Power System Analysis of 66/11 kV Distribution

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Abstract: The paper propose basic of load flow analysis of power system. Load flow analysis essential for planning, operation and control of power system. At present load flow analysis is the initial condition for stability analysis, short circuit analysis, future expansion and economical operation for existing or proposed system. The goal of load flow analysis is to have safe, efficient and trustful power system.

***Index Terms* – Load flow analysis, Power system analysis, Mi-Power simulation, N-R Method**

I. INTRODUCTION

For interconnected power system stability and reliability is the most crucial factor to analyze. Normally electrical power system operates in their steady-state mode and the basic calculation required to determine the characteristics of this state is called **Load Flow Analysis.** Load flow analysis is used to determine the voltage, current, active reactive power and losses in a power system. Also based on the difference between power flow in the sending and receiving ends, we can calculate the losses in a particular line.

Load flow analysis is useful in some important aspect of the system like variation of voltage at the buses, overloading of transmission lines and emergency shutdown of generators or generator outage. Load flow analysis also important for transient stability studies. Thus, the load flow analysis plays a very important role in power system analysis.

1.1 Bus Classification

- Load bus/PQ bus
- Generator bus/Voltage control bus/PV bus
- Slack bus

PQ Bus

In this bus, no generators are connected so generated real and reactive power are zero. Here, Power flowing out so load drawn by these buses are negative (Real power P_{Li} and Reactive power $Q_{L}i$). Load bus is used to find the bus voltage and angle

PV bus

Generators are connected to this bus so it is known as generator bus. Here bus voltage is controlled by voltage regulator so it is also known as voltage controlled bus. Generator bus used to find reactive power and voltage phase angle.

Slack bus

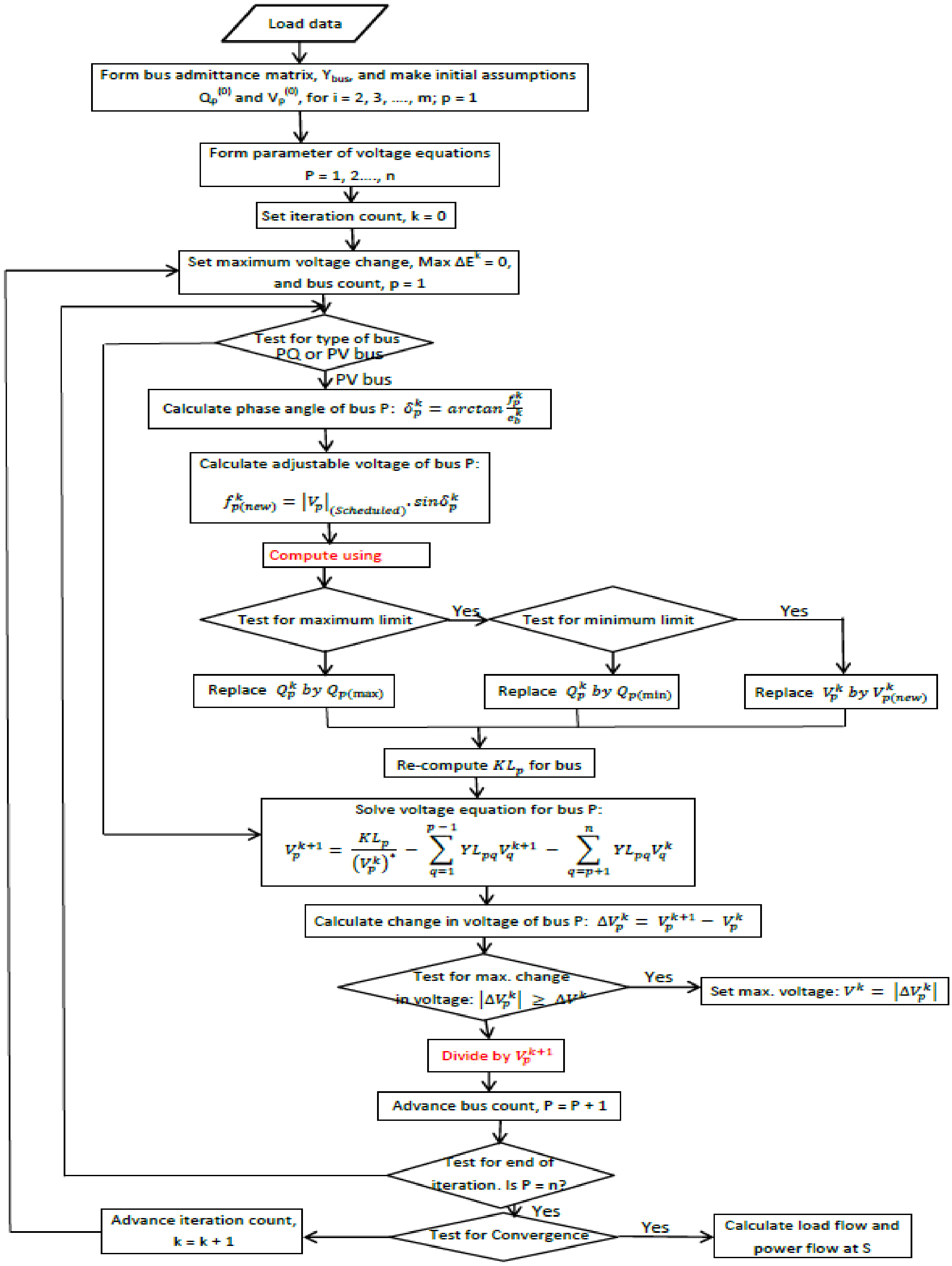
There is usually one slack bus in power system also known as reference bus. It is mainly used for compensation of losses. Hence voltage magnitude is considering 1 and phase angle is 0.

1.2 Load Flow Methods

Selection of load flow method is depends on system configuration. Following methods are widely used to solve load flow analysis of interconnected system.

- G-S Method
- N-R Method
- Fast-Decouple Method

1.3 G-S Method

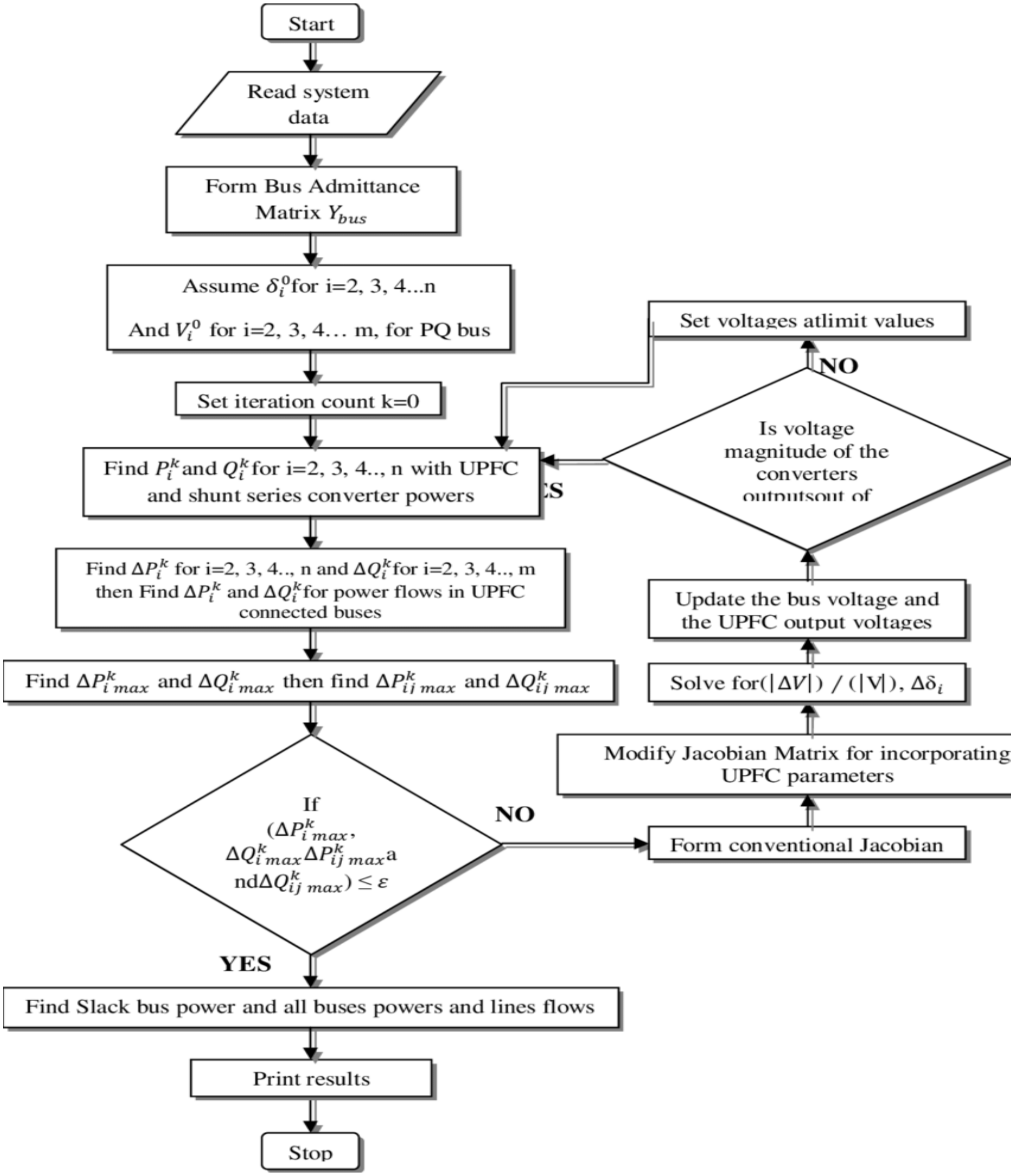


1.1 Flow chart of G-S Method

Limitations of G-S Method

- G-S method is mainly used for small power system.
- It is very effective for system having less no. of buses.
- In G-S method no. of iterations will increase with the no. of buses.
- The rate of convergence of the G-S method is slow.

1.4 N-R Method



1.2 Flow-chart of N-R Method

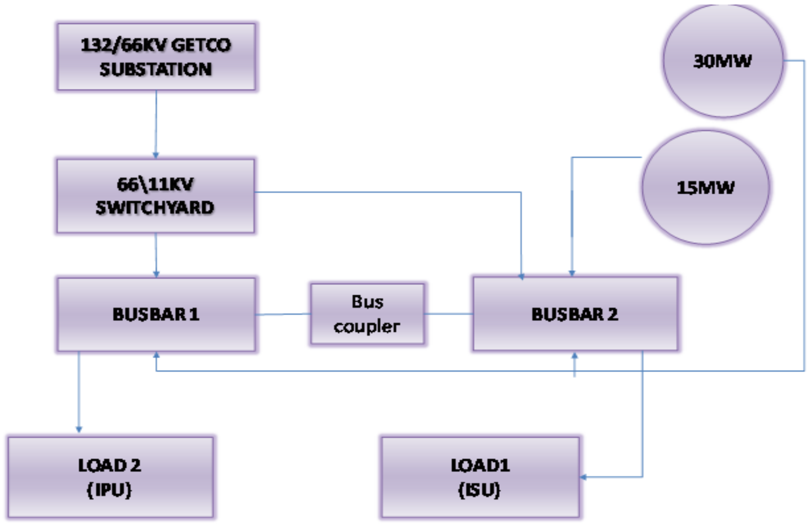
Advantages Over G-S Method

- N-R method is very effective for large power system over G-S method.
- N-R method is more accurate and not sensitive to the choice of slack bus.
- No. of iteration required in N-R method is independent of system size. So it takes less computation time compare to G-S method.
- N-R method requires less number of iteration to reach convergence.

With consideration of above mentioned advantages this paper proposed Load flow Analysis using NR method.

II. 66/11 KV DISTRIBUTION SYSTEM OF ET (ELECTROTHERM INDIA LTD.)

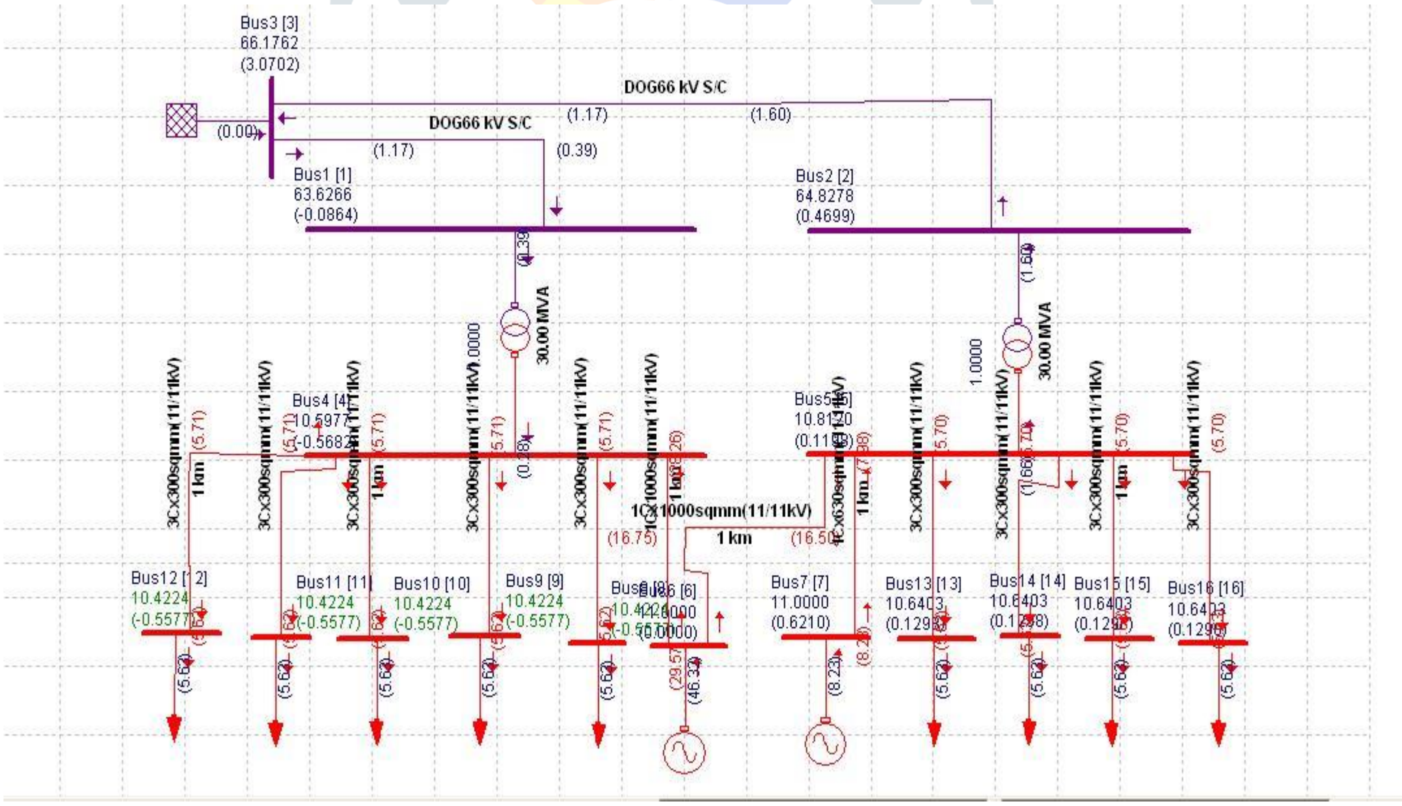
2.1 Block Diagram



2.1 Block Diagram Of 66/11 KV Distribution

In our system there are two units ISU (Integrated Steel Unit) and IPU (Integrated Pipe Unit) both units are connected with the substation which supply Power. Substation consist BUS-1 and BUS-2. Both the buses are connected by bus coupler. In case faults occur in BUS-1 then supply can be provided with the help of BUS-2 or vice versa. Electrotherm has its own Power plant which is known as Captive power plant, one is 30 MW and another one of 15 MW. Both the power plant produces power which is supplied to the substation by transmission line. Here 30 MW CPP is connected to BUS-1 and BUS-2 and 15 MW is connected to busbar-2.There is an alternative source of power which we received from GETCO Station. The supply from the Samakhiyari substation is 66KV which step down 66kv to 11kv with the help of transformer 1 and transformer 2. .In present time the 30 MW CPP is in working condition and 15MW CPP is purposed. Power is generated from 30 MW CPP and supplied to 11 KV Bus line with help of transmission line. Here in the system 2 loads are connected to the substation ISU and IPU. Totally system is synchronized. If any fault occur or demand increase then further power will collect from the GETCO Station.

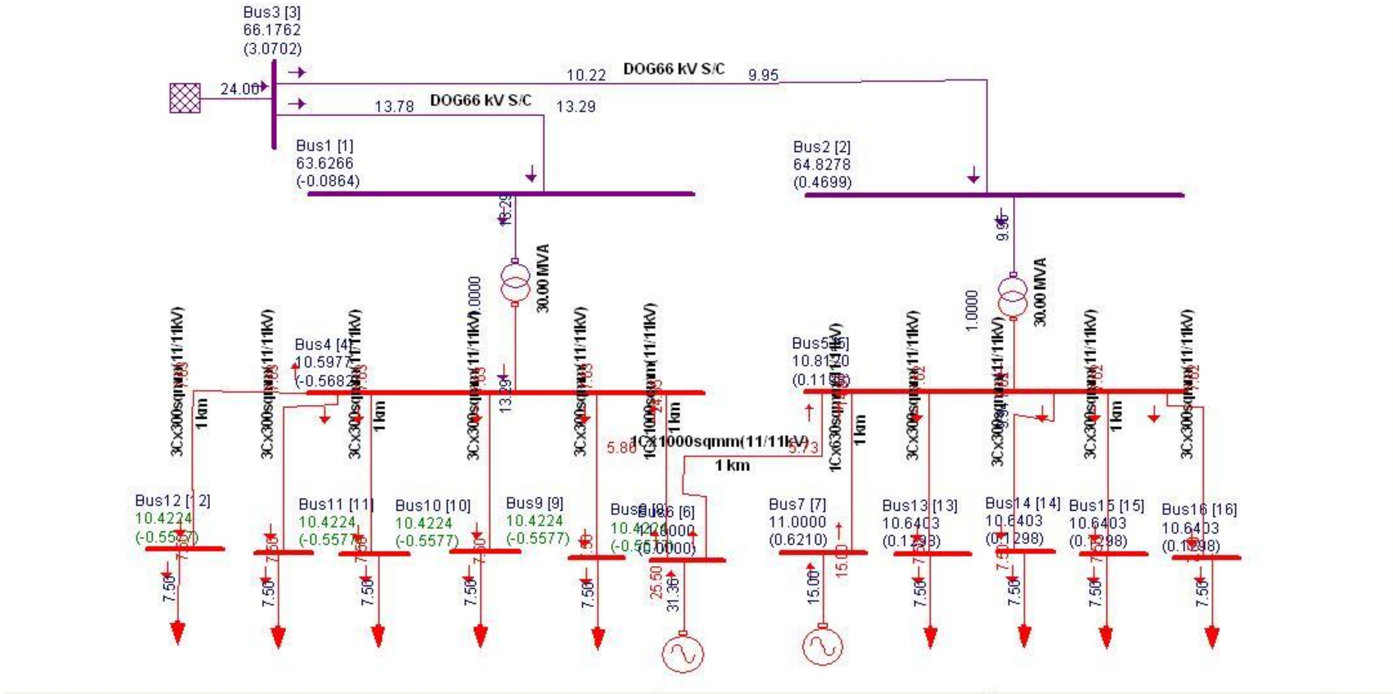
2.2 Simulation in MI-Power



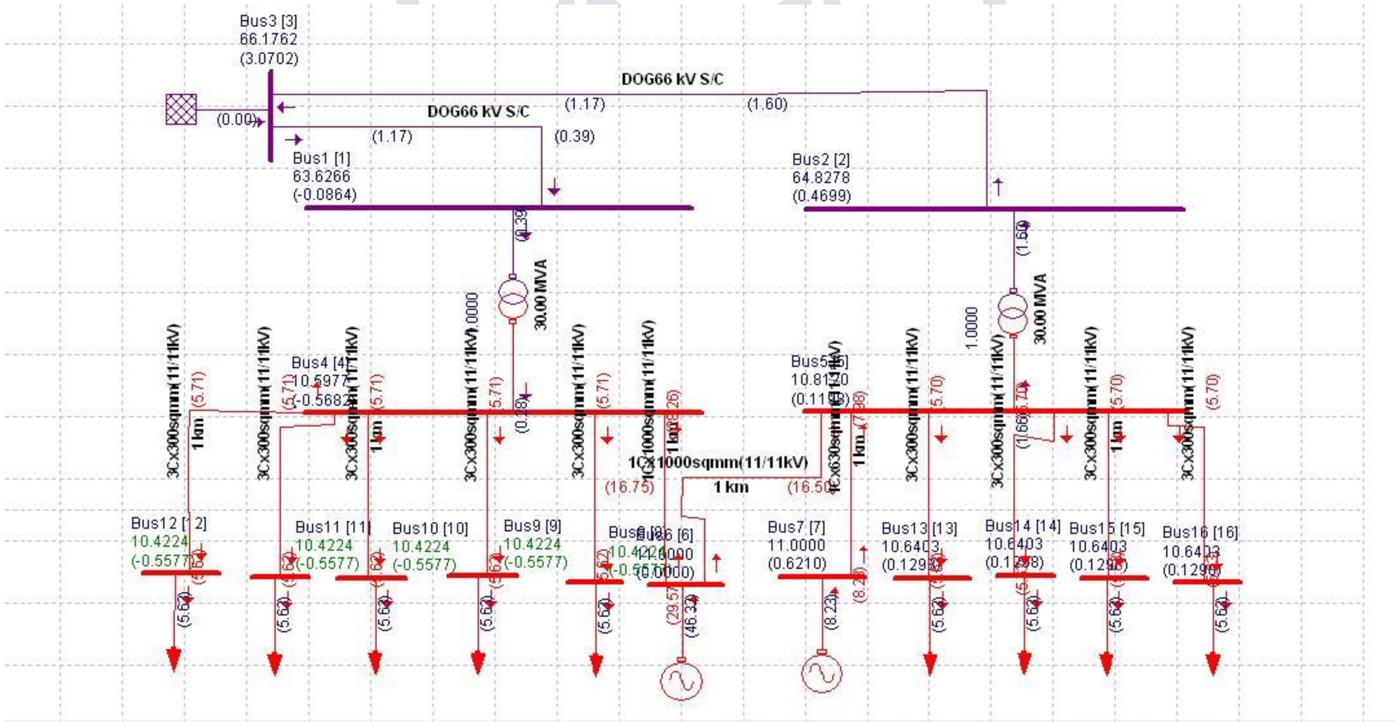
2.2 Simulation in MI-Power

III. RESULT

3.1 Plot



3.1 Real Power Flow Direction



3.2 Reactive Power Flow Direction

3.2 System Specification

It describes no of equipment connected in system.

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|~~~~~ INPUT DATA ~~~~~|

|***** SYSTEM SPECIFICATION *****|

Largest Bus Number Used             :  16
Actual Number of Buses              :  16
Number of Two Winding Transformers  :   2   Number of Three Winding Transformers :   0
Number of Transmission Lines        :  14   Number of Series Reactors            :   0
Number of Series Capacitors         :   0   Number of Circuit Breakers           :   0
Number of Shunt Reactors            :   0   Number of Shunt Capacitors           :   0
Number of Shunt Impedances          :   0   Number of Generators                 :   3
Number of Loads                     :   9   Number of Load Characteristics       :   0
Number of Frequency Relays          :   0   Number of Gen.Capability Curves      :   0
Number of Filters                   :   0   Number of Tie Line Schedules         :   0
Number of Convertors                :   0   Number of DC Links                   :   0
Number of Shunt Connected FACTS     :   0   Number of Power Injections           :   0
Number of TCSC Connected            :   0   Number of SPS Connected              :   0
Number of UPFC Connected            :   0   Number of Wind Generators            :   0
Number of wtg Curves                :   0   Number of wtg Detailed Curves        :   0
Number of solar plants              :   0
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3.3 System Specification

3.3 Transmission Line Data

It describe transmission line condition in the system also its shows the connection in the system and parameter of the line. E.g. a line between bus no 4 and bus no 6 is having an R=0.04270, X=0.0870, B/2=0..0009.

|***** TRANSMISSION LINE DATA *****|

STA	CKT	FROM NODE	FROM NAME*	TO NODE	TO NAME*	LINE PARAMETER R(p.u.)	X(p.u.)	B/2(p.u.)	RATING MVA	KMS
3	1	3	Bus3	1	Bus1	0.25700	0.40800	0.00000	27	1.00
3	1	3	Bus3	2	Bus2	0.25700	0.40800	0.00000	27	1.00
3	1	4	Bus4	6	Bus6	0.04270	0.08700	0.00009	14	1.00
3	1	5	Bus5	6	Bus6	0.04270	0.08700	0.00009	14	1.00
3	1	7	Bus7	5	Bus5	0.06350	0.09220	0.00008	11	1.00
3	1	13	Bus13	5	Bus5	0.13000	0.09520	0.00005	7	1.00
3	1	14	Bus14	5	Bus5	0.13000	0.09520	0.00005	7	1.00
3	1	15	Bus15	5	Bus5	0.13000	0.09520	0.00005	7	1.00
3	1	16	Bus16	5	Bus5	0.13000	0.09520	0.00005	7	1.00
3	1	8	Bus8	4	Bus4	0.13000	0.09520	0.00005	7	1.00
3	1	9	Bus9	4	Bus4	0.13000	0.09520	0.00005	7	1.00
3	1	10	Bus10	4	Bus4	0.13000	0.09520	0.00005	7	1.00
3	1	11	Bus11	4	Bus4	0.13000	0.09520	0.00005	7	1.00
3	1	12	Bus12	4	Bus4	0.13000	0.09520	0.00005	7	1.00

3.4 Transmission Line Data

3.4 Generator Data

Its describe the no of generator are conncted in the system and rating of the generator.

|***** GENERATOR DATA *****|

Sl.No*	FROM NODE	FROM NAME*	REAL POWER(MW)	Q-MIN MVAr	Q-MAX MVAr	V-SPEC p.u.	CAP. CURV	MVA RATING	STAT
1	3	Bus3	24.0000	0.0000	97.0770	1.0000	0	100.00	3
2	6	Bus6	30.0000	0.0000	15.4620	1.0000	0	33.75	3
3	7	Bus7	15.0000	0.0000	11.2500	1.0000	0	18.75	3

3.5 Generator Data

3.5 Line Losses

It describes the connection of the line in the system and losses, loading condition of the line. E.g. A line between bus no 3 and bus no1 having a loss 0.4891mw and loading is 50.55.

|***** LINE FLOWS AND LINE LOSSES *****|

SLNO	CS	FROM NODE	FROM NAME	TO NODE	TO NAME	FORWARD MW	FORWARD MVAr	LOSS MW	LOSS MVAr	% LOADING
3	1	3	Bus3	1	Bus1	13.783	1.170	0.4891	0.7763	50.5$
4	1	3	Bus3	2	Bus2	10.217	-1.167	0.2703	0.4289	37.5^
5	1	4	Bus4	6	Bus6	-24.847	-28.260	0.6512	1.3086	276.9!
6	1	5	Bus5	6	Bus6	-5.730	-16.497	0.1347	0.2559	125.9!
7	1	7	Bus7	5	Bus5	15.000	8.233	0.1860	0.2549	152.2!
8	1	13	Bus13	5	Bus5	-7.500	-5.625	0.1220	0.0792	132.0!
9	1	14	Bus14	5	Bus5	-7.500	-5.625	0.1220	0.0792	132.0!
10	1	15	Bus15	5	Bus5	-7.500	-5.625	0.1220	0.0792	132.0!
11	1	16	Bus16	5	Bus5	-7.500	-5.625	0.1220	0.0792	132.0!
12	1	8	Bus8	4	Bus4	-7.500	-5.625	0.1272	0.0834	134.8!
13	1	9	Bus9	4	Bus4	-7.500	-5.625	0.1272	0.0834	134.8!
14	1	10	Bus10	4	Bus4	-7.500	-5.625	0.1272	0.0834	134.8!
15	1	11	Bus11	4	Bus4	-7.500	-5.625	0.1272	0.0834	134.8!
16	1	12	Bus12	4	Bus4	-7.500	-5.625	0.1272	0.0834	134.8!

3.6 Line Losses

3.6 Load Data

It describes the load rating and reactive MVAR, reactive power of the load in system. E.g. load on the bus no 8 having a 7.5mw load.

|***** LOAD DATA *****|

Sl.No. *	FROM NODE	FROM NAME*	REAL MW	REACTIVE MVAr	COMP MVAr	COMPENSATING MVAR MIN	MAX	VALUE STEP	CHAR NO. STAT	F/V NO.
1	8	Bus8	7.500	5.625	0.000	0.000	0.000	0.000	0 3	0 0
2	9	Bus9	7.500	5.625	0.000	0.000	0.000	0.000	0 3	0 0
3	10	Bus10	7.500	5.625	0.000	0.000	0.000	0.000	0 3	0 0
4	11	Bus11	7.500	5.625	0.000	0.000	0.000	0.000	0 3	0 0
5	12	Bus12	7.500	5.625	0.000	0.000	0.000	0.000	0 3	0 0
6	13	Bus13	7.500	5.625	0.000	0.000	0.000	0.000	0 3	0 0
7	14	Bus14	7.500	5.625	0.000	0.000	0.000	0.000	0 3	0 0
8	15	Bus15	7.500	5.625	0.000	0.000	0.000	0.000	0 3	0 0
9	16	Bus16	7.500	5.625	0.000	0.000	0.000	0.000	0 3	0 0

3.7 Load Data

3.7 Area Wise Distribution

It is describe Area wise distribution of the system.

|----- AREA WISE DISTRIBUTION -----|

Description	Area # 1
MW generation	70.3627
MVAr generation	54.5577
MW wind gen.	0.0000
MVAr wind gen.	0.0000
MW solar gen.	0.0000
MVAr solar gen.	0.0000
MW load	67.5000
MVAr load	50.6250
MVAr compensation	0.0000
MW loss	2.8641
MVAr loss	3.9322
MVAr - inductive	0.0000
MVAr - capacitive	0.0000

3.8 Area Wise Distribution

3.8 Summary of Results

The real power generation in system is 70.63MW and the total load is connected in this system is a 67.50MW and total losses in the system is 2.86409MW.

|***** SUMMARY OF RESULTS *****|

TOTAL REAL POWER GENERATION (CONVENTIONAL) :	70.363 MW
TOTAL REAL POWER INJECTION (-ve LOAD) :	0.000 MW
TOTAL REACT. POWER GENERATION (CONVENTIONAL) :	54.558 MVAr
GENERATION p.f. :	0.790
TOTAL REAL POWER GENERATION (WIND) :	0.000 MW
TOTAL REACT. POWER GENERATION (WIND) :	0.000 MVAr
TOTAL REAL POWER GENERATION (SOLAR) :	0.000 MW
TOTAL REACT. POWER GENERATION (SOLAR) :	0.000 MVAr
TOTAL SHUNT REACTOR INJECTION :	0.000 MW
TOTAL SHUNT REACTOR INJECTION :	0.000 MVAr
TOTAL SHUNT CAPACIT.INJECTION :	0.000 MW
TOTAL SHUNT CAPACIT.INJECTION :	0.000 MVAr
TOTAL TCSC REACTIVE DRAWL :	0.000 MVAr
TOTAL SPS REACTIVE DRAWL :	0.000 MVAr
TOTAL UPFC INJECTION :	0.000 MVAr
TOTAL SHUNT FACTS INJECTION :	0.000 MVAr
TOTAL SHUNT FACTS DRAWAL :	0.000 MVAr
TOTAL REAL POWER LOAD :	67.500 MW
TOTAL REAL POWER DRAWAL (-ve gen.) :	0.000 MW
TOTAL REACTIVE POWER LOAD :	50.625 MVAr
LOAD p.f. :	0.800
TOTAL COMPENSATION AT LOADS :	0.000 MVAr
TOTAL HVDC REACTIVE POWER :	0.000 MVAr
TOTAL REAL POWER LOSS (AC+DC) :	2.864099 MW (2.864099+ 0.000000)
PERCENTAGE REAL LOSS (AC+DC) :	4.070

3.9 Summary of Results

IV. CONCLUSION

This paper represents the load flow analysis by N-R method using Mi Power software. After analyze load flow analysis of the system we conclude that for 70 MW generation and 67 MW load, system real power losses are 2.864 MW and reactive power losses are 3.932 MVAR. Hence system losses are 4.07 %. T & D losses generally range between 6% to 8%. In proposed system losses are 4.07%. Hence this study indicates proposed system work satisfactory and give reliable and stable operation.

V. FUTURE WORK

The load flow analysis is an intial condition for the short circuit analysis so after load flow analysis we will perform short circuit analysis of different faults like LG, LLG, LLLG, LL, Single phase open fault, Three phase open fault to anlyze system performance during abnormal conditions.

VI. REFERENCES

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