

Synchronous Motor Starting

Purpose and Description

The purpose of this exercise is to model the synchronous motor and study its effects during the motor start.

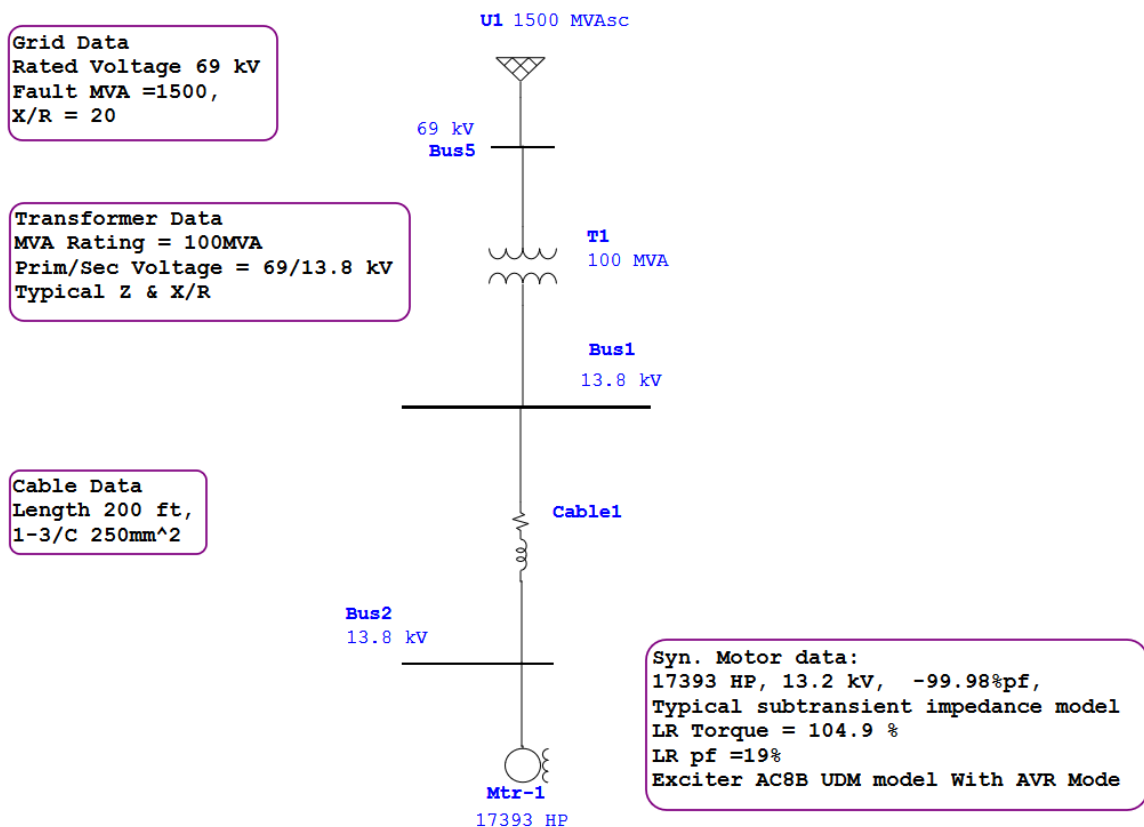
Procedure:

OTI File Location:-TS-Case20 Syn Mtr starting -> Sync Mtr Starting ->Syn_Mtr_start.oti

ETAP Library from C: -> ETAP 1410 -> lib -> etaplib1410.lib

UDM file location: TS-case20 Syn Mtr starting->Sync Mtr Starting->UDM Models-> MTR-1_EXC_AC8B.udm

Review System details as below



Synchronous Motor Starting

- Note: synchronous motor name plate data as follows:

Synchronous Motor Editor - Mtr-1

| Starting Mode | Cable/Vd | Cable Amp | Protection | Reliability | Remarks | Comment |
|---------------|-----------|-----------|--------------------------|-------------|---------|---------|
| Info | Nameplate | Model | LR Model | Inertia | Exciter | Load |
| 1 | 17393 HP | 13.2 kV | Cable Info not available | | | |

Ratings

| | Rated | 100 % | 75 % | 50 % | |
|-----|-------|-------|-------|-------|--------|
| HP | 17393 | kV | 13.2 | % PF | -99.98 |
| MVA | 13.21 | FLA | 577.8 | % Eff | 98.2 |

Library... None SF 1

Loading

| | Category | % | HP | MW | Mvar | Motor Load | Feeder Loss |
|----|-------------|----|-------|--------|--------|------------|-------------|
| 1 | Design | 89 | 15480 | 11.76 | -0.235 | 0 | 0 |
| 2 | Normal | 90 | 15654 | 11.892 | -0.238 | 0 | 0 |
| 3 | Brake | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 | Winter Load | 0 | 0 | 0 | 0 | 0 | 0 |
| 5 | Summer Load | 0 | 0 | 0 | 0 | 0 | 0 |
| 6 | FL Reject | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 | Emergency | 0 | 0 | 0 | 0 | 0 | 0 |
| 8 | Shutdown | 0 | 0 | 0 | 0 | 0 | 0 |
| 9 | Accident | 0 | 0 | 0 | 0 | 0 | 0 |
| 10 | Backup | 0 | 0 | 0 | 0 | 0 | 0 |

Operating Load: 0 MW +j 0 Mvar

Mtr-1

- Rotor type is selected as salient pole and sub-transient impedance model.

Synchronous Motor Editor - Mtr-1

| Starting Mode | Cable/Vd | Cable Amp | Protection | Reliability | Remarks | Comment |
|---------------|-----------|-----------|--------------------------|-------------|---------|---------|
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| 1 | 17393 HP | 13.2 kV | Cable Info not available | | | |

Impedance

| | % | % | Ohm |
|-----|----|--------|-----|
| Xd" | 19 | Xd"/Ra | 35 |
| X2 | 21 | X2/R2 | 35 |
| Xo | 8 | X0/R0 | 35 |

Rdc 0 Rdc 0

Dynamic Model

| | % | % | Sec |
|--------------|-----|--------|-----|
| None | Xd | 123 | Xq |
| Subtransient | Xdu | 130.51 | Xqu |
| Transient | Xd' | 27 | Xq' |
| Equivalent | Xd | 123 | Xq |

Typical Data X_L 15.6 X_q" 20 T_{qo}" 0.28 Damping 2

Machine Type

Application Motor

Rotor Type Salient-Pole

IEC 60909 S.C.

Exciter Type Salient Pole 160%

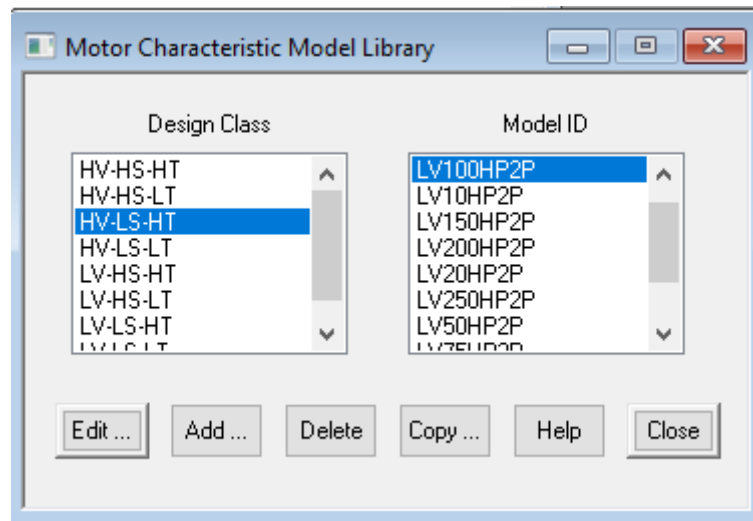
GOST S.C.

Exciter Type Thyristor Self-Excitation

Mtr-1

Synchronous Motor Starting

- Note Motor LR data from standard ETAP library as below:-



- Observe Motor LR data Torque-Slip Curve.

| Motor Characteristic Model Library Editor | | | | | |
|-------------------------------------------|------|--------|-------|-------|----------------|
| Slip [1 - Wm/Ws] in % | | | | | 100 |
| Torque Slip Curve | | | | | ID : LV100HP2P |
| | Slip | Torque | I | PF | |
| 1 | 100 | 104.9 | 625.7 | 31.01 | |
| 2 | 90 | 96.31 | 613.9 | 31.08 | |
| 3 | 80 | 89.82 | 600 | 31.17 | |
| 4 | 70 | 85.44 | 583.5 | 31.31 | |
| 5 | 60 | 82.83 | 563.4 | 31.5 | |
| 6 | 50 | 81.71 | 538.5 | 31.8 | |
| 7 | 40 | 82.79 | 506.6 | 32.32 | |
| 8 | 30 | 89.68 | 464.1 | 33.35 | |
| 9 | 20 | 111.6 | 403.6 | 35.9 | |
| 10 | 10 | 161.4 | 306.6 | 45.48 | |
| 11 | 9 | 167.9 | 293 | 47.62 | |
| 12 | 8 | 174.7 | 278.4 | 50.18 | |
| 13 | 7 | 181.6 | 262.4 | 53.26 | |
| 14 | 6 | 188.5 | 244.8 | 56.94 | |
| 15 | 5 | 195.3 | 225.2 | 61.3 | |
| 16 | 4 | 200.2 | 202.9 | 66.41 | |
| 17 | 3 | 191.8 | 176.8 | 72.24 | |
| 18 | 2 | 163.5 | 145 | 78.7 | |
| 19 | 1.5 | 137.9 | 125.6 | 82.11 | |
| 20 | 1 | 102.5 | 102.1 | 85.59 | |
| 21 | 0.8 | 85.33 | 90.9 | 73.39 | |
| 22 | 0.6 | 66.45 | 78 | 58.79 | |
| 23 | 0.4 | 45.87 | 62.5 | 44.2 | |
| 24 | 0.2 | 23.67 | 41.8 | 29.6 | |
| 25 | 0.04 | 5.08 | 14.2 | 18.07 | |

Synchronous Motor Starting

- Observe synchronous motor data in LR-Model page. Note LRC=447% and starting pf as 19%. With start or LR torque as 104.9 %.

Synchronous Motor Editor - Mtr-1

| Starting Mode | Cable/Vd | Cable Amp | Protection | Reliability | Remarks | Comment |
|---------------|-----------|-----------|------------|-------------|-----------|-----------|
| Info | Nameplate | Model | LR Model | Inertia | Exciter | Load |
| | | | | | Start Dev | Start Cat |

1 17393 HP 13.2 kV Cable Info not available

Locked Rotor

LRC 447 %

PF 19 %

Grounding

Connection Type

Y Open

LR Model (starting)

| Slip | Torque | I | PF |
|------|--------|-------|-------|
| 100 | 104.9 | 625.7 | 31.01 |
| 90 | 96.31 | 613.9 | 31.08 |
| 80 | 89.82 | 600 | 31.17 |
| 70 | 85.44 | 583.5 | 31.31 |
| 60 | 82.83 | 563.4 | 31.5 |
| 50 | 81.71 | 538.5 | 31.8 |

% Torque

% Slip

% PF

HV-LS-HT LV100HP2P

Print

None Circuit Characteristic

Library...

OK Cancel

- Note inertia data as follow:

Synchronous Motor Editor - Mtr-1

| Starting Mode | Cable/Vd | Cable Amp | Protection | Reliability | Remarks | Comment |
|---------------|-----------|-----------|------------|-------------|-----------|-----------|
| Info | Nameplate | Model | LR Model | Inertia | Exciter | Load |
| | | | | | Start Dev | Start Cat |

1 13 MW 13.2 kV Cable Info not available

Load Coupling

Motor Coupling Gear Load

Inertia Calculator

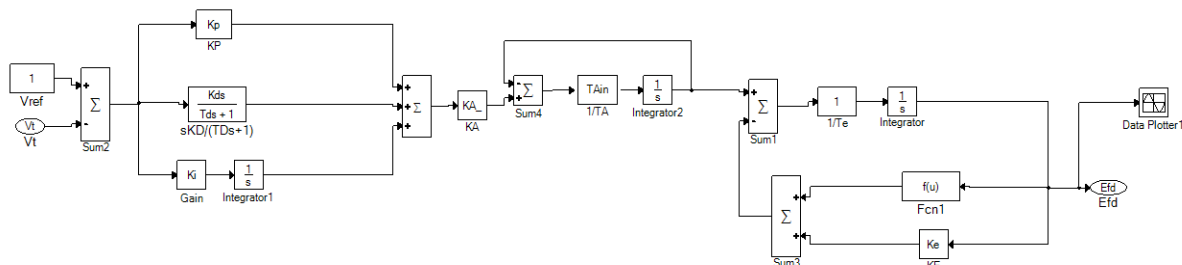
| | Motor | Coupling | Load | Total |
|-----------------|-------|----------|------|-------|
| RPM | 1800 | 1800 | 1800 | 1800 |
| WR ² | 17161 | 24768 | 6369 | 48298 |
| H | 0.97 | 1.4 | 0.36 | 2.73 |

☐ Include Shaft Torsion Effect

OK Cancel

Synchronous Motor Starting

7. Note Exciter selected standard IEEE-AC8B UDM model from UDM folder.



8. Note motor load library data selected from standard polynomial library “CLSD VALVE”.



9. Note data on starting Mode page, Note discharge resistance value of 0.2 Ohm and note excitation application at 98 % speed in the starting Mode Page.

Synchronous Motor Starting

Synchronous Motor Editor - Mtr-1

| Info | Nameplate | Model | LR Model | Inertia | Exciter | Load | Start Dev | Start Cat |
|---------------|-----------|-----------|------------|-------------|---------|---------|-----------|-----------|
| Starting Mode | Cable/Vfd | Cable Amp | Protection | Reliability | Remarks | Comment | | |

1 13 MW 13.2 kV Cable Info not available

Discharge Resistance

0.2 Ohms

Apply Excitation

☐ Fixed Time

☒ Motor Speed

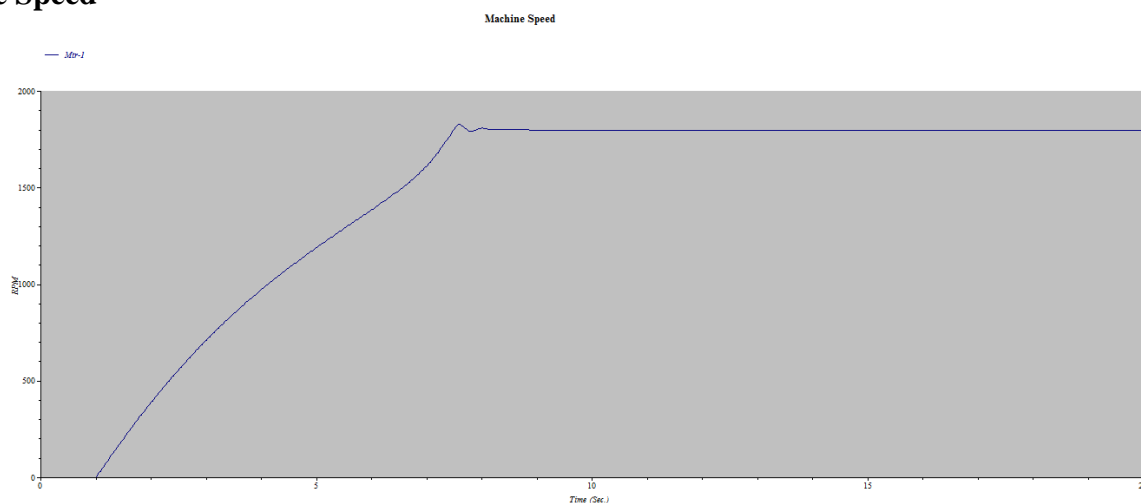
98 % Speed 1764 RPM

2 % Slip

OK Cancel

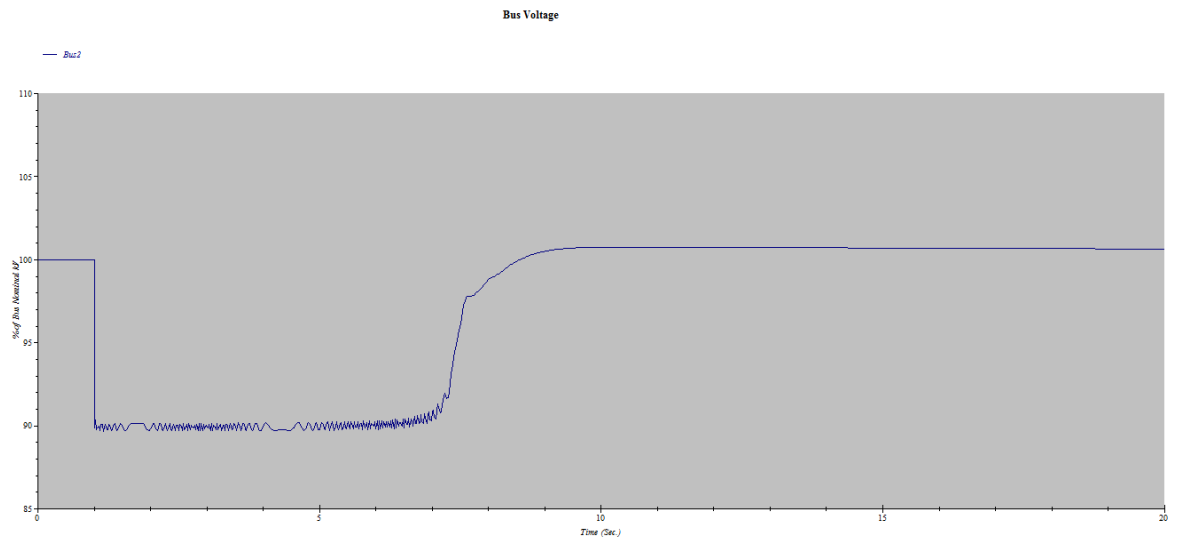
10. Open TS case name "Start_Mtr1". Note motor start at 1 sec in the Events Page with simulation time of 20 sec.
11. Note Plot page of TS file selected to plot 'Mtr-1' in Syn. Motor & 'Bus2' in Buses.
12. Run Transient-stability with output report name as 'Start_MTR1'.
13. Go to the plots, and check the results.

Machine Speed

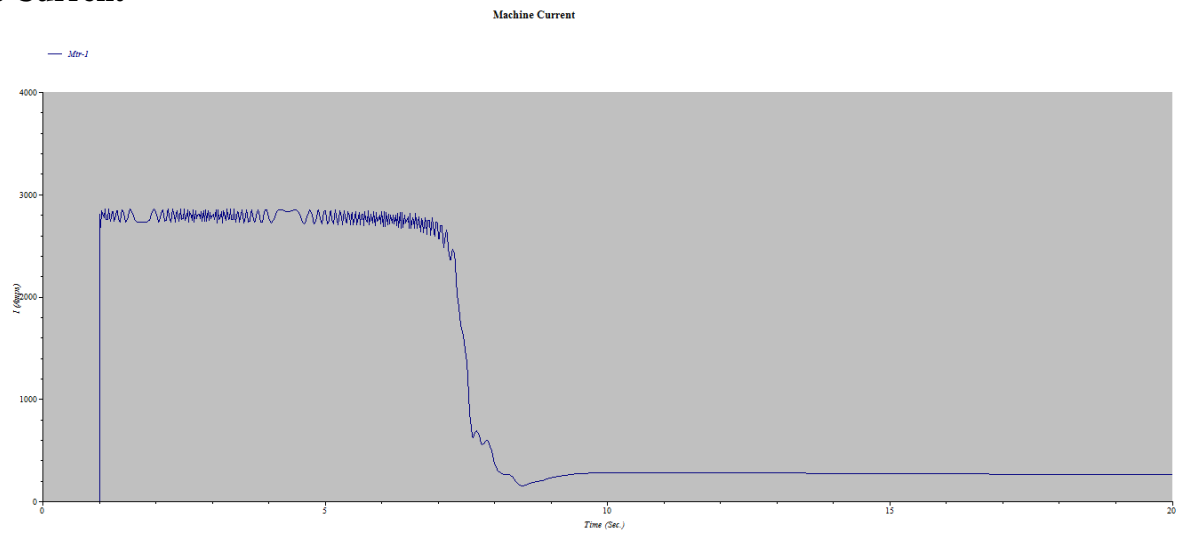


Synchronous Motor Starting

Bus Voltage

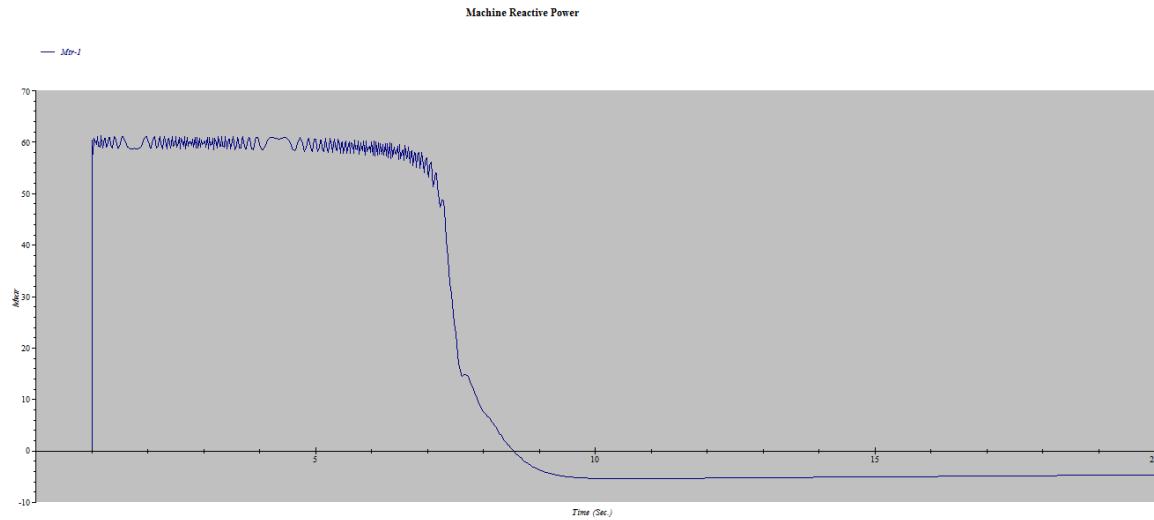


Machine Current



Synchronous Motor Starting

Machine Reactive Power



Note:

During starting period of synchronous motor, transient oscillations are noted in the motor responses. These oscillations due to saliency effect are superimposed on the average voltage and average current response of the motor.