

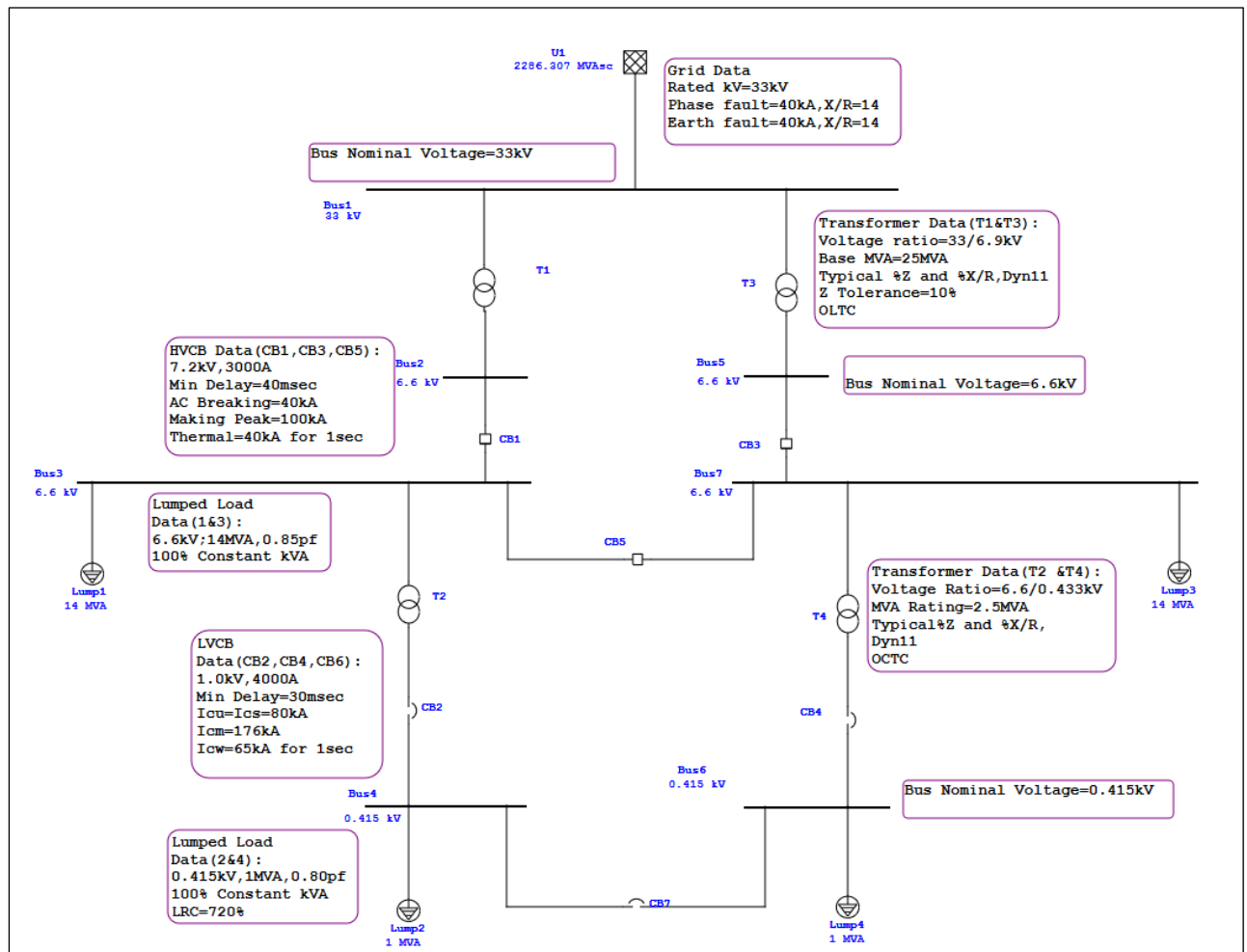
Faulted Motor Transients

Purpose and Description

The purpose of this exercise is to study the behavior of induction machine during faults. A loading shedding scenario will be explained using a voltage relay.

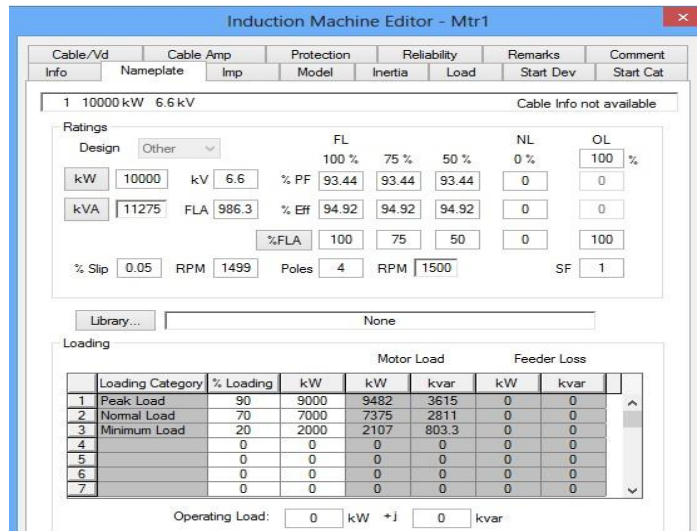
Procedure

1. Open LF-Example1.oti file from load flow exercise. Notice a single line diagram as shown below.



Faulted Motor Transients

2. Run a scenario 'Peak LFC' using scenario wizard.
3. Drag and drop an induction machine on OLV, connect it to Bus3 and proceed entering kW rating, poles & load factors as shown below. (Assume kW rating of Induction machine to 10000 to arrive at actual kW rating from Load flow results).



Induction Machine Editor - Mtr1

Cable/Vd	Cable Amp	Protection	Reliability	Remarks	Comment
Info	Nameplate	Model	Inertia	Start Dev	Start Cat
1	10000 kW 6.6 kV			Cable Info not available	

Ratings

Design: Other

FL: 100 % 75 % 50 % 0 % 100 %

NL: 0 %

OL: 100 %

kW: 10000 kV: 6.6 % PF: 93.44 93.44 93.44 0 0

kVA: 11275 FLA: 986.3 % Eff: 94.92 94.92 94.92 0 0

% FLA: 100 75 50 0 100

% Slip: 0.05 RPM: 1499 Poles: 4 RPM: 1500 SF: 1

Library: None

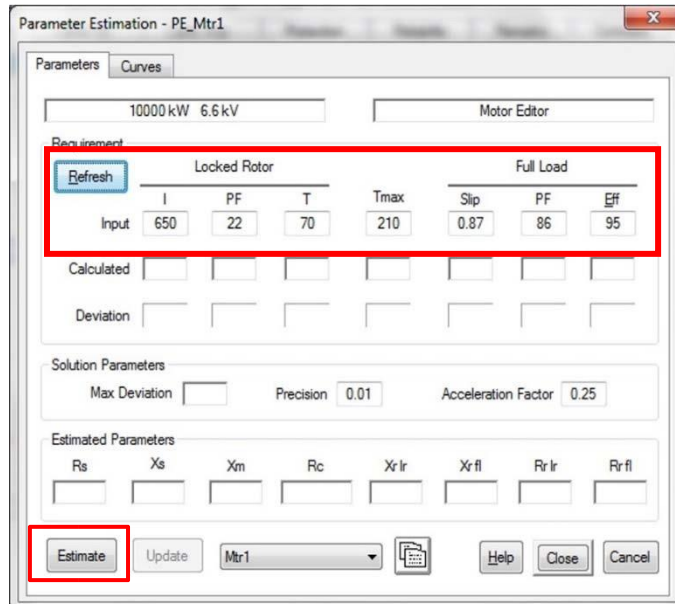
Loading

Loading Category	% Loading	Motor Load			Feeder Loss	
		kW	kW	kvar	kW	kvar
1 Peak Load	90	9000	9482	3615	0	0
2 Normal Load	70	7000	7375	2811	0	0
3 Minimum Load	20	2000	2107	803.3	0	0
4	0	0	0	0	0	0
5	0	0	0	0	0	0
6	0	0	0	0	0	0
7	0	0	0	0	0	0

Operating Load: 0 kW +j 0 kvar

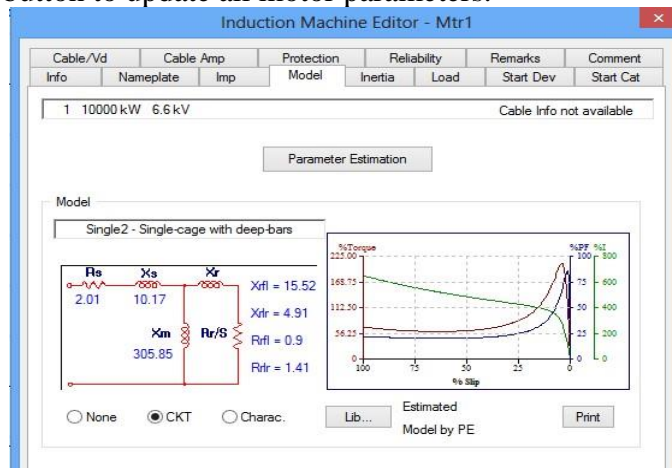
4. Go to Model Page, click on Parameter Estimation and enter locked rotor & full load data with 0.01 precision as shown below and click estimate.

Faulted Motor Transients



Requirement				Full Load			
	I	PF	T	Tmax	Slip	PF	Eff
Input	650	22	70	210	0.87	86	95
Calculated							
Deviation							

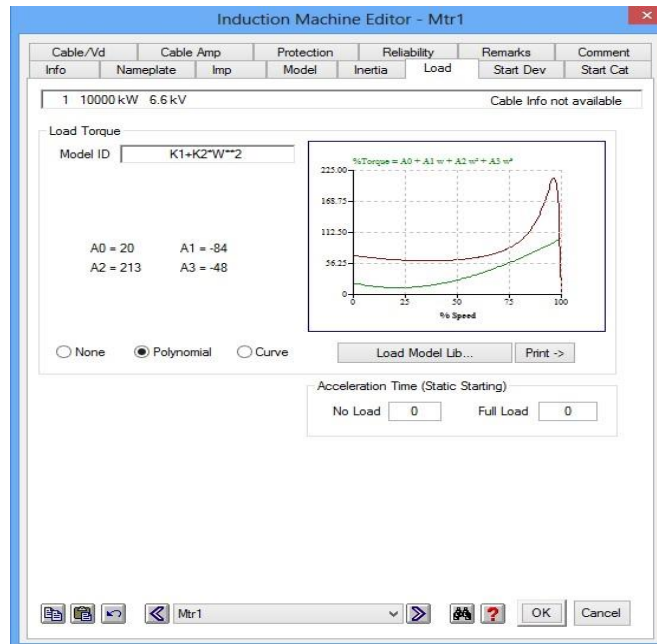
- Click on update button to update all motor parameters.



Note: Parameter estimation is an iterative process, the results of your calculation might be slightly different.

- Go to Load Page, check polynomial radio button & pick model “K1+K2.W**2” from Model ID dropdown button.

Faulted Motor Transients



7. Run peak load flow with both motor & lumped load.

For Peak load flow following results are obtained.

The lumped load consumption is 10710 kW & 6637 kVar and the motor consumption with 10000kW & 90% load factor is 9373 kW & 5827 kVar.

So to select right name plate kW instead of 10,000 kW and to achieve Motor consumption = Lumped load consumption = 10710 kW following calculation is performed.

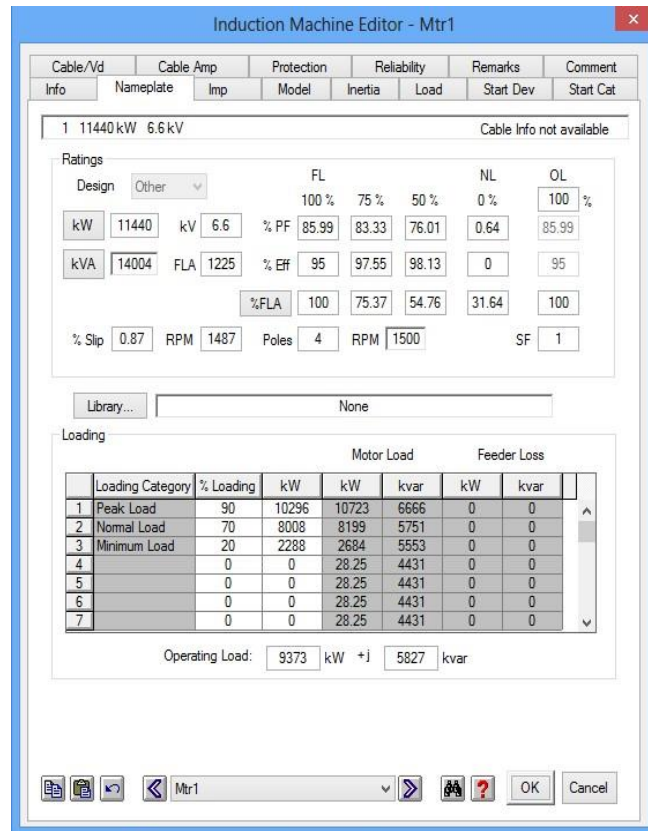
Consumption	Rating
9373 kW	10,000 kW
10710 kW	?

Motor Rating = $10710 \times 10000 / 9373$

= 11440 kW ... (Nameplate rating of equivalent motor)

8. Model dynamic motor at 6.6 kV voltage with above derived value as shown below.

Faulted Motor Transients



Induction Machine Editor - Mtr1

Cable/V/d	Cable Amp	Protection	Reliability	Remarks	Comment
Info	Nameplate	Imp	Model	Inertia	Load
1	11440 kW 6.6 kV				

Cable Info not available

Ratings

Design: Other

	FL	NL	OL
100 %	75 %	50 %	0 %
100 %	85.99	83.33	76.01
0.64	85.99		
14004	1225	95	97.55
95	98.13	0	95
100	75.37	54.76	31.64
100			

% Slip: 0.87 RPM: 1487 Poles: 4 RPM: 1500 SF: 1

Library: None

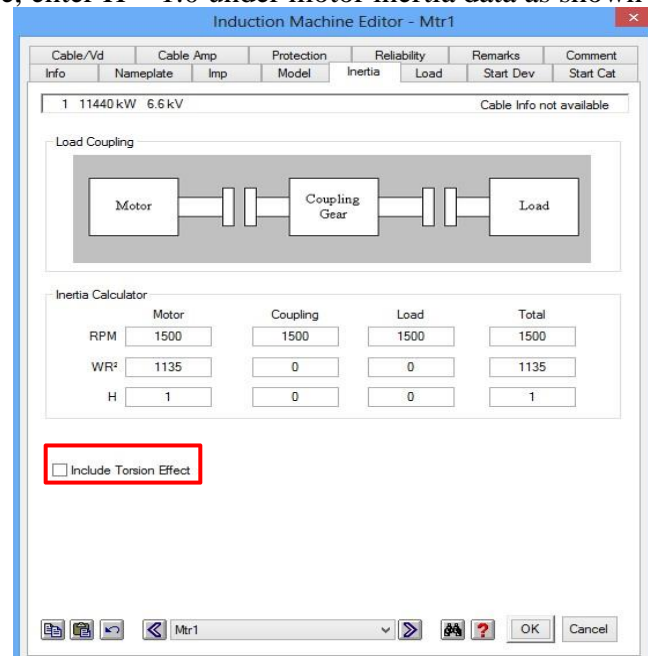
Loading

Loading Category	% Loading	Motor Load			Feeder Loss	
		kW	kvar	kW	kvar	
1 Peak Load	90	10296	10723	6666	0	
2 Normal Load	70	8008	8199	5751	0	
3 Minimum Load	20	2288	2684	5553	0	
4	0	0	28.25	4431	0	
5	0	0	28.25	4431	0	
6	0	0	28.25	4431	0	
7	0	0	28.25	4431	0	

Operating Load: 9373 kW +j 5827 kvar

Buttons: OK Cancel

9. Go to Inertia Page, enter $H = 1.0$ under motor inertia data as shown below.

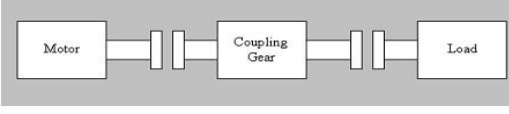


Induction Machine Editor - Mtr1

Cable/V/d	Cable Amp	Protection	Reliability	Remarks	Comment
Info	Nameplate	Imp	Model	Inertia	Load
1	11440 kW 6.6 kV				

Cable Info not available

Load Coupling



Inertia Calculator

Motor	Coupling	Load	Total
RPM: 1500	1500	1500	1500
WR ² : 1135	0	0	1135
H: 1	0	0	1

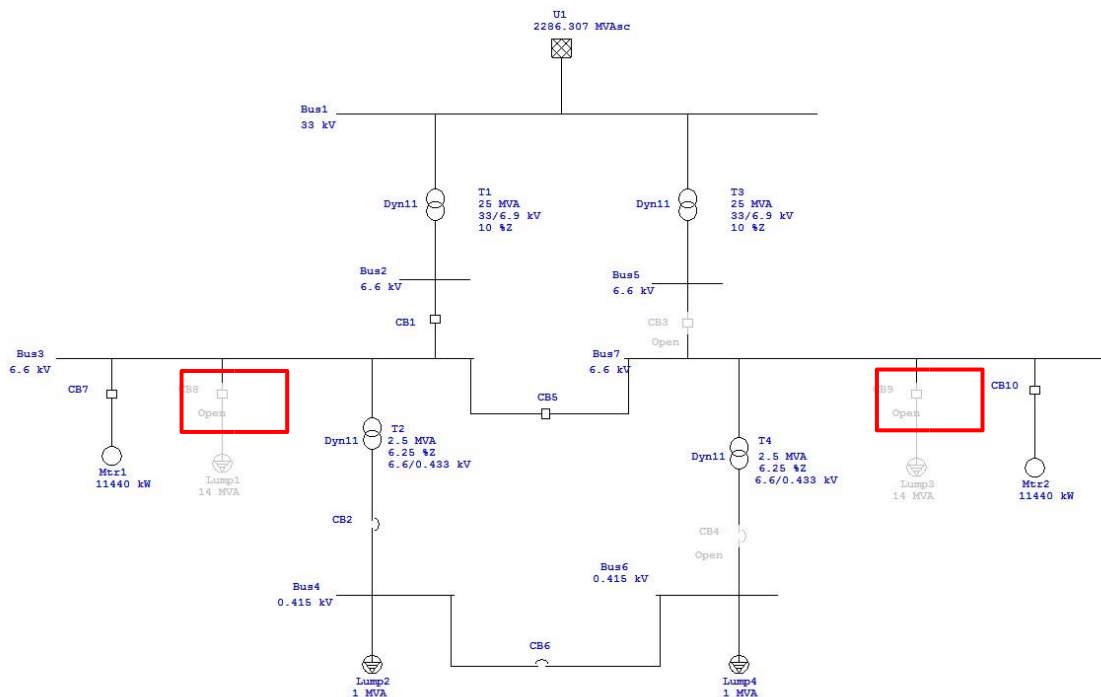
☐ Include Torsion Effect

Buttons: OK Cancel

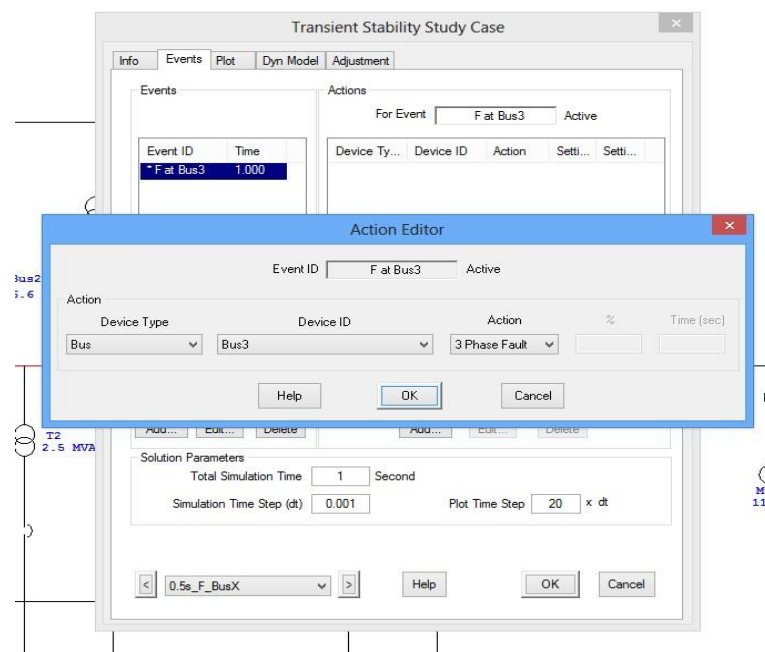
10. Copy left side bus final Dynamic bulk motor to right side bus.

11. Add HVCBs on lumped load and motor connected to Bus3 & Bus7. Open CB8 & CB9 as shown below.

Faulted Motor Transients

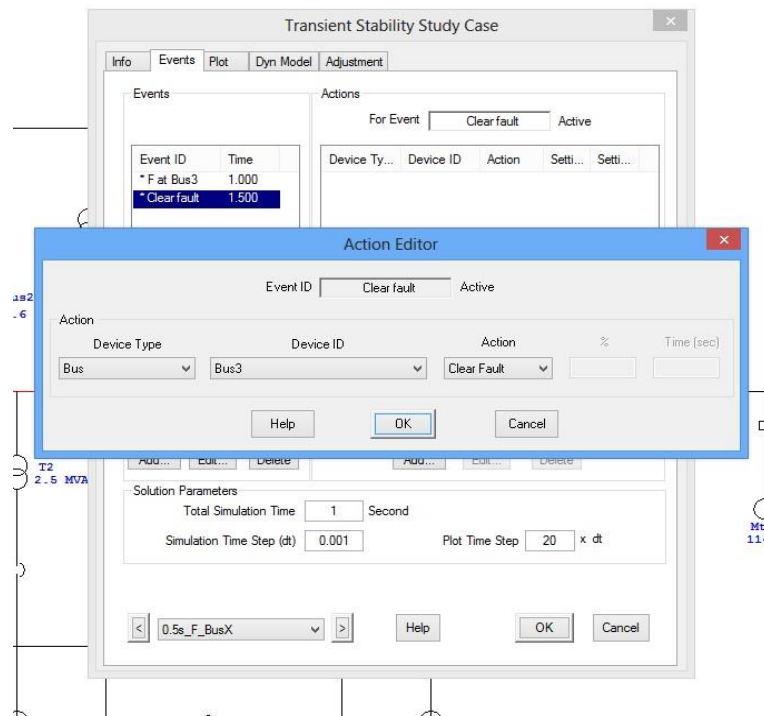


12. Go to transient analysis module, create a new study case with name “0.5s_F_BusX”.
13. Go to events page and create an event to simulate 3 phase fault on Bus 3 at 1 sec as shown below.

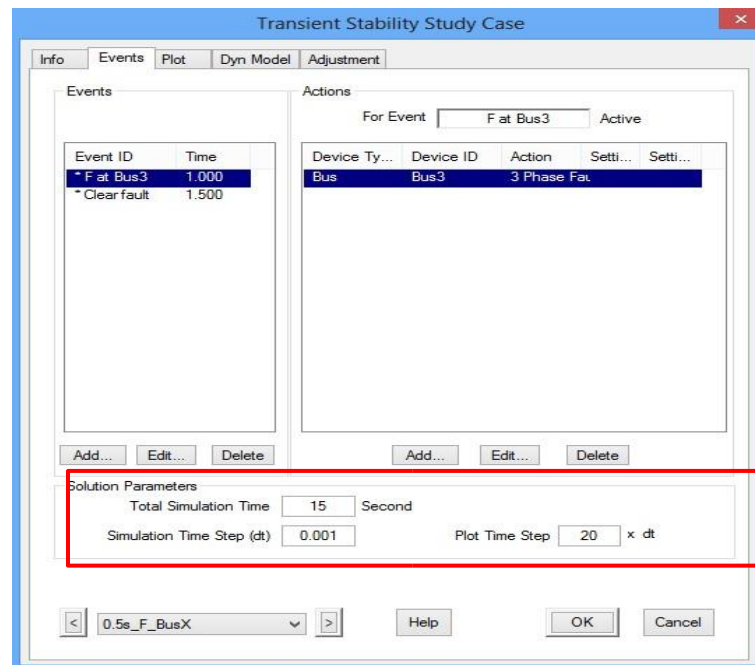


14. Similarly create one more event to clear the fault on Bus 3 at 1.5 sec. Add action for this event in Action Editor as shown below.

Faulted Motor Transients

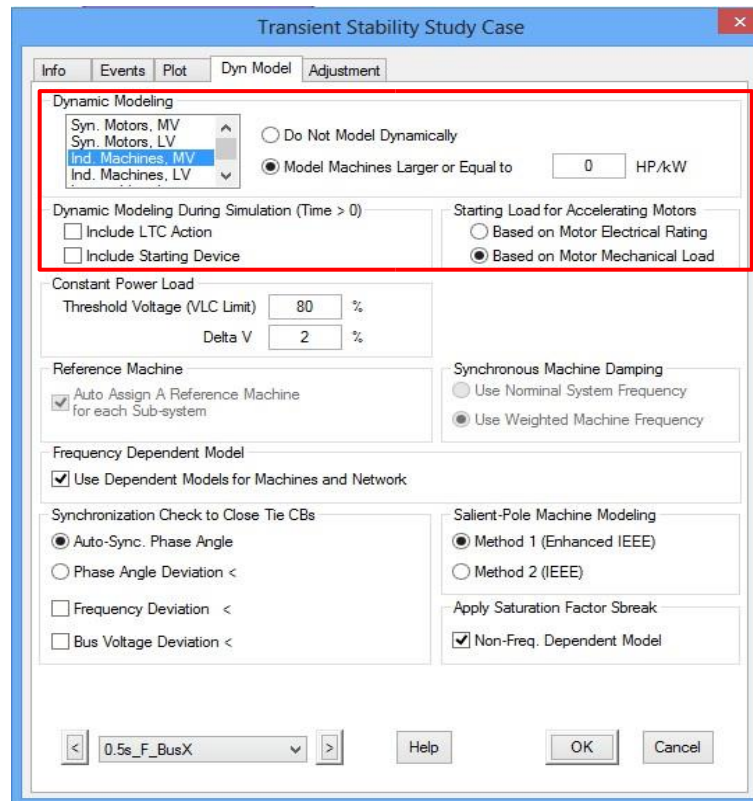


- Set total simulation time as 15 sec with time step of 0.001 and plot time step of 20 x dt as shown in Solution Parameters.



- Set the options on the Dyn Model page of transient stability study case as shown below.

Faulted Motor Transients



Transient Stability Study Case

Info Events Plot Dyn Model Adjustment

Dynamic Modeling

Syn. Motors, MV
Syn. Motors, LV
Ind. Machines, MV
Ind. Machines, LV

☐ Do Not Model Dynamically
☒ Model Machines Larger or Equal to HP/kW

Dynamic Modeling During Simulation (Time > 0)
☐ Include LTC Action
☐ Include Starting Device

Starting Load for Accelerating Motors
☐ Based on Motor Electrical Rating
☒ Based on Motor Mechanical Load

Constant Power Load
Threshold Voltage (VLC Limit) %
Delta V %

Reference Machine
☒ Auto Assign A Reference Machine for each Sub-system

Synchronous Machine Damping
☐ Use Nominal System Frequency
☒ Use Weighted Machine Frequency

Frequency Dependent Model
☒ Use Dependent Models for Machines and Network

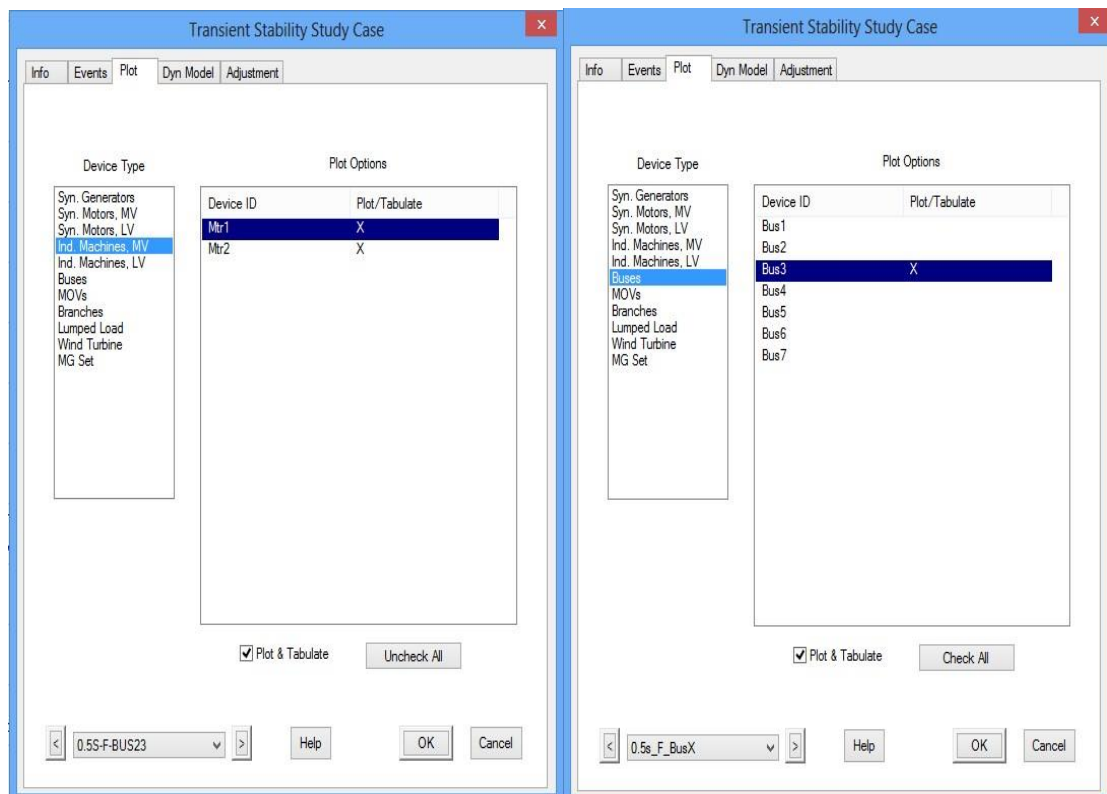
Synchronization Check to Close Tie CBs
☒ Auto-Sync. Phase Angle
☐ Phase Angle Deviation <
☐ Frequency Deviation <
☐ Bus Voltage Deviation <

Salient-Pole Machine Modeling
☒ Method 1 (Enhanced IEEE)
☐ Method 2 (IEEE)

Apply Saturation Factor Sreak
☒ Non-Freq. Dependent Model

< 0.5s_F_BusX > Help OK Cancel

17. Go to plot page, check for following motor & bus plots in transient stability study case as shown below.



Transient Stability Study Case

Info Events Plot Dyn Model Adjustment

Device Type

Syn. Generators
Syn. Motors, MV
Syn. Motors, LV
Ind. Machines, MV
Ind. Machines, LV
Buses
MOVs
Branches
Lumped Load
Wind Turbine
MG Set

Plot Options

Device ID	Plot/Tabulate
Mtr1	X
Mtr2	X

☒ Plot & Tabulate Uncheck All

< 0.5s-F-BUS23 > Help OK Cancel

Transient Stability Study Case

Info Events Plot Dyn Model Adjustment

Device Type

Syn. Generators
Syn. Motors, MV
Syn. Motors, LV
Ind. Machines, MV
Ind. Machines, LV
Buses
MOVs
Branches
Lumped Load
Wind Turbine
MG Set

Plot Options

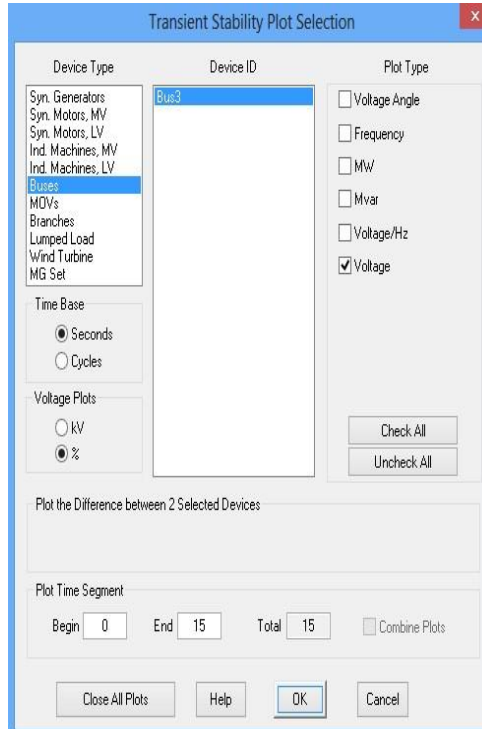
Device ID	Plot/Tabulate
Bus1	
Bus2	
Bus3	X
Bus4	
Bus5	
Bus6	
Bus7	

☒ Plot & Tabulate Check All

< 0.5s_F_BusX > Help OK Cancel

Faulted Motor Transients

18. Run transient stability and click on transient stability plots to check the results for bus and motor as shown below.



Transient Stability Plot Selection

Device Type	Device ID	Plot Type
Syn. Generators	Bus3	<input type="checkbox"/> Voltage Angle
Syn. Motors, MV		<input type="checkbox"/> Frequency
Syn. Motors, LV		<input type="checkbox"/> MW
Ind. Machines, MV		<input type="checkbox"/> Mvar
Ind. Machines, LV		<input type="checkbox"/> Voltage/Hz
Buses		<input checked="" type="checkbox"/> Voltage
MOV's		
Branches		
Lumped Load		
Wind Turbine		
MG Set		

Time Base
☒ Seconds
☐ Cycles

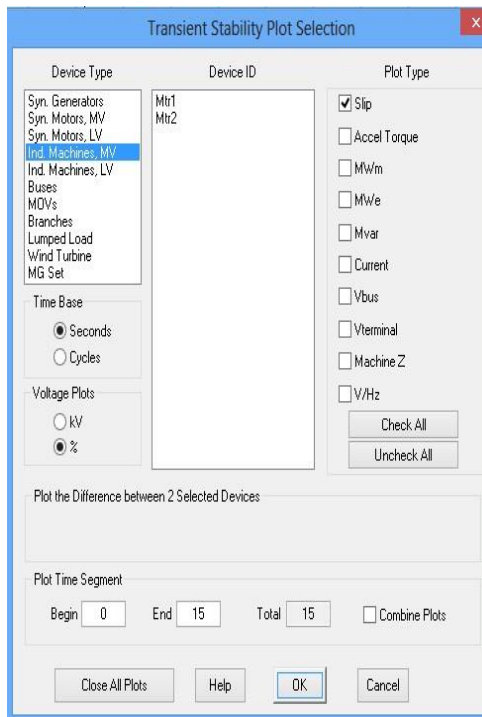
Voltage Plots
☐ kV
☒ %

Check All
 Uncheck All

Plot the Difference between 2 Selected Devices

Plot Time Segment
 Begin: 0 End: 15 Total: 15 ☐ Combine Plots

Close All Plots Help OK Cancel



Transient Stability Plot Selection

Device Type	Device ID	Plot Type
Syn. Generators	Mtr1 Mtr2	<input checked="" type="checkbox"/> Slip
Syn. Motors, MV		<input type="checkbox"/> Accel Torque
Syn. Motors, LV		<input type="checkbox"/> MW/m
Ind. Machines, MV		<input type="checkbox"/> MW/e
Ind. Machines, LV		<input type="checkbox"/> Mvar
Buses		<input type="checkbox"/> Current
MOV's		<input type="checkbox"/> Vbus
Branches		<input type="checkbox"/> Vterminal
Lumped Load		<input type="checkbox"/> Machine Z
Wind Turbine		<input type="checkbox"/> V/Hz
MG Set		

Time Base
☒ Seconds
☐ Cycles

Voltage Plots
☐ kV
☒ %

Check All
 Uncheck All

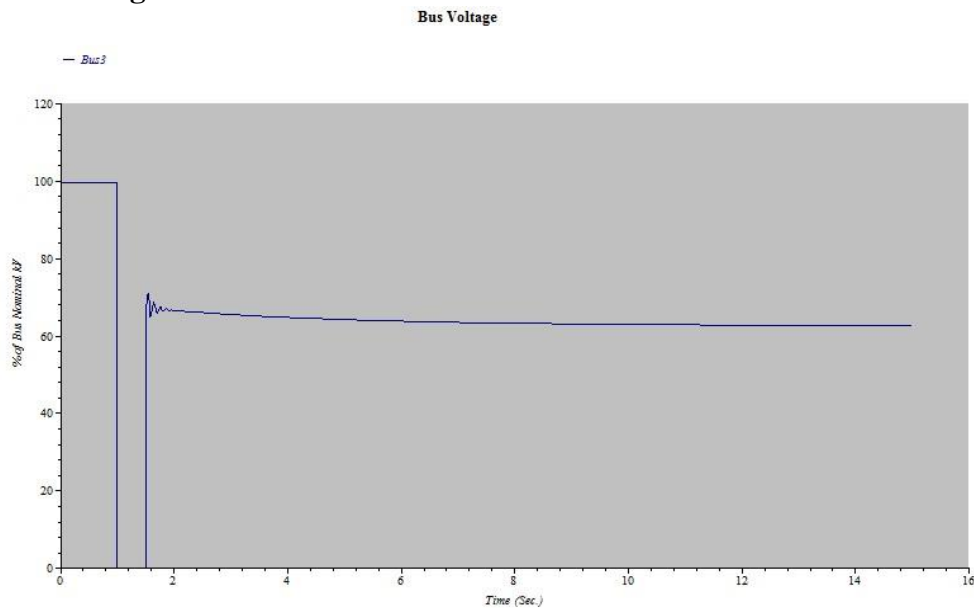
Plot the Difference between 2 Selected Devices

Plot Time Segment
 Begin: 0 End: 15 Total: 15 ☐ Combine Plots

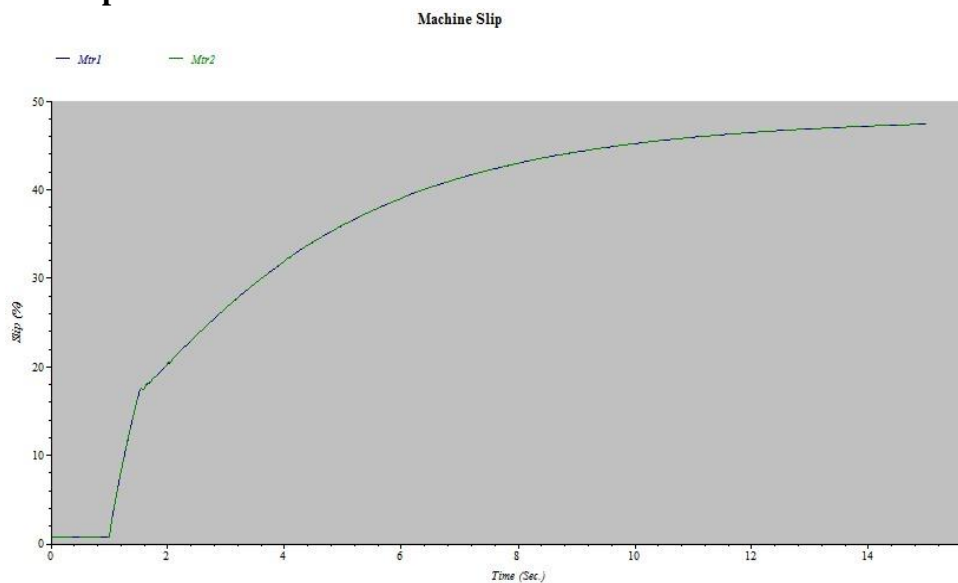
Close All Plots Help OK Cancel

Faulted Motor Transients

Bus3 Voltage



Motor Slip



For fault on Bus3, motors slow down. After the fault clearance at 0.5 sec, the motors draw heavy current from the system resulting in bus voltage collapse which leads to collapse in motor torques and motors get stalled.

19. Similarly, create new study case with name “0.1s_F_BusX”. Create 3-phase fault on Bus3 at 1 sec and clear the fault at 1.1 sec in the events page as shown below.

Faulted Motor Transients

Transient Stability Study Case

Info Events Plot Dyn Model Adjustment

Events

Event ID	Time
* F at Bus3	1.000
* Clear fault	1.100

Actions

For Event Active

Device Ty...	Device ID	Action	Setti...	Setti...
Bus	Bus3	Clear Fault		

Add... Edit... Delete

Solution Parameters

Total Simulation Time Second

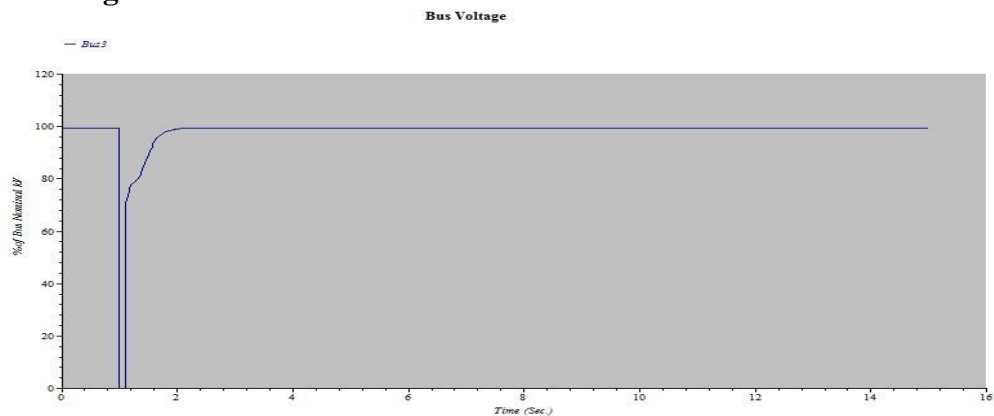
Simulation Time Step (dt) Plot Time Step x dt

< 0.1s_F_BusX >

Help OK Cancel

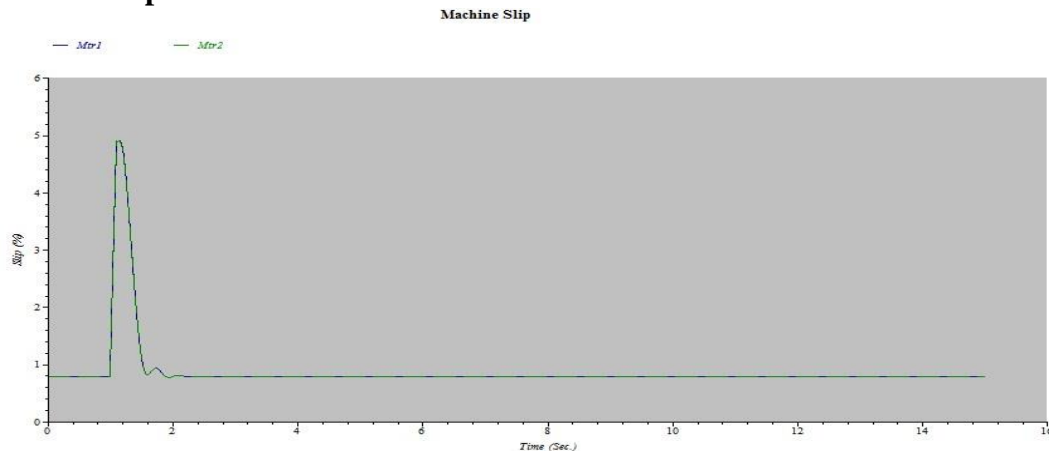
20. Run transient stability and click on transient stability plot to check the results for bus and motor.

Bus3 Voltage



Faulted Motor Transients

Motor Slip



For 0.1 sec fault on Bus3, motors slow down slightly. After the fault clearance, the reactive power demand of the motor is less as compared to the earlier case. Hence the motor bus voltage recovers satisfactorily as shown above.

Additional Case with Load shedding:

21. Drag & drop voltage relay in OLV and connect to Bus3 with following Under Voltage settings.

Voltage Relay Editor - VR1

Info Setting Remarks Comment

OverVoltage (59) Control Interlock

Setting	Unit	CB ID	Action	Delay
Add...				
Edit...				
Delete				

UnderVoltage (27) Control Interlock

Setting	Unit	CB ID	Action	Delay
20	V %	CB10	Open	0.4
75	V %	CB7	Open	5
Add...				
Edit...				
Delete				

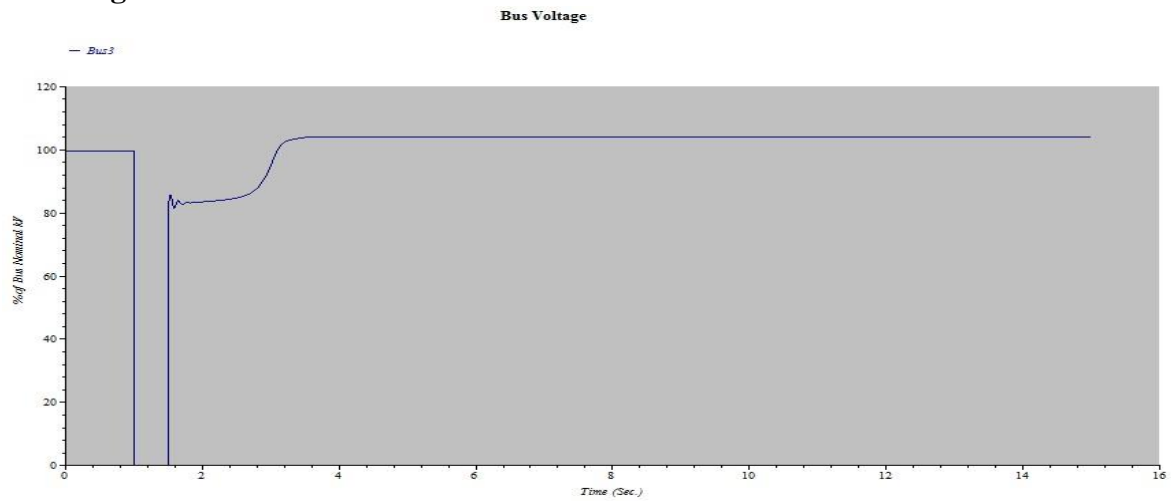
VR1

OK Cancel

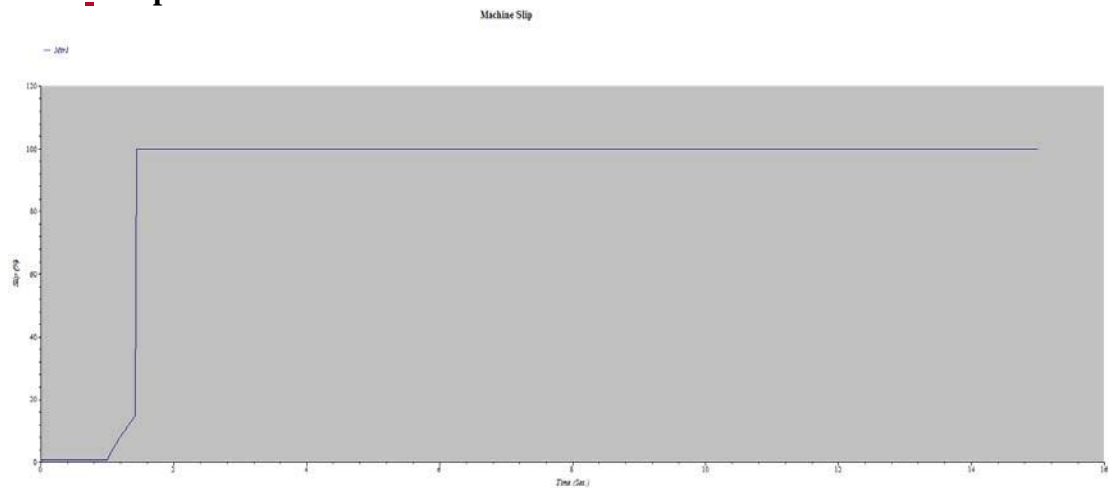
22. Run transient stability with “0.5s_F_BusX” case and plot to check the results for bus and motor.

Faulted Motor Transients

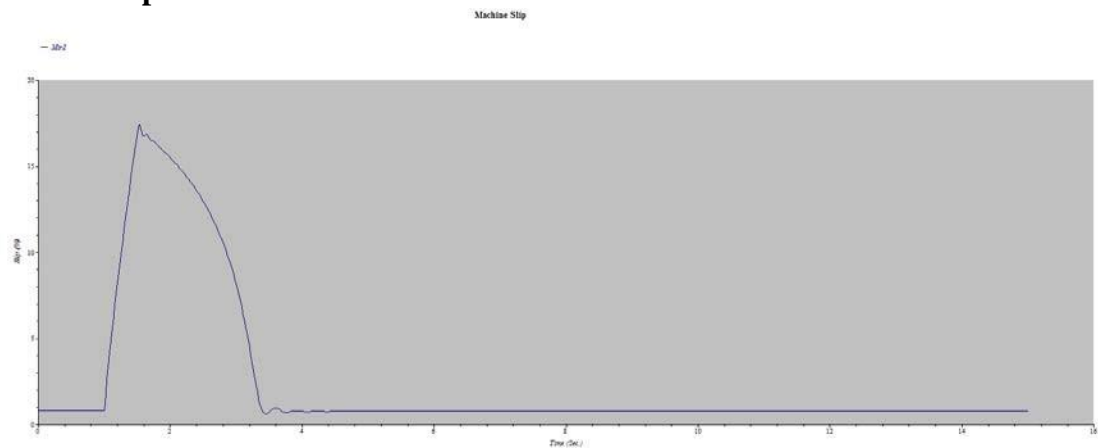
Bus3 Voltage



Motor_1 Slip



Motor 2 Slip



Note: This case is the remedy for study case “0.5s_F_BusX”, with two stage under voltage load shedding scheme implemented at Bus3.