TP#1

Take a small power system of your choice, simulate it in PSCAD and demonstrate the Ferranti effect. Also show the effect of varying loading conditions on the voltage waveforms.

TP#2

Take a 3 bus radial system, with a transformer in between every two buses. SImulate it in MATLab Simulink. Model the T-lines as short T-lines, and load as the static load. Provide a periodic input of trapezoidal shape at the first bus, and plot the voltage waveforms at every bus of the system.

TP#3

Perform Economic Load Dispatch on IEEE 14-bus System using Power World Software.

TP#4

Take the IEEE 14-bus system, and write a MatLab code for computing DC load flow. Run it under the base case. Print results. Now write a MatLab code for ranking N-1 contingencies using GSF and LODF.

TP#5

(a) Create an IEEE 14 Bus system in PSCAD (Use Tline modeling). Datasheet for 14 Bus system has been attached along with. (Assume missing data if any and also mention in your report for the same along with calculations)

(i) Observe the voltages and currents at all the buses and transmission lines.

(b) Create a 3 phase LLL symmetrical fault between Bus 5 and Bus 4 in the middle at time t = 0.2 sec and clear the fault at t = 0.4 sec.

(i) Observe voltages at all the buses

(ii) Breaker Currents pre, post and during fault conditions

(iii) Active and Reactive power at bus 5 during all the scenarios

TP#6

Take the IEEE 14-bus system, and write a MatLab code for computing DC load flow. Run it under the base case. Print results. Now write a MatLab code for ranking N-1 contingencies using the direct flow security PI based method.

TP#7

Take a 3 bus radial system, with a transformer in between every two buses. SImulate it in PSCAD. Model the T-lines as short T-lines, and load as the static load. Provide a periodic input of trapezoidal shape at the first bus, and plot the voltage waveforms at every bus of the system.

TP#8

(a) Create an IEEE 9 Bus system in PSCAD (Use RL modeling). Datasheet for 9 Bus system has been attached along with. (Assume missing data if any and also mention in your report for the same along with calculations)

(i) Observe voltages and currents in all the buses

(b) Create a variable PQ load at bus 6 and vary the load non linearly (w.r.t square of time) from 10% to 90% of the given value in the dataset and run for a simulation time of 5 sec. Observe all the bus voltages and Active and Reactive power at bus 6.

(c) Observe the power factor at bus 6 using the FFT block.

TP#9

Take a small power system of your choice, simulate it in MATLab Simulink and demonstrate the Ferranti effect. Also show the effect of varying loading conditions on the voltage waveforms.

TP#10

(a) Create an IEEE 14 Bus system in PSCAD (Use Tline modeling). Datasheet for 14 Bus system has been attached along with. (Assume missing data if any and also mention in your report for the same along with calculations)

(i) Observe the voltages and currents at all the buses and transmission lines.

(b) Create an LG (A phase) fault at Bus 6 at 0.5 sec and a LLLG fault between Bus 2 and Bus 4 at 0.8 sec. Clear each fault after 0.2 sec and

(i) Observe voltages and currents at bus 6, bus 2 and bus 4 at pre, post and during fault scenarios.

(ii) Breaker currents during the same three conditions.

TP#11

Build a PSCAD Model consisting of 11kv, 50hz, three phase fixed source block feeding through an 11kv,415V, 0.75MVA delta –wye transformer to a 1 KW resistive load. Plot and observe the voltage and current waveforms under normal conditions for 1 second.

Now switch ON a capacitor at the load bus at 1 second, and observe the Capacitor switching transients in the voltage waveform.

Replace the load with a 100 Ohm resistor and parallel RC circuit having C= 0.1uF and R= 10 Ohm, fed through three parallel single phase bridge rectifiers. Observe the voltage waveforms and also show the harmonic contents in the voltage using the FFT block.

TP#12

Build and simulate IEEE 9 bus system in PSCAD as well as in POWERWORLD Simulator using the datasheet provided along with the problem. Perform the following tasks:

A. Analyze the impact of contingency using the Generator Shift Factor (GSF), Line Outage Distribution Factor (LODF), PI based ranking of various components etc.

B. Identify the weak buses in the system from part (a) and increase the active power (P) and reactive power (Q) demand at the top 3 weak load buses in the system. Plot the waveforms for fundamental rms voltages, voltage angles, injected active powers (P_i), injected reactive powers (Q_i) as well as PV curve at these load buses.

C. Identify the weak line in the system from part (a). Simulate a case study in which due to 3 phase fault at this critical line, the line gets opened. Plot the waveforms for fundamental rms voltages, voltage angles, injected active powers (P_i) as well as injected reactive powers (Q_i) at these load buses.

D. Now, let's assume that PMUs are installed at these weak load buses to measure fundamental rms voltages and angles. Export the data of these buses (For the case studies in both part (b) and part (c) of the question) with the sampling time of (1/60) sec in a separate excel sheet.

TP#13

Build and simulate IEEE 14 bus system in PSCAD software using the datasheet provided along with the problem. Perform the following tasks on the model:

A. Replace all of the static loads (Fixed loads) in the IEEE 14 bus system with the dynamic load models characterized by following equations:

$$P_{Li} = P_{L0}\,(1 + K_{Pi} * \lambda) \qquad (1)$$
$$Q_{Li} = Q_{L0}\,(1 + K_{qi} * \lambda) \qquad (2)$$

Where,
P_{Li} and Q_{Li} = Active and reactive power demand at the i^{th} dynamic load bus
P_{L0} and Q_{L0} = Steady state active and reactive power absorption or nominal active and reactive power load demand at the i^{th} dynamic load bus
K_{Pi} and K_{qi} = Constants which decides the direction of load increase at i^{th} bus
λ = Time dependent load varying parameter λ i.e. $\lambda = f(t)$

B. By considering the increasing nature of load-varying parameter λ wrt time in Part (1), observe the following waveforms in the output channel:

a. Fundamental voltages(rms) and angles at all load buses
b. Injected power (active and reactive) at all load buses
c. The PV and QV curve at bus 12, bus 13 and bus 14

C. Let's assume that PMUs are placed optimally at Bus 2, Bus 6 and Bus 9 such that the overall system becomes observable. PMUs are delivering the voltages and angles at that buses with the reporting rate of 60Hz. Hence, collect that voltage phasor data at these buses in excel sheet with sampling frequency of 60 Hz i.e. sampling time = (1/60 sec).

NOTE:

1. **The transmission lines in the test system must be modelled using Coupled PI section model of the transmission line.**
2. **Take K_{Pi} and K_{qi} as 1 for this simulation. λ should be increasing with simulation time.**
3. **Refer to the datasheet in case of any doubt regarding the test system.**

TP#14

Build and simulate IEEE 9 bus system in PSCAD software using the datasheet provided along with the problem. Perform the following tasks on the model:

A. Replace all of the static loads (Fixed loads) in the IEEE 9 bus system with the dynamic load models characterized by following equations:

$$P_{Li} = P_{L0}\,(1 + K_{Pi} * \lambda) \qquad (1)$$
$$Q_{Li} = Q_{L0}\,(1 + K_{qi} * \lambda) \qquad (2)$$

Where,
P_{Li} and Q_{Li} = Active and reactive power demand at the i^th dynamic load bus
P_{L0} and Q_{L0} = Steady state active and reactive power absorption or nominal active and reactive power load demand at the i^th dynamic load bus
K_{Pi} and K_{qi} = Constants which decides the direction of load increase at i^th bus
λ = Time dependent load varying parameter λ i.e. $\lambda = f(t)$

B. Consider the increasing nature of load-varying parameter λ in Part (1) in such a way that load active (P_{Li}) and reactive power (Q_{Li}) at individual bus should increase by 5MW and 5MVAr respectively at every 1 sec. Observe the following waveforms in the output channel:

a. Fundamental voltages(rms) and angles at all load buses
b. Injected power (active and reactive) at all load buses
c. The PV and QV curve at bus 5, bus 6 and bus 8.

C. Let's assume that PMUs are placed at Bus 5, Bus 6 and Bus 8. PMUs are delivering the voltages and angles at that buses to the Phasor Data Concentrator (PDC) with the reporting rate of 60Hz. Hence, collect that voltage phasor data at these buses in excel sheet with sampling frequency of 60 Hz i.e. sampling time = (1/60 sec).

<u>NOTE</u>:

1. **The transmission lines in the test system must be modelled using Coupled PI section model of the transmission line.**
2. **Take K_{Pi} and K_{qi} as 1 for this simulation.**
3. **Refer to the datasheet in case of any doubt regarding the test system.**

TP#15

Build the IEEE 5 bus system in POWERWORLD Simulator using the data sheet provided with the problem. Perform contingency analysis on the system to identify the weak transmission lines associated with the system. Now, build the same IEEE 5 bus system in PSCAD software and perform following tasks:

A. Create a single line to ground (SLG) fault at the most vulnerable line for a duration of 0.2 sec. After sometime a three phase to ground fault (LLLG) takes place at the second weakest transmission line. Circuit breakers are activated to isolate the transmission line with a delay of 0.02 sec. Observe the following waveforms:

  a. Fundamental voltages (rms), angles, injected active and reactive powers at all buses.
  b. Active and reactive power flows through the top 3 critical lines.

B. Let us assume that PMUs are installed at all buses. PMUs send data of voltage phasors (fundamental rms voltage and angles) to the Phasor Data Concentrator with the reporting rate of 60 Hz. Now, collect that received data in an excel sheet with the sampling time of (1/60) sec.

C. Simulate a different case study in which the most critical generator in the circuit is isolated from the power system network for scheduled maintenance. Gather PMU data (rms voltage and angle) from all of the buses in the network with sampling time of (1/60) sec.

<u>NOTE:</u>

1. **Consider fault location based on your choice.**
2. **Contingency ranking will provide the ranking of generators and T. lines based on their sensitivity.**
3. **Assume the data wherever necessary**

TP#16

Build the IEEE 9 bus system in POWERWORLD Simulator using the data sheet provided with the problem. Perform contingency analysis on the system to identify the weak transmission lines associated with the system. Now, build the same IEEE 9 bus system in PSCAD and perform following tasks:

A. Create a single line to ground (SLG) fault at the most vulnerable line for a duration of 0.2 sec. After sometime a three phase to ground fault (LLLG) takes place at the second weakest transmission line. Circuit breakers are activated to isolate the transmission line with a delay of 0.02 sec. Observe the following waveforms:

   a. Voltages (rms), angles, injected active and reactive power at all buses.
   b. Active and reactive power flows through all the lines.

B. Let us assume that PMUs are installed at all buses. PMUs send data of voltage phasors (rms voltage and angles) to the Phasor Data Concentrator with the reporting rate of 60 Hz. Now, collect that received data in an excel sheet with the sampling time of (1/60) sec.

C. Simulate a different case study in which the most critical generator in the circuit is isolated from the power system network for scheduled maintenance. Gather PMU data (rms voltage and angle) from all of the buses in the network with sampling time of (1/60) sec.

<u>NOTE:</u>

1. **Consider fault location based on your choice.**
2. **Contingency ranking will provide the ranking of generators and T. lines based on their sensitivity.**
3. **Assume data wherever necessary.**

TP#17

Build and simulate IEEE 5 bus system in PSCAD as well as in POWERWORLD Simulator using the datasheet provided along with the problem. Perform the following tasks:

A. Analyze the impact of contingency using the Generator Shift Factor (GSF), Line Outage Distribution Factor (LODF), PI based ranking of various components etc.

B. Identify the weak buses in the system from part (a) and increase the active power (P) and reactive power (Q) demand at the top 2 weak load buses in the system. Plot the waveforms for fundamental rms voltages, voltage angles, injected active powers (P_i), injected reactive powers (Q_i) as well as PV curve at these load buses.

C. Identify the weak line in the system from part (a). Simulate a case study in which due to 3 phase fault at this critical line, the line gets opened. Plot the waveforms for fundamental rms voltages, voltage angles, injected active powers (P_i) as well as injected reactive powers (Q_i) at these load buses.

D. Now, let's assume that PMUs are installed at these weak load buses to measure rms voltages and angles. Export the data of these buses (For the case studies in both part (b) and part (c) of the question) with the sampling time of (1/60) sec.

TP#18

Build a Simulink model consists of 11 kV, 30 MVA, 50 Hz three-phase source block feeding through a 11 kV/0.4 kV, 1 MVA delta/wye transformer to a 1 MW resistive load, and a single-phase bridge with 2,000 μF capacitive filter and 10 Ω resistive load for each phase. There are instantaneous waveform scopes located at 11 kV and 0.4 kV buses for measurement. Observe 11 KV and 0.4 KV bus voltage waveforms. Also use power gui block to analyze harmonic content in the waveforms.

Now replace the load with a 6-pulse controlled three-phase rectifier connected to a 600 V, 10 kW resistive and 1 kVA inductive load. Again carry out the harmonic analysis as before for any two pulse firing angles of your choice.

TP#19

(a) Create an IEEE 14 Bus system in PSCAD (Use RL modeling). Datasheet for 14 Bus system has been attached along with. (Assume missing data if any and also mention in your report for the same along with calculations)

(i) Observe voltages in all the buses

(b) Create a variable PQ load at bus 5 and vary the load non linearly (w.r.t square root of time) from 5% to 80% of the given value in the dataset and run for a simulation time of 4 sec. Observe all the bus voltages and Active and Reactive power at bus 5.

TP#20 (PSCAD)

Design an IEEE 5-Bus system in PSCAD/Simulink using the data given below. Create any fault at any one of the buses and operate the circuit breaker using the IDMT relay.

Now restore the system back to the original state and create different types of faults at the same bus . The desired relay plug setting is 150 % and the CT ratio is 400/5. Plot the standard IDMT characteristics i.e operating time of relay v/s PSM. Assume that the characteristics obtained above are for TMS = 1 . Again plot the standard IDMT characteristics for different TMS.

Assume any further information (the base values) is required and mention the same. Comment on the obtained results.

Table.1 Bus data

Bus Code P	Assumed Bus Voltage	Generation		Load	
		Megawatts	Megavars	Megawatts	Megavars
1	1.06 + j0.0	0	0	0	0
2	1.0 + j0.0	40	30	20	10
3	1.0 + j0.0	0	0	45	15
4	1.0 + j0.0	0	0	40	5
5	1.0 + j0.0	0	0	60	10

Table.1 Line data

Bus Code $p - q$	**Line impedance Z_{pq}**		**Line charging** $\sqrt{Y_{pq}/2}$
	R per unit	**X per unit**	
1 - 2	0.02	0.06	X per unit
1 - 3	0.08	0.24	0.0 + j0.025
2 - 3	0.06	0.25	0.0 + 0.020
2 - 4	0.06	0.18	0.0 + j0.020
2 - 5	0.04	0.12	0.0 + j0.015
3 - 4	0.01	0.03	0.0 + j0.010
4 - 5	0.08	0.24	0.0 + j0.025

TP#21 (Simulink)

Design an IEEE 5-Bus system in PSCAD/Simulink using the data given below. Create any fault at any one of the buses and operate the circuit breaker using the IDMT relay.
Now restore the system back to the original state and create different types of faults at the same bus . The desired relay plug setting is 150 % and the CT ratio is 400/5. Plot the standard IDMT characteristics i.e operating time of relay v/s PSM. Assume that the characteristics obtained above are for TMS = 1 . Again plot the standard IDMT characteristics for different TMS.
Assume any further information (the base values) is required and mention the same. Comment on the obtained results.

Table.1 Bus data

Bus Code P	Assumed Bus Voltage	Generation		Load	
		Megawatts	Megavars	Megawatts	Megavars
1	1.06 + j0.0	0	0	0	0
2	1.0 + j0.0	40	30	20	10
3	1.0 + j0.0	0	0	45	15
4	1.0 + j0.0	0	0	40	5
5	1.0 + j0.0	0	0	60	10

Table.1 Line data

Bus Code p – q	Line impedance Z_{pq}		Line charging $\sqrt{Y_{pq}/2}$
	R per unit	X per unit	
1 - 2	0.02	0.06	X per unit
1 - 3	0.08	0.24	0.0 + j0.025
2 - 3	0.06	0.25	0.0 + 0.020
2 - 4	0.06	0.18	0.0 + j0.020
2 - 5	0.04	0.12	0.0 + j0.015
3 - 4	0.01	0.03	0.0 + j0.010
4 - 5	0.08	0.24	0.0 + j0.025