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The Design, Construction, and Expert Appraisal of A 220v Inverter

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ABSTRACT

This project is about the design and construction of a 220 volts inverter at a frequency of 50Hz. The device is constructed with locally sourced components and materials of regulated standards. The basic principle of its operation is a simple conversion of 12V DC from a battery using integrated circuits and semiconductors at a frequency of 50Hz, into a 220V AC across the windings of a transformer. A battery charger is used to charge the battery using an intelligent digital display charger. This project (device) offers a better alternative to Public Power Supply, Generators as well as UPS considering it is cost-effective, noiseless, and easy maintainability. It was concluded that the inverter was constructed with considerable cost, available and reliable components rather than the more exorbitant unavailable ones. It was however recommended that the Government at various levels should encourage engineering practice by financing and training engineering within and outside the country for the benefit of the students and the nation at large.

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1. INTRODUCTION

Electricity supply is one of the economic infrastructural facilities that are indispensable to a nation's economic development (Valensia *et al.*, 2021). The efficiency of the supply of electricity will not only influence returns on investment on existing enterprises, but it also plays a major role in the creation of an economic environment that influences decisions on the potential investment. The electricity which is the main source of power for our domestic consumption, industrial development, the center of learning, and medical centers should be rehabilitated into the enhancement of productivity. However, power failure has resulted in people buying generators for their daily activity. Other businesses are also not functioning due to the absence of a constant power supply.

These are the reasons that necessitate the designing and construction of inverter and other standby systems that can deliver maximum output power to the load (Lee *et al*., 2006). As society grows from simple to complex, mankind began to spread all over the earth and so it becomes necessary to enjoy power using the inverter. Statistics have shown that the number of business that has been closed simply because of power problem and cannot be overemphasized, so mankind need inverter seriously in other to restore technology development, businesses, communications, learning center and medical centers.

Incessant power failure is endemic to the power supply system in Nigeria today causing disruptions in almost all spheres of life including research institutions. Most experiments in our University laboratories and research institutes are not finalized and concluded due to the epileptic nature of our public power supply system. Forwarded research on this issue (dc to ac inverter) will provide a partial or lasting solution to this end if properly harnessed. Moreover, the proposed automatic inverter system will provide an alternative power source to research students and scientists in remotes locations where electricity is not accessible. On recreational grounds, it can be used during tourism, outdoor parties, and picnics.

Electric power interruptions are quite common in every place, especially after a heavy downpour or a severe storm (Khan *et al*., 2015). To counter this power outage, a search has been to find a reliable and economical alternative source of electricity. An inverter (or dc-to-ac converter) is a device for converting direct current (DC) into an alternating current (AC) (Evalina, 2019). An automatic switching standby source of power supply is in no doubt required, especially, in laboratories for experimental and/or research purposes as well as in household electrical appliances. The quest for an automatic alternative source of power supply to supplement erratic power supply is the rationale behind this automatic inverter system design and construction.

An inverter is a great tool used to run household/office appliances, where there is no electricity. The input voltage and frequency of the inverter may be fixed or it may vary depending on its application. Inverters find several applications of which are the valuable speed, alternating current motors, uninterrupted power supply, etc. They can be used as the front stage of dc-to-dc converter. Standby inverters are mostly used to provide emergency supply to the main frequency (50Hz). In the event of the main failure, the inverter immediately operates with no loss of waveform. This unique ability makes it related to an automatic change over switch but it differs in a way in that it has a battery, which stores energy when the mains is on and gives out energy when the mains is off while the automatic change over switch operates on contactor (open and close).

There are many types of inverters (Kavya *et al*., 2019), but they all have the same principle of operations and it all depends on the component used, whether with a thyristor or a bipolar junction transistor for switching the current ON/OFF. The need for man to prevent his

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activities from being interrupted in order not to render it incomplete which may subsequently become an unfinished job (loss of files in the computer when there is a sudden power outage) has motivated engineers across the globe to design a device which will be more economical, durable and efficient.

It is pertinent to note that in a well-organized company in a developing country like Nigeria, where a lot of transactions are made, if there is an epileptic power supply, the flow of transactions will greatly be hindered and there will be no open ground for the infant companies to spring up and wax great. Power should not be an obstruction between companies and their maximum profits, in essence, makes the use of a power inverter relevant and recommended to all and sundry. Hence, the need for the design and construction of a 240-VA inverter. Finally, the success of this study will be beneficial to society at large. Mass production of inverters will lead to improving the standard of living of the populace and the nation will move forward in its pursuit of technological development.

The primary aim of engineers in society is to solve the problems militating against technological growth, provide solutions to challenges facing humanities, and bringing about an efficient flow of ideas and innovators in the world of technology throughout society and all nations of the earth. The inverter is that device that is being employed by the engineers to tackle and support the power supplies. This support comes to play when there is a power outage. Immediately, the power inverter begins to act in place of the main power. The inverter is used in the conversion of direct current to a conventional alternating current, but the need for reliable and more efficient, stable power supplies make the inverter indispensable especially in a developing country like Nigeria where there is an epileptic power supply.

Although the electric power in an alternating current form is very difficult to store due to power loss, which is associated with the alternating current and when converted, it can be stored in the battery of which can be recharged. The epileptic power supply in Ilorin is alarming as most workers are limited in their duty due to power outages. Even inside the university of Ilorin, there are some occasions where the outage of power jeopardize academic and administrative activities. Thus, the research will construct a 240-VA inverter which could be of help to a section within the department to stay on power whenever there is a power outage.

This project aimed to design and construct a 240-VA inverter. The objectives were to:

(i) design a circuit that will convert dc to ac power for various appliances used in the domestic home.
(ii) provide a noiseless source of electricity generation with low maintenance cost and zero fuel cost.
(iii) a source of generating electricity that has no negative effect on the environment (i.e. no greenhouse effect).
(iv) determine expert rating on the developed Inverter.

Research questions are

(i) how can a circuit that will convert dc to ac power for various appliances used in the domestic
(ii) home be designed?
(iii) how can a noiseless source of electricity generation with low maintenance cost and zero fuel cost be generated?
(iv) how can a source of generating electricity that has no negative effect on the environment be generated?
(v) How do experts rate the developed Inverter?.

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2. METHODS

This project is about the design and construction of a 220 volts inverter at a frequency of 50Hz. The device is constructed with locally sourced components and materials of regulated standards. The basic principle of its operation is a simple conversion of 12V DC from a battery using integrated circuits and semiconductors at a frequency of 50Hz, into a 220V AC across the windings of a transformer. A battery charger is used to charge the battery using an intelligent digital display charger. This project (device) offers a better alternative to Public Power Supply, Generators as well as UPS considering it is cost-effective, noiseless, and easy maintainability.

3. RESULTS AND DISCUSSION

3.1. Research Question One: How can a circuit that will convert dc to ac power for various appliances used in the domestic home be designed?

Testing of components is important during construction to ensure that the works compiled together are perfect with their specifications. Testing is also essential during operation and after the completion of the construction made to determine the longevity of the inverter to detect common faults that may arise. There are sequences of tests needed to undergo for any successful project.

(i) Component testing
(ii) System testing

Every component was tested simply to ensure that each was in good condition before assembling on the board. The major test carried out on these components was continuity testing done with the use of multi-meter-like transistors. The test made on transistors was used to test each terminal of a transistor. Polarity testing was also performed on some components like a diode, capacitors, etc.

This involves the testing of the entire circuitry and thus, examine it for errors like short-circuits, lead flux, joining unwanted links. Proper insertion of IC pin layout and also checking if ICs of these pin numbers are slotted in their proper base. After checking, cross-check again before powering the system.

It was observed that components used for the construction are not predominantly static, electronic data books played a major role in identifying other available components in the absence of one.

The first section that was carried out was the MOSFET arrangement which was tested and was found working. The second was the oscillating circuit while the third is the charging circuit.

All the circuits were tested and found to be working. The MOSFET arrangement later developed some problems likewise the oscillating circuit, the problems were later resolved after consulting the supervisor and our senior colleagues.

3.2. Research Question Two: How can a noiseless source of electricity generation with low maintenance cost and zero fuel cost be generated?

The MOSFET used for this project is IRF3205 and the drain current rating of the MOSFET is 100A (at 25^0C). By considering the increase in temperature (let say 100^0C), the drain current rating is taken as 105A. This is because as the temperature increases, the drain current also increases. Therefore, the drain current is taken as 105 A. Then, when inverter power rating = 240 VA, the value of input voltage is 12 V. Therefore, to determine the current, it will flow in the input circuit: P = I.V . Therefore, I = 240 VA and I = 20A.

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The frequency of oscillation is set to 50Hz. This is determined by the values of the charging resistor R_A and R_B, capacitor C_1 and discharging resistor RB. To obtain approximately 50% duty cycle, the value of R_A is set to 1 kΩ (See **Figure 1**).

This is the final and output section of the inverter circuit is always steps up transformer to increase the ac voltage generated. The transformer determines the power of the inverter. For our project (i.e. 240VA inverter) a 12V/220V step up center-tap transformer was used.

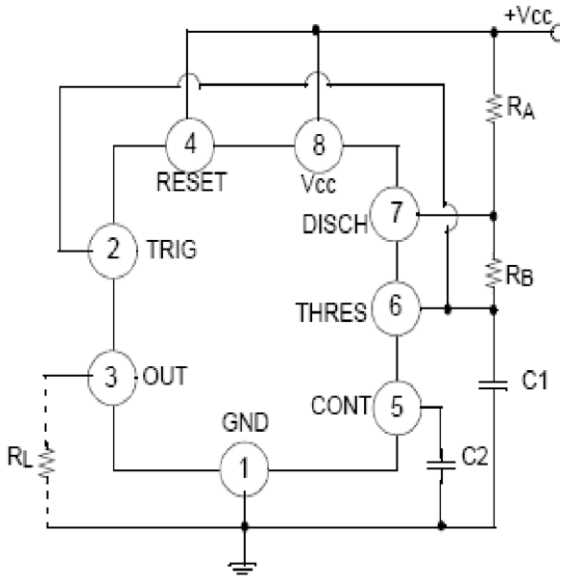

Figure 1. The circuit diagram of astable multi-vibrator circuit using NE555IC.

3.3. Research Question Three: How can a source of generating electricity that has no negative effect on the environment be generated?

The power rating of the inverter is 240 VA. Therefore, at the input (primary side), and V = 12V, P = 240VA. Therefore, I = 20 A. At the output (secondary side), V = 220 V, and P = 240VA, we can get $I = \frac{P}{V} = \frac{240VA}{220V}$ and I = 1.09A.

After all stages had been coupled, the output of the inverter was tested. This was done by first connecting a voltmeter to the output terminal of the inverter to test the output voltage. A mobile phone and a laptop were connected to the output terminal of the inverter to see if it charges at a desirable rate.

A new casing was purchased, and also a cover board to produce a neat and durable production. We ensured that the casing purchased contains a ground wire to give it a proper earthling (see **Figure 2**).

The sections were assembled in the casing properly and carefully to avoid destroying the circuit arrangements. We also ensured that the assembling does not create an avenue or chance for a short circuit and so, we connect the circuit to a ground wire.

It is often easier while assembling the components on the board to erect them according to their height. That is, the lowest components first, usually the resistor and other tiny ones while others with higher height follow. Care was taken in getting the polarity of components (e.g. a diode, electrolytic capacitor, etc) before they were being soldered on the panel. Also, the biasing of the transistor was vividly ascertained before permanent soldering on the board was carried out.

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Figure 2. Casing of the inverter**.**

The use of an IC socket was employed to avoid any damages that might result from excessive heat while soldering the IC. The pin configuration of the IC used and its connectivity with other components on the board was strictly adhered to as shown on the design work before the socket was permanently soldered. In fact, the IC socket was the first item on the board while other components were placed around it (**Table 1**).

This is a way of identifying, tracking, and locating faults for immediate rectification. Problems may result from inadequate soldering and most likely be the reason why the circuit may not work. Other reasons may be due to electrical contact between the leads of the component, excessive voltage supply to the circuit (in case of using an adapter), etc. Soldered joints were carefully checked under a bright light to ensure adequacy. All components were also checked to make sure they were in their correct position on the board. The voltmeter was used to check voltage at various points on the circuit was also embraced to follow the connection tract.

Maintenance and repair of an inverter are tedious to carry out. It involves the technical know-how of an individual to put together his garnered experiences to properly handle the repair of an inverter. Nevertheless, some routine maintenance checks may be carried out for precautionary and safety measures. Some of these maintenance checks are:

(i) Check for proper ventilation in the inverter which is provided by the cooling fan.
(ii) Ensure proper charging of the battery to avoid overcharge of battery which may cause damage to the battery.
(iii) The battery terminal should be checked regularly to ensure proper supply to the inverter.

Other maintenance and repair can also be carried out at the different stages of the inverter as this helps to detect faults that may arise and for it to be rectified immediately.

Table 1. The cost expenses of the project.

S/N	Description	Price
1	Components	10,000
2	Battery	18,000
3	Transportation	4,500
4	Transformer purchase	5,000
5	Casing expenses	4,300
6	Battery charger	15,000
Total		56,800

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3.4. Research Question Four: How Do Experts Evaluate the Developed Inverter?

Expert rating of the developed inverter was determined and the results from the expert were presented in **Table 2**. It indicated that out of the 14 experts who evaluated the inverter, 12(86%) agreed that the inverter has a smooth and well packaged body, the inverter does not require incessant maintenance but requires charging regularly. 13(93%) experts agreed that the inverter offers a decent backup of 3 hours. However, 8(57%) rated the inverter as not having an expected lifespan of around 3 years and weigh much that it cannot be handled with ease. Thus, most experts rated the developed inverter as a good alternative to electric power supply.

Results from the experts' rating of the developed inverter were determined and were presented. It indicated that out of the 14 experts who evaluated the inverter, 12(86%) agreed that the inverter has a smooth and well-packaged body, requires charging regularly, and does not require incessant maintenance. 13(93%) experts agreed that the inverter offers a decent backup of 3 hours, 10(71%) agreed that the inverter's charging mechanism is quite easy, 9(64%) agreed that the inverter's charging rate is quicker. 6(43%) agreed that the inverter has an expected lifespan of 3 years, does not weigh much that you can handle it with ease but has a battery acid leakage possibility. However, 8(57%) rated the inverter as not having an expected lifespan of around 3 years, weighs much that it cannot be handled with ease but has zero battery acid leakage possibility. Thus, most experts rated the developed inverter as a good alternative to the electric power supply.

Table 2. Expert evaluation of the developed inverter.

S/N	Test Results	True	False
1.	The inverter has a smooth and well-packaged body.	12(86%)	2(14%)
2.	The inverter offers a decent backup of 3 hours.	13(93%)	1(7%)
3.	The inverter has an expected lifespan of around 3 years.	6(43%)	8(57%)
4.	The inverter does not weigh that you can handle it with ease.	6(43%)	8(57%)
5.	The inverter does not require incessant maintenance	12(86%)	2(14%)
6.	The inverter's charging mechanism is quite easy.	10(71%)	4(19%)
7.	The inverter works under any weather condition.	11(79%)	3(21%)
8.	The inverter has a zero acid leakage possibility.	8(57%)	6(43%)
9.	The inverter's charging rate is quicker	9(64%)	5(36%)
10.	The inverter requires charging regularly.	12(86%)	2(14%)

4. CONCLUSION

The proper running of this inverter is a clear indication that the set aim and objectives have been achieved. The construction is based on the theoretical knowledge gained so far during our lecture times. It was constructed with considerable cost, available and reliable components rather than the more exorbitant unavailable ones. The practical knowledge of the multi-purpose use of SG3524 IC, MOSFETs, relay, etc makes the project interesting, tasking, and educating.

Logically, irrespective of how good a design might be, there is always room for improvement. By so doing, the following recommendations could be taken into consideration for a more effective and useful inverter:

(i) Competent personnel should be consulted in case of any damage to the unit and every source of power supply should be disconnected from the inverter before removing the cover.

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(ii) The soldering of components should take a network system to minimize heat to the components.
(iii) On no occasion should the inverter be loaded above 80% of its maximum capacity.
(iv) The student should be exposed to more practical works so that they would be able to construct all practical works themselves.
(v) The government at various levels should encourage engineering practice by financing and training engineering within and outside the country for the benefit of the students and the nation at large.

5. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. Authors confirmed that the paper was free of plagiarism.

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