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Distribution System Reliability Analysis using ETAP

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ABSTRACT— *With recent advents in technology, efficient utilization of resources is now a need for secure and reliable electrical power distribution system. For the concern of both customers and power utilities, reliability is a major issue for power distribution system. In this paper, reliability of distribution side is assessed using ETAP software with various scenarios viz. consideration of lateral distributor protection and passive failure rate of components and large impact of distributed generations. The improvement in reliability in various cases has been evaluated on the basis of various reliability indices such as load point indices and system indices. The variation of indices has been followed with various different cases. The usefulness of this work is analysis of reliability, security and efficient operation of electrical distribution system. The analysis is performed on Roy Billinton Test System (RBTS) using Electrical Transient Analyzer Program (ETAP).*

Keywords— reliability, etap, failure rate, distribution, indices, rbts

1, INTRODUCTION

Radial Distribution systems are much simple and less costly. However they are more vulnerable to outages instead of meshed system. During outage normal operating conditions of distribution systems are disturbed and fail to supply loads. Despite the fact that distribution system outages have localized effects, statistics show that distribution system failures affect the system as much as 85% towards the unavailability of supply to a load as compared with failure of other parts of electric power system [1].

Forced or scheduled outages will cause momentary or sustained interruptions and reliability of distribution system worsens. Connections of various protection devices reduce the passive failure of components. Integration of distributed generations (DG) will add extra generation for the normal and captive power supply [2]. The placement of DG and protection devices will affect the reliability of system with respect to DG penetration [3]. Reliability assessment of power distribution networks and customers has been done in conjunction with micro-grid. While using some logical and matrix operations and some different methods it is evaluated in a different way [4-7].

The Paper is structured in five sections. Section 1 Describes about the requirement of this work and historical background of research. Section 2 briefs about the basic concepts of the indices, impact of DG. Section 3 leads to modeling of network in various scenarios. Section

4 comprises the results and their comparison with base case values. Section 5 discusses the conclusion and possible future work.

2, BASIC CONCEPTS FOR RELIABILITY EVALUATION

The basic concepts for reliability evaluation of the distribution side, integrated with distributed generation are classified as follows—

2.1 Reliability Indices

Reliability Indices are the functions of various factors such as failure rate, repair time, switching time, etc. of various components. As factors are random in nature, reliability indices are also random in nature. Three primary indices average failure rate, average outage duration and average annual unavailability or annual outage time are fundamentally important, they do not always give a complete representation of system behavior and response. So customer oriented indices and load-oriented indices such as System Average Interruption Frequency Index (SAIFI), System Average Interruption Duration Index (SAIDI), Customer Average Interruption Frequency Index (CAIFI), Customer Average Interruption Duration Index (CAIDI), Average Service Availability (or Unavailability) Index (ASAI (or ASUI)), Average Energy Not Supplied (AENS) are used to evaluate the complete scenario of reliability of distribution system [1, 8-9].

2.2 Impact of Distributed Generation on Reliability

DGs are defined on different bases depending upon capacity, point of interconnection, etc. But summarizing all points it can be stated as-"DG are the electric power sources, connected to grid at distribution level voltages, serving a customer on-site or providing support to a distribution network" [10,11].

DG affects the power system positively in terms of voltage and reactive power support, losses-reduction, and enhancement of reliability by using complete available assets. While negative impact of DG on power system includes the voltage rise and fluctuation, frequency and voltage instability, etc. [12-14]. While deploying a DG on distribution side need a complete effect analysis for stand-alone and integrated operation. The proper utilization of DG in distribution side can minimize its negative impact by enhancing the positive ones [15]. Utilizing DG resources in proper manner the sustained interruption time can be reduced by using it as an alternate supply. All system and load point indices will be improved. This procedure performs the summary operation. The restoration capability of feeders can be improved using DG [16]. Various different conventional and other type of modeling of DG with distribution system is available [17-18].

3, NETWORK MODELLING AND RELIABILITY EVALUATION

RBTS, developed at University of Saskatchewan, Canada, is a Six-Bus Test System with 5 load buses, 2 generator buses [19-20]. The network modeled here in ETAP is Bus 2 of RBTS. The software tool used in these analyses is ETAP, which is a fully integrated AC and DC electrical power system analysis tool. The reliability analysis using ETAP provide distribution system reliability level for radial and looped systems with a very efficient algorithm [21].

For the purpose of reliability evaluation, impact of lateral distributor protection and passive failure rate and impact of DG on reliability of a complete Bus 2 of RBTS has been done.

3.1 Impact of Passive Failure Rate and Lateral Distributor Protection

Passive failure is defined as a component failure mode that does not cause operation of protection breakers and does not have an impact on the remaining energized system [21]. While lateral distributor protection is required to isolate healthy part if there is any fault on lateral side otherwise it will lead to operation of main circuit breaker of that feeder. In this analysis Bus 2 of RBTS is selected with its own data [14]. Bus 2 is modeled in ETAP with and without lateral circuit breaker on every load point. Figure-1 shows the Bus 2 of RBTS and its ETAP modeling.

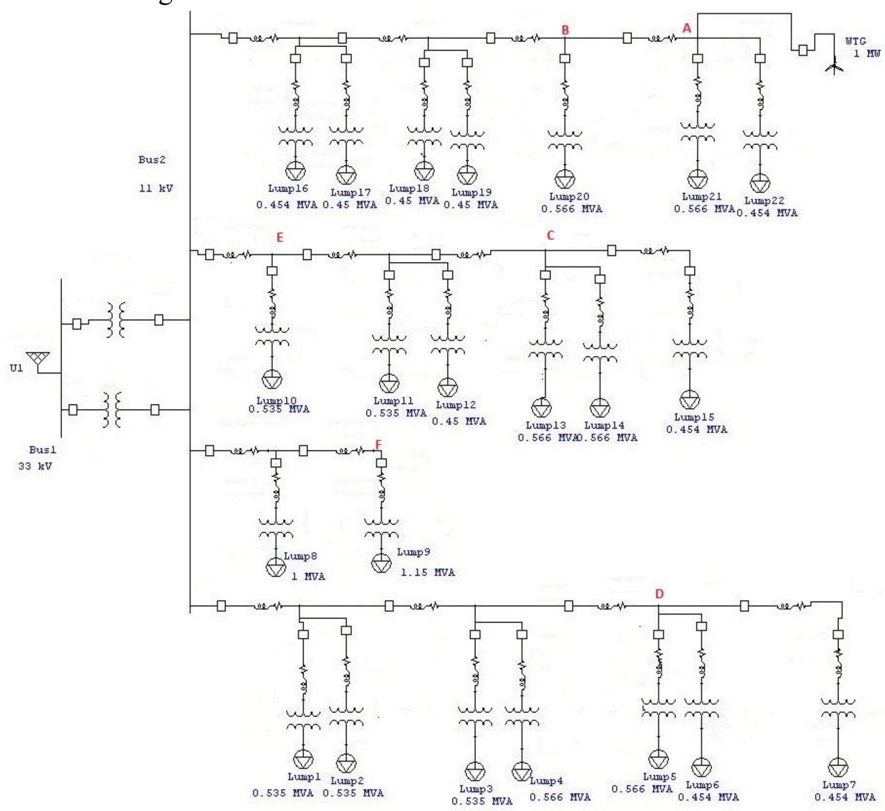

Figure.1 ETAP Modeling of Bus 2 of RBTS

3.2 Impact of DG on Reliability

With consideration of fully reliable generation and transmission units bus 2 of RBTS is modeled in ETAP (shown in figure-1). A wind Turbine Generator (WTG) is used as DG at different locations so that the variation in system reliability indices can be recognized with variation of distances from feeder. All the active and passive failure rates of components are considered here as per RBTS data [14, 15]. The Data for WTG is provided in table-1:

Type of Unit	Failure Rate	Repair Time	Switching Time
1 MW WTG	2 f/yr	80 hr	1 hr

Table.1 Reliability Parameters of WTG used

The WTG is integrated with the system described above at various points, shown in figure-1 and various reliability indices are obtained for all points.

4, RESULTS

The results obtained as shown in table-2, clearly indicates that the indices of system (i.e. Bus 2 of RBTS) with lateral protection and passive failure rate are a bit higher than some values but still it is more useful because this case is more near to real-world problem.

RELIABILITY INDICES	With Passive Failure Rate		Without Passive Failure Rate	
	With Lateral Protection	Without Lateral Protection	With Lateral Protection	Without Lateral Protection
SAIFI	0.4264	1.1435	0.2733	1.0096
SAIDI	3.0128	6.5696	2.4003	4.0916
CAIDI	7.066	5.745	8.784	4.053
ASAI	0.9997	0.9993	0.9997	0.9995
ASUI	0.00034	0.00075	0.00027	0.00047

Table.2 Comparison of Reliability Indices for Bus 2 of RBTS

With integration of DG at different locations the reliability of system improves. But it is dependent on the location at which the WTG is coupled.

Point A is farthest more from 11 bus feeder i.e. 2.9 km, while point E is at minimum distance from 11 KV feeder, i.e. 0.75 km. While the distances of points B, C, D, F from 11kv feeder bus are 2.3, 2.15, 2.25, 1.35 km. respectively. It is clear from the table-3 that indices values are increasing as we come near to the feeder i.e. from point A to point F, as distance from feeder decrease and load supplied is also decreasing. Thus from these six locations, best location is found as point A at which system is most reliable.

RELIABILITY INDICES	Base case (without any DG)	With DG connected					
		At point A	At point B	At Point D	At Point C	At Point F	At Point E
SAIDI	3.0128	2.3511	2.3546	2.4080	2.4640	2.6280	2.5372
SAIFI	0.4264	0.3100	0.3108	0.3227	0.3367	0.3762	0.3534
CAIDI	7.066	7.585	7.577	7.461	7.319	6.985	7.180
ASAI	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997
ASUI	0.00034	0.00027	0.00027	0.00027	0.00028	0.00030	0.00029
AENS	0.0193	0.0151	0.0153	0.0154	0.0157	0.0164	0.0166

Table.3 Comparison of Indices with WTG integration with Bus 2 of RBTS

V. CONCLUSION AND FUTURE WORK

In this paper, RBTS has been modeled in ETAP. From reliability analysis in ETAP, we find that reliability improves after integration of DGs. The indices value depends upon the lateral protection and passive failure rate as shown in table-2. Considering all possibilities in that case the indices with lateral protection and with passive failure rate are found to be more useful in further analysis. Results show that, the DG impact on reliability is most when it is placed farthest from feeder bus (i.e. point A in figure-1). The indices value is minimum at these conditions. While the variation of indices also depends upon the load they are feeding. This can be concluded from values of indices when DG is connected to point D and point F.

Further reliability-worth assessment and optimized utilization of assets can be done. The effect of collaborated use of renewable sources with their power output pattern and the load-pattern of distribution side can be analyzed.

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