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Customer Scattering Effect on Distribution System Reliability

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Abstract: ***This paper presents the customer scattering effect on distribution system reliability with Distributed Generation. In this, radial system with thirteen load points is considered and analyzed for six patterns of customer variation. The performance is observed with DG and without DG at different points along the feeder and analyzed customer scattering effect for optimum location of DG in terms of system reliability. Analysis determines the optimum DG location for improvement of system reliability varies with the customer scattering patterns.***

Keywords : Distributed Generation, Customer scattering, Distribution system, Reliability.

I. INTRODUCTION

Distribution system is a main part of power systems. According to the reports about 80% of outages are because of the faults in distribution systems. As customer demands for higher reliability and lower expenses, evaluation of distribution system reliability has became the important issue in power system analysis. Analytical method and simulation methods are the methods used for the evaluation of reliability The system reliability indices depends on availability, location, number of DGs at each location.[2] DG can improve the utility's ability and helps to supply load during contingencies.

II. CLASSIFICATION OF RELIABILITY INDICES

A. Load point indices and Customer oriented indices

Load point indices are average failure rate λ_s, average outage time r_s and annual outage time U_s at any load point 's'. [1]

$$\lambda_S=\sum\lambda_i(\text{failures/year}) \quad (1)$$

$$r=U_S/\lambda_S \text{ (hours/interruption)} \quad (2)$$

$$U_S=\sum\lambda_i r_i \text{ (hours/year)} \quad (3)$$

Customer oriented indices are

i) SAIFI - System Average Interruption Frequency Index

$$SAIFI = \sum_S\lambda_S N_S/\sum N_S \text{ (interruptions / year)} \quad (4)$$

ii) SAIDI - System Average Duration Index

$$SAIDI = \sum_S U_S N_S/\sum_S N_S \text{ (hours / customer)} \quad (5)$$

iii) CAIDI - Customer Average Interruption Duration Index

$$CAIDI = \sum_S U_S N_S/\sum_S \lambda_S N_S \text{ (hours / customer interruption)} \quad (6)$$

III. RELIABILITY ASSESSEMENT

Evaluation of the reliability indices with one installed DG at each load point along the feeder line by considering the different patterns of customer scattering is presented in this paper. Restoration time is also considered in this paper, when a fault occurs in any section of the feeder, the main circuit breaker opens and the steps of restoration process are followed. [5]

The restoration time is calculated as

$$RTLP = \begin{cases} FLT+SWT, \text{ if } LPL<FL \\ FLT+SWT+DG\_SUT, \text{ if } LPL^* >FL \\ FLT+SWT+RWT, \text{ otherwise} \end{cases} \quad (7)$$

Where RTLP is load point repair time, FLT is average fault location time, SWT is average switching time, DG_SUT is DG unit start up time, RPT is average repair time, LPL is load point location, LPL* is load point location restored by DG, FL is fault location.

A. Flow chart

A flow chart is presented for reliability evaluation of the system for various customers scattering of normal, skewed to left, skewed to right distribution for location of DG [3] at various sections of the main line.

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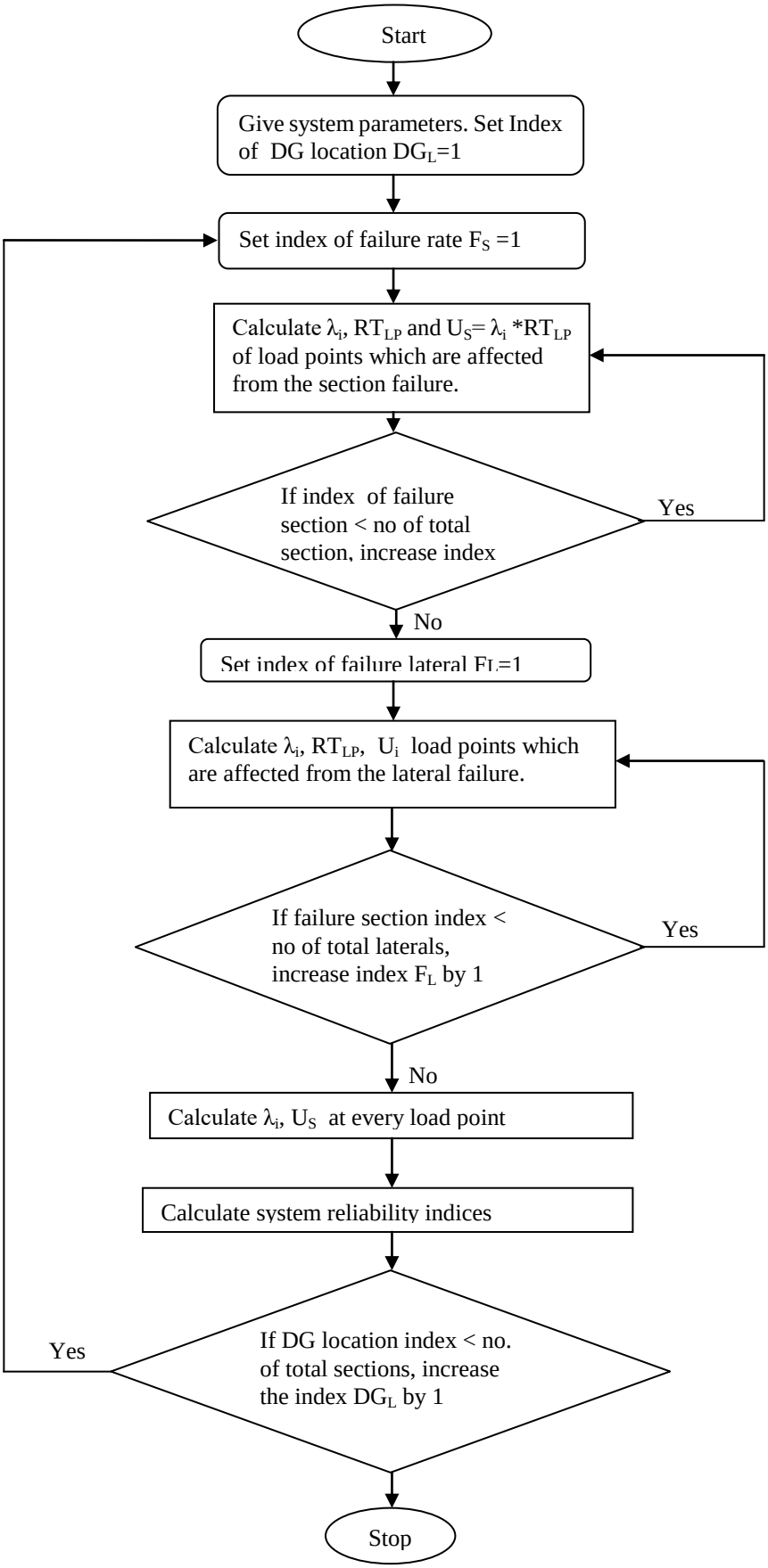
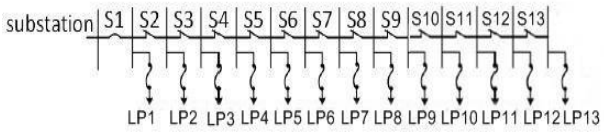

Start
Give system parameters. Set Index of DG location DG_L=1
Set index of failure rate F_S =1
Calculate λ_i, RT_{LP} and U_S= λ_i *RT_{LP} of load points which are affected from the section failure.
If index of failure section < no of total section, increase index
Yes
No
Set index of failure lateral F_L=1
Calculate λ_i, RT_{LP}, U_i load points which are affected from the lateral failure.
If failure section index < no of total laterals, increase index F_L by 1
Yes
No
Calculate λ_i, U_S at every load point
Calculate system reliability indices
If DG location index < no. of total sections, increase the index DG_L by 1
Yes
Stop

Using above process reliability assessment is made for a test system consisting thirteen load points LP1 to LP13 and four different patterns of customer distribution considering the location of the DG at various positions in the thirteen sections. [4]

IV. TEST SYSTEM FOR RELIABILITY ASSESSEMENT

The test system with thirteen load points i.e. one load point for 4 km is shown in the Fig.1.

Fig. 1. Test System used for Reliability Assessment



The feeder length is 52km and length of each lateral distributor is 10 km . The total number of customers in this system is 910 and the total load of the system is 2,600 kW. The load is assumed to be equal for each customer. Further for the analysis of the system the operating conditions of the components and their parameters are assumed as follows. [5]

i) A DG unit capacity is 20% of the feeder load

ii)Operational availability of DG, Circuit breaker, fuses, disconnecting switches is 100%

iii) The failure rate and average repair time of each section are 0.1f/km-yr and 2 hrs respectively.

iv) The failure rate and average repair time of each lateral distributor are 0.2f/km-yr and 4 hours respectively.

v) The average switching time, average fault location time and DG unit start up time are 0.25, 0.5 and 0.0333 hours respectively.

Four patterns of customer distribution are considered and all the cases have the same number of total customers and the average value is 70 as shown in the Table I.

Table-I: Number of Customers in Different Cases

Load points	Case 1	Case 2	Case 3	Case 4
LP1	70	150	20	10
LP2	70	180	35	20
LP3	70	130	55	25
LP4	70	100	80	30
LP5	70	80	90	35
LP6	70	60	110	40
LP7	70	50	130	50
LP8	70	40	110	60
LP9	70	35	90	80
LP10	70	30	80	100
LP11	70	25	55	130
LP12	70	20	35	180
LP13	70	10	20	150
Total	910	910	910	910

V. RESULTS

a. SAIFI is equal for every location of the DG and for every customer distribution.

The value of SAIFI = 7.2 interruptions / customer-year.

b.SAIDI is calculated for different locations of DG shown in Table 2.

Table – II: SAIDI values for four cases

DG Location	Case 1	Case 2	Case 3	Case 4
NO DG	19	16.9077	19	21.0923
Sect. 1	19	16.9077	19	21.0923
Sect. 2	18.8789	16.7521	18.853	20.9626
Sect. 3	18.7579	16.6829	18.7363	20.8070
Sect. 4	18.6369	16.4408	18.5887	20.6730
Sect.5	18.5159	16.2766	18.4813	20.5131
Sect.6	18.3948	16.2593	18.5069	20.3834
Sect.7	18.2738	16.1253	18.3257	20.3488
Sect.8	18.1528	15.8357	18.3343	20.2969
Sect.9	18.0317	15.7319	17.8242	20.0894
Sect.10	17.9107	15.6585	17.6773	19.761
Sect.11	17.7897	15.7147	17.5822	19.9684
Sect.12	17.6687	15.6887	17.6346	19.3806
Sect.13	17.6081	15.6801	17.9842	19.5362

c. CAIDI for four different cases shown in Table III.

Table –III: CAIDI values for four cases

DG Location	Case 1	Case 2	Case 3	Case 4
NO DG	2.6389	2.3483	2.6389	2.9295
Sect. 1	2.6389	2.3483	2.6389	2.9295
Sect. 2	2.6221	2.3267	2.6185	2.9115
Sect. 3	2.6053	2.3171	2.6023	2.8899
Sect. 4	2.5885	2.2834	2.5818	2.8713
Sect.5	2.5717	2.2606	2.5668	2.8490
Sect.6	2.5548	2.2582	2.5704	2.8310
Sect.7	2.5380	2.2396	2.5452	2.8262
Sect.8	2.5212	2.1994	2.5464	2.8190
Sect.9	2.5044	2.1850	2.4756	2.7902
Sect.10	2.4876	2.1748	2.4552	2.7446
Sect.11	2.4708	2.1826	2.4420	2.7734
Sect.12	2.4540	2.1790	2.4493	2.6918
Sect.13	2.4456	2.1778	2.4978	2.7134

VI. CONCLUSION

The customer scattering impact has been evaluated for six different cases of the customer distribution and DG unit placed at nine different locations of test system. The optimal location of the DG unit for a particular customer distribution is calculated using reliability indices in each case and results were analyzed. SAIFI observes as constant among all the patterns of customer scattering, because interruption frequency of the distribution system do not affect restoration time assessment

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