Construction and evaluation of a power inverter.

AKINYELE, O.A., AREMU, D.O., OGUNLOWO, Q.O., AZEEZ, A.A., BABAJIDE, N.A., OGUNLADE, C.A. and ALAKA, A.C.

2015

Construction and Evaluation of a Power Inverter

Akinyele, O. A[1]. Aremu, D. O.[1], Ogunlowo, Q. O.[1], Azeez, A. A.[1], Babajide, N. A.[2] and Ogunlade, C. A.[3], Alaka, A. C.[3]

[1]*Department of Agricultural Engineering, Federal College of Agriculture, Moor plantation, Ibadan.*
[4]*National Rice/Maize Center, c/o Federal Dept. of Agric., Moor Plantation, Ibadan.*
[5]*Department of Agricultural& Environmental Engineering, University of Ibadan, Nigeria*

Abstract: **Due to the erratic power supply in some parts of the World, it is imperative to source for an alternative to the municipal power supply; power generators are uneconomical and generate undesirable noise when in operation. Thus, a power inverter was designed and constructed as an operational unit to serve as an automatic supply unit in case of interruption in the main supply of power and hence reduce power failure for rural and commercial usage. The main objective of this study was to construct and evaluate the performance an electrical power inverter. It was constructed according to the rules and regulation of International Electronic Engineering Standard. Materials used for construction and evaluation of the inverter were carefully sorted and selected locally considering strength, availability, durability and cost. The main component parts include transformer, relay, capacitor, socket, alternator, multi-vibrator, resistor, integrated circuit and transistor. The efficiency was obtained by varying the load on the inverter and measuring the respective power output. The inverter has the highest efficiency of 97.40% at a load of 75W and lowest efficiency of 71.70% at a load of 600W. It was also observed that there is a decrease in the output of the machine when there is a high increase in the load. The inverter can be used for commercial purposes due to its availability in terms of material for construction, strength, its efficiency, conversion of direct current to alternating current and it can also be adopted for use in agricultural establishments.**

Keywords: power inverter, load, efficiency, alternating current, direct current

I. INTRODUCTION

A power inverter is any electric power converter that changes direct current (D.C) to alternating current (A.C). Solid state inverter have no moving part and are used in wide range of applications from small switching power supplies in computers to large electric utility, high voltage direct current application that transport bulk power. Inverters are commonly used to supply AC power from DC sources such as solar panels or batteries. The inverter performs the opposite function of a rectifier. The electrical inverter is a high power electronic oscillator. It's so named because early mechanical AC to DC converters was made to work in reverse and thus was "inverted" to convert DC to AC (Grant, 2003). Electricity, for sometimes now has been one of the most useful source of energy. Its usefulness sterns from the various uses it is put to, its availability and ease of conversion from other source of energy above all. There is no by-product and residual during and after the usage of an inverter. People look on to electricity as a sort of necessities in their lives depending so much on it continued availability as it place such a prominent role in the normal function of the household. An inverter is expected to have a power output of about 1500 watts AC, used mainly for operation purposes with the added ability to charge a battery as it is main source of electric energy (Grafham, 2003; Bedford, 2006 and Bailu, 2003). Due to the erratic power supply in some parts of the World, it is imperative to source for an alternative to the municipal power supply, generators have been designed but it was found to be quite uneconomical, considering the initial high capital and running costs and accompanying undesirable noise when in operation. A power inverter was designed and constructed as an operational unit to serve as an automatic supply unit in case of interruption in the main supply of power and hence reduce power failure in affected societies at affordable cost for rural and commercial usage. The main objective of this study was to construct and evaluate the performance an electrical power inverter.

II. MATERIALS AND METHOD

The power inverter was constructed according to the rules and regulation of International Electronic Engineering (IEEE, 1999). Materials used for construction and evaluation of the inverter were carefully sorted and selected locally considering strength, availability, durability and cost at Ifeleye Area of Ibadan, Oyo State, Nigeria. The major components are highlighted below:

i. Transformer: a major application of transformer is to increase or decrease the voltage before transmitting electrical energy over long distance and to dissipate electrical energy at a rate, proportional to the square of the current through the wire by transmitting electrical power to a high voltage and therefore low current if necessary for transmission and back afterward, it enables transmission of power over long distances. The transformer has two outlets; primary and secondary coil. The primary coil is been connected to the 12v battery which serves the inverter (input), while the secondary coil is the output of the inverter as presented in Figure 1a.

ii. Capacitor: designed to store energy inform of electric charge (Corzine, 2003). It is measured in Micro-farad (μf) and presented in Figure 1b.

iii. Alternator: an automotive charging system is made up of three major components, the battery, voltage and an alternator, the alternator works with the battery to generate power for the electric component. Alternator converts Alternating current (AC) to Direct current (DC). Adapter takes the A.C from a wall outlet and converts it to the D.C that electronics and appliances need, it regularly reverse the direction of its flow in a repeating, cyclical pattern. Ac is the dominate from of power because it can be transformed and transported over long distance.

iv. Relay: an electrical controlled switch whose action is controlled by an electric energy applied to its coil terminal. It consists of two main part the control unit and switch unit.

v. Multivibrator: multivibrator are in two state (high or low) output circuit, multivibrator are mostly used in application, which involve timing pulse generating or pulse triggering of other device. It implements a variety of simple state system, such as oscillator, timer and flip-flop. It's characterized by amplifying devices (transistor, electron tubes). It generates a square wave high level of harmonics in output. It contains capacitor (5uf).

vi. Fuse Holder: located within 5 inches to the panel, fuse was to protect any short circuit in the inverter, additional fuse holder may be required if the inverter is connected to the engine battery instead of the alternator. The fuse holder was installed in an airtight battery compartment.

vii. The Inverter Case: made up of steel metal measuring about 190mm in width, while the breadth was 350mm, and the height of the case was 200mm, it's made in form of box with the front side protruding outwards as it's approaches the top and the case was perforated for good ventilation.

viii. 13AMP Socket Output: output is one of the component inverter we have to put into consideration when designing inverter, because of the output wave-form in terms of peak and RMS (Root Mean Square) values, the output contain transistor with 300w capacity.

ix. Ducted Board: contains the arrangement of the resistor, transistor in type placed on the ducted board for controlling the aspect of the output as appropriate to specific inverter design.

x. Heat Sink: is an environment or object that absorb and dissipates heat from another object using thermal contact (either direct or radiant).

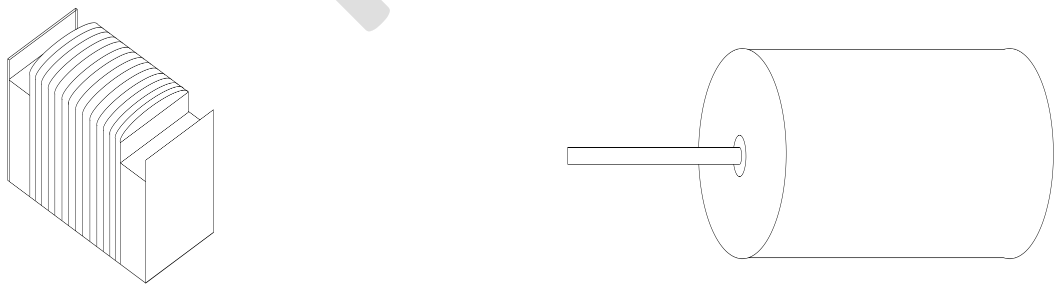
xi. Regulators: A device which has the function of maintaining a designated characteristic in multivibrator.

xii. Transistor: is a semi conductor device commonly used to amplify or switch electronic signals.

xiii. Diode: is a semi conductor device with two terminals, typically allowing the flow of current in one direction only.

xiv. Integrated circuit: is a miniaturized electronic circuit (consisting mainly of semiconductor devices, as well as passive component) that has been manufactured in the surface of a thin substrate of semiconductor materials.

xv. Resistor : it's a two – terminal electronic component designed to oppose an electric current by producing a voltage drop a voltage drop between its terminal in proportion to the current that is in accordance with ohm's law,V=IR.



a b

Fig 1: a-Transformer, b- capacitor

2.1. Methodology

The resistor was connected to the gate (G) of the transistor, the three leg of the resistor was connected to the transistor gate on the ducted board, and Drain (D) is pulled down behind (G) and connected with the resistor, one after the other. Source (S) is the third leg of the transistor, pulled to other side of the drain (D) so as create convenience in the connection process, each source of the resistor was connected together with a wire so as to avoid wrong electric voltage source damage. Each of the resistor legs was connected to the gate in parallel to each other, by leaving the way in connecting the source with a copper wire. The gate leg was labelled (G). The same method was applied at both side of the multivibrator, the two stranded wires that comes out was connected to the output of the inverter. The transformer wire (primary coil) was connected to the d1 of the output while the positive side of the battery was connected to the relay. All the wire used was in stranded, copper conductor for vibration resistance, and most also being protected. The transformer was screw to the back side, also the output connected to the multivibrator while the relay is mounted at the front side, indicator light mounted on the front side together with the output of the inverter which was fed to the load via 13Amp socket mounted on the bottom side for good ventilation. The machine was evaluated by varying the amount of load and obtaining the input and output power with time, the efficiency was however evaluated using Equation 1. The description, unit and total price of the materials used for the construction of the inverter is presented in Table 1,

$$\text{Efficiency } = \frac{\text{output power}}{inputpower} x\,100 \qquad (1)$$

Table 1: Construction Materials and their Specific Cost

S/N	Description of materials	Quantity	Unit Price(₦)	Total Price(₦)
1	Transformer	3	900	2,700
2	Capacitor	3	250	750
3	Resistor	17	50	850
4	Transistor	20	60	1,200
5	Diode	8	100	800
6	Socket	1	300	300
7	Plug	1	100	100
8	Relay	3	450	1,350
9	Alternator	1	5,000	5,000
10	Fuse holder	1	100	100
11	Multivibrator	2	5,000	10,000
12	Inverter case	2	2,000	4,000
13	Ducted board	3	900	2,100
14	Light indicator lamp	5	150	750
15	Switch	2	150	300
16	Heat resistance (stranded wire)	½	2,800	2,800
17	Display voltmeter	1	1,500	1,500
18	Inverter handle	1	500	500
19	Screw	12	25	300
20	Transportation			1,000
21	Miscellaneous			2,000
	Grand Total			**39,000**

III. RESULTS AND DISCUSSION

The result obtained from the machine performance tested is presented in Table 2.

Table 2: Evaluation of the Power Inverter

Trial	Load (W)	Input (V)	Output (V)	Input Current (A)	Output current (A)	Efficiency (%)
1	0	12.63	242	0	0	0
2	60	12.63	229.1	8.43	0.42	90.40
3	75	12.63	236.1	6.30	0.27	80.95
4	120	12.63	232.1	8.45	0.39	84.80
5	600	12.32	220	6.11	0.22	71.70
Mean	171	12.57	231.86	5.89	0.26	65.57
SD	243.63	0.14	8.20	3.46	0.17	37.28
Min	0	12.32	220	0	0	0
Max	600	12.63	240	8.45	0.42	90.40

3.1. Discussions

From the result obtained from the evaluation of the power inverter, the efficiency of the inverter decreases with increase in the output load of the inverter. Therefore to operate the inverter more efficiently, it is advisable to operate the inverter below its maximum rating of maintaining the standard of the inverter. The voltage of the battery used for the evaluation was 12.0V (75 AMP) in order to obtain a good charging characteristics, a voltage well above 12V battery is needed so that 24V winding of the 12V centre tapped transistor is used to control the system circuit and it's advisable to use 200AMP battery to ensure the long serving duration of the inverter when it is on load.

From the result obtained, it could be said that in a case where there is no load acting on the machine, the efficiency of the machine is said to be at 0%. It could be deduced that the machine had the highest efficiency of 97.40% at a load of 75W and the lowest efficiency of 71.70% at a load of 600W. It was also observed that there is a decrease in the output of the machine when there is a high increase in the load. After necessary calculations, the machine is said to have an average efficiency of 65.45%

3.1.1 Effect of Load on Efficiency of the Machine

From the result obtained from the evaluation of the power inverter as shown in Table 4.1 above, it can be shown when the load is high, there is a decrease in the efficiency of the machine while a decrease in the load of the machine, there is an increase in the efficiency of the machine as shown in Fig. 2.

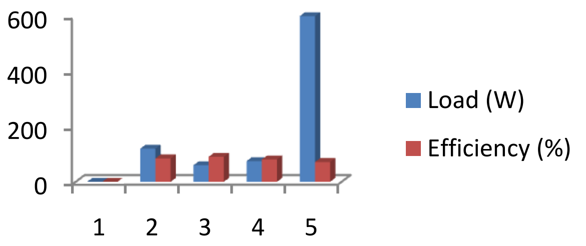


Fig 2: Relationship between load and the efficiency of the machine

IV. CONCLUSION

It can be deduced that the machine had the highest efficiency of 97.40% at a load of 75W and the lowest efficiency of 71.70% at a load of 600W. It was also revealed that there is a decrease in the output of the machine when there is a high increase in the load. After necessary calculations, the machine is said to have an average efficiency of 65.45%. However, the machine can be improved in order to obtain a good performance characteristic by using a voltage above 12V battery voltage to power the inverter. The inverter can be used for commercial purposes due to its availability in terms of material for construction, strength, its efficiency, conversion of direct current to alternating current and it can also be adopted for use in agricultural establishments.

REFERENCES

[1] Bailu M. O. (2011). Power Inverter Manual Fourth edition volume 4, pp 56-59 ISBN 890265011403 Published in India by Scorix Printers.

[2] Bedford A. O. (2006). MIT open-courseware, Power Electronics, Journal on Spring 2006 Seminar.

[3] Corzine F. R. (2003). Multi-level converters. The Hand book on power electronics, power electronics letters, volume 4, number 4, pp 115-119, 120-130, 2003.

[4] Ferguson E. O. (1999). Electric&electronicshttp://web.eecs.utk.edu/~tolbert/publications/ecce_2011_bailu.pdf 11th Oct, 2013.

[5] Gaulard W. O. & Gibbs A.W. (2009).The Great electromagnetic induction book. Pp 75-81 ISBN976-1-58008-122-1

[6] Grafham D.R. (2003). editors, ed. (1972). SCR Manual (Fifth ed.). Syracuse, N.Y. USA: General Electric. pp. 236–239, 242-248. Publication Division of Power inverter Construction and Development co.

[7] Grant S. O. (2003): The Authoritative Dictionary of IEEE Standards Terms, Seventh Edition, IEEE Press, 2000,ISBN 0-7381-2601-2, page 588

[8] Gurdjian and Maxwell (2009):http://www.wpi.edu/Pubs/E-project/Available/E-project-042507-092653/unrestricted/MQP_D_1_2.pdf

[9] IEEE (1999) Institute of Electrical Electronics Engineers;www.ieee.org. Retrieved 2011-01-28.

[10] JEEC, (2012): Inverter future.www.jeec.org/the-inverter/all-important-element-required-by-moderm-inverters/

[11] Jordan K. S. (1999):"Power Electronics: Energy Manager for Hybrid Electric Vehicles". Oak Ridge National Laboratory Review (U.S. Department of Energy) 33 (3). 2000. Retrieved 2006-11-08.

[12] Owen, Edward L. (2003): "Origins of the Inverter". IEEE Industry Applications Magazine: History Department (IEEE) 2 (1): 64–66. doi:10.1109/2943.476602

[13] Rodriguez, Jose;Hey J. C. (2002): "Multilevel Inverters: A Survey of Topologies, Controls, and Applications". IEEE Transactions on Industrial Electronics (IEEE) 49 (4): 724–738. doi:10.1109/TIE.2002.801052

[14] Webber N.H. Barnes, Malcolm (2003):Practical variable speed drives and power electronics. Oxford: Newnes. pp. 97.ISBN 0080473911.

[15] Yablockkav P. A. (2006):http://web.eecs.utk.edu/~tolbert/publications/ecce_2011_bailu.pdf