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Failure Events Analysis of Uninterruptible Power Supply (UPS) In Nigeria

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ABSTRACT: *This paper discusses the failure events trend analysis of uninterruptible power supply (UPS) system taking the Sokoto state experience as a case study. We identified and considered the manner and effects of failure events using empirical method to evaluate the quantities meantime to repair (MTTR) and mean time to detect (MTTD). The data obtained were analyzed using the method of weighted average to compute failure events probabilities. The results of this research show that UPS systems in Sokoto state, failed largely as a result of a significantly poor electrical supply, over utilization and excessive high temperature.*

Keywords: *Failure events, Maintainability, MTTR, MTTD, Weighted average*

I. INTRODUCTION

Nigeria ostensibly since the early 1980s has accepted information technology (IT) as a veritable resource in the country's quest for development technologically, economically and socially. The level of the development of electrical supply system of a nation is one of the factors which determine the socio-economic development of any country [1]. Sokoto state is characterized by energy crises such as voltage fluctuation and transient disturbances in the distribution network of the power supply so that a short term power supply system like UPS becomes inevitable to meet the demand of the constant power demanding equipments like computer system and peripherals which constitutes major component of IT. It is therefore obvious that every UPS will eventually fail which consequently effects the computers and peripheral(s) [1, 2]. The distribution of end users cuts across private establishments, government agencies, educational institutions, recreational centers and the home. The pervasive use of the UPS system in the Nigeria has led to a number of issues, one of which motivated the authors into this research work. Worthy to be mentioned among the issues are: indiscriminate importation of UPS system into the country, after-sales support service availability, equipment quality assurance and maintainability, to mention a few. Equipment maintainability is the central point in this paper

1.1 Problem Definition

According to [5], maintainability is a statistical expression of the quantity mean time to repair (MTTR) that is required in viability analysis. Viability is a concept used in the architecture and engineering of digital UPS measure of a system's capability–performance and reliability. In practice and in theory, a system that cannot fail is unachievable. So therefore, it is obvious that every UPS can and will eventual fail [1]. Hence, it remains to consider the manner and effect of those failures and the cost of minimizing them. In this paper, we identified the various manner failure occurred in UPS over five year period and the effects of those failures on MTTR.

The justification of this study will be its application as an information system base to:

- Government regulatory bodies responsible for policy formulation and monitoring as it affects imported good standardization such as standard organization of Nigeria (SON), customs and exercise department etc.
- Federal office of statistics and Federal Ministry of Trade and Industries.
- Universities and research institutions.

II. LOCATION OF STUDY

The empirical data used for analysis were gathered from the equipment maintenance centre Usmanu Danfodio University Sokoto. In addition to the empirical data, interviews were also organized with selected UPS servicemen in Sokoto metropolis.

2.1 Sample Used in the Study

S/No	MODEL	YEAR OF MANUFACTURE (YM) YR	YEAR OF 1ST FAILURE (YFF) YR	MTTF= (YM–YFF) YR	DIAGNOSIS	REMARKS
1	BK650MI	2005	2007	2	Bad o/p Transfer	Repaired
2	BK650MI	2007	2009	2	Blown MOV	Repaired
3	BK650MKI	2005	2006	1	Blown FET	Repaired
4	BK650MI	2005	2006	1	Blown FET	Repaired
5	BK650MI	2005	2007	2	Blown MOV	Repaired
6	BK650MI	2005	2006	1	Blown MOV	Repaired
7	BK650MI	2005	2006	1	Blown MOV	Repaired
8	BK650MI	2005	2006	1	Blown MOV	Repaired
9	BK650MI	2007	2008	2	Blown MOV	Repaired
10	BK650MI	2005	2006	1	Blown MOV	Repaired
11	BK650MI	2005	2006	1	Blown FET	Repaired
12	BK650MI	2007	2009	2	Blown MOV	Repaired
13	BK650MI	2007	2008	1	Blown FET	Repaired
14	BK650MI	2005	200	1	Blown FET	Repaired
15	BK650MI	2007	2009	2	Blown FET	Repaired
16	BK650MI	2005	2006	1	Blown FET	Repaired
17	BK650MI	2006	2009	3	Bad o/p ransformer	Repaired
18	BK650MI	2005	2008	3	Bad battery	Repaired
19	BK650MI	2005	2008	3	Not charging	Repaired
20	BK650MI	2005	200	2	Bad battery	Repaired
21	BK650MI	2005	2006	1	Blown board	Repaired
22	BK650MI	2006	2007	1	Blown FET	Repaired
23	BK650MI	2007	2009	2	Not charging	Repaired
24	BK650MI	2008	2010	2	Blown FET	Repaired
25	BK650MI	2009	2010	1	Blown MOV	Repaired
26	BK650MI	2005	2006	1	Blown MOV	Repaired
27	BK650MI	2005	200	1	Blown MOV	Repaired
28	BK650MI	2005	2006	1	Blown FET	Repaired
29	BK650MI	2005	2006	1	Blown FET	Repaired
30	BK650MI	2005	2006	1	Blown MOV	Repaired
31	BK650MI	2005	2007	2	Blown FET	Repaired
32	BK650MI	2007	2008	1	Blown Board	Repaired
33	BK650MI	2006	2008	2	Blown FET	Repaired
34	BK650MI	2006	2007	1	Not charging	Repaired
35	BK650MI	2006	2007	1	Bad o/p transfer	Repaired
36	BK650MI	2005	2006	1	Bad Battery	Repaired
37	BK650MI	2008	2010	2	Blown MOV	Repaired
38	BK650MI	2008	2009	1	Blown MOV	Repaired
39	BK650MI	2009	2010	1	Blown FET	Repaired
40	BK650MI	2008	2009	1	Blown FET	Repaired
41	BK650MI	2005	2006	1	Blown MOV	Repaired
42	BK650MI	2005	2007	2	Bad o/p transform	Repaired
43	BK650MI	2006	2007	1	Blown MOV	Repaired
44	BK650MI	2005	2007	2	Blown FET	Repaired
45	BK650MI	2007	2008	1	Blown FET	Repaired
46	BK650MI	2008	2009	2	Not charging	Repaired
47	BK650MI	2008	2009	1	Blown board	Repaired
48	BK650MI	2008	2009	1	Blown FET	Repaired

49	BK650MI	2009	2010	1	Not charging	Repaired
50	BK650MI	2005	2007	2	Blown MOV	Repaired
51	BK650MI	2005	2006	1	Bad battery	Repaired
52	BK650MI	2005	2007	2	Blown MOV	Repaired
53	BK650MI	2005	2006	1	Blown MOV	Repaired
54	BK650MI	2006	2007	1	Blown FET	Repaired
55	BK650MI	2005	2006	1	Not charging	Repaired
56	BK650MI	2006	2007	1	Blown MOV	Re[paired
57	BK650MI	2005	2007	2	Blown MOV	Repaired
58	BK650MI	2005	2008	3	Blown FET	Repaired
59	BK650MI	2005	2006	1	Blown FET	Repaired
60	BK650MI	2006	2007	1	Bad battery	Repaired

Sample were drawn from various users ranging from individuals (staff and students), corporate (faculties, departments and units). We also noted, from interviews conducted with users as preliminary step to troubleshooting procedure that, large number of users deploy UPS as back-up for computer systems largely for word processing and very minimal number for data-base management activities.

2.2 Types of Samples: The type of samples belongs to the circuitry of the BK650MI UPS. A faulty UPS requires a high level manpower skill to diagnose its electronic circuitry and to effective repair it [2]. Failure rate analysis of 60 BK650 BK650MI UPS is given in the table below

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2.2 Tools and Troubleshooting Method

In the process of troubleshooting faulty equipment, a viva session is always arranged between the users and a serviceman. The importance of a viva session is:

- To establish the use to which the equipment being put.
- To picture the working conditions the equipment must have been subjected to and
- How and when the fault was noticed on the equipment.

Also, the main tool used for diagnosis is the multimeter (digital and analogue). The multimeter is used to test electrical components, both passive and active, for short, open-circuited situations and leaky functions [4]. Semi conductor components catalogue is also used to check out the characteristic of active components.

2.3 Mathematical Modeling

MTTR can be viewed as the measure of the expected time required to remove those events that have been accepted to constitute a failure in a device. On the other hand, MTTR may not be easily evaluated as the quantity mean time between failures (MTBF) which measures the expected time between conjunctions of events that are accepted to constitute the failure [5]. However, the time required to repair a malfunctioning device consists of the time to follow a sequence of many steps to a logical conclusion whose duration is uncertain. Therefore, there are steps required to accomplish compound measure of MTTR.

- Detecting that the failure has occurred
- Isolating the malfunctioning element
- Removing the malfunctioning element
- Obtaining a replacement by either repair or form a stock of spare elements
- Inserting the working element
- Verifying that the replacement works.

There is an imaginary stopwatch required to measure MTTR. The stopwatch is started only at the point of failure detection. But, the quantity Mean Time To Detect (MTTD) should be determined first before determining the result of MTTR. We can sufficiently model the number of trials until a successful repair as a geometrical random variable given the probability of successful repair [5, 6].

Moreso, the probability that a device is UP called the availability of the device. The availability of a device is given by

$$\text{Prob}_{(UP)} = \frac{MTBF}{MTBF+MTTR} \text{----------------------(1)}$$

While the probability that the device is down given by

Prob $_{(down)}$ = 1 – prob $_{(UP)}$ = $\frac{MTTR}{MTBF+MTTR}$-----------------------(2)

MTBF and MTTR should reflect the preventive maintenance policy put in place for the system. This is recommended because a device is down during maintenance period as well [6]. To achieve a good maintainability, a low MTTR value is desirable.

III. OBSERVATIONS

The period under review is five years (2005 – 2010). In the course of this investigation, we observed causes of faults. These faults are mainly electrical in nature. These faults are more difficult to diagnose and repair, so therefore contributing to large values of the MTTD and MTTR.

The following are the fundamental causes of electrical faults in UPS system from the user's perspective:

1. Over-usage (OU): this is a situation whereby the user was found to have subjected the equipment to a continuous working condition beyond the limit of the equipment under an unfavorable condition-high temperature [1].
2. Under-usage (UU): a situation found to be common with beginners. The equipment was perhaps used for a while, thereafter packaged and keep in store or long period under unfavorable weather condition such as excessive humidity [1,2,3].
3. Old-age (OA): a situation where in the equipment fails to function as a result of aged electrical components such as electrolytic capacitors with leaky di-electric, leaky diode function, weakened resistors and partial contacts [4]
4. Poor-power supply (PPS): Power supply refers to the quality of electricity available to the users to power their UPS. A poor state is synonymous to a situation of erratic and unstabilised electricity supply. The following conditions of electricity supply have been classified as poor [1, 3]:

   a. Brown-out: Brown-out is a condition of lower than normal power line voltage being supplied by local utility or generating equipment. This condition may be short term (minutes to hours) or long term (½ day or more). A power line voltage reduction of 8 – 12% is usually considered a brown-out.

   b. voltage upsurge beyond 20%

   c. power fluctuation
5. User-negligence (UN): User carelessness is another factor responsible for equipment failure. Newly acquired UPS systems have been reported faulty as a result of poor usage or handling. Very often we have found out the following:

   A. Power supply mis-matching (110/220 volts).

   B. exposure to unfavorable weather conditions such as excessive humidity, temperature, pressure and dust.

   C. Over current drainage

3.1 Maintainability Analysis

From empirical analysis carried out on equipment manufactured over the years (2005-2010). We have been able to estimate MTTR values ranging from 1 hour to 2 hours which have assumed an MTBF value of 10,000 hours that is equivalent to one year of span usually specified for hardware original equipment manufacturer [7].

The media value MTTR $_{(2005\text{-}2010)}$ = $\frac{1+2}{2}$

From equation (2) above

Pr_{DOWN} (2005-2010) = $\frac{1.5}{10000+1.5}$

Approx value = 1/10000

3.2 Data Analysis

We have adopted the method of weighted average in computing probability in this analysis. Arrival rate of equipment and frequency of faults occurrence were obtained from the repair centre log book.

Table2: Fault analysis for 60 BK650MI UPS

S/NO	PARTS	NO. OF OCCURENCE	% OF OCCURENCE
1	Blown Metal Oxide varistor (MOV)	23	38.33
2	Blown FET (Field Effects Transistor)	18	30.00
3	Blown Board	4	6.67
4	Bad Output Transformer	3	5.00
5	Bad Battery	6	10.00
6	Charging Problem	6	10.00
	TOTAL	60	100%

The result shows that Blown MOV and Blown FET accounts for the major faults that are associated with UPS in Sokoto state. Anti surge suppressor and stabilizer will serve as a measure against these problems.

IV. CONCLUSION AND RECOMMENDATIONS

For the system at hand, taken over five years, demonstrates and established the motivation for this study. Our motivation being a significant noticeable inverse relationship between the quality of service of UPS in terms of viability. Furthermore it is not overstatement that the same period under review, experienced a very high demand for UPS to support the constant demand of power by IT equipment, while quality of service was being jeopardized for cheap and huge quantity by importers. From the user's perspective, users suffered huge capital losses as a result of poor maintainability and availability of these UPS system.

The following steps are recommended for the viability and reliability of the UPS system in Nigeria

A .Provision of parallel configuration in the design so as to reduce the rate of failure of the components in the system

B. The design of UPS system that will consider the environmental as well as stress factors in Nigeria

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