Design of an Economical and Technical Distribution Automation System

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ABSTRACT

Continuity of energy supply and outage reduction is one of the main goals of the distribution companies. In this regard, automation of distribution networks is one of the most important duties to reduce the amount of outages. Crucial parts of the Medium Voltage (MV) feeders shall be monitored and controlled by Distribution Automation (DA) system. So the main issue in designing this system is positioning and its required facilities in those points. Totally, systems include economic justification will meet uninterrupted work and services. Therefore, in the process of designing an automation system having economic justification while the technical goals should take into consideration too. For this purpose, this paper tries to present accounting method for determining areas of automation based on optimizing cost/benefit function.

INTRODUCTION

Due to the complexity of accounting method, a practical method is introduced for determining the number of selected automation areas and their location. Finally, the necessary equipment is suggested for installation in those points to have an efficient and economic system. The definition of distribution automation in this paper is to control and monitor the middle points of medium voltage feeders.

Distribution Automation types

MV network automation systems based on implemented projects can be divided into two categories.

Substation Automation
When controlling and monitoring points are the breakers of outgoing feeders in a HV substation, it is called as substation automation. In most of implemented automation projects on MV outgoing breakers in many countries, this is called Distribution Automation (DA). In IRAN this type of automation is subdirectory of sub transmission automation department, and regional electric companies are responsible for this. Features of sub station automation are:

- Concentration of SCADA points
- Existence of suitable hard ware in substation.
- Lack of data of middle points of feeder:
  - Electrical parameters
  - Status of line switches
  - Status of protection devices in feeder

Feeder Automation
The middle line equipments, especially switches (LBS, Recloser and Sectionaliser) are monitored and controlled in this type of automation. The number and specification of these equipments depend on the objectives of feeder automation and line parameters such as load, length, sensibility and historical faults. Features of feeder automation are as follows:

- Large number of monitoring and control points and their distribution
- Complexity of communication network design
- Becoming aware of electrical parameter values and protective devices in middle of feeders.

In Iran feeder automation is called distribution automation, so we use term DA hereafter. Because of the most important point of a feeder is the outgoing breaker in HV substation, combination of two type of automation is more useful.

DA system design

The designing of DA fully depends on the expected targets. Thus first, we examine the automation goals.

Purposes of DA implementation
Continuity of energy supply and outage reduction is one of the main goals of the distribution companies. DA is one of the key steps in the distribution companies to reduce the outages. In addition, the other results will be achieved. As like as:

- Feeder Automation
- Load Management
- Loss Minimisation
- Power Quality management

Only economic DA systems can continue operation. So the goals must have additional specifications:

- Accessible
- Measurable
- Having a certain time to achieve

Computational Method

If a feeder is divided to equal sections with equal probability of fault occurrence, and each section can energized by adjacent feeders, then the probability of energizing of one section is shown in figure1.

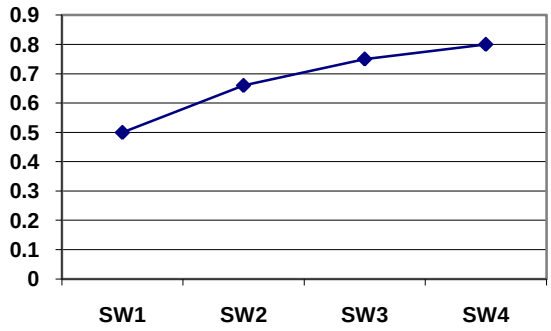

Fig.1 Energizing probability/No. of switches

Optimal design of systems

As mentioned earlier, having a major issue in the implementation of the project is economically justified, therefore, two main points should be considered in the design process:

- Benefits of project
- Implementation costs

So, benefits/costs function is defined. The increase in value of the function shows economically justified.

Benefits/Costs Function

Optimum design of a system for distribution automation, need to optimize the benefit / cost for the system. In order to calculate the economic benefits and costs resulting from the implementation of the automation system must be done.

Economic Benefits of Automation

Determine the economic benefits resulting from the implementation of distribution automation are as follows:

- Identify indicators that will be improved after implementation of automation.
- Calculate the savings resulting from the change in the indexes.
- Calculate the total economic benefits resulting from changes in all indices.

Some of the indicators that the recovery automation projects are:

- Rate of not distributed energy
  - SAIDI
- Average cost of current operations, such as vehicle and personnel costs.
- Damage to network equipment and customers rates
- Number of human events.
- Reduce or delay capital expenditures.
- Improving environmental.

In the next phase of the economic savings resulting from the changes in these parameters should be determined. Some determinants of savings are:

- Rate of energy cost and the selling price
- The rate of pay for emergency department personnel
- Purchase price, freight, and vehicle depreciation
- Vehicle fuel prices
- Average cost of customers losses per not distributed energy
- Overhead and ground network construction costs per kilometer

The improvements in the indexes are not similar and depend on the following parameters:

- Feeder structure (length, cross-section of the conductors, time, life, etc.)
- A history of accidents in any part of the feeder
- The number and location of automated devices
- Capabilities intended for any type of equipment selected for installation.

Algorithm to optimize the benefit / cost

The proposed algorithm for optimizing the operation of the automation of the software calculations described in the following steps is:

- Computer modeling of each feeder and its elements.
- Define and calculation of parameters that must be determined.
- Calculating the amount of benefit / cost.
- Controlling the boundary condition.
- Repetition of the third and fourth to get optimal results.

Practical Method

Due to the complexity of the computational method of determining the optimal locations and automation, in many cases, the data needed for the calculation is missing or properly record is not available, following a systematic method for determining the automation based on specification of feeder, records and certified maneuver operators views is explained.

Feeder automation points determined by dividing the line into pieces with equal load:

- The feeder divided into segments with equal load
- Possibility to isolate each piece of faulty feeder
- The possibility to live no-faulty pieces of feeder

Figure 2 shows this method.

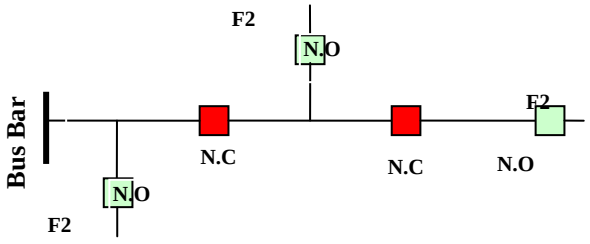

Fig.2 A typical feeder divided into 3 sections

	KOREA	JAPAN	IRAN
Normal Capacity (A)	10MVA (250A)	6MVA	6MVA
Emergency Capacity (B)	14MVA (350A)	8MVA	8MVA
No of sections (K)	2.5 → 3	3	3

A=Normal Capacity of Feeder(MVA)
B=Emergency Capacity of Feeder(MVA)
No of sections (K) = A/ (B-A) =No. of Normally Open switches
N=Normaly Closed switches=K-1
M=No. Of feeders
No. Of required switches=M*((K-1) + K/2)
Thus for a grid with 100 feeder, we need 350 switches.

Automation Intensity Level index

In order to assess the feasibility of developing a distribution network automation system, Automation Intensity Level index (AIL) is defined as follows :
AIL=No. Of switches /No. Of feeders= (K-1) + K/2

Determine the number and location of automation switches

Distribution feeders have different charactristics in term of length and load. So this method must be modified. The following steps are recommended to determine the points of automation:

- Determination of conditions for developing a piece of feeder in term of length and load.
- Determination number of sections in term of last constraints and consequently no of switches.
- Detemination of right places of switches.

Adding a new piece based on the load and length of each feeder

- Adding a section to feeder in term of a MW in city
- Adding a section to feeder in term of b MW in rural
- Adding a section to feeder in term of c Km length in city
- Adding a section to feeder in term of d Km in rural

Determine the number of points for each feeder to automation, based on the number of its divisions:

For doing this, we need SLD of grid including load, consumer, length and geographical conditions. In term of this information and the following notes, the feeder will divided to some sections :

- Important places
- Large consumers
- High fault rate branches

Determination of exact location of automation points
For determining the location of automation switches, some steps must be done:

- Study of geographic maps of each feeder individually
- Offers few options for the automation
- Perform field visited and collected data including geographic coordinates using GPS, network layout and the type of images obtained from the proposed requirements
- Expert meetings attended by experienced operators to select the optimum location

Determination of automation equipment

Given the crucial role for the automation, various equipment may be installed in these areas to be considered

Protection strategy in distribution networks
When a fault accuired in a distribution line, the protection relay of feeder detect it, and will open the breaker in some millisecondes, otherwise the overhand breakers will operate.

Automation system strategy in the event of an error
As explained above, it is divided in to parts:

Short feeders
Due to impossibility of adjustment, in short feeders the relays and breakers will not be used. Thus only switches equipped with fault indicators will be used.

Long feeders
In these types of feeders beside of beginning circuit breaker, some protection devices like reclosers and sectionalizers could be used. The faulty sections will be isolated by protective devices in middle of line.

Maneuver equipments in automation system
In term of strategies explained previously, following devices are suitable for automation :

- Load break switches equipped with fault

indicators and analogue meters.
- Reclosers
- Sectionalizers
- RMU
- Pad mounted LBSes

CONCLUSIONS

Distribution network automation is one of the main methods for reducing the amount of outages that if it is executed well enough, it will have necessary economic definition. The main courses in designing of this kind of systems are shown below:

- Choosing the automation points
- Required equipments for each automation point

In this paper for choosing the automation points, two methods are introduced. These methods are as follows:

- Determining the automation points based on accounting way (optimizing cost/benefit function)
- Practical method: this method regarding the complexity of accounting method could be as shortcut and is shaped based on the experience of expert operators and feeder details.

This paper recommends the Load Breaker Switches (LBS or RMU) that has the ability of ordered remotely and equipped with fault indicator as requirement equipments for automation purposes. When the fault is occurred, whole the feeder is turned to black out status by the breaker is located in beginning of feeders (Substation) then based on received information from the LBS fault indicator, necessary maneuver will executed for separating the faulty section of feeder and make the estimate section alive by network control office (Dispatching).Executing the automation system with above devices (LBS) have necessary technical benefit such as high accuracy in fault locating and acceptable speed in maneuvering. In addition, execution this kind of systems has suitable economic definition.

Regarding long feeders in addition to using LBS, it is highly recommended to use RECLOSERS in one the feeder main path middle points and SECTIONLIZER in the beginning of troubled branches. In this condition there is no outage for whole of the feeder because the faulty branch will be separated automatically by RECLOSER or SECTIONLIZER and then necessary information is sent to control centre.

REFERENCES

[1] E.Javaheri, R.Afshar, A.Saeedi «Distribution Automation System »

[2] Yun, Jung Hyun, « Training Program for Distribution Network, KEPCO Overseas ».

[3] Project : Master Plan For MEEDC AUTOMATION