ELECTRICITY CONGESTION MANAGEMENT

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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CERTIFICATE

This is to certify that the Major Project Report entitled **"Electricity Congestion Management"** submitted by **"Shah Samyak (Roll.No.14MEEE26)"**, 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 Samyak (Roll.No.14MEEE26)"**, give undertaking that the Major Project entitled **"Electricity Congestion Management"** 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 disciplinary action.

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- Shah Samyak Shreyansh

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Abstract

In the current scenario, rapid change in power system; drastic change in generation, transmission and distribution system, power system restructuring and other factor effect on loading on existing network. Ideally transmission network can transfer infinite amount of power to the source to demand. But as the transmission network have loading capacity limit and above that limit it is not advisable to operate. Because of this reason congestion need to be managed. By congestion management this overloaded power can be rerouted using management technique in the existing network like Strengthening of existing network, New lines to reenforce, FACTS devices, PST or HVDC. The PG project is to focus on congestion management for Gujarat network or for a small area, based on available information of system using appropriate software tools/codes. As a part of development process, the specific area of work can be enlisted as below:

- Study congestion and congestion management technique.
- Study of Gujarat network or for a small part of network.
- Congestion pocket finding in the taken network.
- Congestion management techniques to be applied.
- Study of network and impacts over network for applied technique.

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Abbreviations

AC .... Alternating Current
DC .... Direct Current
FACTS .... Flexible AC Transmission System
PST .... Phase Shifting Transformer
ICT .... Inter Connecting Transformer
HVDC .... High Voltage DC
CEA .... Central Electricity Authority
IEGC .... Indian Electricity Grid Code
GEGC .... Gujarat Electricity Grid Code
CTU .... Central Transmission Utility
STU .... State Transmission Utility
ISTS .... Inter State Transmission Utility
Intra-STS .... Intra State Transmission Utility
HV .... High Voltage
EHV .... Extra High Voltage
UHV .... Ultra High Voltage
GETCO .... Gujarat Energy Transmission Corporation Limited
PGVCL .... Paschim Gujarat Vij Company Limited
UGVCL .... Uttar Gujarat Vij Company Limited
MGVCL .... Madhya Gujarat Vij Company Limited
DGVCL .... Dakshin Gujarat Vij Company Limited
AEC .... Ahemdabad Electricity Company
SEC .... Surat Electricity Company
s/s .... Substation

Nomenclatures

$freq$ .... frequency,Hz
$r - o - w$ .... right-of-way

Contents

Chapter 1

Introduction

In any electrical network transmission network plays very important role. As transmission network provides transmission corridor to evacuate the generated power to the grid and supply that to the load center. But as due to growth in generation sector, growth in demand, contingencies etc. these transmission corridors being overloaded or say there is being shortage of transmission capacity which leads to congestion. This congestion hits the transmission elements of the network. To eliminate this there are some techniques which are FACTS, PST (Phase Shifting Transformer), HVDC link and strengthening of existing transmission infrastructure etc.. This project will main focus on the elimination or managing these congested pocket of transmission network.

1.1 Problem Identification

As the growth of any nation happens it is being defined by the growth per capita energy consumption and as the per capita consumption happens demand increases. As the demand changes generation changes need to be occur to fulfill the change in demand. While transmission network transfer this power from generation location to demand. Ideally transmission network can transfer infinite amount of power but taking consideration of the stability, thermal and dielectric limits into consideration it is not advisable to allow transfer power more than the loading capacity of the transmission network elements. Because of these there is shortage of transmission capacity. Which is need to be solve as the transmission network elements have their short time limits above which it can not transfer power in congestion condition. Which may lead to contingency condition or in congestion condition if any contingency happens then it will effect the elements which work on the emergency limits. So by using congestion management technique it is need to be manage with taking consideration of transmission planning criteria and grid codes.

1.2 Objective of the Work

The objective of the work will to find the congested pockets in the network or the section of the network and to explore the possibility to manage this congested pockets using the congestion management technique.

1.3 Methodology / Project Planning

- Literature Survey.
- Deciding the definition and title of the dissertation.
- Understand the Gujarat Transmission Network.
- Take network or section of the network and model it.
- Find congested pockets in the network or section network.
- Congestion Management Techniques to apply over it.
- Impact over the network.
- Best suitable technique to choose base on the comparison of the congestion management technique and its impact over the network.

1.4 Literature Survey

[1]F. Hussin, M. Y. Hassan,[1] "Transmission Congestion Management Assessment in Deregulated Electricity Market" 2006.
This paper gives the overview of the existing congestion management technique with comparison among the existing method in allocating the congestion charge to the participants is highlighted. For the comparison purpose 3 bus system has been used to illustrate the pro and con of the methods. The main advantage of this comparison is that it gives comparison between methodologies for charging congestion charges from the customer involved in the congestion.

[2] Yao Liangzhong, P. Catwright, L. Schmitt, Xiao-Ping Zhang,[2] "Congestion Management of Transmission system using FACTS" 2005.
This paper gives the overview of the congestion management of transmission system using 30 bus system study with and without the SSSC introduction in the system for the high penetration of wind energy in the network for feasibility as well as the effectiveness of it for congestion management. As the advancement in the VSC HVDC, it can alternatively applied over to enhance transfer capacity in case of network congestion.

[3] Xiao Ping Zhang, Yao Liangzhong,[3] "A vision of electricity network congestion management with FACTS and HVDC" 2008.
This paper gives the overview of the WAMS (Wide Area Measurement System) along with the FACTS and HVDC system to ensure electricity network flexible enough to meet new and less predictable supply and demand condition in competitive electricity markets. It carries the study over the future condition where the penetration of renewable sources are more. As the WAMS gives the wide area measurement it is very helpful to carry out the above study with FACTS and HVDC is cost effective to do this study.

[4] A. S. Siddiqui, M. T. Khan, F. Iqbal,[4] "A novel approach to de-

termine optimal location of TCSC for congestion management" 2014.
This paper gives the overview of the optimal placement of the TCSC over the congested pockets by finding the sensitivity index in comparison to with and without the placement of TCSC over the network and if placed then sensitivity of management by placing it. For that an algorithm has been introduced by taking Delhi 33 bus network. This algorithm is based on the sensitivity index comparison over placing TCSC at different nodes.

[5] Central Electricity Authority,[5] "manual on Trransmission Planning Criteria" 2013.
This material gives the overview of the Indian transmission network philosophy; reliability criteria; acceptable limits; Voltage limit for normal and emergency limits in the steady state, switching and load rejection state; System study and modelling; Load Generation scenario; load change for different season; consideration to take for different transmission system elements to plan the transmission system.

Chapter 2

Load Flow analysis

A load-flow study is a steady-state analysis whose target is to determine the voltages, currents and real & reactive power flows in a system under a given load conditions.

Load flow study is being used to analyze the network for any hypothetical situation and to do planning according to it. As if a transmission line is to be taken out of service for maintenance, can the remaining elements can handle the load in this situation without exceeding any limit.

In Load flow study there are two plow equation associated. And there are four parameters are being associated with each bus, which are: P, Q, V and δ.

While in Load Flow study there are two parameters are known or defined and other two are unknown or undefined. This parameters value being known and unknown depends on the type of bus.

The iterative methods are useful when the diagonal elements of the coefficient matrix are large with compare to the off diagonal elements. The round-off errors in are corrected at the successive steps of the iterative process.

The Newton-Raphson method is very much useful for solution of non linear equations, if all the values of the corrections for the unknowns are very small in magnitude and the initial values of unknowns are selected to be reasonably closer to the exact solution.

Each bus in a power system can be classified as one of three types:

a. Load bus (P-Q bus): at which the real and reactive power are specified, and for which the bus voltage will be calculated. All busses having no generators are load busses. In here, V and δ are unknown.

b. Generator bus (P-V bus): at which the magnitude of the voltage is defined and is kept constant by adjusting the field current of a synchronous generator. We also assign real power generation for each generator according to the economic dispatch. In here, Q and δ are unknown

c. Slack bus (swing bus): a special generator bus serving as the reference bus. Its voltage is assumed to be fixed in both magnitude and phase , P and Q are unknown.

2.1 Methods for Load Flow Analysis

There are mainly three methods for load flow analysis.

a. Gauss Seidel method

b. Newton Raphson method

c. Fast Decoupled method

2.2 Comparison of Load flow study

The comparison of the Load Flow methods can be done by comparing them with these mentioned parameters which are computational time taken for preparing the data for carry out the analysis and data processing, easiness in programming, requirement for data storage, per iteration computational time, number of iterations being carried out, easiness and time requirement for modified network data when any operating conditions changes etc.

As here all the mentioned methods are working on bus frame of reference in admittance form, which same for all the methods for which bus admittance matrix can be form using a simple algorithm. Gauss-Seidel method is relatively easy to program due to simplicity of the equations. While for programming of NR method it is complicated when the buses are randomly numbered. It is simpler in programming if the PV and PQ buses are ordered in sequence.

For NR method storage requirements are more, as the Jacobian elements need to be stored. If rectangular coordinates are used then memory is further increased for NR method. If the admittance matrix and Jacobian matices are used then the storage requirement can be drastically reduced as both are sparse matrices. The time taken to perform single iteration depends upon the number of arithmetic and logical operations in a full iteration. While Gauss Seidel method require less number of operations to complete full iteration. In NR method, Jacobian matix is necessary in every iteration. Also, there is need to compute inverse of the Jacobian matrix. Hence, the time reuired per iteration are larger than the GS method which is roughly about 7 times that of the GS method, in large systems. In FDLF method, the Jacobian is constant and needs to be computed only once. In both NR and FDLF methods, the time per iteration increases directly as the number of buses.

Chapter 3

Congestion

3.1 Historical overview

In electrical network there are three major subnetworks:

- Generation Network
- Transmission Network
- Distribution Network

As due to fuel availability, geographical condition, fuel transportation and economical reasons mostly generation is away from the load centres. Because of these reasons transmission network plays crucial role as intermediary be tween generation network and distribution network. This transmission network can ideally transfer infinite amount of power from generation to load centre but due to loading capacity of the transmission elements it is not possible and advisable to run it above capacity. As the lines and equipments are bound to operate within some limit which depends upon

- Type of construction
- Material used for manufacturing
- Type of operation

Now as per the Indian scenario, planning criteria of 1985 was about the self sufficiency of the regional network but the revised transmission planning criteria,1994 was about the changes taking in account the experience gained from EHV system. These regional grids were being interconnect to form the largest electrical grid in the world. Now the philosophy of the criteria was change from self sufficiency to bulk power transfer between inter regional network by forming high capacity AC and HVDC corridors.[5]

But as per the Electricity Act, 2003 there was introduction of unbundling of vertically integrated State Electricity Boards, implementation of open access in power transmission and liberation of generation sector. Phenomenal growth of private sector generation and open access market had brought some uncertainties. Which are large no. of generation plan are coming up with no knowledge of beneficiaries, generation capacity addition, commissioning schedules and fuel availability etc.. However in planning of transmission network some flexibility can be given to cater such uncertainties but it can not totally rule out the congestion.

3.2 Congestion

Whenever the physical or operational constraints in a transmission network become active, the system is said to be in a state of congestion.

It can also be defined as a situation where demand transmission capacity is higher than available transfer capacity.

Due to congestion some transmission network elements being hit with some of the limits or constraints which are

- Line thermal limits
- Transformer Emergency Ratings
- Bus Voltage Limits

- Transient and Oscillatory Stability

It can shortly be said as shortage of transmission capacity or transmission line hitting its limit. This power transfer capability is being limit by some physical and electrical characteristics are

- Thermal Limits
- Voltage Limits
- Stability Limit

Factors contributing congestion are

- Less transmission available capacity than the actual demand over the transmission corridor as the transmission lines for a span being planned before 4 to 5 years before commissioning.
- Seasonal load changes and load growth
- Contingency
- Generation growth

Due to being hit by the congestion the main impact is price gouging by the transmission service provider for transmitting energy which incurs extra cost and other are being hit the constraints of the elements.

Chapter 4

Congestion Management

Techniques being implemented over the network to improve the available transmission capacity to mitigate electricity congestion is called congestion management.

As for the single handling transmission network there are some technique by which this congestion problem can resolve at some points are:

- FACTS (Flexible AC Transmission System)
- PST (Phase Shifting Transformer)
- Strengthening of the transmission network
- Load Shedding or Curtailment

As the transfer of power from a point to another point can be find through this equation

$$P = \frac{V_1 * V_2}{X_l} * sin(\delta) \tag{4.1}$$

Where,

P = Transfer power from point 1 to 2

V_1 = Voltage at bus 1

V_2 = Voltage at bus 2

X_l = Reactance between point 1 to 2

In normal condition power flow depends upon

- Voltage level between two points
- Phase angle difference between voltage of two points
- Reactance between two points (including line, transformer etc.)
- Load angle

As in the condition of congestion this demand power is more than available power transfer capacity. By using above management technique however this capacity can be enhance or reroute to relieve the equipment.

4.1 Congestion Management Technique

4.1.1 FACTS Controllers

As the FACTS controllers divide into four categories:

- Series controllers
- Shunt controllers
- Combined series-series controllers
- Combined series-shunt controllers

In congestion management by using these different FACTS controller above stated parameter can be control at some extent (till the FACTS or the equipment hit the limit). By which the available transfer capability can be enhance. As well it can be used to reroute the power flow to manage the congestion.

4.1.2 PST (Phase Shifting Transformer)

As the phase shifting transformer is not different than the ordinary tap changing transformer with just a change that PST can regulate the voltage angle. This phase angle regulation can be done by zig-zag connection of the primary, secondary and tertiary winding and by changing the no. of turns of the windings. As by this connection and tap angle between bus voltages it can vary the phase angle within limit. But this angle difference between two adjacent buses should not be exceed more than 30 degree [5].

If in the network presence of PST is more than by using them power can reroute to the other line which are having less loading.

PST can not be used to enhance the available transfer capability but by regulating the phase angle difference it can reroute the power transfer.

4.1.3 Strengthening of the existing transmission network

Existing transmission network is slightly prone to congestion. In this case by strengthening the transmission network it can be able to cater the congestion at some extent. These following options may be considered for strengthening of transmission network. The choices shall be based on cost, reliability, right-of-way requirements, transmission losses, down time (in case of upgradation or re-conductoring etc.)

- Addition of new transmission line/substation to avoid overloading of existing system including adoption of higher voltage.
- Upgradation of the existing line with higher voltage using same r-o-w.
- Re-conductoring of existing transmission line with higher ampacity conductor.
- Use of multi-voltage level and multi-circuit transmission lines.

By using these techniques congestion can cater at some extent.

4.1.4 Load shedding or Curtailment

When the generation can not cater the peak demand at that time some of the load being cut off from the network to lower the demand. But it has some pro and cons to service providers. As in the case when any technique can not manage congestion by load shedding those elements of the pockets can be relieved. If those equipment are not being relieved then it can damage those equipment. Utilities may roll black out or as per the agreement with industry high use equipment to be turned off as a part of load shedding. But because of the load shedding service providers need to give incentives to those customers as per the agreement. In the condition of congestion at the last option it is being used.

4.2 Comparison of Congestion Management Technique

From above stated congestion management techniques it can be sort by some parameters. This parameters are the ability to enhance the power transfer capability, capability to reroute the power and economic factors.

As the FACTS device have capability to enhance the power transfer capability and rerouting of energy by compensating reactive power requirement, varying the line impedance by inserting variable impedance in series of line, compensating for real power by using Battery Energy Storage System (BESS)or Superconducting Magnet Energy Storage (SMES) etc. But it is costly.

While PST have capability to reroute the power flow by zig-zag connection with different no. of turns of primary, secondary and tertiary winding. It is less costlier than FACTS but it lags with the FACTS due to not having enhancement of power transfer capability.

Where strengthening of transmission network is lag with the above stated technique because of the time taken by planning for it. As it takes minimum 4 to 5 years before commissioning of it. But it is beneficiary at long term. Here the down time is more for it than above techniques. But if the planning is better then it will help at a long term as the FACTS device or PST can help in solving the congestion but after the growth in generation and demand at a point it will hit the limit of its operation at that time this method is far more better than solving congestion problem using FACTS or PST.

Load shedding and curtailment is very effective to apply but it is not advisable as redundancy become less than the above technique. And also it is last point in the congestion case. It has not any above capability but it can only relieve the network elements.

Because of above reasons if the congestion become severe and all of the above stated technique is not there or it fails to relieve elements from congestion load shedding being used.

Chapter 5

Load Flow Results

5.1 Existing Network

5.1.1 Consideration taken in Load Flow Study of Existing Network

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 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 is not operated.

f. Voltage level less than 132 kV is taken as lump load.

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

- 220 kV Jambuva - Haldarva 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

5.1.2 Loading Report of the Existing Network

Subsystem loading report

Loading above 100 % of rating

(MVA for transformers, current for non transformer branches)

Table 5.1: Brach Limit Report as per the snapshot

FROM BUS		TO BUS			RATE SET A		RATE SET B		RATE SET C	
BUS	**NAME**	**BUS**	**NAME**	**LOAD**	**RATE**	%	**RATE**	%	**RATE**	%
1003	TALOD1	1007	RANASAN21	76.8	66	116.3	70	110	75	102.4
1005	CHILODA1	1007	RANASAN21	91.7	66	139	70	131	75	122.3
1007	RANASAN21	1049	SABARMATI1	77.1	66	116.9	70	110	75	102.8
1007	RANASAN21	1049	SABARMATI1	77.1	66	116.9	70	110	75	102.8
1008	MEHSANA21	1010	SIDDHPUR1	68.5	66	103.8	70	98	75	91.3
1024	KARAMSAD21	1040	NADIAD1	85.7	66	129.9	70	123	75	114.3
1026	HALDARVA21	1058	BHARUCH1	140.7	66	213.1	70	201	75	187.6
1039	AEC21	1049	SABARMATI1	91.4	66	138.5	70	131	75	121.9
1039	AEC21	1049	SABARMATI1	91.4	66	138.5	70	131	75	121.9
1053	NAVSARI21	1055	ATUL1	82.5	66	124.9	70	118	75	110
1065	WANKANER1	1090	SARTANPAR21	118.8	66	180	70	170	75	158.4
1074	JASDAN1	1076	GONDAL21	67.1	66	101.7	70	96	75	89.5
1075	VIKRAM1	1087	NYARA21	67.2	66	101.8	70	96	75	89.6
1079	SHAPUR21	1080	JUNAGADH1	104.7	66	158.7	70	150	75	139.6
1087	NYARA21	1088	VAJADI1	70.9	66	107.4	70	101	75	94.5
1090	SARTANPAR21	1091	LALPAR21	74.5	66	112.8	70	106	75	99.3
1111	VINJOL1	1116	PIRANA1	120.4	66	182.4	70	172	75	160.5

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TableBranch Limit 5.1 – *Continued from previous page*

FROM BUS		TO BUS			RATE SET A		RATE SET B		RATE SET C	
BUS	NAME	BUS	NAME	LOAD	RATE	%	RATE	%	RATE	%
1111	VINJOL1	1116	PIRANA1	120.4	66	182.4	70	172	75	160.5
1113	NIKOL21	2177	NIKOL2	143.2	120	119.3	135	106	150	95.5
2001	SOJA42	2004	JAMLA2	141	140	100.7	185	76	225	62.7
2001	SOJA42	2004	JAMLA2	141	140	100.7	185	76	225	62.7
2007	AGIYOL2	2009	DHANSURA2	153.6	140	109.7	185	83	225	68.3
2007	AGIYOL2	2009	DHANSURA2	153.6	140	109.7	185	83	225	68.3
2009	DHANSURA2	2028	WANAKBORI42	169.2	140	120.9	185	92	225	75.2
2009	DHANSURA2	2028	WANAKBORI42	169.2	140	120.9	185	92	225	75.2
2018	SHIVLAKHA2	2136	TAPPAR2	168.5	140	120.3	185	91	225	74.9
2018	SHIVLAKHA2	2170	BHACHAU2	159.9	140	114.2	185	86	225	71
2026	CHARANKA2	2029	DEODAR2	200.1	140	142.9	185	108	225	88.9
2043	KOSAMBA42	2066	KIM2	191.1	140	136.5	185	103	225	85
2043	KOSAMBA42	2066	KIM2	191.1	140	136.5	185	103	225	85
2050	DEHGAM42	2052	RANASAN2	145.4	140	103.9	185	79	225	64.6
2050	DEHGAM42	2052	RANASAN2	145.4	140	103.9	185	79	225	64.6
2061	AMBHETI2	3012	DNH2	156.8	140	112	185	85	225	69.7
2061	AMBHETI2	3012	DNH2	156.8	140	112	185	85	225	69.7
2062	MOTA2	2077	UKAITH42	215.2	140	153.7	185	116	225	95.7

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TableBranch Limit 5.1 – *Continued from previous page*

FROM BUS		TO BUS			RATE SET A		RATE SET B		RATE SET C	
BUS	**NAME**	**BUS**	**NAME**	**LOAD**	**RATE**	%	**RATE**	%	**RATE**	%
2062	MOTA2	2077	UKAITH42	215.2	140	153.7	185	116	225	95.7
2068	KAWAS2	2070	ICHHAPOR2	175.3	140	125.2	185	95	225	77.9
2068	KAWAS2	2070	ICHHAPOR2	175.3	140	125.2	185	95	225	77.9
2096	MANSAR42	2097	HALVAD42	170.6	140	121.9	185	92	225	75.8
2096	MANSAR42	2097	HALVAD42	170.6	140	121.9	185	92	225	75.8
2111	SAVARKUNDLA2	2120	AMRELI42	250.9	140	179.2	185	136	225	111.5
2111	SAVARKUNDLA2	2120	AMRELI42	250.9	140	179.2	185	136	225	111.5
2111	SAVARKUNDLA2	2129	DHOKADAWA2	152.4	140	108.8	185	82	225	67.7
2121	JETPUR42	2128	SHAPUR2	199.2	140	142.3	185	108	225	88.5
2125	SARDARGADH2	2126	KESHOD2	259	140	185	185	140	225	115.1
2135	HADALA42	2137	KANGASIYALI2	190.5	140	136.1	185	103	225	84.7
2136	TAPPAR2	2139	VONDH2	179.9	140	128.5	185	97	225	80
2136	TAPPAR2	2170	BHACHAU2	159.7	140	114.1	185	86	225	71
2143	KUKMA2	2153	PANANDHRO2	142	140	101.4	185	77	225	63.1
2143	KUKMA2	2153	PANANDHRO2	142	140	101.4	185	77	225	63.1

5.1.3 Load Flow Report Analysis from Loading Report

Saurashtra & Kutch Area

Due to 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. Therefore following elements are loading critically loaded:

a. 220 kV Charanka - Deodar line (190-220 MW)

b. 220 kV Tappar - Shivlakha line (180 - 200 MW)

As per the recent scenario, agricultural loads are being fed from the TATA UMPP and APL, Mundra. Due to new agricultural connections agricultural load has been increase. If wind is available then it will help to control situation but when wind generation is less at that time it critically loads these elements mostly:

a. 220 kV Amreli - Savarkundla line (More than 220 MW)

Central and South Gujarat

Very low generation from Gas Based generating stations located in south Gujarat area, i.e. Utran, Essar, GSEG, CLPI, 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.

a. 220 kV Ukai(Th) - Mota line (More than 200 MW)

North Gujarat

Due to reduction in generation from Gandhinagar TPS, Torrent- Ahmedabad TPS and Dhuvaran TPS, owing to costly generation, following elements are getting critically loaded:

a. 132 kV Ranasan - Sabarmati Linr (80-100 MW)

b. 132 kV Mehsana - Siddhpur Line (70-80 MW)

5.2 Existing Network with Future Condition

Taking consideration of above found congested pocket some future condition has applied and taking consideration of it below list is prepared, in the below subsection, for which the congestion management as well as near future condition are being analysed.

5.2.1 Elements Taken into Consideration

Branches Taken into Consideration

- 400 kV Amreli - GPPC (Amreli) D/C Line
- 400 kV Vadinar(ESSAR) - Amreli D/C Line
- 400 kV Jetpur - Hadala S/C Line
- 400 kV Amreli - Hadala D/C Line
- 400 kV Varsana - Charanka D/C Line (LILO line of Adani(Mundra)-Varsana-Kansari(Zerda) Line)
- 400 kV Charanka - Sankhari D/C Line (LILO line of Adani(Mundra)-Varsana-Kansari(Zerda) Line)
- 400 kV Sankhari - Kansari(Zerda) D/C Line (LILO line of Adani(Mundra)-Varsana-Kansari(Zerda) Line)
- 400 kV Sankhari - Kansari(Zerda) D/C Line (LILO line of Kansari(Zerda)-Vadavi Line)
- 400 kV Sankhari - Vadavi D/C Line (LILO line of Kansari(Zerda)-Vadavi Line)
- 400 kV Charanka - Sankhari D/C Line
- 400 kV Prantij - Wanakbori(Unit 8) S/C Line (LILO line of Wanakbori(Unit 8)-Soja Line)
- 400 kV Wanakbori (Unit 8) - Soja S/C Line

- 400 kV Prantij - Soja S/C Line (LILO line of Wanakbori(Unit 8)-Soja Line)
- 400 kV Prantij - Sankhari D/C Line

- 220 kV Savarkundla - 400 kV GPPC S/C Line(LILO line of Savarkundla - GPPL Line)
- 220 kV GPPL - 400 kV GPPC S/C Line(LILO line of Savarkundla - GPPL Line)
- 220 kV Visavadar - 400 kV GPPC S/C Line(LILO line of Visavadar - Savarkundla Line)
- 220 kV Savarkundla - 400 kV GPPC S/C Line(LILO line of Visavadar - Savarkundla Line)
- 220 kV Amreli - Visavadar D/C Line
- 220 kV Visavadar - Timbadi D/C Line
- 220 kV Otha - 400 kV GPPC D/C Line
- 220 kV Vondh - Radhanpur S/C Line
- 220 kV Vondh - Charanka S/C Line (LILO line of Vondh-Radhanpur Line)
- 220 kV Charanka - Radhanpur S/C Line (LILO line of Vondh - Radhanpur Line)
- 220 kV Tappar - Vondh S/C Line (LILO line of Tappar - Hadala Line)
- 220 kV Vondh - Hadala S/C Line (LILO line of Tappar - Hadala Line)
- 220 kV Radhanpur - 400 kV Sankhari D/C Line
- 220 kV Radhapur - 400 kV Sankhari S/C Line (LILO line of Radhanpur - Mehsana Line)

- 220 kV Mehsana - 400 kV Sankhari S/C Line (LILO line of Radhanpur - Mehsana Line)
- 220 kV Varsana - Charanka D/C Line
- 220 kV Prantij - Dhansure D/C Line
- 220 kV Agiyol - Prantij D/C Line
- 220 kV Ukai(Th) - Songadh S/C Line (LILO line of Ukai(Th) - Achhalia Line)
- 220 kV Songadh - Achhalia S/C Line (LILO line of Ukai(Th) - Achhalia Line)
- 220 kV Songadh - Ukai(Th) S/C Line
- 220 kV Songadh - Ambheta(Chikhli) D/C Line

- 132 kV Deesa - 400 kV Sankhari S/C Line
- 132 kV Mehsana - 400 kV Sankhari S/C Line (LILO line of Mehsana - Patan Line)
- 132 kV Patan - 400 kV Sankhari S/C Line (LILO line of Mehsana - Patan Line)

Transformers Taken into Consideration

a. 400 kV GPPC s/s .... 315 MVA 400/220 kV Transformer

b. 400 kV Charanka s/s .... 315 MVA 400/220 kV Transformer

c. 400 kV Sankhari s/s .... Two 100 MVA 400/132 kV Transformer

d. 400 kV Prantij s/s .... Two 315 MVA 400/220 kV Transformer

Lines Taken Out of Service

a. 400 kV Kansari - Vadavi D/C Line

b. 400 kV Jetpur - Amreli S/C Line

c. 400 kV Amreli - Hadala S/C Line

d. 220 kV Tappar - Hadala S/C Line

e. 220 kV Radhanpur - Mehsana S/C Line

f. 220 kV Savarkundla - GPPL S/C Line

g. 220 kV Savarkundla - Visavadar S/C Line

h. 220 kV Ukai(Th) - Achhalia S/C Line

i. 132 kV Mehsana - Patan S/C Line

5.2.2 Loading Report of After Scenario

Subsystem loading report for Futuren Condition

Loading above 100 % of rating (MVA for transformers, current for non transformer branches)

Table 5.2: Branch Limit Report as per the Future Condition

FROM BUS		TO BUS			RATE SET A		RATE SET B		RATE SET C	
BUS	**NAME**	**BUS**	**NAME**	**LOAD**	**RATE**	**%**	**RATE**	**%**	**RATE**	**%**
410	CGPL4	429	BHIMSAR	593.8	515	115.3	570	104.2	625	95
410	CGPL4	429	BHIMSAR	593.8	515	115.3	570	104.2	625	95
418	AMRELI4	2120	AMRELI42	254.7	252	101.1	280	91	315	80.9
418	AMRELI4	2120	AMRELI42	254.7	252	101.1	280	91	315	80.9
418	AMRELI4	2120	AMRELI42	254.7	252	101.1	280	91	315	80.9
1005	CHILODA1	1007	RANASAN21	72.5	66	109.8	70	103.6	75	96.7
1009	PATAN1	1200	SANKHARI41	74.5	66	112.9	70	106.4	75	99.3
1024	KARAMSAD21	1040	NADIAD1	68.1	66	103.1	70	97.2	75	90.7
1039	AEC21	1049	SABARMATI1	74.8	66	113.3	70	106.8	75	99.7
1039	AEC21	1049	SABARMATI1	74.8	66	113.3	70	106.8	75	99.7
1053	NAVSARI21	1055	ATUL1	78.1	66	118.3	70	111.5	75	104.1
1065	WANKANER1	1090	SARTANPAR21	108.3	66	164.1	70	154.8	75	144.4
1111	VINJOL1	1116	PIRANA1	110.3	66	167.2	70	157.6	75	147.1
1111	VINJOL1	1116	PIRANA1	110.3	66	167.2	70	157.6	75	147.1
2015	RADHANPUR2	2029	DEODAR2	148	140	105.7	185	80	225	65.8
2026	CHARANKA2	2029	DEODAR2	156.8	140	112	185	84.8	225	69.7

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TableBranch Limit 5.2 – *Continued from previous page*

FROM BUS		TO BUS			RATE SET A		RATE SET B		RATE SET C	
BUS	**NAME**	**BUS**	**NAME**	**LOAD**	**RATE**	**%**	**RATE**	**%**	**RATE**	**%**
2030	ASOJ42	2034	JAMBUVA2	140.5	140	100.4	185	76	225	62.4
2043	KOSAMBA42	2066	KIM2	154.9	140	110.6	185	83.7	225	68.8
2043	KOSAMBA42	2066	KIM2	154.9	140	110.6	185	83.7	225	68.8
2061	AMBHETI2	3012	DNH2	157.5	140	112.5	185	85.1	225	70
2061	AMBHETI2	3012	DNH2	157.5	140	112.5	185	85.1	225	70
2062	MOTA2	2077	UKAITH42	157.4	140	112.4	185	85.1	225	69.9
2062	MOTA2	2077	UKAITH42	157.4	140	112.4	185	85.1	225	69.9
2068	KAWAS2	2070	ICHHAPOR2	148.8	140	106.3	185	80.4	225	66.1
2068	KAWAS2	2070	ICHHAPOR2	148.8	140	106.3	185	80.4	225	66.1
2096	MANSAR42	2097	HALVAD42	166.3	140	118.8	185	89.9	225	73.9
2096	MANSAR42	2097	HALVAD42	166.3	140	118.8	185	89.9	225	73.9
2111	SAVARKUNDLA2	2120	AMRELI42	180.4	140	128.8	185	97.5	225	80.2
2111	SAVARKUNDLA2	2120	AMRELI42	180.4	140	128.8	185	97.5	225	80.2
2121	JETPUR42	2128	SHAPUR2	163.7	140	116.9	185	88.5	225	72.8
2135	HADALA42	2137	KANGASIYALI2	169.1	140	120.8	185	91.4	225	75.2
2136	TAPPAR2	2139	VONDH2	147.7	140	105.5	185	79.8	225	65.7
2136	TAPPAR2	2139	VONDH2	147.7	140	105.5	185	79.8	225	65.7
2146	NANIKHAKHAR2	2157	MUNDRA42	140.5	140	100.3	185	75.9	225	62.4

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TableBranch Limit 5.2 – *Continued from previous page*

FROM BUS		TO BUS			RATE SET A		RATE SET B		RATE SET C	
BUS	**NAME**	**BUS**	**NAME**	**LOAD**	**RATE**	**%**	**RATE**	**%**	**RATE**	**%**
2146	NANIKHAKHAR2	2157	MUNDRA42	140.5	140	100.3	185	75.9	225	62.4

5.3 Summary of Results

5.3.1 Saurashtra & Kutch Area

After applying above said future condition lines the above said critically loaded lines are being relieved which are as per:

a. 220 kV Charanka - Deodar Line (190 - 200 MW)

- Before Scenario (Existing Scenario):
  Charanka - Deodar Line Loading: 191.3 MW

- After Scenario (After Addition of Future Network):
  Charanka - Deodar Line Loading: 159.1 MW

b. 220 kV Tappar - Shivlakha Line (180 - 200 MW)

- Before Scenario (Existing Scenario):
  Tappar - Shivlakha Line Loading: 182.3 MW

- After Scenario (After Addition of Future Network):
  Tappar - Shivlakha Line Loading: 132.6 MW

c. 220 kV Amreli - Savarkundla Line (More Than 220 MW)

- Before Scenario (Existing Scenario):
  Amreli - Savarkundla Line Loading: 231.2 MW

- After Scenario (After Addition of Future Network):
  Amreli - Savarkundla Line Loading: 153 MW

The problem of congestion can be managed if the GPPC(220 kV), Pipavav (Gas Based Generating Plant), is in working condition. As in the current scenario, the demand of terminal points in this area/pocket is being fulfilled from the Amreli 400 kV s/s using 220 kV Amreli - Savarkundla transmission line.

5.3.2 Central & South Gujarat

After applying above said future condition lines the above said critically loaded lines are being relieved which are as per:

a. 220 kV Ukai(Th) - Mota Line (More than 200 MW)

- Before Scenario (Existing Scenario):
  Ukai(Th) - Mota Line Loading: 205.6 MW

- After Scenario (After Addition of Future Network):
  Ukai(Th) - Mota Line Loading: 156.9 MW

5.3.3 North Gujarat

After applying above said future condition lines the above said critically loaded lines are being relieved which are as per:

a. 132 kV Ranasan - Sabarmati Line (70-80 MW)

- Before Scenario (Existing Scenario):
  Ranasan - Sabarmati Line Loading: 73 MW

- After Scenario (After Addition of Future Network):
  Ranasan - Sabarmati Line Loading: 59 MW

b. 132 kV Mehsana - Siddhpur Line (70-80 MW)

- Before Scenario (Existing Scenario):
  Mehsana - Siddhpur Line Loading: 68.5 MW

- After Scenario (After Addition of Future Network):
  Ranasan - Sabarmati Line Loading: 45.1 MW

5.4 Proposed Scheme

a. **400 kV Jetpur - Hadala S/C Line**

As to evacuate the power of Vadinar(ESSAR), there has been one line proposed which is 400 kV Amreli - Vadinar(ESSAR) D/C Line. For that two lines are need to be taken out of service which are:

- 400 kV S/C Jetpur - Amreli Line
- 400 kV S/C Hadala - Amreli Line

While all the 400 kV s/s in this pocket are having one generation source

- Jetpur s/s having CGPL as the generator source
- Hadala s/s having Mundra(Adani) as the generator source
- Amreli s/s having Vadinar(ESSAR) as the generator source

Advantage:

- So by using 400 kV line between Jetpur and Hadala reliability can be increased as the network of 400 kV Shapar is going to interconnect with Hadala s/s.

b. **132 kV Bharuch - Haldarva D/C Line**

What is the need?

As in the existing network condition 132 kV Ankleshwar s/s is connected with

132 kV Bharuch and 220 kV Achhalia s/s through D/C line. In this condition if the 132 kV Bharuch - Haldarva S/C line and 132 kV Bharuch - Ankleshwar D/C line are in working condition then the loading over line is:

- Loading over 132 kV Bharuch - Haldarva S/C Line: 80 MW
- Loading over 132 kV Bharuch - Ankleshwar D/C Line: 38 MW (Each Line)

Because of this reason Bharuch - Haldarva line is being put into charging condition whenever it congests and the power is being fed from 220 kV Achhalia by 132 kV Ankleshwar - Achhalia D/C line. To reduce the loading over Achhalia power is need to be fed from Haldarva through Haldarva-Bharuch-Ankleshwar 132 kV D/C line.

Advantage:

- It will help in relieving transformer of Achhalia s/s.

Chapter 6

Simulation Result

Simulation results of the existing network and existing network with future condition has been simulated in PSS-E software and the screenshot of the simulation results are as per below:

- 220 kV Charanka - Deodar Case
- 220 kV Tappar- Shivlakha Case
- 220 kV Amreli - Savarkundla Case
- 220 kV Ukai(Th) - Mota Case
- 132 kV Ransan - Sabarmati Case
- 132 kV Mehsana - Siddhpur Case

Which are shown from next page.

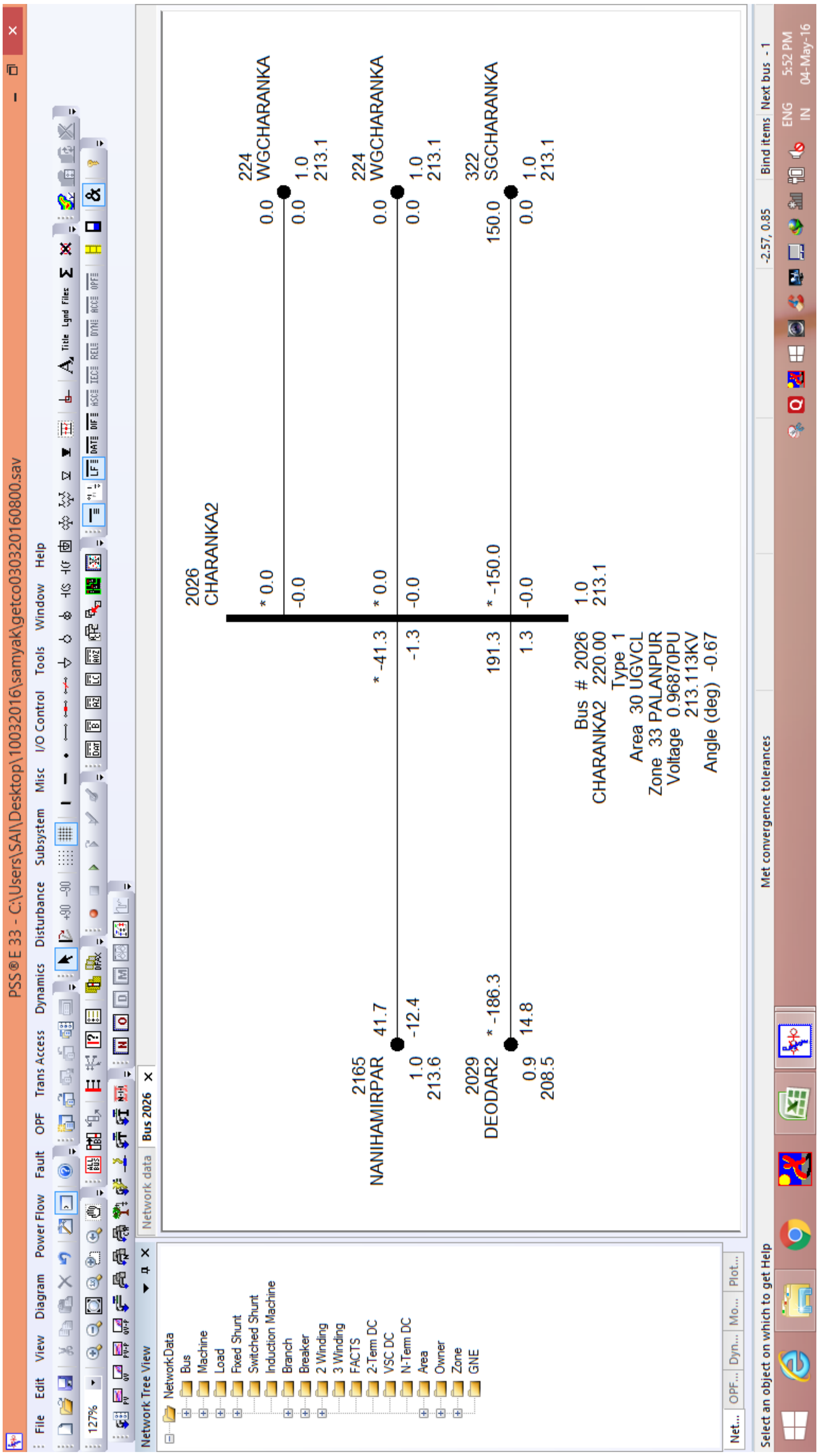

Figure 6.1: 220 kV Charanka - Deodar case (Before Scenario)

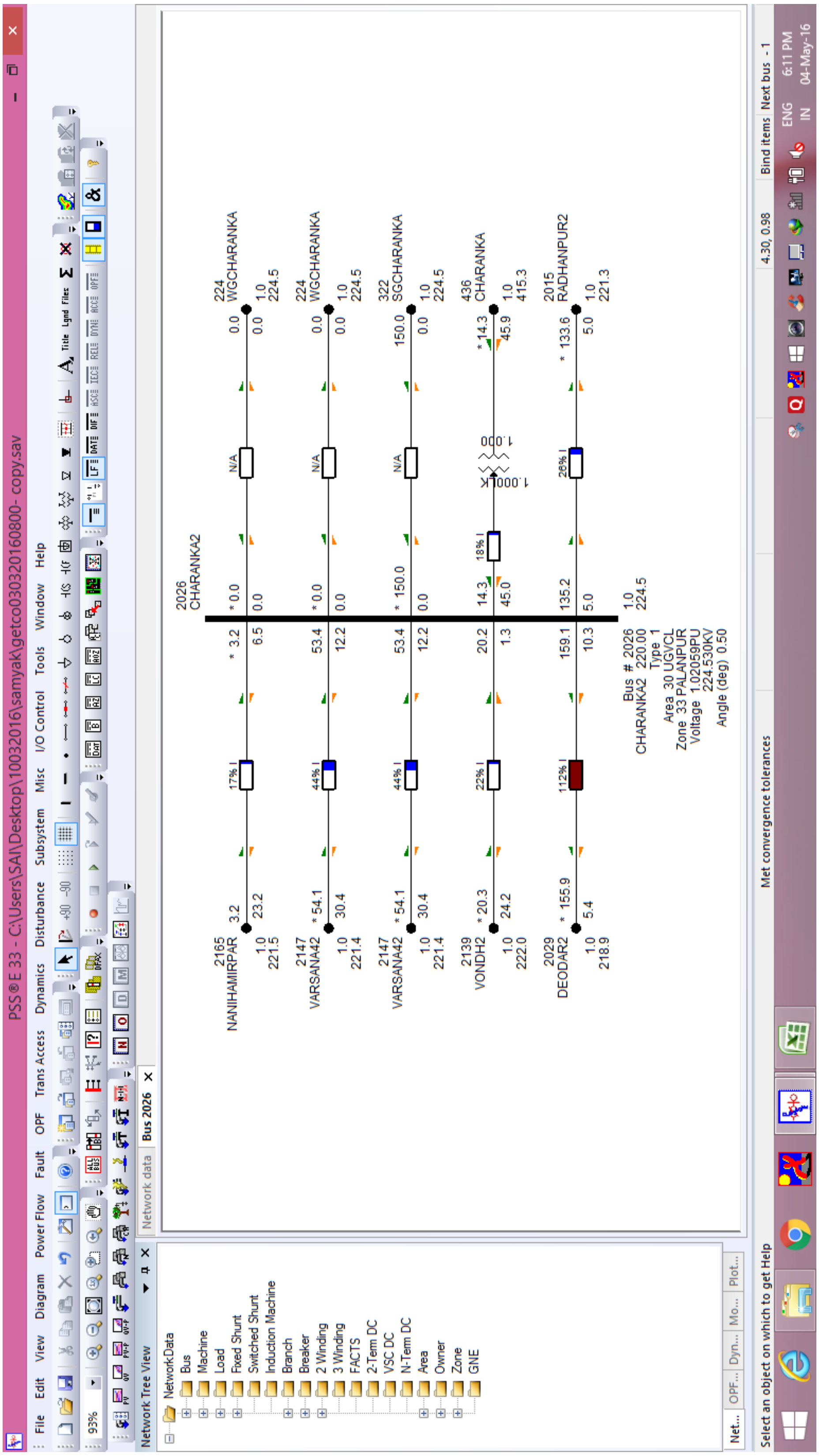

Figure 6.2: 220 kV Charanka - Deodar case (After Scenario)

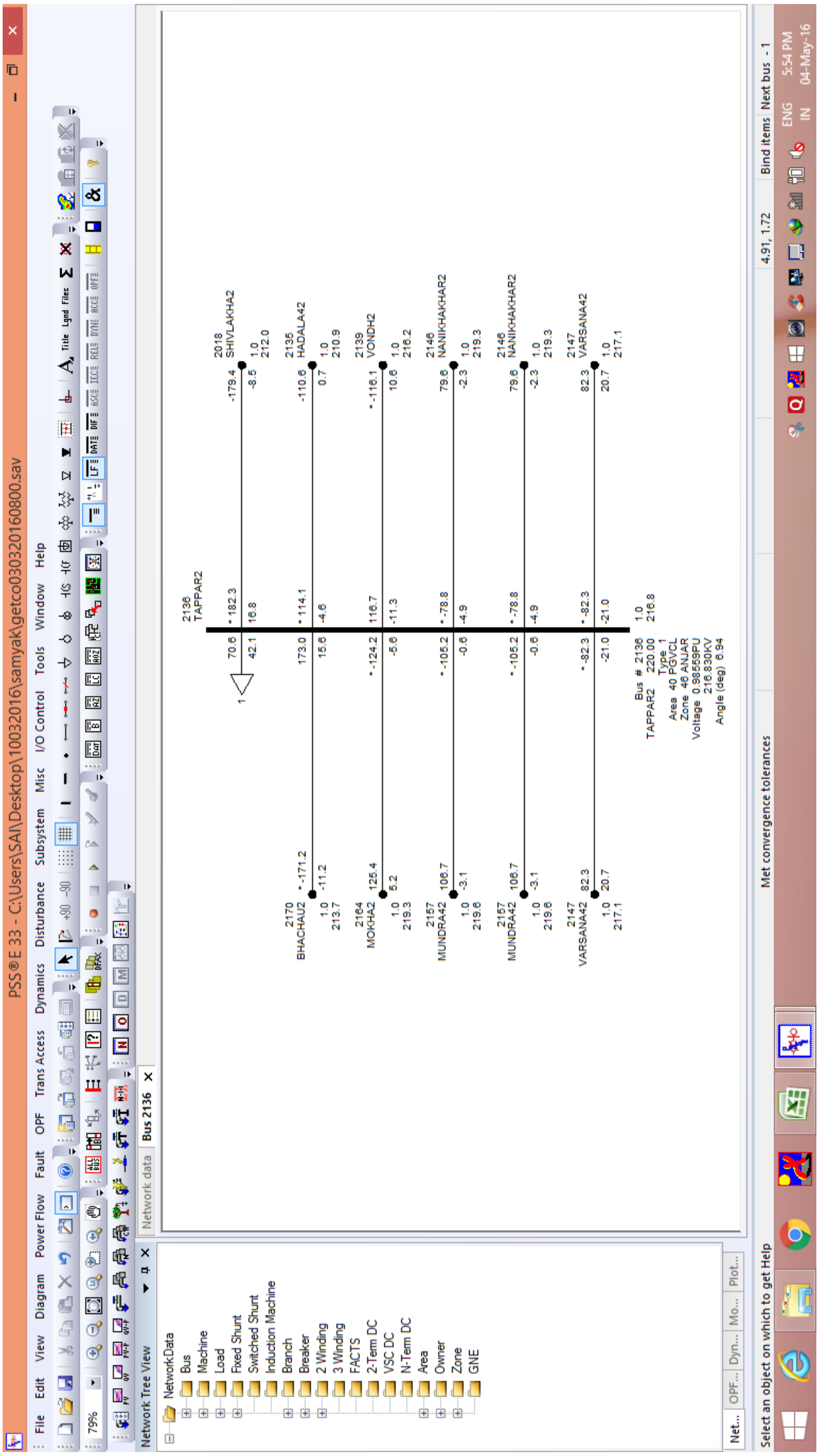

Figure 6.3: 220 kV Tappar - Shivlakha case (Before Scenario)

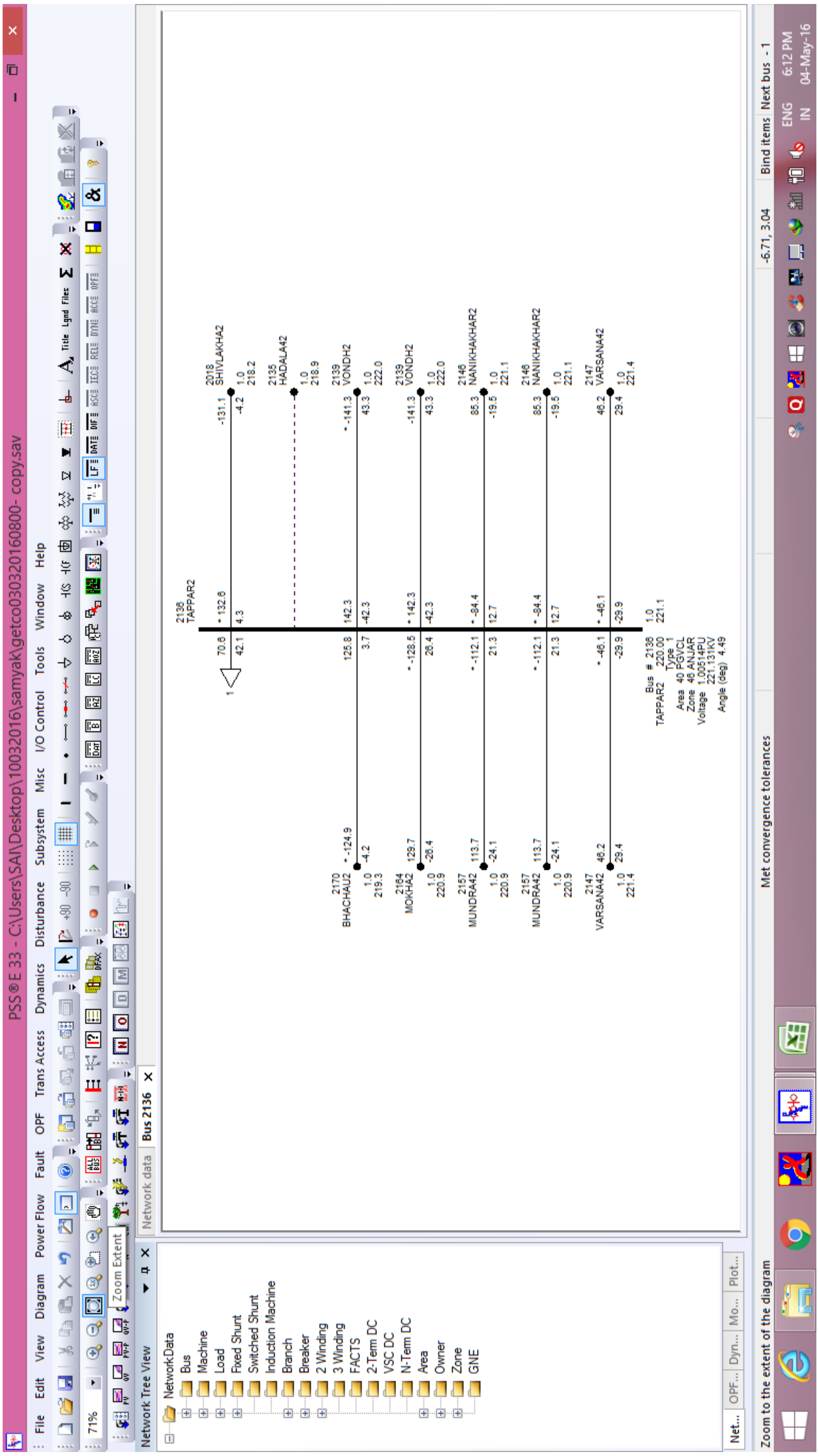

Figure 6.4: 220 kV Tappar - Shivlakha case (After Scenario)

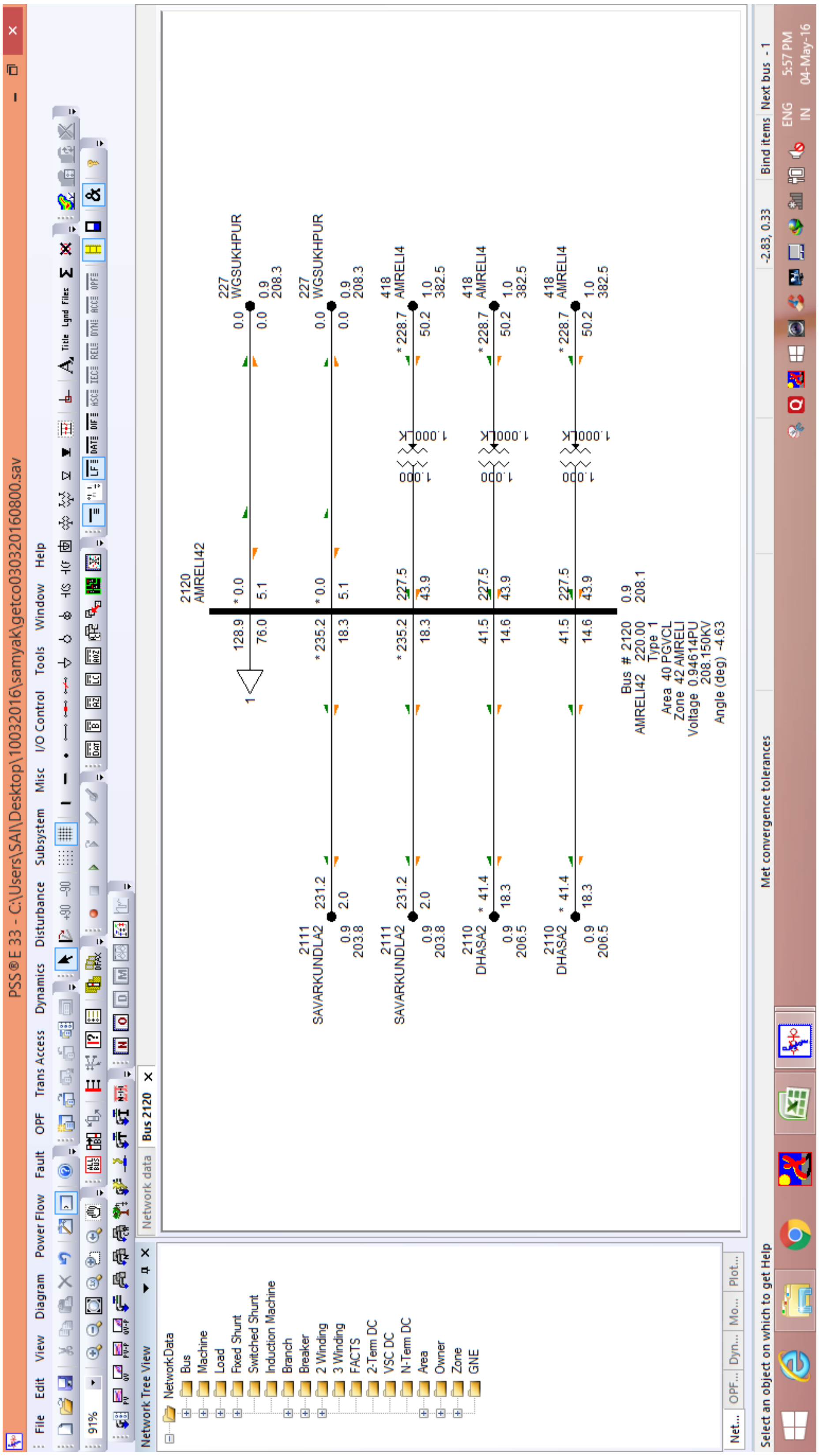

Figure 6.5: 220 kV Amreli - Savarkundla case (Before Scenario)

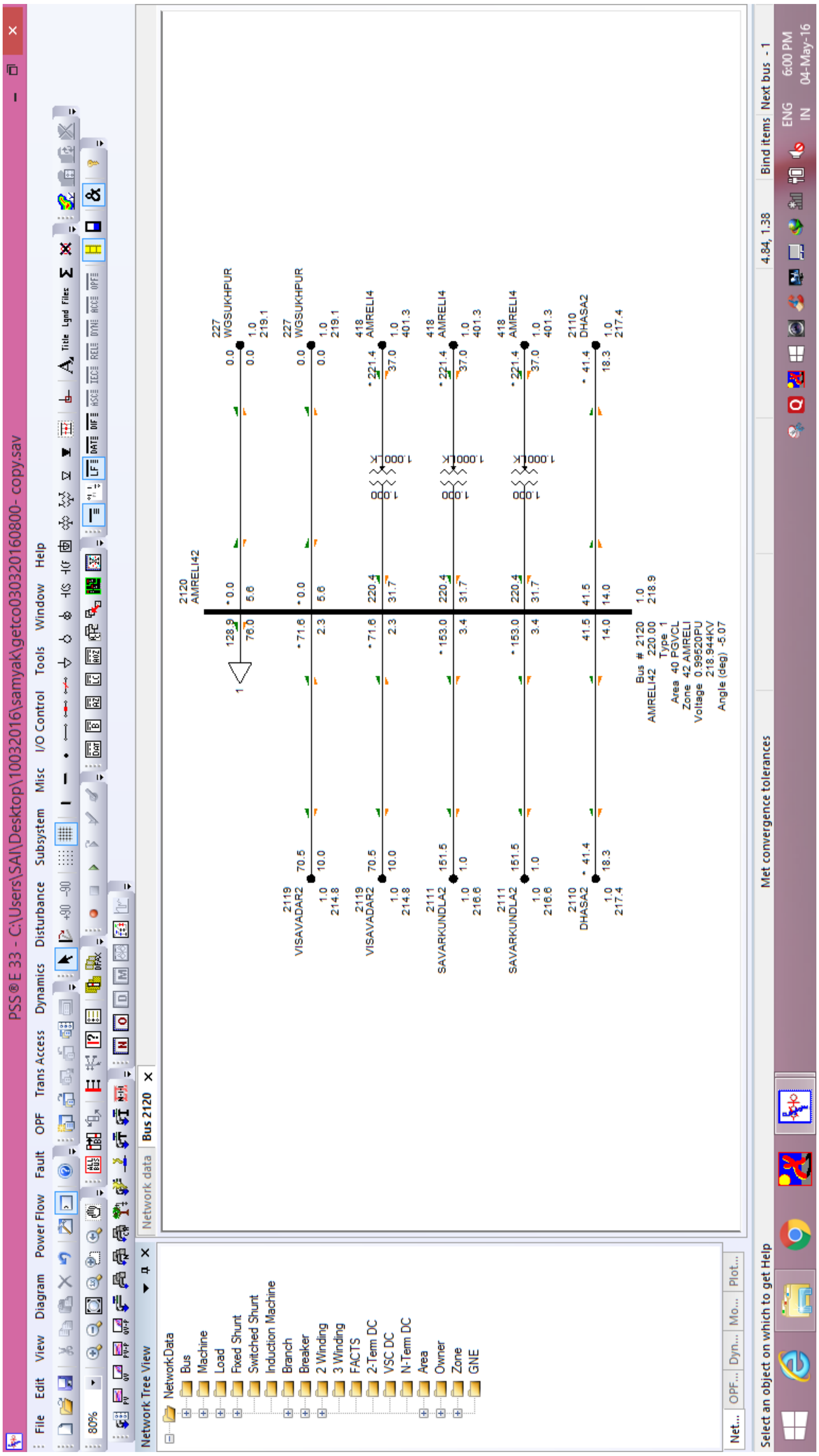

Figure 6.6: 220 kV Amreli - Savarkundla case (After Scenario)

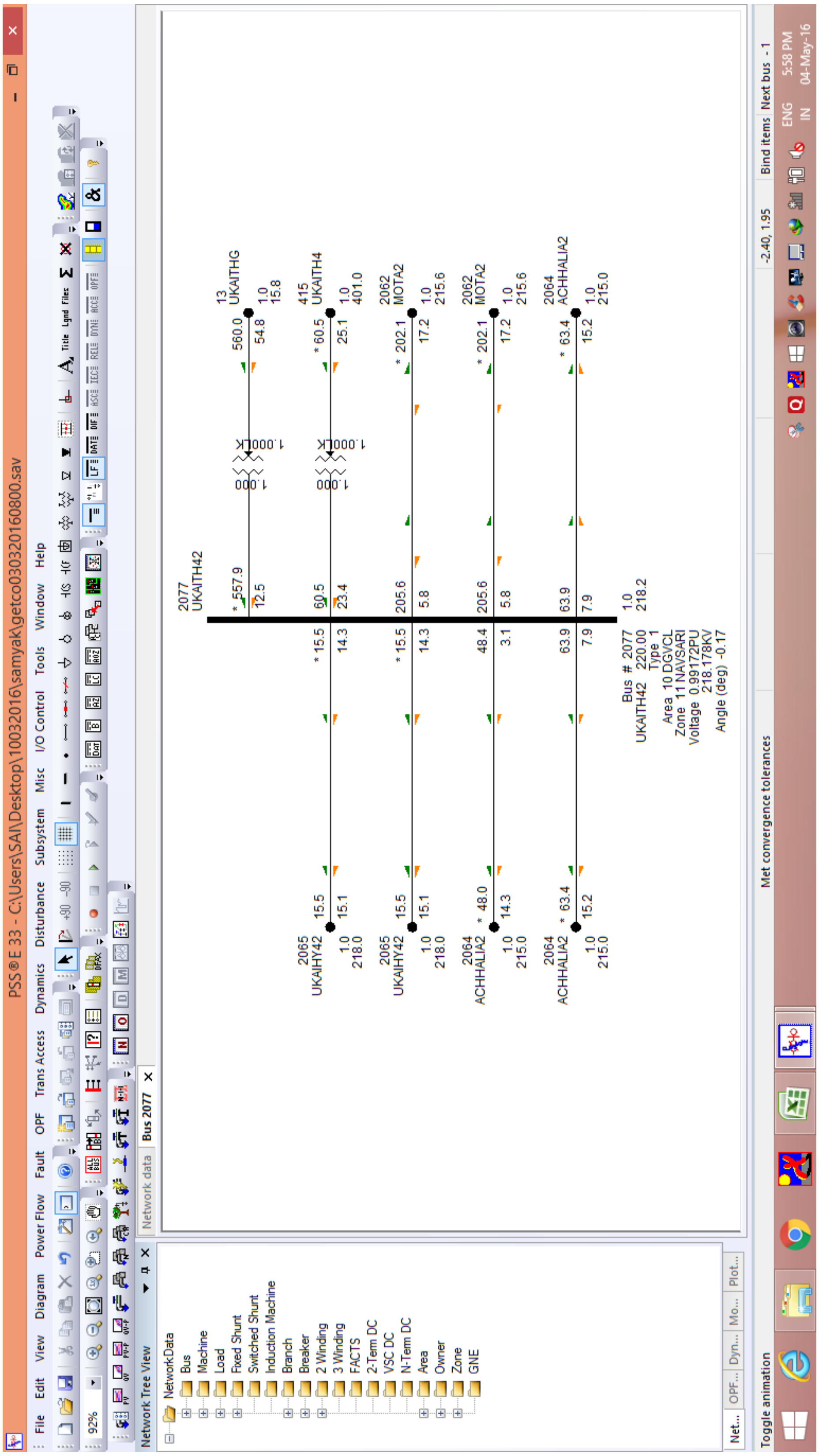

Figure 6.7: 220 kV Ukai(Th) - Mota case (Before Scenario)

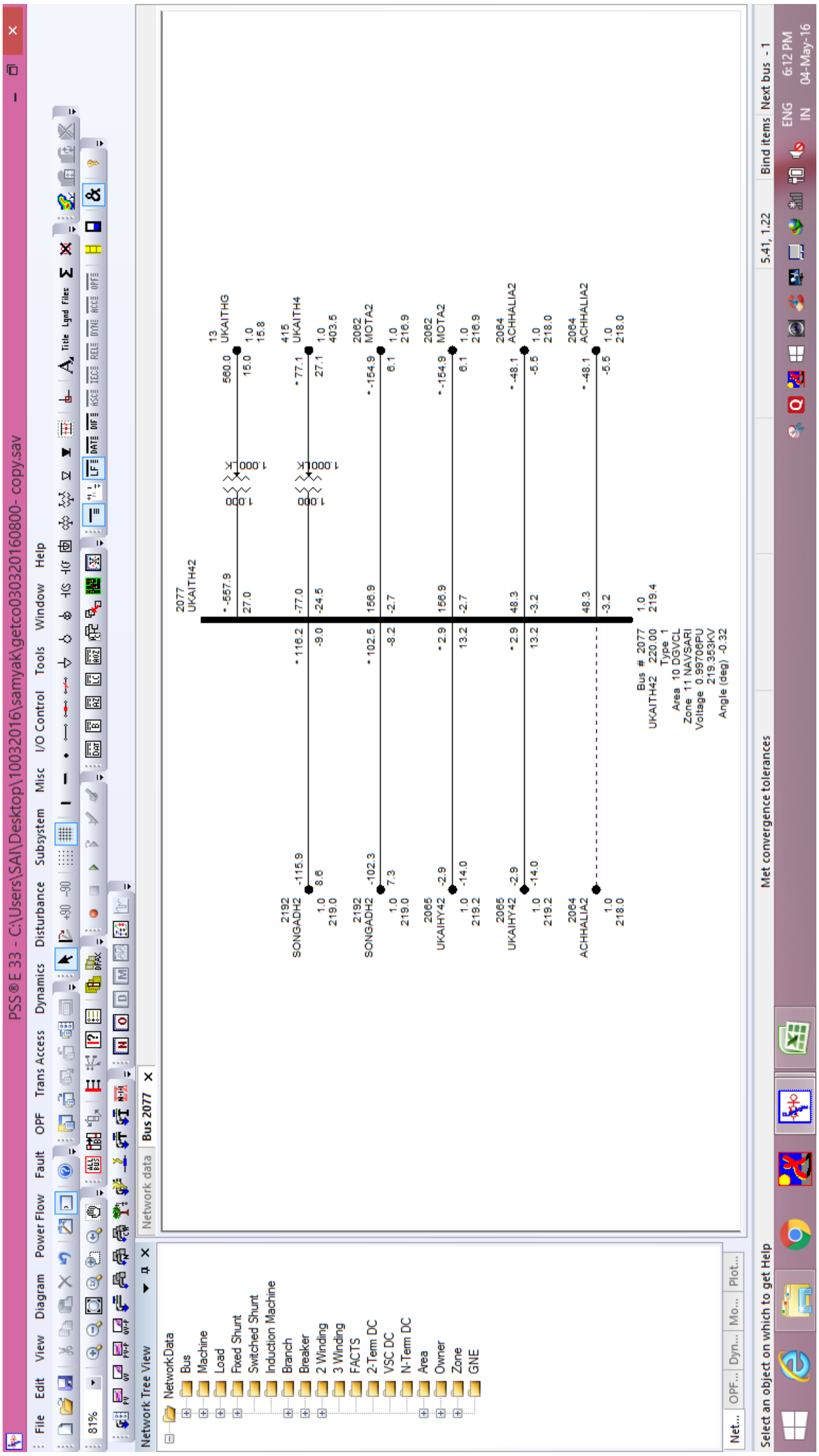

Figure 6.8: 220 kV Ukai(Th) - Mota case (After Scenario)

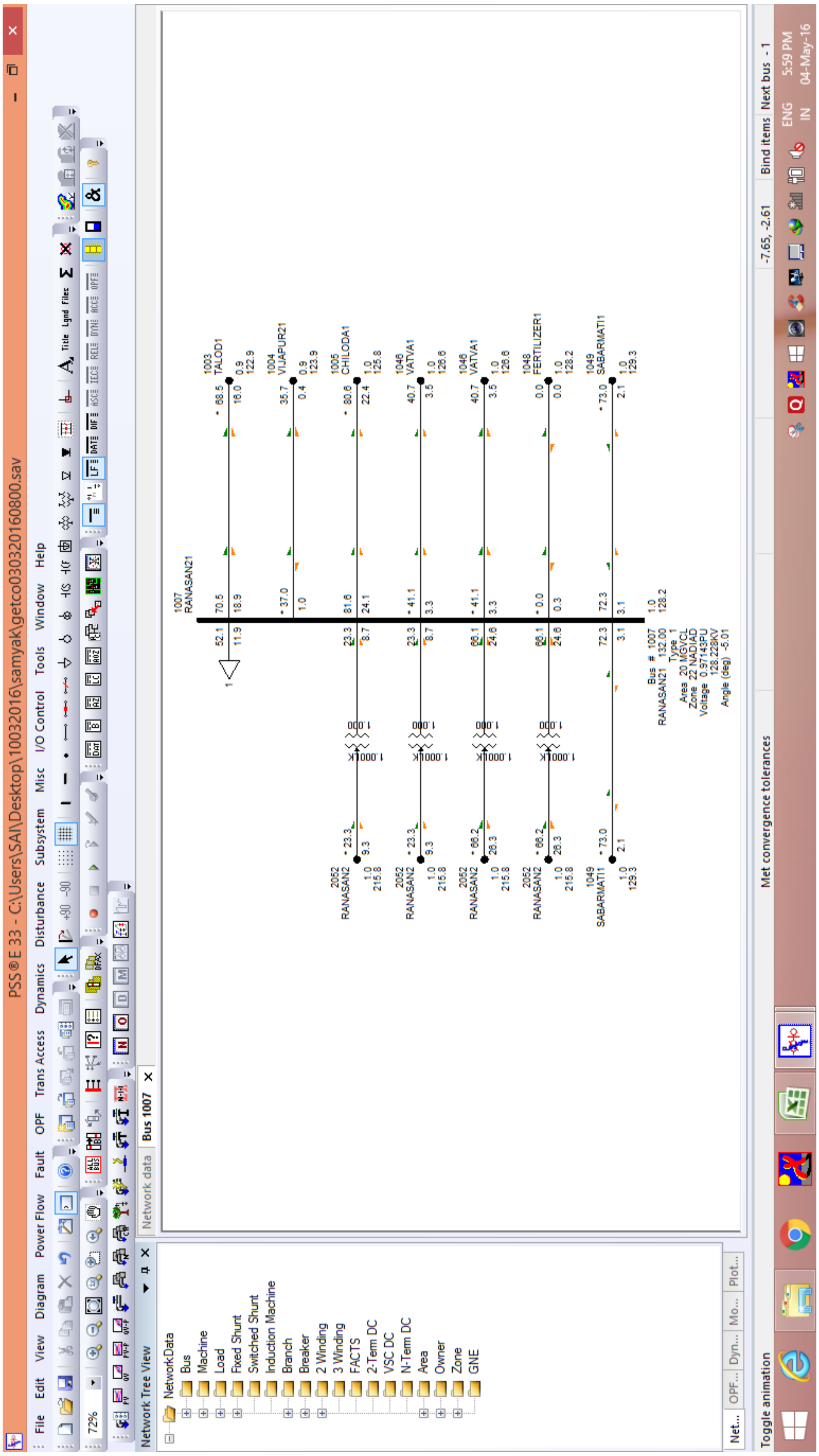

Figure 6.9: 132 kV Ranasan - Sabarmati case (Before Scenario)

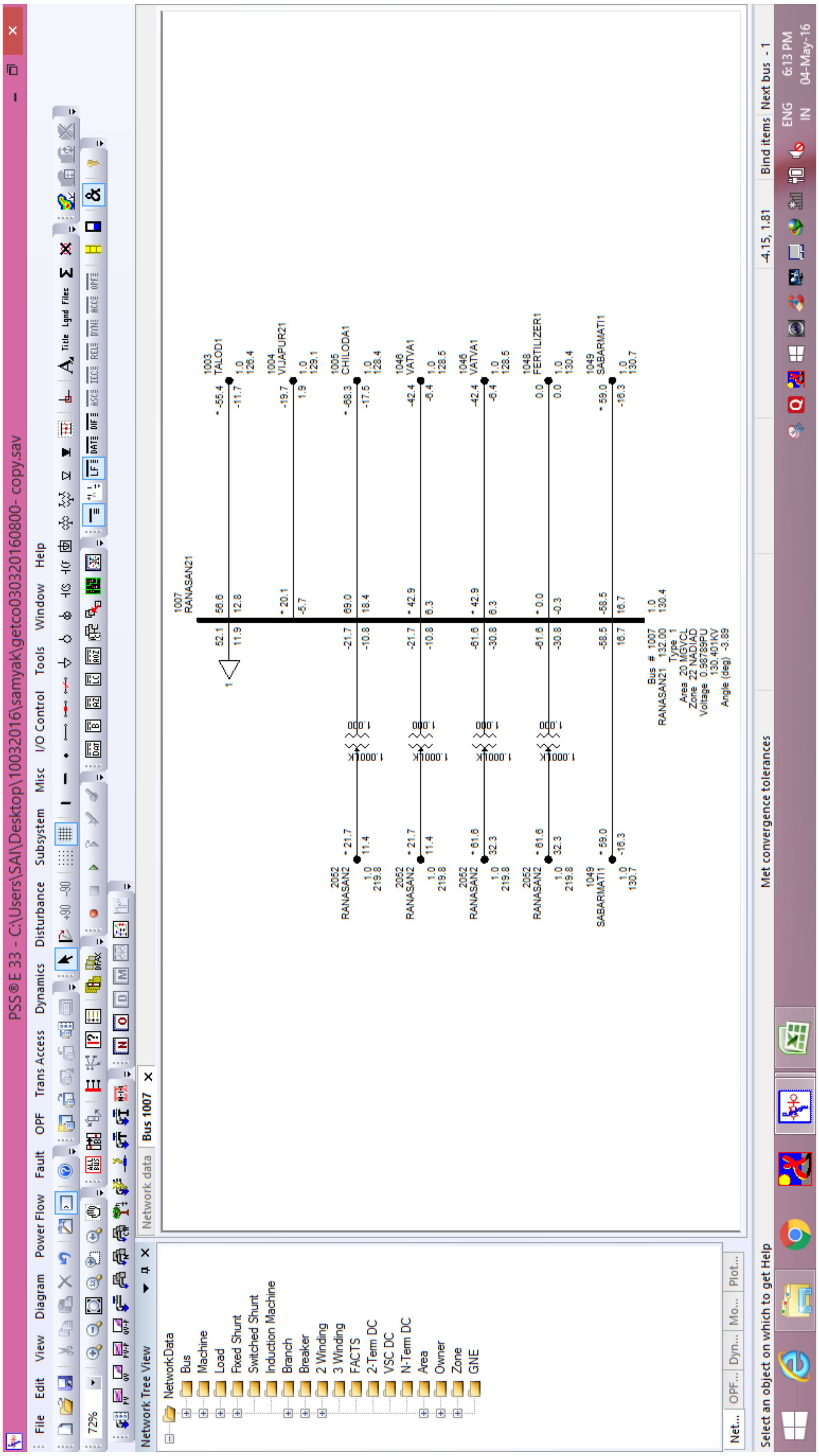

Figure 6.10: 132 kV Ranasan - Sabarmati case (After Scenario)

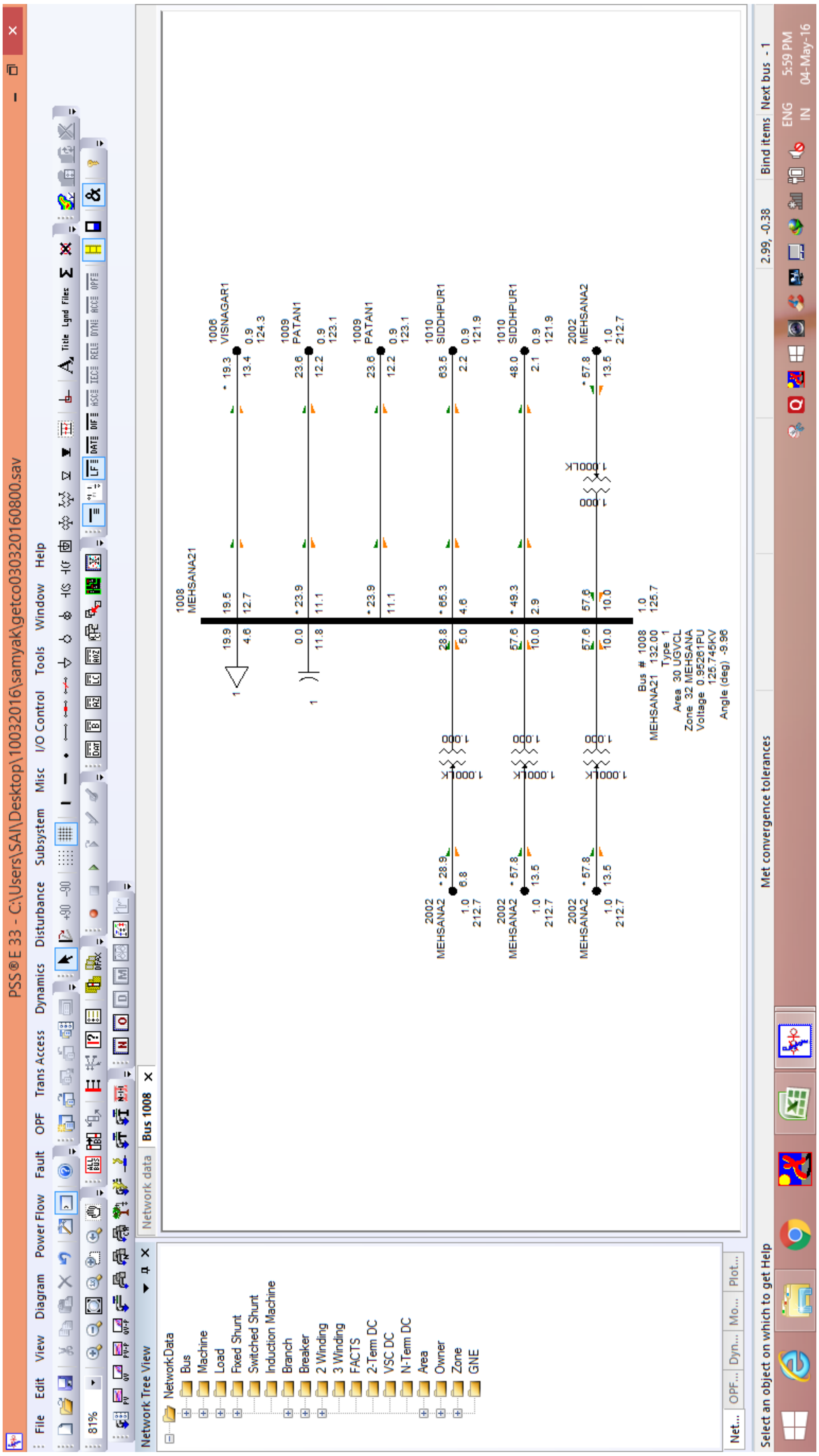

Figure 6.11: 132 kV Mehsana - Siddhpur case (Before Scenario)

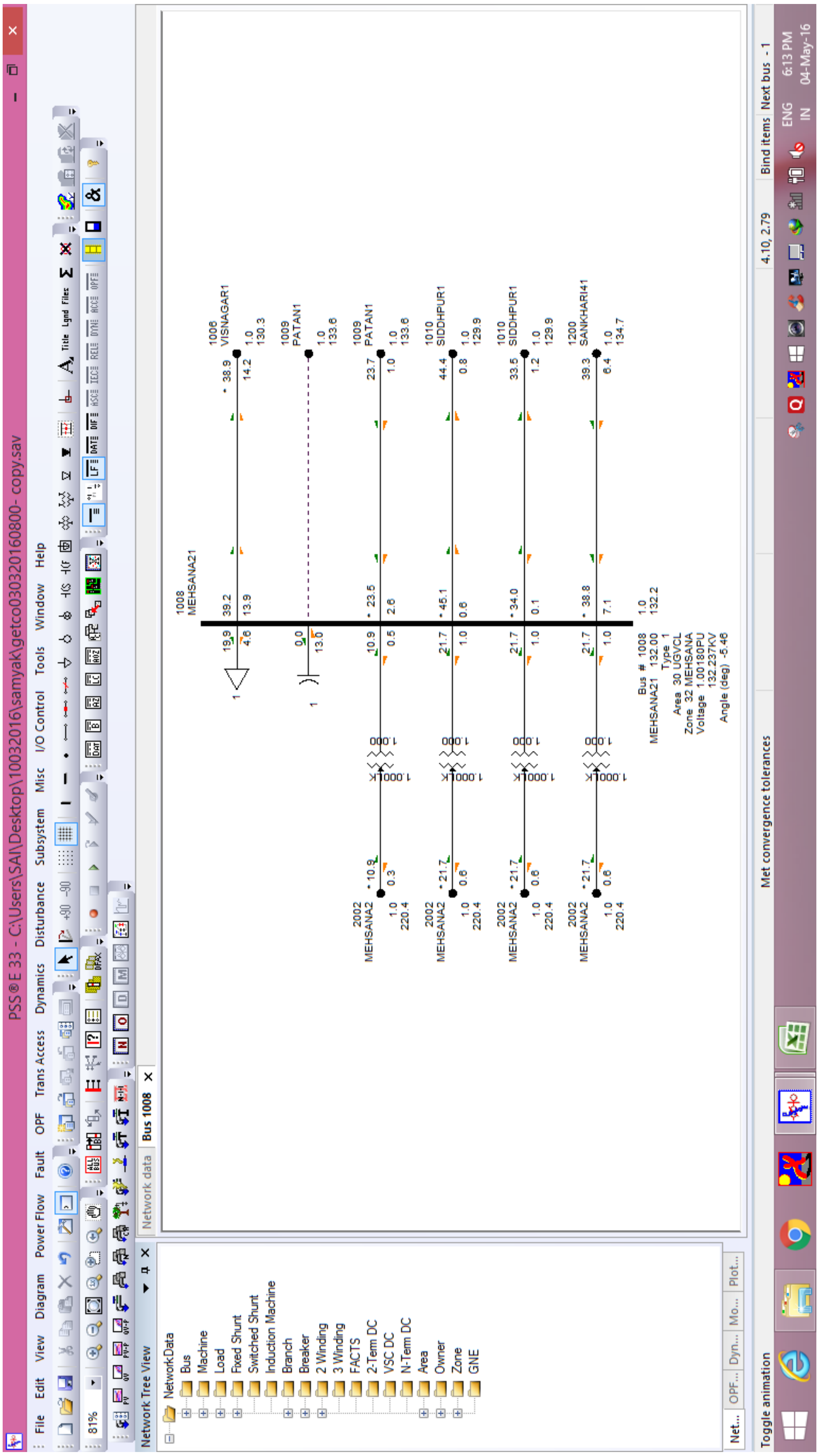

Figure 6.12: 132 kV Mehsana - Siddhpur (After Scenario)

Chapter 7

Conclusion & Future Work

7.1 Conclusion

According to Transmission Planning Criteria brought out by CEA, as per the priority the congestion problem need to be resolved through addition of new transmission lines/ substations to avoid overloading of existing network. As per that new transmission lines need to be proposed for relieving of the congestion.

According to that for the found congested pocket through these addition of line and elements it will solve the problem of congestion.

7.2 Future Work

The scope of the project work will be to propose best suitable location of FACTS device over the congested pocket to manage congestion.

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[2] Yao Liangzhong, P. Catwright, L. Schmitt, Xiao-Ping Zhang; "Congestion Management of Transmission system using FACTS"; $2005 IEEE/PES Transmission and Distribution Conference and Exhibition : Asia and Pacific, China$; Pages 1-5; 2005.

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