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SMART DISTRIBUTION SYSTEM MODELING FOR RELIABILITY IMPROVEMENT OF RING CONFIGURATION

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Reliability, SAIFI, SAIDI, DPG, ETAP, RERs, NRERs.

ABSTRACT

Efficient electrical power system is the backbone of today’s world. Prosperity of a country is supported on supply of reliable electricity. For this purpose, electric distribution system is optimized to provide reliable electricity to their customers. This paper focuses on a novel approach towards reliability improvement by deploying distributed power generation (DPG) into ring distribution system. Therefore electrical transients and analyses program (ETAP) is used to model, simulate and take out results to authenticate the proposed system.

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1. INTRODUCTION

Optimization of renewable energy resources (RERs) (which is mainly used as distributed generation (DG) or distributed power generation (DPG)) is deploying in smart distribution systems. Electricity generating plants are dependable to generate electricity that fulfills user demand [1]. This generated electricity is send to distribution system via transmission lines which terminates in substation. Substations are considered as the joint between transmission system and distribution system where voltage is step-down to required level and enters distribution system [2]. [3, 4] discusses the flow of current control in certain directions. Substations are categorized according to voltage profile that is, distribution substation, step-up substation and step-down substation [5]. A glimpse of power system is depicted in figure 1.1.

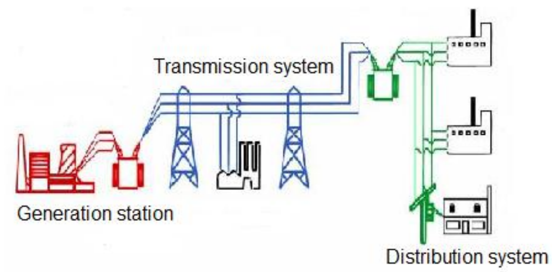

Figure 1.1: Power system.

Power system reliability is main concern for utilities. For reliable power supply to its consumers, various techniques need to be implemented. Reliability assessment of electrical system has a vital role in power system plan [6].

In traditional electrical system the continuity of power to load end is affected by various interruptions. These interruptions may be due to failure rate of electrical components caused by overloading [7], or weather conditions that cause outages [8]. For the system reliability, it is better to improve reliability of distribution system where maximum interruptions occur [9]. In [10] few statistical procedures are discusses for power system reliability improvement.

This research contributes to reliability improvement of ring distribution system. The objectives of this paper are:

- To model ring distribution systems.
- To analyze reliability of modeled system.
- To model DPG unit.
- Integration of DPG into distribution system.
- Analyze reliability of system upon DPG integration.

The arrangement of paper is as follows: section 1 present introduction of electrical system. In section 2 ring distribution system is modeled. The modeled system undergoes reliability assessment in section 3. Section 4 discusses modeling of DPG unit. Section 5 analyzes integration and reliability assessment of distribution system upon DPG integration, respectively. Conclusion is discussed in section 6.

2. DISTRIBUTION SYSTEM MODEL

For the sake of ease and precise calculations electric power systems are modeled through computer programmed softwares.

Test feeder introduced by Roy-Billinton in [11] is choosen for this paper. The basic statistics is given in [12]. Statistics of Bus no.4 is taken from [13] and is modeled in figure 1.2.

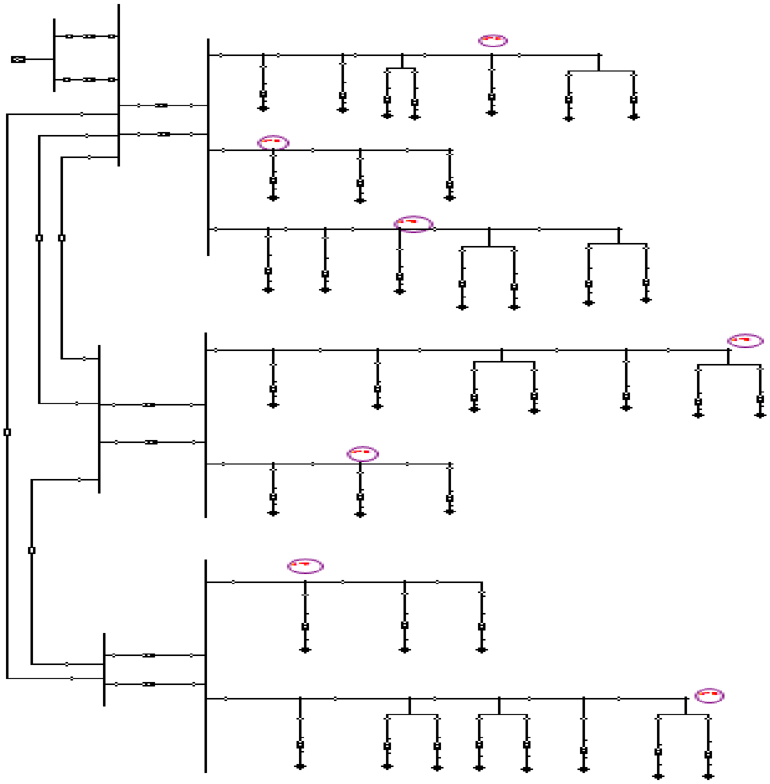

Figure 1.2: Diagram of Bus#04.

The distribution system mentioned above has different types of load, feeders, transformers, protection devices and bus bars. The data for system modeling is of ring distribution system is given in following tables.

2.1 FEEDER SECTION DATA

The data for all feeders of bus# 04 of RBTS is given in table 1.1.

Conductor length (km)	Feeder number
0.60	2, 6, 10, 14, 17, 21, 25, 28, 30, 34, 38, 41, 43, 46, 49, 51, 55, 58, 61, 64, 67.
0.75	1, 4, 7, 9, 12, 16, 19, 22, 24, 27, 29, 32, 35, 37, 40, 42, 45, 48, 50, 53, 56, 60, 63, 65.
0.80	3, 5, 8, 11, 13, 15, 18, 20, 23, 26, 31, 33, 36, 39, 44, 47, 52, 54, 57, 59, 62, 66.

Table 1.1: Feeder section data for Rbts bus#04.

2.2 LOAD POINT DATA

As it is mentioned earlier that system is a combination of different loads connected to different feeders. For this purpose load data of ring distribution network is choosen as test system from rbts. The data for residential load is given in table 1.2.

Load end	Consumer measured in MVA	Total no. of customers
R 01	0.5450	220.00
R 02	0.5450	220.00
R 03	0.5450	220.00
R 04	0.5450	220.00

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R 05	0.5000	200.00
R 11	0.5450	220.00
R 12	0.5450	220.00
R 13	0.5450	220.00
R 14	0.5000	200.00
R 15	0.5000	200.00
R 18	0.5450	220.00
R 19	0.5450	220.00
R 20	0.5450	220.00
R 21	0.5450	220.00
R 23	0.5000	200.00
R 32	0.5450	220.00
R 33	0.5450	220.00
R 34	0.5450	220.00
R 35	0.5450	220.00
R 36	0.5000	200.00
R 37	0.5000	200.00

Table 1.2: Residential load statistics.

Table 1.3 has load statistics for industrial users.

Load end	**Consumer measured in MVA**	**Total no. of customers**
ind 08	01.0000	1.00
ind 09	01.5000	1.00
ind 10	01.0000	1.00
ind 26	01.0000	1.00
ind 27	01.0000	1.00
ind 28	01.0000	1.00
ind 29	01.0000	1.00
ind 30	01.0000	1.00
ind 31	01.5000	1.00

Table 1.3: Load statistics for industrial users

Commercial load statistics is given in table 1.4.

Load end	**Consumer measured in MVA**	**Total no. of customers**
com 06	00.4150	10.00
com 07	00.4150	10.00

com 16	00.4150	10.00
com 17	00.4150	10.00
com 24	00.4150	10.00
com 25	00.4150	10.00
com 38	00.4150	10.00

Table 1.4: Commercial load statistics.

The total consumer loads in MVA and total customers connected are given in table 1.5.

Total Consumer Load in MVA	Total customers connected
24.58	4779

Table 1.5: Total consumer load.

2.3 Component Data

Table 1.6 explains the data for each component used in modeling of ring distribution system.

Name of component		Failure rate per year	Time to re-pair (hrs)	Switch time (hrs)
Transformers	33./11.KV	0.0150	15.00	01.00
	11./0.220 KV	0.0150	10.00	01.00
Circuit Breakers	11kv	0.0060	04.00	01.00
	33kv	0.0020	04.00	01.00
Feeders	11kv	0.6500	05.00	01.00
Bus bars	11kv	0.0010	02.00	01.00
	33kv	0.0010	02.00	01.00

Table 1.6: Statistics of component for ring distribution network.

3 Evaluation Technique

Evaluation of ring distribution system reliability is carried out in ETAP. It has a complete set of electrical power system tool [14].

3.1 Analyzing Reliability of Ring Distribution System

The main features of ETAP are to calculate load point reliability indices and system based reliability indices.
System based reliability indices are:

I. Average rate of failure.
II. Average duration of outage.
III. Outage duration per year.

Load point reliability indexes are:

I. System Average Interruption Frequency Index i-e SAIFI.
II. System Average Interruption Duration Index i-e SAIDI.
III. Customer Average Interruption Duration Index i-e CAIDI.
IV. Average Service Availability Index i-e ASAI.

V. Average Service Unavailability Index i-e ASUI.

A load point index depends upon interruptions that customers experience in a period of time.
The load point indexes are mathematical explained in [15].

The ring distribution system undergoes reliability assessment. In this research, reliability indexes are monitored in order to analyze system before and after integration of a DPG unit.

3.1.1 Reliability analysis of ring distribution system for base case

In this section, base case of distribution system is analyzed for reliability. Bus#04 of Rbts is simulated in ETAP. Figure 1.2 is the system modeled.

System indexes are measured in table 1.7.

System indexes	For base case
System average interruption frequency index (f/Customer* Year)	2.57490
System average interruption duration index (hr/Customer*Year)	11.79930
Customer average interruption duration index (hr/Customer Interruption)	4.5820
Estimated energy not supplied (MW hr/ customer*Year)	244.5580
AENS (MW hr/Customer*Year)	0.05120

Table 1.7: Reliability indexes for base case.

4 Modeling of DPG unit

For the purpose of reliability enhancement different techniques are applied to electrical power system. The best and novel approach is to integrate distributed power generation (DPG) unit in distribution side. [16] Discuss the distributed generation technologies in detail. Table 1.7 shows the reliability indexes for base case however; the impact of DPG injection is compared. Therefore, designing a DPG unit is very important. Wind turbine is considered like a DPG unit and the data is given in table 1.8.

DPG unit in MW	Annual rate of failure	Time to repair in hours	Switching time In hours
03.00	0.020	50.00	01.00

Table 1.8: Statistics of DPG unit.

4.1 DPG unit modeled in ETAP

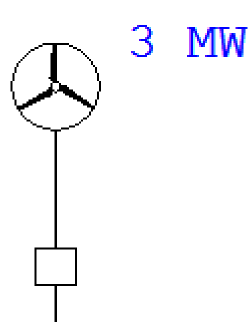

Figure 1.3: DPG unit model.

5 DPG integration in ring distribution network

The modeled system now undergoes a reliability test in the presence of a DPG unit integrated. WTG of 3MW is injected as a DPG unit to ring distribution system at point 4-A, shown in figure 1.4 and figure 1.5 respectively.

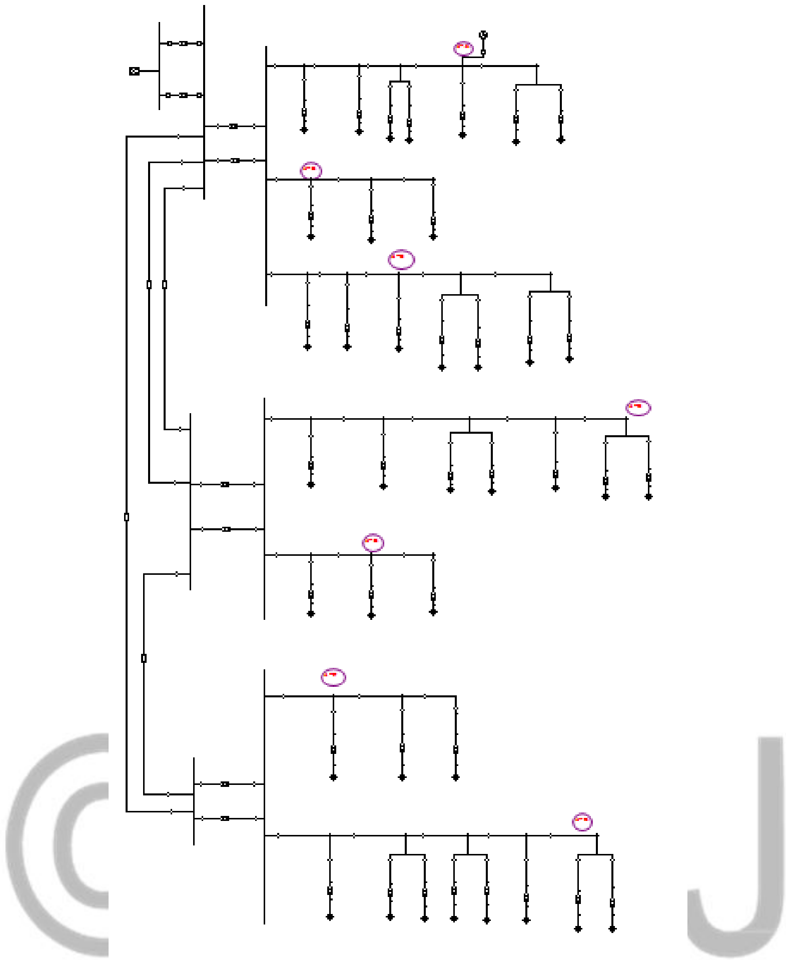

Figure 1.4: DPG unit in ring distribution system.

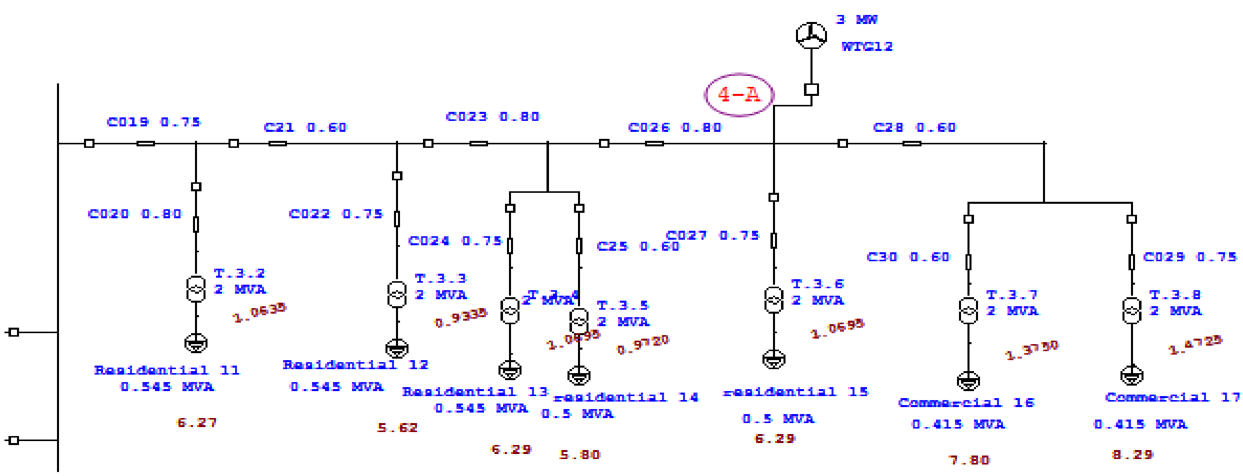

Figure 1.5: Section of ring distribution network at 4-A.

5.1 RELIABILITY ANALYSIS OF RING DISTRIBUTION NETWORK WITH DPG AT 4-A

System indexes	With DPG	Base case
System average interruption frequency index (f/Customer* Year)	1.7421	2.5749
System average interruption duration index (hr/Customer*Year)	9.5945	11.7993
Customer average interruption duration index (hr/Customer Interruption)	5.5070	4.5820
Estimated energy not supplied (MW hr/ customer*Year)	202.9680	244.5580
AENS (MW hr/Customer*Year)	0.0425	0.0512

Table 1.9: Reliability indexes with DPG.

The reliability indexes in Table 1.9 show variation upon DPG unit integration. The values of interruptions are lesser with DPG integration while on other hand the base case show larger interruptions at customer end.

6 Conclusion

From above research, modeling, simulation, analysis and discussion for base case of ring distribution system and DPG unit integration has concluded that reliability is the main focus of power companies. Therefore, introducing DPGs technology to traditional power systems not only enhance the system reliability by lowering the interruptions that end users experience, but also avail renewable energy recourses (RERs) to generate on site energy, conserving depletion of non-renewable energy resources (NRERs).

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