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# IMPLEMENTABLE APPROACHES OF POWER AND ENERGY DISSIPATION CALCULATION FOR DISTRIBUTION NETWORKS USING GIS SOFTWARE PACKAGE

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**Abstract-** Nowadays evaluation of distribution networks seems to be inevitable because of their geographical extension, inappropriate engineering calculations in current distribution networks design, their oldness, daily development of the networks themselves and their load and client increment. To evaluate these distribution networks for power dissipation reduction purposes, the dissipation itself must be calculated. This paper discusses how the dissipation can be calculated in electrical distribution systems and these calculations allow stockholders and designers to decrease the dissipation quickly and take advantages of the resulted decrement.

**Keywords:** Dissipation Calculation, Dissipation Reduction, Power, Energy, Distribution Network, GIS.

## I. INTRODUCTION

Due to the low voltage level and high current in distribution networks, the largest power loss portion among three power system sections, which are generation, transmission, and distribution, belongs to the distribution section, such that the line losses at the distribution level constitute about 5-13% of the total power generation [1].

Even efficient systems of electrical energy transmission cannot have an efficiency equal to 100% and in practice, there always is some dissipation. Therefore, it is needed to some additional energy be lost by the network resistance in the transmission lines. These dissipation is usually negligible in comparison with the total energy delivered to the consumers, but it costs too much for distribution companies because fuel and equipment needed for transmission and distribution of the electrical energy is extensive and the price will grows increasingly in the future. Then it is needed to decrease the network dissipation [2].

Since so many attempts done in order to dissipation decrement in electrical networks, particularly in recent years, two main questions arise:

a) Are these attempts enough?
b) Are these attempts effective?

Then beside the evaluation of the attempts, it is necessary to analyze their impact and effectiveness to assure whether these are enough. So in order to optimize the distribution networks dissipation, the first and the most important step is to estimate and calculate them which allows to control them and evaluate the causes and factors of their decrement and/or increment. It is obvious that without knowing the amount of dissipation, it is not possible to design and develop any appropriate approach to decrease them [3].

## II. DISSIPATION CALCULATION APPROACHES

Two approaches evaluated in this paper are discussed in the following.

## III. THE FIRST APPROACH

The First approach uses network simulation in dissipation calculation based software packages. Various software packages can calculate this dissipations including Cyme, Digsilent, MATLAB, Neplan, etc., which two first ones are more familiar and also are very applicable in network simulation. These two packages are briefly explained in the following.

### A. Cyme Software Package

One of the best numerical software packages in distribution field is Cyme. Cyme is a computer interface which simulates the distribution lines and their network for appropriate and efficient network design purposes. Using this package some of the network properties can be achieved such as power voltage and current drops and short circuit current in a balanced/unbalanced radial network [4].

### B. Digsilent Software Package

Degsilent is the most familiar software for analysis and evaluation of power systems among power electric engineers. This advanced package is a powerful numerical calculator and an accurate analyzer organized for accurate analysis of electrical networks and control systems to achieve main designation purposes and efficient application of these networks. Degsilent includes all calculation modules in a single configuration so that all the modules, such as load distribution, short circuit, stability, security, optimization, etc., can be accessible and be used beside each other.

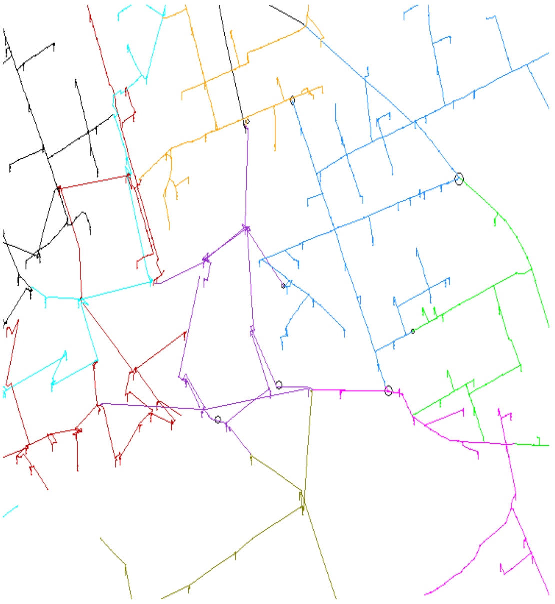
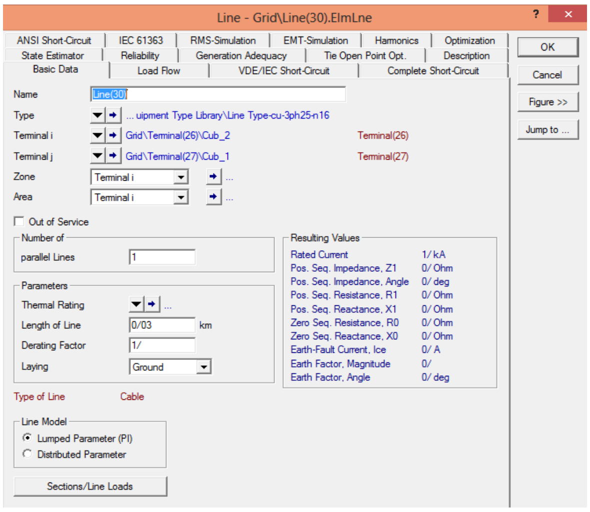


Figure 1. A typical section of mean voltage distribution network of Kerman, Iran based on Digsilent



Line - Grid\Line(30).ElmLne

Name: Line(30)

Type: ... uipment Type Library\Line Type-cu-3ph25-n16

Terminal i: Grid\Terminal(26)\Cub_2 Terminal(26)

Terminal j: Grid\Terminal(27)\Cub_1 Terminal(27)

Zone: Terminal i

Area: Terminal i

☐ Out of Service

Number of parallel Lines: 1

Parameters

Thermal Rating: ...

Length of Line: 0/03 km

Derating Factor: 1/

Laying: Ground

Type of Line: Cable

Line Model

● Lumped Parameter (PI)

○ Distributed Parameter

Resulting Values

| | |
|---|---|
| Rated Current | 1/ kA |
| Pos. Seq. Impedance, Z1 | 0/ Ohm |
| Pos. Seq. Impedance, Angle | 0/ deg |
| Pos. Seq. Resistance, R1 | 0/ Ohm |
| Pos. Seq. Reactance, X1 | 0/ Ohm |
| Zero Seq. Resistance, R0 | 0/ Ohm |
| Zero Seq. Reactance, X0 | 0/ Ohm |
| Earth-Fault Current, Ice | 0/ A |
| Earth Factor, Magnitude | 0/ |
| Earth Factor, Angle | 0/ deg |

Figure 2. A typical section of Digsilent data base

A typical section of mean voltage distribution network of Kerman, Iran based on Digsilent and typical section of Digsilent data base are shown in Figure 1 and Figure 2, respectively.

To simulate a network, first the area network information must be imported to the software. Therefore, a data base is needed to import the network information in the numerical software. The information is saved by GIS software package which requires an interface to convert the data base in a format usable in Degsilent/Cyme package. This interface is developed by programming languages which converts GIS output data to desired numerical software input data.

## C. GIS Software Package

Since effective programming and decision making require achieving accurate and updated data, it is necessary to develop a central data base. GIS can be used as an effective application for data restoring, recovering, and analyzing. GIS systems can manage and analyze high rate information and make predictions reliably, quickly, and non-expensively. GIS can collect, organize, storage, manage, use, and populate conceptual and local information using computer [5].

A typical section of mean voltage distribution network of Kerman, Iran based on GIS and typical section of GIS data base are shown in Figure 3 and Figure 4, respectively.

When its data bases converted to the desired format, network loading must be estimated and imported for each section of the network in the desired software.

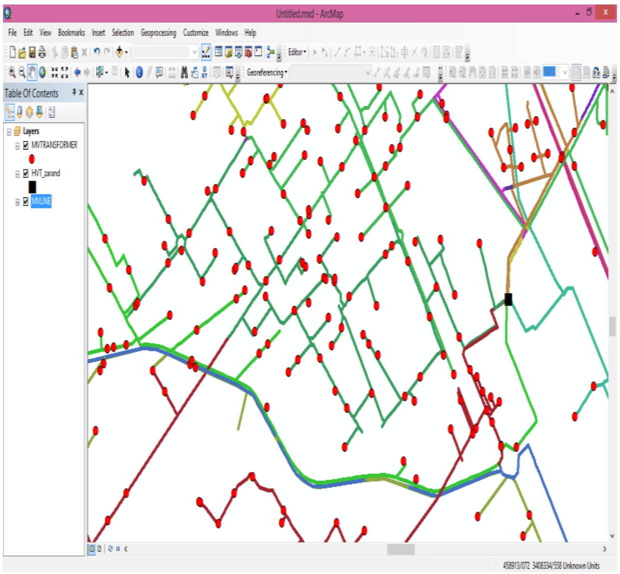
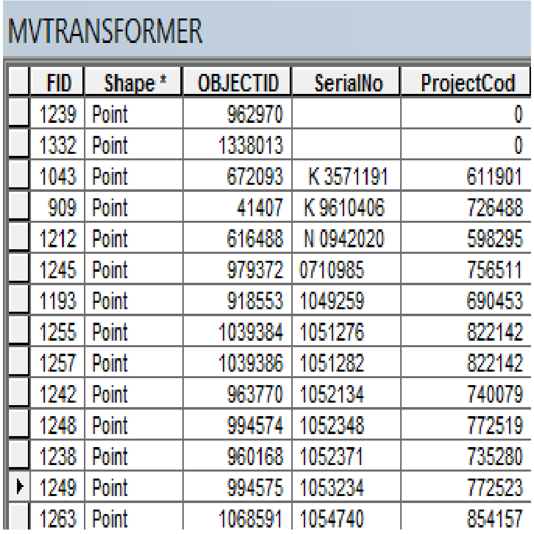


Figure 3. A typical section of mean voltage distribution network of Kerman, Iran based on GIS



MVTRANSFORMER

| FID | Shape * | OBJECTID | SerialNo | ProjectCod |
|---|---|---|---|---|
| 1239 | Point | 962970 | | 0 |
| 1332 | Point | 1338013 | | 0 |
| 1043 | Point | 672093 | K 3571191 | 611901 |
| 909 | Point | 41407 | K 9610406 | 726488 |
| 1212 | Point | 616488 | N 0942020 | 598295 |
| 1245 | Point | 979372 | 0710985 | 756511 |
| 1193 | Point | 918553 | 1049259 | 690453 |
| 1255 | Point | 1039384 | 1051276 | 822142 |
| 1257 | Point | 1039386 | 1051282 | 822142 |
| 1242 | Point | 963770 | 1052134 | 740079 |
| 1248 | Point | 994574 | 1052348 | 772519 |
| 1238 | Point | 960168 | 1052371 | 735280 |
| 1249 | Point | 994575 | 1053234 | 772523 |
| 1263 | Point | 1068591 | 1054740 | 854157 |

Figure 4. A typical section of GIS data base

## D. Load Estimation

Load forecasting is of the most difficult problems in distribution system planning and analysis [6]. There are different approaches to estimate the load in a distribution network. Two fast and applicable approaches are mentioned here.

1. The fastest approach to estimate the load in a distribution network is utilizing distribution transformers so that some of the transformer capacity is considered for the load related to it.
2. Another way to estimate the load is to utilize load balance forms as the input data. Peak loading of distribution transformers are recorded in load balance forms, so these data can be used as input for the desired software.

Since there is always the probability of inaccurate estimation using these two approaches, to correct the error of imported load values, the mean voltage feeder load calculated by the software can be compared with the real peak load of the feeder (achievable in the dispatching department of the distribution company).

Using the algorithm shown in Figure 5, the loading data can be corrected. Then the distribution network and all the information and loading data can be imported into the software so that the loading distribution can be calculated in the software and the dissipation data can also be achieved. Now the local and/or total dissipation of the network can be given by the software.

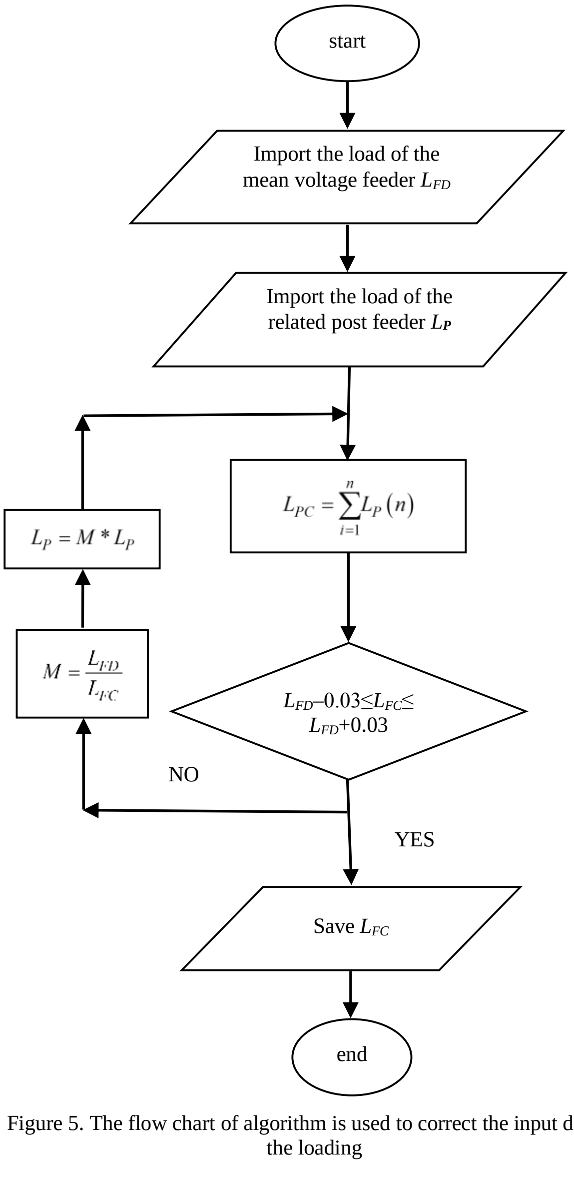


Figure 5. The flow chart of algorithm is used to correct the input data of the loading

### E. Energy Dissipation Calculation

Energy dissipation of an electrical distribution network is the total dissipation of the network in the whole electrical energy delivering process, from the generation to the consumption.

Equation (1) can be used to give the total energy dissipation:

$$E_{LY} = P_{LP} \times 8760 \times L_{SF} \quad (1)$$

where $E_{LY}$, $P_{LP}$, and $L_{SF}$ are total energy dissipation in one year (kWh), peak power dissipation (kW), and dissipation factor, respectively [2].

Dissipation factor is defined by the average dissipation divided by the maximum dissipation. It depends on various parameters, such as loading peak, transmitted energy, and the shape of the loading curve. Therefore its value is essentially a function of the type of consumption. Many different models are presented for dissipation factor calculation which mostly defines it as a function of the loading factor. Considering typical measurements, Equation (2) is proposed to be used to calculate $L_{SF}$.

$$L_{SF} = 0.2 \times L_F + 0.8 \times L_F \quad (2)$$

where, $L_F$ is the loading factor which compares the average loading value with the maximum loading value [2].

## IV. THE SECOND APPROACH

Final goal in distribution network is to use the amount of the energy sold to the consumer, therefore total dissipation can be given by the difference of the total network input energy and total sold energy [7-13]. In this case, in a given area, total energy dissipation of a power electric system can be calculated by the total energy delivered to the network from the distribution post minus the total energy consumed by the consumer in the area so that:

$$\text{Total Energy Dissipation of the Area} = \text{Total Energy Delivered to the Network by The Distribution Post} - \text{Total Energy Consumed by the Consumers in the Area} \quad (3)$$

Since optimal area selection effects on the correction and the simplicity of the delivered and consumed energy calculation, the area can be chosen based on the counter readers working area where the sold energy can be simply calculated by the billing software [2].

Now, yearly delivered energy of each distribution post of the area must be given from the electrical energy market unit to calculate the total delivered energy to the network by the distribution posts of the desired area, and then, after identifying the area feeders (using GIS plans of the network), total feeders energy can be achieved inside the area.

Some of the distribution posts have feeders feeding outside of the specified area, so the energy of these feeders must not be considered in the total delivered energy. There is also some feeders feeding both inside and outside the area, then energy of the outside area must be differenced from the delivered energy. In order to calculate the accurate delivered energy, total capacity of the distributed posts must be considered both inside and outside the area to achieve a factor which can be multiplied in the feeder energy, so the outside feeder energy can be differentiated from the total distribution post energy.

In order to calculate the energy consumed by clients, considering the area based on counter readers, using billing software capabilities, in the first step a list must be develop including all the consumers. Since the energy of each consumer is stored in the billing software and the reading period of different consumers are also different, the energy consumption is normalized in a one-year period, and then the total energy consumed in the area can be calculated using the total consumer's normalized energy.

Now total energy dissipation of the whole area can be calculated using above discussions:

$$E_{LN} = \sum_{i=1}^{n} E_D(i) - \sum_{j=1}^{m} E_C(j) \tag{4}$$

where $n$ is the number of the area feeders, m is the number of consumers, $E_{LN}$ is the area energy dissipation, $E_D$ is the delivered energy to each feeder in the distribution post, and $E_C$ is the consumed energy of each consumer in the area.

## V. CONCLUSIONS

In the typical area, total delivered energy (3889841 MWh) and consumed energy (3376734 MWh) was calculated using second approach firstly, and then total network dissipation (513107 MWh) calculated using Equation (4). Points with highest dissipation values identified using Digsilent software package, then some proposals were presented to decrease the losses. Proposed plans where applied on the network using the software and the dissipation decrement were calculated using each proposed plan. After applying the proposals, total dissipation were calculated by the differentiating the dissipation decrement (calculated in the last step) and the total dissipation using Equation (4). The results are gathered in Table 1.

Table 1. The impact of applying the proposed plans for decreasing dissipation on the total dissipation of the typical area

| Description | Before Applying the Plan | After Applying the Plan |
|---|---|---|
| Total Applying Duration | 12 months | |
| Delivered Energy (MWh) | 3889841 | 3882004 |
| Consumed Energy (MWh) | 3376734 | |
| Energy Dissipation (MWh) | 513107 | 505270 |
| Total Energy Dissipation Decrement (kWh) | | 7836890 |
| Total Power Dissipation Decrement (kW) | | 1164.59 |

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