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Reliability Analysis by Using Various Indices

Naphade K.V. Naphade V.R.
[1](*Prof. at Dept of electrical engg, Loknete LoGMIEER, India*)
(*Prof. at Dept of electrical engg, R.H.Sapat CoE India)*)

Abstract: *The objective of this paper is to study the reliability aspects of a practical transmission and generation system. Reliability is an important issue in power engineering for both utility and customer. In electrical power system, the reliability is defined as the ability to provide uninterrupted electricity to customer, and the reliability of any system is usually evaluated on the average customer interruption indices. These indices provide customer risk dimension. Accordingly, this paper presents the result of reliability indices obtained by analytically for the electricity systems. An approach based on the Markov process method is also utilized to estimate the performance indices for the systems. The system reliability is evaluated for system's generator, transmission line and their load points. Firstly, reliability indices such as the ELC, LOLE, LOLP, EDLC, EENS are determined, analytically, by using one year of outage information..*
Keywords: *Reliability, Markov process, Availability, transmission system*

I. Introduction

The reliability of a power system is usually measured in terms of several indices. They are divided into load point indices and generalized reliability indices. Load point reliability indices are evaluated at each load point of the bus bar system and are evaluated using failure rate outage time/repair duration and the average annual outage time. Although load point primary indices are fundamentally important, they do not always give a complete representation of the system behavior and response. Hence Reliability related indices would be evaluated irrespective of size of customers. In order to reflect the severity or significance of a system outage, LOLP, LOLE and EENS are considered necessary for their detailed analysis.

In order to evaluate whether a system design meets the reliability prediction requirement, reliability modeling is implemented. The need for reliability engineering is critical for understanding deficiencies and faults in system designs, parts, processes, and usage and understanding how those issues could impact performance. Reliability predictions quantify the probability of successfully completing an intended mission for a specified period of time and one tool used for determining the reliability predictions is systems reliability modeling. Markov Analysis is a form of reliability modeling which is very useful when dealing with complex, but relatively medium-to-moderately sized systems. Markov analysis examines a sequence of events and analyzes the nature of one event to be followed by another.

Markov Analysis utilizes diagrams to describe the various sequences of events, or states, and rates of transitions between events to approximate the probability of being in any particular system state. The principle of traditional Markov Analysis, which is typically implemented using random failure rates, and combines it with the concept of wear out, or non constant hazard rates, to broaden the range of problems. In this paper we developed MATLAB programming for the 3 bus system

II. Overview On Reliability Indices

To calculate reliability various indices are use, they are as follows

A. Loss Of Load Probability(LOLP)

In practice the available system capacity is not constant as unit are remove from service for periodic inspection and maintenance. A single capacity outage probability is there for not applicable. The different techniques which maintenance can be include in the LOSS OF LOAD PROBABILITY approach.
Outage of capacity in excess of the Reserve will result in varying numbers of time units during which load loss occur. Expressed mathematically, the contribution to the system loss of load made be capacity outage O_k is $P_k\, t_k$ time units. The time period t_k are shown in below figure The total expected load loss for the study interval is:

$$LOLP=\sum P_k\, t_k \qquad (1)$$

B. Loss of Load Energy (LOLE)

$$E(t) = \sum P_k t_k \quad \text{time units.} \qquad (2)$$

Where Ci = available capacity on day i.

Li = forecast peak load on day i.
Pi(Ci - Li) = probability of loss of load on day i. This value is obtained directly from the capacity outage cumulative probability table.

C. Expected energy not supplied

$$EENS = \sum L_k D_k F_i \quad (3)$$

$$EENS = \sum L_k P_k \, 8760 \quad \text{MWh} \quad (4)$$

Where,
L_k=Load curtail
D_k= Departure rate
F_i= Frequency

D. Expected load curtailed

In expected load curtailed various parameter are use i.e. load curtail and frequency.

$$ELC = \sum L_{kj} F_j \quad (5)$$

E. Expected duration of load curtailment (EDLC)

Departure rate of power system :

Departure rate find by using various parameter, they are availability and unavailability of power system component. The availability and unavailability give from table.[1]

Departure rate (D_k)=[(number of available unit) +(number of unavailable unit)]

$$EDLC = \sum D_{kj} F_j \quad (6)$$

F. Expected number of load curtailments (NLC)

$$\boldsymbol{NLC = P_k F_i} \quad (7)$$

III. Methodology

Its importance, a mathematical treatment of the Markov model is provided. The Markov process can be characterized by lack of memory, as the future of a process are said to be dependent only upon the immediate history. Markov process can be applied to the discreet or continuous time and space. The reliability problem normally deals with system that are discrete in space and continuous in time.

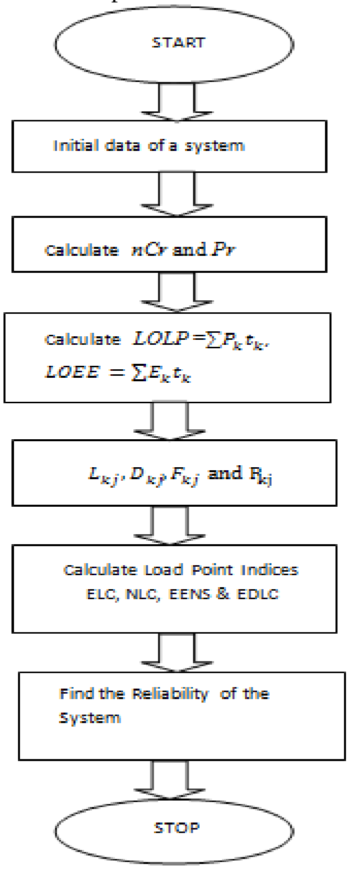

Fig.1. Flowchart for calculation of reliability

IV. Case Study

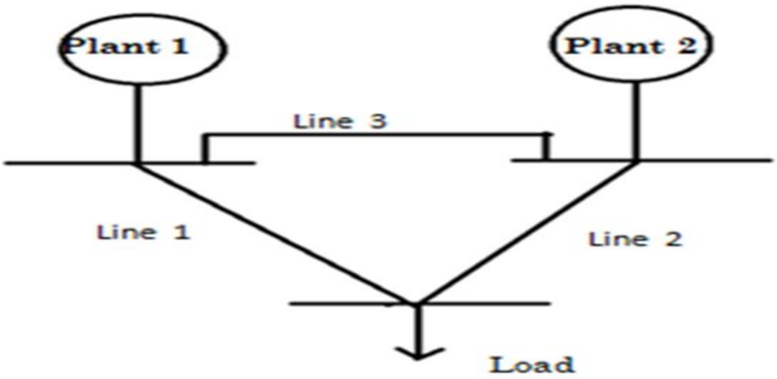

Fig. 2. Network configurations

TABLE NO 1- GENERATION DATA

Plant	No. of Units	Capacity(MW)	Unavailability	λ(f/yr)	μ(r/yr)
1	4	20	0.01	1	99
2	2	30	0.05	3	57
Total	6	140			

TABLE NO 2 – TRANSMISSION LINE DATA

Line	Connected to		Λ	R	R	X	B/2	Rating on 100 MVA base	
	Bus	Bus	(f/yr)	(hours)	(Ohms)	(Ohms)	(mhos)	(MVA)	(p.u)
1	1	2	4	8	0.0942	0.4800	0.0282	80	0.8
2	1	3	5	8	0.0800	0.5000	0.0212	100	1.0
3	2	3	3	10	0.0798	0.4200	0.0275	90	0.9

TABLE NO 3 – CAPACITY OF TRANSMISSION LINE
From Transmission Data

Line	Connected to		Capacity(MVA)	λ	q= 1/MDT	(1/MDT)*8760 =μ	p.f. = cos(tan-1(X/R))	MW
	Bus	Bus	(MVA)	(f/yr)	(hours)	(years)		
1	1	2	80	4	0.125	1095	0.95	76
2	1	3	100	5	0.125	1095	0.95	95
3	2	3	90	3	0.1	876	0.95	86
			270					

There is a range of possible solution techniques which can be used in this case. It should be fully appreciated that each approach involves different modeling techniques and therefore gives different load point reliability indices. The simplest approach is to assume that there are no transmission curtailment constraints and thatcontinuity is the sole criterion

V. Result

State	Elements out	Probability	Frequency F: (occtyr)	Capacity available (MW)
1	-	0.85692158	18.85227476	140
2	Gl	0.03462309	4.15477080	120
3	G1.G1	0.00052449	0.11436062	100
4	G1.G2	0.00364454	0.63414996	90
5	G1,L1	0.00012648	0.15329376	120
6	G1,L2	0.00015810	0.19145910	86
7	G1,L3	0.00011857	0.11774001	95
8	G2	0.09020227	6.85537252	110
9	G2, G2	0.00237374	0.30858620	80
10	G2, LI	0.00032951	0.38783327	110
11	G2, L2	0.00041188	0.48438029	86
12	G2, L3	0.00030891	0.29115559	95

13	LI	0.00313030	3.48402390	140
14	L1,L2	0.00001430	0.03150290	60
15	L1,L3	0.00001072	0.02128992	95
16	L2	0.00391288	4.35112256	86
17	L2, L3	0.00001340	0.02659900	0
18	L3	0.0029346	2.62652070	95

State	P_{kj}	D_{kj}(hours)	L_{kj}(MW)	ELC(MW)	NIC	EENS(MWh)	EDLC(hours)
1	0	398.18	0	0	0	0	0
2	0	73.00	0	0	0	0	0
3	1	40.18	15	1.7154	0.11436	68.92	4.5454
4	1	50.34	25	15.8537	0.63415	798.08	31.9262
5	0	7.23	0	0	0	0	0
6	1	7.23	29	5.5500	0.19142	40.13	1.3850
7	1	8.82	20	2.3548	0.11774	20.77	1.0387
8	1	115.26	5	34.2769	6.85537	3980.76	790.1719
9	1	67.38	35	10.8005	0.30859	727.74	20.7940
10	1	7.44	5	1.9392	0.38783	14.43	2.8864
11	1	7.45	29	14.0470	0.48438	104.65	3.6081
12	1	9.23	20	5.8631	0.29316	54.12	2.7061
13	0	7.87	0	0	0	0	0
14	1	3.84	55	1.7327	0.03150	6.90	0.1253
15	1	4.41	35	0.7451	0.02129	3.29	0.0939
16	1	7.88	29	126.1025	4.35112	993.69	34.2768
17	1	4.41	110	2.9254	0.02660	12.90	0.1174
18	1	9.79	20	52.5304	2,62652	514.27	25.7076
Total				274.441	16.444	7310.65	919.4327

VI. Conclusion

In this paper we understand the concept of reliability in power system and also importance of reliability in various sector, such as existing power system to understand the reliability. In our paper we used two generator and three bus system to understand the reliability. By using the Markov process we have analyses the reliability in useful life period and their various indices such as LOLE,LOLP,ELC,ELDC etc. Using these indices we calculate the reliability of power system in the form of availability and unavailability of component. In our paper we provide result up to the expectations.

References

[1]. *Roy Billioton* proposed the power system reliability theory, which analysis the power system by using various criteria and evolution technology like transmission system reliability evolution, generating system reliability evolution .

[2]. *Selma K.E. Awadallah, Jovica V.Milanovi'c and Paul N. Jarman* proposed the quantification of the effect of uncertainty in end of the life failure models and system reliability indices.

[3]. *Anis Ur Rehaman, Atiq Ur Rehaman and Sheharyar Mehmood* proposed the reliability assessment and worth analysis of a distribution network with incorporation of distributed generation under extreme load growth.