J. Sci. Engr. Tech. 15 (3) : 8502 – 8511 October 2008

AUTOMATIC VOLTAGE STABILIZERS (AVSs) : CAUSES OF FAILURES AND SOLUTIONS

Hope Evwieroghene Orovwode* and S.T. Wara+
Department of Electrical and Information Engineering
Covenant University, Ota
Ogun State, Nigeria
E-mail : ejipe2002@yahoo.com GSM No: 08033528581

+ Present address : Department of Electrical and Electronics Engineering, Igbinedion University, Okada, Edo State, Nigeria
E-mail : docwarati@yahoo.com

* To whom all correspondence should be addressed

ABSTRACT

The causes of failures in various types of automatic voltage stabilizers (AVS) were investigated. It was discovered that the major cause of failure was principally overloading which resulted from the very low power supply from the supply authority thereby reducing the unit's capacity. The power rating of the stabilizers fell as the input voltage fell outside the nominal voltage range of 200V-240V. It was recommended that manufacturers should improve on their design in selecting the appropriate size of winding conductors, positioning of conductors (winding disposition) as well as forced cooling the unit. Consumers on the other hand are advised to purchase thrice the rating of the determined load capacity when planning to use or purchase the product so as to prolong the lifespan and get maximum benefit.

INTRODUCTION

Power supply authorities are by world standard obliged to supply power to consumers at ± 6% of declared voltage (corresponding to 415/230V in Nigeria). However, measurements at some consumer terminals give voltage values as low as 120Vac (45% of rated minimum) (1).

The low voltage supplied by Power Holding Company of Nigeria (PHCN) cannot operate efficiently most consumer equipment and lightings. The voltage supplied can be attributed to overloading of distribution transformers and long span of distribution network (2).

To solve this problem locally, consumers resort to the use of Automatic Voltage Stabilizers (AVSs) which are popularly called Stabilizers to raise the voltage to an acceptable level. Therefore, the use of AVSs is very necessary in Nigeria's power system at least for now. However, annually, a lot of money is being spent in the importation of this equipment due to their high failure rate. Technical details on the manufacturer's manual indicate that an AVSs can last up to 10 years without failing if properly utilized (properly rated and maintained) (3). Investigations reveal that AVSs hardly last six months with some consumers. This is a serious wastage of resources. This paper, therefore, focused on the types of failures, cause of failure of the AVSs and suggests possible solutions on how AVSs can be used so that its lifespan can be fully guaranteed.

The AVS is an equipment that has two sections: the auto-transformer and the electronic control sections (4). The auto-transformer is a type of transformer that has one continues winding with the input and output tapped at different points on the winding. The type of auto-transformer used in the AVS is a multi-tapped type. The auto-transformer can act as a step-up or step-down depending on the position of the input tap relative to the output tap. If the input is connected to terminals A and B, it is acting as a step up while with input connected to point C, D, E and F, it is acting as a step down (Fig. 1).

The electronic control circuit is responsible for sensing output voltage and switches automatically the input voltage terminal to an appropriate tap of the auto-transformer that would make the output voltage fall within the acceptable limits so it is an automatic tap changer for the auto-transformer.

Types and causes of failures in the AVSs

Failure in AVSs can be categorized as control circuit failure, switch failure and transformer failure.

Control circuit failure arises when the AVS cannot sense and instruct the appropriate switch to be energized. This could be as a result of electrical component failure from any or a combination of diodes, transistors, capacitors, resistors and integrated circuits. These components fail as a result of surges in the power supply system, aging or excessive current flowing in the circuit as a result of fault condition.

The switches which change the taps of the auto-transformer are electromagnetic relays, which could fail if the energizing coil is bad or the contacts are burnt due to arcing resulting from excessive current flowing in the contacts.

The most common failure is the transformer failure which arises when there is insulation breakdown. This occurs as a result of excessive current flowing and (I^2R) heat generated. Over loading and improper replacement of blown fuse could case this failure.

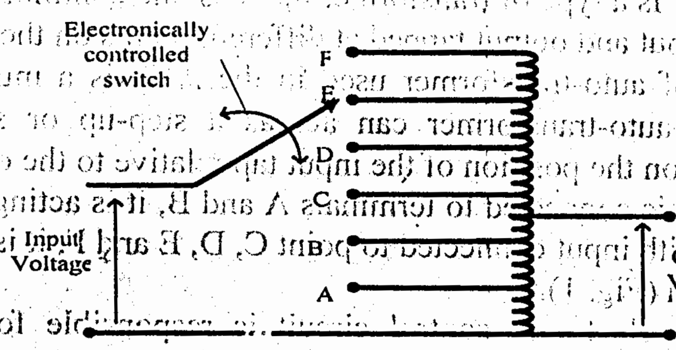

Figure 1 Schematic sketch of the AVS

MATERIALS AND METHOD

To investigate the cause of frequent failure of AVSs, measurement were carried out to know the actual voltage being supplied by PHCN to some selected consumers at six different locations in Benin City and Okada Crown Estate. The result is as shown (Table I).

Secondly, three shops where AVSs were repaired were visited to ascertain the types of faults reported to them by clients. Fifty samples were taken of ratings 500VA, 1000VA, 1500VA, 2000VA, 3000VA and 5000VA from different manufacturers (Super Master, Binatone, Century, Qlink etc). The statistics is as shown in the bar and pie charts (Table II and Fig. Fig. 2).

Thirdly, five burnt stabilizers were dismantled to observe and measure the dimensions of the copper wire used for the windings and the point where the coil burning starts from. The sizes of the conductors used in winding the various ratings of the AVS are as shown (Table III) (5).

Lastly, three units of AVS (1000VA, 200VA and 300VA) were put on an inductive load to obtain the input – output correlation and see the loading implication arising from the correlation (Table IV and Fig. 3).

V_p is the input voltage read from the voltmeter, I_p is the input current read from the ammeter

Present output power =

- $V_p \times I_n$ (for 100V – 220V)............ (1)
- $I_p \times V_n$ (for 240V – 260V).......... ..(2)

where I_n = rated power / normal output voltage (V_n) i.e. 220V

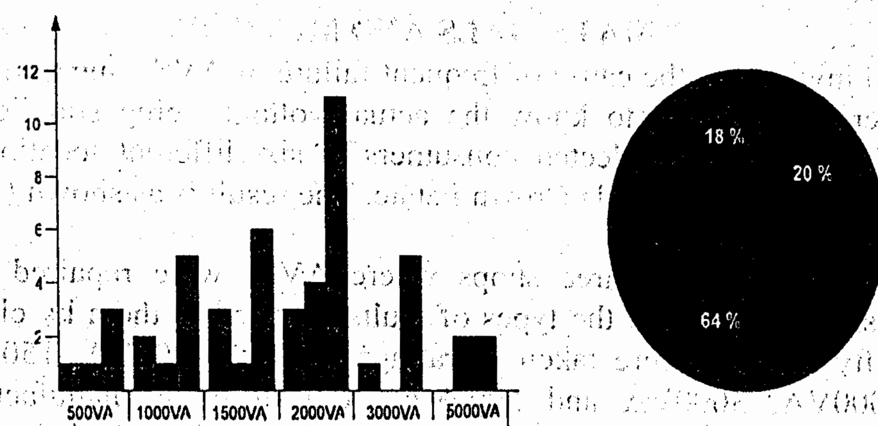

Fig. 2. Bar chart showing classes of faults for the 50 AVSs according to ratings selected and pie chart showing percentage of fault class

Key: RED = Control circuit fault, BLUE = Switching Device fault, GREEN= Transformer failure fault

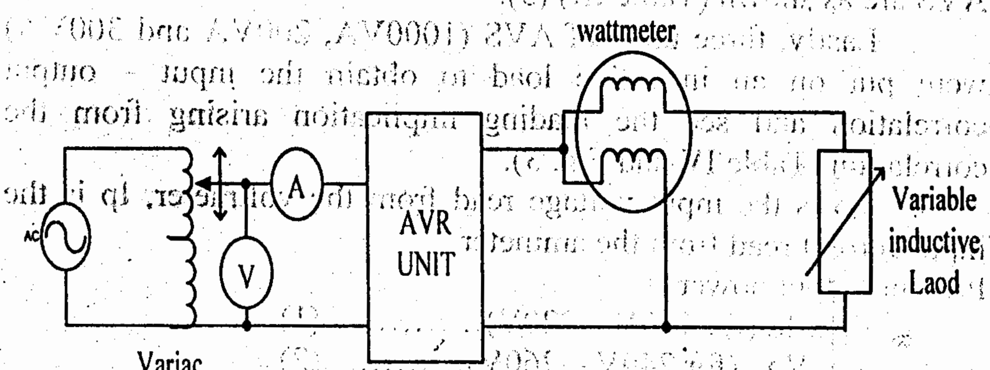

Fig.3. Experimental set-up to determine the input-output relationship of the AVS

RESULTS AND DISCUSSION

Table I. Voltage supply measurements taken at different locations in Benin City and Okada between 7-9pm

Location	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10
Ekenwan road	210	218	213	211	209	218	214	207	211	206
Ogba road	173	182	168	159	175	162	171	156	192	164
Urora village	124	152	147	119	136	139	142	139	133	128
Ekae village	205	216	202	218	212	198	203	208	201	205
Evbotubu qtrs	193	208	189	196	201	192	198	206	187	206
Crown Estate Okada	176	183	168	184	161	174	187	169	164	181

Table II. Classes of faults reported by AVSs users

AVS Rating	Quantity of faulty AVSs	Control circuit fault	Switching Device fault	Transformer failure fault
500VA	4	1	1	3
1000VA	8	2	1	5
1500VA	10	3	1	6
2000VA	18	3	4	11
3000VA	6	1	-	5
5000VA	4	-	2	2
Class percentage	Total =50	Total = 10 %=(10/50)x 100= 20%	Total = 9 %=(9/50)x 100= 18%	Total = 32 %=(32/50)x 100 = 64%

Note some AVSs have two or more of the faults classified hence the overlap.

Table III. Conductors used in winding different ratings of a brand of AVR

Rating (VA)	Smaller gauge			Bigger gauge		
	Standard wire gauge number	Diameter (mm)	Maximum current capacity of wire (A)	Standard wire gauge number	Diameter (mm)	Maximum current capacity of wire (A)
500	26	0.4572	2.2	22	0.7112	7.0
1000	24	0.5588	3.5	21	0.8128	9.0
1500	23	0.6096	4.7	19	1.0199	14.0
2000	22	0.7112	7.0	18	1.2199	16.0
3000	20	0.9144	11.0	17	1.4224	19.0
5000	18	1.2192	16.0	15	1.8288	28.0

Other brands vary in conductor gauge size by ± 1%

Table IVa. 1000VA input – output relationship

IV	IC	OP	POP	POPARO
100	10.04	1000	454.6	45.5
120	8.42	1000	545.5	54.5
140	7.22	1000	636.4	63.6
160	6.26	1000	727.3	72.7
180	5.56	1000	818.2	81.8
200	5.01	1000	909.1	90.9
220	4.57	1000	1000.0	100.0
240	4.17	1000	917.4	91.7
260	3.86	1000	849.2	84.9

IV = Input Voltage (Vp) IC = Input Current (A)
OP = Output Power (W) POP = Present output power (W)
POPARO = Present output power as % of rated output power

Table IVb. 2000VA input – output relationship

IV	IC	OP	POP	POPARO
100	20.01	2000	909.1	45.5
120	16.68	2000	1090.9	54.5
140	14.30	2000	1272.7	63.6
160	12.52	2000	1454.6	72.7
180	11.13	2000	1636.4	81.8
200	10.01	2000	1818.2	90.9
220	9.10	2000	2000.0	100.0
240	8.35	2000	1837.0	91.7
260	7.70	2000	1694.0	84.9

Table IVc: 3000VA input – output relationship

IV	IC	OP	POP	POPARO
100	30.03	3000	1363.8	45.5
120	25.02	3000	1636.5	54.5
140	21.44	3000	1909.2	63.6
160	18.78	3000	2181.9	72.7
180	16.68	3000	2454.6	81.8
200	15.01	3000	2727.3	90.9
220	13.63	3000	3000.0	100.0
240	12.51	3000	2752.2	91.7
260	11.55	2000	2541.0	84.9

It can be seen that all the locations were experiencing low voltages (Table I). Therefore, the use of AVSs was justified. AVSs installed in these areas were basically working as step-up transformers. The coils examined showed that the transformer starts burning from the common coil. The implication of this was that the common coil in sorely responsible for its operations hence more heat was generated in the inner oil. If this heat was not given rid off quickly enough, it can lead to insulation breakdown there by reducing the life of the transformers. Table II confirmed this since most of the fault associate with the AVS was transformer breakdown which is about 64%.

Table III revealed that at the input voltage of 120V, common coil was experiencing great stress as it was required to draw current more than its rated value to be able to deliver an output voltage of 220V at the rated power. This also endangered the life of the transformer.

Most importantly, the rating of the AVS drops as the input voltage fell outside the normal voltage which considering 220V ± 6% ranged between 206.7V – 233.3V. The results showed clearly that at the input of 100V, the present power of the AVS dropped to 48% of its rated value (Table 4a, b, c and Fig. 4). The AVS can only produce 90% of its rated power if the input voltage ranged between 188V and 230V.

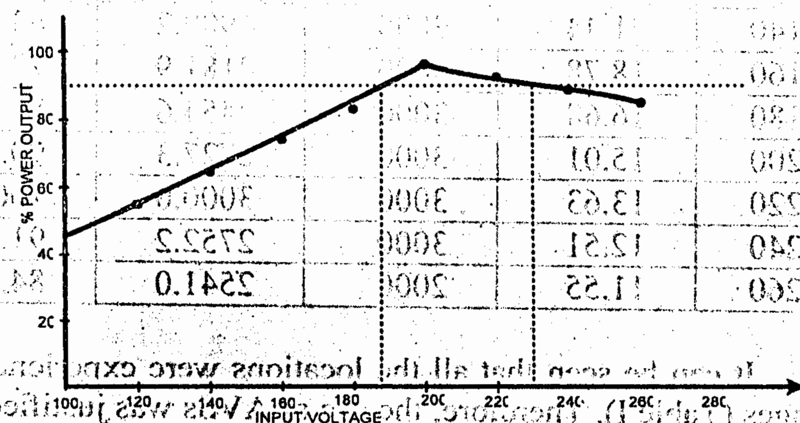

Fig. 4: Plot input voltage vs present output power as % of rated output power

RECOMMENDATIONS

The following points could be of interest to both manufacturers and users of AVS to ensure its full utilization

- Attempts should be made by manufacturers to locate the common inner winding outside during winding of the transformer so that the heat generated could be dissipated off easily and speedily.
- Forced cooling is recommended to enhance heat extraction during operation.
- For those users whose supply voltage drops to about 100V, the power rating of AVS to be installed should be thrice the load requirement as shown (Table V).

Table V. Load and recommended AVS rating to power it.

Load	Recommended commercially available AVR rating
500W	1000VA – 1500VA
1000W	2500VA – 3000VA
2000W	3000VA – 5000VA
3000W	5000VA
5000W	10,000VA

CONCLUSION

The study has revealed the causes of failure of the automatic voltage Stabilizers (AVS). It was discovered that the major cause is overloading which results from very low power supply from the supply authority. It has been shown that the power rating of the AVS falls as the input voltage falls outside the normal voltage range of 200V-240V. Therefore, users of AVS should bear this in mind whilst purchasing the product. Thrice the rating of the load is recommended so as to prolong the life span of the AVS and to deliver the required output without excessive over heating of the common winding. Though it costs more initially, it is cheaper in the long run considering the cost / benefit ratio.

REFERENCES

1. Kuale, P. A. Safety and reliability in power systems. Conference Proceedings, Nigerian Institute for Biomedical Engineering, October, 2000.
2. Cotton, H., Barber, H. Transmission and distribution of electrical energy, 1985 ed. Hodder and Stonghton, New Jersey, USA. 1985.
3. Binatone Stabilizer technical manual, Binatone international, United Kingdom.
4. Sawhney, A.K. A course in electrical machine Design. Dhanpat Rai and Co. Ltd., New Delhi. 2001.
5. http://www.powerstream.com

(Accepted 04 August 2008)