GPS BASED POWER SYSTEM OPTIMIZATION ON MEDIUM/LOW VOLTAGE FEEDER

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ABSTRACT-*Power system comprises of generation, transmission and distribution. Distribution system is connected with generation through different transmission and sub transmission networks. Not all the energy generated at generation side is delivered to distribution side. Considerable amount of energy is lost in terms of different losses yielding system inefficiency. To date, methods of maintenance of distribution system depend on experience, handmade drawings of feeders also called maps. Surveys which are being conducted to gather relative data is not up to the mark. Lengths have major impact on losses and that are measured by measurement tapes, which can add error or inaccurate measurements. This study provides a unique and innovative method to manage and analyze 11kV feeders. 11kV feeder is modeled using its geographical location. For analysis one of the 11kV feeders of Power distribution company (DISCO) is selected. Firstly it will be mapped according to its geographical location then it is analyzed for losses calculation and analysis. High loss sections are figured out and then suitable recommendations are given to save energy. It becomes very easy to manage distribution side by computers. It not only provides easy rejuvenation of information but also increase work efficiency by saving time. This study ensures efficient power system and is economical.*

Keywords: GPS, Distribution system, Losses, Efficiency

1- INTRODUCTION:

Power is provided to consumers comes by covering several stages from generation to distribution. Distribution side is normally at low voltage level. It can be categorized into primary distribution and secondary distribution. Primary distribution covers 11kV feeders and this 11kV is stepped down into 400/220V which is used for domestic purposes is called secondary distribution. Electricity is transferred by means of electric current. It is the key of all human activities. Efficiency of the entire power system depends on all sub systems. Making any system more efficient, overall efficiency will increase.

In a recent story line, Pakistan is facing a huge problem of energy crisis. With the rapid increase in industries and improved life style, consumers of electricity are increasing. Gap between generation and demand is so huge that it seems an unresolved problem. On the long run there is need to build large capacity dams and power plants but it will take time. Up to that time steps are to be taken to improve existing power grids and power system to increase overall efficiency. Losses in the system are to be controlled by using some new fast methods. Losses in the system can be technical or non-technical. According to Davidson [1], technical losses are the losses due to current flow in electrical equipment; it is the drop due to resistance of any particular material. It can be categorized as no load and load losses. No load losses are when there is no load is connected. They are due to magnetic properties of materials like losses in core of transformer. Load losses are when current passes through the load connected. Non-technical losses are independent of current flow and resistance. These can be regarded as undetected loads and can be on hand of administration or faulty equipment.

Existing methods of maintenance and rehabilitation of 11kV feeders depend on manual handmade maps and data collection which leads to errors. Data is entered manually and any mistake in entry of length between two spans yields incorrect losses associated with it [2]. Wrong entry of length in software not gives accurate results and to find out mistake, each length is to be checked. It wastes a lot of time results in poor work efficiency.

Secondly, the site has to be visited again and again whenever alternations are to be made which not only affects overall work efficiency but also add cost in terms of fuel charges. There is a need to upgrade system using some new and efficient technologies. GIS and GPS technology can help to manage and deal with expected problems. GIS is a system having a collection of hardware and software which in collaboration are used to store, analyze and visualize data in a unique way [3]. It is based on geographical location of site (distribution network). 3D models of distribution networks were prepared using GIS technology to prepare base maps for sites [4]. Both the technologies were used to prepare a base map for the Chennai distribution network [5]. GPS device is used to map location according to its coordinates. It also takes record of all assets in system. GIS technology was used to avoid power theft in system by gathering information on monthly bases about consumers and their need and databases were used to store this data [6]. Geographic based technology was also used for crisis management to point out areas with more danger so that their security can be provided. [7]. Suitable GIS based software is used for mapping. Arc Info was used, but company provides another tool which is very much similar to that, but have more benefits named as Arc View [8]. Data is stored in different layers using databases. This helps to edit data at any time. As there is a separate layer for each equipment, e.g. conductor, pole, transformer complete map is made by combining all these layers. For specific visualization according to requirement and conditions, GIS allows to apply different queries to get required display of information [9]. After finalizing map, it is interfaced with electrical GIS based software named as SynerGEE for load flow analysis. Network routing is also available to calculate exact lengths between poles to have an accurate calculation of losses in respective spans and also suggests optimum lengths for cost reduction [10]. From load flow sections with high losses are figured out and suitable recommendation is given to save energy. Finally map is uploaded on Google earth as well.

GIS is also helpful to prepare a utility network to avoid wastage of time and to have better fault assessment [11].

2- METHODOLOGY:

This study can be divided into two parts

(i) Mapping

(ii) Load flow analysis for loss calculation

Figure 1 shows some of the major activities of mapping, which have to be followed for good results.

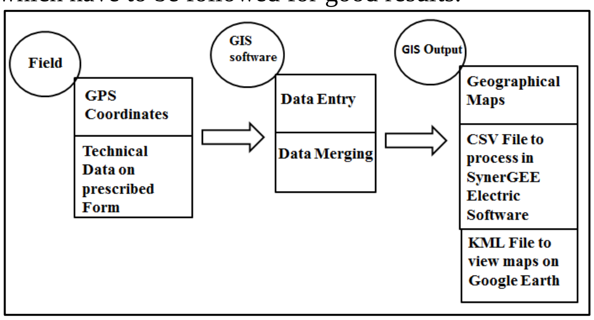

Figure 1: Mapping Activities

Figure 2 shows process flow chart for mapping in detail.

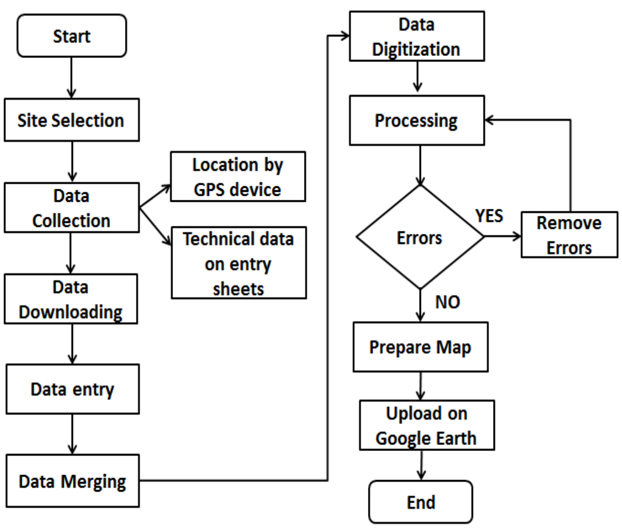

Figure 2: Flow Chart of Mapping

Mapping process starts by selecting a location which is to be mapped by ArcGIS software using GPS device. Site survey of selected site is being conducted. GPS device is used to collect geographical locations of elements in network as it is connected to satellite which collects required data in terms of longitude and latitude of desire equipment/element and technical data associated with it can be entered in prescribed forms or sheets. Collected GPS data is downloaded in computers. This device can easily be interfaced with using data transfer cable. A suitable software is required that is GPS supported to download geographic data. Map source software is used here. It plots poles on basis of its coordinates (latitude, longitude and altitude, which is distance from sea level). Technical and non –technical data sheets are entered manually in computer in MS Access that was entered in sheets. Both sets of data (geographical, technical and non-technical) are being merged using ArcGIS to make a complete set of data. For data merging in ArcGIS there should be some unique id in both, or separate fields can be created and data is imported in those fields using field calculator. To move towards the digitization some steps are in between which has to be followed. Data base item are created i.e. feeder name and grid name from which it is emanating. This step will create files and feature classes. After this GPS data is processed in which field survey information has to be given e.g. dates on which survey was conducted. Then data is processed for error checking. If there will be errors there will be no output. Possible errors can be several points are taken by standing at a point. Branches are not ended accurately that it makes a loop is network etc. If there are errors remove them and then run processing again. If still there are errors repeat the process and if there are no errors prepare a final complete map. After that data it is digitized in forms of different symbols. Assigning symbols makes it easy to identity its poles, conductor or transformers. Now collected data is processed to analyze for errors. For better understanding different conductors, poles and transformers can be digitized differently. After finalizing it is uploaded to Google earth as well.

Now moving towards load flow analysis for losses calculation Overall process can be described using a flow chart. Figure 3 shows methodology for load flow analysis.

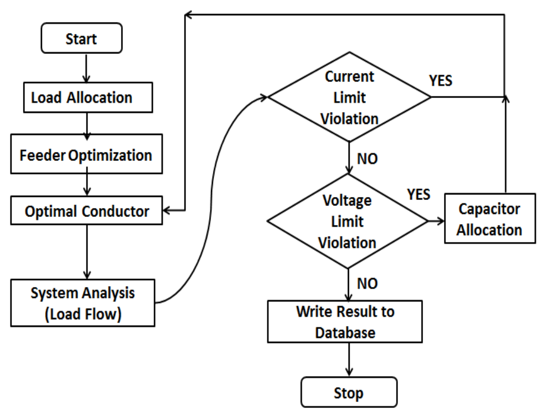

Figure 3: Process Flow Chart for Analysis

Calculation of technical losses starts by allocating load which is in terms of amperes to feeder. Each 11 kV feeder in system has its own load depending on its usage and consumers. Every month load is measures by the respective grid station. Peak load is used for analysis for worst cases. After allocating load optimization technique is selected. Here re-conducting technique is used for loss reduction. Re-conducting means to replace existing conductor with some other suitable conductor as each conductor has its own current carrying capacity. Load flow analysis is performed and high loss sections are figured out. Current violation is checked for each conductor. Is there is a violation; existing conductor will be replaced with next suitable conductor having higher current carrying capacity than existing one. This procedure will continue until no more replacements can be made. One other parameter voltage drop is also to be checked. It is also improved by changing conductor but a point will come when no more replacements can be made in conductor and still voltage drop is of large magnitude. It then can be improved by installing capacitors in system. When parameters will be in permissible limit result will be written in databases and analysis will be stooped.

3- MAPPING AND ANALYSIS: CASE STUDY

3.1 Mapping

11 kV Barnala feeder of distribution company FESCO is being selected for mapping and further analysis. This feeder is emanating from Chak Jhumra grid station of Chak Jhumra subdivision. Its overall route including poles, conductors, grid station and transformers are being mapped. After mapping load flow analysis is performed and high loss sections will be figured out. Data is collected in terms of geographical coordinates and technical. Geographical data is downloaded in map source software. Figure 4 shows downloaded geographical downloaded data.

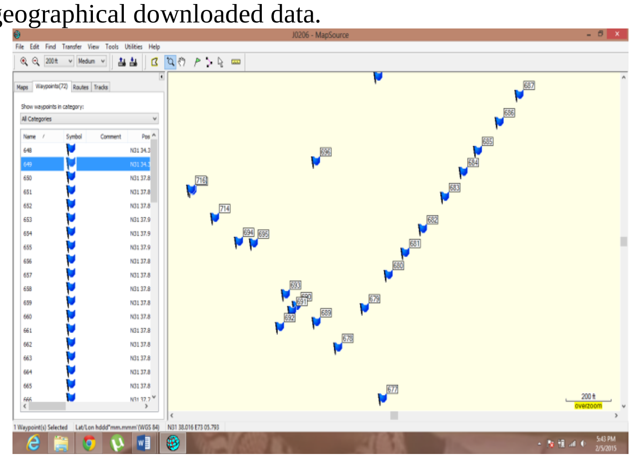

Figure 4: Waypoints in Garmin Map Source

Each flag represents location of pole in field having unique coordinates with respect to other poles in network. All the data can be downloaded in a single file but to download and save it as date wise is recommended. After downloading data, it is interfaced with ArcGIS software for mapping. It works in layers. Separate layer is made for each entity then integrating them gives a complete high quality map. Layers of poles, conductor and transformer are given below

Figure 5 shows layer of pole, having location of poles according to coordinates which are written in database. These are similar to the point shown in figure 4. It is clear from figure that different types of poles have been used in the system e.g. PC ordinary, Pc spun etc. Pannel category represents the start of feeder.

Figure 5: Pole Layer

Figure 6 shows transformer layer having all the transformers in selected feeder having different capacities previously stored in database of transformer. From figure capacities can also be seen.

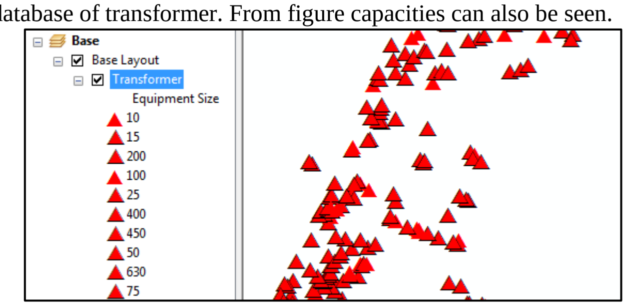

Figure 6: Transformer Layer

Figure 7 shows layer of conductor showing g its complete path according to its field location. Location is measured previously by GPS device**.**

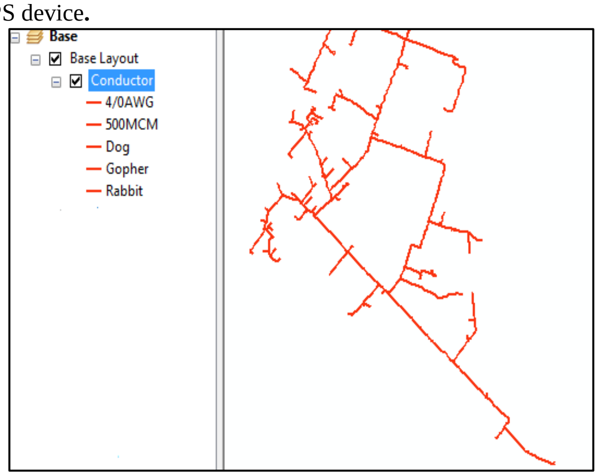

Figure 7: Conductor Layer

Figure 8 shows a combined map having poles, transformers and conductor which are formed previously in separate layers.

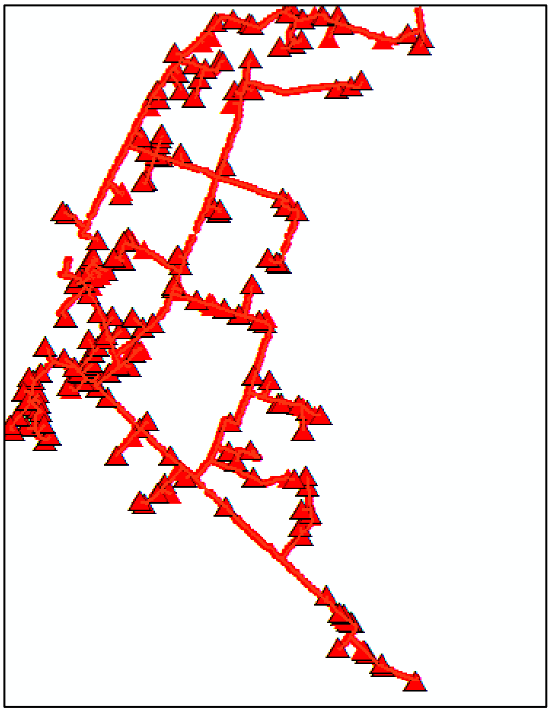

Figure 8: Integrated Map

3.2 Analysis for Loss Calculation

Integrated map is interfaced with GIS based electrical software named as SynerGEEs. It is new software having a lot of attractive features offering reliability, forecasting, protection, planning etc. First step is to allocate load in terms of maximum amperes. Selected feeder has maximum of 390A load. Next steps are according to the detail described in methodology section. Results of load flow analysis are shown in table 1.

Table 1: Feeder Summary

Parameter	Value
Demand -KVA	7417
Demand - %pf	90
Demand - Amps	389
Conn - KVA	16235
Load Factor	60
Demand KW	6682
Max Load (Amp)	389
KW Loss - %	24.55
KW Loss - Line	1534.19
KW Loss - Trans	106.22
% Max- Volt drop	40.39

Table 2 shows high loss sections having existing conductor Dog. This conductor is working beyond its limits so it needs to be replaced with another suitable conductor having greater current carrying capacity than conductor dog. To save energy in these sections conductor osprey can be used. Replacement of conductor dog to conductor osprey, replacement criteria is to be fulfilled i.e. to change conductor dog to conductor osprey minimum current in span should be 168 amperes. These 22 sections are figured out where replacements can be made.

Table 3 shows high loss sections with existing conductor rabbit. To save energy in these sections there are two possibilities either to use conductor dog or conductor osprey. Replacement of conductor rabbit to either of the conductors, replacement criteria is to be fulfilled i.e. to change conductor rabbit to conductor osprey minimum current in span should be 106 amperes and 74 amperes needed for replacement with dog. By using conductor dog satisfactory results are not achieved that is why osprey is recommended.

Table 2: High Loss Sections with Conductor Dog

Section	Amps	Loading	KW Loss	Kvar Loss
Section2	389	127	10.69	13
Section4	389	127	144.37	172
Section5	388	126	7.7	9
Section7	383	125	76.62	91
Section8	382	124	14.2	17
Section9	382	124	2.5	3
Section10	380	124	5.47	7
Section11	378	123	73.56	88
Section14	368	120	68.04	81
Section19	362	118	6.74	8
Section22	359	117	17.56	21
Section23	357	116	11.43	14
Section29	350	114	72.4	86
Section33	335	109	186.57	223
Section34	324	106	106.41	127
Section36	324	106	104.59	125
Section38	324	105	128.09	153
Section41	272	89	20.75	25
Section55	257	84	75.91	91
Section60	256	83	26.28	31
Section155	180	59	17.86	21
Section156	179	58	9.22	11

Table 3: High Loss Section with Rabbit Conductor

Section	Amps	Loading	KW loss	Kvar loss
Section210	124	61	8.31	3
Section211	123	61	16.06	6
Section221	102	51	8.44	3
Section226	91	45	13.86	5

3.3 RESULTS AFTER RECOMMENDATIONS:

Table 4 shows results after replacing conductors in high loss sections.

Table 4: Results

Parameter	Value
Demand -KVA	7417
Demand - %pf	90
Demand - Amps	389
Conn - KVA	16235
Load Factor	60
Demand KW	6682
Max Load (Amp)	389
KW Loss - %	11.05
KW Loss - Line	767.9
KW Loss - Trans	67.4
% Max- Volt drop	15.2

3.4 View from Google earth

Integrated map can be digitized, integrated and uploaded on Google earth as well. It will help to cross check overall work. Figure 9 shows 11kV Barnala feeder on Google earth.

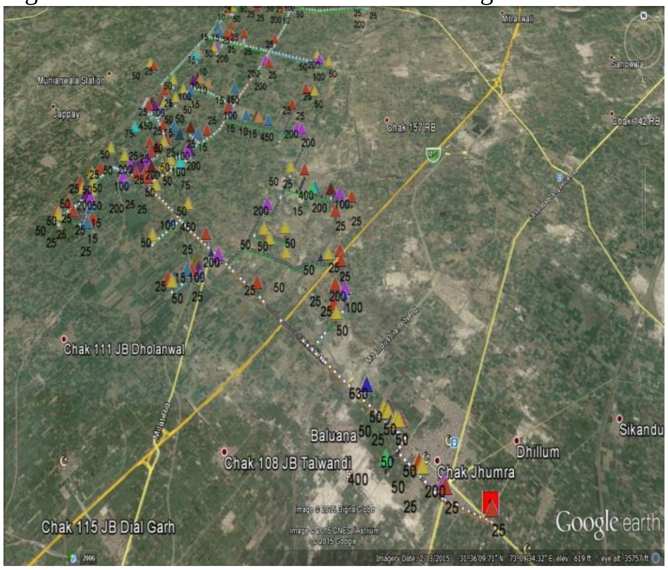

Figure 9: Map on Google earth

4- CONCLUSION

This innovative technique provides an easy access to distribution networks. It becomes so easy to keep record of assets in system. Load shifting and extensions now no longer needs to visit site for couple of time which save not only time but also fuel charges. Lengths are calculated automatically which results in accurate loss calculation. This technique also helps to keep check on staff conducting survey and collecting data of distribution networks. It provides an ease for hilly areas. GIS and GPS in collaboration prove to be a valuable tool to plan, secure and maintenance of distribution system.

5- FUTURE WORK

For improved performance of distribution system this study can further be used for calculation of non-technical losses, for system protection as well as system reliability and forecasting.

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