DESIGN AND CONSTRUCTION OF 1KVA POWER INVERTER SYSTEM

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DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

DECEMBER 2009

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A THESIS SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF BACHELOR OF ENGINEERING DEGREE IN ELECTRICAL AND COMPUTER ENGINEERING, FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA.

DECEMBER 2009

DEDICATION

I dedicate this project to the glory of Almighty God and my parent, High Chief & Mrs J.O.O. Sangokeye.

DECLARATION

I Sangokeye, Olusegun Ademola declare that this project work was done by me and has never been presented else where for the award of a degree. I also hereby relinquish the copyright to the Federal University of Technology Minna.

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ACKNOWLEDGEMENT

I give thanks to Almighty God for his numerous blessing throughout my university education. My special thanks goes to my lovely parents High Chief and Mrs. J.O.O. Sangokeye who have been supporting me financially, spiritually and morally. I pray to Almighty God to make their life easy for them.

My profound gratitude goes to my brothers and sisters for their moral and spiritual support through the course of my programme. Special thanks to my supervisor Engr. (Dr.) Y.A. Adediran. The HOD Electrical & Computer Engineering Department for his role toward the successful completion of the project, and the technician in-charge. Also, my sincere appreciation goes to my friends, Oluwaseun Adewusi, Adeola Olubode, Femi Adeleye, Akamo Sunday, Awobade Ayo, Ibiyemi Bello, Omolola Lawal. My cousin Niyi Salako.

My appreciation is incomplete without mentioning my guardian Mrs. Adeosun and Mrs. Odebode.(NPHCDA Minna Zonal Office).

ABSTRACT

Regular power supply is one of the factors that contribute immensely to the economic growth of a nation. But when a country starts to experience incessant power outages there will be reduction in the rate of growth of the economy. Mostly affected by this irregular power supply are the industries that rely on the national grid for the supply. The operation of most of these industries has been grounded because of the epileptic power supply. Some of the machines used by these industries for their production are very sensitive to power failure, hence when the parts get damaged it is not easy to get replacement, because most of the machines are imported. Consequently, there is need for an alternative that will salvage this ugly situation, hence the need for an inverter technology. Unlike others, the inverter is very efficient, pollution free and noiseless.

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CHAPTER ONE

INTRODUCTION

This project is on analysis, design and construction of a 1000VA power inverter, which was embarked upon due to inadequate supply of electricity for domestic use from the primary source (Power Holding Company of Nigeria). It has become very important to produce an alternative secondary source of power generation that is completely independent of Power Company (primary source). Power failure has become a disturbing and common phenomenon. Its unplanned occurrence has given rise to damages to domestic appliance, loss of lives and increase in the tariff by telecommunication operators in the country, who claim that they waste money on fuel to power their power generating set.

The shortage of power supply to places where constant power is inevitable such as hospitals, banks, theatre rooms, laboratories, hostel and similar institution to mention but few, gives needs for an alternative source of power. Supply must be more efficient and reliable for adequacy of electrical energy in form of an alternating current, especially when there is failure from the primary source PHCN.

This has actually led to research, discovery and development of power inverter designed to handle electric power back-up problems which consumers in case of failure from power supply utility. This device will serve as a secondary power supply in remote areas where the facility of PHCN is not available. Also it can back-up in some places where the utility is present but always fluctuating. It can be used as standby supply when the battery is well charged that is enough DC.

1. 220- 240 volts with 50Hz frequency is used by countries like Nigeria; Britain Germany, Ghana etc.
2. 110- 120 volts with 60Hz frequency is used by the United States of America Saudi Arabia, Korea, Japan.

This power inverter is designed to handle a wide range of appliances that may urgently require power or no interruption when the main utility source is off, such is off, such devices are central processing unit(CPU), domestic electronics set (TV, VIDEO, RADIO), audio set, (public address system) and also sensitive equipment in the hospitals.

To this end the maximum output power of this inverter is 1000 Watts with tolerance of 10%. The inverter is designed to have two inputs, one for the main utility supply (i.e. AC input) and the other one is DC input from the battery. It is also designed to cover wide range of electronics.

1.1 DEFINITION OF INVERTER

An inverter is an electronic device that contain an electronic circuit that is capable of converting direct DC to alternating current AC. That is a DC power inverter is an electronic device used to convert low DC volts (which was used for this project), to a higher AC voltage (which after it has been inverted is 220 volts power output) of a particular frequency. For this project 50Hz is used.

1.2 AIMS/OBJECTIVES OF POWER INVERTER

The major aim of this power inverter is to develop an alternative power supply which will convert DC to AC. The design of 1000VA power inverter is relatively simple and the electronic components are readily available in the market. The objective is to maximize all the advantages of inverter, increase the efficiency and provide the power for household appliances (e.g. TV and RADIO sets).

1.3 APPLICATION OF POWER INVERTER

Power inverter has a variety of applications which range from domestic to industrial use. It is also classified based on the type, design and the function they perform. Below are examples of the areas of application:

1. DC power utilization.

2. Uninterruptible power supply; uses batteries to store power and an inverter to supply AC power from batteries.
3. Variable frequency drives to control the operating speed of an AC motor by controlling the frequency and the voltage of the supply to the motor.
4. Electric vehicle drives; adjustable speed control inverters are currently used in some electrical locomotives.

1.4 METHODOLOGY

The 1000VA DC- to- AC inverter was designed and constructed after the consultation with individuals and expertise in the electronic and electrical field. In the construction of the power inverter a modular form of the design was employed. Design was carried out in stages which were first built on bread board.

1.5 USES OF POWER INVERTER

Below are some of the uses of the inverter;

1. It can be used in research centres and local areas where the AC supply generated by PHCN cannot reach.
2. Emergency lighting and bulbs used in homes, hospital and generator rooms.
3. It can be used where constant AC supply is not accessible.

1.6 ADVANTAGES OF POWER INVERTER

1. It is cost effective
2. It is easy to maintain
3. Components are readily available in the market
4. It is portable.

CHAPTER TWO

LITERATURE REVIEW

Inverter is used to supply clean and uninterrupted power to critical loads, under any normal or abnormal utility power conditions, including outages from a few milliseconds up to several hours duration. As a result of this, many versions of inverter have been developed with each employing various forms of circuit connections and compounds.

In 2003, engineers at the University of Aberdeen in Scotland designed and constructed an inverter in which a Darlington pair was used in the driver stage of the device. The transistors of the Darlington pair are basically two BJT devices with the emitter of first connecting the base of next while the two collector are joined together. The output of the multivibrator is fed into the Darlington pair, which consists of 2N6107 and BD140 transistors (PNP) that are connected to the output of the frequency generator (multivibrator). The output of the Darlington pair arrangement is used to drive push-pull NPN power transistor of resistor 22KΩ,15W each. The bank of transistors consists of four NPN (BU508A) each connected to the output of the power resistors used, which taps its input from collector of the Darlington pair.

In 1993, Krishan and Srinivasan constructed an inverter using large step up transformers. However the pulse-width modulated signals which feed the transformers are generated in real time by a PCI RISC microcontroller. The microcontroller senses AC output voltage via an 8-bit analogue to digital converter (ADC) that adjusts the pulse width accordingly using a closed control loop algorithm. The functions of waveform timing, pulse width adjustment and error control (shut down when overload occurs) are all done in software, making upgrades easy to accomplish. This design was observed to convert over 1KVA of power. Software control of the inverter allows the inverter to be overloaded for a period of time before shutdown occurs.

The inverter has been tested on 1/3 hp single phase motor loads as well as with large resistive loads of over 1500W and has performed well. Power factor correction was found to be required with large motor loads and has been included in the design. Efficiency of the inverter (power output/power input) driving a variety of both resistive and inductive loads ranges between 71% and 82%. With an improved sine wave algorithm it is felt that the inverter can approach the theoretical efficiency limit of 92%.

Also a lighting circuit of a 1KVA inverter was designed which a single IC (CD4011B) was used in conjunction with some other components.

2.1 COMMERCIAL APPLICATION AND IMPORTANCE OF INVERTER

In transmitting energy using A.C. some problems are encountered, which are enumerated below

a. With long transmission lines the series reactance of the line becomes so large that it imposes a severe limit to the maximum power that can be transmitted.

b. Underground or undersea high voltage A.C. cables are limited to a few of kilometers because of considerable reactive current.

The construction of inverter is shown below.

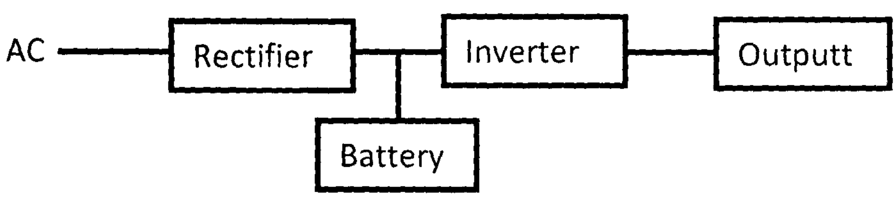


Fig. 2.1 Block Diagram of Power Inverter

The functions of inverter are

i. To provide continuous supply of A.C. in case of supply failure for an electrical appliance or electronics system.

ii. To protect electrical appliance or electronics system from electrical surge.

With these, the project is analyzed into format that makes inverter as an electronics device understandable in construction, function, operation and importance.

2.2 OVERVIEW OF EARLY DC-AC MOSFET INVERTER

In early inverter this unit is capable of converting DC voltage to AC voltage, since there is a means of storing DC current better than AC current. Hence the DC voltage derived from a DC battery can be inverted to an AC voltage to run the required equipment that requires AC voltage like an electric florescent, bulb, computers and some other electronic devices [1].

2.3 PRINCIPLE OF OPERATION OF POWER INVERTER

The principle of operation is to generate square wave pulse from DC power source with the aid of astable multivibrator. The pulsating waveform generated by astable multivirator is then used to alternately switch ON and OFF power MOSFET which in turn drives the power winding of a step-up transformer. This action causes alternating current to be generated at the secondary winding. The voltage generated at the secondary is dependent on the turns ratio of the transformer winding and the peak voltage level from astable multivibrator output.

The current demand from the battery requires that charging has to be regular if the battery must not run down permanently. Hence a battery charger stage which regulates DC from main voltage is used to charge the battery.

Also, a relay is based to switch main voltage to output when there is public supply to conserve power for the unit to make it friendlier.

CHAPTER THREE

DESIGN OF INVERTER SYSTEM

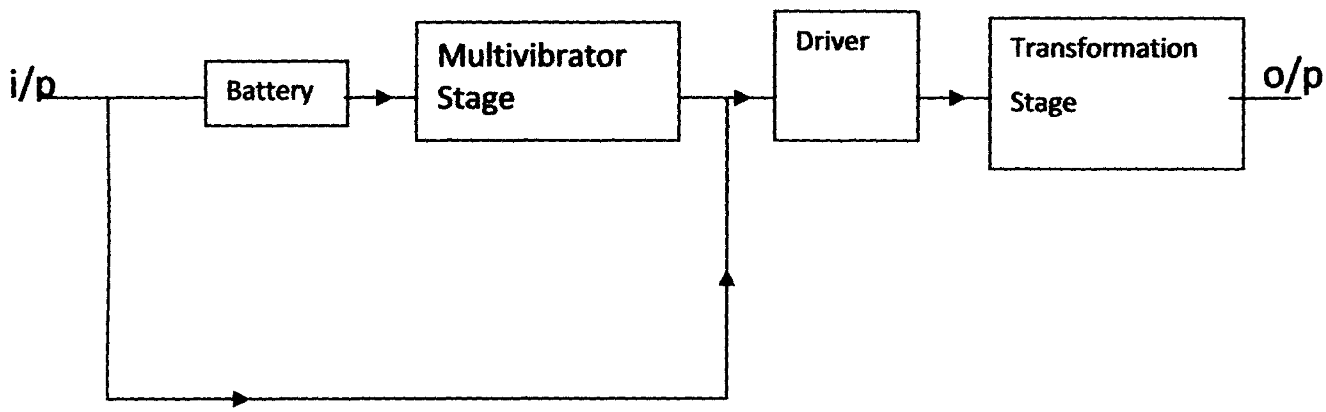


Fig. 3.1 block diagram of power inverter

3.1 MULTIVIBRATOR STAGE (THE ASTABLE MULTIBRATOR)

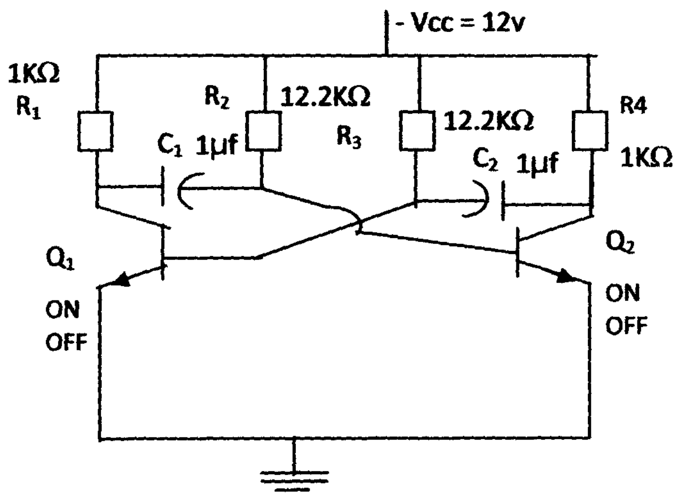


Fig. 3.2 Astable Multivibrator

In the design of astable multivibrator stage, this consists of two transistors amplifier connected in cascade, in which all the output of one state is fed back (100 percent feedback) to the input of the other stage.

When the supply is switched ON, unbalance between the two stages causes one transistor to conduct while the other remains cut off. Suppose that Q1 saturates, then a fall in its emitter voltage is transferred to the base of Q2, which ensures that Q2 is cut –off during the time that the current remains in this state Capacitor C1 charges from -Vcc towards at a rate depending on the time constant.

After this, the capacitor voltage causes Q2 to start conducting and the regenerative action causes Q1 to be cut-off so that the emitter voltage rises towards +Vcc at a rate depending on time constant C1R1. This sequence is repeated.

Current gain A_i = 3.67

Ic (max) = I_{CE} (ON) For transistor Q1 and Q2

Vbe (ON) = V_{CE} (ON) = 0

Target output frequency = 60Hz

V_{BE}(ON) = V_{CC}(ON) = 12V

$$R_4 = R_L = \frac{V_{CC} - V_{CE}}{I_C(ON)}$$

$$= \frac{12}{4.4 \times 10^{-4} A}$$

$$= 27k\Omega$$

$$= \frac{12}{1 \times 10^3}$$

$$Ic = 0.012$$

$$I_B(ON) = \frac{I_C(ON)}{A_i}$$

$$= \frac{1.2 \times 10^{-4}}{3.67}$$

$$= 3.27 \times 10^{-5}$$

$$R2 = \frac{Vcc - VB(ON)}{I_B(ON)} = \frac{12V}{1.2 \times 10^{-4}} = 100k\Omega$$

To calculate value of capacitor C1 = C2 = C

$$F = \frac{1}{2RCin2}$$

$F = Target$ output frequency = 50Hz

R = Resistance = 100kΩ

I = F × 2RCin2

$$C = \frac{1}{2Rfin2}$$
$$= \frac{1}{2 \times 100 \times 103 \times 50in2}$$
$$= \frac{1}{713941.596}$$
$$c = 0.14\mu F$$
$$= 0.14\mu F$$

Thus period time, T = 2RCIn2

$$2 \times 100 \times 103 \times 0.14 \times 10^{-6} \times in2$$
$$= 0.002 \text{ second}$$

Time duration for which Q1 is OFF is 0.002 seconds.

3.2 DRIVER STAGE

The driver stage consists of group of 10 FETs (Field Effect transistor) connected in parallel. The output of the multibrator is square pulse, which is used to open the gate of the FET. All the drains and source of the FETs are connected in parallel separately [3]. The output of the driver stage is tapped the drain of either a side of set of FET, which is then used to drive the transformer.

3.3 TRANSFORMATION STAGE

This is the stage where the voltage from the driver stage is step-up, i.e. the A.C. output from 12Volts to 220volt A.C. In the transformer design shell type transformer is used with E-lamination. This is used because it is compact and economical to produce [3].

The magnetic flux is built on E-lamination.

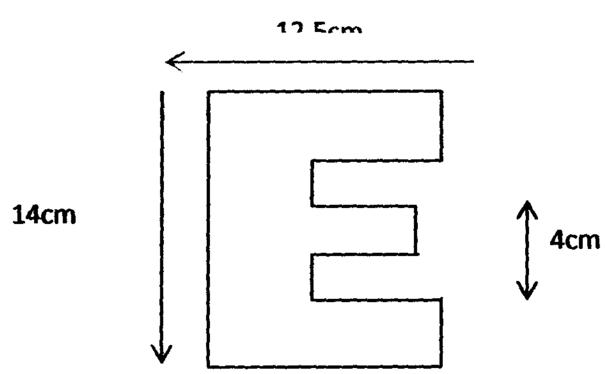


Fig. 3.3a E-lamination of the designed transformer.

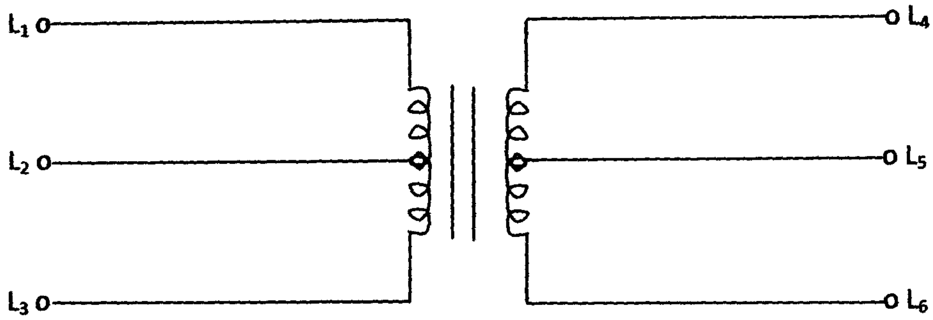


Fig. 3.3b Circuit symbol of a designed transformer

Number of turns of secondary, $N_s = 300$

Number of turns of primary, $N_p = ?$

Voltage in secondary, $V_s = 220V$

Voltage in primary, $V_p = 12V$

$$\frac{N_s}{N_p} = \frac{V_s}{V_r}$$

$$\frac{300}{N_p} = \frac{220}{12}$$

$$300 \times 12 = 220N_p$$

$$N_p = \frac{300 \times 12}{220}$$

$$= \frac{3600}{220}$$

$$N_p = 16 turns$$

COIL GUAGE

Primary = 22 S.W.G

Secondary = 17 S.W.G

3.4 OUTPUT STAGE

The output stage is the final reset produced at the stages which the inverter is obtained through the secondary terminal of a step-up transformer. The quantity and quality of output obtained on the value of A.C. voltage and the quality of the waveform with it is produced.

3.5 CONSTRUCTION OF POWER INVERTER

The construction is of a standard Ferro resonant type using large step-up transformer to convert 12V into 220V A.C 12Volts D.C from large high capacity battery is chopped into alternating square wave.

The battery used in this construction is an 56638 12volts/ 45Ah type. It has both positive and negative terminal through which 12 volts is taken from the recharging of the battery is done through this terminal. The negative is fed into the source of the FETs in the driver stage while the positive is fed from the relay, which as a switching device when there is cut-off in power supply [4].

The FETs used are in two rows of ten transistors each, making a total of 20 FETs used. The output of the driver stage (i.e. FETs') is fetched from drains of either side of the set of FET. The output is fed into the transformer stage.

The relay in used is an OMRON MK3P-I. It has 11 rapid pins and is plugged into the socket that is fixed tightly into the casing. Pins 2 and 10 are used as reference in switch when there is no supply.

3.6 PROTECTIVE DEVICE

The protective device consists of two 5A, 250V fuse which controls the amount of voltage that is fed into the system and the output from the system. The fuse controlling the mains is connected from the A.C. source to a voltmeter mounted on the front of the inverter.

The fuse controlling the output of the power inverter system is connected to a voltmeter for reading the output voltage. This is then connected to the receptacle at the back of the power inverter system to accept plugs from supported equipment.

The two voltmeters are indicates the input, that is, for reading input voltage and output, for reading the output voltage.

3.7 MATERIALS AND TOOLS USED

Some materials and tools are used in carrying out this project.

The materials include

- **BATTERY**

Lead acid battery

Ampere hour rating -11Ah

- **TRANSFORMER**

Shell type

16/300 turns

22 S.W.G/ 17 S.W.G

- **CAPACITOR**
- **DIODE**
- **RESISTOR**
- **FET (Field Effect Transistor)**
- **HEAT SINKS** – To provide means for conducting, away the heat generating within the transistor.
- **RELAY**
- **LED**
- **VROBOARD**
- **METAL CASING**
- **INSULATORS**

THE TOOLS USED INCLUDE

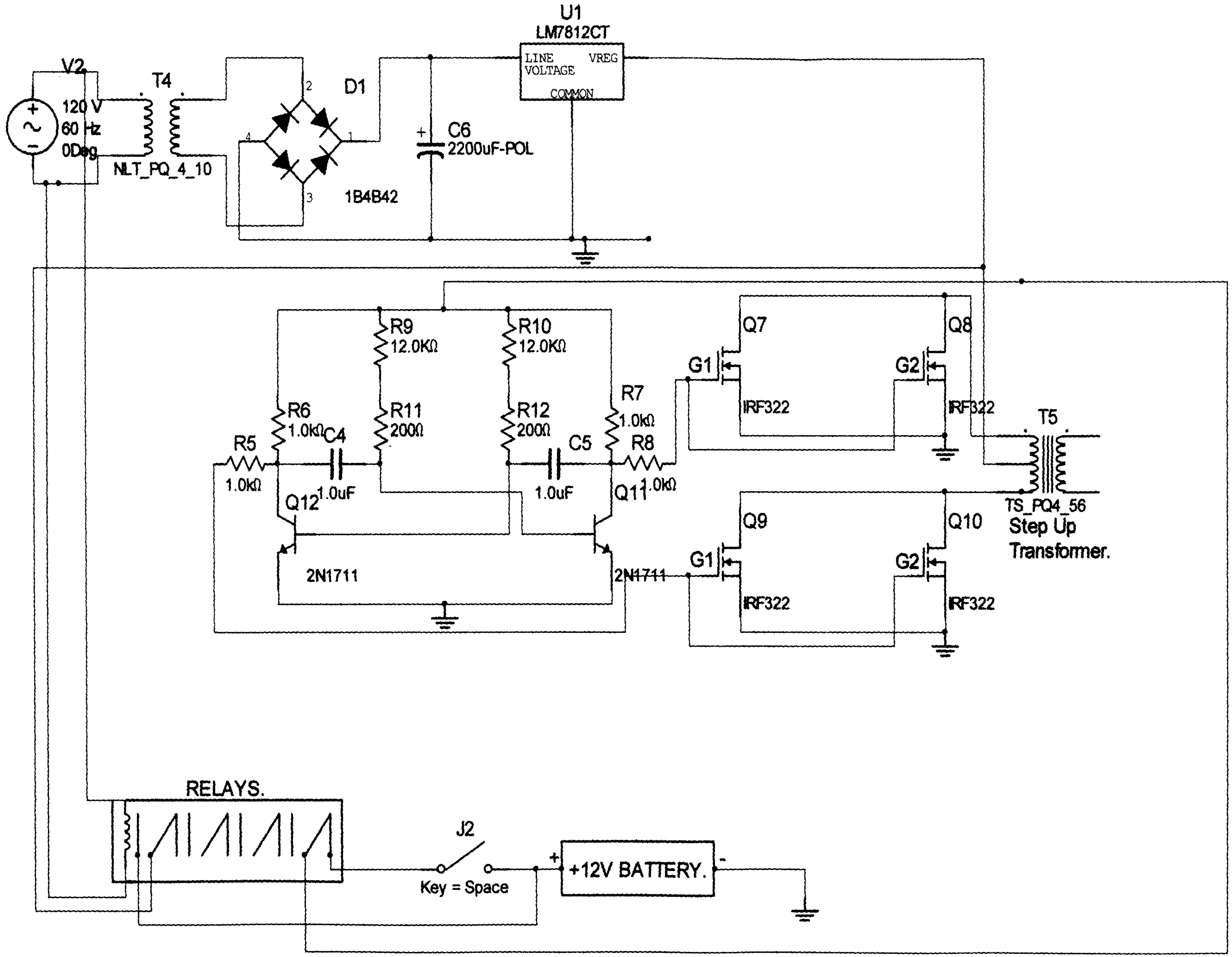
- Soldering iron & lead
- Plier
- Screwdriver
- Paper tape
- Insulating vanish

3.8 ASSEMBLY OF THE INVERTER

The assembly of the various components requires a bit of expertise. This will enable subsequent connections of the terminals. The transformer is then fitted with a bolt and nut to the base of the metal casing tightly.

The driver stage comprising the transistors is connected into the heat sink. They are connected side by side given enough space for heat to be radiated freely. The multivibrator stage circuit on the veroboard is connected directly beside the driver stage; because the square pulse from the output of the miltivibrator will be fed into the driver stage.

The relay is also mounted inside the metal casing. All the other components, including voltmeter, LED, socket outlet and receptacle, are fitted to the front and back of the INVERTER system.



CIRCUIT DIAGRAM OF 1KVA POWER INVERTER

CHAPTER FOUR

TESTING AND RESULTS

4.1 TESTING

After assembly of the projects the Inverter, which consists of an inverter and a transformer, was connected to the 12volts battery. After connection, the output voltage was measured when the battery was fully charged to 220V. The Inverter was tested with various loads within its power handling capacity and operation was noticed to be perfect with little transistor heat dissipation when operating at full load.

4.2 PRACTICAL PERFORMANCE TEST

Two transistors (Q1 and Q2) were configured as an astable multivibrator to generate pulses that are 180^0 out of the phase of 50Hz each. The pulses were amplified to the driver stage. In the event of power supply failure 13A 220V AC, 13A 12VDC coil relay will automatically switch the circuit from AC to DC mode.

The inverter transformer step up which switch the circuit from AC mode to DC mode.

The inverter transformer steps up which switch 12V D.C. at the primary terminal to 220V A.C. at the secondary terminal. And on resumption or supply, the relay will out automatically switch the circuit back to A .C. mode and the in-built charger will continue to charge the battery [5].

4.3 THE RESULTS

The stages of the whole circuit were tested to function very well and the circuit was also tested with different battery sizes load and charging transformer sizes in order to know the back-up time for different sizes of batteries and loads.

The relay is also mounted inside the metal casing. All the other components including voltmeter, LED, socket outlet or receptacle are fitted directly to the back of the inverter system respectively

The results obtained are as follows.

Table 4.3a Table of battery sizes backup time using different loads

BATTERY SIZES (Vah)	LOAD SIZE (VA)	BACK UP TIME (mins)
12V 7.0 Ah	310VA	10min
12V 12Ah	310VA	32min
12V 40Ah	310VA	65min
12V 70Ah	620VA	6min
12V 24Ah	620VA	13min
12V 40Ah	620VA	34min
12V 70Ah	930VA	5min
12V 24Ah	930VA	9min

The result of charging time with different sizes were as follows:-

Table 4.3b Table of batteries sizes recharging time using different loads

BATTERY SIZES (Vah)	**LOAD SIZE (VA)**	**BACK UP TIME (mins)**
12V 7.0Ah	620VA	144mins
12V 12Ah	620VA	160mins
12V 40Ah	620VA	200mins
12V 70Ah	930VA	130mins
12V 24Ah	930VA	295mins
12V 40Ah	930VA	480mins

The tests conducted showed that the inverter could perfectly handle loads of the following categories:

- Operate a lighting point, a cassette player, TV set and standing/ ceiling fan.
- Operate a series of fluorescent
- Operate electric blender with a light point

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

In conclusion, the project presented is a 1 KVA inverter system. It shows its design and the construction including all the components used. Various control schemes have been developed for the inverter to maintain a high-quality sinusoidal output voltage under highly non linear rectifier loads.

The project was an indispensable opportunity to combine both theoretical knowledge acquired during the course of the degree Programme. Through this project it shows that the problem of epileptic power supply can be tackled through the use of the inverter. It is more reliable, pollution free and noiseless.

5.2 RECOMMENDATIONS

1. More time should be given to students so that research scope would be wider so as so to enable them to build a large and much more resistive power inverter system.
2. Any constructive project should be thoroughly supervised and best of it should be sponsored for exhibition as well as promoting the construction of the project.

This will consequently increase innovation in the students.

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