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EFFECTS OF PROTECTION EQUIPMENTS ON RELIABILITY INDICES OF LOAD POINT IN DISTRIBUTION SYSTEM

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ABSTRACT

The reliability of the network is evaluated by neglecting the reliability of generating sources and considering only the ability of the network in supplying the load demands. Distribution reliability is especially important in this competitive climate because the distribution system feeds customers directly. One of ways to improve reliability of distribution system is to make system improvements. Adding protective equipment such as reclosers, sectionalizers, and fuses can affect reliability very positively. In this paper, the various system protection cases is considered and the effects on the reliability indices of load points has been evaluated for a simple distribution system.

1. INTRODUCTION

Distribution systems have received considerably less of the attention devoted to reliability modelling and evaluation than have generating systems. The main causes for this are that generating stations are individually very capital intensive and that generation inadequacy can have wide spread catastrophic consequences for both society and its environment. A distribution system, however, is relatively cheap and outages have a very localized effect.

Therefore less effort has been devoted to quantitative assessment of the adequacy of various alternative designs and reinforcements. On the other hand, analysis of the customer failure statistics of most utilities shows that the distribution system makes the greatest individual contribution to the unavailability of supply to a customer. Several other aspects must also be considered in the need to evaluate the reliability of distribution systems. Firstly, although a given reinforcement scheme may be relatively inexpensive, large sums of money are expended collectively on such systems. Secondly, it is necessary to ensure a reasonable balance in the reliability of the various constituent parts of a power system, i.e. generation, transmission, distribution. Thirdly, a number of alternatives are available to the distribution engineer in order to achieve acceptable customer reliability, including alternative reinforcement schemes, allocation of spares, improvements in maintenance policy, alternative operating policies [1, 2].

In this paper, the reliability indices of each load point in a typical radial distribution network have evaluated and effects of fusegears and breaking switches on the reliability of distribution system have described.

2. DISTRIBUTION SYSTEMS

Many distribution systems are designed and constructed as single radial feeder systems. There are additionally many other systems which although constructed as meshed systems. They are operated as single radial feeder systems by using normally open points in the mesh. The purpose of these normally open points is to reduce the amount of equipment exposed to failure. In the event of a system failure or during scheduled maintenance periods, the normally open point can be closed and another opened in order to minimize the total load that is disconnected. If a more rigorous analysis is desired of parallel systems and systems that are meshed, additional techniques are required. One method that can be used to evaluate the reliability of a continuously operated system is based on the construction of state diagrams. An alternative method to state space diagrams is a method based on a set of appropriate equation for evaluating the failure rate, outage duration and annual outage time or unavailability. Thirdly, it is the network reduction method that creates a sequence of equivalent components obtained by gradually combining series and parallel components [3].

2.1. Reliability evaluation of radial networks

A radial distribution system is a series system. This system consists of a set of lines, cables, sectionalizers, busbars, etc. A load point connected by means of lateral distributor to the main feeder of radial system requires all components between himself and the supply point to be operating. A simple radial system is as shown in Fig.-1.

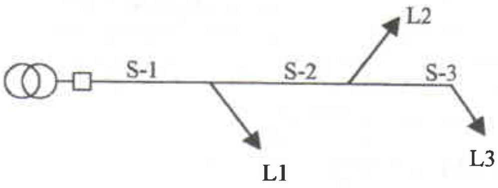

Figure-1. Simple Radial Network

There are three basic reliability parameters. These are average failure rate, average outage time, and average annual outage time.

λ_s , average failure rate
r_s , average outage time or repair time
U_s , average annual outage time

Reliability parameters for series system with n components have given as follow,

$$\lambda_s = \sum_{i}^{n} \lambda_i \quad \text{failure / years} \tag{1}$$

$$U_s = \sum_{i}^{n} \lambda_i r_i \quad \text{hours/years} \tag{2}$$

$$r_s = \frac{U_i}{\lambda_i} = \frac{\sum_{i}^{n} \lambda_i r_i}{\sum_{i}^{n} \lambda_i} \tag{3}$$

It is normally found in practice that lines and cables have a failure rate which is approximately proportional to their length. If all component failures are short circuits then each failure will cause the main breaker to operate. If there are no points at which the system can be isolated then each failure must be repaired before the breaker can be reclosed [3].

3. PROTECTION AND SWITCHING EQUIPMENTS

Additional protection is frequently used in practical distribution systems. For example, a fusegear is installed at the point in each lateral distributor of the system shown in Fig.-1. In this case a short circuit on a lateral distributor causes its appropriate fuse to blow. This causes disconnection of its load point until the failure is repaired but does not affect or cause the disconnection of any other load point. A second or alternative reinforcement or improvement scheme is the provision of sectionalizers or isolators at judicious points along the main feeder. These are generally not fault-breaking switches and therefore any short circuit on a feeder still causes the main breaker to operate. After the fault has been detected, however, the relevant sectionalizer can be opened and the breaker reclosed. This procedure allows restoration of all load points between the supply point of isolation before the repair process has been complete [4].

. If fusegear operates with a probability of P(fuse-up), i.e. the fuses operate successfully n-1 times out of n when required. In this case, the contribution to failure rate of load point can be evaluated using the concept of expectation.

fuse operates= S , fuse fails = F

$$\lambda = (\lambda \mid S) \times P(S) + (\lambda \mid F) \times P(F) \tag{4}$$

Where λ is failure rate. If sectionalizer operates with a probability of P(sectionalizer operates). Then similarly, the contribution to failure rate of load point can be evaluated

sectionalizer operates= S , sectionalizer fails = F

$$\lambda_s = (\lambda_s \mid S) x P(S) + (\lambda_s \mid F) \times P(F) \tag{5}$$

Where λ_s is failure rate for sectionalizer that operate successfully n-1 times out of n when required.

4. SYSTEM STUDIES

Using the equations described in the previous section, reliability indices of load points has been evaluated for radial system given figure-2. Reliability indices of components are given in table-1

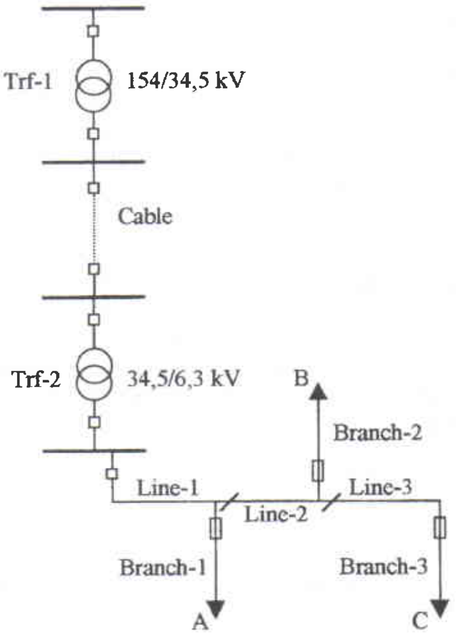

Figure-2 Radial System Improvement with Sectionalizers and Fusegear

Results of six protection cases with each other different are shown in fig-3, fig-4, fig-5.

Table-1 Reliability indices of components for system shown in fig-2

	Length	λ	λ	r
Component	(km)	(f/yr.km)	(f/yr)	(hours)
Trans-1	--	0,1	0,1	6
Trans-2	--	0,1	0,1	6
Cable	3	0,2	0,6	5
Line-a	2	0,1	0,2	3
Line-b	1	0,2	0,2	3
Line-c	3	0,3	0,9	3
Branch-1	3	0,1	0,3	2
Branch-2	1	0,4	0,4	2
Branch-3	2	0,3	0,6	2

In the table-2,3 and 4 are given reliability indices of load point-A,B and C for variables cases.

These tables illustrate the effect of various system protection cases on the reliability indices of load points.

Table-2. Reliability İndices for Load Point-A

Cases	λ (f/yr)	r (hours)	U (hours)
C-1	1.19	2.85	3.39
C-2	0.89	3.13	2.79
C-3	0.89	2.35	2.09
C-4	0.95	2.23	2.12
C-5	0.89	2.51	2.23
C-6	0.95	2.38	2.26

Table-3. Reliability İndices for Load Point-B

Cases	λ (f/yr)	r (hours)	U (hours)
C-1	1.19	2.85	3.39
C-2	0.69	3.46	2.39
C-3	0.69	2.70	1.87
C-4	0.79	2.42	1.92
C-5	0.69	2.86	1.97
C-6	0.79	2.56	2.02

Table-4. Reliability İndices for Load Point-C

Cases	λ (f/yr)	r (hours)	U (hours)
C-1	1.19	2.85	3.39
C-2	0.79	3.28	2.59
C-3	0.79	3.28	2.59
C-4	0.87	3.02	2.63
C-5	0.79	3.28	2.59
C-6	0.87	3.02	2.63

Cases are given as following,

C-1: Reliability indices for the system of Fig. 2 without protection and switching devices.
C-2: Reliability indices for the system of Fig. 2 with fusegear at the tee-point of each branch.
C-3: Reliability indices for the system of Fig. 2 With sectionalizer and fusegear at the tee-point of each branch.
C-4: Reliability indices when the fuses operate with a probability of one given.
C-5: Reliability indices when the sectionalizer operate with a probability of one given.
C-6: Reliability indices when the sectionalizer and fuses operate with a probability of one given.

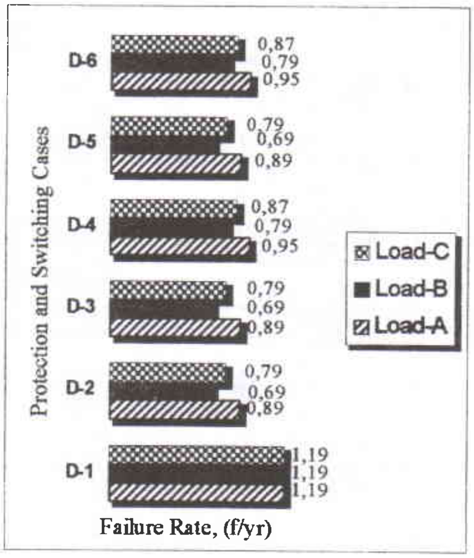

Figure-3. Failure Rate Variation for Different Cases on the Load Point-A,B and C

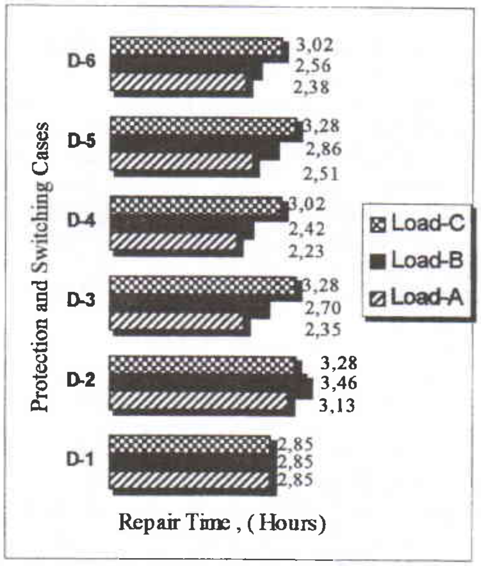

Figure-4. Outage Time Variation for Different Cases on the Load Point-A,B and C

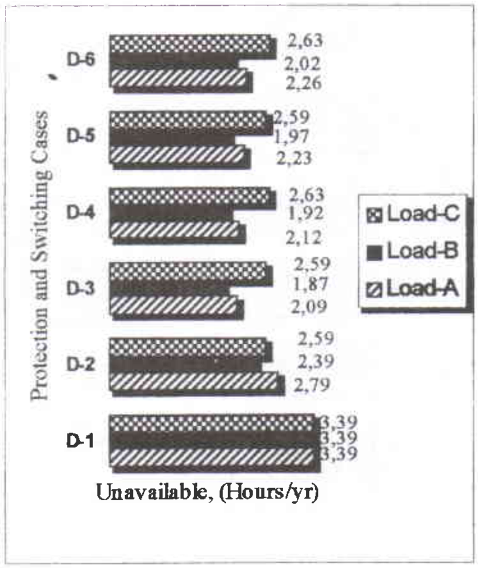

Figure-5. Unavailable Variation for Different Cases on the Load Point-A,B and C

The failure rate at each load-point busbar for different protection cases are shown in Fig. 3. As seen from Fig. 3 the failure rate of a system without protection is always higher than that of a system with protection device. In both cases system that only protected by fuses and protected by fuses and sectionalizer, the failure rate is identical. İn case that fuse operates with a probability of P, the failure rate increases. If sectionalizer operates with a probability of P, it can be seen from fig. 3 that the failure rate does not change.

As seen from Fig. 4 , the outage time of a system that protected by fusegear increases. In both cases system that only protected by fuses and protected by fuses and sectionalizer, the outage time decreases. In case that fuse operates with a probability of P, also the outage time decreases. . If sectionalizer operates with a probability of P, it can be seen from fig. 4 that the outage time is higher than the outage time of a system that protected by fuses and sectionalizer. İn case that fuse and sectionalizer operates with a probability of P, the outage time occured is approximately equal to that of case that fuse operates with a probability of P.

CONCLUSIONS

Failure rate of a system that only protected by fuses is equal to that of a system that protected by fuses and sectionalizer . it can be seen from fig. 3-4 the outage time of a system that only protected by fuses increases and the outage time of a system that protected by fuses and sectionalizer decreases. It is observed that the sectionalizers will decrease the outage time of a system. . In case that fuse operates with a probability of P, as the failure rate increases, the outage time decreases. In case that sectionalizer operates with a probability of P, as the outage time increases, the failure rate does not change.

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