VOLTAGE STABILITY IMPROVEMENT USING FACTS DEVICES

Major Project Report

Submitted in Partial Fulfillment of the Requirements for the degree of

MASTER OF TECHNOLOGY

IN

ELECTRICAL ENGINEERING

(ELECTRICAL POWER SYSTEMS)

By

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May 2016

CERTIFICATE

This is to certify that the Major Project Report entitled **"VOLTAGE STABILITY IMPROVEMENT USING FACTS DEVICES"** submitted by Mr. **"Shah Lokesh (Roll.No.14MEEE25)"**, towards the partial fulfillment of the requirements for the award of degree of Master of Technology (Electrical Engineering) in the field of Electrical Power Systems of Nirma University is the record of work carried out by him under our supervision and guidance. The work submitted has in our opinion reached a level required for being accepted for examination. The results embodied in this major project work to the best of my knowledge have not been submitted to any other University or Institution for award of any degree or diploma.

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Undertaking for Originality of the Work

I, **"Shah Lokesh (Roll.No.14MEEE25)"** , give undertaking that the Major Project entitled **"VOLTAGE STABILITY IMPROVEMENT USING FACTS DEVICES"** submitted by me, towards the partial fulfilment of the requirements for the degree of Master of Technology in Electrical Power Systems of Nirma University, Ahmedabad, is the original work carried out by me and I give assurance that no attempt of plagiarism has been made. I understand that in the event of any similarity found subsequently with any published work or any dissertation work elsewhere; it will result in severe disci- plinary action.

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"To achieve something that we had never before, we need to do something better which we have never done before."
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14MEEE25

Abstract

Current electric system are inclined to failure because of numerous reasons. With the expansion in power demand, the operation and planning of power system is becoming more and more complex. So, the problem of instabilities is observed in the entire system working environment and it required to modify the future planning and reconsider the method of operation. Recently, some of network blackouts occurs due to voltage collapse. The problem of voltage stability play a major role in deregulated power system. FACTS devices are used because of maintain the active and reactive power control as well as adaptive to voltage control simultaneously because of their flexibility and fast control characteristics. Placing of FACTS devices in a suitable location is important to improves the voltage stability and reduce power system losses. The project shall focus on the determination of type of FACTS device, placement and explore the rating for the same.

Nomenclature/Abbreviations

$FACTS$ .... Flexible AC Transmission System

SVC .... Static VAR Compensator

$STATCOM$ .... Static Synchronous Compensator

$SSSC$ .... Static Synchronous Series Compensator

VSC .... Voltage Source Converter

S/S .... Substation

D/C .... Double Circuit

S/C .... Single Circuit

BTB .... Back To Back

$GETCO$ .... Gujarat Energy Transmission corporation limited

STU .... State Transmission Utility

$DGVCL$ .... Dakshin Gujarat Vij company limited

$MGVCL$ .... Madhya Gujarat vij company limited

$UGVCL$ .... Uttar Gujarat vij company limited

$PGVCL$ .... Paschim Gujarat vij company limited

SEC .... Surat Electricity company

AEC .... Ahmedabad Electricity company

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Chapter 1

Introduction

Electric power system stability investigation has been perceived as a critical and testing issue for secure system operation. At the point when extensive disturbance occur in interconnected power system, the security of such power system ought to be inspected. Power system security will rely on upon complete stability investigations of system to check and guarantee security.

It is eminent that the capacity move through transmission line might be a perform of line impedance, phase angle of bus voltage and magnitude. In the event that these parameters might be controlled, the capacity move through the line might be controlled in an extremely preset way. Adaptable ac transmissions system (FACTS) utilizes propelled power electronics device to deal with the parameters inside the facilities to totally use the present transmission facilities.

stability relies on each the underlying in operation states of the system furthermore the severity of the unsettling influence. Late advancement of power electronics presents for usage of FACTS devices in electrical power system. Static VAR Compensator (SVC) might be an original FACTS gadget that may manage voltage at the predetermined buses in this manner rising the voltage profile of the system. SVCs are utilized for prime execution steady state and transient voltage management contrasted and traditional shunt compensation.

The term FACTS devices denote the quick quick controllable devices, which provide a chance of quick adaptation of the system to the circumstances and sure demands (flexibility). All of them are static and supported the facility power electronics parts, power thyristor, being the essential a part of the technology.

1.1 Literature survey

[1] Gupta, S.; Tripathi, R.K.; Shukla, R.D. "Voltage Stability Improvement in Power Systems using Facts Controllers: State-of-the-Art Review" Power, Control and Embedded Systems (ICPCES), 2010. [1]
This paper gives the overview of the voltage stability improvement using FACTS controllers. They are suitable of maintaining the system profile immediately and because of this ability FACTS can be improved the voltage stability of power system. In this paper, Technical benefits of different FACTS devices are given.

[2] Musunuri, S.; Dehnavi, G. "Comparison of STATCOM,SVC, TCSC, and SSSC Performance in Steady State Voltage Stability Improvement" North American Power Symposium (NAPS), 2010. [2]
This paper gives the overview of the different FACTS devices. In this paper gives comparison of FACTS devices by their V-I characteristics and power angle characteristics. In this paper one base case taken which is IEEE-14 bus system for the stability improvement using FACTS.

[3] Dheebika, S.K.; Kalaivani, R. "Improvement of Voltage Stability and Reduce Power System Losses by Optimal GA-based Allocation of Multi-type FACTS Devices"Green Computing Communication and Electrical

Engineering (ICGCCEE), 2014. [3]

This paper presents a optimal location of FACTS devices for improvement of stability and reducing the losses of the system. In this paper IEEE-30 bus system taken and by using generatic algorithm method find out the optimal location of FACTS.

Chapter 2

About GETCO

GETCO started working as a free organization from first April 2005. The mass power produced at different generating stations in the state and the offer of power produced by Central Sector Stations is transmitted to Distribution Companies at different interface focuses in the State through a broad system of 400 KV, 220 KV, 132 KV and 66 KV transmission lines and substations. GETCO conveys vitality to all the six distribution organizations in the state, including AEC and SEC, which thus supply energy to more than 1.20 Crores buyers over the state. The organization is composed into 13 circles. Every circle has separate development and operation & maintanance divisions that handle particular errands. The Construction Divisions are set up for development of new substations and lines, while the transmission divisions are built up for operation, support and increase of the current substations and lines.

Chapter 3

Electrical Power System Stability

Electric Power system stability is defined as the capability of a power system to remain in operating condition after being subjected to a disturbance for given initial operating conditions.

considerations:

a. Way of the subsequent instability mode demonstrated by the watched flimsiness on certain system variables

b. The measure of the disturbance which subsequently impacts the device used to evaluate the system stability.

c. The time edge expected to evaluate system dependability.

The power system stability of a system alludes to the ability of a system to return back to its consistent state when subjected to an unsettling influence. Power is created by synchronous generators which is synchronize with whatever remains in the power system. Generator is synchronized with a buses when them two have same voltage, frequency and phase sequence.so, in this manner system stability is characterize the into **Steady State, Transient** and **Dynamic Stability**.

The classification of system stability as shown in Figure 2.1.

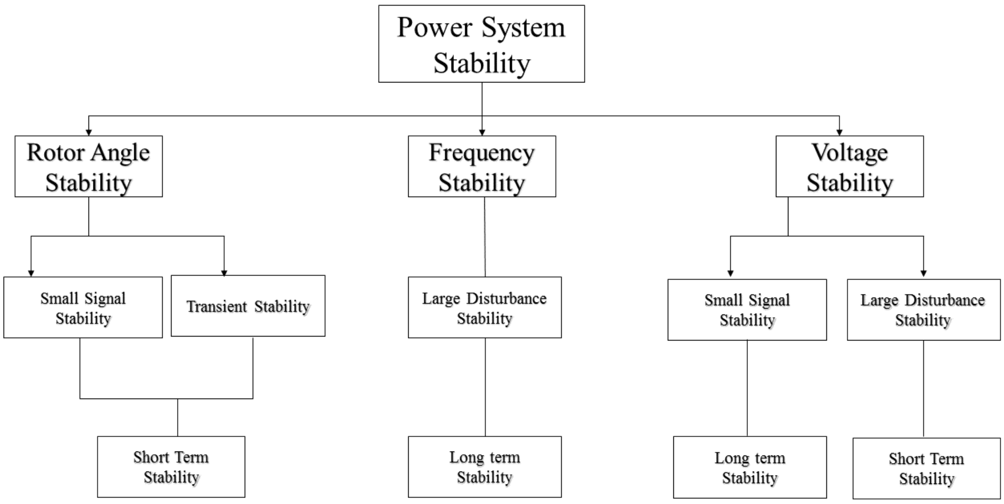

Figure 3.1: Classification of system stability
[6]

Steady State Stabilitystudies are related with the small disturbance occur in normal system.in this stability analysis voltage does not go to the beyond limits and remains in steady state point. Also phase angle of the two power transfer buses are not more than 30 degree . These checks are typically done utilizing power flow study.

Transient Stability It contains the investigation of the power system taking after a noteworthy unsettling influence. After a huge unsettling influence the synchronous generator load angle changes because of sudden increasing speed of the rotor shaft. Task of the transient instability study is to determine whether the load angle comes back to an enduring worth after the leeway of the unsettling influence.

Dynamic Stability It means The ability of a power system to keep up stable under continuous little unsettling influence. (small signal stability). In an interconnected power system, these irregular varieties can lead cataclysmic disappointment as this may drive the rotor angle to increment relentlessly.

3.1 Factor affecting voltage stability

Factors for transient stability :

a. System impedance, which must incorporate the reactances of all producing units. This influences phase angle and the stream of synchronizing power.

b. Duration of the fault, picked as the paradigm for stability. Term will be reliant upon the circuit-breaker speed and the relay scheme utilized.

c. Generator loadings before the issue which will decide the inside voltages and the adjustment in yield. system stacking, which will decide the stage points among the different inside voltages of the generators.

d. voltage at far end decreased with expansion in load and voltage increment with abatement in load.

3.2 PV and QV Curve Analysis

- PV and QV curves determine the ability of the power system to remain in stable point in normal and abnormal condition
- PV curves gives an idea about the voltage stability in power system for all the buses
- From the QV curve , We can find out how much compensation required in the system
- In PV curve , voltage increase with the power but at one point power increase but voltage decrease. which is knee point of PV curve and that gives the idea about stability
- similarly for the QV curve, voltage collapse point gives the idea about the stability and voltage collapse

Chapter 4

FACTS (Flexible AC Transmission System) devices

The FACTS controllers give an incredible probability to direct the transmission of rotating current (AC), expanding or reducing the electricity flow through particular lines and reacting very quickly on the stability issues. FACTS is a static gear utilized for the transmission of AC electrical power. It is intended to improve controllability and expansion power exchange limit. It is by and large a power electronics based gadget. The FACTS gadgets can be partitioned in three gatherings, subject to their exchanging innovation: mechanically made, (for example, stage moving transformers), thyristor exchanged or quick exchanged, utilizing IGBTs. While some writes of FACTS, similar to the phase shifting transformer (PST) and the static VAR compensator (SVC) are as of now surely understood and utilized as a part of electric power systems, new advancements in power electronics and control have broadened the product scope of FACTS. Moreover, irregular renewable vitality assets and expanding universal power streams give new applications to FACTS.

4.1 Advantages of FACTS devices

- Better usage of existing transmission system resources
- Increased transmission system unwavering quality and accessibility

- Load stream control in fit systems
- Increased dynamic and transient stability system and diminishment of circle streams
- Increased nature of supply for delicate commercial enterprises
- Environmental advantages better usage of existing transmission system resources

4.2 Static Synchronous Compensator (STATCOM)

The STATCOM depends on a solid state synchronous voltage source which creates an adjusted arrangement of three sinusoidal voltages at the fundamental frequency with quickly controllable abundancy and phase angle. The setup of a STATCOM is appeared in Figure 3.1. Normally it is comprise with one voltage source, DC capacitor and coupling transformer. If reactive power needed than it is working as capcitor bank to inject the reactive power otherwise it has been work as reactor to absorb the reactive power.

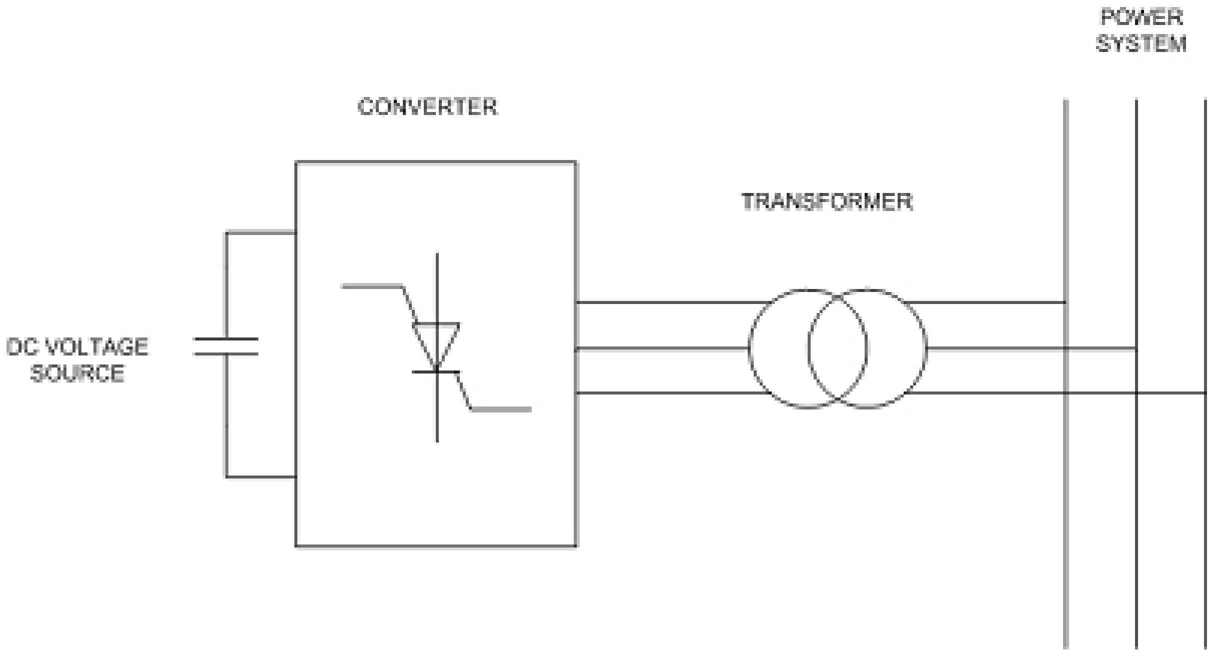

Figure 4.1: Simplified diagram of STATCOM
[2]

4.3 Static VAR Compensator

SVCs are a fast and dependable method for taking care of voltage on transmission lines. With normal reaction times running from 30 to 40 ms, SVCs are speedier than customary by fake means exchanged reactors and capacitors (100 to 150 ms) and can be utilized to effectively soggy power amplitude. At the point when system voltage is low, the SVC provides capacitive responsive force. When system voltage is high, it retains inductive receptive power. Static compensation system perform the accompanying obligations: Stabilize voltage, Control intense reactive power, Improve transitive stabilitys, Damp dynamic electric motions, Increase power duplicate capacity, Balance system voltage.

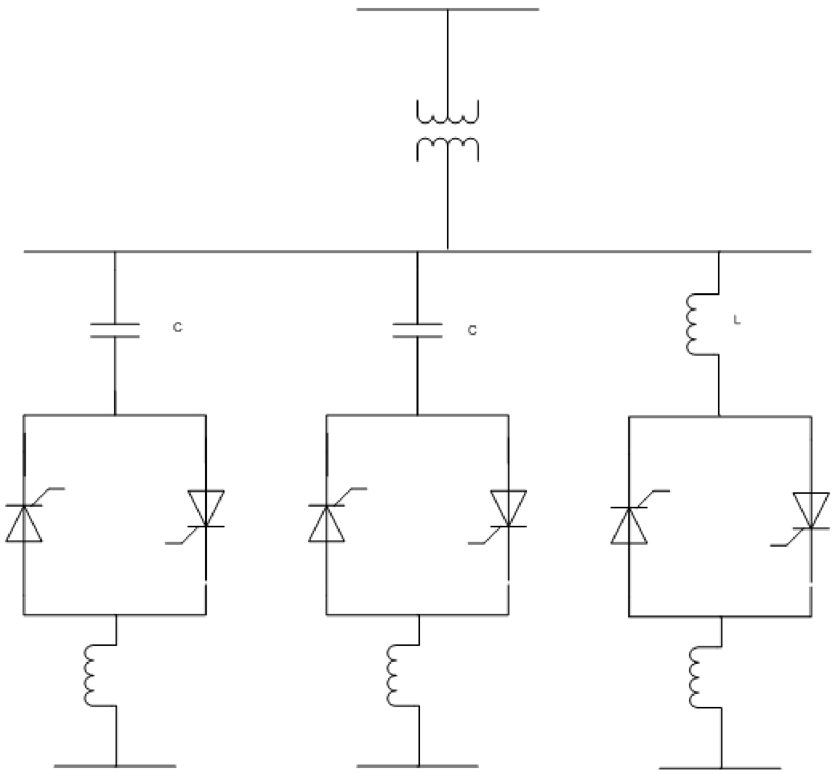

Figure 4.2: Simplified diagram of SVC
[2]

4.4 STATCOM features

- Size is compact
- System voltage backing and adjustment by smooth control over an extensive variety of working conditions.
- Dynamic reaction taking after system possibilities
- High dependability with excess parallel converter outline and module developments.
- Flexibility to future reconfiguration to BTB power transmission or UPFC and other design.

4.5 Comparison of SVC and STATCOM

Controls	**SVC**	**STATCOM**
operating principle	Controlled or switch shunt impedance	Controlled voltage current source behind reactance
Output of reactive power	Different capacitive and inductive output possible	same capacitive and inductive output
Behavior at high/low voltage	Constant impedance/Susceptance. Minimum voltage for Thyristors turn-on/ off	Constant current.
MVAr regulation	In a control range	In a control range
Space requirements	Large (reactor, capacitor)	Smaller than SVC
Losses	1.0 to 1.5 percentage	1.0 to 1.5 percentage
System frequency variation	Behaves as constant C or L	Behaves as constant current source
Contribution at fault level	No	Rated current is maximum
Voltage control and response	Related with system strength and may require variable gain control	Related with system strength, but most faster than SVC
Power transfer, stability damping improvement	Depends upon rating and locations	Depends on rating and locations but significant better than SVC
Initial Energization	By direct Energization from HV system	Rapid charging of energy storage to operating voltages

Chapter 5

Power Flow analysis

A power flow study (load-flow study) is an unfaltering state investigation whose objective is to decide the voltages, current and flows, and real and reactive power flows in a system inside given burden conditions.

The motivation behind power flow studies is to built up ahead and represent changed hypothetical things. for instance, if a conductor is more often than not to be begun away line for upkeep, will the remaining lines inside the system handle the coveted burdens while not surpassing their rated values.

There are four variables that are connected with every transport: P, Q, V, and δ. In the mean time, there are two power flow mathematical equations connected with every bus.

In a power flow study, two of the four variables are distinguished a the other two are obscure. That way, the same amount of comparisons as the quantity of obscure. The known and unknown variables depend upon the type of bus.

The iterative strategies are more valuable when the diagonal components of the coefficient matrix are vast when contrasted and the off diagonal components. The round-off mistakes amid these techniques are rectified at the progressive steps of the iterative procedure.

The Newton-Raphson strategy is greatly bounteous accommodating for answer of non linear mathematical statements, in the event that all the estimations of the amendments for the questions are unpleasantly little in magnitude furthermore the underlying estimations of questions are chosen to be tolerably closer to the exact answer.

5.1 Methods for power Flow Analysis

Three methods for power flow analysis.

a. Gauss Seidel method

b. Newton Raphson method

c. Fast Decoupled method

5.2 Comparison of Load flow study

The most prominent techniques are the Gauss seidel strategy , Newton Raphson technique and the Fast decoupled load flow strategy. In littler system , the simplicity programming and the memory necessities , make GS technique alluring. However calculation time increment with expansion in size of the system. Thus in vast frameworks NR and FDLF techniques are more well known. There is exchange off between different necessities like speed,storage , unwavering quality ,calculation time , meeting attributes and so forth. No single strategy has all the alluring elements. However , NR technique is most well known as a result of its adaptability , dependability and exactness.

Chapter 6

Load Flow Results

6.1 Existing GETCO network

6.1.1 Peak load condition

It was the base case of September 09, 2015 at 14:00 hrs. For which the taken considerations and operational constraints are as per below

a. Impedance of Transmission line and Transformer taken as per the Transmission planning criteria.

b. Generation and Loads are schedule as per the SLDC snapshot of 09/09/2015 at 14:00 hrs

c. Generating voltage of generators schedule as per Transmission planning criteria

d. Rate A,B,C are the loading of transmission line and transformers.
Rate A - Normal loading - 90% of the Thermal loading
Rate B - Thermal loading - as per transmission planning criteria
Rate C - Emergency loading - 110% of Thermal loading

e. Tapping of transformer are not taken in load flow study

f. Lines taken out of service as per the snapshot data are as per below.

- 220 kV Haldarwa - Jambuva line
- 220 kV Kim - Vav line
- 220 kV Chikhli - Vapi line
- 220 kV Kosamba - Zagadia line
- 220 kV Navsari - Bhilad line
- 132 kV Bharuch - Ankleshwar line
  Due to overload over single circuit of Haldarwa - Bharuch line because of the load at Ankleshwar 132 kV Substation.

Buses with voltage less than 0.95 pu

Table 6.1: Bus Voltage Report

BUS	NAME	BASE kV	V(PU)	V(kV)
1001	AGIYOL21	132	0.9433	124.52
1002	IDAR1	132	0.9152	120.8
1003	TALOD1	132	0.9297	122.72
1004	VIJAPUR21	132	0.938	123.82
1006	VISNAGAR1	132	0.9415	124.27
1009	PATAN1	132	0.9324	123.07
1010	SIDDHPUR1	132	0.924	121.97
1011	DEESA1	132	0.925	122.09
1020	VASEDI1	132	0.9472	125.03
1029	TILAKWADA1	132	0.9444	124.66
1040	NADIAD1	132	0.9491	125.28
1044	MAHEMDABAD1	132	0.9443	124.65

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TableBus Limit Less Than 0.95pu – *Continued from previous page*

BUS	NAME	BASE kV	V(PU)	V(kV)
1045	RLY MAHEMDAB	132	0.9443	124.65
1055	ATUL1	132	0.9309	122.88
1056	RLY ATUL1	132	0.9309	122.88
1070	BOTAD21	132	0.9425	124.41
1071	PALIYAD1	132	0.9381	123.82
1072	BARWALA1	132	0.9411	124.22
1073	VALLABHIPUR2	132	0.9352	123.45
1074	JASDAN1	132	0.8913	117.65
1075	VIKRAM1	132	0.9296	122.71
1076	GONDAL21	132	0.9398	124.05
1077	HARIPUR1	132	0.8684	114.63
1078	DHORAJI1	132	0.912	120.38
1079	SHAPUR21	132	0.9	118.8
1080	JUNAGADH1	132	0.8479	111.93
1081	TALALA1	132	0.8601	113.54
1082	BHAYAVADAR1	132	0.9421	124.36
1083	TIMBADI21	132	0.8729	115.22
1084	AMBUJA1	132	0.8731	115.25
1085	CCGL1	132	0.873	115.23
1088	VAJADI1	132	0.9434	124.53
1113	NIKOL21	132	0.9471	125.02
2007	AGIYOL2	220	0.9495	208.88
2008	BHUTIYA2	220	0.9474	208.43
2011	KHERALU2	220	0.9489	208.75
2017	PALANPUR2	220	0.9494	208.86
2022	THARAD2	220	0.9445	207.78
2023	THAVAR2	220	0.9437	207.62
2024	AGTHALA2	220	0.9395	206.68

Continued on next page

TableBus Limit Less Than 0.95pu – *Continued from previous page*

BUS	**NAME**	**BASE kV**	**V(PU)**	**V(kV)**
2029	DEODAR2	220	0.9489	208.77
2045	BOTAD2	220	0.9459	208.1
2111	SAVARKUNDLA2	220	0.9475	208.45
2113	OTHA2	220	0.9456	208.03
2114	SAGAPARA2	220	0.9376	206.26
2115	GPPL2	220	0.9494	208.86
2116	KOVAYA2	220	0.9493	208.85
2117	VARTEJ2	220	0.9384	206.44
2118	BECL2	220	0.9401	206.82
2119	VISAVADAR2	220	0.9498	208.96
2126	KESHOD2	220	0.9153	201.37
2127	TIMBADI2	220	0.8833	194.33
2128	SHAPUR2	220	0.9237	203.22
2129	DHOKADAWA2	220	0.9062	199.36
2143	KUKMA2	220	0.9319	205.01
2144	ANJAR2	220	0.9367	206.08
2145	WELSPUN2	220	0.9412	207.07
2163	VALLABHIPUR2	220	0.9409	207.01

6.1.2 GETCO network with future condition

In future condition so many transmission lines and substations add in excisting GETCO network

Future transmission lines for the Timbdi pocket

- 400 kV Pipavav - Amreli D/C 2 line
- 220 kV Timbadi - Visavdar D/C 2 line
- 220 kV Amreli - Visavdar D/C 2 line
- 220 kV Pipavav - Dhokadwa D/C 2 line
- 220 kV Pipavav - Otha D/C 2 lines
- 220 kV Pipava - savarkundla S/C 1 line
- 220 kV Visavdar - Pipavav S/C 1 line
- 220 kV GPPL - Pipavav S/C 1 line

Buses with voltage less than 0.95 pu

Table 6.2: Bus Voltage Report with future condition

BUS	NAME	BASE kV	V(PU)	V(kV)
1002	IDAR1	132	0.9152	120.8
1003	TALOD1	132	0.9298	122.73
1004	VIJAPUR21	132	0.9382	123.84
1009	PATAN1	132	0.9325	123.09
1010	SIDDHPUR1	132	0.9241	121.98
1011	DEESA1	132	0.925	122.11
1055	ATUL1	132	0.9338	123.27
1056	RLY ATUL1	132	0.9338	123.27
1074	JASDAN1	132	0.9059	119.58

Continued on next page

TableBus Limit Less Than 0.95pu – *Continued from previous page*

BUS	NAME	BASE kV	V(PU)	V(kV)
1075	VIKRAM1	132	0.9362	123.58
1077	HARIPUR1	132	0.9159	120.9
1078	DHORAJI1	132	0.9391	123.96
1079	SHAPUR21	132	0.9327	123.12
1080	JUNAGADH1	132	0.8905	117.55
1081	TALALA1	132	0.9107	120.21
1083	TIMBADI21	132	0.9274	122.42
1084	AMBUJA1	132	0.9277	122.45
1085	CCGL1	132	0.9275	122.43
2022	THARAD2	220	0.9447	207.83
2023	THAVAR2	220	0.944	207.67
2024	AGTHALA2	220	0.9397	206.73
2117	VARTEJ2	220	0.9477	208.5
2126	KESHOD2	220	0.9428	207.37
2127	TIMBADI2	220	0.9284	204.3
2143	KUKMA2	220	0.9325	205.15
2144	ANJAR2	220	0.9375	206.25
2145	WELSPUN2	220	0.9421	207.26

6.1.3 Off peak condition

In off peak condition , PGVCL loads are decrese 40-50 percentage due to agriculture load , similarly UGVCL load decrease 30-40 percentages. No more changes in DGVCL and MGVCL loading during off peak condition. It is slight decrease 10-15 percentages.

Buses with voltage greater than 1.05 pu

Table 6.3: Bus Voltage Report with Off peak condition

BUS	NAME	BASE kV	V(PU)	V(kV)
1075	VIKRAM1	132	1.053	139
1077	HARIPUR1	132	1.056	139.4
1078	DHORAJI1	132	1.052	138.2
1079	SHAPUR21	132	1.060	140
1081	TALALA1	132	1.056	139.5
1083	TIMBADI21	132	1.078	142.3
1084	AMBUJA1	132	1.071	141.5
1085	CCGL1	132	1.078	142.3
2022	THARAD2	220	1.0654	234.5
2023	THAVAR2	220	1.07	235.4
2024	AGTHALA2	220	1.0633	234.2
2117	VARTEJ2	220	1.0681	235
2126	KESHOD2	220	1.0863	239
2127	TIMBADI2	220	1.1090	244
2143	KUKMA2	220	1.078	237.2

6.1.4 Contingency situation

Contingencies applied at Tata Umpp lines. contingency at 400kV Umpp-Jetpur line and second at 400kV Umpp-Bhimsar line. Because of this Jetpur 400kV voltage down to the 372kV and also angular stability occur. The angle between this two buses near about 30 degree. This problem is also solved by introducing FACTS at Timbadi substation which improve the voltage level at Jetpur 400kV substation.

6.2 Summary of the results

South and Central Gujarat

Very low generation from Gas Based generating stations located in south Gujarat area, i.e. Utran, Essar, GSEG, CLP, Kawas, Jhanor, Sugen and GIPCL, Dhuvaran located in central Gujarat area, due to fuel cost. Therefore, local generation support is not available and power is coming from up stream 400kV/ 220 kV network.

- Low voltage problem in South Gujarat area during peak load condition:
  220 KV Navsari, Sachin, Vav, Chikhli , Bhilad and Vapi S/s - 200 kV to 207 kV

- Overvoltage problem in Central Gujarat area during off-peak load condition especially during non agriculture season
  220 KV Kapadwanj, Ranasan s/s - 230 kV to 238 kV

- When contingency applied at the south Gujarat , Mainly at KIm-Kosamba , Ukai-Mota , Mota-Vav, Dastan-Navsari and Chikhli-Vapi lines then Navsari , Chikhli and Bhilad voltage goes down to very low . so It is critical case for Gujarat network.

Saurashtra and Kutch area

Critical loading for few elements during Peak wind season, especially with off-peak demand scenario. This happens especially in the Kutch area where low cost conventional generation is available under merit order.

- Low voltage and large voltage variation for few substations along with load variations.
  220KV Dhokadava, Timbdi, Savarkundla, Visavadar, Mahuva and Keshod S/s - 189 kV to 204 kV

- Over voltage problems during off-peak demand period.
  400 KV Hadala, Amreli, Jetpur, Chorania, Varsana substation - 415 kV to 436 kV

- After the Q-V curve analysis the Timbadi and nearby substations are critical for the voltage stability. By adding future lines the timbadi voltage rise up to 204 kV . so , there is necessary to use FACTS devices to maintain the voltage and STATCOM is good choice for that. 120 MVAr STATCOM introduce at 220 kV Timbadi s/s solved the problem of instability.

Chapter 7

Simulation Results

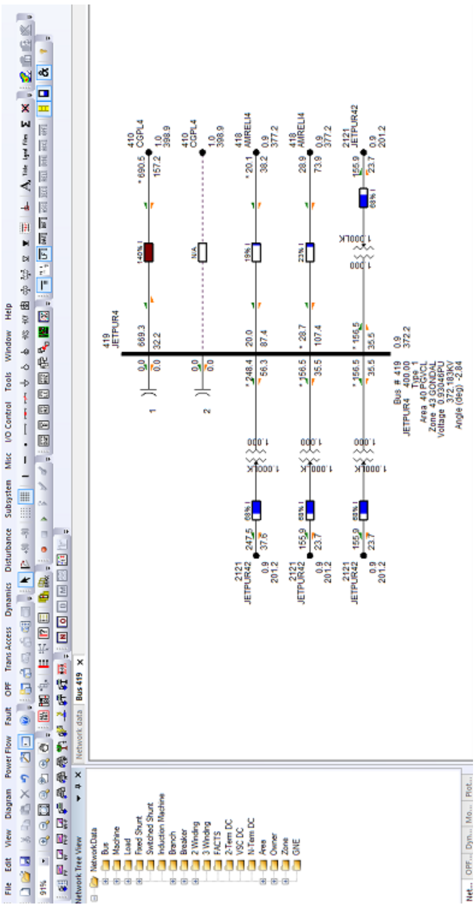

Figure 7.1: without FACTS Jetpur 400kV s/s

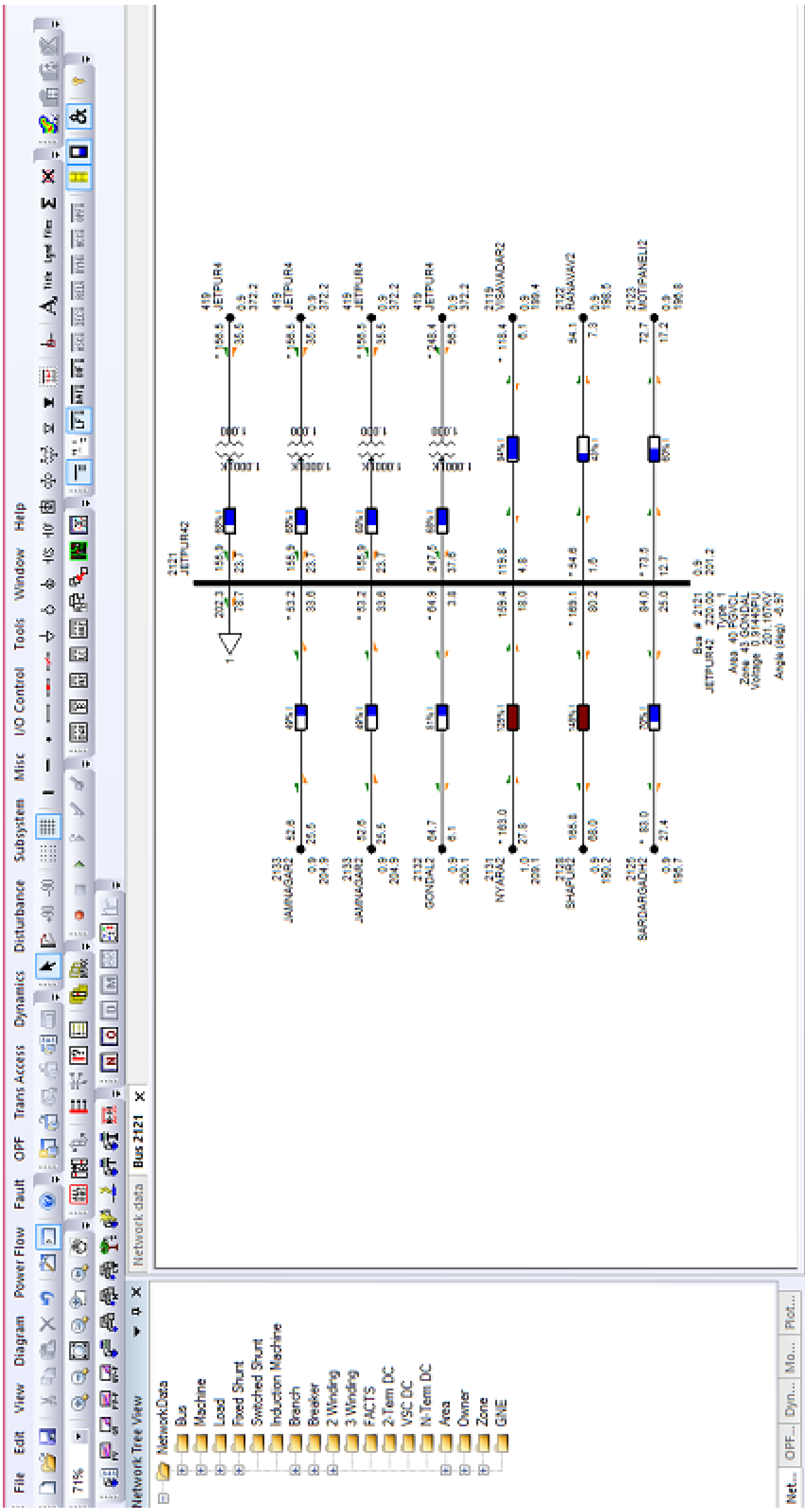

Figure 7.2: without FACTS Jetpur 220kV s/s

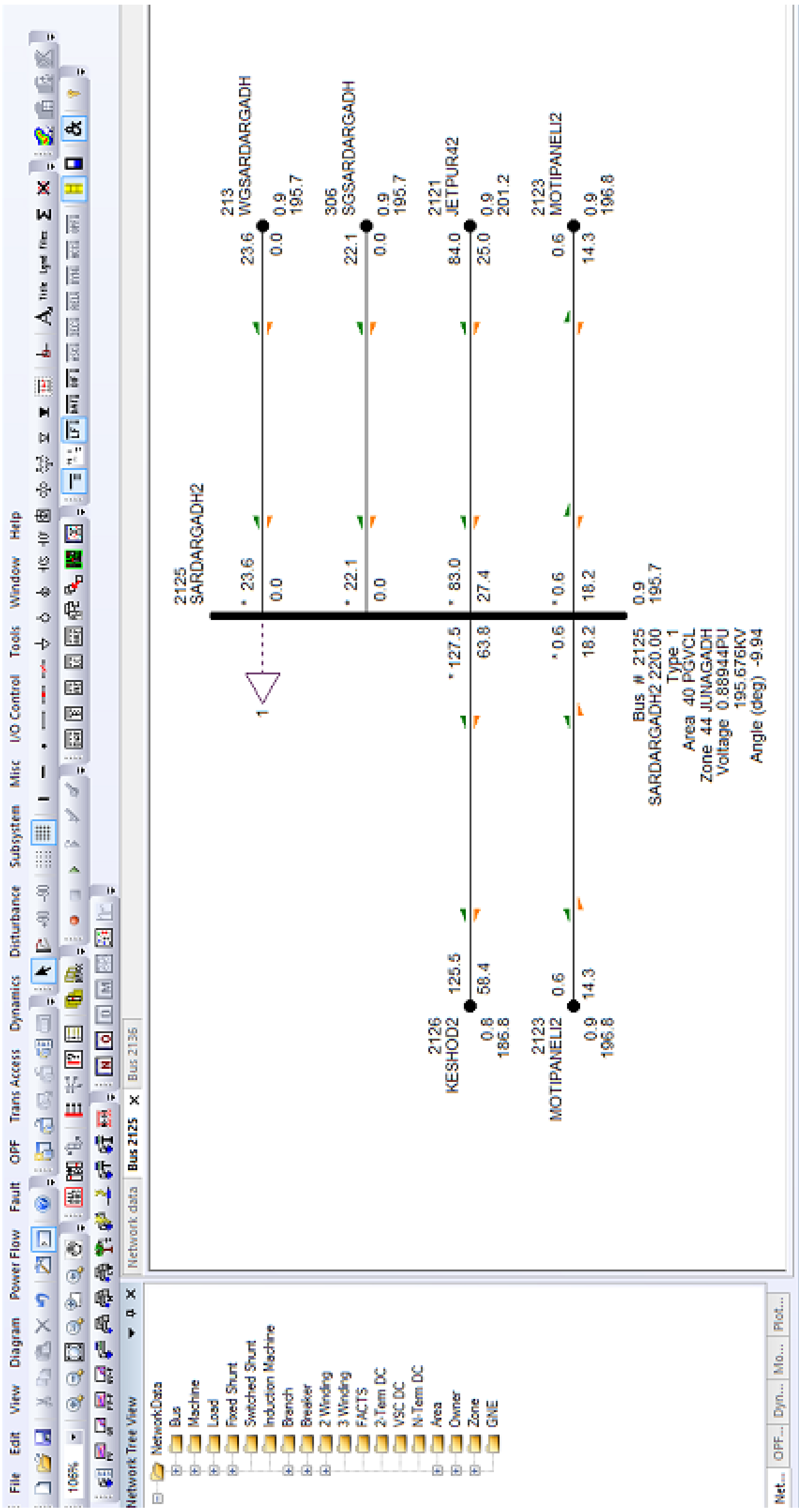

Figure 7.3: without FACTS Sardargadh 220 s/s

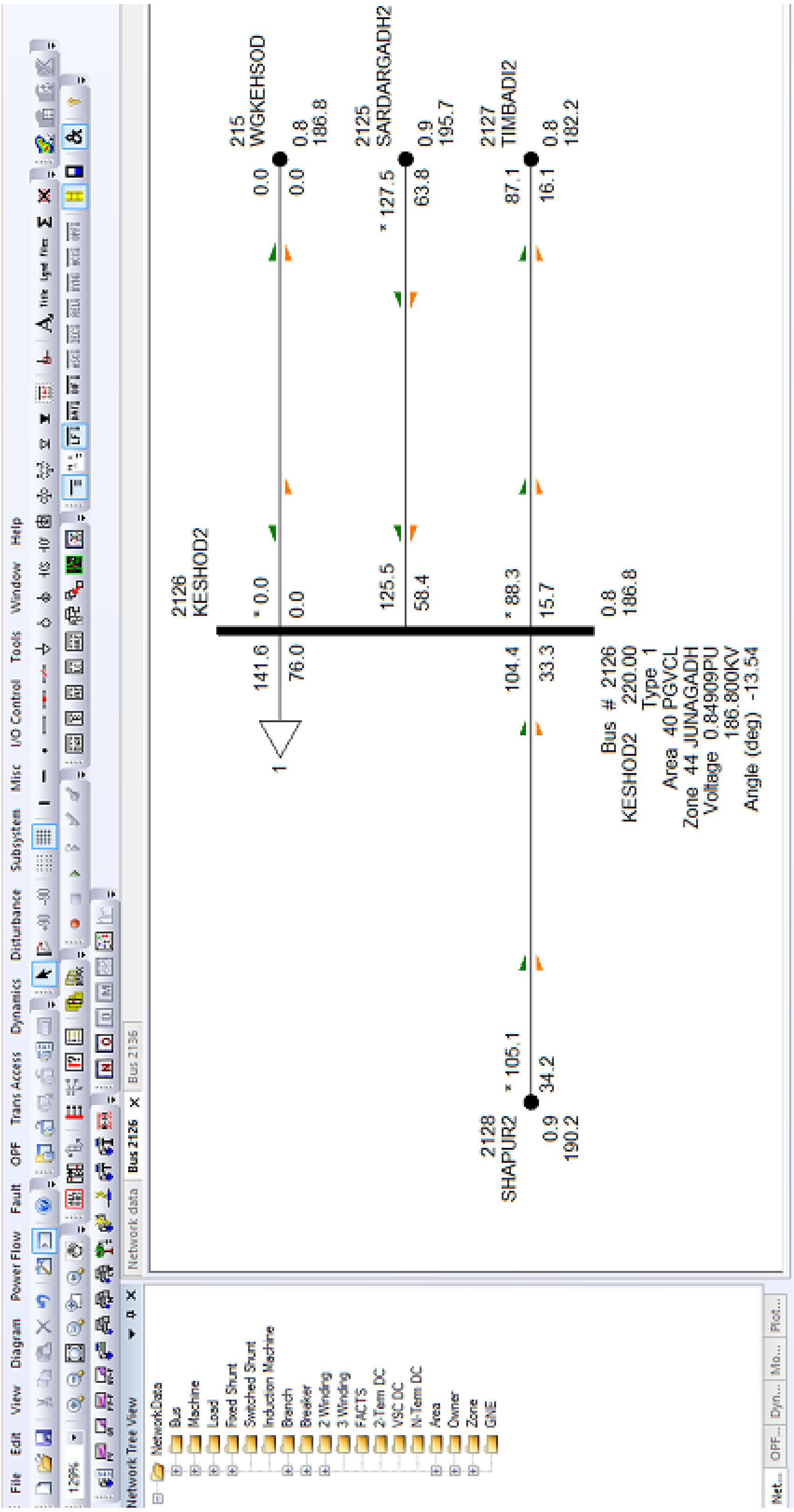

Figure 7.4: without FACTS Keshod 220kV s/s

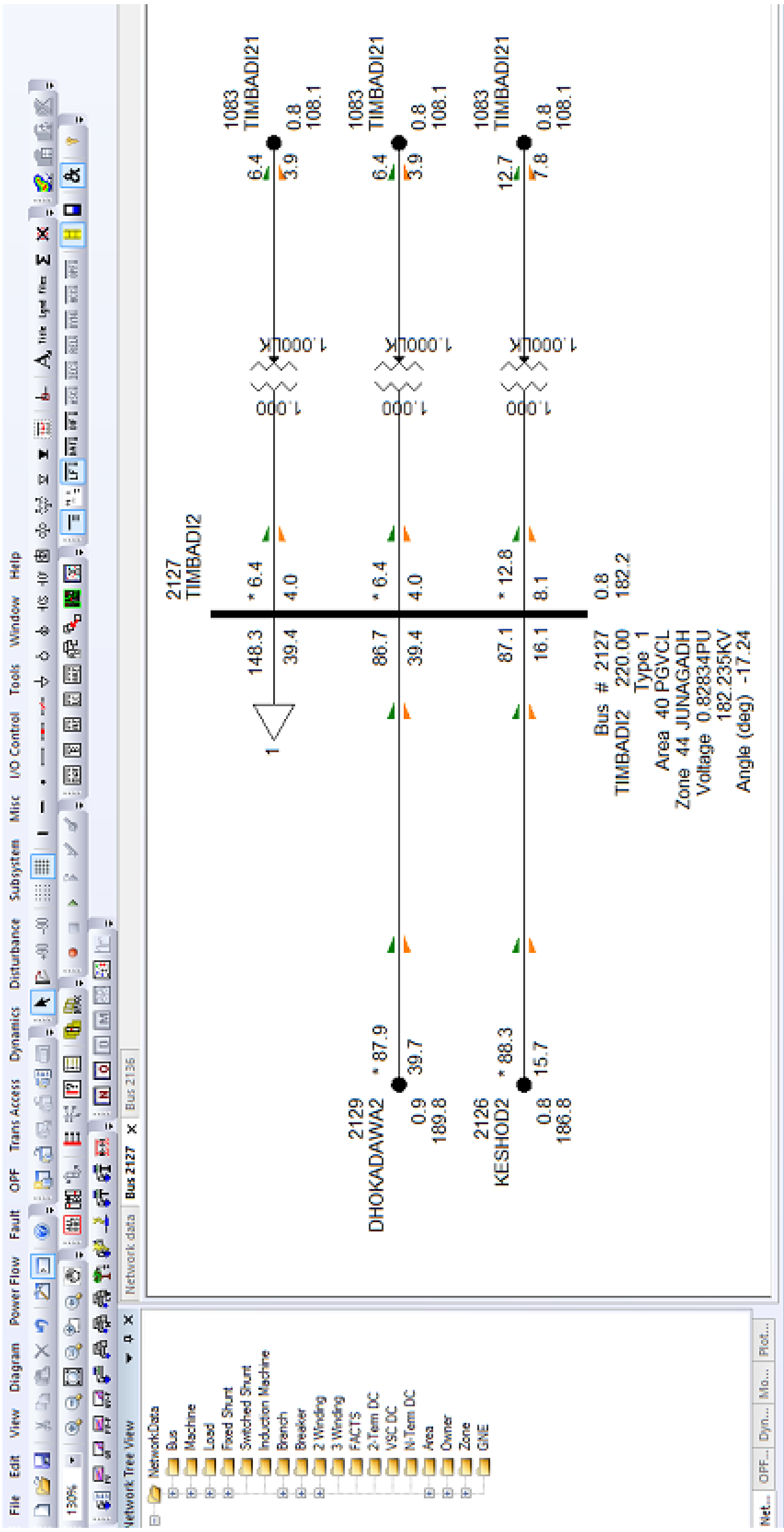

Figure 7.5: Without FACTS Timbadi 220kV s/s

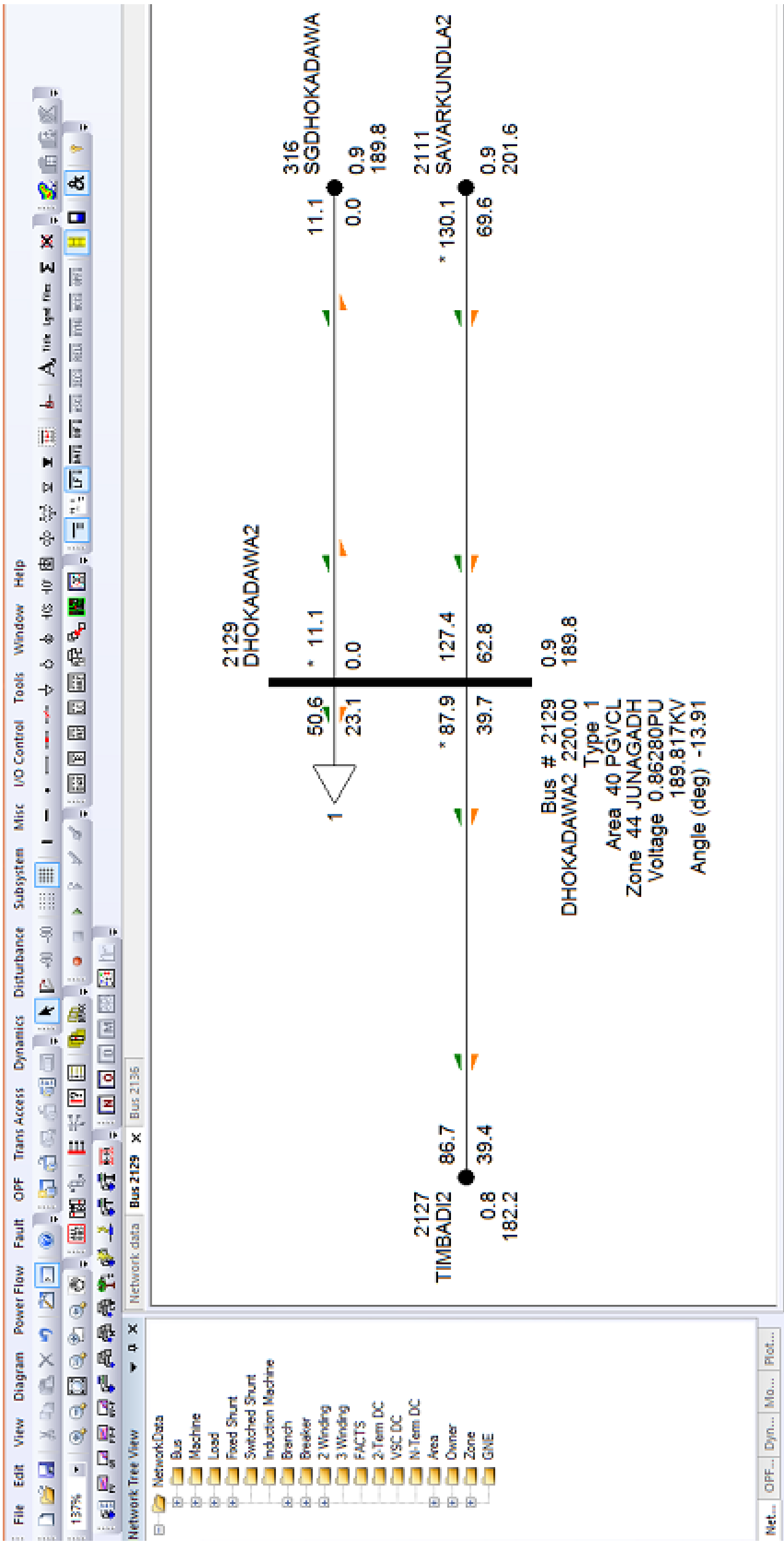

Figure 7.6: without FACTS Dhokadwa 220kV s/s

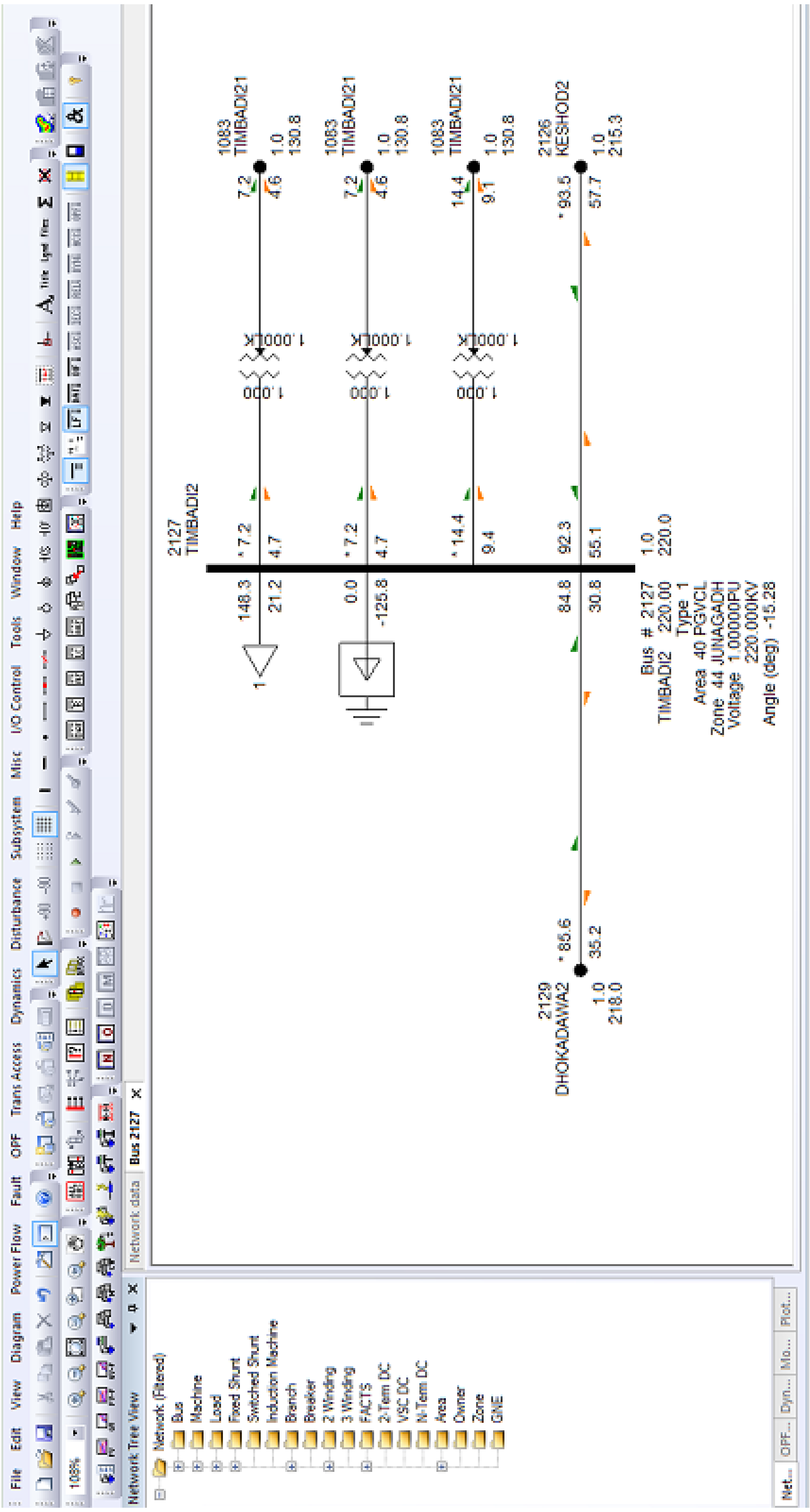

Figure 7.7: With FACTS Timbadi 220kV s/s

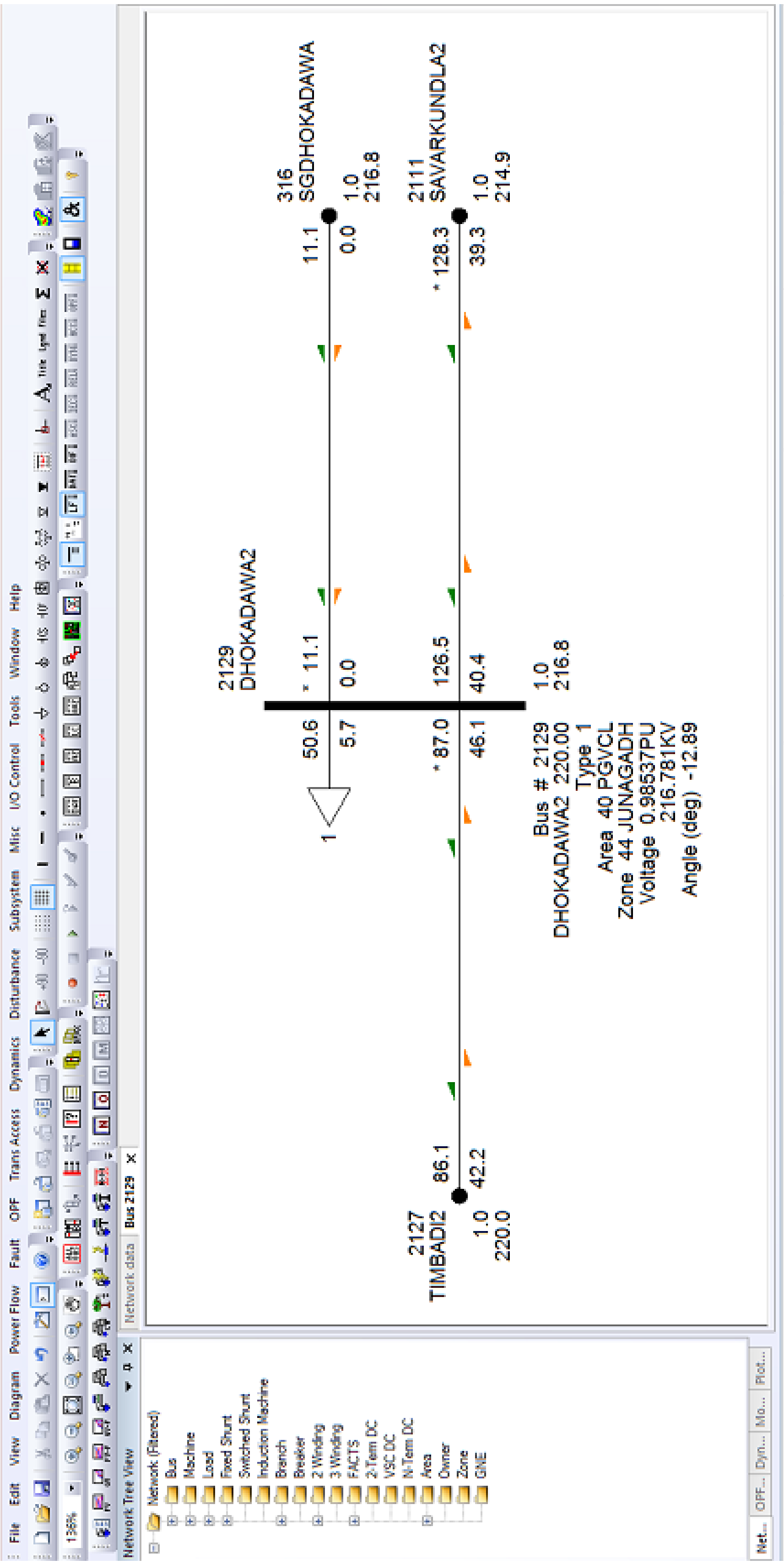

Figure 7.8: With FACTS Dhokadwa 220kV s/s

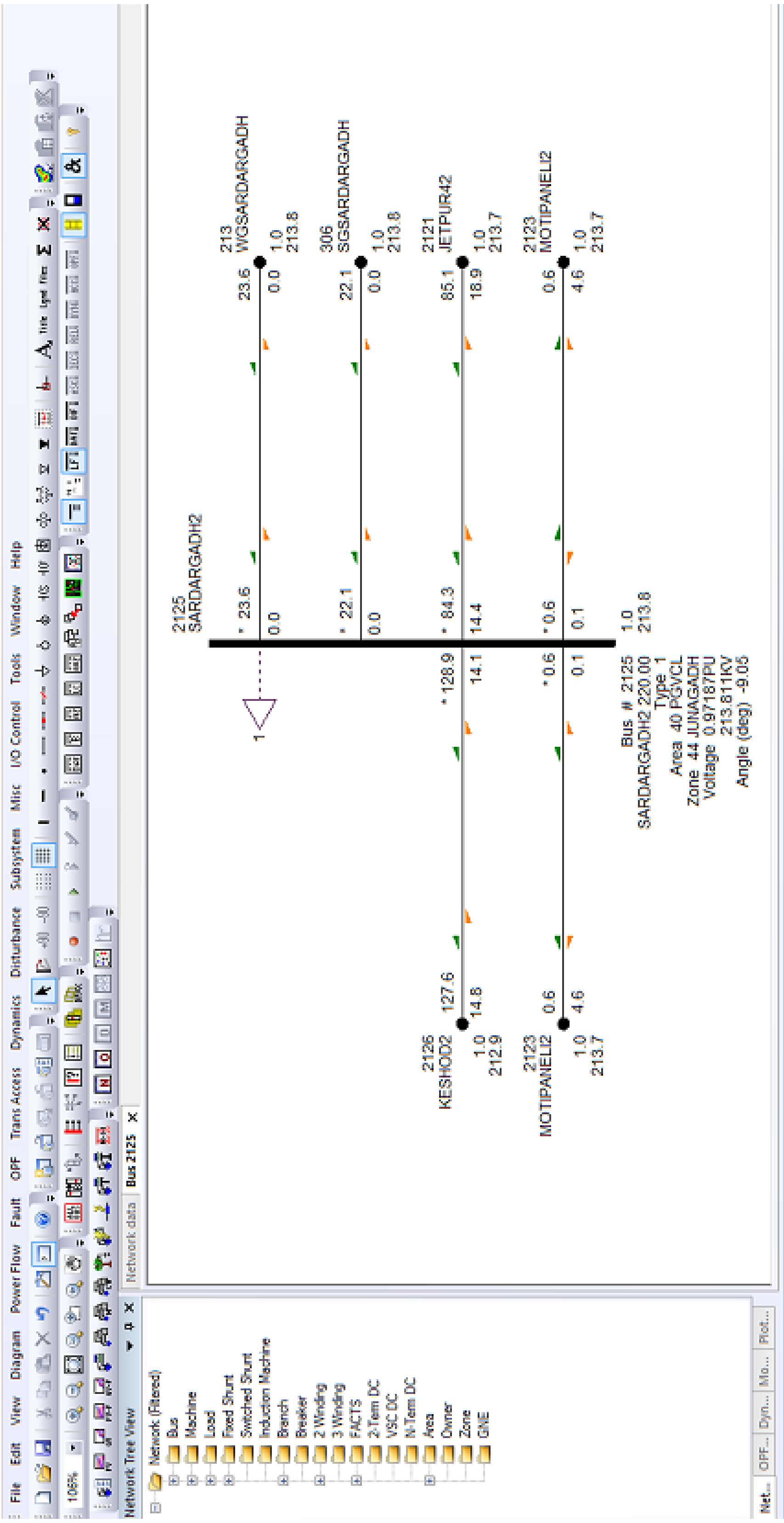

Figure 7.9: With FACTS Sardargadh 220kV s/s

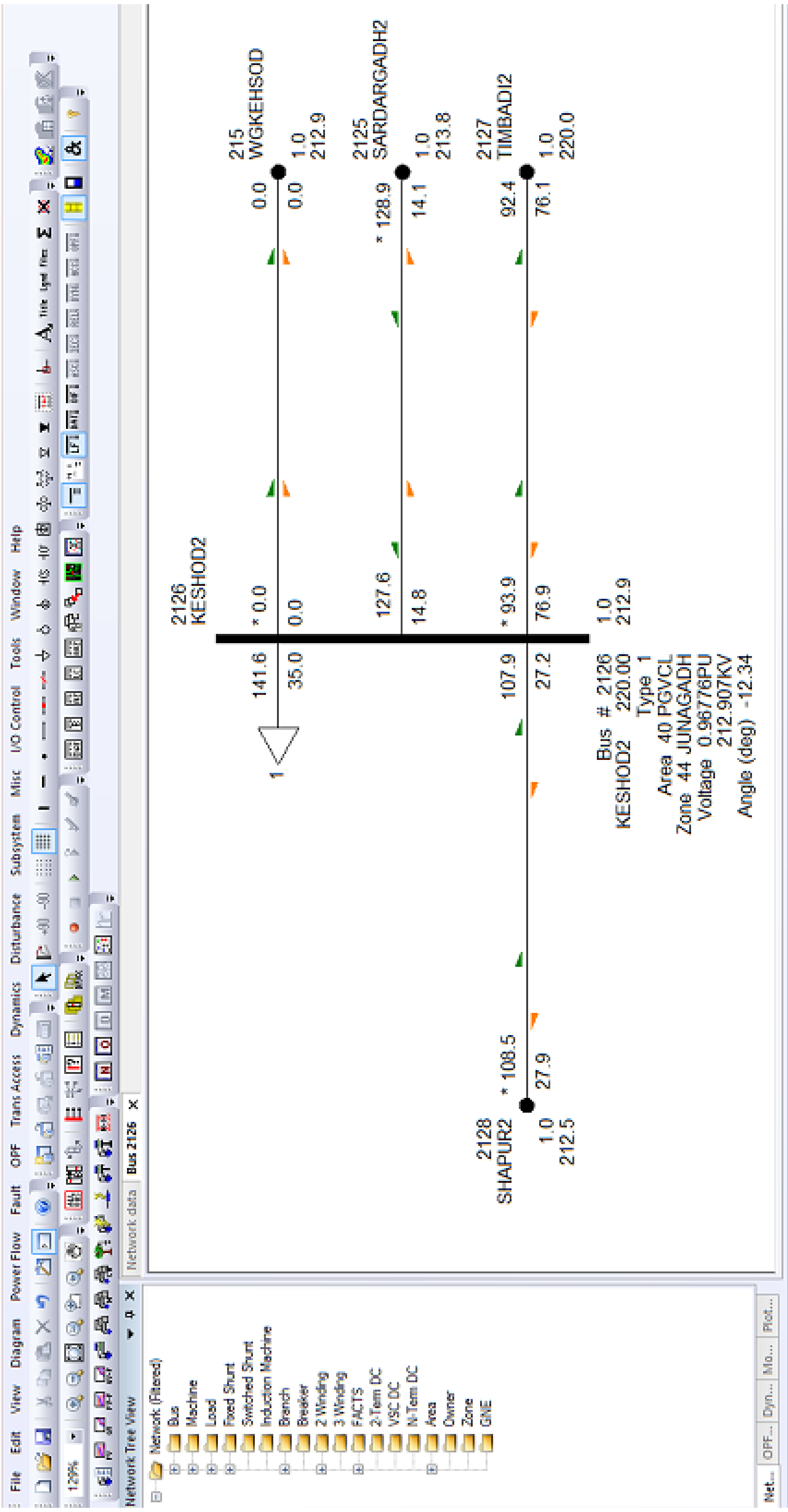

Figure 7.10: With FACTS Keshod 220kV s/s

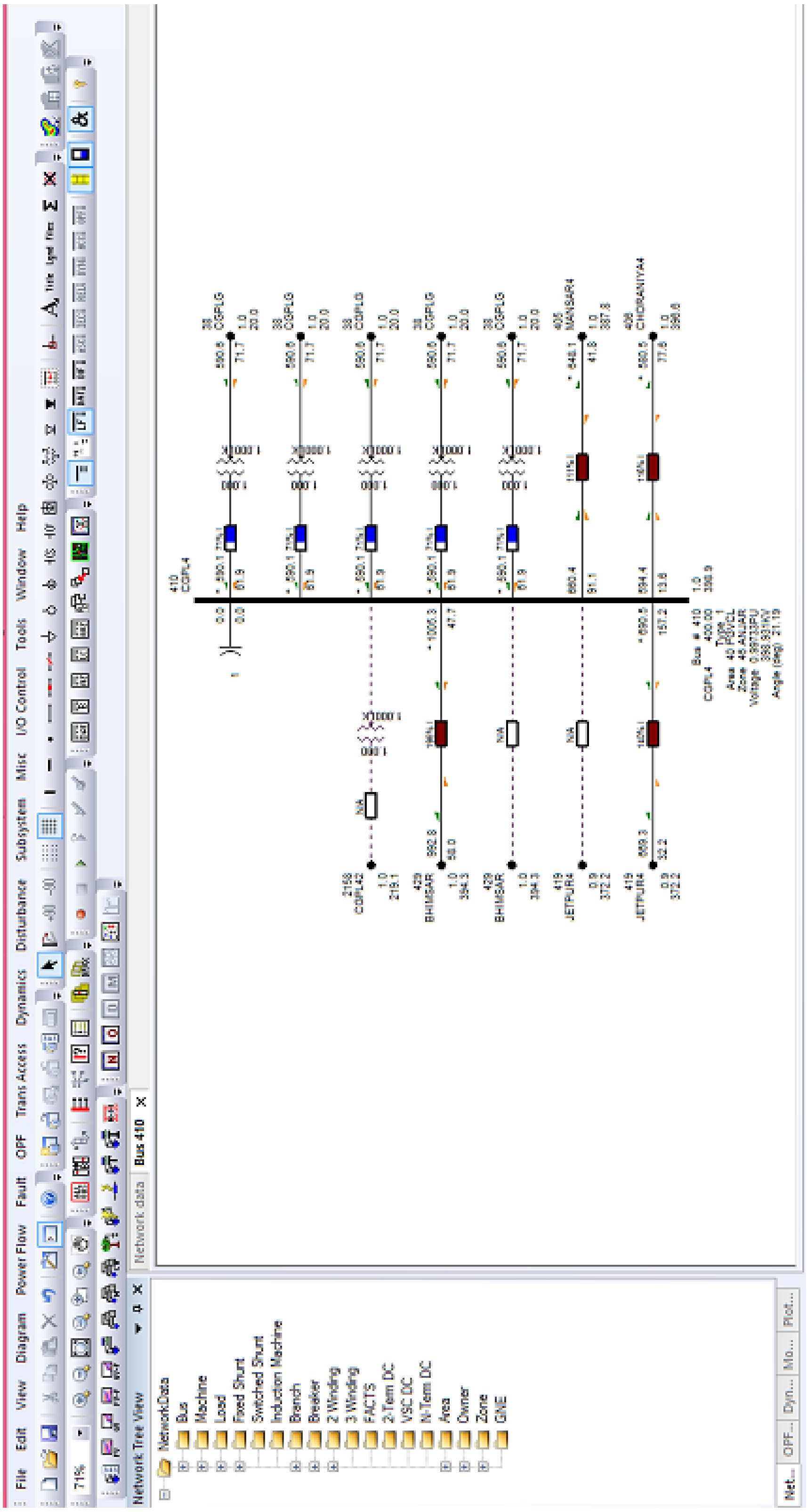

Figure 7.11: With FACTS CGPL 400kV s/s

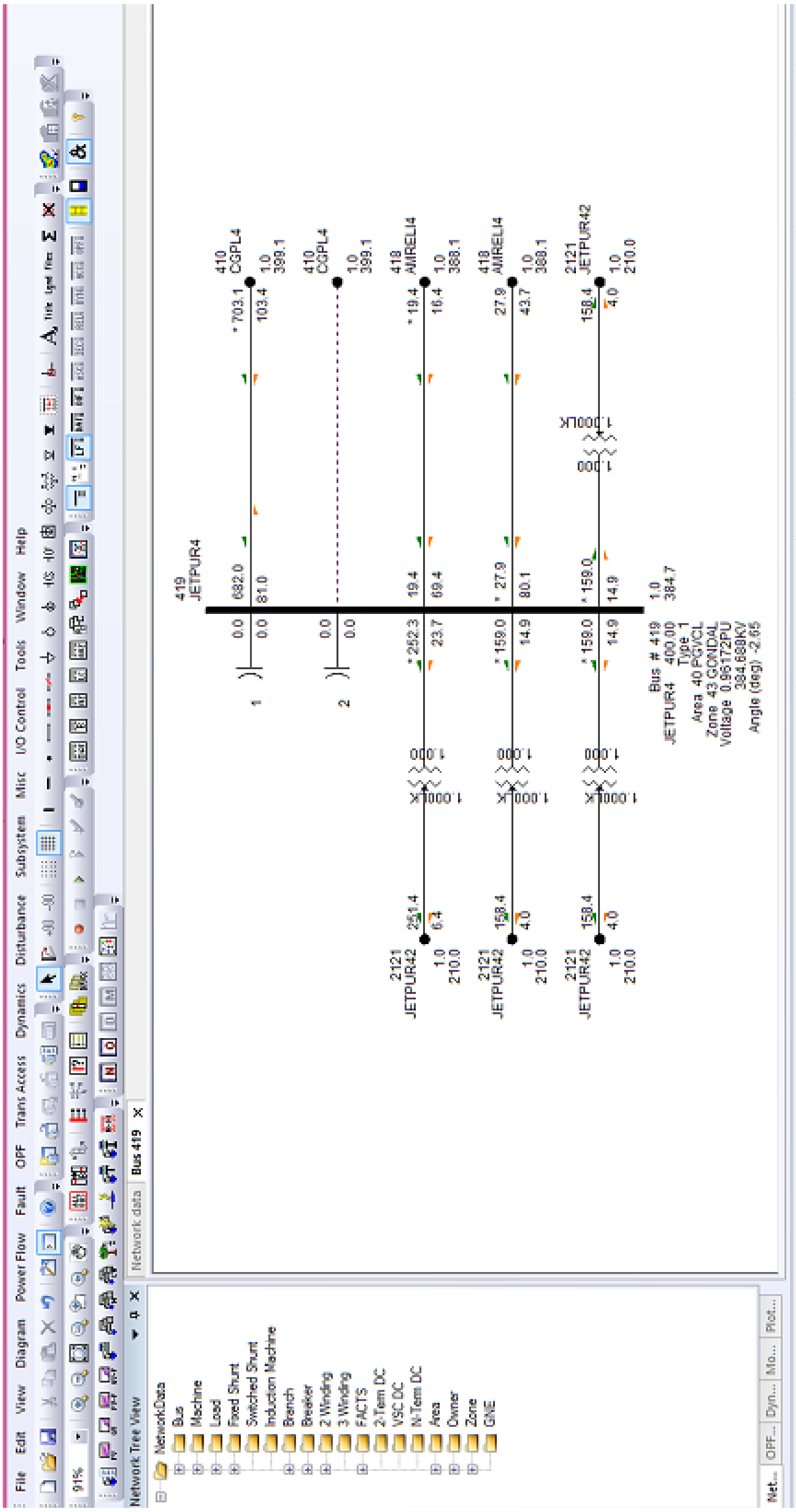

Figure 7.12: With FACTS Jetpur 400kV s/s

Chapter 8

Conclusion

8.1 Conclusion

According to Transmission Planning Criteria, voltage stability defined by load flow study with P-V & Q-V Curve method. After performing these methods on the Gujarat network, Only one pocket has voltage instability problem which is Timbadi pocket.As this pocket consists mainly agricultural load. In peak load condition voltages decrease upto 182 kV and in off-peak condition voltage is increase upto 248 kV. This problem is being analyzed by using PSS-E software using 120 MVAr STATCOM on 220 kV Timbadi bus. By considering very critical case when one of the 400 kV line of TATA-UMPP and JETPUR is out of service or any contingency occur at that line, the angular stability problem occurs and Jetpur 400 kV s/s voltage goes below the 375 kV. Which can also solve by STATCOM introduced at Timbadi. Gujarat grid is very strong, safe and reliable as it has no such critical instability problem.

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