Estimation of Available Transfer Capability

Major Project Report

Submitted in Partial Fulfillment of the Requirements

for the Degree of

MASTER OF TECHNOLOGY

IN

ELECTRICAL ENGINEERING

(Electrical Power Systems)

By

NAYAN DHIMMAR

13**MEEE**03

DEPARTMENT OF ELECTRICAL ENGINEERING

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NIRMA UNIVERSITY

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Undertaking for Originality of the Work

I, **Nayan Dhimmar** (**Roll.No.13MEEE03**), give undertaking that the Major Project entitled "**Estimation of Available Transfer Capability"** submitted by me, towards the partial fulfillment 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.

____

Signature of Student

Date :-

Place :- Ahmedabad

Endorsed by:

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GETCO Team	**Prof. Chanakya Bhatt**
Race course	Department of Electrical Engineering
Vadodara	Institute of Technology
	Nirma University
	Ahmedabad

Certificate

This is to certify that the Major Project Report entitled "**Estimation of Available Transfer Capability"** submitted by **Mr. Nayan Dhimmar** (**Roll No:13MEEE03**) towards the partial fulfillment of the requirements for the award of degree in 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 our knowledge have not been submitted to any other University or Institution for award of any degree or diploma.
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Abstract

Available Transfer Capability(ATC) calculation is a trivial task, which includes determining the Total Transfer Capability (TTC) and Transmission Reliability Margin (TRM). The amount reserved for the total transfer capability required to confirm that the transmission system connected is safe in a reasonable range of uncertainty. With modern trends close to the deregulation of the supply system worldwide, the calculation of transfer capability of the new issues as key to easily run the electricity market with more transactions. For proper operation of the system under multiple transactions, the calculation of the ATC must be substantially accurate and fast enough. ATC is an important key that represents the ability of streaming on a network of system strength and for other commercial transactions. TTC as a key element in defining the ATC is not deterministic due to the random behavior of transmission failures. ATC transmission network is an amount of unused system to a specific period depends on distribution system such as generation, load, power transfers between areas, the network topology, the thermal limit, voltage limit and the limit of stability. In this context of deregulation, the networks of power systems should be checked to confirm a competitive, open and reliable economy, which depend on the performance of different evaluation functions of transmission. This project is to focus on the estimation of the ATC on the basis of the information available in the system using software tools/proper codes.

Nomenclature

B . . . Susceptance

P . . . Active power

Q . . . Reactive power

R . . . Resistance

V . . . Voltage

X . . . Reactance

δ . . . Delta

Abbreviations

ATC . . . Available Transfer Capability

TTC . . . Total Transfer Capability

CEA . . . Central Electricity Authority

CERC . . . Central Electricity Regulatory Commission

IEGC . . . Indian Electricity Grid Code

SLDC . . . State Load Dispatch Center

S/C . . . Single Circuit

D/C . . . Double Circuit

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Chapter 1

Introduction

Bulk power networks consisting of generating units connected by wide transmission and distribution network extend throughout large area. These systems are run by the dynamic nature of its natural features and continuous human experience, environmental and other physical influences. To ensure reliable and quality supply to consumers, the power system must be used within the standards prescribed reliability criteria defined in transmission planning and Indian Electricity Grid Code (IEGC). This is achieved through extensive offline and online coordination among many of people in charge of several activities of the electricity supply namely generation, transmission and distribution.

1.1 Literature Survey

The first and the most key part of study are to know the fundamental concepts and the importance of the topic. This is achieved by survey of wide literature available. This section describe about some important papers referred to know ATC and TTC calculation with different methods.

- **Yan Ou** [1] The paper entitled "Assessment of Available Transfer Capability and Margins" discussed currently used TTC determination methods the popularly used methods to calculate TTC can be categorized into the following three types: Continuation power flow (CPF) method, Repeated power flow (RPF) method, Security constrained optimal power flow (SCOPF) method.

- **G.C. Ejebe, J. Tong, J.G. Waight, J.G. Frame, X. Wang, W.F. Tinney** [2] The paper entitled "Available Transfer Capability Calculations" discussed a calculation background for defining ATC the resulting program calculates transfer capabilities which respect transmission thermal limits, voltage limits, reactive power limits, voltage collapse, the effects of the transfer through set boundaries and are protected with respect to a set of critical contingencies.

- **C.Hamoud** [3] The paper entitled "Assessment of Available Transfer Capability of Transmission Systems" discussed the basic idea for ATC calculation for given set of system condition i.e generation dispatch, load distribution, system load level, network topology, power transfers between areas, and the transmission line limits.

- **N.D.Ghawghawe and K.L.Thakre** [4] The paper entitled "Application of Power Flow Sensitivity Analysis and PTDF for Determination of ATC" discussed congestion can be avoided by providing exact information of ATC to the market participants. In case of smaller ATC, the system operators can charge higher transmission prices for further transactions. These charges may be further utilized for improvement of transmission infrastructure hereby improving ATC.

- **Dong-Joon Shin, Jin-O. Kim, Kyu-Ho Kim, C. Singh** [5] The paper entitled "Probabilistic Approach to Available Transfer Capability Calculation" discussed TTC is minimum of thermal, voltage and stability limit. The methods to calculate ATC should offer operational flexibility and consider time varying feature of power systems and the market.

- **Power Grid Corporation of India Limited** [6] The paper entitled "Approach Paper for Assessment of Transfer Capability in the Indian Bulk Electric Power System" discussed about basic transfer capability concept and available transfer capability calculation and examples.

- **Central Electricity Regulatory Commission** [7] The report entitled "Indian Electricity Grid Code (IEGC)" discussed to plan, grow, sustain and work the power system, in the most safe, dependable, commercial and well-organized way, while simplifying strong competition in the generation and supply of power.

- **Central Electricity Authority** [8] The report entitled "Manual on Transmission Planning Criteria" discussed the manual covers the preparation philosophy, the information required from various units, acceptable limits, reliability criteria, wide choice of system studies, modeling and analysis, and gives guidelines for transmission planning.

- **North American Electric Reliability Council** [9] The report entitled "A reference document for calculating and reporting the electric power transfer capability of interconnected electric system" discussed to present a consistent set of definitions and guidelines for calculating and reporting the transmission transfer capability of interconnected system.

- **Gujarat Electricity Regulatory Commission** [10] The report entitled "Gujarat Electricity Grid Code (GEGC)" discussed to plan, develop, maintain and operate the power system, in the most secure, reliable, economic and efficient manner, while facilitating healthy competition in the generation and supply of electricity.

- **Weerakorn Ongsakul Dieu Ngoc Vo** [11] The book entitled "Artificial Intelligence in Power System Optimization" includes methodologies to calculate ATC. The methodology for Import/Export TTC and ATC calculation is adopted from this book. It also includes transfer capability concepts.

1.2 Objective

The objective is to calculate Import/Export Available Transfer Capability (ATC) and Total Transfer Capability (TTC) of Southern Gujarat area network and develop general methodology for calculation. ATC and TTC is to know transfer capability of transmission network, for power transfer from one area to another area. This task is carried out by various methods to calculate ATC and TTC. The performance assessment of ATC on the transmission line may help for increasing power transfer. This report discusses different ATC and TTC calculation technique existing in the literature.

1.3 Proposed Work

The main focus of the project is to increase power transfer capability of transmission line under normal condition and also in any contingencies.

- Literature survey
- Different methods to calculate ATC and TTC
- Selection of suitable methods
- Input data from Gujarat Energy Transmission Corporation (GETCO)
- PSS®E software
- Base case simulation and load flow result
- Find out inter area lines and study Inter area lines flow
- Match result with system study group
- Calculate ATC and TTC for different scenario

1.4 Outline of Thesis

The Thesis is organized in following manner.

- **Chapter 1** includes introduction of transfer capability and objective of transfer capability also it includes literature survey and proposed work.
- **Chapter 2** dwells on the definition of transfer capability and defines exactly how transmission capacity is different from transfer capability. It discusses the numerous considerations for calculation of transfer capability i.e. planning criteria, operating limits, network topology and reliability margins.
- **Chapter 3** describes introduction of Gujarat energy transmission corporation limited and work profile of company.
- **Chapter 4** includes required data for base case and load flow. It also includes information about software tool is used for simulation
- **Chapter 5** consolidates the methodology for assessing the ability to transfer in the context of India.
- **Chapter 6** includes the simulation results and discussion.
- **Chapter 7** includes the conclusion and future scope.

Chapter 2

Theory of Available Transfer Capability

2.1 Definition of Transfer Capability

For the purpose of operational jurisdiction, management control and commercial simplicity, the power system is demarcated into control areas. When power is transferred between two control areas, all interconnected system responds to the transaction. The power flow on each transmission path is not the same that, changes in proportion to the response of the transfer path. This response is achieved by generation, dispatch, load distribution, system load level, network topology, power transfers between areas and maintaining the transmission line limits[6].

When power is transferred from one region to another region power flow of parallel line is not same. The line elements have different capacities in transmission network determines the "permissible power flow" along various section of the network. This "permissible power flow" is known Transfer Capability of transmission network[6].

2.2 Difference between Transfer Capability and Transmission Capacity

Transfer capability is a measure of the ability of the interconnected system to transfer power from one area to another area in all the ways of transmission between these areas under the reliable manner and system specified conditions.
Transfer capability may be limited by the physical and electrical characteristics of the system. Transfer capability is dynamic in nature. The conditions that limit the transmission network capability are thermal, voltage and stability limits as the network operating conditions change over time. Transfer capability also depends on ambient temperature. Transfer capability is different from transmission capacity. The comparison table is shown below:

Table 2.1: Transmission Capacity vs Transfer Capability [6]

No.	**Transmission Capacity**	**Transfer Capability**
1	Non-directional	Directional
2	Deterministic	Probabilistic
3	Time independent	Time dependent
4	Constant under set of conditions	Always varying
5	Declared by designer	Declared by the system operator
6	Depends on design	Depends on network topology, system conditions
7	Determines directly by design	Estimated indirectly through simulation studies
8	Is a physical property in isolation	Is a collective behavior of system

Transfer capability depends mainly on the system response for individual transactions between the control areas of the network. The distribution of power for each element in the area is not the same. This means that the domain transfer capability can not be determined by the arithmetic sum of the capacities of all parallel transmission lines on individual transmission area. Since the increase of energy transfer through the section of one or more elements may reach the limit before the other. Total power transfer through the section should be limited value where the first element reaches the limit value.

2.3 Total Transfer Capability

TTC is the amount of electric power that can be transferred reliably over the inter-control area transmission system under a given set of operating conditions considering the effect of occurrence of the worst credible contingency[7].
TTC is defined as the amount of electric power that can be transferred over the interconnected transmission network in a reliable manner while meeting all of following conditions:

- For existing network topology and pre-contingency operating procedures in effect, all elements loading are within its normal ratings[6].
- The system should capable of absorbing power swing and remain stable, following a fault that results in the loss of any single element i.e. transmission line, transformer, generating unit[6].
- As describe above after the operation of any operating systems, but before any post-contingency operator initiated system adjustments are implemented, all transmission elements are within emergency ratings[6].

2.4 Simulation Methods

From the literature survey, calculation of TTC and ATC can be done by four methods:

Table 2.2: Simulation Methods [6]

No.	**Method**	**Description**
1	Linear approximation	dc power flow model, thermal limit only
2	Optimal power flow	ac power flow model, thermal limit + voltage limit
3	Continuation power flow	ac power flow model, thermal limit + voltage collapse
4	Stability constrained	time domain simulation with dynamic model

The DC power flow is simple and easy method of calculation. It may not be accurate when difference voltage and var flow are considerable. Continuation Power Flow Method (CPF) considers a range of power system solutions to solve and test to the limit. The amount of transfer step increases in the base case until a binding limit is reached. Optimal Power Flow Method (OPF) requires the formulation of a constrained optimization problem resulting power flow. Results attained from optimal power flow might vary depending on the description of objective function and limitations. Stability constrained method involve transient stability studies to be carried over to a case established with the expected situation[6].

2.5 Input Data for Assessment of Total Transfer Capability

- Planning criteria
- Network topology
- Transmission elements details
- Unit availability
- Thermal generation schedule
- Hydro generation schedule
- Loads

2.6 Reliability Margin

Reliability margin have two components. Transmission Reliability Margin (TRM) and Capacity Benefit Margin (CBM).

Transmission Reliability Margin (TRM) is the amount of margin kept in the total transfer capability necessary to ensure that the interconnected transmission network is secure under a reasonable range of uncertainties in system conditions[6].

Capacity Benefit Margin (CBM) is defined as that amount of transmission transfer capability reserved by load serving entities to ensure access to generation from interconnected systems to meet generation reliability requirements[6].
TRM = TTC in the base case - TTC in the worst scenario[6]
Computation of TRM for a region or control area or group of control areas would be based on the consideration of the following:

- Two percent of the total anticipated peak demand met in MW of the area[7]
- Size of largest generating unit in the area[7]

Therefore the amount of reliability margin depends on the characteristics of the power system network and its operating condition. The margins would be lower in power systems with robust transmission system, acceptable security of network and reliable protection. The margins would also be lower when the planned maintenance schedules are firm and load-generation can be forecasted with substantial accuracy. A rigorous calculation of the margin in the context of India would give much higher figures presently considered by the various Regional Load Dispatch Centers (RLDC) in India.

2.7 Available Transfer Capability (ATC)

ATC is the transfer capability of the inter- control area transmission system available for scheduling commercial transactions (through long term access, medium-term open access and short-term open access) in a specific direction, taking into account the network security. Mathematically, ATC is the Total Transfer Capability less Transmission Reliability Margin[10].
The system transfer capability inter-control area available for planning in a specific direction, considering network security.
ATC is defined as the Total Transfer Capability (TTC) minus Transmission Reliability Margin (TRM), less the sum of existing transmission commitments and the Capacity Benefit Margin (CBM)[7].
“Short Term Open Access” (STOA) means open access for a period up to one month at one time[7].

"Medium Term Open Access" (MTOA) means the right to use interstate transmission for more than three months but not exceeding three years[7].
"Long Term Open Access" (LTOA) means the right to use the inter-state transmission for a period of more than 12 years but not more than 25 years[7].

ATC = TTC - Reliability Margin [6]

Northern Regional Load Dispatch Center (NRLDC) recorded total import capacity of the North (three months in advance), based on computer simulations. It is available on the link "open access" in the main (www.nrldc.org) page[13].

2.8 Summary

This chapter defines the transfer capability occurs and develops how transfer capability is different from the transmission capacity. In this chapter various considerations for evaluating the transfer capability of knowing examined i.e. planning criteria, operating limits, operating margins, network topology and reliability.

Chapter 3

Gujarat Energy Transmission Corporation Limited

3.1 About GETCO

Gujarat Energy Transmission Corporation Ltd (GETCO) was formed in 1999 and registered under the Companies Act 1956 as part of the reform of the electricity sector in the state[12].

Organizational development and capacity building are other areas where management plans to transform GETCO in to commercially viable vibrant organization. In addition to domestic reforms - institutional strengthening and organizational development - GETCO also preparing to meet the challenges of regulation, both in terms of operational efficiency and & commercial and their financial consequences.

3.2 Power Map

Figure 3.1 shows power map of Gujarat transmission network including 400 kV, 220 kV, 132 kV as on date 31^{st} January 2015

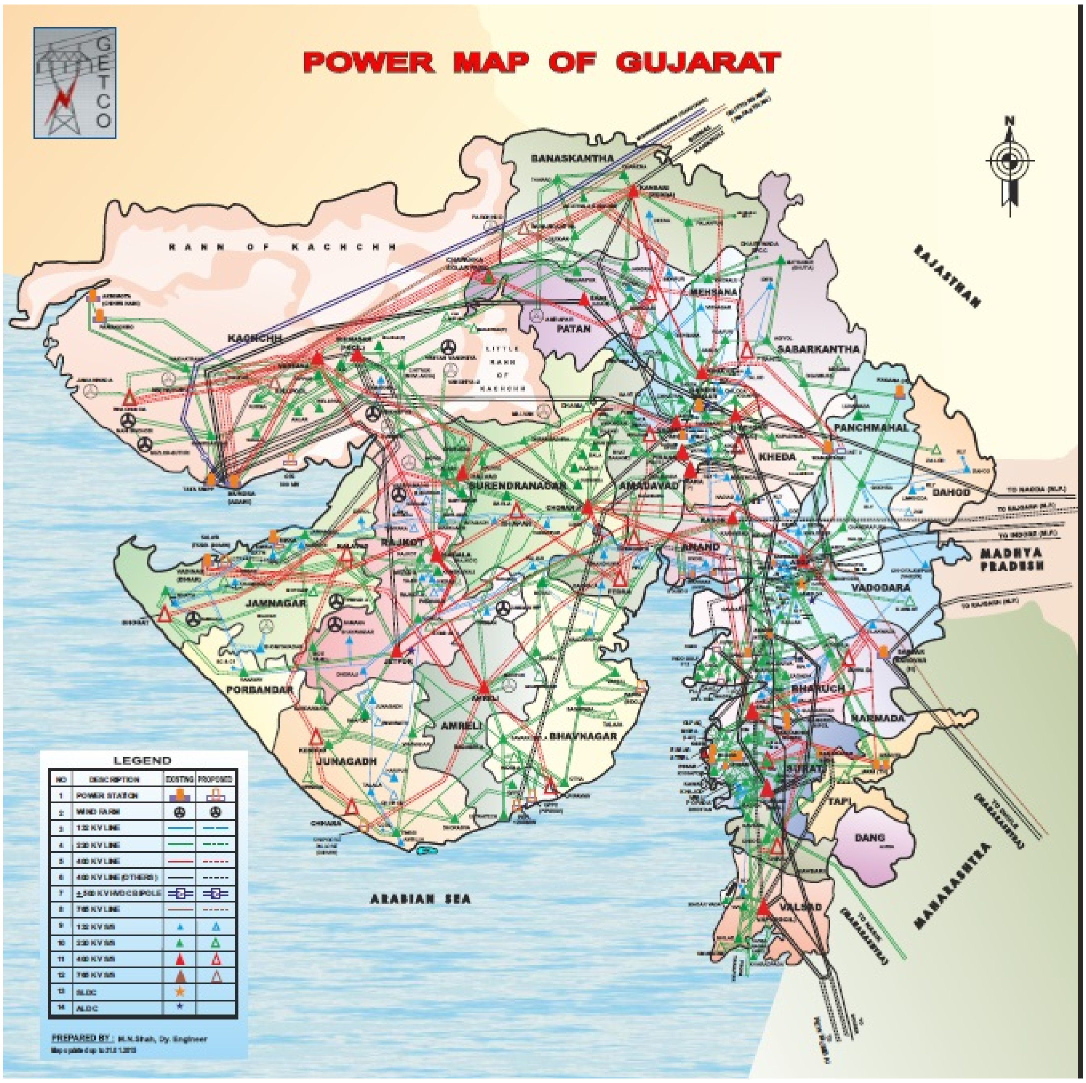

Figure 3.1: Power Map of Gujarat[12]

3.3 Operational Profile

The power generated in several power plants located in state and shares from Central sector received through Inter-State Generating Station (ISGS) network is transmitted to the distribution companies in various parts of the state interface through an extensive network of 400 kV, 220 kV, 132 kV and 66 kV transmission lines and substations. The company is organized into 13 circles. Each circle has the construction and operation & maintenance divisions are responsible for their respective tasks. Construction divisions are established for the construction of new lines and stations, while the divisions are defined in the transmission operation, maintenance and improvement of existing lines and stations.

3.4 System Strength (as on 31^{st} March 2015)

Table 3.1: System Strength[12]

System Voltage in kV	No. of Substations	Transmission Lines in (circuit km)
400	12	4052
220	94	16987
132	54	5073
66 & 33	1410	26430
All	1570	52542

As on date 31^{st} March 2015 Gujarat installed capacity is **23997 MW**[14].

3.5 Summary

This chapter describes introduction of Gujarat Energy Transmission Corporation Limited and work profile of company. It also includes system strength of Gujarat transmission network.

Chapter 4

Base Case of Gujarat Transmission Network

4.1 Base case

For calculating ATC and TTC first step is to create a base case and for that require data are:

- Generating station detail
- Installed capacity of generating station
- Substation with voltage class
- No of transformers along with voltage ratio and transformation capacity, Shunt compensation (Capacitor and Reactor)
- Line Resistance (R), Reactance (X) and Susceptance (B)
- Line length
- Transmission lines
- Load data
- Area classification

- Zone classification

In this base case line parameter Resistance (R), Reactance (X), Susceptance (B) are obtained from transmission planning criteria report for different conductor and voltage level[8].

4.2 Load Flow Calculation of Base Case

Power system load flow study is a numerical analysis of the flow of electric power in system. A load flow study commonly uses basic notation such as a single line diagram and per-unit system and concentrates on several aspects of ac power parameters such as voltages (V), load angles (δ), active power (P) and reactive power (Q). Load flow studies are key for planning future expansion of power systems network as well as in defining the best operation of existing network. Transmission planning criteria report guidelines are followed during simulation of base case. When all data is entered in PSS®E, convergence of load flow is checked and load flow results verified with actual results.

This simulation also contains specific area and zone details for each substation. When load flow is converged first check that slack bus generation is less than its total installed capacity and then all line flow and bus voltages are in limit which is mentioned in planning criteria.

4.3 Inter Area Lines

Now a day power systems are separated into many areas. For example in state of Gujarat, there are four areas. e.g. Southern Gujarat, Central Gujarat, Northern Gujarat and Paschim Gujarat. These areas are interconnected to its other areas. The transmission lines that connects an area to various other areas are called inter area lines. Powers sharing between two areas occur through these inter area lines.

4.4 Power System Simulator for Engineering

Power System Simulator for Engineering is a software tool used for electrical transmission networks. It is combined, interactive program for simulating, studying and improving power system performance and delivers probabilistic and dynamic modeling features. The software provides for transmission planning and engineering a tool for use in the project and process of reliable networks. PSS®E is used to calculate ATC and TTC. It is high-performance transmission planning software has supported the power community with particular and complete modeling abilities. The probabilistic analysis and advanced dynamics modeling capabilities included in this software.

Chapter 5

General Methodology for TTC and ATC

General methodology is adopted considering NERC report[9], CERC approved check list document[7], Text book by Weerakorn Ongsakul Dieu Ngoc Vo on "Artificial Intelligence in Power System Optimization"[11] and IEEE papers[2][3].

5.1 Consideration

- The TTC/ATC for Southern Gujarat area has been calculated considering Gujarat transmission network for the year 2014 and for following corridors[12].

  a. Central to Southern

  b. North to Southern

  c. Saurashtra to Southern

- The load generation data is considered for peak load condition as per SLDC snapshots and considering various assumption for such model for ATC/TTC calculation[14].

- The limit of inter area 400 kV, 220 kV, 132 kV lines respectively 615 MW, 180 MW, 70 MW[8].

5.2 General Methodology for Calculation of Import ATC and TTC

a. **Decrease in generation of area**

b. **Increase in load of area**

- Consider all elements in service.
- Decrease generation of area for which import TTC is to be calculated[11][9].
- If there is any of line or transformer in inter area or in intra area not getting overload then gradually decrease generation of particular area.
- When any of line or transformer is getting overload stop decreasing generation of that area[9].
- Consider all power plants in import area one by one. All contingencies arising due to generator outage to be taken in account. On the basis of this, decide which lines are critical within area and out of area[7].
- If this line or transformer is within area or out of area than consider contingency of line or transformer which is worst credible. This contingency will definitely overload parallel lines[11].
- Now add generation in importing area which will reduce the line flow and try to maintain the line loading is in limit.
- Now see the inter area lines flow and this incoming and outgoing power in inter area lines will give import TTC of required area.

5.3 General Methodology for Calculation of Export ATC and TTC

a. **Increase in generation of area**

b. **Decrease in load of area**

- Consider all elements in service.
- Increase generation of area for which export TTC is to be calculated[11][9].
- Decrease generation of other areas where power is going[11].
- Gradually increase generation of exporting area till any of the elements in inter area or in intra area hits its thermal capacity or design capacity[11].
- When any of elements is getting overload stop increasing generation of that area and make a list of overloaded elements[11][9].
- If this element is within area or out of area than consider contingency of element which is worst credible. This contingency will definitely overload parallel lines[11].
- Now add generation which will reduce the line flow and try to maintain the line loading is in limit.
- Now see the Inter area lines flow and this incoming and outgoing power in inter area lines will give export TTC of required area.

Chapter 6

Case Study

6.1 Base Case

GETCO network is modeled for a specific operating condition and same is verified and modified based on State Load Dispatch Center (SLDC) real time data, snapshots and then it will studied based on various assumption like different generation dispatch, network configuration.

The load flow result is shown in Figure 6.1

```
ITER    DELTAP      BUS       DELTAQ     BUS       DELTA/V/     BUS        DELTAANG     BUS
 0.0    30.5700(    5023  )   6.4889(    5000  )
                                                    0.00000(          )   0.47399(     2348  )
 0.5     0.9434(    2045  )   8.0989(    5000  )
                                                    0.10575(    1067  )   0.00000(           )
 1.0     0.5096(    4008  )   0.0586(    5000  )
                                                    0.00000(          )   0.10266(     1271  )
 1.5     0.1782(    4004  )   2.3291(    5039  )
                                                    0.05406(    8001  )   0.00000(           )
 2.0     0.5814(    7001  )   0.0800(    7001  )
                                                    0.00000(          )   0.01560(     7003  )
 2.5     0.0266(    7001  )   0.1150(    7003  )
                                                    0.00560(    7003  )   0.00000(           )
 3.0     0.0421(    7003  )   0.0347(    5003  )
                                                    0.00000(          )   0.00133(     1034  )
 3.5     0.0080(    2327  )   0.0348(    5003  )
                                                    0.00137(    5003  )   0.00000(           )
 4.0     0.0104(    5003  )   0.0016(    5003  )

Reached tolerance in 4 iterations

Largest mismatch:       0.03 MW      0.00 Mvar      0.03 MVA at bus 5408 [TATA_UMPP   400.00]
System total absolute mismatch:                     0.90 MVA

SWING BUS SUMMARY:
  BUS# X-- NAME --X BASKV      PGEN     PMAX    PMIN      QGEN     QMAX    QMIN
  7002 400_INDORE  400.00    1000.4   2999.0     0.0    -401.3   1500.0  -750.0
```

Figure 6.1: Load Flow

Gujarat state is connected to its neighboring states namely Maharashtra, Madhya Pradesh, Rajasthan, Haryana. As shown in Figure 6.2 power is coming from other states and power is going to other states through inter area lines.

In Southern Gujarat there is sub area namely Torrent power Surat and also in Northern Gujarat is having sub area namely Torrent power Ahmedabad. These sub areas have their own generation and load. The tentative power flow in inter-area are as following.

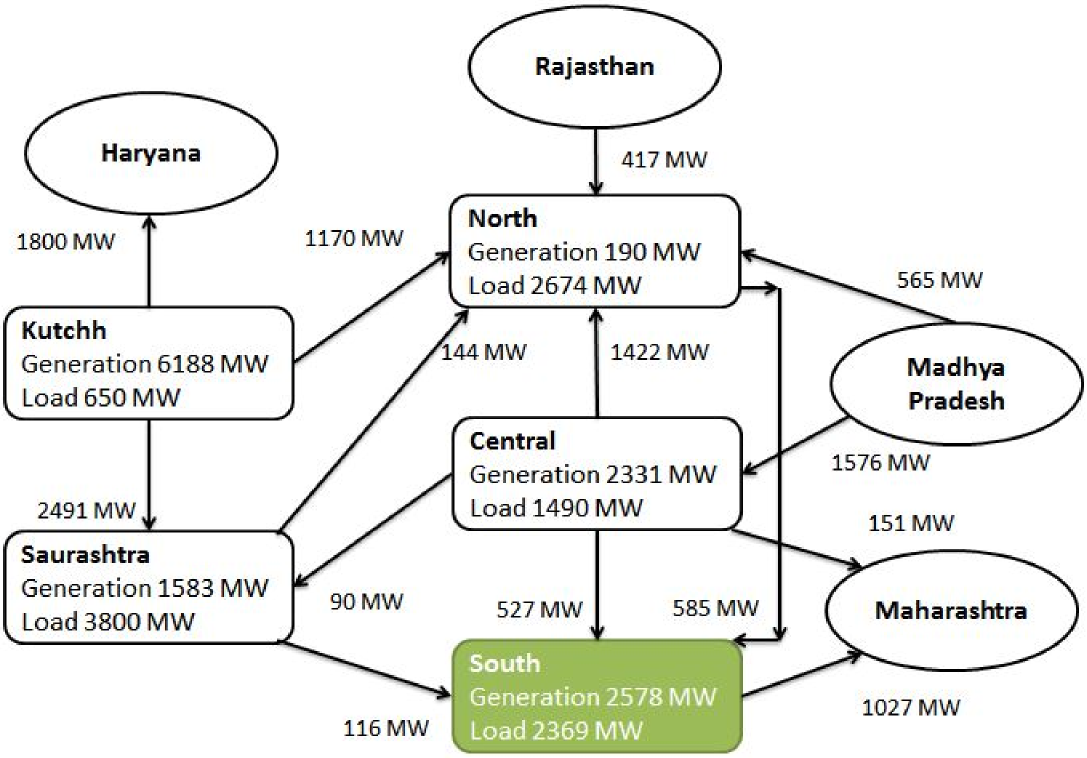

Figure 6.2: Base case considering all lines of network in service

6.2 Import TTC and ATC Calculation of Southern Gujarat Area

GETCO network is modeled for a specific operating condition and same is verified and modified based on State Load Dispatch Center (SLDC) real time data, snapshots and then it will studied based on various assumption like different generation dispatch, network configuration.
The base case is modified as per above mentioned methodology to calculate ATC/TTC for a typical operating condition with assumption like changes in load and generation in Southern Gujarat area and other connected areas.

6.2.1 Methodology for Calculation of Import TTC

As discussed in above chapter for Import TTC, generation of Import area (southern area) is reduced and other areas (central area and Saurashtra area) generation is increased. load in southern area is increased and other areas (central area, northern area, Saurashtra area) load is decreased. Hence at certain instance any of line will get overload which is **220 kV S/C Asoj - Jambuva** line as shown in Figure 6.3

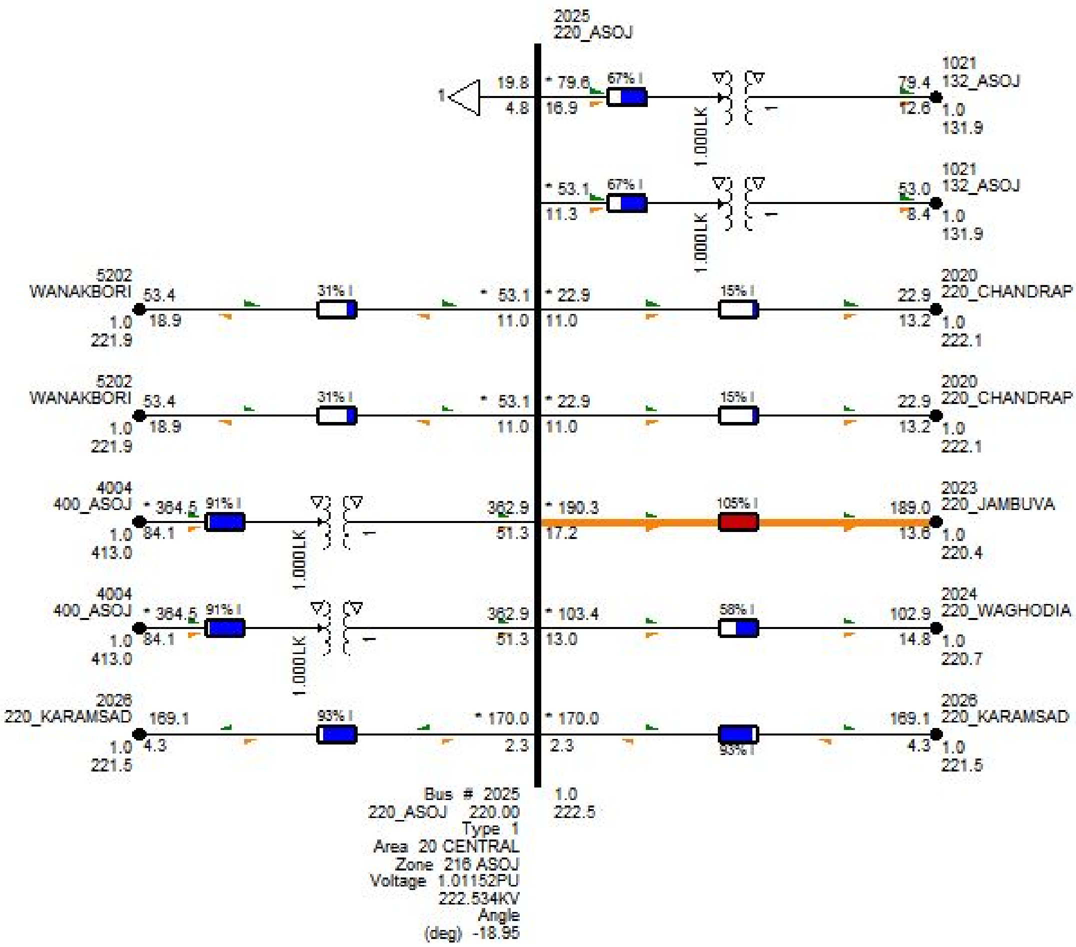

Figure 6.3: 220 kV S/C Asoj - Jambuva line Overload

In central area 220 kV S/C Asoj - Waghodia line is worst credible line which affect 220 kV S/C Asoj - Jambuva line. hence contingency of 220 kV S/C Asoj - Waghodia line is considered as shown in Figure 6.4

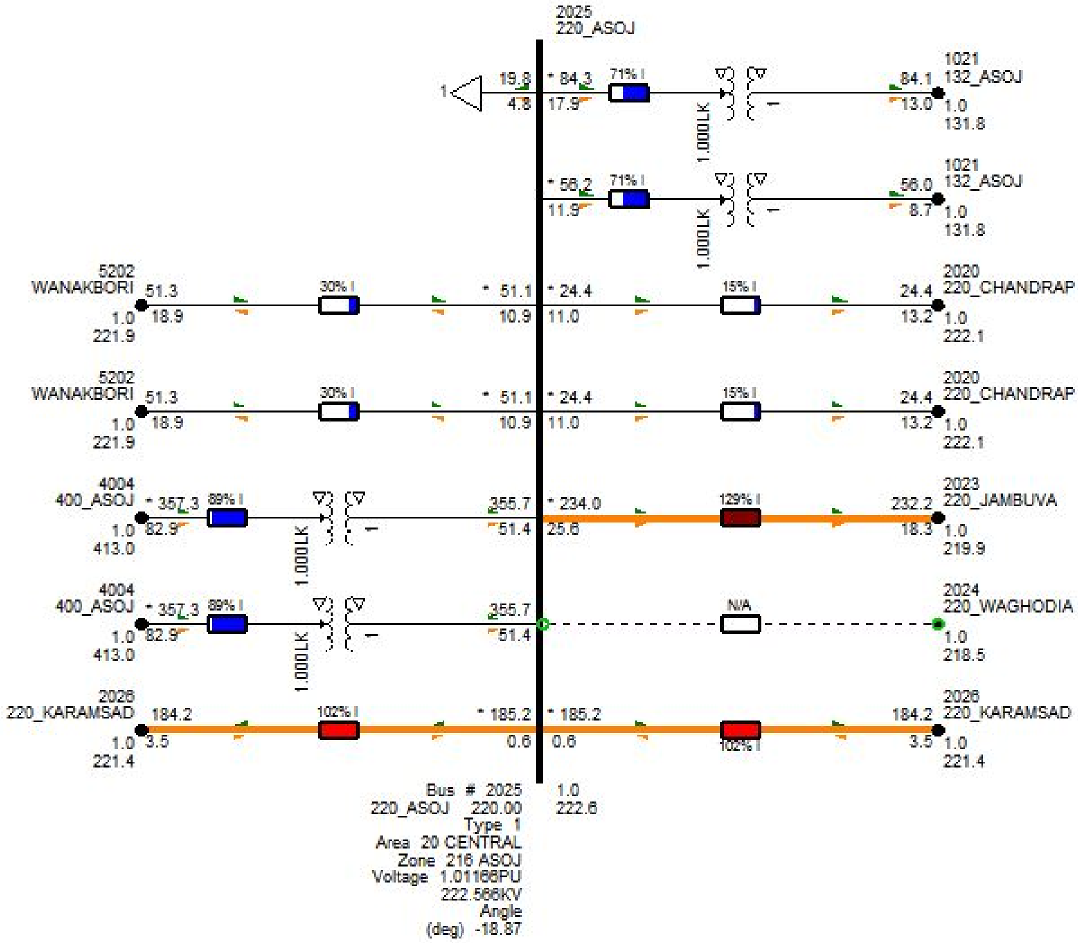

Figure 6.4: N-1 Contingency of 220 kV S/C Asoj - Waghodia line

Generation and loads of Southern, Central and Northern Gujarat are modified and 220 kV S/C Asoj - Jambuva line power flow is in under limit as shown in Figure 6.5

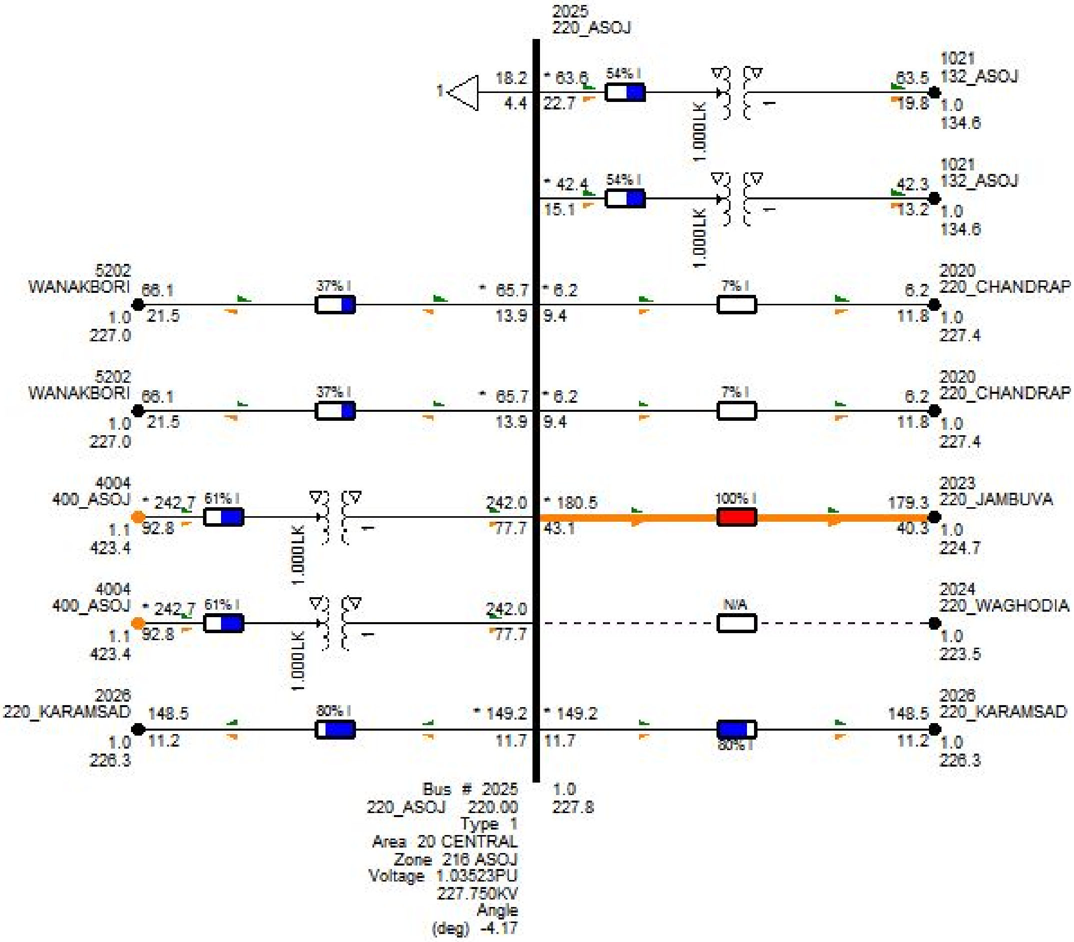

Figure 6.5: 220 kV S/C Asoj - Jambuva line power flow is in under limit

6.2.2 Result

Gujarat state is connected to its neighboring states namely Maharashtra, Madhya Pradesh, Rajasthan, Haryana. As shown in Figure 6.6 power is coming from other states and power is going to other states through inter area lines.

In Southern Gujarat there is sub area namely Torrent power Surat and also in Northern Gujarat is having sub area namely Torrent power Ahmedabad. These sub areas have their own generation and load. The tentative power flow in inter-area are as following.

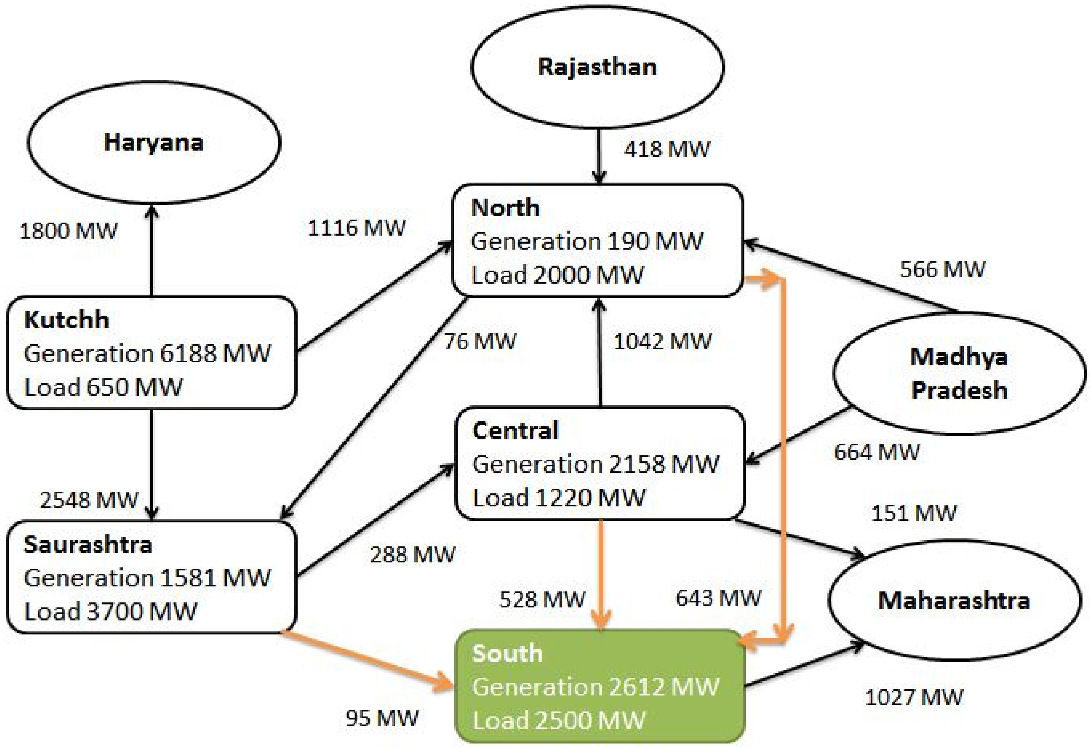

Figure 6.6: As per above case study imopor

6.2.3 Import TTC/ATC of Southern Gujarat Area

Table 6.1: Power flows from different area to Southern Gujarat area for above case study is as under:

Corridor	**Power Flow** (MW)
Central - South	528
Saurashtra - South	95
North - South	643
Total	1266

Considering TRM of 50 MW (as per CERC approved procedure[7])

Import ATC for Southern Gujarat = TTC - TRM = 1266 - 50 = **1216 MW**

Above TTC/ATC calculations are indicative only for a typical simulation as above and may vary as per change in operating conditions.

6.3 Subject to clarification

This study is purely an indicative study considering all assumptions as per methodology to understand and derive ATC/TTC calculations. Hence, due care shall be taken that this study report and calculations is not to be used for any commercial and/or legal purposes.

Chapter 7

Conclusion & Future Scope

7.1 Conclusion

- GETCO network model developed based on methodology adopted for calculation of Import/Export Total Transfer Capability for Southern Gujarat area
- Gujarat system topology for real time operation has been understood.
- Base-case simulation for a typical grid operating condition has been simulated and validated with SLDC data.

7.2 Future Scope

- Addition of new elements can be identified for future network planning.
- Priority of the upcoming element can be identified in the network.

References

[1] Yan Ou, *"Assessment of Available Transfer Capability andMargins"* IEEE Transaction on Power Systems, Vol.17, no. 2, May 2002

[2] G.C. Ejebe, J. Tong, J.G. Waight, J.G. Frame, X. Wang and W.F. Tinney, *"Available Transfer Capability Calculations"* IEEE Transactions on Power Systems, Vol. 13, No. 4, November 1998

[3] G. Hamoud, *"Assessment of Available Transfer Capability ofTransmission Systems"*IEEE Transaction on Power Systems, Vol.15, no. 1, February 2000

[4] N.D.Ghawghaweand K.L.Thakre, *"Application of Power Flow Sensitivity Analysis and PTDF for Determination of ATC"*

[5] Dong-JoonShin , Jin-O. Kim,,Kyu-Ho Kim, C. Singh, *"Probabilistic approach to availabletransfer capability calculation"* Science Direct Electric Power Systems Research 77 (2007)813-820

[6] Power Grid Corporation of India Limited, www.powergridindia.com

[7] Central Electricity Regulatory Comission, www.cercind.gov.in

[8] Central Electricity Authority, New Delhi, www.cea.nic.in

[9] North American Electric Reliability Council

[10] Gujarat Eletricity Regulatory Comission, www.gercin.org

[11] Weerakorn Ongsakul Dieu Ngoc Vo text book on *"Artificial Intelligence in Power System Optimization"*

[12] Gujarat Energy Transmission Corporation Limited, www.getco.co.in

[13] Northern Region Load Dispach Center, www.nrldc.in

[14] State Load Dispatch Center - Gujarat, www.sldcguj.com