DESIGN AND CONSTRUCTION OF A 1.5KVA HYBRID POWERED MODIFIED SINE WAVE MODULAR INVERTER TRAINER KIT

BY

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EEE/13/1104

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IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF

BACHELOR OF ENGINEERING (B.Eng.) DEGREE IN ELECTRICAL ELECTRONICS ENGINEERING

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CERTIFICATION

This is to certify that the project titled "design and construction of a 1.5kva hybrid powered modified sine wave modular inverter trainer kit" carried out by Eneji Abdulsalam Onimisi, has been read and approved for meeting part of the requirements and regulations governing the award of the BSc. Electrical and Electronic Engineering degree of FEDERAL UNIVERSITY OYE EKITI.

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ENGR. K.O OLUSUYI DATE

(PROJECT SUPERVISOR)

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DR.(ENGR.) J.Y ORICHA DATE

(HEAD OF DEPARTMENT)

DECLARATION

I hereby declare that I carried out the work reported in this report in the Department of Electrical and electronics Engineering, federal university oye ekiti, ekiti state under the supervision of ENG. KO Olusuyi. I solemnly declare that to the best of my knowledge, no part of this report has been submitted here or elsewhere in a previous application for award of a degree. All sources of knowledge used have been duly acknowledged.

(Signature & Date)

EAOnimisi 5/03/2019.
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ENEJI ABDULSALAM ONIMISI

EEE/13/1104

DEDICATION

I dedicate this report to God almighty the maker of heaven and earth who had granted me the enabling grace for the successful completion of my project and my parents Mr. and Mrs. Eneji for their love and support in life, studies and in my project. Duly appreciated.

ACKNOWLEDGMENT

The satisfaction that accompanies the successful completion of this project would be incomplete without mentioning the names of those who made it possible. It is evident that without the constant guidance and encouragement received from these great personalities, all efforts would have gone in vain. I convey thanks to my supervisor Engr. K.O Olusuyi, for providing me with the required encouragement, sacrifice, moral support and constant support which was of a great help to complete this scheme of my final phase of developing a project in my final year successfully.

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My profound gratitude goes to my parents Mr. and Mrs. Eneji and also to my siblings and well-wishers. God bless you all.

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ABSTRACT

A training device for instructing students in inverter circuits, which includes a large flat panel that is vertically disposed for visual display before the students, locations on the front surface of the panel for attachment of digital devices, 'a number of digital-logic circuit devices having means for both mechanical and electrical connection to the panel, a power circuit associated with the panel for energizing the electronic devices, and circuit connections for making selected logical circuit interconnections between the digital-logic devices displayed on the panel.

This invention relates to trainers and more particularly is concerned with a trainer capable of displaying digital devices operatively connected in a circuit configuration which precisely duplicates the schematic diagram of the circuit under consideration.

The primary objective is to design an inexpensive, simple to use device that could be retained by students, so that they can undertake digital experimentation.

CHAPTER 1 INTRODUCTION

1.1 BACKGROUND

Power Electronics is one of a key subject of electrical engineering. Power electronics is of vital importance to understanding of control, conversion and conditioning of power in electrical industries. The power electronics laboratory is actively engaged to reinforce and enhance understanding of the fundamentals of semiconductor switches and power converters. This laboratory deal with practical realization of theory concept related with power electronics. The all experimental set-ups are designed and developed by the institute according to the standards. The power electronics laboratory is equipped with different converters setups like as rectifier, inverter, AC voltage converter, DC-DC converter, switching characteristics, BLDC drive and DC motor drive, where students can visualize the basics principles of different converters.

However, this work is focused on a modified sinewave inverter modular inverter kit which is a power device used in laboratory to understand the principle and behavior of single phase inverter which converter DC supply into AC supply. The trainer consists of power circuit of inverter, microcontroller based control circuit, power supply section, load section and protection circuit. All different types of control signals are generated using single control circuit by changing the program of individual switching pulse like square wave, QSW and SPWM. Separate CRO or digital signal oscilloscope is used to observe the behavior of the inverter.

1.2 STATEMENT OF THE PROBLEM

The main problem that leads to the construction of this project is, problem uncounted by the sources of power provided in the laboratory is unsuitable which reduce practical aspect, use of equipment and tools by the student. To overcome this problem a stable or constant power supply is needed.

1.3 AIM OF THE PROJECT

The main aim of this work is to design and construct 1.5kVA hybrid powered modified sine wave trainer kit inverter capable of powering wide variety of electronics, household and laboratory equipment such as Computers, Oscilloscope, Signal generator, Mobile phones etc.

1.4 OBJECTIVE OF THE PROJECT

The following are the specific objectives of the project:

To design and implement a 1.5kVA modified sine wave inverter that converts 12V dc to 220V ac

Explain various types of inverter circuit.

To design and construct a charge control system for the appropriate charging of the battery bank.

To design and construct two-source modified sine wave power inverter.

To provide sustainable and reliable (i.e. cost effective and easy maintainability power source) power supply for EEE department

To construct an oscillating circuit using SG3524 integrated circuit

To construct a battery charging circuit

To construct a switch using power pausing transistor (mofet)

To construct a step up transformer

Also to design noiseless power source during operation because most of the power generators are noisy during its operation, this causes disturbances to the neighborhoods

1.5 SIGNIFICANCE OF THE PROJECT

The Inverter trainer is a versatile training System for Laboratories. It is designed such that all the basics of Inverter can be easily understood. This training system provides understanding about conversion of DC into AC by PWM Technique.

1.6 APPLICATION OF THE PROJECT

This device is equipment for education, engineering and vocational training - Inverter Trainer.

1.7 SCOPE OF THE PROJECT

The scope of work is to design an inverter circuit and automatic battery charger that will recharge the battery while in use and produce a continuous power supply. Different blocks are explained like charging of battery, DC to AC conversion, AC mains sensing circuit, etc. also provided with fault switches to develop the troubleshooting practice. PWM Inverter Technology Standalone Operation Compact design self-explained layout provided with Rechargeable Battery On board LED indication for mains, charging, inversion. A Battery 12V 100AH is required to operate this apparatus. Different test points have been provided to check wave shape and amplitude of pulses how DC supply is changed to AC supply.

CHAPTER TWO

2.1 LITERATURE REVIEW

An inverter is a device that changes D.C. voltage into A.C. voltage. A direct current (D.C) is a current that flows in only one direction, while an alternating current (A.C.) is that which flows in both positive and negative directions. At the early stage, sun was the source of energy for generating power. Due to the inadequacy of the power generated through this source, there was a need to find other ways to improve the power supply when the generating station could not meet the demand of the people. As the technology advances, the hydroelectric generation was developed, gas firing generating station, and wired tubing methods of generating power supply were developed. In spite of all these developments, there was still failure in electrical power generation as a result of obsolete equipment at the generating stations. There was still need to find alternative for solving the problem. As a result of this, some options like alternators, inverters and others were developed.

The electrical inverter is a high power electronic oscillator. It is so named because early mechanical AC to DC converters was made to work in reverse, and thus was "inverted", to convert DC to AC. The inverter performs the opposite function of a rectifier formed in the late nineteenth century through the middle of the twentieth century; DC to AC power conversion was accomplished using rotary converters or motor-generator sets (M-G set). In the early twentieth century, vacuum tubes and gas filled tubes began to be used as switches in inverter circuits. The most widely used type of tube was the thyratron. The origins of electromechanical inverters explain the source of the term inverter. Early A.C to D.C converters used an induction or synchronous AC motor direct – connected to a generator (dynamo) so that the generators commutator reversed its connections at exactly the right moments to produce DC. A later development is the synchronous converter, in which the motor and generator windings are combined into one armature, with slip rings at one end and a commutator at the other end only one field frame. The result is either AC – in, DC – out with an M-E set, the DC can be considered to be separately generated from the AC, with a synchronous converter, in a certain sense it can be considered to be mechanically rectified AC" Given the right auxiliary and control equipment, an M-G set or rotary converter can be run "backwards", converting DC to AC. Hence an inverter is an inverted converter. There have been a large number of articles written concerning power conversion in recent years. This can be attributed in part to the rise in popularity of high voltage DC transmission systems. And their integration with existing AC supplies grids.

Power supply from the national grid is inefficient and unreliable, hence the need to provide alternative source of power. Electrical power supply from renewable sources is advantageous as the increasing Electrical demand is a scientific contribution to the peak demand on the grid. As individuals and companies generate their power through renewable energy, the stress on the grid is reduced. However, there is an ongoing interest in the possibility of making wider use of renewable energy, particularly in homes, offices and industries, for the purpose of lighting, heating and powering of appliances. In most rural and sub-urban regions in Nigeria, inhabitants do not have access to electricity supply. Where the Electrical energy is available, it is not reliable; hence inhabitants resort to other forms of energy such as wood, paraffin, and diesel generators, which pollute the environment and cause harm to man and plants.

The transmission network (that is from national grid) is overloaded with a wheeling capacity less than 4000MW. It has a poor voltage profile in most parts of the network, inadequate dispatch and control infrastructure, radial and fragile grid network, frequent system collapse, exceedingly high transmission losses. It is a known fact that, Electric power availability enhances economic development of any society, while non availability of power or power outage creates economic hardship. The power sector is unable to match supply with demand of electric power and access to Electricity is low as about 60% of the population (approximately 80 million people in Nigeria) are not served with Electricity. Electric power sustains the society in almost all ramifications; it becomes necessary for the Nigerian Government to sustain Electric power availability to its citizenry.

Electricity has never been adequate to the Nigerian populace, for 115 years now, epileptic power supply and blackout is a regular phenomenon. Solar energy is the energy transmitted from the sun in the form of electromagnetic radiation, which requires no medium for transmission. Solar energy is the most promising of the renewable energy sources in Nigeria, in view of its apparent unlimited potential. The sun radiates its energy at the rate of about 3.8 × 1023KW per second. Most of this energy is transmitted as electromagnetic radiation which comes to about 1.5KW/M2 at the boundary of the atmosphere. After traversing the atmosphere, a square metric of the earth's surface can receive as much as 1KW of solar power, averaging to about 0.5 over all hours of daylight. Studies relevant to the availability of the solar energy resources in Nigeria have indicated its viability for practical use.

2.2 REVIEW OF RELATED WORKS

Babarinde et al, (2014) designed and constructed of a 50HZ, 240V 1kVA inverter is primarily based on an inverter circuit which inverts the D.C. source voltage from a battery, AC voltage for AC powered appliances. The overall operation of this system comprises inter connections of many sub-circuits to give optimum performances. The sub circuit include; the oscillator circuit, PWM circuit, driver circuit, low battery/overload shutdown circuit, charging control/soft charging circuit, surge protection circuit, changeover/power supply circuit, and the output circuit (MOSFET and transformer section). This project incorporates monitoring circuit that employs visual display

Samimi et al. (1997) analyzed the optimal tilt angle and other aspects of PV modules in various climates. However, an economic optimization design tool for optimal PV size based on technology information, current tariffs and policy has not yet been developed. Hernández et al. (1998) developed a methodology for optimal size of PV system for different building types. The adopted design criterion was to optimize the profitability and amortization of PV installation.

Ekpenyong et al, (2012) interest involves a careful design of 1.5KVA hybrid power supply for power reliability. A renewable single source system for a higher power demand application is often high in cost due to sizing of the source of supply component to meat reliability requirements. The system design is considered for the administrative office of the head of department, electrical and electronics engineering in Cross River University of technology, Calabar, Nigeria. The system operates at minimum running cost, population free environment, noiseless, reliable and provide the convenient of a twenty-four-hour power supply. With this system, energy efficiency is achieved by lowering demand using demand response, incorporating temporary and permanent load shifting by back-up and parallel mode respectively.

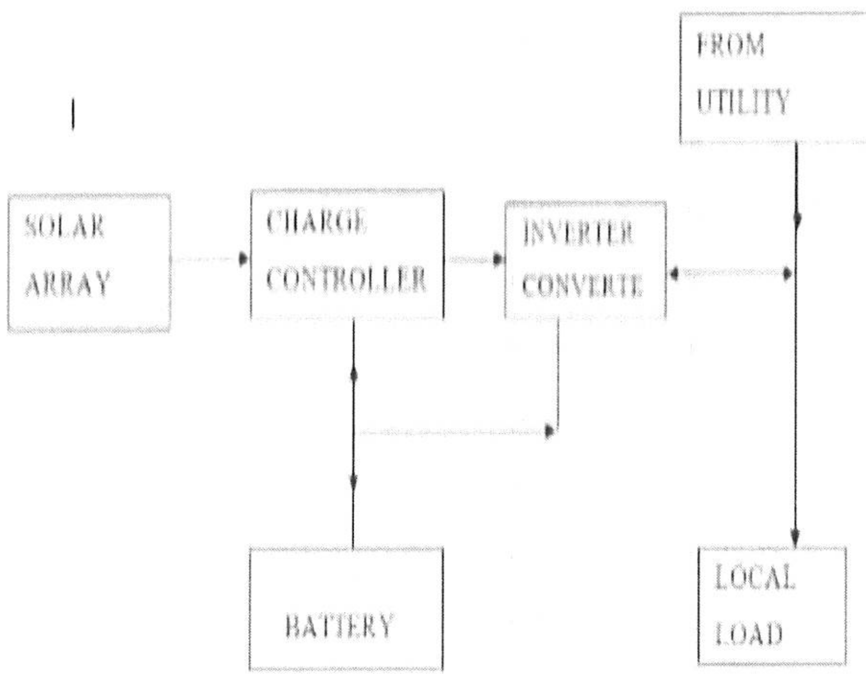


Figure1: Basic photovoltaic system integrated with grid

Ekwuribe and Uchegbu, (2016) explained the epileptic nature of power generation via hydro and thermal sources in Nigeria has given rise to source alternate forms of power generation. This gap, period of no supply or cut off from the grid, is what this paper will solve by way of designing and constructing an alternate source using solar power for household use. The design and construction of the unit, a solar powered 2.5KVA inverter was achieved by using a 21/400 turns wound transformer, an SG3524N PMW fixed frequency voltage regulator controller, MOSFET transistors, five80W/18Asolar panel, three200AH deep cycle battery, and a charge controller to monitor the output of the battery for safety. The battery is connected to the inverter circuit to generate 220V alternating current in its output via a step-up transformer. The inverter uses the SG 3524N IC chip fixed frequency Pulse–Width-Modulator (PMW) Voltage regulator controller. The designed oscillation period is set at 50% duty cycle or 0.02 seconds to match the frequency of loads connected to it. From table of results; the inverter was able to maintain stability for 4 hours when a refrigerator and other loads up to a 2000W were connected to it. But at peak sunshine and the solar panel tilted 0° relative to the roof inclination, the inverter output for the same load lasted longer hours.

Omitola et al., (2014) worked on the design and construction of a 1000Watts (1KW) 220 Volts inverter at a frequency of 50Hz. This 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, to a 220V AC across the windings of a transformer. An additional power supply to the public power supply with the same power output is thus provided at an affordable price.

Adaramola et al., (2017) experimented on the inverter performance model which provides a new opportunity for accurately monitoring the performance and health of the inverter in real time. Grid-tied inverter monitoring can be accomplished by using a data acquisition system which provides a periodic measurement of dc voltage and power, as well as true ac power. In real time, inverter's efficiency can be calculated empirically and compared to the inverter efficiency determined using the inverter performance model. Deviations between measured and calculated inverter efficiency would provide direct evidence of inverter malfunction or degradation in performance. It is likely, given experience, that the nature of the deviations would provide the diagnostic information needed to define required inverter maintenance for optimum future performance.

Peng Kong et al., (2011) proposed a series-parallel resonant high frequency inverter for stand-alone hybrid photovoltaic (PV)/wind power system in order to simplify the power system and reduce the cost. The proposed inverter consists of two power stages: a DC/DC resonant converter as the input stage and a full bridge DC/AC inverter as the output stage. The input converter is operated with phase shift control, which guarantees zero current switching for most power range. This resonant converter generates a high DC voltage, which is conditioned by the DC/AC inverter to generate the desired low frequency output voltage. The DC/AC inverter is controlled using a pulse width modulation strategy. Simulation and experimental results are given to verify the system's efficiency and have shown the performance of the proposed inverter with desired features.

Kabir Usman (2005) worked on the design and construction of 3KV A inverter with the use of 24volt DC and produces 230volt AC. An inverter is an electrical device that converts direct current (DC) to alternating current (AC). The converted AC can be at any required voltage and frequency with the use of appropriate oscillator circuit, transformers, switching, and control circuits. Incorporated into these systems are devices such as transistors, MOSFETs, diodes, resistors and batteries which work hand in hand to obtain the overall desired operation of an inverter. Problems were encounter and solved in the course of this project design. This project was well research, criticized, analyzed, designed and constructed to give a specified output.

Abdulrahman Aliyu. (2004) worked on the inverter requires a fully charged 12-volt DC battery whose negative

terminal is connected to the drain of the power mosfet. This is achieved using the power mosfet as the main switching component in this project. The pulses generated was gotten from oscillator that is capable of converting DC to AC which is the pulse width modulator and is used to pass signals via I K resistor to the isolated gates of the mosfet. A center tapped step up transformer is used to change the voltage from 12 volts to the desired 220 volt from which the output of the inverter is gotten and is connected to the load.

Chukwuka Anene et al. (2016) worked on the design and construction of a 5KVA Pulse Width Modulated (PWM), Metal Oxide Semiconductor Field Effect Transistor (MOSFET) based Inverter, which works on the principle of Pulse Width Modulation. The inverter uses the IC SG3524 and a pair of Twelve MOSFETs to drive the load. The design and implementation starts with the power supply. Component selection was made with the aid of electronics data book, which made the design and calculations very easy. One main feature of this inverter is the monitoring section, and the battery-charging section connected to the inverter circuit. The inverter converts DC supply of the battery into AC power supply required by most electrical appliances/equipment when the AC main is not available, and when the AC main is available; this AC mains supply goes to the AC mains Sensor, the Relays and Battery charging section of the inverter. This inverter can be used for domestic purpose and it is not recommended for industrial purpose where high current is required for application, such as starting a heavy-duty motor.

Taeyeong et al. (2019) proposed a pulse width modulation(PWM) strategy for improving the efficiency of a 5-level H-bridge T-type neutral point clamped (TNPC) inverter. In the case of the proposed PWM strategy, unlike the conventional PWM strategy in which both of the switching legs of the H-bridge inverter operate at a high frequency, one switching leg of the inverter operates at a low frequency. As the switching frequency is lowered, the switching loss is reduced, this improving the efficiency of the system. The duty references for the switching legs and the operating principle of the inverter are described in detail. The proposed PWM strategy, however, causes distortion of the output filter inductor current. The cause of the distortion has been analyzed and a compensation method is proposed to mitigate the distortion of the current. The effect of the proposed PWM strategy can be predicted through the loss calculation of the inverter for each modulation strategy. Furthermore, current distortion mitigation obtained by compensation method is confirmed through the simulation. In order to verify the effectiveness of the proposed strategy, a2kWH-bridgeTNPCinverterprototype is implemented and tested. The simulation and experimental results show that the efficiency of the inverter is improved when the proposed PWM strategy is applied.

Osuwa et al. (2014) worked on the use of inverters in preference to generators as an alternative for un-interruptible power supply is gaining wide acceptability in developing countries, due to inverters' greater environmental compatibility. However, the major challenge remains local production of sufficiently high powered inverters for big loads and longer periods of time. In this study, effort is made to produce a robust 1 KVA inverter. Requirements for the implementation include locally sourced 80 Ah 12V deep cycle battery, IC SG3524 oscillator, MOSFETs and BJT types of transistors, diodes, transformer, relay, contactor, resistors, capacitors and other electronic components. The construction is divided into four units consisting of oscillator unit, MOSFET assembly unit, Transformer unit and battery charger monitor unit. Each constructed unit was independently tested for proper functionality before the composite coupling. The assembled composite unit worked successfully well. Oscilloscope measurements tallied with set frequency of 50 Hz, switching period of 0.02 seconds and square wave oscillator output. The system is capable of providing power to adequate loads for up to six hours

Abadal-Salam et al. (2015) worked on a 300 W/ 50 Hz single-phase sine wave with a 555 timer IC controller was designed, simulated, implemented and tested to investigate output AC power quality. An input 12 VDC power supply, which simulates PV-Wind power source, was connected to the inverter circuit and charge discharge energy storage was also studied. Results of simulation show that as well as the experiment result is obtained. This paper is present the advantage of hybrid system wind &solar together in power supply system from the integration between time and location. It shows the evolution of wind-solar in single-phase sine wave power inverter and provides the structure of information and communications technology and equipment. Some main techniques such as the circuit topology and operation modes of the key link, algorithm of the intelligent control charging and discharging and so on.

Indrajit Sarkar et al. (2014) talked about carrier based pulse width modulation (PWM) techniques, Phase Shifted PWM (PS-PWM) technique is preferred for Cascaded H-Bridge (CHB) multilevel inverters. This technique distributes power evenly among the modules and also ensures equal utilization of inverter switches within a module. On the other hand, Carrier Disposition PWM (CDPWM) technique has superior output voltage profile, but results in uneven power distribution and non-uniform switch utilization. Modified CD-PWM and Hybrid-PWM techniques can be used to mitigate the problem related to uneven power distribution. In this paper, the performance comparison of above mentioned modulation techniques is presented for a 7-level CHB multilevel inverter for same device switching frequency. It is found that at low modulation index, the line voltage and line current THDs are less with Hybrid-PWM technique as compared to those with PSPWM and Modified CD-PWM techniques. But in Hybrid PWM technique, the switches within a module are not equally utilized. A Modified Hybrid-PWM technique is proposed, which retains the power distribution and uniform switch utilization features of PS-PWM technique and results in output voltage profile similar to that with Hybrid-PWM technique.

SHEKHAR KUMAR BISWAS. (2016) looked at the electronics device which converts DC power to AC power at required output voltage and frequency level is known as inverter. Inverters can be broadly classified into single level inverter and multilevel inverter. Multilevel inverter as compared to single level inverters have advantages like minimum harmonic distortion and can operate on several voltage levels. Inverters are used for many applications, as in situations where low voltage DC sources such as batteries, solar panels or fuel cells must be converted so that devices can run off of AC power. One example of such a situation would be converting electrical power from a car battery to run a laptop, TV or cell phone.

This report focuses on design and simulation of single phase, three phase and pulse width modulated inverter and use of pulse width modulated inverter in the speed control of Induction motor.

(Omotosho, et al., 2017) researched on the design and implementation of a sine wave inverter circuit developed to run AC appliances at a low cost which high efficiency. The design consists of two stages i.e. the DC-DC step up stage and a DC-AC Inverter stage. The DC-DC step up converter is based on a push-pull design to step 24VDC to 300VDC. Pulse width modulation was used i.e. the SG3525 pulse width Modulator. The DC-AC inverter stage comprised of four power mosfets in an H-bridge configuration, driven by a 40kHz square wave encoded/modulated by a 50Hz sine wave that was derived from a TL084 quad op amp sine wave oscillator. An output voltage range of about 240-260VAC from 300VDC input was obtained. A low pass filter was used to filter out the high frequencies and thus isolate the harmonics so a 50Hz fundamental frequency was retained.

The Inverter system is an electrical system which accepts direct current (DC) as input and produces alternating current (AC) of appropriate voltage, frequency and phase as an output. The reliability of power company electricity service varies greatly due to many factors including the design of the power grid, protective features, power system maintenance practices and severe

Alumona et al., constructed a 5KVA inverter system with RF remote control using Pulse Width Modulation (PWM) switching scheme to supply AC utilities with emergency power. The remote section of this project is built using the radio frequency transmitter and receiver module operating at the frequency of 434 MHz This inverter system is designed in such a way that it can be operated manually using a switch or automatically using a remote but not both at the same time. The system is also designed to automatically switch over to charging mode when the battery goes below a threshold value of 18v and to stop charging above a threshold value of 25V. This feat is achieved using the LM358 IC which continually checks the voltage level of the battery and subsequently react accordingly by either switching off the inverter to recharge the battery or continue supplying the inverter.

Michel et al., (2017) experimented on inverter performance model which provides a new opportunity for accurately monitoring the performance and health of the inverter in real time. Grid-tied inverter monitoring can be accomplished by using a data acquisition system which provides a periodic measurement of dc voltage and power, as well as true ac power. In real time, inverter's efficiency can be calculated empirically and compared to the inverter efficiency determined using the inverter performance model. Deviations between measured and calculated inverter efficiency would provide direct evidence of inverter malfunction or degradation in performance. It is likely, given experience, that the nature of the deviations would provide the diagnostic information needed to define required inverter maintenance for optimum future performance.

2.3 REVIEW OF DIFFERENT POWER ELECTRONICS TRAINER KIT

2.3.1 Device characteristics kit

The trainer kit is used to understand the behavior of different power electronics switches. The trainer consists of a SCR/TRIAC characteristics section, MOSFET/IGBT characteristics section, DIAC characteristics section, MOSFET switching section and power device section. Ammeters and voltmeters are connected from outside to observe the behavior of individual switches at varying supply voltage.

2.3.2 Gate triggering circuits kit

The trainer kit is used to understand the latching/turn-on process of different semiconductor switches. The trainer consists of a control supply, DC triggering circuit, R triggering circuit, RC triggering circuit, UJT triggering circuit, SCR power circuit, MOSFET power circuit and MOSFET/IGBT gate driver circuit. Separate CRO or digital signal oscilloscope is used to observe the latching/turn-on process of individual switches. This kit provides conventional to modern triggering technique of switches.

2.3.3 Single Phase Inverter Kit

The trainer kit is used to understand the principle and behavior of single phase inverter which converter DC supply into AC supply. The trainer consists of power circuit of inverter, microcontroller based control circuit, power supply section, load section and protection circuit. All different types of control signals are generated using single control circuit by changing the program of individual switching pulse like square wave, QSW and SPWM. Separate CRO or digital signal oscilloscope is used to observe the behavior of converter.

2.3.4 Three Phase Inverter Kit

The trainer kit is used to understand the principle and behavior of three phase inverter which converter DC supply into AC supply. The trainer consists of power circuit of inverter, microcontroller based control circuit, power supply section, load section and protection circuit. All different types of control signals are generated using single control circuit by changing the program of individual switching pulse like square wave, QSW and SPWM. Separate CRO or digital signal oscilloscope is used to observe the behavior of converter. Three Phase Inverter behavior can also be analyzed at different load condition like R and RL.

2.3.5 Single Phase Rectifier Kit

The trainer kit is used to understand the principle and behavior of single phase rectifier which converter AC supply into DC supply. The trainer consists of power circuit of rectifier, microcontroller based control circuit, power supply section, load section and protection circuit. All different types of control signals are generated using single control circuit by changing the program of individual switching pulse. Single Phase Rectifier behavior can also analyze at different load condition like R and RL. Also understand the function of free-wheeling diode using this trainer kit. Separate CRO or digital signal oscilloscope is used to observe the behavior of converter.

2.3.6 Three Phase Rectifier Kit

The trainer kit is used to understand the principle and behavior of three phase rectifier which converter AC supply into DC supply. The trainer consists of power circuit of rectifier, microcontroller based control circuit, power supply section, load section and protection circuit. All different types of control signals are generated using single control circuit by changing the program of individual switching pulse. Three Phase Rectifier behavior can also analyze at different load condition like R and RL. Also understand the function of free-wheeling diode using this trainer kit. Separate CRO or digital signal oscilloscope is used to observe the behavior of converter.

2.3.7 Switch mode DC-DC converter kit

The trainer kit is used to understand the principle and behavior of DC-DC converter which converter fixed DC supply into variable DC supply. The trainer consists of power circuit of DC-DC converter, microcontroller based control circuit, power supply section, load section and protection circuit. Output voltage can be changed by varying duty ratio of switching pulse, is done by control circuit of converter. Continuous conduction mode and discontinuous conduction mode operation also performed for all DC-DC convert using single kit. Separate CRO or digital signal oscilloscope is used to observe the behavior of converter.

2.3.8 Three Phase AC Voltage Converter

The trainer kit is used to understand the principle and behavior of AC voltage converter which converter fixed AC supply into variable AC supply. Same kit is also performed as single phase AC voltage controller also. The trainer consists of power circuit of AC-AC converter, microcontroller based control circuit, power supply section, load section and protection circuit.

Different load connections like star-delta are performed on the same kit. Separate CRO or digital signal oscilloscope is used to observe the behavior of converter.

2.3.9 Single Phase Controlled Rectifier Fed Separately Excited DC Motor Drive

The trainer kit is used to understand the concept to control the speed of separately excited DC motor using single phase controlled rectifier. The trainer consists of power circuit of field and armature side converters, microcontroller based control circuit, power supply section, SEDC motor and speed sensor. Open loop as well as close loop control of separately excited DC motor is performed on the same kit. Separate CRO or digital signal oscilloscope is used to observe the behavior of this drive.

2.3.10 Brush Less DC Motor Drive Kit

The trainer kit is used to understand the basic operation and speed control mechanism of BLDC motor. The trainer consists of voltage source inverter section, BLDC motor, hall sensors, microcontroller based control circuit and power supply. Forward as well as reverse rotation of BLDC motor can be achieved using this drive. Separate CRO or digital signal oscilloscope is used to observe the operation of drive.

2.4 HISTORICAL BACKGROUND OF AN INVERTER

From the late nineteenth century through the middle of the twentieth century, DC-to-AC power conversion was accomplished using rotary converters or motor-generator sets (M-G sets). In the early twentieth century, vacuum tubes and gas filled tubes began to be used as switches in inverter circuits. The most widely used type of tube was the thyratron.

The origins of electromechanical inverters explain the source of the term inverter. Early AC-to-DC converters used an induction or synchronous AC motor direct-connected to a generator (dynamo) so that the generator's commutator reversed its connections at exactly the right moments to produce DC. A later development is the synchronous converter, in which the motor and generator windings are combined into one armature, with slip rings at one end and a commutator at the other and only one field frame. The result with either is AC-in, DC-out. With an M-G set, the DC can be considered to be separately generated from the AC; with a synchronous converter, in a certain sense it can be considered to be "mechanically rectified AC". Given the right auxiliary and control equipment, an M-G set or rotary converter can be "run backwards", converting DC to AC. Hence an inverter is an inverted converter.

2.4.1 Controlled rectifier inverters

Since early transistors were not available with sufficient voltage and current ratings for most inverter applications, it was the 1957 introduction of the thyristor or silicon-controlled rectifier (SCR) that initiated the transition to solid state inverter circuits.

The commutation requirements of SCRs are a key consideration in SCR circuit designs. SCRs do not turn off or commutate automatically when the gate control signal is shut off. They only turn off when the forward current is reduced to below the minimum holding current, which varies with each kind of SCR, through some external process. For SCRs connected to an AC power source, commutation occurs naturally every time the polarity of the source voltage reverses. SCRs connected to a DC power source usually require a means of forced commutation that forces the current to zero when commutation is required. The least complicated SCR circuits employ natural commutation rather than forced commutation. With the addition of forced commutation circuits, SCRs have been used in the types of inverter circuits described above.

In applications where inverters transfer power from a DC power source to an AC power source, it is possible to use AC-to-DC controlled rectifier circuits operating in the inversion mode. In the inversion mode, a controlled rectifier circuit operates as a line commutated inverter. This type of operation can be used in HVDC power transmission systems and in regenerative braking operation of motor control systems.

Another type of SCR inverter circuit is the current source input (CSI) inverter. A CSI inverter is the dual of a six-step voltage source inverter. With a current source inverter, the DC power supply is configured as a current source rather than a voltage source. The inverter SCRs is switched in a six-step sequence to direct the current to a three-phase AC load as a stepped current waveform.

CSI inverter commutation methods include load commutation and parallel capacitor commutation. With both methods, the input current regulation assists the commutation. With load commutation, the load is a synchronous motor operated at a leading power factor.

As they have become available in higher voltage and current ratings, semiconductors such as transistors or IGBTs that can be turned off by means of control signals have become the preferred switching components for use in inverter circuits.

2.4.3 Rectifier and inverter pulse numbers

Rectifier circuits are often classified by the number of current pulses that flow to the DC side of the rectifier per cycle of AC input voltage. A single-phase half-wave rectifier is a one-pulse circuit and a single-phase full-wave rectifier is a two-pulse circuit. A three-phase half-wave rectifier is a three-pulse circuit and a three-phase full-wave rectifier is a six-pulse circuit.

With three-phase rectifiers, two or more rectifiers are sometimes connected in series or parallel to obtain higher voltage or current ratings. The rectifier inputs are supplied from special transformers that provide phase shifted outputs. This has the effect of phase multiplication. Six phases are obtained from two transformers, twelve phases from three transformers and so on. The associated rectifier circuits are 12-pulse rectifiers, 18-pulse rectifiers and so on

When controlled rectifier circuits are operated in the inversion mode, they would be classified by pulse number also. Rectifier circuits that have a higher pulse number have reduced harmonic content in the AC input current and reduced ripple in the DC output voltage. In the inversion mode, circuits that have a higher pulse number have lower harmonic content in the AC output voltage waveform.

2.4.4 Modified Sine-Wave Inverter Enhanced

Altering the waveform produced by a modified sine-wave inverter reduces distortion products, while still permitting use of efficient switching techniques.

Aug. 1, 2006 James H. Hahn, Associate Professor Emeritus, University of Missouri-Rolla Engineering Education Center, St. Louis | Power Electronics

With the increasing popularity of alternate power sources, such as solar and wind, the need for static inverters to convert dc energy stored in batteries to conventional ac form has increased substantially. Most use the same basic concept: a dc source of relatively low voltage and reasonably good stability is converted by a high-frequency oscillator and step up transformer to a dc voltage with magnitude corresponding to the peak of the desired ac voltage. A power stage at the output then generates an ac voltage from the higher-voltage dc.

2.4.5 Implementation

As demonstrated here, the modified-sine-wave inverter can be modified further to produce a much closer approximation to a sine wave, at a relatively small increase in manufacturing costs, simply by incorporating another level into the waveform. The design still uses switching technology in the power stage, assuring high efficiency. A patent application has been submitted for the approach described in this article.

The switching stage could be implemented with a combination of bridge and half-bridge components commonly used in power switching applications. To produce the proposed multiple-level waveform, several implementations are possible. In general, they all involve connecting the output lead to a specific voltage level with switches such as power MOSFETs capable of handling substantial current.

Appropriate digital logic and timing circuits will be used to activate each switch at the correct time to achieve the α and β pulse widths. A table can be developed to indicate which switches must be closed for each section of the output waveform.

Unlike conventional PWM-inverter designs, which switch at high frequencies, the proposed inverter design switches at just three times the line frequency. As a consequence, the proposed inverter design will reduce switching losses from that of the PWM-controlled inverter and will save power regardless of the output power level.

2.5 REVIEW OF HOW TO CHOOSE THE RIGHT INVERTER

Depending on how you use them, pure sign wave inverters have distinct advantages over modified sign wave inverters. There are, however, some instances when the latter are just as effective as the former, if not more so. For example, if you need to power equipment that requires a single induction load, or a resistive load, modified sine wave inverters are an ideal choice for two reasons: they often cost less than pure sine wave inverters, and they use DC power quite efficiently.

Choosing a DC to AC inverter is an important decision concerning the type of equipment that will be powered; the amount of energy consumed by the inverter, and the inverter's cost.

2.6 REVIEW OF THE DIFFERENCE BETWEEN SINE WAVE AND MODIFIED SINE WAVE INVERTER

As their names would suggest, the primary difference between pure sine wave and modified sine wave inverters lies in the type of sign wave they exhibit. A modified sign wave is similar to a square wave, which looks like a succession of evenly spaced squares when it is expressed as a waveform. However, unlike a square wave, a modified sine wave's output rests at zero volts for a short time before switching positive or negative.

Far from looking like a succession of blocks when viewed as a waveform, a pure sine wave looks like a series of smooth, evenly spaced hills and valleys. Due to its nearly perfect sine wave output, a pure sine wave inverter is compatible with all types of electronics, even sensitive, specialized equipment such as laser printers and audio equipment. A modified sine wave inverter, on the other hand, is not compatible with these electronic devices. It can power most types of standard electrical, but cannot be used for equipment whose performance requires refined sine wave input.

Another difference between pure signs wave inverters and modified sine wave inverters is the latter offer less energy efficiency than the former. For example, while an AC motor will run off a modified sine wave, its operational efficiency is nearly twenty percent less than it would be if a pure sine wave were present. For companies whose green initiatives include energy efficiency, using an AC to DC inverter that delivers a pure sine wave is typically the best choice. Using a transformer less inverter will also boost efficiency.

2.7 REVIEW OF INVERTER CAPACITY

Different models of power inverters vary in how many watts of power they can supply. The capacity of an inverter should equal the total number of watts required by each device, plus at least a 50% addition to account for peaks or spikes in the power draw. For example, if a DVD player draws 100 watts and a small TV another 100 watts, a minimum 300-watt inverter is recommended. Getting an inverter with more capacity than what is immediately needed is a good idea for many people, as it means that different or new devices can be added without the need for a new power inverter.

2.8 SAFETY OF INVERTER

When using a power inverter continuously inside a vehicle that is not turned on, the engine should be started at least once an hour for 10 to 15 minutes to keep the battery from running down. A vehicle should never be started in a closed garage, as the carbon monoxide in the exhaust is fatal.

Power inverters should only be used with batteries that are in good condition and fully charged. A weak battery will be drained easily if demand is too high. If used in a car, this could leave a driver stranded, so the battery's condition should be checked before using an inverter in a stationary vehicle. If the inverter is being used while the vehicle is running, as in the case of a road trip, there should be no problem with the extra draw as long as the battery is in good condition.

Working with large batteries can be dangerous, and when not done properly, can result in serious injury. Improper use of a power inverter can even lead to electrocution. For safety reasons, someone attempting to hook an inverter directly to a battery should be sure to read and follow any and all safety precautions listed in the inverter's instruction booklet.

It is important for people to always use a power inverter that is rated high enough for the device that needs to be run. If a heavy-duty power saw is plugged into a cigarette lighter, for example, the lightweight inverter might overheat and cause a fire in the dashboard. Adapters that allow more outlets than the unit is designed to accommodate should be avoided, and proper ventilation around the inverter is required to prevent overheating.

2.9 INVERTER RATINGS

The ratings that you should look at when buying an inverter (depending on the type) are:

Continuous Rating: This is the amount of power you could expect to use continuously without the inverter overheating and shutting down.

Half Hour Rating: This is handy as the continuous rating may be too low to run a high energy consumption power tool or appliance, however if the appliance was only to be used occasionally then the half hour rating may well suffice.

Surge Rating: A high surge is required to start some appliances and once running they may need considerably less power to keep functioning. The inverter must be able to hold its surge rating for at least 5 seconds. TVs and refrigerators are examples of items that require only relatively low power once running, but require a high surge to start.

IP rating - defines the ability of the inverter seals to prevent water and dust ingress. Although some inverter manufacturers claim high IP ratings suitable for outdoor installation, the quality and location of the seals and ventilation will greatly affect the ability of the inverter to outlast the many years' solar installations are expected to work.

Peak efficiency - represents the highest efficiency that the inverter can achieve.

2.10 WHY CHOOSE A MODIFIED SINE WAVE INVERTER?

For running typical resistive loads like lights and appliances, a modified sine wave inverter is a reliable, cost-effective choice. Though modified sine wave inverters do not produce a perfect replica of AC true sine wave power, they do provide an affordable option that for many mobile power applications is perfectly adequate. Some devices, however, may not recognize the modified sine wave and may run poorly or not at all.

Some of our most popular modified sine wave inverters are from our Heavy-Duty line up. These are excellent solutions for fleet, utility trucks and vans looking for a powerful and economical alternative to a pure sine wave product.

2.11 TYPES OF INVERTER

There are different types of inverters for home and industries available which can suit your various electricity needs. Following are the two basic types of inverters.

2.11.1. Modified Sine Wave Inverters

This type of home inverter obtains power from a battery of 12 volts and must be recharged using a generator or a solar panel. Appliances like microwave ovens, light bulbs, etc. can be run using these types of inverter.

They can be rightly held as the best inverters for homes as they are efficient enough to provide power to the normal home requirement.

They are the home inverters that are most affordable too.

You can run the daily used home appliances using the modified sine wave home inverters.

The electric appliances that involve motor speed controls or timers are not to be run using these types of home inverters.

The wave form of a modified sine wave inverter is as below:

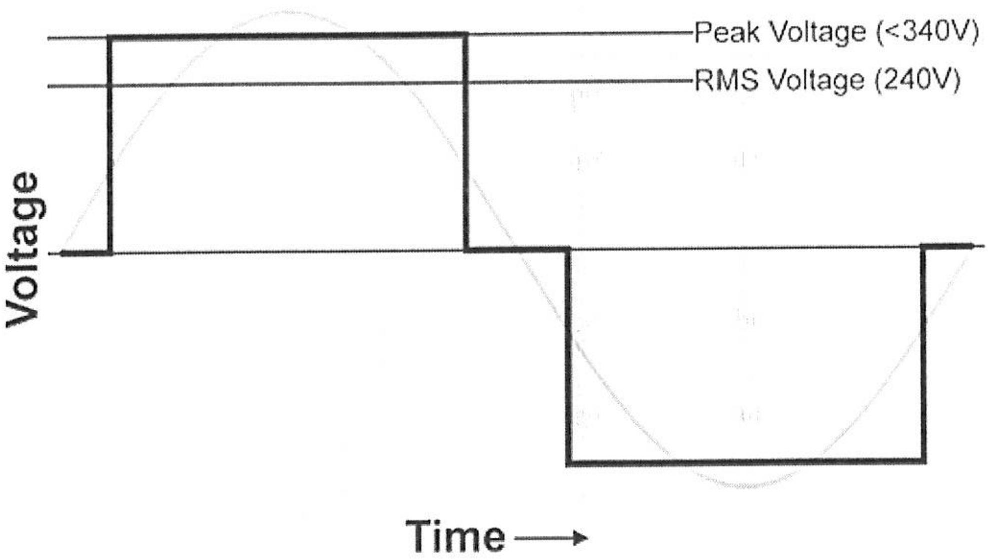


FIG 2. MODIFIED SINE WAVE

2.11.2 True sine wave inverters

This is one of the better types of inverters as they provide better power as compared to the modified sine wave inverters for homes. These types of home inverter are also run using a battery of a larger capacity.

Technically speaking, the sine waves they produce are purer, thus the efficiency.

They are best inverters employed for the power sensitive appliances like refrigerators, televisions, air conditioners, washing machines, etc.

These types of inverters are extremely reliable. The only drawback is that they are a bit expensive and cannot be afforded by the common man.

There are various models available based on the electricity requirement of the house.

The wave form of a sine wave inverter is as below:

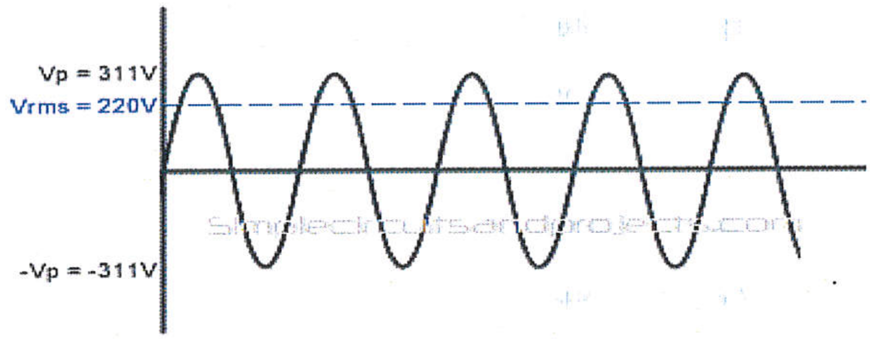


FIG 3. SINE WAVE

2.11.3 Square wave inverter

This is the simplest form of output wave available in the cheapest form of inverters. They can run simple appliances without problem but much else. Square wave voltage can be easily generated using a simple oscillator. With the help of a transformer, the generated square wave voltage can be transformed into a value of 240VAC or higher. The wave form of a square wave inverter is a below:

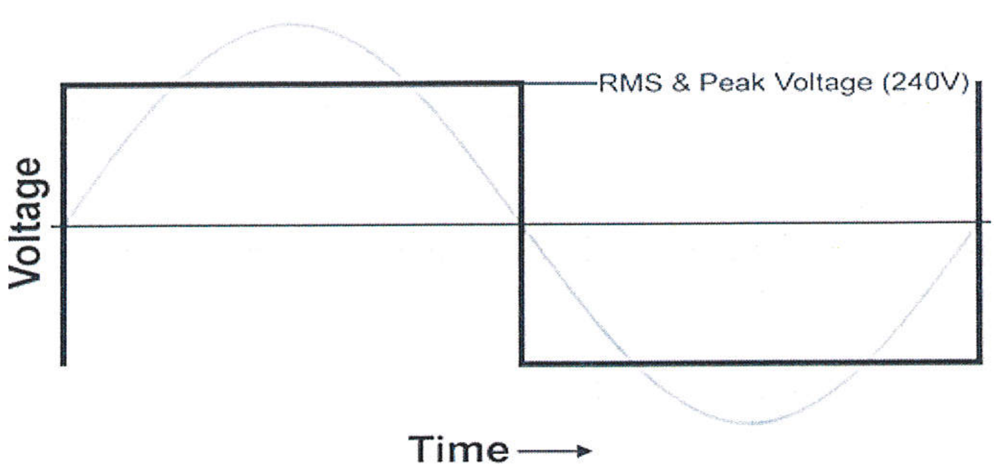


FIG4. SQUARE WAVE INVERTER

CHAPTER THREE

3.1 METHODOLOGY

Power Electronic Training Board has been designed specifically for the study of working of inverter. The Inverter trainer is a versatile training System for Laboratories. It is designed such that all the basics of Inverter can be easily understood. This training system provides understanding about conversion of DC into AC by PWM Technique. Different blocks are explained like charging of battery, DC to AC conversion, AC mains sensing circuit, etc. also provided with fault switches to develop the troubleshooting practice. PWM Inverter Technology Standalone Operation Compact Design Self explained layout Provided with Rechargeable Battery On board LED indication for mains, charging, inversion.

This trainer kit is required for studying different types of single phase inverter circuits. The kit should provide platform for rigorous experimentation on single phase inverters. Various popularly used controlling methods should be experimented. The kit should work with directly with 230V; 50Hz AC supply and all measuring meters connected externally. Loading arrangement should be a part of kit.

3.2 SYSTEM COMPONENTS

The board consists of the following built-in parts:

1. IC-1 & IC-2 to generate AC signals to drive

2. 12-0-12V AC at 4 Amp. Transformer.

3. Four NPN low Power Transistors.

4. Four NPN high Power Transistors

5. Red, Black and Green terminals for test points.

6. Unit is operative on 12 volts 100AH battery

7. Sufficient quantity of patch cords. Good Quality, reliable terminal/sockets are provided at appropriate places on panel for connections/ observation of waveforms

3.3 LIST OF TOOLS

Soldering kit

Glue gun

Screwdrivers

Wire strippers / jumper wire.

Lead sucker

Digital Multimeter

FIG 2 THE BLOCK DIAGRAM OF A MODIFIED SINE WAVE INVERTER IS AS BELOW:

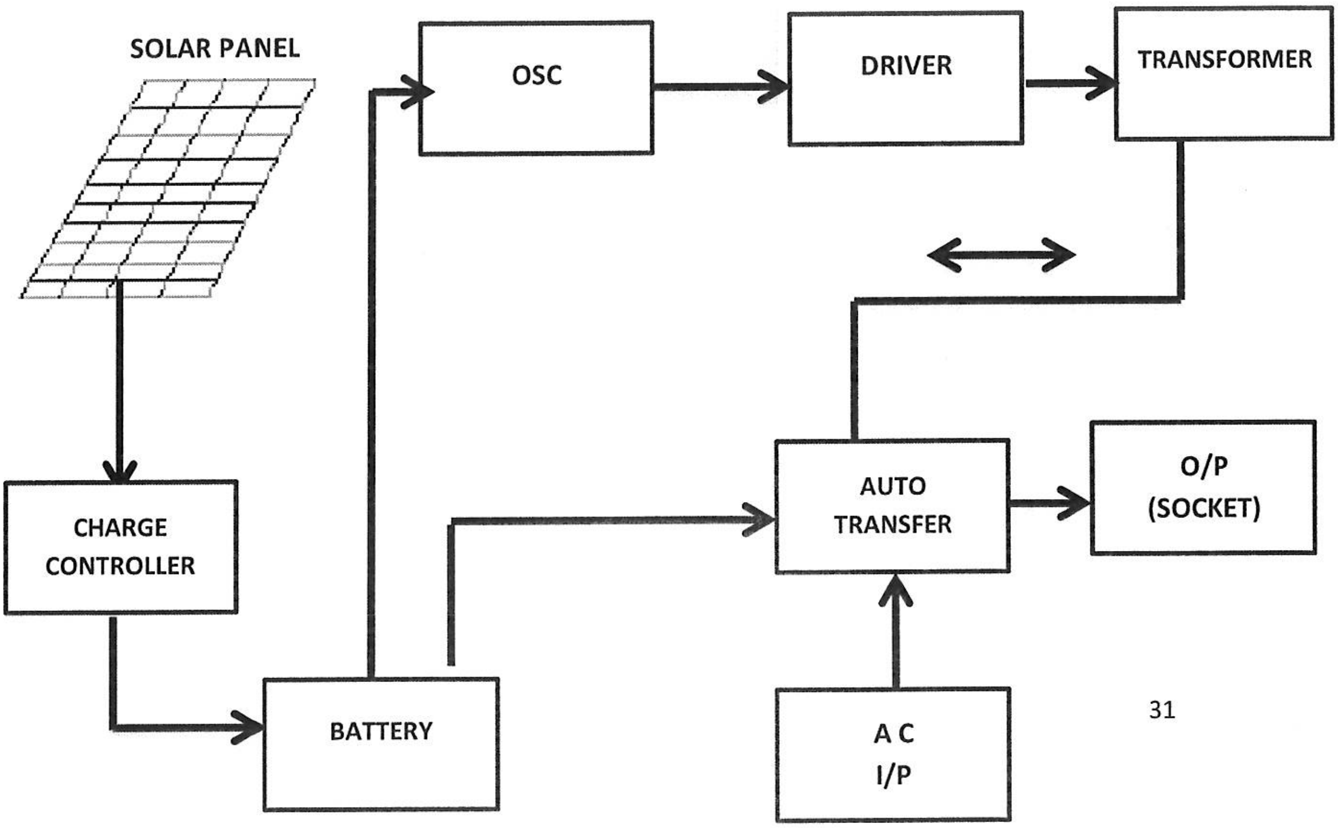
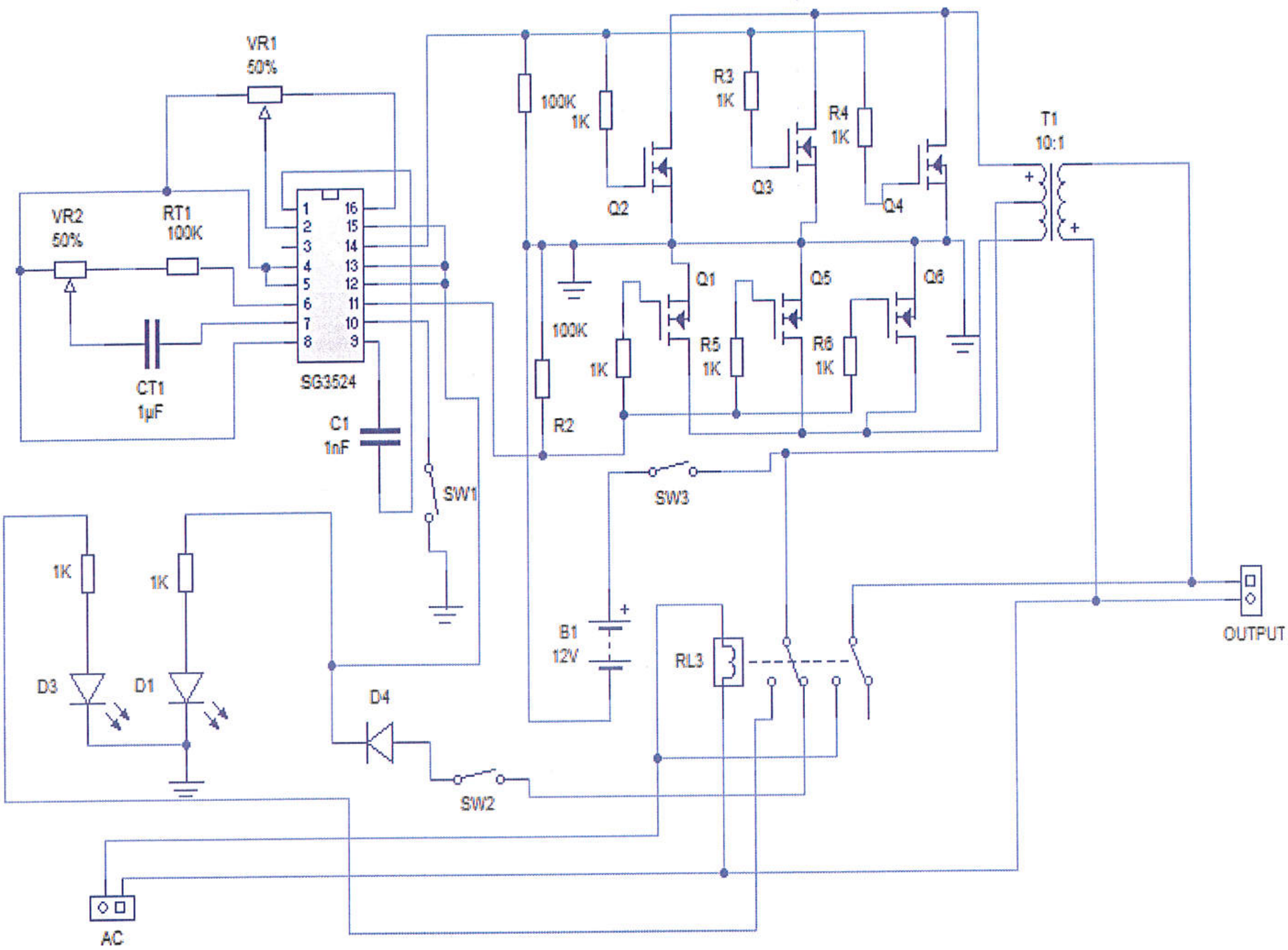


FIG 3. CIRCUIT DIAGRAM OF THE PROECT



Under this section, details of auto transfer modules design and construction of the project are discussed.

3.4 AUTO TRANSFER DESIGN

An Automatic transfer switch (ATS) is an electrical/electronic switch that senses when the mains or public utility(ac) supply is interrupted and automatically starts up a secondary supply (solar which is the dc) if the utility remains unavailable. ATS also known as "Generator Transfer Switches, has an additional circuit component which is normally in the form of a computer that monitors the incoming power supply. This circuit according to Silva and Kolo [2-3], also monitors the voltage sags, power surges, power spikes, or brownouts. It also initiates the changeover action when there is a complete power loss. Whenever a fault is being detected, the automatic transfer switch starts up the emergency power supply. The ATS is connected to both power supply sources and supplies the load with power from only one of the sources at any particular instant in time.

3.5 DESIGN STAGES/COMPONENTS

3.5.1 The Relay switching stage:

This block consists of the combination of the voltage monitoring relay(VMR) and the finder relays (11-pin relays) which serve as sensor used to determine the availability or non-availability of voltage supply from either power sources before triggering the control sections of the ATS. The VMR is used for measuring and comparing the voltage level of the utility supply with a set voltage tolerance range (185-250V A.C).

3.5.2 The Timer Relay Stage:

This block is made up of delay timer relays operating as normally open timed closed (NOTC) timer relays on each section of the ATS. The Timer relay on the utility section helps to delay the supply of electric power from the public utility, thus preventing the occurrence electrical damage due to fluctuations in voltage supply. The Timer relay helps to stabilize the power and allows it to warm up before it finally supplying power to the connected load. The delay time for the utility timer relay is 5-6 seconds

3.5.3 The contactor switching stage:

This block is made up of Contactors on each side of the ATS (i.e. the utility contactor (KN) and the generator contactor (KG)). The function of the contactor is to switch the current to the connected loads easily. This is because they are made to handle large amount of current flow in electrical installations. The maximum load rating of the contactors is 12Amps.

3.5.4 contactor selection:

With the input voltage supply from either power sources (V) = 220-240Va.c supply

Generator power rating (P) = 1.5KVA

Assuming Power factor (Cos Θ) = Unity

Rated generator set current (I) in Ampere $= \frac{power\ in\ kva \times 1000}{operating\ voltage}$

$$= \frac{1.5 \times 1000}{220}$$

$$= 6.8 \approx 7A$$

3.6 OPERATION OF THE AUTO TRANSFER

The A.C voltage monitoring and control circuit are designed and constructed. This was achieved by using voltage monitoring relay (VMR) as a primary component of the power sensing and control circuit; which is used for measuring and comparing the voltage level of the utility supply with a set voltage tolerance range (185-250V A.C) while a 12A miniature circuit breaker will act as a switch to the power supply from the public utility end of the ATS.

The power switching circuit was designed. ABB-type power contactors rated 12A, 220V a.c, timer relays to provide some delays (5 seconds) during the starting of the secondary source(dc) and transfer of the connected load vice versa from the both power sources depending on the side with steady electrical power at any point in time are used. The switching mechanism of the generator is done with a 12V d.c supply battery and auxiliary contacts of the timer relays and the contactor. The automatic ignition and stopping of the generator depends on whether the contactors are energized and deenergized. Display unit was also designed. The digital multimeter (DMM) displaying the output voltage and the rated current of the ATS have a 12V and 5V d.c power supply unit (PSU), a current transformer (C.T), an ADC microcontroller (PIC 16F877) to convert the measured analogue ac voltage and current to digital values for display on the liquid crystal display (LCD) display.

3.7 TYPES OF AUTOMATIC TRANSFER SWITCHES

Open-transition switches. An open-transition ATS utilizes a break-before-make system, meaning your transfer switch will break contact with the previous power source (grid versus generator) before establishing new contact. This system does create a brief total loss of power, but a stable connection is reached within seconds. Many smaller businesses, or businesses where a two second or so delay will not hamper processes utilize open-transition switches. These switches are the most widely used and tend to be highly reliable due to the sheer simplicity of the device and its processes.

Standard or "fast" closed-transition. These operate on essentially the same principles of an open-transition system, but the switch will maintain contact with both power sources (grid and generator) until a stable connection is established. Connection is held usually for roughly a tenth of a second, so there's no real danger of back feeding or harmful overlap. Since these systems avoid the power interruption of an open-transfer switch, they are often used by businesses that can be harmed by even the briefest losses of power. Most often these are large-scale commercial businesses, hospitals, data centers, etc.

Delayed-transition systems. With these ATS systems, a break-before-make is still established, much like an open system, but there is an engineered and purposeful delay before the switch from grid to generator power is made (and vice-versa). This delay acts as a failsafe against power surges that can be common to heavy industrial equipment when powered on and off within seconds.

3.8 HOW TO CHOOSE THE RIGHT INVERTER

Inverter is a type of electronic power generator which convert low voltage direct current (DC) from a battery to a high voltage alternating current(AC). Power failures can be really very frustrating at times, especially during the night time. Inverters will help you to cope up with the blackout and do away with your problems. Choosing a right inverter and battery is not very easy.

CHAPTER FOUR

4.0 CONSTRUCTION PROCEDURE AND TESTING

In building this project, the following procedures were properly considered,

I. Purpose of the entire materials / Components needed

ii. Resistance check of the components bought with the help of ohmmeter before making the necessary connection with the components

iii. Drafting out a schematic diagram or how to arrange the materials / components.

iv. Testing the completed system to see if the design works and

v. Finally, implementation of design of the project.

Having procured all the materials, I processed into the arrangement of the components into the Vero board but we could not place the MOSFETs on the bread board because the heat it emit when we load it, proper soldering of the components then followed. The components were all soldered into the board after which it was correctly confirmed done.

After carrying out all the paper design and analysis, this project was implemented and tested to ensure it's working ability, and was finally constructed to meet desired specifications. Stage by stage testing was done according to the block representation.

The process of testing and implementation involved the use of some test and measuring equipment which are listed below:

Digital Oscilloscope: The digital oscilloscope as shown in Fig. 4 below was used to visualize and analyze the output waveform

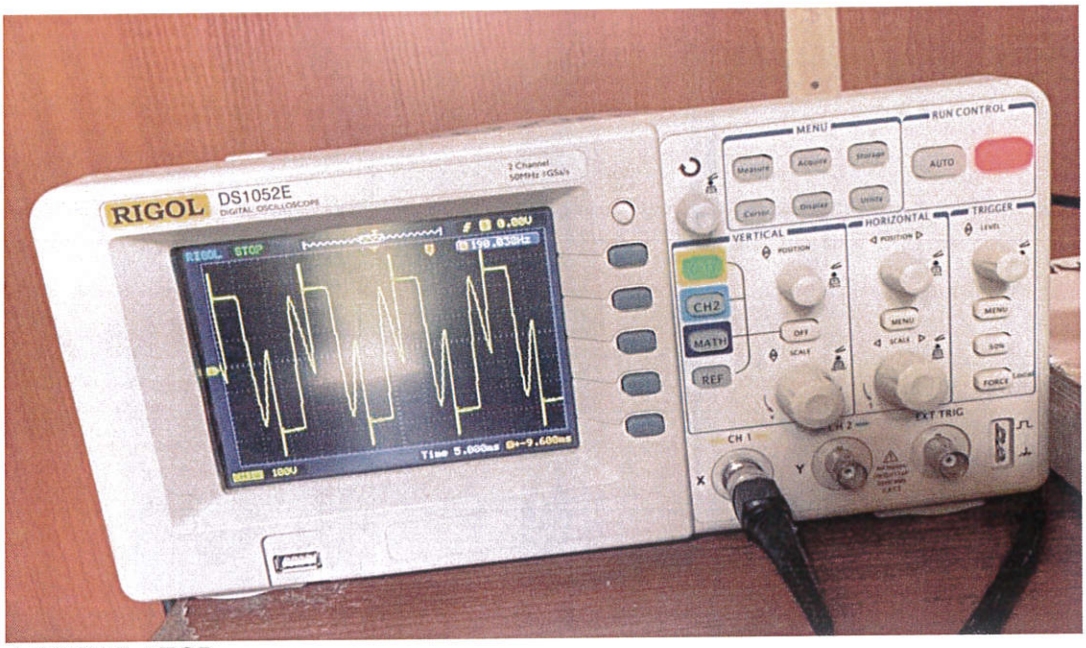


FIG. 4 OSCILLATOR

Digital Multimeter: The digital multimeter was used to measure the output voltage and current

Clamp meter: the clamp meter was used to measure the current of the battery

Fig. 5

4.1 RELIABILITY TEST

When tested with various loads such as resistive loads and inductive loads such as electric hand drilling machine, 200watts filament bulb, the inverter worked perfectly.

4.2 STABILITY ANALYSIS

This was done by examining the inverter system for a period of 21 minutes under no load condition and load condition.

Table.1 stability test under no load

Time (minutes)	Voltage (Volts)
0	214
3	214
6	214
9	214
12	214
15	213
18	213
21	213

The Graph of voltage (volts) against time (minutes)

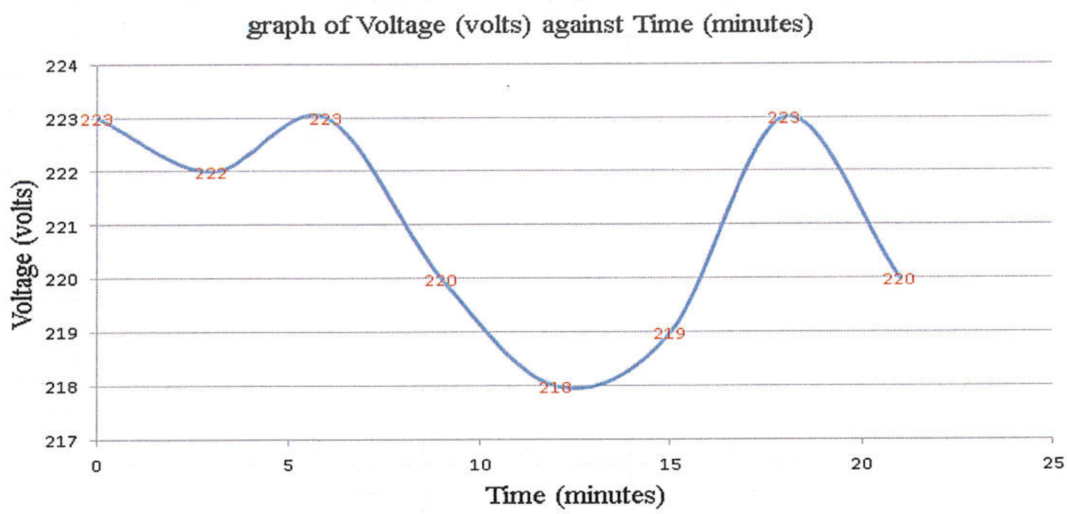


Fig.6: stability test

From Figure 6, it was discovered that the output voltage is still within the range of the expected output voltage (±5%).

4.3 LOAD ANALYSIS

The inverter was loaded up to 900W by a mixture of three 200W and three 100W tungsten filament bulbs and the inverter still worked perfectly.

Table 2: Load analysis

Load (watts)	Current (ampere)
100	0.31
200	0.49
300	0.78
400	0.93
500	1.19
600	1.42
700	1.55
800	1.75
900	1.94

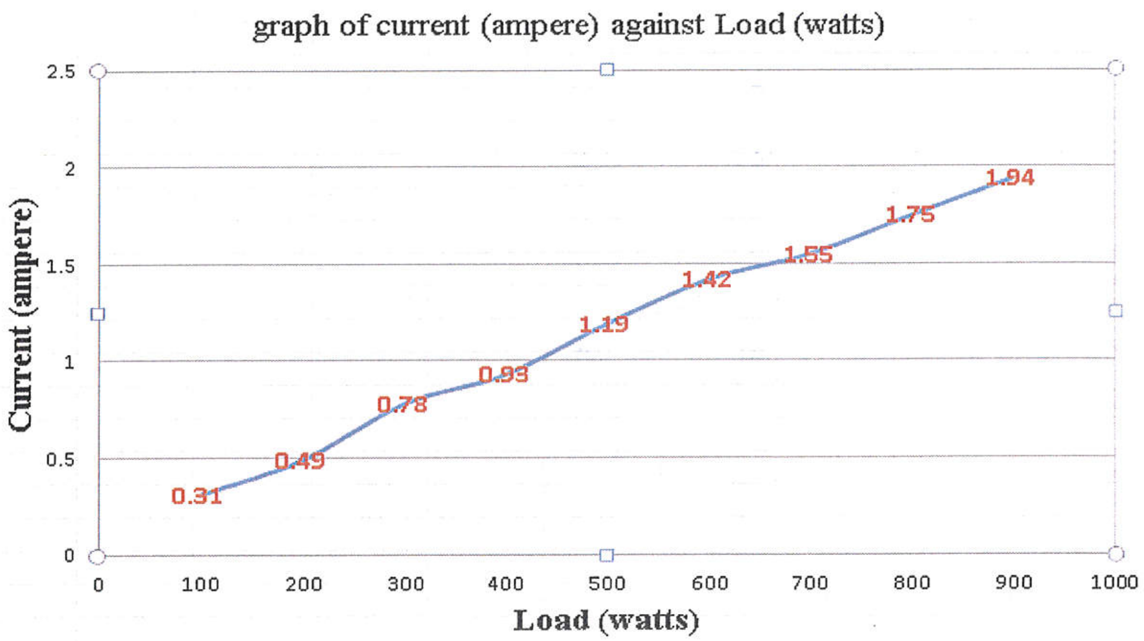


Fig.7: Load analysis

From Figure 7 above, it is discovered that the current drawn for the inverter system is directly proportional to the load drawing the current which follows that it obeys the equation 1:

$P=IV$ .... (1)

When Voltage is constant, as P increases, I increase. Where P is the power, V is the Voltage and I is the Current

4.4 CASING AND PACKAGING

All the components were soldered onto the Vero Board. Then after that, a meter board was gotten where the entire circuit was mounted follow by other external components such as indicators, switch, transformer, auto transfer, driver and oscillator.

4.5 ASSEMBLING OF SECTIONS

Having provided the meter board and having finished the construction of the sections of this system, the assembling into the meter board are as followed. The sections were properly laid out and assembled into the meter board where the general coupling and linkages into the peripheral devices took place.

Finally; the indicator was brought out to indicate when the system is powered. Switch was brought out for powering the system and battery contact was also brought out where batteries are being connected.

4.6 TESTING OF SYSTEM OPERATION

In this stage, the system was due for testing and operation. The system operation was tested where all its required performance was maintained.

First; batteries were connected and the system was powered through the switch the LED displayed indicating ON. Then after we powered the system, the measuring terminal was connected to the system.

4.7 COST ANALYSIS

The expenditure made in purchasing all the components / materials and quantity used in building this project is tabulated as show below:

S/N	COMPONENT	COMPONENT DESCRIPTION	QUANTITY	UNIT AMOUNT (₦)	TOTAL AMOUNT (₦)
1	RESISTOR (OHMS)	1K	6	10.00	60.00
		100K	3	10.00	30.00
		50K (VARIABLE)	2	10.00	20.00
2	CAPACITOR(F)	1u	1	10.00	10.00
		1n	1	10.00	10.00
3	IC	SG3524	1	250.00	250.00
4	SOCKET	IC SOCKET	1	50.00	50.00
5	MOSFET	IRFP260N	6	500	3000
6	DIODE	LED	2	20.00	40.00
		IN4001	2	20.00	40.00
7	SWITCH	SPST	1	50.00	50.00
8	FAN		1	250.00	250.00
9	AC RELAY	DPCO	1	2500.0	2500.0
10	METER	DIGITAL AC METER	1	1500.0	1500.0
11	CABLE CLIP		16	5.00	80.00
12	CABLE LUG		2	20.00	40.00
13	TRANSFORMER	CENTER TAP	1	20,000	20,000
14	BOARD	PCB	1	250.00	250.00
15	CHARGE CONTROLLER		1	12,000	12,000

16	OUTLET	TWIN SOCKET	1	250.00	250.00
17	SOLAR PANEL	150 WATTS	1	3,5000	3,5000
18	CONNECTOR	TWO WAYS	1	30.00	30.00
19	BATTERY	12V, 100AH	1	3,5000	3,5000
	GRAND TOTAL				

CHAPTER FIVE

5.1 CONCLUSION

At the end of this work, a modified sinewave inverter trainer kit was built and all the external testing and measuring terminals were brought out of the casing after the circuit was printed in the board of the device. At this point we conclude that the aim of the work was achieved which is to design an inexpensive, simple to use device that could be retained by students, so that they can undertake digital experimentation.

This invention relates to trainers and more particularly is concerned with a trainer capable of displaying digital devices operatively connected in a circuit configuration which precisely duplicates the schematic diagram of the circuit under consideration.

5.2 PROBLEMS ENCOUNTERED

Following problems were encounter during the construction of the project

1. Transformer continuity test failed i.e. there was continuity between the coil and the laminations of the transformer.
2. Digital AC meter stop working during testing of the project
3. When the inverter was on charging mode, the cooling fan was making irrelevant sound.

5.3 SOLUTION TO THE PROBLEM ENCOUNTERED

1. The transformer laminations were readjusted and aligned
2. It was discovered that the capacitor of the Digital AC meter had been burnt. The meter was replaced with another one.
3. It was discovered that the cooling fan blade was scratching its body. The blade was properly aligned and part of its body was scrapped.

5.4 RECOMMENDATION

Although the objectives of this project have been achieved, the inverter cannot be used to power any device of higher power rating. In addition, when the inverter is operating on mains supply, any fluctuation of the AC input gets to the inverter output.

Therefore, for improvement on this project, further research can include; increasing the power rating of the inverter by increasing the number of the power switching devices and the current rating of the transformer.

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