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# Design and Simulation of a 2KVA Inverter with an Overload Protector

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***Abstract:** In this research, the design and simulation of 2000VA inverter is presented. The method implemented for the design was the d.c. – a.c. inverter topologies. The d.c. – a.c. inverter circuit made use of a 555 timer, to digitally pulse the transistors on the inverter side, and the oscillating circuit, to drive the inverter. The system consists of the main inverter stage and the charging unit. These units are further subdivided into different stages. The main inverter performs the basic operation of converting the input d.c. voltage from the battery into an a.c voltage. The charging unit contains an automatic switch that charges the battery when it senses no supply from the mains. Each unit of the project was simulated individually at every different stage of the design by using a simulating software (every circuit). The waveform given at the final stage of the simulation shows that it is a modified sine wave inverter, and it successfully converts a 12V d.c. into a 220V a.c. with a load capacity of 2000VA. The inverter should be able to power the electronic device connected for a reasonable amount of hours*

## I. INTRODUCTION

Energy is the driver and vehicle for socio-economic development of any country. The majority of population of Nigeria lives in rural areas without power utility grid and this is the main hindrance to social and economic development. The rural electrification plays vital role for the development of the rural areas for obtaining economic growth and improvement of livelihood of the villages. More than 77 million households still use kerosene for lighting in Nigeria (Imdadullah, 2017). Others use energy sources that are not only unsustainable but equally destructive to the environment. The populace therefore, seeks for an alternative power supply using petrol and diesel power generating machines, for those that can afford them, and use of fuelwood and charcoal which deplets our forest resources with inherent desertification. Given the populous nature of the country, there is urgent need for solution because absence or insufficient power supply translates to absence or low socio-economic activities and low Gross Domestic Product (GDP) for the country. Inverters are used for many applications, particularly in situations where low voltage d.c. sources such as batteries, solar panels or fuel cells must be converted, so that appliances can be powered where grid a.c. source is not available

## II. METHODS

The highlight of the various components used in the design of the circuits that makes up the project as well as calculation involved where documented. The components making up the inverter include relays, resistors, switch and various ICs etc. capacitors, transistors, voltage regulators, MOSFET. The block diagram of the circuit is shown in fig 1. below.

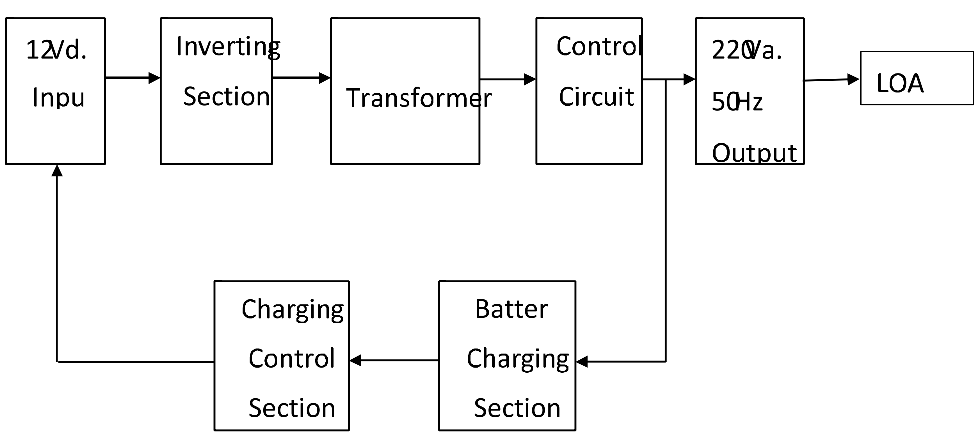


Fig.1 block diagram

### *A. DC Input*

For every inverter, the battery provides the required dc power to run the device through oscillation and passing the signal through a transformer to boost it up

### *B. The Pulse Width Modulation Stage*

The circuit at the lower half is the section which actually does the sine wave modifications by switching the upper AMV according to its PWM settings.

Frequency, $f = \frac{1}{1.1 \times CT \times RT}$ (Theraja and Theraja, 2005)

Timer Capacitor (CT) = 0.22µF

Fixed Resistor (RF) = 56kΩ

Variable Resistor (VR) = 10kΩ

Time Resistor (RT) =5 6kΩ+ 10kΩ = 66kΩ

Therefore, $f = \frac{1}{1.1 \times (0.22 \times 10^{-6}) \times (66 \times 10^{3})}$

f = 62.2 Hertz

It should be noted that the variable resistor was varied until the frequency of the signal was 50Hz.

### *C. Signal Amplifier Design*

Determination Of The Transistor (Mosfet) Switching Current

The MOSFET used is the IRF260 in the power switching circuit due to high switching speed. By using 3.67volts supplied by the two NPN and the two PNP transistors, the switching time (T) is determined from the oscillating frequency as well as the gate switching current $I_{G.}$

T= 1/f =1/50Hz

T = 0.02sec

$I_G = \frac{Cdv}{dt} = \frac{5000 * 10^{-6} * 3.67}{0.02} = 183.5.$

$I_G$ = 917.5ηA

### *D. Power Amplifier Design*

Power Switch Circuit for Construction of Power Inverter

Inverter power output (P) = 2000Watts

Output voltage, V = 220V

Inverter Input = battery output voltage =12V

Frequency = 50Hz

Power factor = 0.8

Apparent power= Real Power/P.F = 2000/0.8 = 2500VA

Therefore, the full load current flowing at the transformer primary;

Real power (P) = current (I) * voltage

2000 = I * 12

Hence, I = 2000/12 = 166.1A

### *E. Transformer Design*

$\frac{N1}{N2} = \frac{V1}{V2}$ (Bird, 2009)

Where $\frac{N_1}{N_2}$ is the ratio of primary turns to secondary turns.

$\frac{V_1}{V_2}$ Is the ratio of primary voltages to secondary voltages.

The power rating of inverter transformer KVA = 2KVA, E2=12V

ASSUMING the efficiency of transformer = 85%

Then input rating = output/ efficiency$= \frac{2000}{0.85} = 2352.9VA$

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Ip = P/VP = 220V
Ip = 2352.9/ 220 = 10.695A.
Is = 2000/12 =166.66A.
Number of turns per volt for both primary and secondary winding is given by;
NT per V= 7A
Where A is the area of transformer former in sq. inch
A is 2.3inch by 1.5inch = 3.45sq.inch
NT per V= 7/3.45=2

NT per V= 2 (approximate value).

1) *Primary Winding*
   Charger tapping winding turns
   Np1= NT per V * E1=220V
   Np1 = 2 * 220 = 440turns
2) *Secondary Winding*
   Secondary turns Ns= NT per V * E2 = 12V
   Ns= 2 *12= 24turns.
3) *SWG Size and Gauge Estimation*

Standard Wire Gauge Weight, SGW, can be estimated as follow;
Considering conduction current density J (with fixed value of 2.5A/mm2) and windings coil current.
For Ip = 10.69A.
For Is = 166A.

### *F. Change Over Selection*

The change over helps to switch over from inverter ac source to domestic power to avoid fusing both source together, the change over are rated base on current , voltages and contact point but in this design, we will consider a dual pole double contact relay with 2000A capacity

### *G. MOSFET*

MOSFET, abbreviated from “Metal Oxide Semiconductor Field Effect Transistor”, are by far the most popular transistors used for switching in circuits today. In most cases, the Bipolar Junction Transistors are still used. The main difference between MOSFETS and BJTs is that the former are voltage controlled (little or no current is used) and the later are current controlled (voltages are there to control currents). Therefore, MOSFETs require less power to drive them, so they are preferred choice (Paul, 2010).
MOSFETs are either N-channel, made mostly of N-type semiconductor material, or P- channel where they are made mostly of P-type semiconductor material. They operate in two modes enhancement mode and depletion mode.

### *H. IRF260N MOSFETs*

The IRF260N MOSFET was used for the design. It has a current rating of 15A. Since a battery is meant to be used with the inverter, the input d.c. voltage is taken to be 12V (Battery’s Voltage rating). The determination of the number of MOSFETs required to give the desired output power is a function of the current flowing in the primary side of the transformer i.e. the output of the MOSFET.
MOSFET Calculation:
Transformer rating = 2000VA
Power factor = 0.8
Voltage = 12V
Wattage rating = transformer rating × power factor (Can, 2010)
Wattage rating = 2000 × 0.8 = 1600W
Power= current × voltage
Current = 1600 / 12 =133.33A
By implication, the MOSFET must be able to allow a current of 133.33A without any risk of damage to the component.

The maximum drain current of the MOSFET is 30A at 25˚C but it is difficult to keep the MOSFET at this temperature during high power operation.
The required numbers of MOSFET is calculated as follow:
Maximum current = 133.33A
Maximum drain current for each MOSFET = 15A
Number of MOSFET = $\frac{\text{maximum current}}{\text{MOSFET drain current}}$
Number of MOSFET =133.33/15 ≈ 8 MOSFETs

## III. RESULT AND DISCUSSION

Every Circuit Simulation software was used for the design and simulation analysis.

### *A. Oscillating Unit*

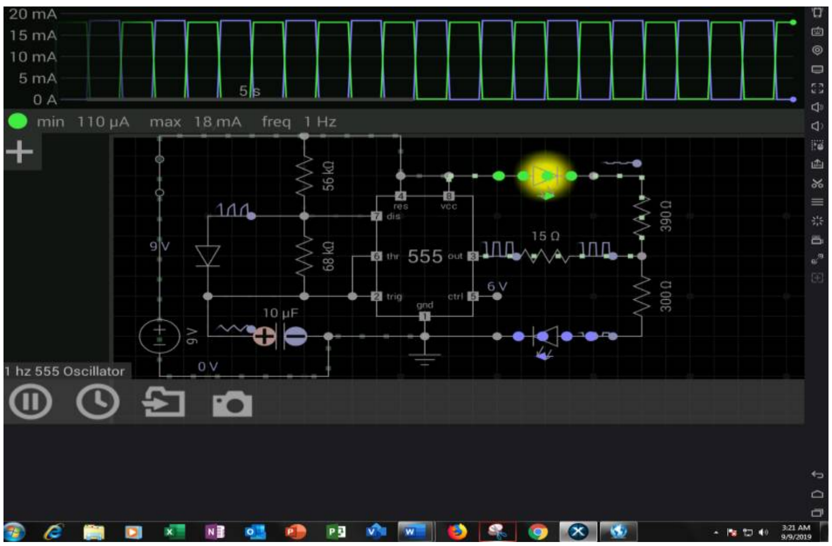


Fig 2: screen short of oscillating unit

The oscillating unit stage of an inverter is a stage basically responsible for the generation of oscillating pulses through a transistorized circuit also shows the process of oscillation between two states as illustrated in figure 2, the 555 timer is used for oscillation at 50 hertz that is given to transistors for switching.

### *B. MOSFET Switching*

The MOSFET ( metal oxide semiconductor field effect transistors) is a semiconductor device widely used for switching and amplifying electronic signals in the electronic devices.

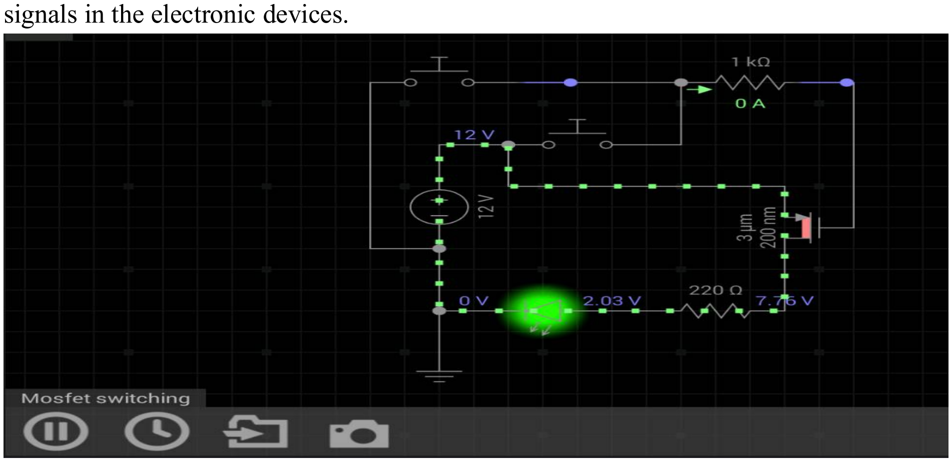


Figure 3 : MOSFET Switching (SCREEN SHOT)

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### *C. MOSFET Power Amplification*

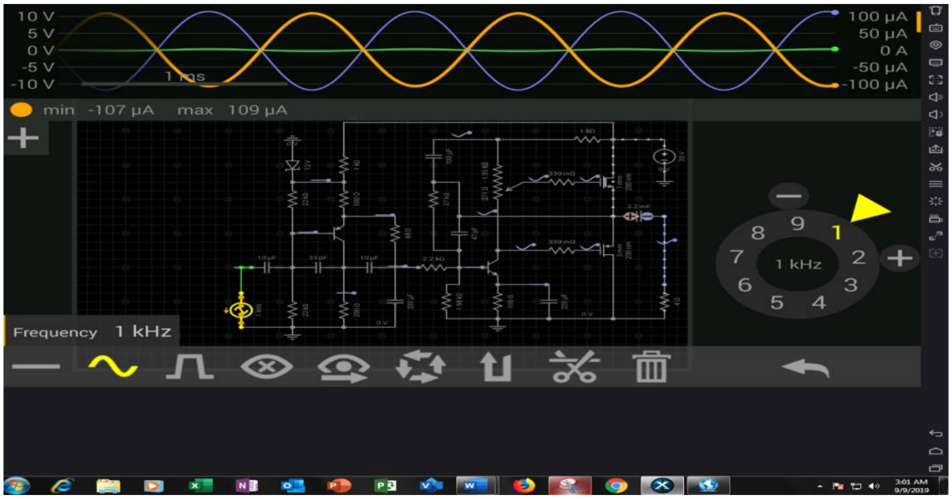


Fig 4: Mosfet Power Amplification (SCREEN SHOT)

### *D. Charger Unit*

The charging unit system for this project is the internal and the external charging system. This implies that at the time the mains or the grid power supply is available, the internal charging system would partially recharge the battery. Figure 5 shows the battery charging circuit.

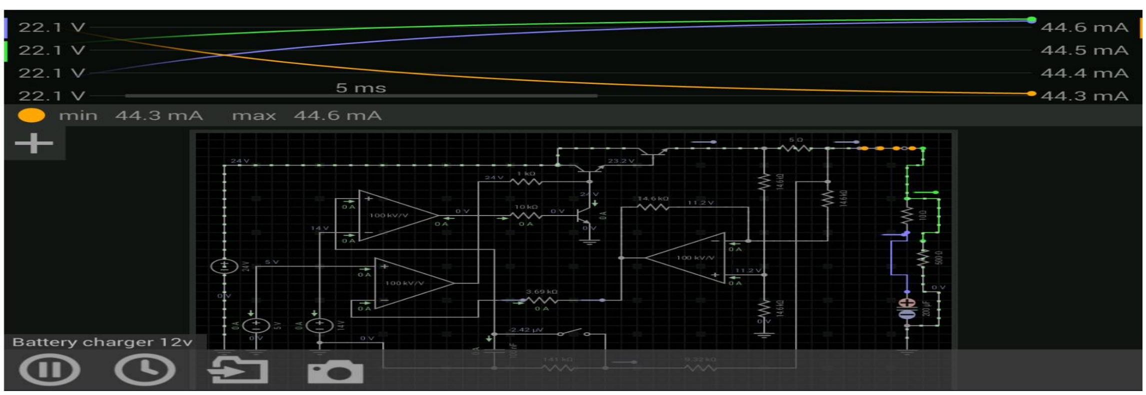


Figure 5: Charging Unit with cut off (SCREEN SHOT)

### *E. Protection Unit*

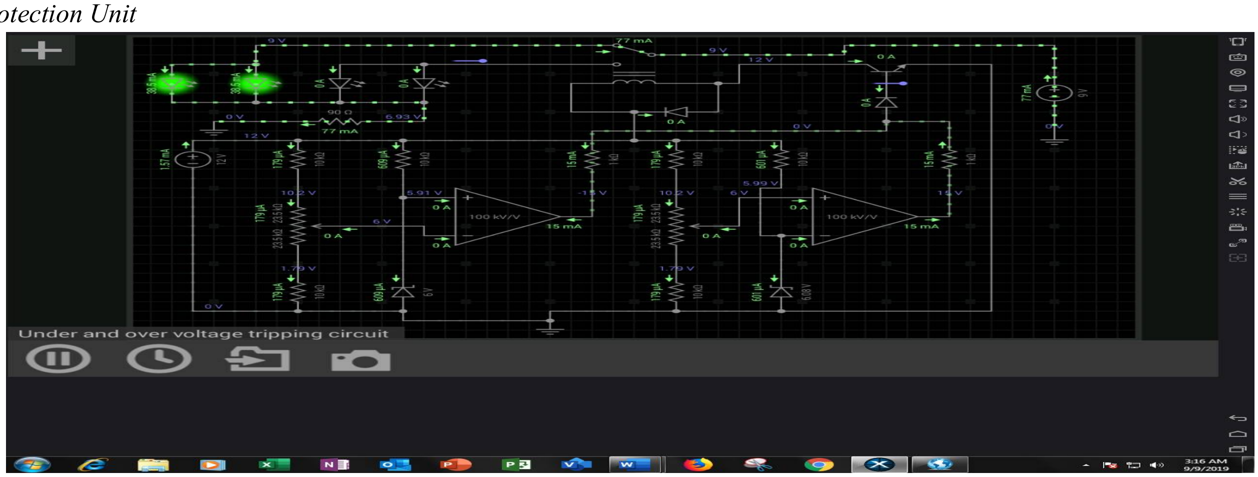


Figure 6: protection unit (screen shot)

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*F. Graphical Illustration*

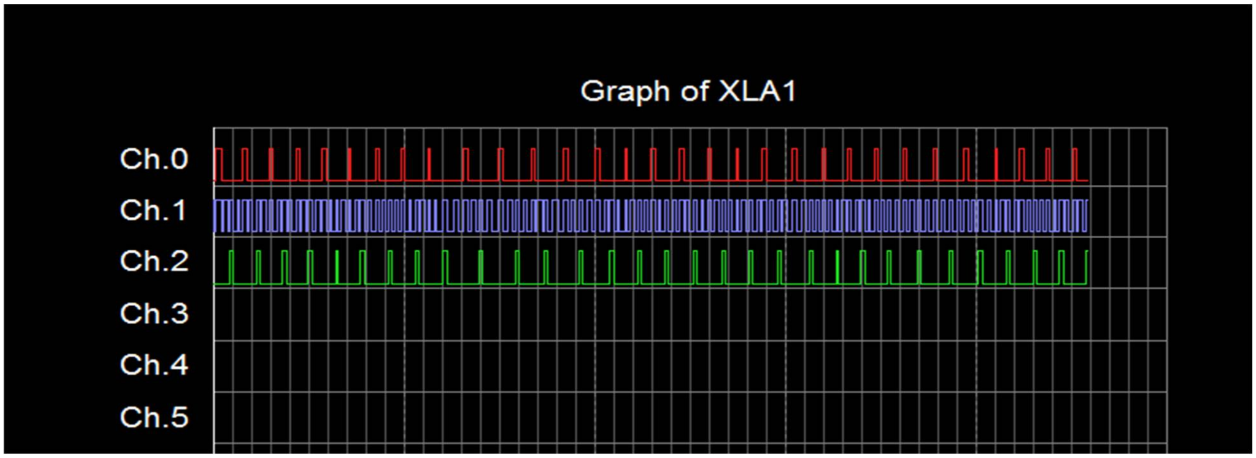


Figure 7: Graphical View (Screen Shot)

*G. Modified Sine Wave 2KVA Inverter with an Overload Protector*

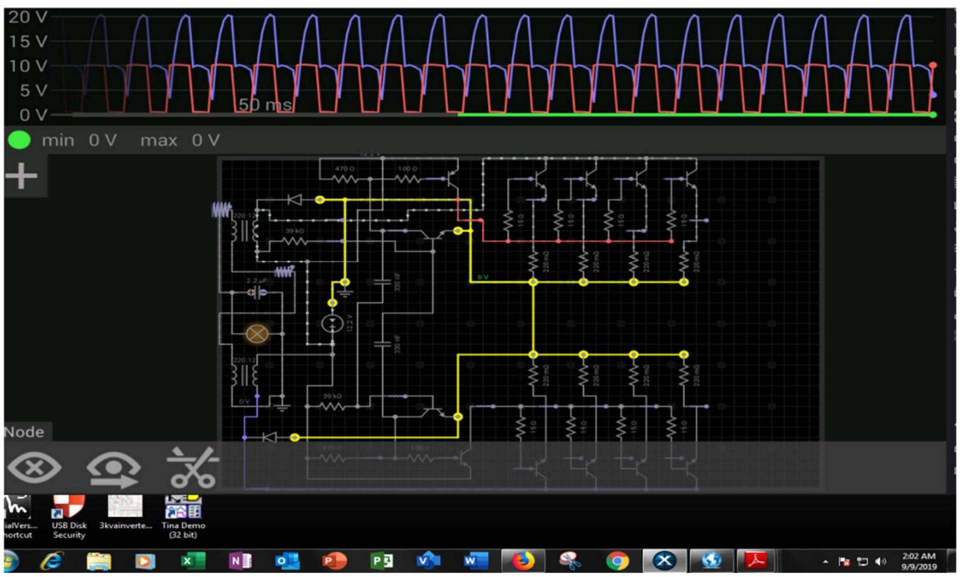


Fig 8: modified sine wave genaration of 2kva inveter. (SCREEN SHOT)

As shown in the figure above, the 12V d.c been converted into a 220V a.c, also the output waveform shows it is a modified sine wave inverter

Table 1 : Parameter settings of the inverter.

| | |
|---|---|
| Input voltage | 12Vd.c. |
| Output voltage | 220Va.c. |
| Minimum battery voltage | 10V |
| Maximum loading capacity | 1600W |
| Minimum a.c. output voltage | 200V |
| Maximum a.c. output voltage | 223V |
| Frequency | 50Hz – 53.4Hz |

## IV. DISCUSSION

The simulation work is focus on generating 2kva inverter with an overload protector using electronic software system with basic circuit analysis, the work was carried out with design equation and to test the actual value without building but several changes were observed like slight voltage drop and difference in current and also I will like to point out that the transformer rating is base on root mean square value which is twice the voltage rating.

## V. CONCLUSION

The results given after the simulation process showed that the inverter function as expected. The inverter successfully converts 12Vd.c. source into 220Va.c. at a frequency of 50Hz, with a power capacity of 2000W. The inverter should be able to power the electronic device connected to its output - like TV set and standing fan, for a reasonable amount of hours with a durable and effective batteries.

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