Design of underground Power distribution network for smart city Baroda

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Abstract
Electrical Energy Transmission & Distributions are the important part of any country's Economic growth and it's progress. This paper gives an understanding of underground distribution design scheme for one subdivision of smart city Vadodara & its voltage studies analysis for different load condition.

Keywords: *ETAP, Distribution line, Smart city, Current injection*

INTRODUCTION

With the rapid progress of capital India and rapid growth of the city areas. People are relocating you from village areas to an area. City because this Distribution of electric power system becomes complicated in the city area. Unstoppable electric supply and improved voltage supply profile become important in Smart cities.

Smart cities include infrastructure, Power supply, transportation, Governance, policies etc. should smart.[1].For good View of urban cities and reliable power supply, underground system is important[2].Types of underground line power cables & it's laying, Different types of component used in underground energy supply system[3].Algorithms for load flow used in ETAP software is understand[4]. Value of impedance/Km is taken from Polycab brousher[5].

This Paper considers one subdivision area of Vadodara, Gujarat. Voltage study is taken for 11KV/415V consumer end line.

I. CASE STUDY

One Subdivion of Baroda, Gujarat of 11KV/415V line is considered for Analysis. Two substations feed electrical power supply to this substation i.e. Jambuva Substation and Guvagasad substation of 220KV via 66KV Motibaug and Subhanpura substations. Total 11 KV distributing feeding points are 28 and load points of 96.

This system can divide into below parts:-

1. Transmission part
2. Distribution part
   1 Primary distribution of 1
   2 Secondary distribution of 415V to user end.

1. Transmission System:-

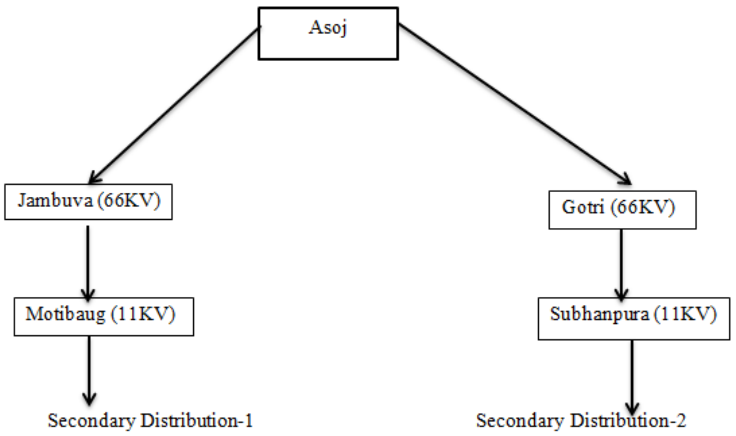

Fig. 1Transmitting System

Transmitting system includes 220KV Asoj substation to 66KV substations. This Portion includes primary and secondary transmission.

2. Distribution System:-

Distribution energy supply system can be subdivided into two parts.

2.1 Primary distribution:-

The Primary distribution includes 11KV feeders which step down to the 415V supply for LT consumer. This 11KV feeder also feeds supply to HT consumers i.e. Commercial and Industrial consumers.

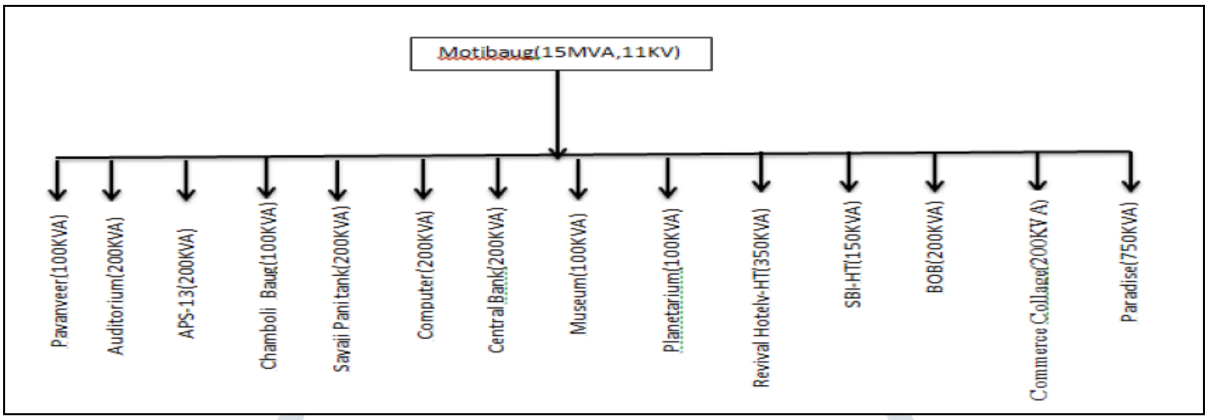

Figure 2 Primary distributor -1

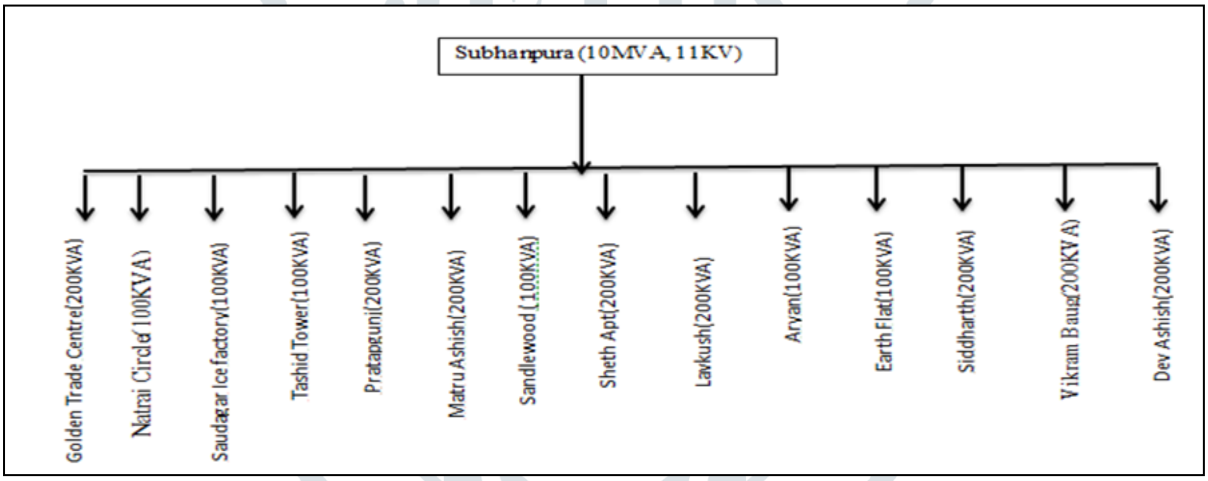

Figure 3 Primary Distributor-2

28 feeders of the subhanpura subdivision, Vadodara, Gujarat is considered for analysis.

2.2 LOAD POINT CONSIDERATION

Load point is selected by using GPS system by using feeder to feeder end distance and feeder to load point distance.

GPS system gives a path for installation of distribution line from one feeder to another feeder. Figure 1 gives a brief understanding of feeder to feeder and feeder to load endpoint path for this subdivision system.

By using GPS system 96 load points of 415V are considered for 28 feeders. Maximum load is calculated for same

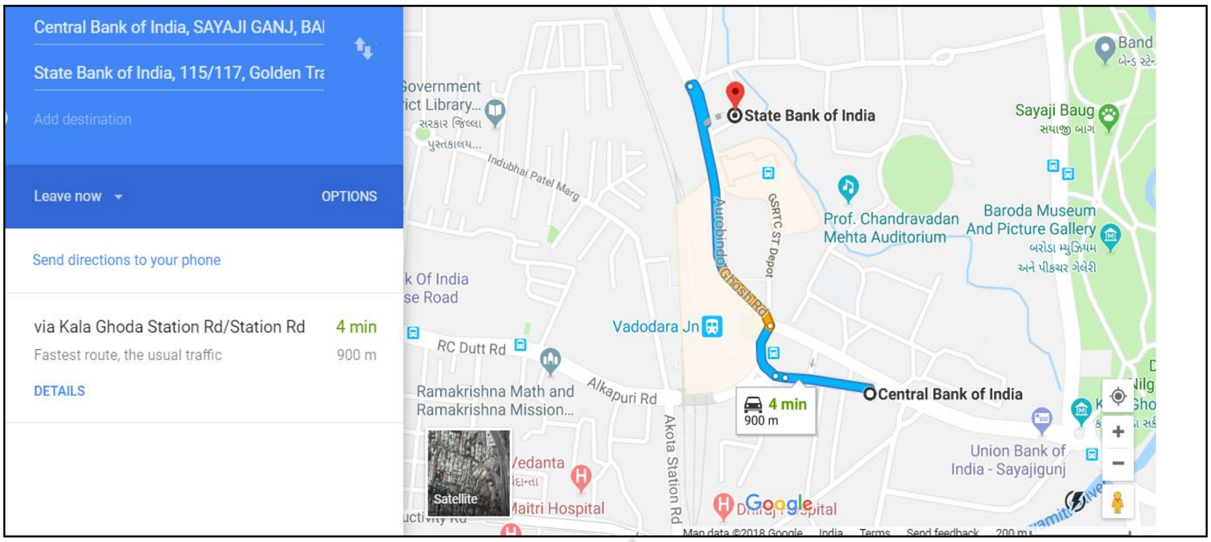

Fig 4GPS system for selection of 415V load points

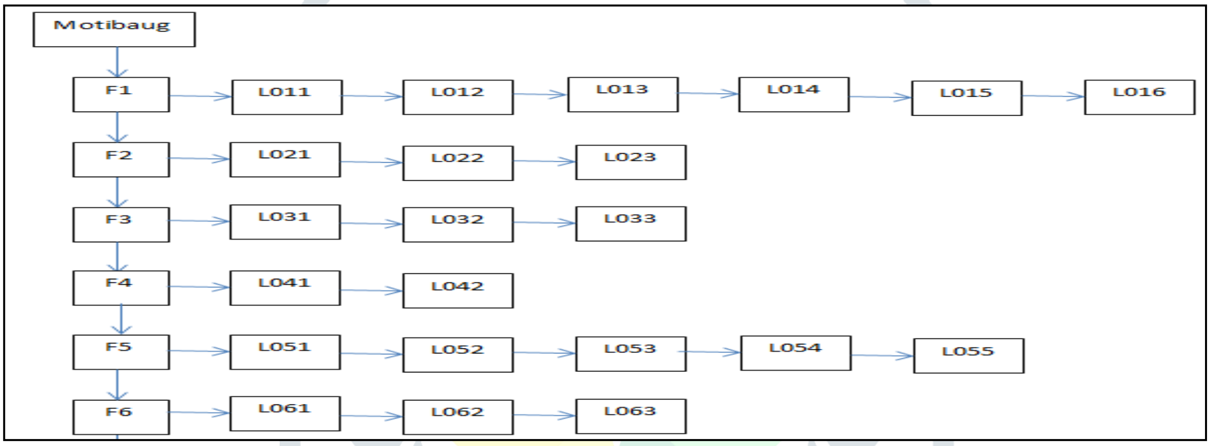

Fig 5 Secondary distribution system

III. SIMULATION OF SYSTEM

Simulation of this network is done by using Software ETAP 12.6.0.Fig 7 represents the full layout of the network from Asoj substation to Customer end side.

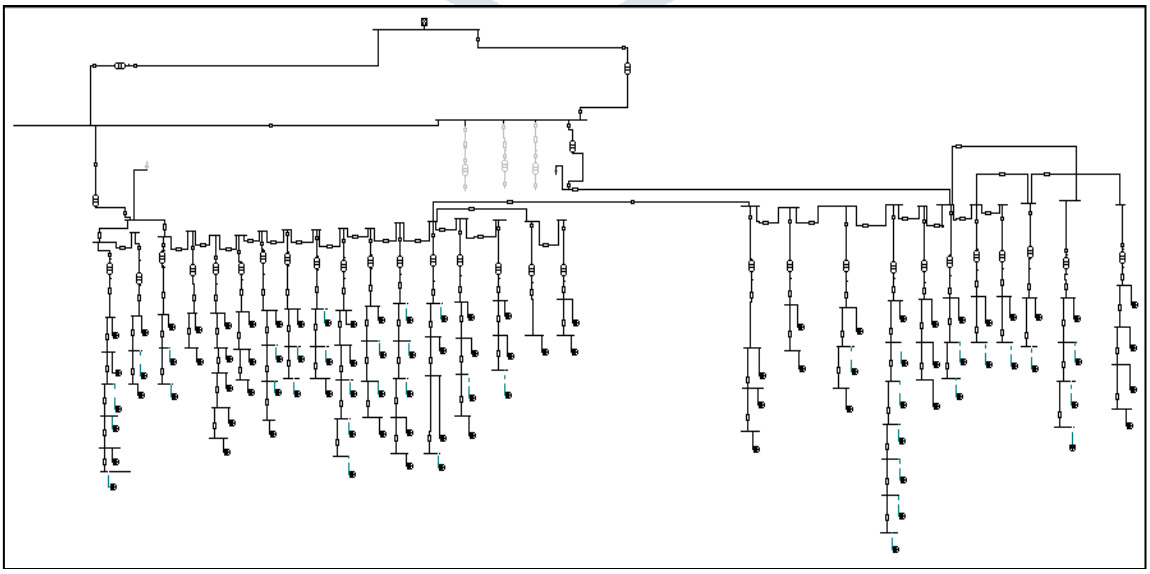

Figure 6 overall layout of the network of subdivision in ETAP

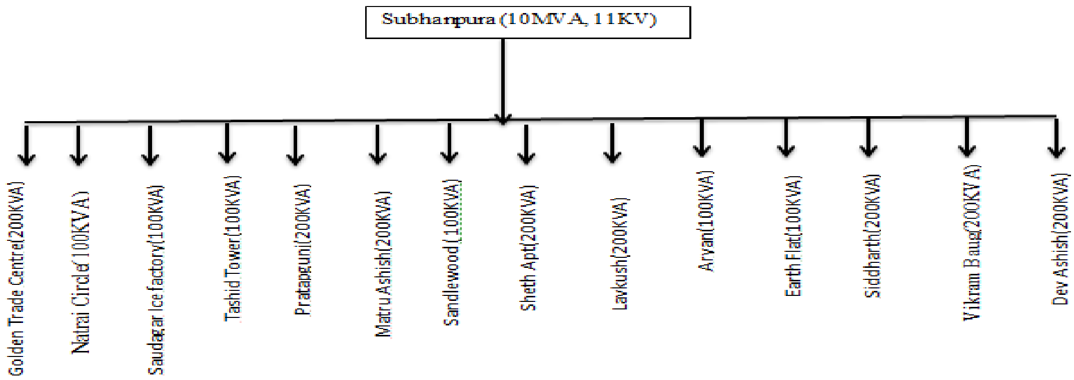

Fig 8, Fig 9 & Fig 10 is the basic layout for Power Transmission & Distribution. Fig shows the network for Distribution power for both the sources.

The diagram is in two parts:

1. Transmitting part system
2. Distributing part System
    2.1 Primary distribution system
    2.2 Secondary distribution system

1.Transmission system:-

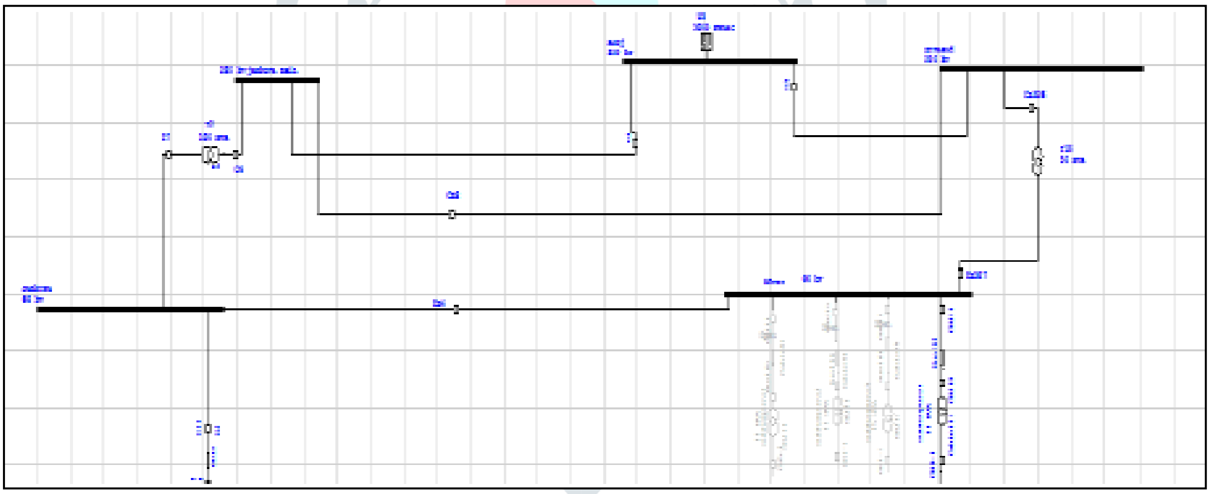

Figure 7 Transmitting system

2.Distributing system :-

As any subdivision takes Power from minimum two supplies. Some consumers will be feed by Subhanpura Substation through Motibaug 11KV feeder. This feeder will supply Power to 3- H.T consumers and 11- L.T consumers.

Some consumers will be feed by Gotri Substation through Subhanpura 11KV feeder. This feeder will supply Power to 11- L.T consumers. No H.T consumer is connected with this source**.**

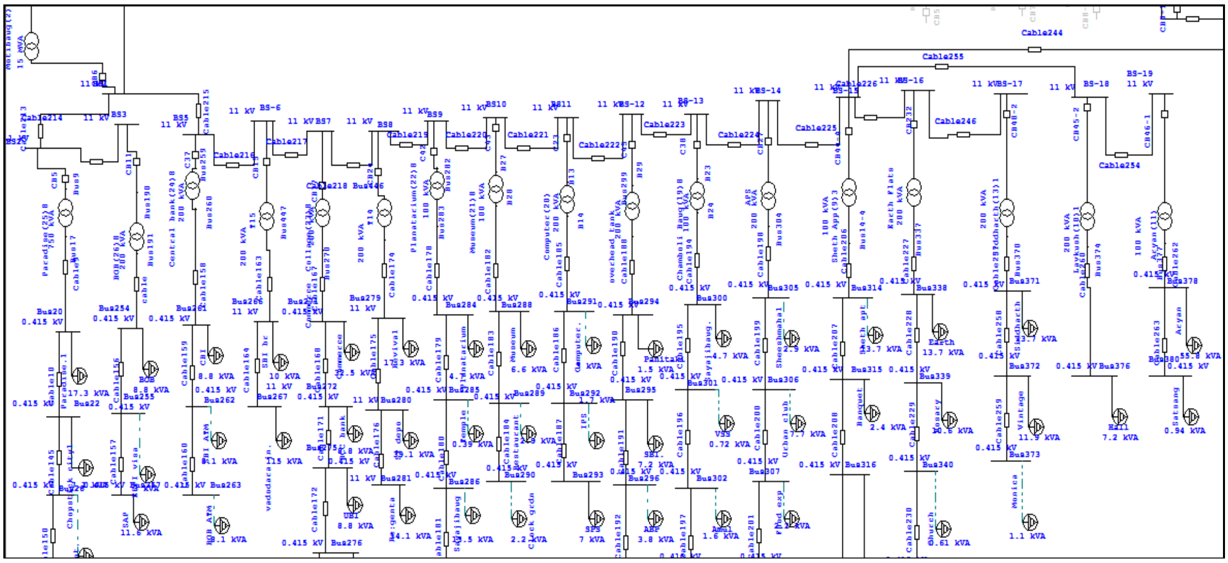

Figure 8 Distribution system

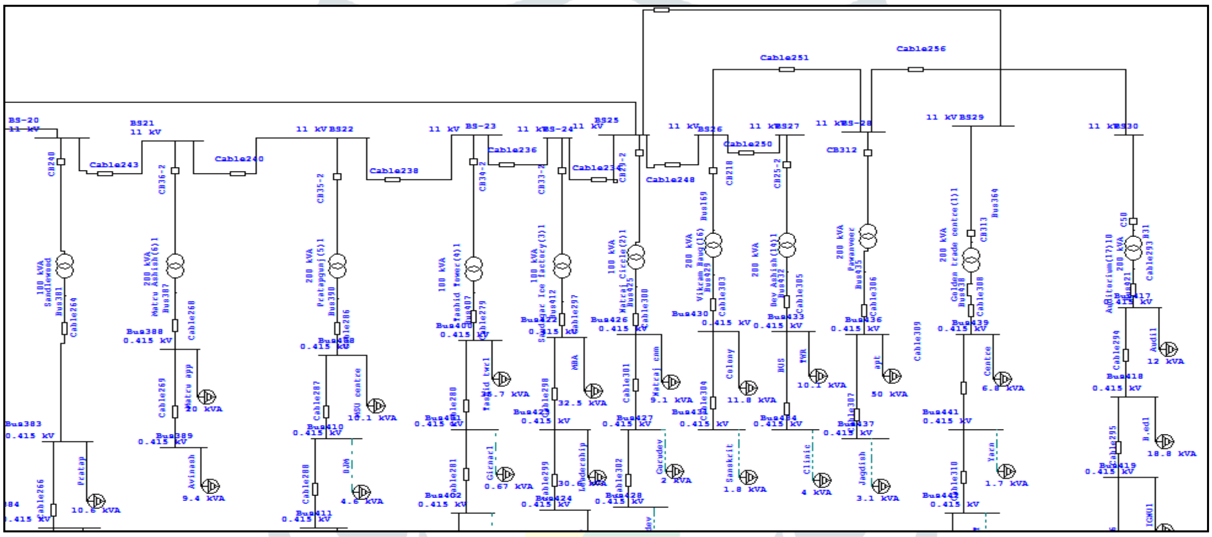

Figure 9 Distribution system 2

IV. ASSUMPTIONS MADE FOR ANALYSIS BEFORE LOAD FLOW STUDIES

1. Power Factor and Frequency is assumed 0.85 lag & 50Hz.
2. As all the appliances will not work at the same time so diversity considered after power calculation is about 80%.
3. Impedance for the 11KV line is 0.196+j0.324Ω/km and for 415 V line is 5.90+0.123Ω/km.
4. Operating Load to any feeder is between 40% ≤ Operating load ≤ 70%.In 40% load is during offload condition and & 70% loading is during ON peak condition.
5.

V. OPERATION & UNBALANCED LOAD FLOW ANALYSIS

In this analysis distribution system is considered so that conventional load flow methods i.e. Gauss-Seidel or Newton Raphson method is not convenient and can't give accurate results As R/X ratio is very high at distribution side so that other advanced methods used.

ETAP software uses the method of injected current for unbalanced load flow analysis method and gives results in terms of voltage, Current, Active & reactive power.

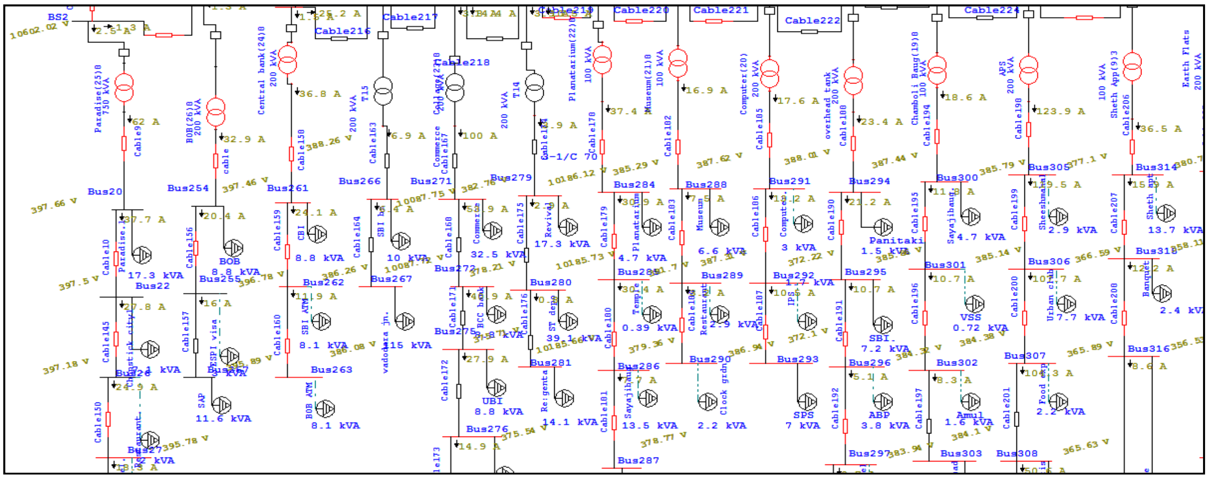

Figure 10 Load flow at distributor-1

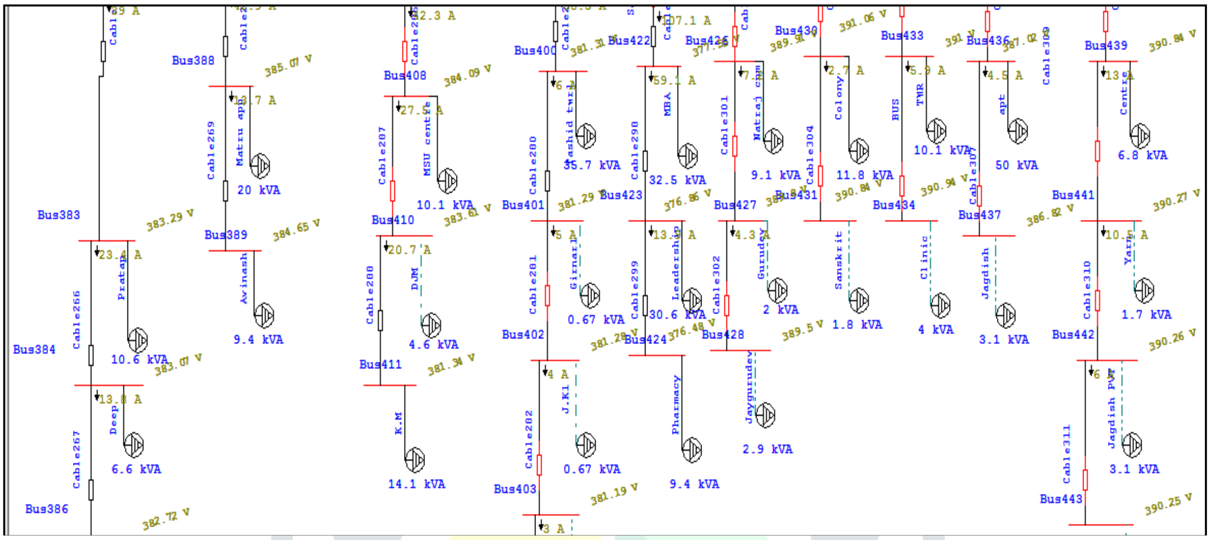

Figure 11 Load flow at distributor -2

The Same analysis is done for Summer &Winter load condition too.

VI. CURRENT INJECTION METHOD

This method is generally used for unbalanced load flow in ETAP software When X/R ratio is very high at secondary distribution side. In this situation, conventional methods can not give reliable and perfect accurate results.

Algorithms for current injection method are as follows:

Suppose the following system is considered.

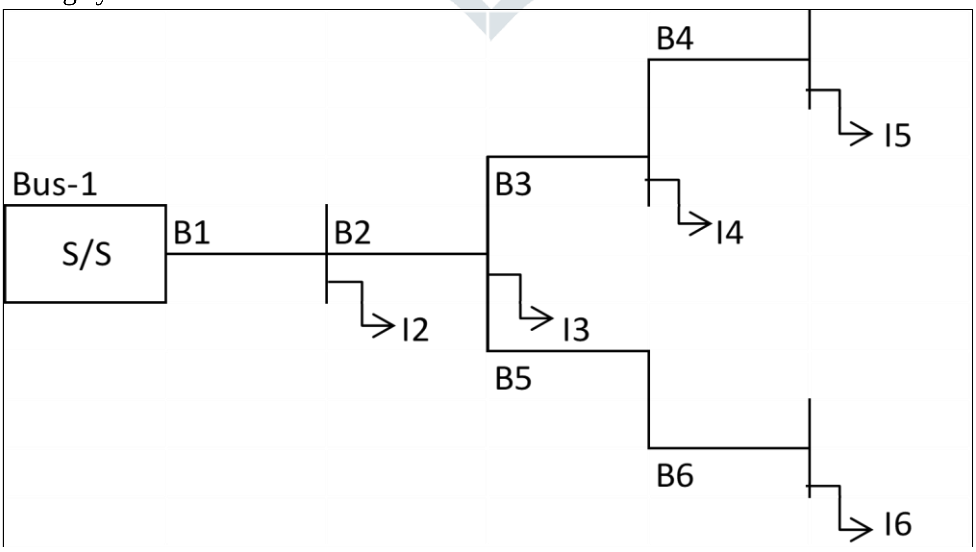

Figure 12 unbalanced load flow analysis by current injection

1. Calculation Of BIBC(bus injection to branch current):-

Apply KCL on above diagram-

B2=I2+I3+I4+I5+I6 (1)

B3=I3+I4+I5 (2)

B4=I4+I5 (3)

B5=I6 (4)

[B]=[BIBC][I] (4A)

2. Calculation of BCBV(branch current - bus voltage):-

Apply KVL on above diagram:-

V2 = V1 - B1 Impedance of line-12 (5)

V3 = V2 - B2 Impedance of line- 23 (6)

V4= V3 - B3 Z34 (7)

[V]= [BCBV][B] (7A)

3. Calculation of distribution load flow (DLF):-

DLF is a multiplication matrix of BCBV and BIBC matrix.

[DLF] = [BCBV][BIBC] (8)

[Change in voltage]= [DLF][I] (9)

4. Calculate voltage with the increase in iterations:-

$$I_i^k = \frac{P_i + Q_i}{V_i^k}$$ (10)

Change in voltage^{k+1} = [DLF] [I^{k+1}] (11)

[V^{k+1}]= V^{0} + [Change in Voltage^{k+1}] (12)

5. Flowchart for method algorithms:-

Consider one load point of proposed Baroda area network for analysis and for comparison for load flow results using ETAP software L011 in which first 01 is feeder number and last 1 is load point number.

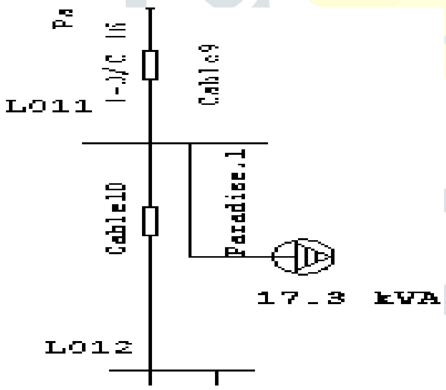

Figure 13 unbalance load flow analysis using current injection method

- After considering from source point voltage drop is 0.290264KV.So voltage reached at 0.415 KV bus will be 0.405264KV
- Consider V_i^o = 0.405264KV
- Now, DLF for this point is,
- [DLF] = [BCBV][BIBC]
- Where, BIBC=$I_1 + I_2 + I_3 + I_4 + I_5 + I_6$

  BCBV= $V_2 = V_1 - B_1 Z_{12}$
- DLF= [BCBV][BIBC]

- SO, DLF= 0.0317

➢ ITERATION -1

- $V_1^O = 0.405264KV$

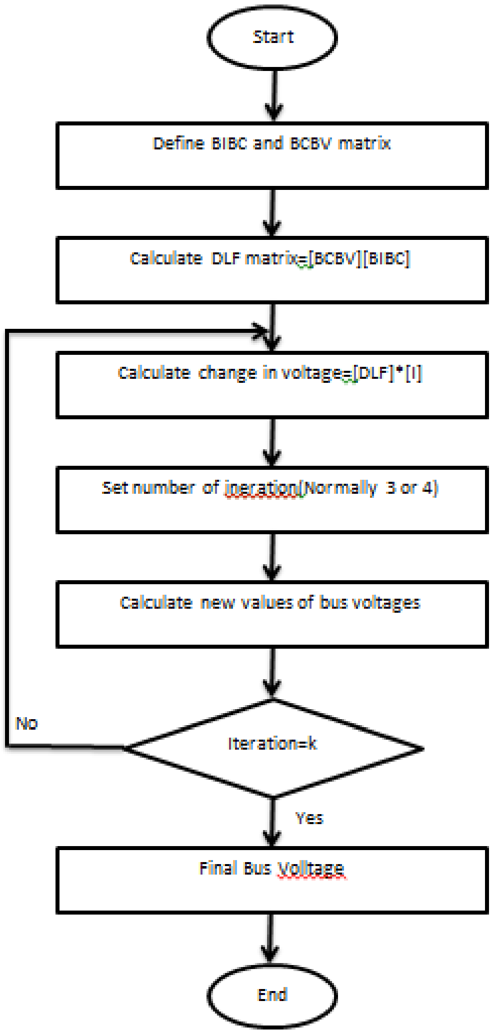

Figure 14 Unbalanced Load flow analysis

- $I_1^O = (\frac{P_I + jQ_I}{V_1^0})^*$

$= \frac{14.703 - j9.112}{0.405264 < 0^0}$

$= 36.280\text{-j } 22.48$ A

$= 42.68 < 31.78^0$

- Change in voltage $V_1^1 = [0.0317][42.68 < 31.78^o]$

$= 1.3529 < 31.78^o$ V

$= 0.00011501 + j\ 0.00007126$ KV

- $V_1^1 = 0.405264 + 0.0011501 + j\ 0.0007126$

$= 0.40641 + j0.0007126$ KV

➢ ITERATION -2

- V_1^1 = 0.40641 + j0.0007126 KV
- $I_1^1 = (\frac{P_I + jQ_I}{V_1^0})^*$

$$= \frac{14.703 - j9.112}{0.40641 - j0.0007126}$$

$$= \frac{17.29759 < -31.788^o}{0.8192 < -0.10046^o}$$

= 42.560<-31.679° A

- Change in voltage
- V_1^2 = [0.0317][42.560< -31.679]

= 1.3491< -31.69°

= 1.14808-j+0.708 V

=0.001148+j0.000708KV

V_1^2 = 0.40641+ 0.001148+ j0.000708

= 0.407558+0.000708KV

➢ ITERATION -3

- V_1^2= 0.407558+0.000708KV
- $I_1^2 = (\frac{P_I + jQ_I}{V_1^0})^*$

$$= \frac{17.297 < -31.788^o}{0.40755 < -0.09953^o}$$

= 42.44< -31.68 A

- Change in voltage V_1^3 = 1.3453< -31.68° V

= 0.00114+0.000706

- V_1^3 = 0.40641+0.00114+j0.000706

=0.40755+j0.000706

VII. RESULTS OF LOAD FLOW AT DIFFERENT LOAD CONDITION FOR VOLTAGE PROFILE ANALYSIS

Voltage analysis study for Normal, Summer & winter load condition is done and for understanding some points are taken for analysis.

For this Feeder no 1, 7.14.21.28 is considered. As feeder number 14 is at a middle of the system. Both the supply sources will be away from the midpoint.so least voltage and high current are present at the feeder 14. This can be understood by simple line diagram.

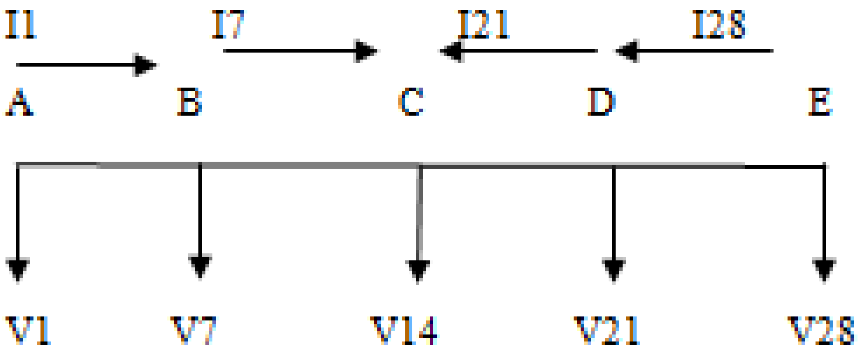

Figure 15 Distribution system calculation

So, At the Node C current flow through the network will be maximum as all the current points are meeting at node C and node C is away from both the source points distance across mid-point and supply sources are large so that high amount of losses will occur. So that least voltage will be at node C.

Voltage profile will be V1>V7>V14<V21<V28.

Voltage profile for the considered network is as follows:-

Table 1Voltage profile during a different load condition

	Voltage Profile		
Feeder no	Normal	Summer	Winter
F1	397.66	396.36	398.56
F7	385.29	383.6	387.8
F14	380	378.7	382.12
F21	383.31	381.5	386.4
F28	395.7	394.3	396.2

Similarly, voltage profile can be learned from graph too.

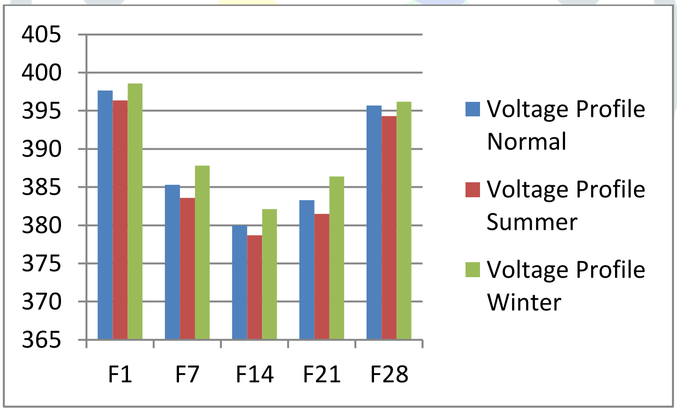

Fig 16 representation of voltage profile studies

FUTURE SCOPE

In the summer load condition, there is a high amount of loss and degraded voltage profile. So, for modification

1. By using Capacitor power bank.

CONCLUSION

The ETAP software unbalanced load flow tool is used for load flow and analysis of Baroda subdivision secondary distribution network for different loading conditions i.e. summer, winter and normal load condition by using redial system condition. Load points are considered by using GPS system. This paper also explains Voltage profile till the consumer end by taking tapings on the 415V transformers and feeds supply to L.T and HT consumers.

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