

GSJ: Volume 7, Issue 3, March 2019, Online: ISSN 2320-9186 www.globalscientificjournal.com

RELIABILITY INVESTIGATION OF THE GUINNESS 33KV FEEDER OF THE BENIN ELECTRICITY DISTRIBUTION COMPANY (B.E.D.C.)

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Abstract

The reliability of any system is normally calculated in terms of reliability index. It will be wrong to estimate the reliability of any protection scheme based on its tripping rate, as such report will resort to nothing more than a more understatement, unjustified report and poor conclusion. A comprehensive analysis of the protection system can be achieved using statistical data and figures. The data collected and presented in this paper are true data/report on Guinness 33KV feeders as recorded on the daily fault report book in dispatch unit of Ikpoba Hill Business District of Benin Electricity Distribution Company, Benin Distribution Zone, between the period of December 2017 and November 2018.

Keywords:

Feeder, Protection Scheme, Tripping Rate, Reliability, Statistical Data.

I. INTRODUCTION

The term 'reliability' is closely associated with outages, interruptions, failures, availability etc. According to the Oxford Advanced Learner's Dictionary, International Student's Edition, reliability is the ability to trust someone or something to do well. From the Engineering point of view, it simply refers to continuing services without failure and it is normally calculated in terms of reliability index. Relative to the fast expanding transmission network, the fault level has also increased. The probability of faults occurrence on the

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and bad terrains. This in turn has reduced the availability period of supply and to greater extent cause damage to electrical equipment. There is probably no other subject of greater importance to a power system electrical engineer than the question of providing protection mechanisms to combat the destructive power and uneconomic threat posed by the line faults on equipment and economic activities of the nation. Benin transmission station is one of the main transmission stations in Nigeria. It receives power from the national grid at 330KV and with the help of its transformers; the voltage is stepped down to 132KV and 33KV depending on the proximity to final consumer. Guiness 33KV feeder is one of the main 33KV feeders emanating from Benin transmission station. It is the biggest and longest at that voltage level. It feeds through Ikpoba Hill, Ugbowo, Upper Sakponba, Nifor, Okada and Ifon community (Ondo State). Due to its long route length with better parts of the feeder on bush path, it experiences high tripping rate as compared to other feeders. Consequently, the consumer taking supply from the feeder has high degree of instability in supply.

II. OUTAGE REPORT OF FAULTS

The data was collected and presented in the tables below. The data were analyzed on a monthly basis. In this research work, there are tables showing the summary of nature of fault i.e. the causes of power supply outage, the frequency of their occurrence and the duration of power supply outage associated with each fault.

Table 1-12 shows the various kinds of fault that is common with Guiness 33KV feeder, the frequency of their occurrence and the hour of power supply outage on the feeder. These faults and their corresponding hours of outage are sorted out and arranged in tabular format on a monthly basis between December, 2017 to November, 2018. Faults that trips CB_2 is a combination of overcurrent faults, earthfaults, broken pole/cross and shattered pin or disc insulator. Mal-operation of breakers combines inter-trip of breaker and no relay indication faults. It also entails analysis with the aid of barchart, the nature of fault occurrence,

GSJ: Volume 7, Issue 3, March 2019 **freq 2022** (1) Soft fault occurrence and the period of power supply outage as it relates to the 159

reliability of the protection system.

The reliability of the protection system was further simplified with the aid of pie chart

representation of the nature of faults and the average frequency of the occurrence.

TABLE 1: OUTAGE REPORT: DECEMBER 2017

CAUSES OF POWER SUPPLY OUTAGE	FREQUENCY OF OCCURENCE	DURATION OF OUTAGE (MINS)
T _X T ₂₁ LOAD LIMITATION	1	15
POOR SYSTEM FREQUENCY	9	2514
EARTH FAULT	14	461
FUALT THAT TRIPS CB3	12	450
INVERSE TIME OVERCURRENT	15	712
BROKEN POLE/CROSS ARMS	Nil	Nil
GENERAL MAINTENANCE	Nil	Nil
CB ₂ BREAKER MALOPERATION	2	18
FAULT WITHOUT TRIPPING	2	173
CB ₃ BREAKER MALOPERATION	16	530

(Guinness Distribution Log Sheet, 2017–2018).

TABLE 2: OUTAGE REPORT: JANUARY 2018

GUINESS 33KV FEEDER			
CAUSES OF POWER SUPPLY OUTAGE	FREQUENCY OF OCCURRENCE	DURATION OF OUTAGE (MINS)	
T _X T ₂₁ LOAD LIMITATION			
POOR SYSTEM FREQUENCY	3	284	
EARTH FAULT	15	4,428	
FAULTS THAT TRIP CB3	14	824	
INVERSE TIME OVER CURRENT	49	2,624	
BROKEN POLE/CROSS ARMS	Nil	Nil	
GENERAL MAINTENANCE	6	799	
CB ₂ BREAKER MALOPERATION	3	116	
FAULT WITHOUT TRIPPING	4	840	
CB3 BREAKER MALOPERATION	20	200	

(Guinness Distribution Log Sheet, 2017–2018)

TABLE 3: OUTAGE REPORT: FEBUARY 2018

GUINESS 33KV FEEDER		
CAUSES OF POWER SUPPLY OUTAGE	FREQUENCY OF OCCURRENCE	DURATION OF OUTAGE (MINS)
T _X T ₂₁ LOAD LIMITATION		
POOR SYSTEM FREQUENCY	2	165

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BAR THE FAIBLE	20	5,639
FAULTS THAT TRIP CB3	17	900
INVERSE TIME OVERCURRENT	26	798
BROKEN POLE/CROSS ARMS	1	227
GENERAL MAINTENANCE	4	187
CB ₂ BREAKER MALOPERATION	2	153
FAULT WITHOUT TRIPPING	4	1467
CB ₃ BREAKER MALOPERATION	20	210

(Guinness Distribution Log Sheet, 2017–2018)

TABLE 4: OUTAGE REPORT: MARCH 2018

GUINESS 33KV FEEDER		
CAUSES OF POWER SUPPLY OUTAGE	FREQUENCY OF	DURATION OF OUTAGE
	OCCURRENCE	(MINS)
T _X T ₂₁ LOAD LIMITATION		
POOR SYSTEM FREQUENCY	2	1,239
EARTH FAULT	15	3,328
FAULTS THAT TRIP CB3	15	524
INVERSE TIME OVERCURRENT	22	2368
BROKEN POLE/CROSS ARMS	Nil	Nil
GENERAL MAINTENANCE	6	331
CB ₂ BREAKER MALOPERATION	Nil	Nil
FAULT WITHOUT TRIPPING	4	1110
CB ₃ BREAKER MALOPERATION	10	233
(Guinnage Distribution Log Shoot 2017	2018)	

(Guinness Distribution Log Sheet, 2017–2018)

 TABLE 5: OUTAGE REPORT: APRIL 2018

GUINESS 33KV FEEDER		
CAUSES OF POWER SUPPLY OUTAGE	FREQUENCY OF OCCURRENCE	DURATION OF OUTAGE (MINS)
T _X T ₂₁ LOAD LIMITATION	Nil	Nil
POOR SYSTEM FREQUENCY	1	50
EARTH FAULT	18	8,883
FAULTS THAT TRIP CB3	10	690
INVERSE TIME OVERCURRENT	28	1961
BROKEN POLE/CROSS ARMS	1	61
GENERAL MAINTENANCE	5	105
CB ₂ BREAKER MALOPERATION	5	275
FAULT WITHOUT TRIPPING	5	1354
CB ₃ BREAKER MALOPERATION	15	62

(Guinness Distribution Log Sheet, 2017–2018)

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GUINESS 33KV FEEDER		
CAUSES OF POWER SUPPLY OUTAGE	FREQUENCY OF OCCURRENCE	DURATION OF OUTAGE (MINS)
T _X T ₂₁ LOAD LIMITATION	3	895
POOR SYSTEM FREQUENCY	10	1,580
EARTH FAULT	14	4,422
FAULT THAT TRIP CB3	13	452
INVERSE TIME OVERCURRENT	27	2531
BROKEN POLE/CROSS ARMS	NIL	Nil
GENERAL MAINTENANCE	7	3,345
CB ₂ BREAKER MALOPERATION	1	4
FAULT WITHOUT TRIPPING	4	1156
CB ₃ BREAKER MALOPERATION	12	300

(Guinness Distribution Log Sheet, 2017–2018)

TABLE 7: OUTAGE REPORT: JUNE 2018

GUINESS 33KV FEEDER		
CAUSES OF POWER SUPPLY OUTAGE	FREQUENCY OF OCCURRENCE	DURATION OF OUTAGE (MINS)
T _X T ₂₁ LOAD LIMITATION	1	23
POOR SYSTEM FREQUENCY	8	283
EARTH FAULT	29	6,813
FAULTS THAT TRIP CB3	11	800
INVERSE TIME OVERCURRENT	23	1686
BROKEN POLE/CROSS ARMS		93
GENERAL MAINTENANCE	3	365
CB ₂ BREAKER MALOPERATION	2	223
FAULT WITHOUT TRIPPING	5	514
CB ₃ BREAKER MALOPERATION	9	21

(Guinness Distribution Log Sheet, 2017–2018)

TABLE 8: OUTAGE REPORT: JULY 2018

GUINESS 33KV FEEDER		
CAUSES OF POWER SUPPLY OUTAGE	FREQUENCY OF OCCURRENCE	DURATION OF OUTAGE (MINS)
T _X T ₂₁ LOAD LIMITATION	2	15
POOR SYSTEM FREQUENCY	8	569
EARTH FAULT	21	4,290
FAULTS THAT TRIP CB3	17	1000
INVERSE TIME OVERCURRENT	15	809
BROKEN POLE/CROSS ARMS	Nil	Nil
GENERAL MAINTENANCE	4	660
CB ₂ BREAKER MALOPERATION	5	331
FAULT WITHOUT TRIPPING	6	3104

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(SBNB2R20A9K26CR MALOPERATION	24	674
		16:

(Guinness Distribution Log Sheet, 2017–2018)

TABLE 9: OUTAGE REPORT: AUGUST 2018

GUINESS 33KV FEEDER		
CAUSES OF POWER SUPPLY OUTAGE	FREQUENCY OF	DURATION OF OUTAGE
	OCCURRENCE	(MINS)
T _X T ₂₁ LOAD LIMITATION	3	1,322
POOR SYSTEM FREQUENCY	4	969
EARTH FAULT	27	5,519
FAULTS THAT TRIP CB3	16	980
INVERSE TIME OVERCURRENT	10	1025
BROKEN POLE/CROSS ARMS	Nil	Nil
GENERAL MAINTENANCE	3	572
CB ₂ BREAKER MALOPERATION	5	1,391
FAULT WITHOUT TRIPPING	4	1333
CB ₃ BREAKER MALOPERATION	24	580

(Guinness Distribution Log Sheet, 2017–2018)

TABLE 10:OUTAGE REPORT: SEPTEMBER 2018

GUINESS 33KV FEEDER		
CAUSES OF POWER SUPPLY OUTAGE	FREQUENCY OF OCCURRENCE	DURATION OF OUTAGE (MINS)
T _X T ₂₁ LOAD LIMITATION	2	636
POOR SYSTEM FREQUENCY	2	148
EARTH FAULT	18	5,631
FAULTS THAT TRIP CB3	18	700
INVERSE TIME OVERCURRENT	12	1521
BROKEN POLE/CROSS ARMS	Nil	Nil
GENERAL MAINTENANCE	6	479
CB ₂ BREAKER MALOPERATION	8	517
FAULT WITHOUT TRIPPING	4	375
CB ₃ BREAKER MALOPERATION	18	334

(Guinness Distribution Log Sheet, 2017–2018)

TABLE 11: OUTAGE REPORT: OCTOBER 2018

GUINESS 33KV FEEDER			
CAUSES OF POWER SUPPLY OUTAGE	FREQUENCY OF OCCURRENCE	DURATION OF OUTAGE (MINS)	
T _X T ₂₁ LOAD LIMITATION	Nil	Nil	
POOR SYSTEM FREQUENCY	2	268	
EARTH FAULT	24	6,541	
FAULTS THAT TRIP CB3	22	640	
INVERSE TIME OVERCURRENT	5	770	
BROKEN POLE/CROSS ARMS	Nil	Nil	
GENERAL MAINTENANCE	4	166	

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(SBNB2B2029K86R MALOPERATION	5	456
	_	16
FAULT WITHOUT TRIPPING	6	471
	-	
CB ₂ BREAKER MALOPERATION	16	500
02, 21011121111120121111011	10	200

(Guinness Distribution Log Sheet, 2017–2018)

TABLE 12:OUTAGE REPORT: NOVEMBER 2018

GUINESS 33KV FEEDER			
CAUSES OF POWER SUPPLY OUTAGE	FREQUENCY OF OCCURRENCE	DURATION OF OUTAGE (MINS)	
T _X T ₂₁ LOAD LIMITATION	1	221	
POOR SYSTEM FREQUENCY	2	275	
EARTH FAULT	18	3173	
FAULT THAT TRIP CB3	12	500	
INVERSE TIME OVERCURRENT	16	1161	
BROKEN POLE/CROSS ARMS	Nil	Nil	
GENERAL MAINTENANCE	5	184	
CB ₂ BREAKER MALOPERATION	3	637	
FAULT WITHOUT TRIPPING	6	1324	
CB ₃ BREAKER MALOPERATION	25	610	

(Guinness Distribution Log Sheet, 2017–2018)

III. RELIABILITY FORMULAR

Reliability = $\frac{W - (X + Y + n + Z)}{N}$ (Gupta, 2008) and (Mehta and Mehta, 2005).

where, N represents the total number of days in a month

n represents total frequency of CB₃ Breaker mal-operation.

W represents frequency of fault occurrence that trips CB2

- Y represents frequency of fault occurrence that causes CB₂ and CB₃ to inter-trip simultaneously.
- Z represents the frequency of fault occurrence on the feeder without tripping the circuit breaker.

IV. RELIABILITY CALCULATION OF THE PROTECTION SYSTEM

DECEMBER 2017

N = 31, W = 61, X = 29, Y = 2, Z = 2, n = 16

Reliability = $\frac{61 - (29 + 2 + 2 + 16)}{31} = 0.39$

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JANNARA-KI 86 2	018
N = 31, W =	105, X = 64, Y = 3, Z = 4, n = 20
Reliability	$= \frac{105 - (64 + 3 + 4 + 20)}{31} = 0.45$
FEBRUARY	2018
N = 29, W =	94, X = 59, Y = 2, Z = 4, n = 22
Reliability	$=\frac{94 - (51 + 2 + 4 + 22)}{29} = 0.52$
MARCH 201	8
N = 31,W =	66, X = 37, Y = 0, Z = 4, n = 20
Reliability	$=\frac{-66 - (37 + 0 + 20 + 4)}{31} = 0.48$
APRIL 2018	
N = 30, W =	79, X = 47, Y = 5, Z = 5, n = 15
Reliability	$=\frac{79 - (47 + 5 + 15 + 5)}{30} = 0.23$
MAY 2018	
N = 31, W =	71, X = 41, Y = 1, Z = 4, n = 12
Reliability	$=\frac{71 - (41 + 1 + 12 + 4)}{31} = 0.42$
JUNE 2016	
N = 30, W =	79, X = 52, Y = 2, Z = 5, n = 9
Reliability	$=\frac{79-(52+2+5+9)}{30} = 0.37$
JULY 2018	
N = 31, W =	77, X = 36, Y = 5, Z = 6, n = 24
Reliability	$=\frac{77 - (36 + 5 + 6 + 24)}{31} = 0.19$
AUGUST 202	18
N = 31, W =	85, X = 37, Y = 5, Z = 3, n = 24
Reliability	$=\frac{85 - (37 + 5 + 3 + 24)}{31} = 0.52$
SEPTEMBE	R 2018
N = 30, W =	76, X = 30, Y = 8, Z = 4, n = 16
Reliability	$=\frac{76-(30+8+4+16)}{30}=0.60$

OCTOBER 2018

GSJ: Volume 7, Issue 3, March 2019 NSM 2320, NB = 85, X = 38, Y = 5, Z = 6, n = 16Reliability = $\frac{85 - (38 + 5 + 6 + 16)}{31} = 0.65$ **NOVEMBER 2018**N = 30, W = 83, X = 37, Y = 3, Z = 6, n = 25 Reliability = $\frac{83 - (37 + 3 + 6 + 25)}{30} = 0.40$

CHART 1: BAR CHART REPRESENTATION OF VARYING FAULTS ANNUALLY.



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CHART 2: A B AR CHART REPRESENTION OF THE DURATION OF OUTAGE AND

ITS CAUSES.



THROUGH THE FREQUENCY OF FAULTS OCCURRENCE



CHART 4: PIE CHART REPRESENTATION OF PERIOD OF POWER SUPPLY \

OUTAGE ON GUINNESS 33KV FEEDER.



TABLE 13: CAUSES OF POWER SUPPLY OUTAGE AND AVERAGE PERIOD OF

POWER SUPPLY OUTAGE ANNUALLY.

CAUSES OF OUTAGE	AVERAGE PERIOD OF OUTAGE(HRS)
Fault that trip CB ₂	17.42
Fault that trip CB ₃	17.41
Inter-trip of CB ₂ and CB ₃	10.72
Fault without tripping	15.91
Tx T ₂₁ limitation	4.58
Poor system frequency	11.58
General maintenance	10.00

TABLE 14: NATURE OF FAULTS AND AVERAGE VALUE OF FAULT OCCURENCE

NATURE OF FAULTS	AVERAGE	
	VALUE OF FAULT OCCURENCE	
Fault that trip CB ₂	41.58	
Fault that trip CB ₃	14.25	
Inter-trip of CB ₂ and CB ₃	3.42	
Fault without tripping	4.42	
CB ₃ Breaker Mal-operation	15.67	

DISCUSSION OF RESULTS

Guiness 33kv feeder is one of the six feeders which emanates from 132/33k to transmission network of Benin transmission zone. Apart from G.R.A feeder, it is another feeder that is attached alone to a single transformer of 60MVA capacity. It has a route length of about 225km. Owing to the fact that this equipment (transformer, conductors) are expensive and are not readily available there is need for protection Engineers to design and put in place a reliable protection system. It can be deduced from chart 1 showing the frequency of fault occurrence and the nature of faults, that CB₂ which is located at the switch yard of Benin transmission zone trips more frequently on fault than CB₃ located behind Ugbowo injection substation. Analysis shows that more than 52% of the total fault occurrence on Guiness 33kv

GSJ: Volume 7, Issue 3, March 2019 Seviler 20 auses CB₂ to trip. This indeed is a gross inefficiency on behalf of the protection system on the feeder. In a reliable and a well co-ordinated protection scheme, CB2 should be the last breaker to be tripped by any fault from the outgoing lines. It is supposed to act as a backup protection for every other protection system located along the network. But in the case of Guiness 33ky feeder, the only protection system along the network is the one located on the Okada leg of the feeder which covers only 30 percent of the network. This implies that any Fault from the remaining section of the network bounces back directly on CB₂. This accounts for one of the major reason why the feeder suffers a drastic period of outage. On the occurrence of such fault, the feeder may not be reclosed until the three business district taking supply from the feeder have successfully patrolled the network, with a written undertaking to report any fault found in the course of tracing the line. Hence only 38% of the total fault on the feeder is selectively isolated. Besides, 4% of the faults on Ugbowo section of the network trips breaker CB₃ and inter-trip breaker CB₂, especially when the fault is accompanied by a very high surge. CB₂ and CB₃ do not respond to 6% of the total faults occurrence on the feeder. Power supply outage is not only caused by faults. Among other factors that contribute to outage period are: equipment limitation, poor system frequency, and periods when general

maintenance are being carried out. Although they occur less frequently, nevertheless they are worth discussing. It is however clear from the tables and the charts that the period of outage on Guiness feeder on a daily, weekly, monthly and yearly basis is very high. From the charts, over 80% of the total power supply outage results from forced outage. The increase rate of fault occurrence and outage period is not just a seasonal thing, but an all year round affair. This can be explained based on the fact that the network runs through bushy path, where the lines are susceptible to disturbance from trees and animals. Protection system equipment limitation is another major factor militating against the stability of the power supply on the feeder. Firstly, the route length of the feeder is too long compared to a normal 33kv transmission network. In a situation like this, to minimize the duration of power supply network, most especially T-off to bush paths.

V. CONCLUSION

Reliability is the soul of a good and effective protection system. Without reliability, the protection would be rendered fundamentally ineffective and could even become a liability. The main objective of every protection scheme is to keep the power supply stable by isolating only the component of the network under fault conditions while leaving the other in good working condition and operation.

From the analysis of the feeder, only 38% of the total fault occurrence on the feeder is selectively isolated. Other causes unusual disturbance to the system, thereby resulting to unsteadiness in the power system and lingering period of power supply outage. It is quite obvious that the reliability of the protection system on Guinness 33KV feeder is poor. A situation whereby CB_3 trips on fault at the same time inter-trip CB_2 , fault occurs along the network and thus, the protection system does not respond at all. The frequent tripping of CB_2 on fault condition contributes to the unpleasant inefficiency of the protection system on the existing feeder. It is evident that the protection scheme on Guinness 33KV feeder is unreliable.

VI. RECOMMENDATION

In order to improve the reliability of the protection system on Guinness 33KV feeder, the following are highlighted:-

 A minimum of three protective devices should be connected to the feeder network. One should be located at Welfare inspection substation, the next at EBS and the third, would be between Azagba village and Egba village. While, the one at Welfare injection substation to isolate the system from every faults occurrence on the feeder between EBS the final isolator will be from Azagba village to Egba village.

- 2. In order to enhance a simple and effective zoning of the protection system, it is proper that the existing protection system at Ugbowo Injection Substation be relocated to the position where Estate 33KV Isolator is located, and a replacement with the standard rating of the isolator should be effected, to isolate every fault on Ugbowo axis of the network.
- 3. Proper co-ordination of the protection system should be considered according to the zone or area of coverage for protection. The reliability of a protection system in place but mostly dependent on accurate setting of the protective mechanism. One of the major reasons why CB₃ inter-trip CB₂ is because of poor relay setting at the actual spot in order to trap faults on time.
- Trace clearing of trees close to transmission lines should be carried out at least twice in a year on the entire network of Guinness 33KV feeder as well as all distribution feeder networks.
- 5. Proper splitting of Guinness 33KV feeder into sub-feeders, would also help to reduce fault emergence or outcome.
- 6. Routine maintenance of the feeder's protection system should be carried out within a short period of time.

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