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Reliability Analysis of Power Distribution System: a Case Study

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***Abstract*— As the electricity plays very important role now a days, the reliability analysis of power distribution also has same important role. The daily load data of lakya feeder collected by the log book chikkamagaluru muss and various indices are calculated. The outages are classified in to types, frequency and duration. The reliability indices are calculated on monthly basis for an year from January to December from the year 2013 to 2016.The average availability of lakya feeder is 0.68.The suggestions were made to minimize the outages and hence to improve reliability.**

Keywords— Reliability; Distribution; Average Availability.

I. INTRODUCTION

In this modern world the Electricity has become part and parcel of daily life. Every consumer expects a reliable power supply. The electric supply companies now a days working in competitive environment where they have to supply electricity to consumer which is economical to both consumers and as well as companies. To achieve this companies have to measure system reliability [1]. These reliability indices include measures of outage duration, frequency outages, system availability, and response time. Power quality and system reliability are off course not the same parameters. Power quality involves voltage fluctuations, abnormal waveforms, and harmonic distortions [2]. System reliability pertains to sustained interruptions and momentary interruptions. An interruption of greater than five minutes is generally considered a reliability issue, and interruptions of less than five minutes are a power quality concern. Since the primary purpose of electric power is to satisfy customer's requirements, power system basically consists of generation, transmission and distribution [3]. Chikkamagaluru MUSS comprising of twelve 11kV feeders. Out of twelve feeders the lakya feeder is taken for study and analysis for 3 years namely 2014, 2015 and 2016.The study and analysis of outages of the lakya feeder is useful in planning, design operation and maintenance [4]. According to improving distribution system is the key to improving reliability of supply to customers.

DISTRIBUTION INDICES:

The most common distribution indices include SAIDI, SAIFI CAIDI, ASUI and ASAI [5]. Reference [6] also cited for general application. We will review each of these indices with an example of how to use them.

i. **System Average Interruption Duration Index (SAIDI)**:

The most often used performance measurement for a sustained interruption is the System Average Interruption Duration Index(SAIDI).This index measures the total duration of an interruption for the average customer during a given time period. SAIDI is normally calculated on either monthly or yearly basis; however, it can also be calculated daily, or for any other time period. In this paper all indices are calculated on monthly Basis.

SAIDI = Total Duration in Hours/Number of customers supplied

ii. System average interruption frequency index (SAIFI): it is the average number of the times that the customer experiences outage during that particular time**.**

SAIFI = Frequency of outages/ Number of customers supplied

iii. Customer Average **Interruption Duration Index (CAIDI):** It is the ratio of system Average Interruption Duration Index(SAIDI) to the System Average Interruption frequency index(SAIFI).This ratio gives the average customer out of supply.

CAIDI = SAIDI/SAIFI

iv. Average system utility Index (ASUI): It is the ratio of the outage hours to the total hours demanded for a particular time period.

ASUI = Duration of outages in hours/Total hours demanded

v. Average Service Availability Index (ASAI): It is the ratio of the total number of customer hours that service was available during a given time period to the total customer hour demanded. The ASAI is usually calculated on either monthly basis or yearly basis, but can be calculated for any time period.

ASAI = 1-ASUI

The most important factor for this function to be used is that the hazard rate (λ) should be constant known as failure rate(λ).

Reference [7] gave the density function as follows

$$f(t) = \lambda e^{-\lambda t}$$

And the hazard rate is given by

$$\lambda(t) = \frac{f(t)}{1-f(t)}$$

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Failure Rate (λ)

λ = number of times that failure occurred/number of unit-hours of operation

And the reliability distribution function is given by

$$R(t) = 1 - f(t) = e^{\lambda t}$$

Further reliability parameters given by are as follows:
Mean Time Between Failure (MTBF)

MTBF = Total system operating hours/number of failures

Also Mean Time to Repair (MTTR) or Mean Down Time (MDT)

MTTR=total duration of outages/frequency of outages

Availability (A) = MTBF-MTTR/MTBF

II. METHODOLOGY

Reliability engineering with regard to distribution systems involves gathering outage data and evaluating system designs. The outage data collected from chikkamagaluru MUSS for lakya feeder comprise of information on each failure event within the period of the year 2016. The information recorded in a narrative form was translated into a statistical database. The outages were classified as forced and scheduled. Hence, data on failure rates and repair times of component used in the distribution system were compiled for reliability calculations. In addition, data on statistical information consisting of outages arising from the load shedding, system collapse, scheduled or unscheduled maintenance and hourly load shedding on each feeder were collected. These data were used to compute the reliability indices (MTBF, MDT, and Availability), total hours of outages and the number of interruptions (frequency) per day and Customer Orientation Indices (SAIFI, SAIDI, CAIDI, ASAI and ASUI) using equations discussed in the above section. A low value of MDT indicates good maintainability. SAIFI indicates how often an average customer is subjected to sustained interruption over a predefine time interval whereas SAIDI indicates the total duration of interruption an average customer is subjected for a predefined time interval. CAIDI indicates the average time required to restore the service. ASAI specifies the fraction of the time that a customer has received power during the predefine interval of time and vice versa for ASUI. The results are shown in Tables 1 to 7 and analyzed graphically in Fig 1 to Fig .3.

III. RESULTS AND DISCUSSIONS

The frequency and duration of outages, basic reliability indices and customer oriented indices are tabulated form Table 5 to7 for the year 2016.The graphs to show the outage hours, event/hr and availability are shown from figures 1 to 3.

The statistical data also collected for the years 2014 and 2015 for the lakya feeder. The Tables 1 to 4 shows the summarized basic reliability indices and customer oriented indices.

The lakya feeder had 1283, 1590 and 1155 interruptions in the years 2014,2015 and 2016 respectively and the duration of outage in hours are 2735.46, 2770.13 and 2730.35 respectively. The failure rate is 0.15, 0.18 and 0.13 for the years 2014, 2015 and 2016 respectively. For the analyzed period the failure rate is high for the year 2015.In the years 2015 and 2016 the failure rate is high during the months march to may due to heat weather and winds. The availability factor is almost same for the three analyzed years and it is 0.68. Most of the outages occurred are due to load shedding.

Failure rate	MTBF	MDT(Hr)	Availability
0.15	7.11	2.24	0.69

TABLE 1. SUMMARY OF BASIC RELIABILITY INDICES FOR THE YEAR 2014

SAIDI	SAIFI	CAIDI	ASAI	ASUI
1.09	2.33	2.24	0.69	0.31

TABLE 2. SUMMARY OF CUSTOMER ORIENTED RELIABILITY INDICES FOR THE YEAR 2014

Failure rate	MTBF	MDT(Hr)	Availability
0.18	5.75	1.84	0.68

TABLE 3. SUMMARY OF BASIC RELIABILITY INDICES FOR THE YEAR 2015

SAIDI	SAIFI	CAIDI	ASAI	ASUI
2.14	1.22	1.84	0.68	0.32

TABLE 4. SUMMARY OF CUSTOMER ORIENTED RELIABILITY INDICES FOR THE YEAR 2015

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Months	Scheduled Outage		Forced Outage		Total outage	
	Freq	Duration(Hr)	freq	Duration(Hr)	freq	Duration(Hr)
Jan	70	253:20	24	6:21	94	259:41
Feb	70	245:45	32	18:54	102	264:39
Mar	82	285:04	13	2:25	95	287:29
Apr	65	264:07	23	10:21	88	274:28
May	79	228:35	93	55:30	172	284:05
Jun	67	201:43	54	43:37	121	245:20
Jul	32	61:57	42	34:56	74	96:53
Aug	42	125:16	34	9:57	76	135:13
Sep	35	170:17	52	16:39	87	186:56
Oct	40	168:42	27	4:55	67	173:37
Nov	66	250:21	39	17:24	105	267:45
Dec	58	246:54	16	7:35	74	254:29
TOTAL	706	2502:01	449	228:34:00	1155	2730:35

TABLE 5. SUMMARY OF FREQUENCY AND DURATION OF OUTAGES ON LAKYA FEEDER OF CHIKKAMAGALURU MUSS FROM JANUARY TO DECEMBER 2016

MONTHS	FREQUENCY	OUTAGE	TOTAL(HR)	FAILURE RATE(event/hr)	MTBF	MDT(Hr)	Availability(pu)
Jan	94	259.68	744	0.1263	7.9149	2.7626	0.6510
Feb	102	264.65	672	0.1518	6.5882	2.5946	0.6062
Mar	95	287.48	744	0.1277	7.8316	3.0261	0.6136
Apr	88	274.47	720	0.1222	8.1818	3.1190	0.6188
May	172	284.08	744	0.2312	4.3256	1.6516	0.6182
Jun	121	245.33	720	0.1681	5.9504	2.0275	0.6593
Jul	74	96.88	744	0.0995	10.0541	1.3092	0.8698
Aug	76	135.22	744	0.1022	9.7895	1.7792	0.8183
Sep	87	186.93	720	0.1208	8.2759	2.1486	0.7404
Oct	67	173.62	744	0.0901	11.1045	2.5913	0.7666
Nov	105	267.75	720	0.1458	6.8571	2.5500	0.6281
Dec	74	254.48	744	0.0995	10.0541	3.4389	0.6580
TOTAL	1155	2730.57	8760	0.132	8.077	2.416	0.687

TABLE 6. COMPUTED BASIC RELIABILITY INDICES ON LAKYA FEEDEROF CHIKKAMAGALURU MUSS FROM JANUARY TO DECEMBER 2016

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MONTHS	INTERRUPTIONS	OUTAGE(Hours)	TOTAL HOURS	CUSTOMERS	SAIFI(INT/CUST)	SAIDI(OUTAGE/CUST)	CAIDI(SAIDI/SAIFI)	ASAI	ASUI
Jan-16	94	259.68	744	1424	0.0660	0.1824	2.7626	0.6510	0.3490
Feb-16	102	264.65	672	1424	0.0716	0.1858	2.5946	0.6062	0.3938
Mar-16	95	287.48	744	1424	0.0667	0.2019	3.0261	0.6136	0.3864
Apr-16	88	274.47	720	1424	0.0618	0.1927	3.1190	0.6188	0.3812
May-16	172	284.08	744	1424	0.1208	0.1995	1.6516	0.6182	0.3818
Jun-16	121	245.33	720	1424	0.0850	0.1723	2.0275	0.6593	0.3407
Jul-16	74	96.88	744	1424	0.0520	0.0680	1.3092	0.8698	0.1302
Aug-16	76	135.22	744	1424	0.0534	0.0950	1.7792	0.8183	0.1817
Sep-16	87	186.93	720	1424	0.0611	0.1313	2.1486	0.7404	0.2596
Oct-16	67	173.62	744	1424	0.0471	0.1219	2.5913	0.7666	0.2334
Nov-16	105	267.75	720	1424	0.0737	0.1880	2.5500	0.6281	0.3719
Dec-16	74	254.48	744	1424	0.0520	0.1787	3.4389	0.6580	0.3420
TOTAL	1155	2730.57	8760	17088	0.8111	1.9175	2.41	0.68	0.31

TABLE 7. COMPUTED CUSTOMER ORIENTATION INDICES ON LAKYA FEEDER OF CHIKKAMAGALURU MUSS FROM JANUARY TO DECEMBER 2016

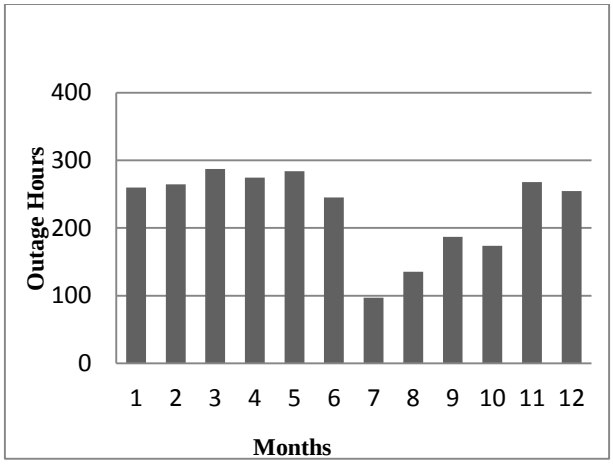

Figure 1. Chart of Monthly Outage Duration (Hours) Demanded on Lakya Feeder For The Year 2016

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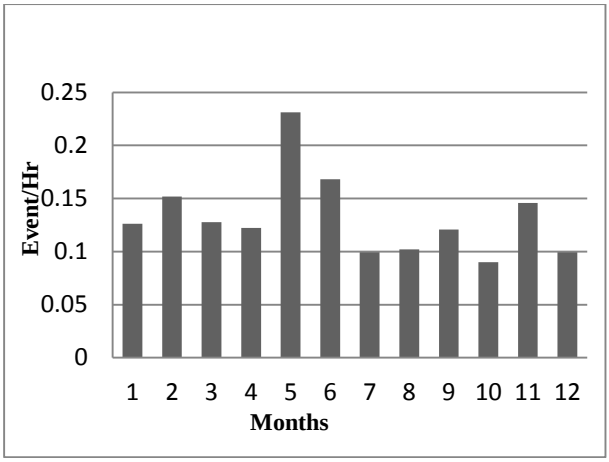

Figure 2. Chart of Monthly Failure Rate On Lakya Feeder in the Year 2016

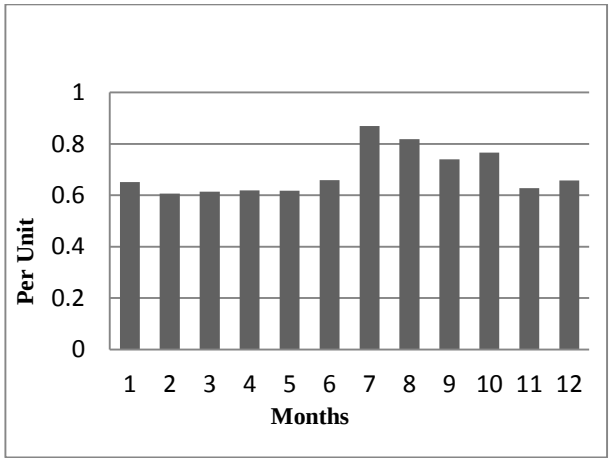

Figure 3. Chart of Monthly Availability of Lakya Feeder for the Year 2016

Based on the data analysis from the above tables it is clear that the avearge availability for the lakya feeder is 0.68.Apart from the Load shedding, the monthly maintainance work and earth faults are also other factors to affect power supply to customers.

1V. CONCLUSION

The data from the above tables shows that the failure rate is 0.13, MTBF is 8.07, MDT is 2.41 and availability is 0.68.The customer oriented indices are SAIFI is 0.81, SAIDI is 1.91, CAIDI is 2.41, ASAI is 0.68 and ASUI is 0.31 for the year 2016.The indices for the other two years are also tabulated in the tables 1, 2, 3 and 4.

The frequent power interruption and voltage drops in the line is inconvenience to the customers and it may affect production in manufacturing sector. Hence definitely reliability should be improved. This could be achieved by using the distributed generation. The in and around area of chikkamagaluru is having a wind potential and could be possible to install wind mills for distributed generation.

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