage at Fault Location (p.u.): 0.5776 < -2.73 degrees
```

Experiment No. 10

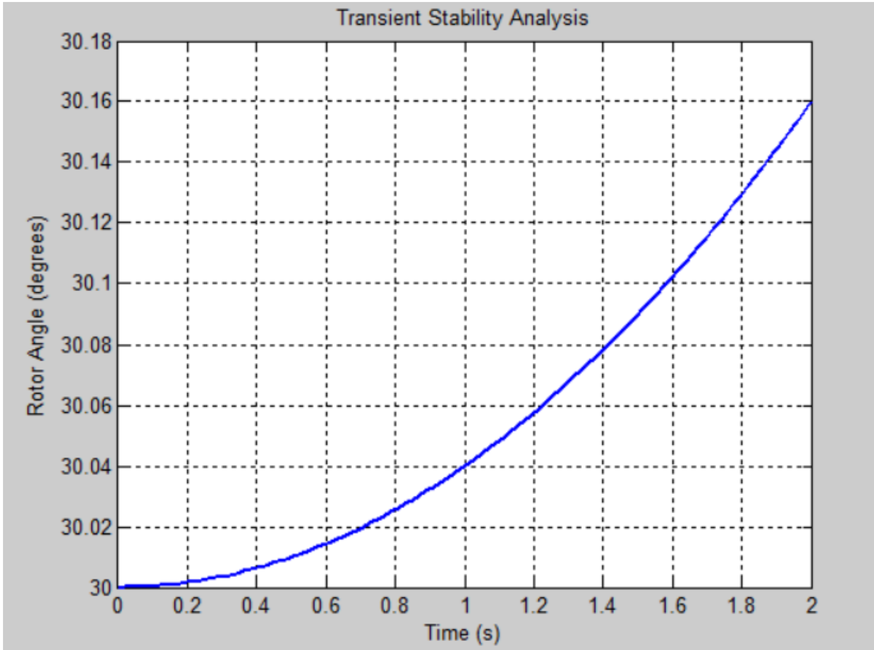
Transient stability of single machine connected to infinite bus

Write a program to evaluate transient stability of single machine connected to infinite bus for the following data.

System Inertia: M = 5 MJ-s/rad
Initial rotor angle: δ_0 = 30 degrees
Mechanical power: Pm = 0.9 p.u.
Electrical power before fault: Pe_1 = 0.9 p.u.
Electrical power after fault: Pe_2 = 0.5 p.u.

MATLAB Code:

```
clc;
clear;

% Given Data
M = 5;      % Inertia constant in MJ-s/rad
Pm = 0.9;   % Mechanical power input (p.u.)
Pe1 = 0.9;  % Electrical power before fault (p.u.)
Pe2 = 0.5;  % Electrical power after fault (p.u.)
delta0 = 30; % Initial rotor angle in degrees
t = linspace(0, 2, 100); % Time vector

% Compute acceleration power before and after fault
Pa1 = Pm - Pe1; % Before fault
Pa2 = Pm - Pe2; % After fault

% Solve swing equation using numerical integration
delta = delta0 + cumtrapz(t, (Pa2/M) * t);

% Plot Results
figure;
plot(t, delta, 'b', 'LineWidth', 2);
xlabel('Time (s)');
ylabel('Rotor Angle (degrees)');
title('Transient Stability Analysis');
grid on;

% Display Results
fprintf('Initial Acceleration Power: %.2f p.u.\n', Pa1);
fprintf('Acceleration Power After Fault: %.2f p.u.\n', Pa2);
```




```
Initial Acceleration Power: 0.00 p.u.
Acceleration Power After Fault: 0.40 p.u.
```