Optimal Allocation and Number of Automatic Switches in Distribution Networks

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Abstract:

Automatic switches play an important rule in automated distribution networks. The location of this switches is important in improvement of network reliability. Besides the number of automatic switches impressed in investments cost of overhead distribution Networks, This paper presents a new Formulation for automatic switches number and placement into consideration outage, operating and investments Costs. The formulation of automatic switches number and placement is non-linear optimization problem with a number of factors and constraints. For optimization of cost function a Computer program based improved genetic algorithm is used. At the end efficiency of method tested on an actual distribution Network and analysis results.

Keywords: Distribution Networks, Automatic Switches, Genetic Algorithm, Reliability, Optimal Location

1. Introduction

Feeder switch automation can increase the system reliability and reduce customer outage. The degree of improvement in system reliability is sensitive to the number and location of automatic switches. Determining optimum location and number of automatic switches is a complex procedure and involves a number of factors and constraints. Some methods have been developed for placing switches, but they mainly deal with non-automated or low level automated systems [1].

Reference [2] for each switch number, an improved genetic algorithm based on compressed Coding is applied to obtain the optimal allocation of switches**,** Consequently set of quasi- optimal switch allocations is established. In [3] solution methodology based on the optimization technique of simulated annealing, is proposed to determine (i) The number of sectionalizing switches and (ii) the locations of the switches.Reference[4]introduces automatic switches and analyses their operation and efficiency to improvement of system reliability. In [5] an automation system for supplies with high quality is introduced، and this system shows the fault Isolation process.

In mentioned papers، the location of switches is presented with non-automated systems. In this paper ،careful automation systems in feeder level formulation problem and based an improved genetic algorithm determined number and location of automatic switches. Finally، the value of cost function is evaluated in some cases analysis.

2. Feeder Automation

Automation Devices play an important rule in operating of distribution networks. These Devices in addition to reduction of outage can affect in load restoration, reduction of loss, load balancing and maintenance. With Installation a number of automatic switches in feeder additional to cost reduction can be arrived to power quality parameters [6].

In feeder automated when a even fault at the first open circuit breaker in 63KV substation and interrupted the total of feeder loads .then two automatic switch to event fault in between have opened .

Then circuit breaker, other automatic switches and loop switch are closed until some of loads are connected after the switching and maneuver time. Therefore the fault zone is isolated from the circuit very fast. This process is shown in figure1.

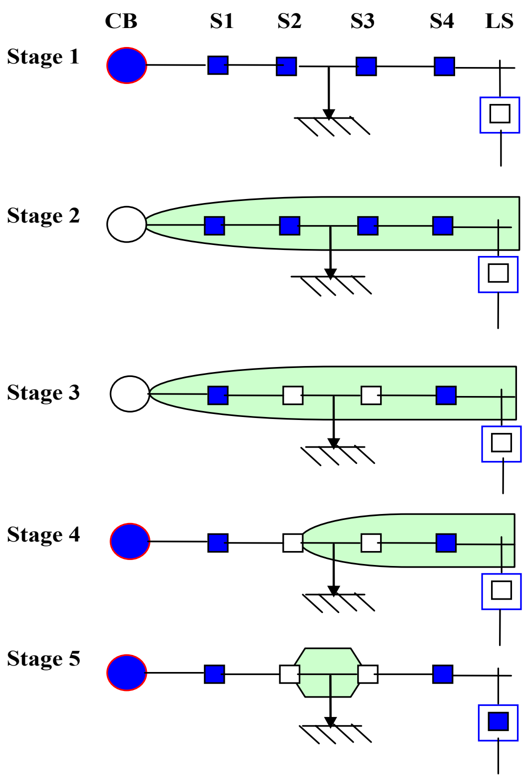

Figure 1.Fault isolation process in automated feeder

3. Formulation of Problem

Number and location of automatic switches is related to factors such as: outage, maintenance, operating and investments costs. Therefore we can formulate the problem as follow:

MinimizeCostF=

$$\sum_{t=1}^{NY}(EF)^t.(TCENS)+\sum_{i=1}^{NS}CAS+\sum_{t=1}^{NY}(EF)^t\cdot(OC)$$

$$EF=\left(\frac{1+BR}{1-IR}\right)$$

Where:

Cost F= Total value of cost Function ($)

TCENS= Total outage cost in Feeder ($)

EF= Economic factor for changes of time study costs to current costs

BR= Annual benefit rate

IR= Annual Inflation rate

NY= Time Study (year)

NS= Number of automatic switches.

CAS= Installation cost. of one automatic switch. ($)

OC= Maintenance and operation costs ($)

4. Total Outage Cost in Feeder (TCENS)

Fault in feeder causes an interruption in total of feeder loads and some of loads are fed after switching and maneuver time and some other loads enter to network after the maintenance time. However, in automated feeders, switching and maneuver time is so short.

In this paper the switching and maneuver time is ignored. Therefore TCENS formulation is:

$$\text{TCENS}=\sum_{i=1}^{NB}\sum_{j=1}^{NLP}\lambda_i.L_i.TM_i.PL_j.(CAT)_j$$

Where:

NB: Number of total feeder sections

NLP: Number of load points connected after the maintenance time

λ_i = Failure rate in section i(per KM)

Li= Length of section i (km)

PLj= Average load at point j (KW)

$(CAT)_j$ = Cost of energy at point j ($/KWH)

$(TM)_i$ =Average time of maintenance in Section i (hour)

5. Optimization Method using Genetic Algorithm

The genetic algorithm is a method for solving optimization problems that is based on “natural selection”. The process that derives biological evolution [7]. Unlike many Conventional optimization methods, which are generally Single path searching algorithms, Genetic algorithm starts searching from several points and “evolves” to ward an optimal solution.

In the beginning, the first population included several individuals is created. These individuals are then evaluated by the target fitness function. Throughout successive generations, the populations are created using three methods:

i) Elite selection
ii) Crossover
iii) Mutation

INITIAL POPULATION:

The primary population is a collection of a specific number of individuals created randomly: the larger the number of individuals, the bigger the probability of finding optimum value.

On the other hand, large number of individuals would result in long and unsuitable response time as well as huge amount of mathematical computations. In our problem, the populations are 1-by-n matrices, in which n represents the location of suggested switching devices.

CREATING THE NEXT GENERATION:

At each stage, the genetic algorithm uses the current population to create the children that makes up the next generation. The algorithm selects a group of individuals in the current population, called parents, who contribute their genes (the entries of their vectors) to their children.

The algorithm selects individuals that have better fitness values of parents.

Totally, three types of children are generated:

a) ***Elite children*** are the individuals with the best fitness values that are directly passed to the next generation.

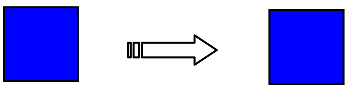

Figure 2. Elite children generation

b) ***Crossover children*** are generated by combining the vectors of a pair of parents.

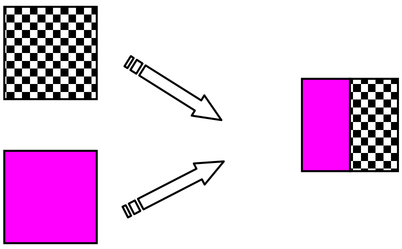

Figure 3. Crossover children generation

c) ***Mutation children*** are generated by exerting random changes (mutation) to an individual.

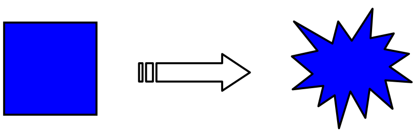

Figure 4. Mutation children generation

6. Case study and Analysis

According to the cost function and algorithm presented in this paper, we calculate the 20KV Farhangsara feeder from 63KV Kamal substation in Neishabour city. (Feeder) single line diagram is show in figure 5.

There are 57 sections, 39 load points. Data base of feeder is presented in table1.

In this case study values of the parameters are:

λ=1.2

TM=2 hour

CAT=for the residential, commercial, agriculture and public load respected to 0.847, 1.16, 1.48, 1.27 ($/KWH)

CAS= 9500$ for one Automatic Switch

OC =1% (CAS) Installation cost

BR=17%

IR=15%

NY=20 years

Optimization process based on improved genetic algorithm is shown in figure 6.

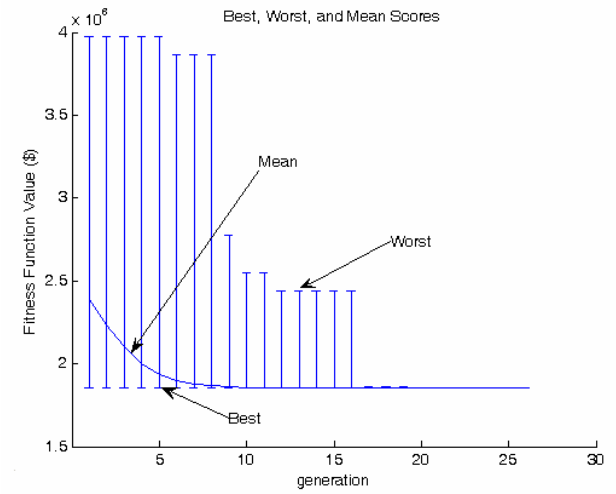

Figure 6.Optimization process

In figure6, cost function value is calculated for different generations in three cases (value of worst, mean and best in each population).

Proposed algorithm, analyzes different number of automatic switches and the results are shown in table 2. For each case, optimal location of switches and value of cost function are presented.

Table 2. Different number of automatic switches

No. of Automatic Switches	Switch Location	Function Value($/year)
2	At the beginning of a section: N/A At the end of a section:**18-36** **(Scheme 1)**	**88111.76**
3	At the beginning of a section: N/A At the end of a section:**10-18-36** **(Scheme 2)**	**85694.12**
4	At the beginning of a section:**10-36-48** At the end of a section:**18** **(Scheme 3)**	**88711.76**
5	At the beginning of a section: **10-36-28** At the end of a section:**18-48** **(Scheme 4)**	**92817.65**

Comparing 4 schemes of automatic switches optimal location and number, the scheme 2 is the best case.

7. Conclusion

The number and placement of automatic switches plays an important rule in automated distribution networks. This problem is non-linear optimization which should satisfy both economic and reliability considerations. This paper determinates automatic switches optimal location and number in feeder based on problem formulation and an improved genetic algorithm.

Results show that the present algorithm is so efficient in feeder automation.

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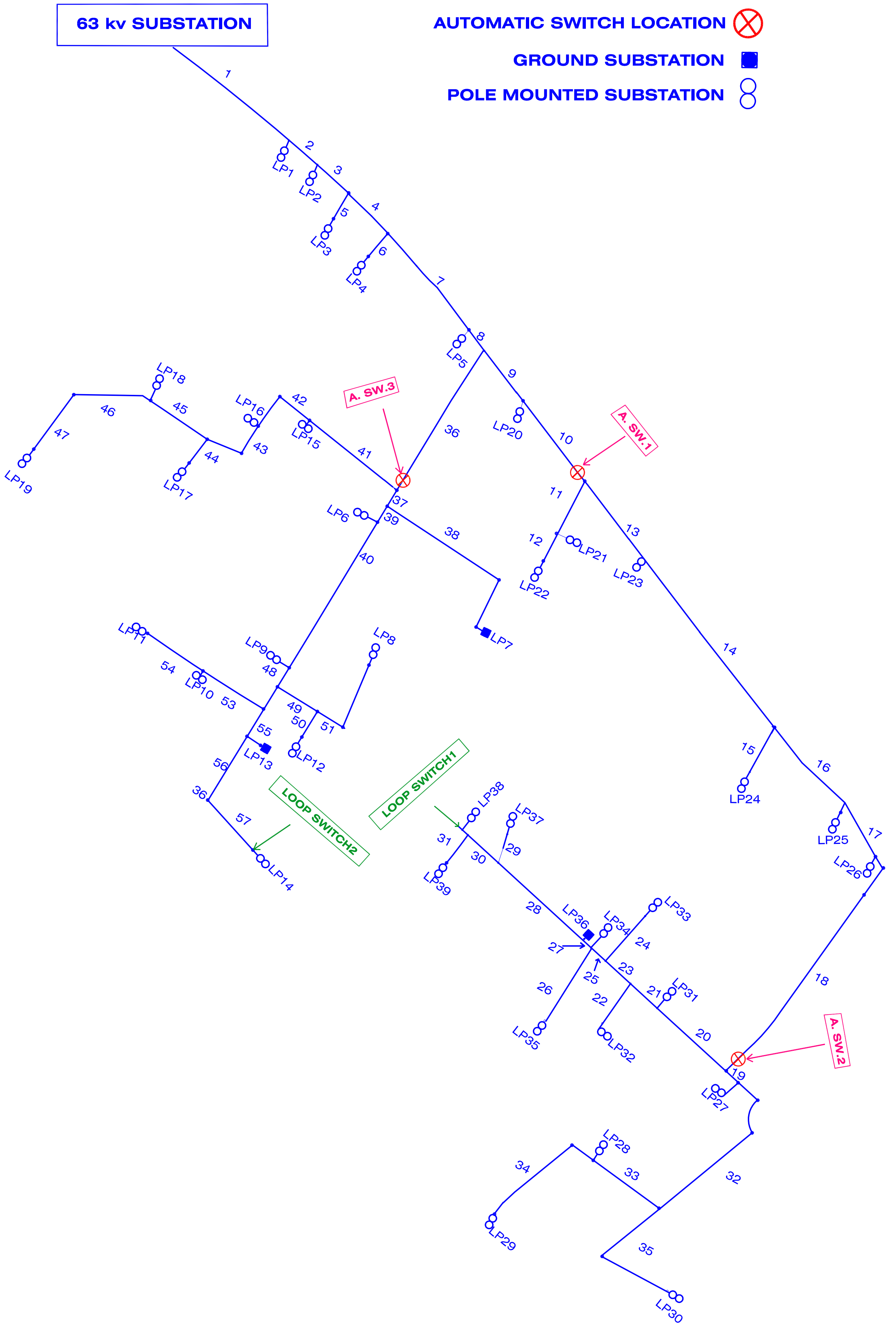

Figure 5.Optimum Location of Automatic Switches on Typical Feeder

Table1.Typical Feeder Data Base

LOAD POINT	Substation Name	Rating (KVA)	LOAD TYPE				Peak load(kw)
			Residential	Commercial	Agricalture	Public	
1	taavoni	50		✓			30
2	edareh rah	100	✓				36
3	ghalee no	100			✓		50
4	andisheh	315	✓				18
5	bari	200	✓				144
6	gahad	400	✓				300
7	deh tark	500	✓				282
8	shoor gashti	315	✓				144
9	mokhaberat	100		✓			40
10	taraghi	200			✓		116
11	koocheh bag	315	✓				180
12	moallem	315	✓				210
13	kiusk	315	✓				240
14	emamreza	400	✓				270
15	koy hosseini	315	✓				228
16	zargarani	50		✓			15
17	gahan abad	200		✓			100
18	baghat	315	✓				180
19	shori	200			✓		116
20	mansoori far	315	✓				144
21	kelid	315	✓				160
22	deh tark	400	✓				240
23	hefdah shahrivar	800				✓	360
24	farhangian	315	✓				144
25	forghani	100	✓				48
26	gaz	50		✓			30
27	takhti	315	✓				144
28	renoos	250	✓				180
29	khatam	400	✓				258
30	arg	250	✓				96
31	pepsi	315	✓				240
32	hekmat	315	✓				162
33	nokhodi	250		✓			100
34	behesht	315	✓				192
35	kusk mokhaberat	315	✓				150
36	bahonar	800	✓				390
37	negarestan	200			✓		63
38	naiieri	315	✓				180
39	amir kabir	400	✓				264