Volume: 5 Issue: XII Month of publication: December 2017

DOI:

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor :6.887
Volume 5 Issue XII December 2017- Available at www.ijraset.com

Reliability Analysis of Sectionalized Busbar with Redundant Star Automation Scheme and its impact on Radial Feeder

E. Vidya Sagar[1], S. Deepti[2], A. Purna Chandar[3], T. Kavitha[4]
[1]*Associate Professor, University College of Engineering, Osmania University, Hyderabad.*
[2]*Associate Professor, Bhoj Reddy Engineering College for Women, Saidabad, Hyderabad.*
[3]*ACE Engineering College, Hyderabad*
[4]*M.E, OU, Hyderabad.*

Abstract: Reliability improvement at the distribution system increases the economic growth of different customers like industrial, commercial, seasonal and agricultural sector. One of the methods to improve the reliability is implementing automation at different levels such as at substation, feeder and customer level of power system network. In this paper, the analysis is carried out to investigate the impact of on redundant star automation scheme on Sectionalized bus bar substation and automated 11 kV radial feeder on the reliability of complete distribution system.
Keywords: Power System reliability, Reliability Indices, Substation Automation Scheme (SAS), Feeder Automation, and Reliability improvement.

I. INTRODUCTION

The distribution system consists of distribution substation, primary feeder and service lines. The substations are classified into various configurations based on the configuration of busbars and one such configuration that is used in this paper is Sectionalized busbar. The substations and feeder can be monitored and controlled either manually or automatically.

When a fault occurred in a non-automated system, switching action takes place manually, whereas in an automated substations the operation and service restoration performed by a distribution system automation scheme and which will have a significant effect on the distribution system reliability. In modern power system networks, the outage of electric power even for a small period of time can affect more on the economic status of customer and utility.

Hence, it is necessary to minimize the average outage duration.

One of the ways to reduce the outage duration is by adopting automation schemes at different levels such as at substation level, feeder level and customer level of power system network. In this paper reliability evaluation is done for the 4 different system configurations. They are A) Percentage availability of redundant star automation configuration B) Sectionalized substation without and with redundant star automation C) Four Radial Feeders of RBTS bus-2 without and with automation D) Complete Distribution system. .

II. TEST SYSTEM AND METHODOLOGY

This section describes the test system and the methodology used for the reliability evaluation of radial feeder, redundant star automation scheme shown in Fig 1 and sectionalized substation shown in Fig. 3 respectively.

A. Redundant Star Automation Scheme:

Substation Automation is mainly used in controlling, protecting and monitoring of substations. Substation Automation system consists of three levels, the station level with operating place HMI and the NCC gateway, Bay level with its units for protection and control, and process level near switchyard.

All these levels are connected by the communication system. The Automation scheme may be either non- redundant and redundant. In this paper, Redundant Star automation scheme is considered because has maximum availability due to the existence of double ESW and parallel controlling path. The availability of the components for three different states i.e. Success, Marginable failure and failure are calculated using the method proposed in [3].

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor :6.887
Volume 5 Issue XII December 2017- Available at www.ijraset.com

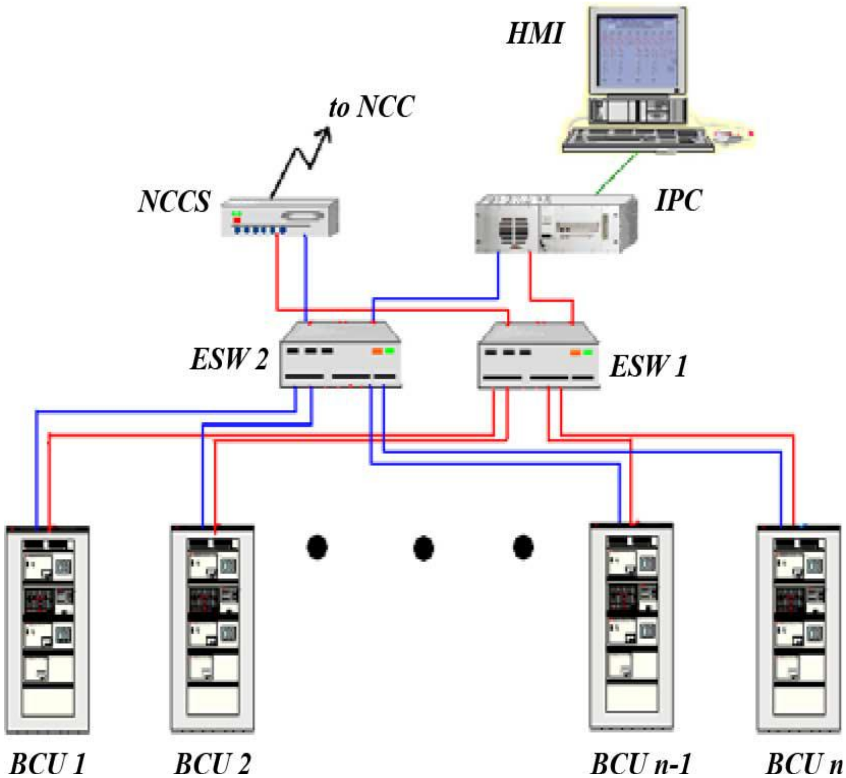


Fig 1: SAS with Redundant Star Architecture

Reliability modelling of the redundant star automation scheme is done in three separate steps [1]].

1) Step 1: The functional model of the SAS is created by building the event tree [5] for automatic switching action.
2) Step 2: The hardware of the SAS is modelled through the RBD approach. The RBD redundant star automation scheme is shown from Fig 2.

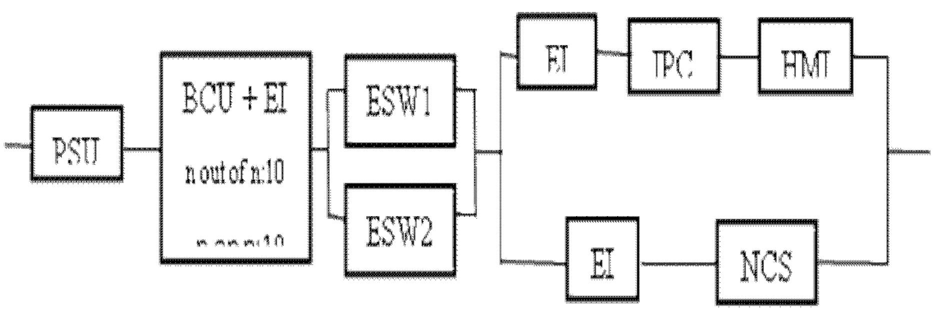


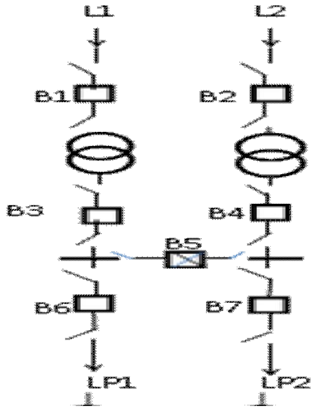
Fig 2: Reliability block diagram of Redundant Star structure

3) Step 3:, The system reliability is calculated by a minimal path sets method The reliabilities of OPT, ESW, PSU, NCCS, SCSS and HMI can be denoted by P_{OPT}, P_{ESW}, P_{PSU}, P_{NCCS}, P_{SCSS} and R_{HMI} respectively.

$$
\begin{aligned}
P_{SCS\ \&\ NCCS} = \; & 2P_{ESW} P^{n+1}_{EI} P_{PSU} P_{IPC} P_{HMI} \\
& +2P_{ESW} P^{n+1}_{EI} P_{PSU} P_{NCSS} \\
& -2P_{ESW} P^{n+2}_{EI} P_{PSU} P_{IPC} P_{NCSS} P_{HMI} \\
& -P^{2}_{ESW} P^{n+1}_{EI} P_{PSU} P_{IPC} P_{HMI} \\
& -P^{2}_{ESW} P^{n+1}_{EI} P_{PSU} P_{NCSS} \\
& +P^{2}_{ESW} P^{n+2}_{EI} P_{PSU} P_{IPC} P_{NCSS} P_{HMI} \quad \ldots\ldots\ldots\ldots\ldots\ldots(1)
\end{aligned}
$$

The reliability of the combined blocks of substation scheme shown from Fig 2 is calculated by using Equation 1.
Using the unavailability data of substation automation components [2], the percentage availability of 3 different states are calculated as Success(S)- 99.74 %, Manageable Failure(MF)- 0.14 % and Failure(F) - 0.1%

B. Case B: Non automated Sectionalized substation.



. Fig 3: Single line diagram of Sectionalized Bus Bar

Reliability assessment of the Sectionalized bus bar is done by cut – set method based on the criteria of continuity of service. The failure modes considered in this paper for sectionalized bus bar are (i) first order total failure (ii) first order active failure (iii) first order active failure with stuck condition of circuit breaker and (iv) second order overlapping failure events. The parallel failure rate of each paralleled group of two components is calculated. The total failure rate is then the sum of the paralleled rates. The overall substation failure rate of load point1 (λ) is the sum of failure rates of all failure modes [1]

C. Radial feeders of RBTS (Bus-2).

In India most of the feeders are radial in nature. So, the test system that is used in the analysis is Roy Billinton Test system (RBTS bus 2). RBTS bus 2 consists of one 33 kV main bus which is connected to the 11 kV supply point. There are 4 main radial feeders at 11kV with 22 load points. While calculating reliability indices it is assumed that the fuses and section switches are are 100% reliable and also assumed that there is an alternative supply link to the feeders. Load point and system performance indices are calculated for Bus -2 using FMEA method. Reliability of the radial feeder can be improved by automating the feeder

Feeder automation scheme consists of control centre (CC), Remote controlled switches, Communication systems (CS) and remote terminal units (RTUs)[8].

III. ANALYSIS AND RESULTS

This section presents the evaluation of reliability indices and analysis of results for the test system under four scenarios.

They are

A.Evaluation of Reliability indices for Sectionalized Busbar

Load point indices are calculated for Sectionalized Busbar shown in Fig 3 for three different cases as follows:

1) Cases 1: Non automated Sectionalized Busbar and the manual switching time is equal to 1 h
2) Cases 2: Non automated Sectionalized Busbar and the manual switching time is equal to 0.5 h
3) Cases 3: The Redundant star automated scheme is used; the automatic switching is equal to 6 min.

The Components reliability data of sectionalized substation, including active failure rate, passive failure rate, mean time to repair (MTTR) and the probability of a stuck condition of a CB are considered from [2]. Load point indices are calculated and the results are shown in Table I.

TABLE I LOAD POINT INDICES OF SECTIONALISED BUSBAR SUBSTATION

Load indices	Case 1	Case 2	Case 3
λ (f/yr)	0.225	0.225	0.225
r(hr)	2.8404	2.4317	2.1052
U(hr/yr)	0.6391	0.5471	0.4736

From the results of Table 1 it is observed that outage time is decreased from case 1 to case 3

*B.*Reliability Evaluation of Feeder:

Using the feeder data, load data and component data from slandered RBTS [2], load point and system performance indices are calculated for 4 feeders. The graph is drawn for the system performance indices SAIDI of 4 feeders with and without automation and is shown in Fig 4.

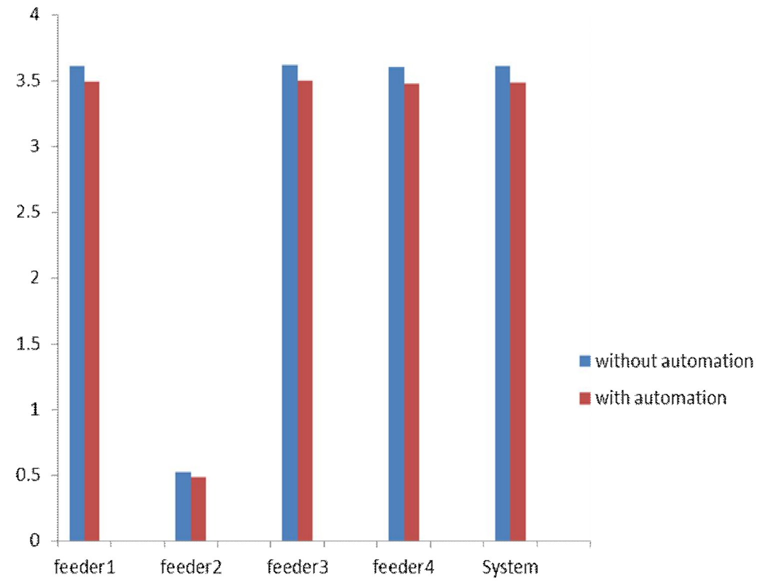


Fig 4: SAIDI of four feeders of RBTS Bus 2 without and with automation

Fig 4 shows that there is the decrease in SAIDI in all the four feeders with automation and increase in reliability
The complete system performance indices of RBTS bus-2 are calculated and the results are shown in Table II.

TABLE III. Complete system indices

System description	SAIFI	SAIDI	CAIDI	ASAI	ENS
Without Automation	0.24821	3.6125	14.5545	0.99958	37.7456
With Automation	0.24821	3.4865	14.0463	0.99960	36.3525

From the results of Table II, it is observed that SAIDI and ENS are decreased by automation which indicates the increase in reliability.

C. Distribution System Analysis

System performance indices are calculated for Feeder 1(F1) of RBTS - BUS 2 with Sectionalized bus bar for three cases shown in Table III and the results are shown in Table IV.

Table III. Case studies for Feeder 1 with Sectionalized Bus

Case	Description of Feeder 1 of RBTS Bus -2	Description of Sectionalized Substation
A	Without automation MST-60 min	Without automation MST – 60 min
B	Without automation MST—30 min	Without automation MST – 30 min
C	With automation AST – 5sec	Redundant star automation AST – 6min

Table IV. Results: System performance indices of Feeder 1 with Sectionalized Bus

System performance indices	Case A	Case B	Case C
SAIFI	0.472993	0.472993	0.472993
SAIDI	4.257467	4.109211	3.966757
CAIDI	9.001119	8.687677	8.386501
ASAI	0.999514	0.999531	0.999547
ENS	15.50158	14.49972	14.43839

Comparing case A to case C of Table IV shows there is a decrease in SAIDI, CAIDI and ENS. This shows that the reliability is improved by automating substation and feeder.

IV. CONCLUSIONS

Load point indices of the sectionalized bar substation for the three case studies are calculated. The percentage availability of different components of automation system are included in the reliability assessment of the automated substations. There is the decrease in the annual down time of 14 % to 28 % from cases 1 to case 3 and increase in reliability,

Reliability indices were calculated for the Feeder 1 of RBTS bus 2 with Sectionalized bus bar substation configuration for three different cases. It is concluded from the results that Substation automation and feeder automation has more effective impact on its reliability performance.

A. Nomenclature

B	:	Circuit Breaker
L1	:	Transmission Line1 (33 kV)
T	:	Transformer (33 kV/11 kV)
AST	:	Automatic switching time
BC	:	Bay Computer
BCU	:	Bay Control Unit
CB	:	Circuit Breaker
DI	:	Digital Input
DO	:	Digital output
EI	:	Ethernet interface
ENS	:	Energy not supplied
LP	:	Load Point
MF	:	Manageable failure
ESW	:	Ethernet Switch
HMI	:	Human- machine interface
IED	:	Intelligent electronic device
MST	:	Manual switching time
OPT	:	Optical connection
PSU	:	Power supply unit
RBD	:	Reduced block diagram
SAS	:	Substation automation system
NCCS	:	Network control center server

REFERENCES

[1] R. Billinton and R. N. Allan, Reliability Evaluation of Power Systems, 2nd ed. New York: Plenum, 1996
[2] R. N. Allan, R. Billinton, I. Sjarrief, L. Geol, and K. S. So, "A Reliability Test System for Educational purposes Purposes-Basic Distribution System Data and Results," IEEE Trans. Power Syst., vol. 6, no. 2, pp. 813–820, May 1991
[3] Hamze Hajian-Hoseinabadi, Meysam Hasanaianfar, and Mohamad Esmail Hamedani Golshan, "Quantitative Reliability Assessment of Various Automated Industrial Substations and their impacts on Distribution Reliability," IEEE Trans. Power Delivery, vol. 27, no. 3, July 2012.

[4] R. Billinton and G. Lian, "Station reliability evaluation using a Monte Carlo approach," IEEE Trans. Power Del., vol. 8, no. 3, pp. 1239–1245, Jul. 1993.
[5] Z. Dong, D. O.Koval, and J. E. Propst, "Reliability of various industrial substations," IEEE Trans. Ind. Appl., vol. 40, no. 4, pp. 989–994, Jul. 2004.
[6] J.C Tournier and T. Werner, "A Quantitative Evaluation of IEC 61850 Process Bus Architectures," presented at the IEEE Power Eng. Soc. Gen. Meeting, Minneapolis, MN, Jul.2010
[7] B. Yunus, A. Musa, H. S. Ong, A. R. Khalid, and H. Hashim, "Reliability and availability study on substation automation system based on IEC 61850," in Proc. IEEE Int. Conf. Power Energy, Dec. 1–3, 2008, pp.148–152.
[8] R. E. Brown, Electric Power Distribution Reliability. New York: Marcel Dekker, 2002