FOREX Publication
Open Access | Rapid and quality publishing

International Journal of
Electrical and Electronics Research (IJEER)
Research Article | Volume 12, Issue 2 | Pages 453-460 | e-ISSN: 2347-470X

Risk Assessment of Radial Distribution Systems using Modified Jelly Fish Search Algorithm to analyse the Performance Indices

K.C. Archana[1*], Y.V. Sivareddy[2] and V. Sankar[3]

[1]Research Scholar, Jawaharlal Nehru Technological University Anantapur, Ananthapuramu; archanatechno@gmail.com
[2]G. Pulla Reddy Engineering College, Kurnool, Affiliated to Jawaharlal Nehru Technological University Anantapur, Ananthapuramu
[3]JNTUA College of Engineering, Ananthapuramu, Constituent college of Jawaharlal Nehru Technological University Anantapur, Ananthapuramu

*Correspondence: K.C. Archana.; archanatechno@gmail.com

ABSTRACT- One of the essential techniques for figuring out Power Distribution System performance is reliability evaluation. With time, the range of methods for assessing reliability has grown, and the distribution system's evolution has also become more intricate. The likelihood of a network failing grows with time once it begins to function, especially if it is used for an extended period. Reliability indices have been evaluated using different algorithms such as Particle Swarm Optimization (PSO), Genetic Algorithm (GA) and various modified versions of algorithms. The Jelly Fish Search Algorithm has been used in various power system applications such as to determine the most cost-effective way to dispatch generating units' loads, integrate Distributed Generation (DG) units, track the maximum power of photovoltaic systems, and determine optimal power flow solutions, among other uses. The performance indices for the Radial Distribution System (RDS) have not been evaluated using JFSA.Variation of performance indices with respect to unavailability has not been discussed in the literature. Here an attempt is made to analyse the variation of the indices with the unavailability. The proposed algorithm is evaluated first on 3 load point radial distribution system and the computations are performed on the popular IEEE-RBTS Bus2 test system. Based on the output it is observed that for the both the systems the behaviour of the indices with respect to the unavailability is in similar fashion. The equations are derived for the performance indices using the Minitab. With the equations obtained the Performance indices values can be predicted for the given unavailability value. It is the better appropriate method for the assessing the performance indices of Radia Distribution System.

Keywords: Reliability assessment, Failure rate, Repair time, JFSA, Performance Indices, Radial Distribution System (RDS).

ARTICLE INFORMATION
Author(s): K.C. Archana, Y.V.Sivareddy and V.Sankar;
Received: 22/02/2024; **Accepted**: 18/04/2024; **Published**: 05/05/2024;
e-ISSN: 2347-470X;
Paper Id: IJEER 2202-23;
Citation: 10.37391/IJEER.120217
Webpage-link:
https://ijeer.forexjournal.co.in/archive/volume-12/ijeer-120217.html

Publisher's Note: FOREX Publication stays neutral with regard to Jurisdictional claims in Published maps and institutional affiliations.

1. INTRODUCTION

Power distribution is the major bridge between the end used and power grid. Reliability analysis is the fundamental method to assess the stability of the power distribution system reliability. Two main types of indices are often used to assess the quality of service in power distribution networks. The first one includes load centre indices such as failure rate, repair time and the unavailability (U). These indices are determined independently for every load centre. The System Average Interruption Frequency Index (SAIFI), System Average Interruption Duration Index (SAIDI), and Customer Average Interruption Duration Index (CAIDI), Average Service Availability Index (ASAI), Average Service Unavailability Index (ASUI) are examples of the system dependability indices that fall within the second category. These indices will provide the information about average system performance.

In literature many methods have been discussed to evaluate the distribution reliability indices. Most papers discussed the evaluation of performance indices both with analytical and simulation methods. The analytical methods such as Markov model, state space, contingency enumeration methods, minimal cut set methods have already been discussed in papers [6,3]. Monto Claro Simulation (MCS) method for complex networks is used to evaluate the reliability indices by enhancing the number of samples is discussed in papers [1,2,9]. The MCS approach is the most precise way to assess the probability functions of all reliability indices. Sequential Monto claro and non-sequential Monto Carlo simulation methods are discussed in the paper [8] to evaluate the performance indices. The degree of reliability of supply of a Medium-Voltage (MV) distribution network is analysed by calculating the system indices in paper [5]. A simple Particle Swarm Optimization (PSO) technique is used for calibration of reliability indices for a distribution system [12]. Failure rate probability prediction is done with help of machine learning algorithm XG boost along with the PSO technique in paper [13]. Stochastic Multi-Valued (SMV) models has been proposed for evaluating the reliability of a multi-state system with dependent multi-state components

(MSCs) is in papers [4,5]. Quantum mechanized Particle Swarm Optimization (QPSO) and enhanced Genetic Algorithm (GA) has been discussed in paper [16] to reduce dependability metrics and cost. The reliability of electric power distribution system is improved by applying the Ant Colony Optimization (ACO) and Simulated Annealing (SA) techniques [10]. PSO approach has been used to improve the load curtailment management in medium voltage distribution systems [7]. A new method has been proposed by using PSO and Deep Belief Network (DBN) for the analysis of reliability of distribution network [11]. Recent advances algorithm is JFSA as discussed in [14] is implemented to for many real time applications. JFSA has been used for MPP Tracking of PV System [15].

Several attempts have been made to reduce the amount of computation time required to assess reliability indices while dealing with large-scale power distribution systems. The literature show Reliability indices are calculated using different papulation-based optimization methods like GA, PSO, PSO-DBN, PSO-XGBOOST and many more other methods. Here an attempt is made to evaluate the Performance Indices using newly proposed bio inspired optimization technique called Jelly Fish Search Algorithm. This proposed approach utilizes the modified Jellyfish search algorithm to model the failure rate, repair time for a particular load point of the RDS. The performance of the proposed algorithm is analysed by illustrated with a basic 3 load point Radial Distribution System (RDS) and a case study is analysed for IEEE 22 load point RBTS Bus 2 system. The test data for these systems is taken from the references [17,18,19,20]. The ability of JFSA to select a suitable fitness function and track failure states in a predefined, controlled, and intelligent manner explains why the developed techniques exceed other traditional approaches. The suggested method calculates the performance indices for a given RDS. The behaviour of performance indices with the variation of unavailability is expressed in the form of equation using Minitab software.

The paper is organized as follows: In *section 2*, Modified Jelly Search Algorithm is explained. In *section 3*, methodology and work flow to calculate performance indices is presented. The methodology is applied to sample 3 load point Radial Distribution System in *section 4*. Case study analysis is done on IEEE 22 Load point RBTS system in Section Result analysis is done in *section 6*. Conclusions are provided in *section 7*. Finally, limitations and future Scope is explained in *section 8*.

2. MODIFIED JELLY FISH SEARCH ALGORITHM

Inspired by the behaviour of jellyfish, the Jellyfish Search Optimization (JSO) technique is a meta heuristic algorithm. Two parameters failure rate and repair time are considered here in this Modified JSFA algorithm

Step 1: Define the objective function for reliability mention failure state range the maximum number of samples (N_m), the upper limit search space (U_B), and the lower bound search space. (L_B) for the failure rate.

Step 2: Calculate the time-control value c(t). Search criteria will take two paths among active motion along with passive motion depending on value of c(t)

$$C(t) = \left| \left(1 - \frac{t}{N_m}\right) * ((2 * rand(0,1) - 1) \right| \quad (1)$$

The search criteria are followed by the jellyfish. Jellyfish have a tendency to follow inside the swarm when its value is less than predefined value C(t). C(t)is considered to have a predefined value

Step 4: Jellyfish moves inside the swarm if C(t) is greater than this number. If its number is less than C(t), they move within the motion

Step 5: If C(t) greater than predefined value (Lies between 0 and 1). Then following steps.

(i) When rand (0,1) is greater than (1-c(t)), and a new location is discovered, the jellyfish adopts Type A motion.

$$X_j(t+1) = X_j(t) + rand(0,1) * 0.01 * (U_B - L_B) \quad (2)$$

(ii) When rand (0,1) is below the (1-c(t)), the search criteria follow the Type B motion, and a new position is discovered by

$$X_j(t+1) = X_j(t) + \overrightarrow{Step}1 \quad (3)$$

$$\overrightarrow{Step1} = rand(0,1) * 0.1 * X_j(t) - Xi(t) \ if \ f(x_i) \geq f(x_j) \quad (4)$$

Step 6: Then follows the following steps.

$$X_j(t+1) = X_j(t) + rand(0,1) * 0.1 * \overrightarrow{trend} \quad (5)$$

$$\overrightarrow{trend} = X_{best} - \beta \times rand(0,1) * 0.1 \times \mu \quad (6)$$

Step 8: The reliability of the system for the failure rate value should be within the limits (0,1) the search criteria should be repeated. Or if the maximum number of samples are completed the algorithm stops.

Step9: With this reliability and failure rate(λ) the repair time (r)is calculated using the *formula 3*.

Step10.For the given value of the failure rate, repair time and unavailability the reliability indices such as SAIFI, SAIDI, CAIDI, ASAI, ASUI are calculated with the formulae A.5, A.6, A.7 and A.8.

Based on the steps explained below flow chart for evaluation of performance indices is explained below *figure.1*

3. METHEDOLOGY AND WORK FLOW

Main objective of this paper is to analyse the variation of the performance indices [20] with respect to unavailability using Modified Jelly Fish Search Algorithm. The basic indices failure rate (λ) and Repair time (r) has been calculated at each load

FOREX Publication
Open Access | Rapid and quality publishing
International Journal of
Electrical and Electronics Research (IJEER)
Research Article | Volume 12, Issue 2 | Pages 453-460 | e-ISSN: 2347-470X

point and performance indices are calculated for the Radial distribution system. The procedure of the work flow is explained here below.

Step1: Generate a random number

Step2: Convert this random number into an appropriate failure rate. Calculate the Reliability(R) using exponential distribution using the equation A.1[21].

Step3: The Reliability(R) calculated should be within the limits of 0 and 1.

Step4: Use modified search algorithm to get the failure rate value whose reliability nearly equal to 1.

Step5: Random number is considered for further if the reliability lies within the limits otherwise this random number is not considered.

Step6: Repeat the steps 1 to 4 if the random number does not lie within the limits.
Step7: For the failure rate (λ) generated calculate the repair time(r) using the formula A.4.

Step8: Unavailability(U) is given by the product of failure rate(λ) and repair time(r). Calculate Unavailability(U) using the formula A.5

Step9: Calculate the Reliability indices SAIFI, SAIDI, CAIDI, ASAI, ASUI [19] for a given RDS using the formulae A.6, A.7, A.8, A.9, A.10

Step10: Repeat the steps 1 to 9 for the different range of failure rate (λ).

Step11: The repair time(r) variation should be within the limits rmin to rmax (rmin=0 and rmax is 8760 hours)

Step12: The data obtained from above steps is analysed using Minitab. Graphs has been drawn for reliability indices with variation of unavailability. Equations are derived for the curves obtained using Minitab

Step13: Repeat the above steps for 3 load point radial bus system and IEEE 22 load point RBTS Bus 2 system. Analyse the results of both the systems.

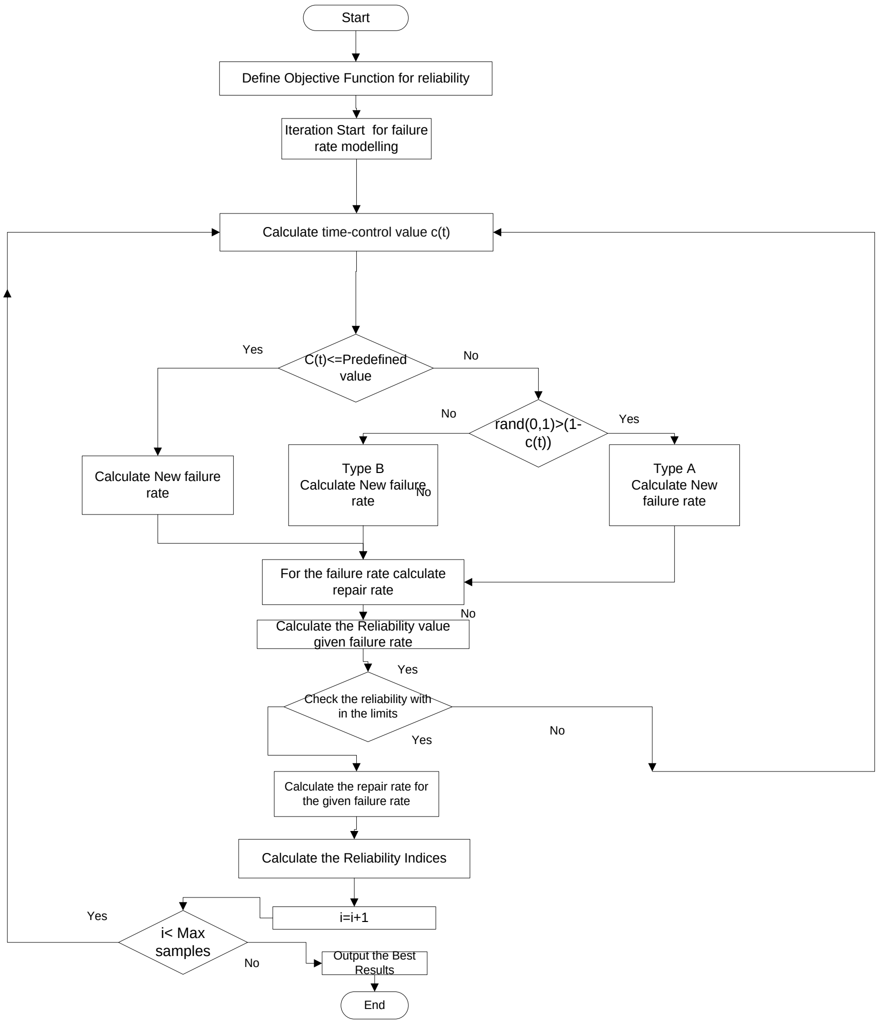

Figure.1 Flow chart for Modified JFSA

FOREX Publication
Open Access | Rapid and quality publishing
International Journal of
Electrical and Electronics Research (IJEER)
Research Article | Volume 12, Issue 2 | Pages 453-460 | e-ISSN: 2347-470X

4. ILLUSTRATION WITH SIMPLE 3 LOAD POINT RADIAL DISTRIBUTION SYSTEM

The proposed algorithm is first analysed for a simple 3 load point radial distribution system [17] as shown in the Fig.B. The failure rate(λ) and repair time(r) for each load point obtained are tabulated in Table 1. The reliability indices are calculated for the different range of failure rate value where the reliability of the system is changing from 0.00001 to 0.9999. Failure rate is evaluated at different ranges and corresponding repair rate is calculated. SAIFI, SAIDI, CAIDI, ASAI, ASUI values are calculated at different unavailability values using MATLAB. These results are tabulated in *table 2*.

The results obtained are analysed Minitab software to get the relation between the reliability indices with the value of unavailability(U). The graphs are shown in *fig. 2,3,4*. The is used to get the relation between the different parameters. Minitab is statistical software tool which can provide the expressions for the given data. It is extensively utilized in several sectors, including as industry, healthcare, and education. Users of Minitab may do statistical analysis using methods such as ANOVA, regression analysis, and hypothesis testing. Furthermore, Minitab offers a range of graphical tools to assist users in visualizing data. Minitab is used to curve fitting equations of SAIFI, CAIDI and ASAI and the *equations 7,8,9* are obtained.

$$\text{SAIFI} = 0.6752 + 0.6947\ln(U) \quad (7)$$

$$\text{CAIDI} = 3.3642 + 0.038U - 1 * 10^{-6} * U^2 \quad (8)$$

$$\text{ASAI} = 0.9983 - 2 * 10^{-5} * U \quad (9)$$

Table 1: Failure rate and repair time for 3 load point RDS

Line	Length (KM)	λ fault/year	r hours
A	0.75	0.12	1.0625
B	0.8	0.128	1.0668
C	0.9	0.144	2.6796

Table 2: Results for 3 load point RDS

λ faults/year/KM	r hours	U hours/year	SAIDI hours/ customer	SAIFI interruptions/ customer	CAIDI hours/customer interruption	ASAI	ASUI
0.16	1.0848	0.17357	0.17079	0.128	1.3343	0.99998	2E-05
0.26	1.142	0.29692	0.26357	0.208	1.2672	0.99997	3E-05
0.36	1.2037	0.43333	0.36413	0.288	1.2643	0.99996	4E-05
0.46	1.2697	0.58406	0.47313	0.368	1.2857	0.99995	5E-05
0.56	1.3405	0.75068	0.59127	0.448	1.3198	0.99993	7E-05
0.66	1.4164	0.93482	0.71933	0.528	1.3624	0.99992	8E-05
0.76	1.4977	1.13825	0.85815	0.608	1.4114	0.9999	1E-04
0.86	1.5851	1.36319	1.0086	0.688	1.4660	0.99988	0.00012
0.96	1.6789	1.61174	1.1718	0.768	1.5258	0.99987	0.00013
1.6	2.4706	3.95296	2.5954	1.28	2.0276	0.9997	0.0003
2.6	4.7937	12.4636	6.9901	2.08	3.3606	0.9992	0.0008
3.6	9.8884	35.5982	16.9122	2.88	5.8723	0.99807	0.00193
4.6	21.4096	98.4842	39.4037	3.68	10.7075	0.9955	0.0045
5.6	48.1119	269.427	90.5962	4.48	20.2224	0.98966	0.01034
6.6	111.2265	734.095	207.5979	5.28	39.3178	0.9763	0.0237
7.6	262.7889	1997.2	476.1237	6.08	78.3098	0.94565	0.05435
8.6	631.472	5430.66	1094.9763	6.88	159.1535	0.875	0.125
9.1	983.9882	8954.29	1662.686	7.28	228.3909	0.8102	0.1898

International Journal of
Electrical and Electronics Research (IJEER)
Research Article | Volume 12, Issue 2 | Pages 453-460 | e-ISSN: 2347-470X

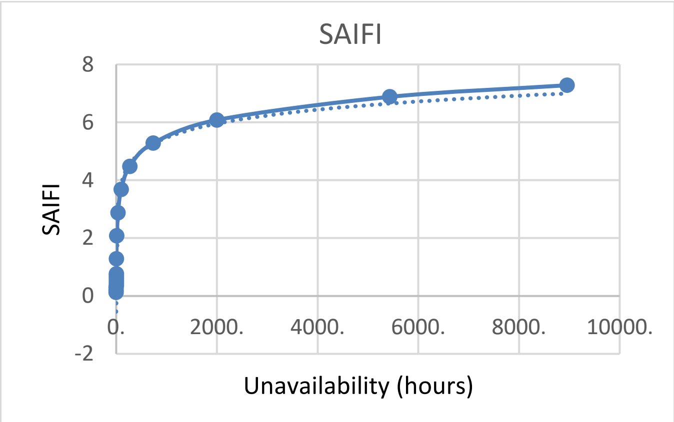

Figure 2. SAIFI vs U for 3 Load point RDS

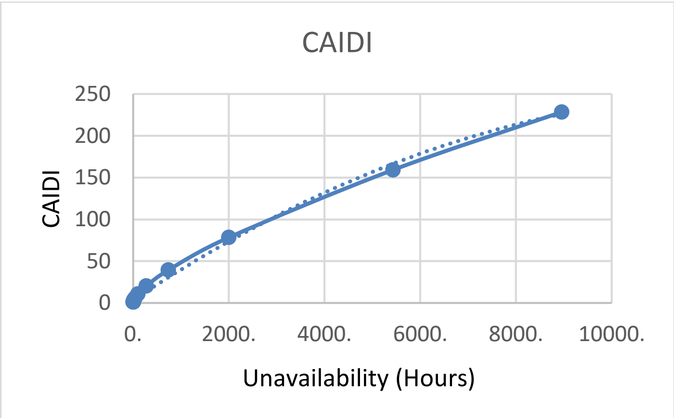

Figure 3. CAIDI vs U for 3 Load point RDS

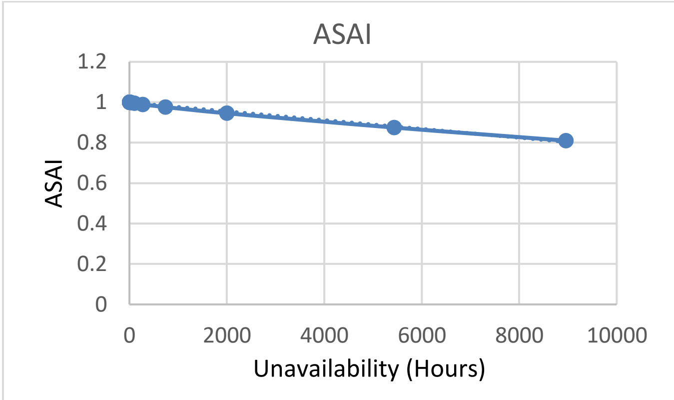

Figure:4 ASAI vs U for 3 Load point RDS

5. CASE STUDY WITH IEEE 22 LOAD POINT RBTS BUS-2 SYSTEM

Basic structure and information of the Bus 2 of RBTS system is given in the reference paper [18]. The failure rate λ calculations for Feeder 1 of the RBTS Bus 2 system is given as shown in the *table 3*.

Sample calculation for failure rate λ in *table 3*.

At Load point 1: Feeder section consists of the line segments: 1, 4,7,10. The lateral section for LP1 is 2 as shown in fig C. The length of the segments is given as 0.75,0.75,0.75,0.6,0.6. Then the total of the section is 0.75+0.75+0.75+0.6+0.6=3.45km. For failure rate λ=0.16.The failure rate at load point 1 LP1 is 3.45*0.16=0.552.Similarly failure rate for at all the load point 1 to 7 has been calculated using same above procedure. For different values of failure rate, the calculation is done for feeder 1 for all load points 1 to 7.

Table 3. Failure rate λ calculations for Feeder 1 of IEEE RBTS Bus 2 system

	LP1	LP2	LP 3	LP 4	LP 5	LP 6	LP 7
No of Customers	210	210	210	1	1	10	10
Sections/Length(km)							
1 (0.75)	0.12	0.12	0.12	0.12	0.12	0.12	0.12
4 (0.75)	0.12	0.12	0.12	0.12	0.12	0.12	0.12
7 (0.75)	0.12	0.12	0.12	0.12	0.12	0.12	0.12
10(0.6)	0.096	0.096	0.096	0.096	0.096	0.1	0.096
distributor							
2(0.6)	0.096						
3(0.8)		0.128					
5(0.8)			0.128				
6(0.6)				0.096			
8(0.8)					0.128		
9(0.75)						0.12	
11(0.8)							0.128
	0.552	0.584	0.584	0.552	0.584	0.576	0.584

Research Article | Volume 12, Issue 2 | Pages 453-460 | e-ISSN: 2347-470X

Reliability Indices SAIFI, SAIDI, CAIDI, ASAI, ASUI are calculated for different range values unavailability. The results are tabulated as shown in *table 4*. The data obtained here is analysed with the Minitab. The equation obtained for the performance indices like SAIFI, CAIDI and ASAI are *equations 10,11,12*. The graphs obtained from Minitab software is as shown in *figure 5,6,7*.

$$SAIFI = 3.0589 + 3.0622\ln(U) \tag{10}$$

$$CAIDI = 4.0148 + 0.1306 * U - 2 * 10^{-6} * U^2 \tag{11}$$

$$ASAI = 1 - 0.004 * U \tag{12}$$

Table 4. Reliability Indices for IEEE RBTS Bus 2 system

λ fault/year/KM	r hours	U hours/year	SAIFI interruptions/ customer	SAIDI hours/ customer	CAIDI hours/customer interruption	ASAI	ASUI
0.16	1.0848	0.173568	0.5735	0.622133	1.0844	0.99993	7.10E-05
0.26	1.142	0.29692	0.93197	1.0643	1.142	0.99988	0.0001215
0.36	1.2037	0.433332	1.2904	1.5533	1.2037	0.99982	0.00017731
0.46	1.2697	0.584062	1.6489	2.0936	1.2697	0.99976	0.000239
0.56	1.3405	0.75068	2.0073	2.6908	1.3405	0.99969	0.00030717
0.66	1.4164	0.934824	2.3658	3.3508	1.4164	0.99962	0.00038251
0.76	1.4977	1.138252	2.7242	4.0802	1.4977	0.99953	0.00046577
0.86	1.5851	1.363186	3.0827	4.8863	1.5851	0.99944	0.00055779
0.96	1.6789	1.611744	3.4411	5.7771	1.6789	0.99934	0.00065949
1.6	2.4706	3.95296	5.7352	14.1697	2.4706	0.99838	0.0016175
2.6	4.7937	12.46362	9.3197	44.6764	4.7937	0.9949	0.0051
3.6	9.8884	35.59824	12.9042	127.6022	9.8884	0.98543	0.014566
4.6	21.4096	98.48416	16.4887	353.0179	21.4096	0.9597	0.040299
5.6	48.1119	269.42664	20.0733	965.7614	48.1119	0.88975	0.11025
6.6	111.227	734.0949	23.6578	2631.371	111.2265	0.69962	0.30038
7.6	262.789	1997.19564	27.2423	7158.967	262.7889	0.18277	0.81723

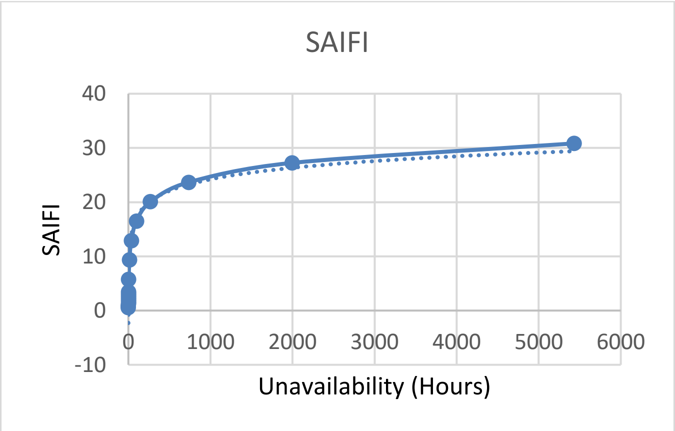

Figure 5. SAIFI Vs U for IEEE RBTS Bus 2 system

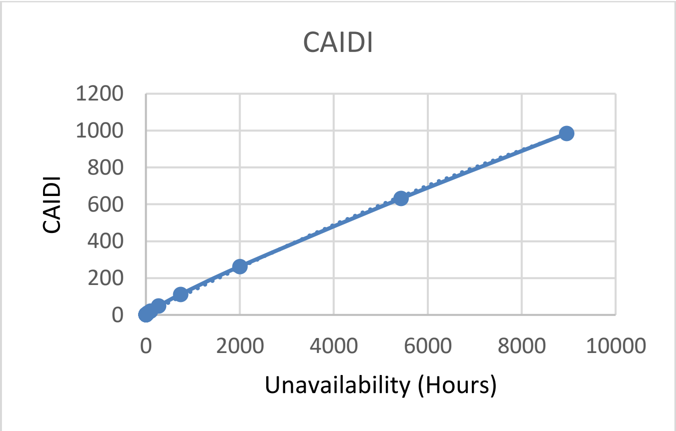

Figure 6. CAIDI Vs U for IEEE RBTS Bus 2 system

FOREX Publication
Open Access | Rapid and quality publishing

International Journal of
Electrical and Electronics Research (IJEER)
Research Article | Volume 12, Issue 2 | Pages 453-460 | e-ISSN: 2347-470X

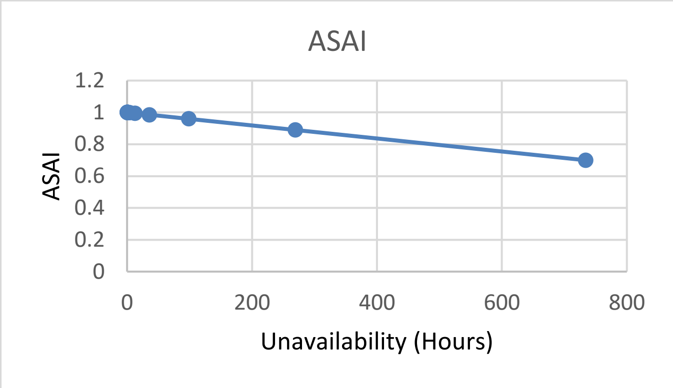

Figure.7. ASAI Vs U for IEEE RBTS Bus 2 system

6. RESULT ANALYSIS

The behaviour of Reliability indices with the variation in the unavailability is analysed using the Minitab software. Nonlinear regression analysis used to fit the data into a particular curve model and then it is expressed as a mathematical function. The reliability indices are expressed as a mathematical equation using Minitab software for 3 load point RDS and 22 load point RBTS Bus2 system.

• SAIFI is the frequency of continuous interruptions experienced by the average customer for the time period of one year is analysed. As the unavailability increases the SAIFI is changing is in natural logarithmic manner. From the equation A.6 SAIFI is directly proportional λ means indirectly SAIFI proportional to Unavailability U. Thats how variation of SAIFI against unavailability is linear initially later it went to some saturation value.

• The CAIDI is the amount of time needed to restore service over a certain amount of time of one year is analysed. The variation of CAIDI with unavailability curve fits into quadratic polynomial equation. CAIDI is proportional to U and indirectly proportional to λ from equation A.8 means CAIDI is directly proportional to U2. That is how equation for CAIDI curve is quadratic in nature.

• ASAI total hours service was available is linearly decreasing manner. The variation of ASAI with unavailability curve fits into linearly decreasing manner. From equation A.9 ASAI is decreases as the unavailability U increases. Form Minitab software also got the equation in linearly decreasing manner.

7. CONCLUSION

In this paper using Modified JFSA, failure rate(λ)value is modelled and equations for reliability indices are derived. With these equations we can predict the values of reliability indices for a given values of failure rate and repair time of any given system. It is advantageous to predict the future behaviour of the system with these values. Minitab is used to formulate the equations for the reliability indices.

8. LIMITATIONS AND FUTURE SCOPE

JFSA converges more quickly and offers superior search capabilities compared to other conventional optimization methods. Sometimes, the algorithm can experience early convergence, get stuck in local optima, or take a long time to converge. It can be overcome by regulating the exploration and exploitation search, maintaining the search's variety, and quickening convergence can all lead to the necessary improvements. Exploration is the process of going to areas inside the search space that have not yet been explored. The act of searching regions of a search space next to places that have already been visited is known as exploitation.

Appendix A: Basic Reliability Equations

$$\text{Reliability (R)} = e^{-\lambda t} \quad \text{(A.1)}$$

$$\text{Mean Time to Failure (MTTF)} = \frac{1}{\lambda} \quad \text{(A.2)}$$

$$\text{Availability} = \frac{\text{MTTF}}{\text{MTTF} + \text{MTTR}} \quad \text{(A.3)}$$

$$\text{Unavailability } U = \lambda * r \quad \text{(A.4)}$$

System Average Interruption Frequency Index (SAIFI)

$$\text{SAIFI} = \frac{\sum \lambda_i * N_i}{\sum N_i} \text{ interruptions/customer}$$

System Average Interruption Duration Index (SAIDI)

$$\text{SAIDI} = \frac{\sum U * N_i}{\sum N_i} \text{hours/customer} \quad \text{(A.6)}$$

Customer Average Interruption Duration Index (CAIDI)

$$\text{CAIDI} = \frac{\sum U * N_i}{\sum \lambda_i N_i} = \frac{\text{SAIDI}}{\text{SAIFI}} \text{ hours/customer interruption} \quad \text{(A.7)}$$

Average Service Availability Index (ASAI)

$$\text{ASAI} = \frac{\text{Customer Hours Service Availability}}{\text{Customer Hours Service demand}}$$

$$= \frac{\sum N_i * 8760 - \sum N_i U_i}{\sum N_i * 8760} \quad \text{(A.8)}$$

Average Service Availability Index (ASAI)

$$\text{ASUI} = 1 - \text{ASAI} \quad \text{(A.9)}$$

Appendix B: 3 Load point Radial Distribution system

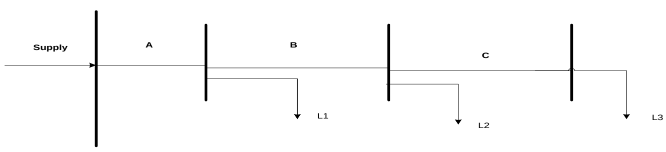

Fig. B: 3 Load point Radial Distribution system

Table B: Load point reliability indices

Line	Length (KM)	λ f/yr	r hrs
A	0.75	0.12	1.0625
B	0.8	0.128	1.0668
C	0.9	0.144	2.6796

Appendix C:

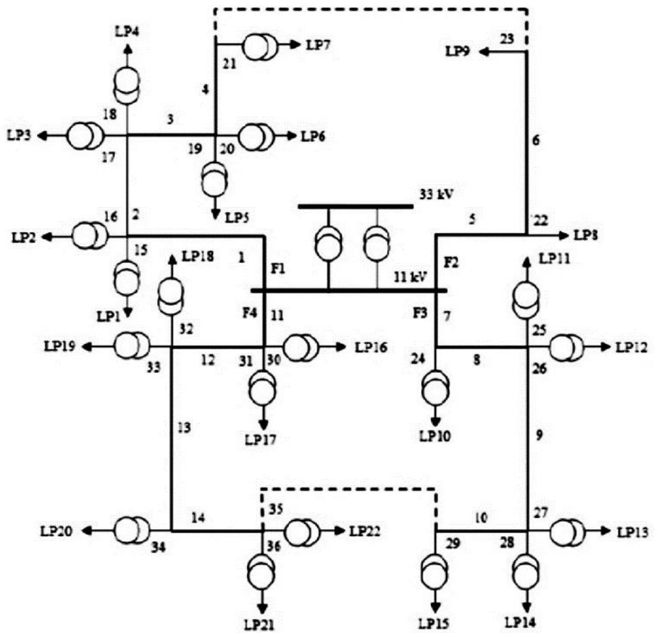

Fig. C: IEEE 22 Load point RBTS Bus 2 System

REFERENCES

[1] G. T. Heydt and T. J. Graf, "Distribution System Reliability Evaluation Using Enhanced Samples in a Monte Carlo Approach," in IEEE Transactions on Power Systems, vol. 25, no. 4, pp. 2006-2008, Nov. 2010, doi: 10.1109/TPWRS.2010.2045929.

[2] Arya L.D, Choube S.C, Arya, Rajesh & Tiwary, Aditya. (2012). "Evaluation of reliability indices accounting omission of random repair time for distribution systems using Monte Carlo simulation." International Journal of Electrical Power & Energy Systems. 42. 533-541. 10.1016/j.ijepes.2012.04.064.

[3] C. V. S. S. Sailaja, K. V. Ramanamurthy and P. V. N. Prasad, "Evaluation of reliability indices using FMEA technique," 2013 International Conference on Power, Energy and Control (ICPEC), Dindigul, India, 2013, pp. 554-557, doi: 10.1109/ICPEC.2013.6527719.

[4] Song, Xiaogang, et al. "A stochastic approach for the reliability evaluation of multi-state systems with dependent components." Reliability Engineering & System Safety 170 (2018): 257-266

[5] Maher M.A, Al Maghalseh," Evaluating the Reliability worth Indices of Electrical Medium Voltage Network: Case Study," Procedia Computer Science, Volume 130,2018, Pages 744-752, ISSN 1877-0509, https://doi.org/10.1016/j.procs.2018.04.129.

[6] Ghiasi M., Ghadimi N. & Ahmadinia E. "An analytical methodology for reliability assessment and failure analysis in distributed power system." SN Applied. Sciences(2019). 1:44https://doi.org/10.1007/s42452-018-0049-0

[7] Cruz L.M., Alvarez D.L., Al-Sumaiti A.S., Rivera S. "Load Curtailment Optimization Using the PSO Algorithm for Enhancing the Reliability of Distribution Networks." Energies 2020, 13, 3236. https://doi.org/10.3390/en13123236.

[8] N. N. R. B. Roslan, N. F. B. M. Fauzi and M. I. M. Ridzuan, "Sequential and Nonsequential Monte Carlo in Assessing Reliability Performance of Distribution Network," 2020 Emerging Technology in Computing, Communication and Electronics (ETCCE), Bangladesh, 2020, pp. 1-6, doi: 10.1109/ETCCE51779.2020.9350906.

[9] N F M Fauzi, N N R Roslan and M I M Ridzuan, "Low voltage reliability equivalent using monte-Carlo simulation technique." IOP Conference Series: Materials Science and Engineering. 863(2020) 012042. Doi:10.1088/1757-899X/863/1/012042.

[10] Hadi Suyono, Rini Nur Hasanah, Panca Mudjirahardjo, M Fauzan Edy Purnomo, Septi Uliyani, Ismail Musirin and Lilik J. Awalin. (2020). "Enhancement of the power system distribution reliability using ant colony optimization and simulated annealing methods". Indonesian Journal of Electrical Engineering and Computer Science. Vol. 17, No. 2, February 2020, pp. 877-885. ISSN: 2502-4752, DOI: 10.11591/ijeecs.v17.i2. pp 877-885

[11] Hongtao Shan, Yuanyuan Sun, Wenjun Zhang, Aleksey Kudreyko and Lijia Ren "Reliability Analysis of Power Distribution Network Based on PSO-DBN". IEEE Access. PP. 1-1. 10.1109/ACCESS.2020.3007776.

[12] Shojaeian, Shahrokh and Rizi Sajjad Hashemi. "A Simple PSO-Based Method for Power Distribution System Components Reliability Parameters Calibration" Acta Marisiensis. Seria Technologica, vol.18, no.1, 2021, pp.40-46. https://doi.org/10.2478/amset-2021-0007

[13] Jian Fang, Hongbin Wang, Fan Yang, Kuang Yin, Xiang Lin & Min Zhang (2022) "A failure prediction method of power distribution network based on PSO and XGBoost", Australian Journal of Electrical and Electronics Engineering, Vol.19, No 4, 371-378, DOI: 10.1080/1448837X.2022.2072447

[14] M. S. Alvarez-Alvarado et al., "Power System Reliability and Maintenance Evolution: A Critical Review and Future Perspectives," in IEEE Access, vol. 10, pp. 51922-51950, 2022, doi: 10.1109/ACCESS.2022.3172697.

[15] Chou, Jui-Sheng, and Asmare Molla. "Recent advances in use of bio-inspired jellyfish search algorithm for solving optimization problems." Scientific Reports 12.1 (2022): 19157.

[16] Avishek Banerjee, Samiran Chattopadhyay, Mihai Gavrilas, Gheorghe Grigoras," Optimization and estimation of reliability indices and cost of Power Distribution System of an urban area by a noble fuzzy-hybrid algorithm," Applied Soft Computing, Volume 102,2021,107078, ISSN 1568-4946, https://doi.org/10.1016/j.asoc.2021.107078.

[17] R. Billinton, R.N.Allan,I.Sjarief L.Goel, K.S.So , "A reliability test system for educational purposes-basic results," in IEEE Transactions on Power Systems, vol. 5, no. 1, pp. 319-325, Feb. 1990, doi: 10.1109/59.49123.

[18] Roy Billinton & Ronald N. Allan, Reliability Evaluation of Engineering Systems (Concepts and Techniques, Plenum Press, New York, 1992

[19] Roy Billinton and Ronald N. Allan, Reliability Evaluation of Power Systems, Plenum Press, New York and London, Second Edition.

[20] Wenyuan Li, Risk Assessment of Power Systems: Models, Methods, and Applications, IEEE Press, Wiely -Interscience 2005

[21] V. Sankar, System Reliability Concepts,2015,Himalaya Publishing House,ISO-9001:2003 Certified.