DESIGN AND CONSTRUCTION OF AN INVERTER WITH A BATTERY CHARGER

BY

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(98/6943EE)

A PROJECT REPORT SUBMITTED TO

ELECTRICAL AND COMPUTER ENGINEERING DEPARTMENT

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NIGER STATE, NIGERIA.

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF BACHELOR OF ENGINEERING (B.ENG) DEGREE IN ELECTRICAL AND COMPUTER ENGINEERING.

NOVEMBER 2004.

DECLARATION

I, **DUROJAIYE KEN OMOBOLA** with Matriculation number **98/6943EE** hereby declare that this project, **Construction of an inverter with a battery charger**, is an original concept and was designed by me. This project has not been submitted in this institution or any other institution for the award of any degree.

.... 9TH DEC. 2004

Durojaiye Ken Omobola Date

CERTIFICATION

This is to certify that, this work titled, **Design and Construction of an Inverter with a Battery charger** was carried out by **Durojaiye Ken Omobola** under the supervision of **Engr. M. S. Ahmed** for the award of Bachelor of Engineering in the Electrical and Computer Engineering Department of the University of Technology, Minna.

ENGR. M. S. AHMED 11/12/04

(Project Supervisor) **Signature and Date**

ENGR. M. D. ABDULLAHI .... 10/12/2004.

(Head of Department) **Signature and Date**

....

(External Examiner) **Signature and Date**

DEDICATION

I dedicate this project to the triune God for preserving my life and also to my mum, Mrs. B.A. Durojaiye for sponsoring me throughout my academic career.

ACKNOWLEDGEMENT

I would like to thank the following people who in one way or the other, contributed toward the successful completion of this project.

Firstly, I thank God for keeping me alive up to this moment and also for giving me the strength, health and the necessary finances required for completing this project.

I express my gratitude to my supervisor Engr. M. S. Ahmed for his contributions. I also want to thank the H.O.D., the lecturers and the entire staff of the Electrical/Computer Engineering Department, Federal University of Technology, Minna.

Special thanks to my parents, Mr. E T. O. Durojaiye and Mrs. B. A. Durojaiye for the financial, moral and spiritual support which they provided during my stay in this school.

Thanks also to my brother, Dele Durojaiye for his support.

Special thanks also to Mike and Alpha for allowing me to use their systems, thanks also to Kola, Okenna, Joe and Nurudeen for the technical assistance they provided. Last of all, thanks to all my former course mates for making the journey a worthwhile one.

ABSTRACT

An inverter is an electrical device that converts direct current electrical power into alternating current electrical power.

There are basically three types of inverters, these are: Square wave inverter, modified sine wave inverter and pure sine wave inverter. The objective of this project is to produce an inverter that can supply a substantial amount of a.c. electrical power by using easily sourced components. The inverter is made up of several sections and these sections are; the oscillator power supply, the amplifier, the switches, the transformer, the 12V battery and the battery charger. The circuit was first constructed on a breadboard for preliminary testing and was later permanently constructed on a veroboard with the aid of a 40W soldering iron and some lead. The inverter was then tested; the tests revealed the inverter's output to be approximately 200V which is reasonably okay. The charger also worked as expected. In concluding, the project was a successful and exciting one.

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CHAPTER ONE: GENERAL INTRODUCTION

1.1 INTRODUCTION

An inverter is an electrical device which is used to convert or change a direct current (from a direct current source such as a battery) into alternating current at the power frequency (50Hz or 60Hz depending on the geographical location). Inverters are quite similar to UPS (Uninterrupted Power Supply) systems, in fact, they work on the same principle with the difference being that, UPS systems are usually automatic. UPS systems are mainly used for short period backup purposes whereas an inverter is normally used for long period power supply, an inverter can be used to supply power to an appliance, a room, or even a house. In reality, a UPS is a special type of inverter which can provide backup power automatically. The convenience of an inverter can be better appreciated when it is compared with its main rival; the petrol and diesel engine driven generator sets. In contrast to the fuel engine generators, an inverter:

- Does not produce unwanted mechanical vibrations
- Does not generate noise
- Does not produce killer fumes of carbon (I) oxide (carbon monoxide)
- Can be placed in any desired location.
- Needs little or no serving and maintenance because there are no mechanical parts
- Has negligible running cost as it does not use expensive petrol or diesel.

In line with the points given above, inverters have gained worldwide acceptance as the preferred means of power supply in the event of a power outage. They are widely used in industrialized and developed countries.

There are basically three types of inverters and this classification is based on the shape of the output waveform produced by the inverter. These inverter types are:

1. Square wave inverter.
2. Modified sine wave inverter
3. Pure sine wave inverter.

1.1.1 SQUARE WAVE INVERTER.

A square wave inverter has an output with a square waveform, it is the simplest type of inverter to build and it is also the cheapest to purchase. A simplified diagram of a square wave inverter is shown below.

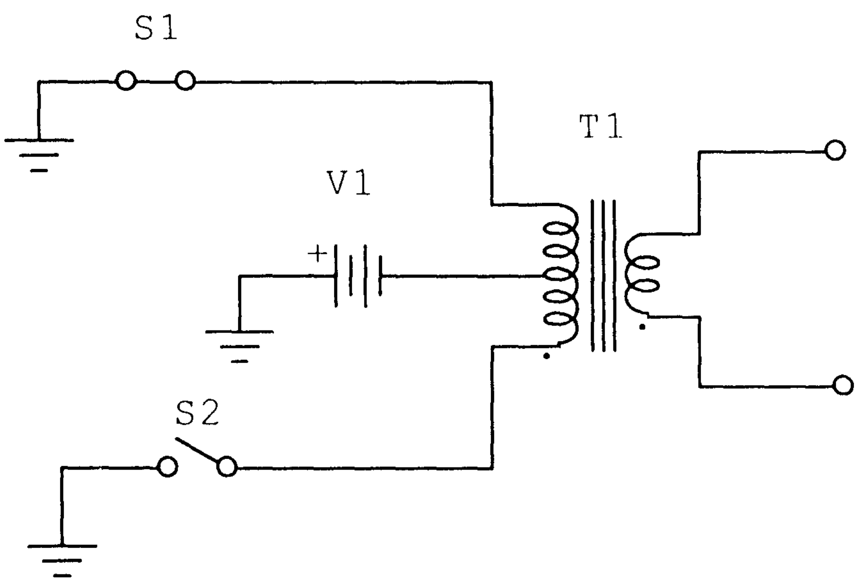

Fig 1.1 Square wave inverter, state 1.

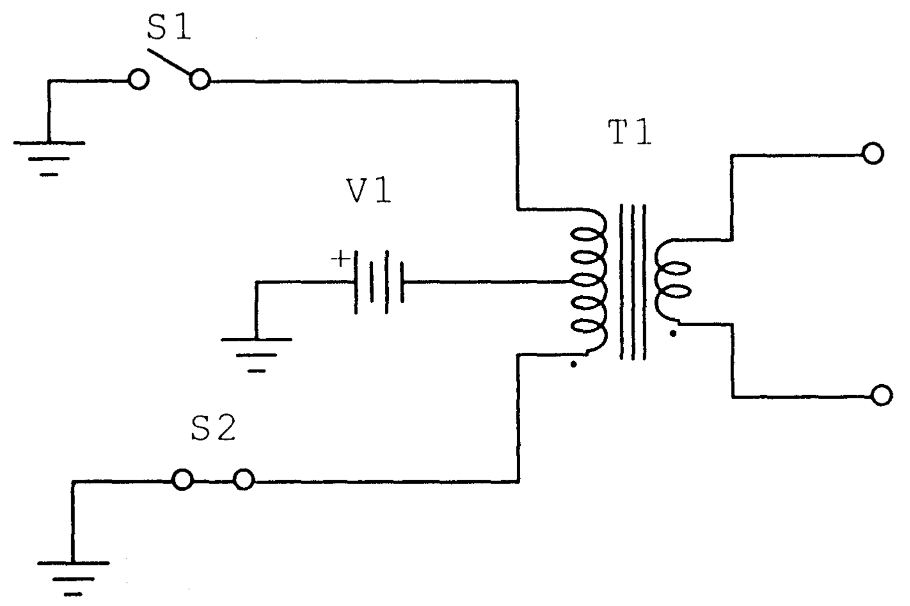

Fig 1.2 Square wave inverter, state 2.

This particular connection is called the push pull topology. Only one switch is on at any particular time.

1.1.2 MODIFIED SINE WAVE INVERTER

This is an improvement over the square wave inverter and it has fewer load compatibility problems than the square wave inverter although it cannot power all types of loads. The modified sine wave inverter uses the H-bridge topology which is on the next page. As seen on the next page there are 3 states as compared to the square wave inverter's 2 states.

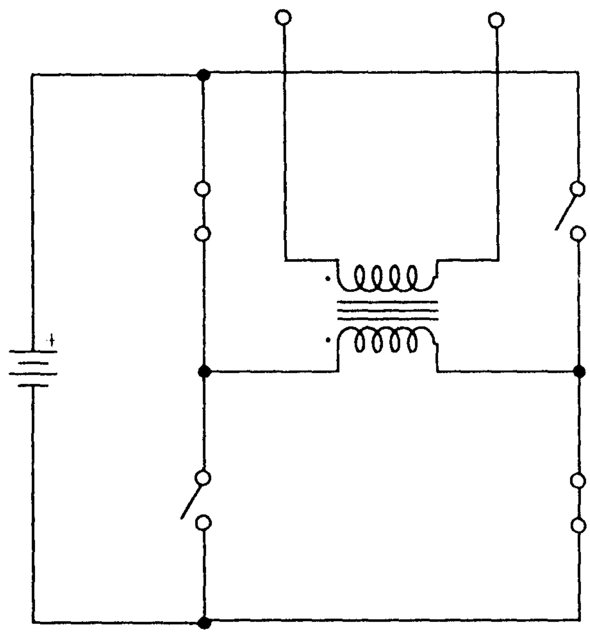

Fig. 1.3 H Bridge topology, state 1

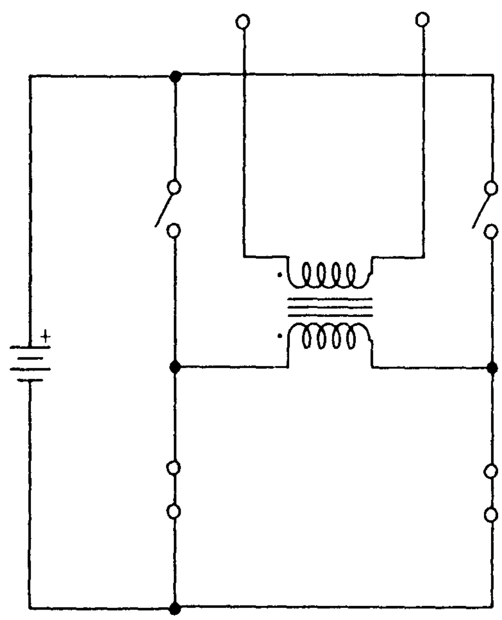

Fig. 1.4 H Bridge topology, state 2

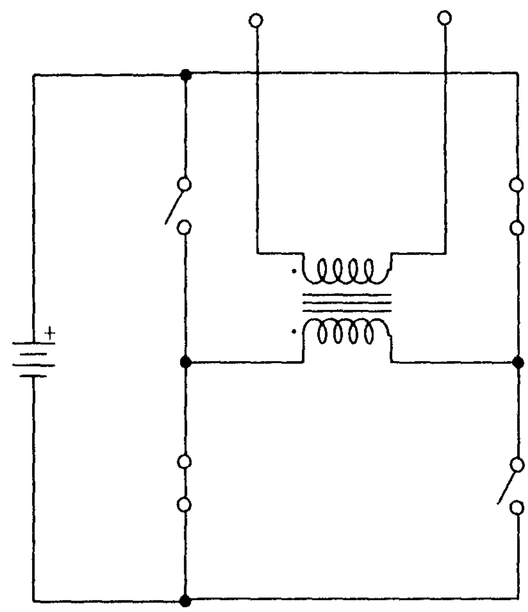

Fig. 1.5 H Bridge topology, state 3

1.1.3 PURE SINE WAVE INVERTER

A pure sine wave inverter produces a sinusoidal output waveform. In most cases, the output waveform is even "cleaner" than that supplied by the power company. Pure sine wave inverters have no load incompatibilities and are ideal for all loads. The sine wave inverter utilizes several H-bridges which are controlled by a microcontroller or microprocessor. Sine wave inverters are expensive compared to the other inverter types.

In this project, I intend to construct a square wave inverter because of its simplicity and availability of components.

1.2 PROJECT OBJECTIVE AND MOTIVATION

The objectives of this project are:

- To provide a functional device
- To produce an inverter that can supply a substantial amount of power
- To produce an inverter using commonly sourced components

This project was motivated or necessitated by the incessant power interruptions and blackouts which are prevalent throughout the country. This project aims to provide a viable alternative to the petrol fueled generators (which are expensive to purchase and even more expensive to run and maintain) in the event of a power failure.

1.3 LITERATURE REVIEW

Inverters have been around for a long time and have been in use from as far back as World War II. The inverters of that time (which are the earliest inverters) were of the motor-generator variety; you had an AC generator whose armature was being driven by a DC motor. At that time, this was the only way to convert DC power to AC power and a very popular brand of that era was Redi-line, which is still around today. The motor generator was quite reliable with its output waveform fitting a wide variety of applications, but it was inefficient, it required 30amps to turn on and it had no startup surge capacity.

TrippLite a Chicago based company founded in 1922 started producing inverters. The early units used mechanical vibrators to oscillate DC power into square wave AC. In the early 1960s, after the invention of the transistor by William Shockley in 1948, solid state transistors replaced the mechanical vibrators. The first advantage of this type of inverter was that it was not a motor generator. The unregulated square wave design could operate resistive loads but it had no surge power for starting motors. It was unable to operate reactive loads like compressors, ice makers or microwave ovens. There were many compatibility problems including no frequency control, which was added later. This allowed a steady draw, which could operate turntable motors and clocks. Through the years, square wave technology has been phased out. Present day modified sine wave technology is utilized in TrippLite's line of UPS devices and inverters.

Vanner Inc., was established I 1977. In 1979, Vanner introduced their first inverter: a 1000 Watt modified sine wave unit. For this 100W inverter, Vanner patented true RMS regulation and a power transistor drive technique. This transistor drive technique achieved an unheard of 87% efficiency. A few years later, the product line expanded with 2200W and 3000W inverters. In 1986, one of the inverter models included a microprocessor control circuit.

First generation inverters used Metered Darlington Technology. This special circuit metered base current to power a transistor proportional to load. The magnetic design increased efficiency. Second generation inverters used FETs (Field Effect Transistors). Since FETs have almost no switching losses, efficiency was markedly improved. In 1990, integrated circuits allowed the creation of energy management systems. In 1993, the first microprocessor-controlled inverter/charger was introduced. The advantages of modified sine wave technology are efficiency and relative economical cost. The modified sine wave, however, still cannot run all loads because of poor peak voltage regulation and the fact that AC output is not a "true" sine wave.

Trace engineering developed and patented improvements to the modified sine wave technology in their SW series inverters while not a true sine wave, the output is a multi-step approximation that results in fewer load incompatibilities. Trace Engineering supplies inverters to a global market. In fact, in South America the word for "inverter" is "Trace".

Statpower Technologies Corporation with headquarters in British Columbia, Canada, was founded in 1988. The company manufactured MSW (Modified Sine Wave) inverters using high frequency design, and provided portable power for remote areas worldwide. In 1995, they introduced a pure sine wave inverter/charger. Using high frequency switching techniques, they were successful in producing a high output charger with a power factor approaching "1". There is negligible distortion at the DC port in both inverter and charger, which is viewed as a technological milestone.

1.3 PROJECT OUTLINE

This project was written in four chapters.

Chapter One: This chapter contains the literature review, the introduction, project objective and motivation and the project outline

Chapter Two: This chapter is about the Design Analysis and contains relevant information about the design and the calculations carried out.

Chapter Three: This chapter contains information on the construction, testing, results, discussion of results and the precautions taken.

Chapter Four: The final chapter, it has the conclusion, recommendations and references used.

CHAPTER TWO: THEORY AND DESIGN

Shown below is a functional block diagram of the inverter to be constructed in this project.

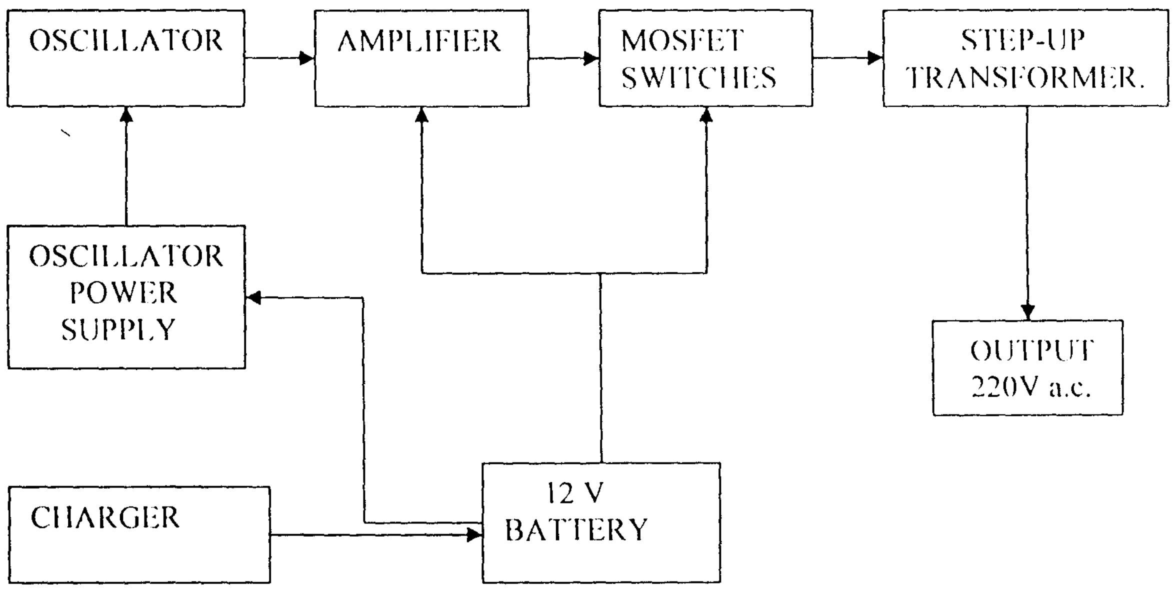

Fig. 2.1 Block Diagram of the project.

2.1 THE OSCILLATOR

The oscillator used in this project is an RC relaxation oscillator; its circuit diagram is shown below:

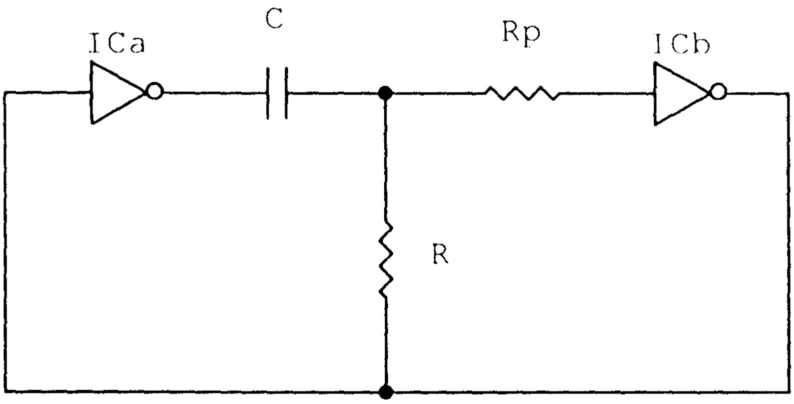

Fig. 2.2 RC Relaxation oscillator

The oscillator circuit was shown this way so that the operation explanation can be easier to understand.

When the circuit is switched on, assume the output of ICb is low; the output of ICa will be high. Assuming the capacitor to be fully discharged, it charges up (from 0V) to the supply voltage (+5V) plus the threshold voltage of the IC (it happens to be +2.5V in this case), the voltage across R, the potential at point X rises to this value (supply voltage plus threshold voltage) in a negligible time interval, then, it decreases to the threshold voltage. This voltage across R is then applied to ICb through resistor R_p, now because the voltage at point Y is greater than the threshold voltage of the IC, ICb sees it as a high signal and subsequently its output (which is ICa's input) will be low.

For the second half-cycle, after capacitor C has charged up to the supply voltage plus the threshold voltage i.e. $(V_{DD} + V_{TH})$ it starts discharging towards V_{TH} subsequently, the voltage at point X decreases instantaneously to $(V_{TH} - V_{DD})$ after which it gradually rises to V_{TH}, the input of ICb will be low so that its output now becomes high. This cycle of charging and discharging of capacitor, C, is repeated indefinitely to obtain a square waveform at the oscillator's output.

The purpose of resistor R_p is to limit the current passing through ICb and also to limit the voltage applied across ICb to the range 0-V_{DD} volts. Resistor R_p does not affect the oscillation frequency. The charge time constant and discharge time constant of capacitor, C is RC.

The NOT gates are gotten from a 4069UB, hex inverter IC, which has 6 NOT gates.

Charging period = $t_1 = RC\ln (2V_{DD} - V_{TH}) / (V_{DD} - V_{TH})$

Where $V_{DD} = +5$ V and $V_{TH} = 2.5$ V

Discharging period = $t_2 = RC\ln \{(V_{DD} + V_{TH}) / (V_{TH})\}$

Total period = $T = t_1 + t_2 = RC\ln [\{(V_{DD} - V_{TH})*(V_{DD} + V_{TH})\} / \{(V_{DD} - V_{TH})*(V_{TH})\}]$

$T = RC\ln [\{(10 - 2.5)*(5 + 2.5)\}/ \{(5 - 2.5) * (2.5)\}]$

$= RC\ln \{(7.5/2.5)(7.5/2.5)\}$

$T = RC\ln (56.25/6.25) = RC\ln (9) = RC(2.2) = 2.2RC.$

Therefore, the oscillation frequency, $f = 1/T = 1/(2.2RC)$

For an oscillator frequency of 50 Hz, C was made to be 2.2 μF while R was calculated

from: $f = 1 / (2.2RC)$

⇨ $1/R = 2.2fC$

Therefore, $R = 1 / (2.2fC)$

$$R = 1 / (2.2 * 50 * 0.0000022) = 4.13\ k\Omega$$

To get an accurate frequency of 50 Hz, R was realized using a fixed 2.2 kΩ resistor in series with a 2.5 kΩ variable resistor.

2.2 THE TRANSFORMER

The transformer is used to change the voltage profile of the system from 12V to 220V a.c. i.e. it acts as a step-up transformer. The output of the inverter is gotten across the transformer's 220V terminals. The transformer utilized in this project has the following rating:

Primary: 12V center trapped. 15A maximum current

Secondary: 220V

With the transformer's primary rating, it implies that the maximum power that can be handled by the transformer on its primary windings is (12 * 15) VA = 180VA and assuming the transformer has 100% efficiency (i.e. input power = output power), the maximum power that can be gotten from the secondary windings will be 180VA although the practical value is less than this because of the various losses in the transformer viz copper losses, I^2R losses and eddy current losses. A schematic diagram of the transformer is shown below.

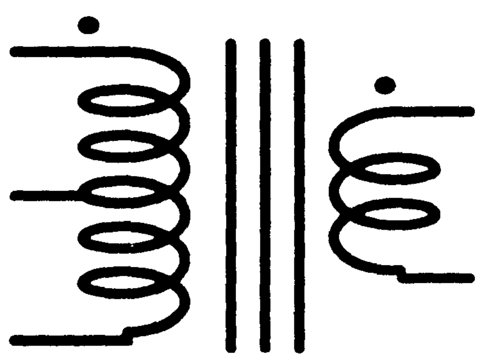

Fig.2.3 Step-up transformer

2.3 OSCILLATOR POWER SUPPLY

The oscillatory circuit (actually, the 4069UB hex inverter IC) is powered from the 12V battery with the aid of a 7805, +5V regulator IC and some capacitors. The 7805 IC has three (3) terminals; the input terminal, the ground terminal and the output terminal. It has very good voltage regulation properties and is quite suited for this application. The only drawback is that it has a dropout voltage of about 2V to 3V i.e. to get a +5V output, the input must be greater than +7V, this arises because of some transistor V_{BE} drops in the IC. The schematic of the circuit used is shown below:

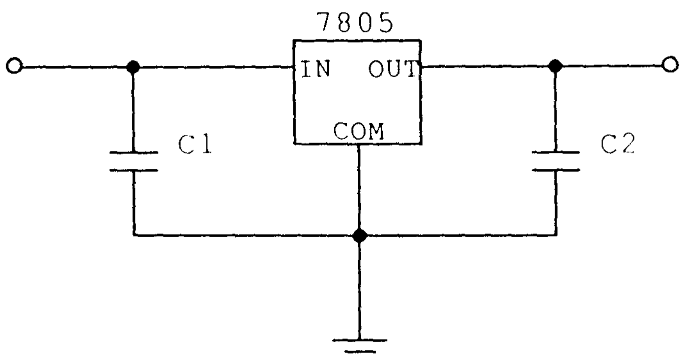

Fig. 2.4 +5 V Regulator IC

The 0.1μF capacitor across the output improves the IC's transient response and keeps the impedance low at high frequencies. The 0.33μF capacitor is used because the IC is located at some distance from the battery and it also pours the high frequency component of the power into ground. The 7805 IC I used came in a TO-220, plastic power package with the IC able to deliver a maximum current of 1A at it output.

2.4 THE CHARGER

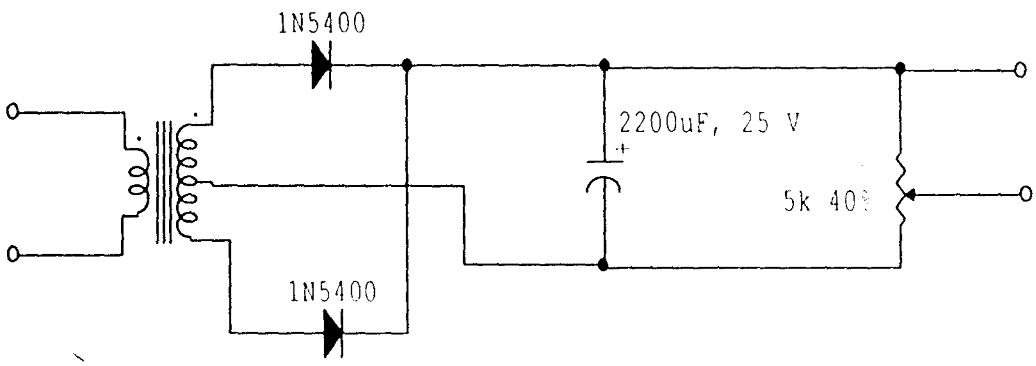

Fig. 2.5 Charging circuit.

The charger consists of a 220V/15-0-15V step down transformer with a center tapped secondary, two 1N5400 silicon rectifier diodes (which can rectify a maximum current of 3A, this is more than the transformers maximum output of 2A); these diodes are used to rectify the transformers output, a 2200μF/25V electrolytic capacitor which is used to minimize the output voltage ripple and a 5KΩ variable resistor which is used to set the exact value of the output voltage to be used in charging the 12V battery. The output voltage is set to 13.8V, which is the recommended voltage for charging a 12V battery.

2.5 THE BATTERY

The battery used was a 12V rechargeable, lead-acid battery, having a minimum capacity of 4.5Ah.

2.6 AMPLIFIER

The amplifiers used are two 2SC1815, NPN transistors. These two transistors are used to amplify the two output signals from the oscillator section, so that they can be used to drive the gates of the power MOSFETS. These transistors are operated in the cut-off and saturation region i.e. they act as switches.

The 2SC1815 has the following specifications:

Maximum collector current $I_{c(max)} = 0.15A$

Turn on/Turn off time < 12.5ns

Maximum power dissipation = 0.4W.

Current gain, $h_{FE} = 100$ (typically)

The amplifier schematic (only one since the two amplifiers work the same way) is shown below:

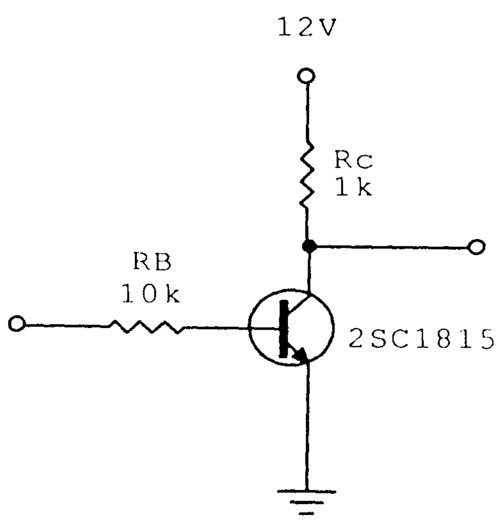

Fig. 2.6 Transistor Amplifier

$= 43$ mA

And $I_C(sat) = 12$ V / 1kΩ

$= 12$ mA

Therefore, the transistor is well into saturation, output, $V_{CE} = 0V$. when there is a low signal from the oscillator, $I_B = 0$, which makes $I_C = 0$, the transistor will be working in the cut-off region and output, $V_{CE} = 12V$.

2.7 MOSFET SWITCHES

Two n-channel enhancement mode MOSFETs (Metal Oxide Semiconductor Field Effect Transistors) are used as switches to switch the 12V battery's current on and off across one half of the primary windings of the transformer so as to induce an alternating current and voltage in the secondary windings of the transformer. Each MOSFET is controlled by applying the square wave output of the oscillator (which has been amplified by NPN transistors) to the gate terminal of each MOSFET. The signal that will be applied to the gate of MOSFET 1 will be the "NOTed" version (or inverse) of what will be applied to the gate of MOSFET 2. With this arrangement, when MOSFET 1 is on, MOSFET 2 will be off and vice versa, with the on and off frequency being determined by the frequency of the oscillator.

The circuit action is shown below:

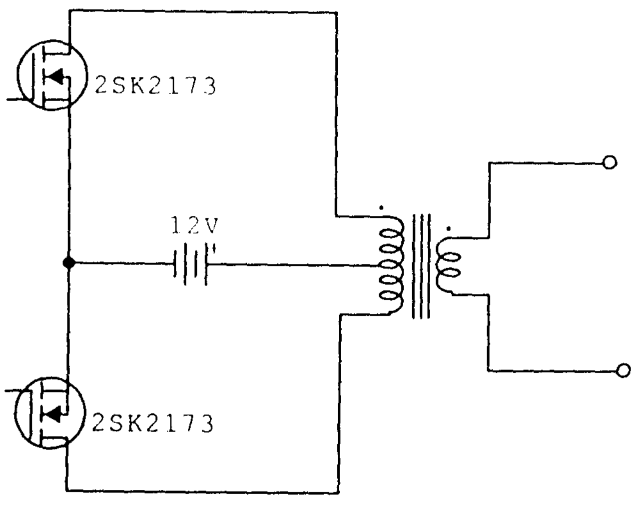

Fig 2.7 MOSFET switching 1

From the diagram above, if we assume a high signal is applied to the gate of MOSFET 1, then a low signal will be applied to the gate of MOSFET 2. As a result of the high signal at the gate of MOSFET 1, MOSFET 1 conducts the battery current from drain to source through one-half of the transformer's primary in a particular direction, while MOSFET 2 is off. During the next cycle, with a high signal applied to the gate of MOSFET 2 and low signal applied to the gate of MOSFET 1, MOSFET 2 conducts in the same way MOSFET 1 did during the first half cycle, the only difference being that it uses the other half of the transformer primary and the current is in the opposite direction.

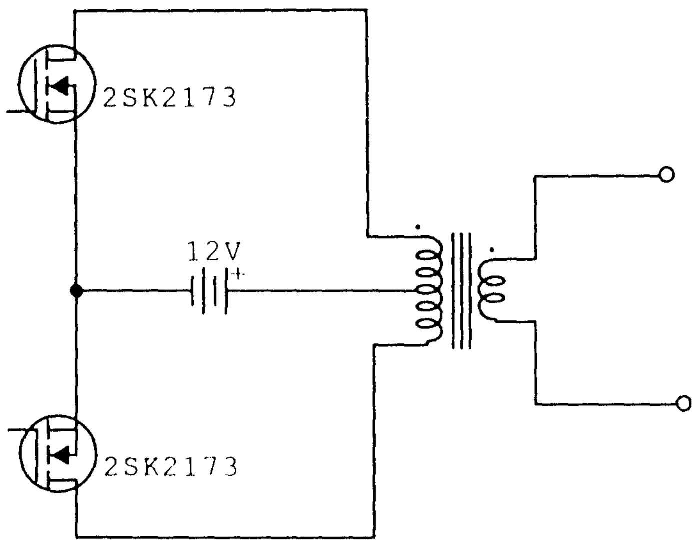

Fig 2.8 MOSFET switching 2

This cycle is repeated indefinitely with the consequence being that a square wave AC signal is gotten from the secondary of the transformer.

Two 2SK2173 n-channel enhancement only MOSFETs were used for this project. The 2SK2173 has a maximum drain to source current of 50A and an "on" resistance less than 17mΩ which makes it suitable for this project.

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11	[A]	[B]	[C]	[D]	[E]	36	[A]	[B]	[C]	[D]	[E]	61	[A]	[B]	[C]	[D]	[E]	86	[A]	[B]	[C]	[D]	[E]
12	[A]	[B]	[C]	[D]	[E]	37	[A]	[B]	[C]	[D]	[E]	62	[A]	[B]	[C]	[D]	[E]	87	[A]	[B]	[C]	[D]	[E]
13	[A]	[B]	[C]	[D]	[E]	38	[A]	[B]	[C]	[D]	[E]	63	[A]	[B]	[C]	[D]	[E]	88	[A]	[B]	[C]	[D]	[E]
14	[A]	[B]	[C]	[D]	[E]	39	[A]	[B]	[C]	[D]	[E]	64	[A]	[B]	[C]	[D]	[E]	89	[A]	[B]	[C]	[D]	[E]
15	[A]	[B]	[C]	[D]	[E]	40	[A]	[B]	[C]	[D]	[E]	65	[A]	[B]	[C]	[D]	[E]	90	[A]	[B]	[C]	[D]	[E]
16	[A]	[B]	[C]	[D]	[E]	41	[A]	[B]	[C]	[D]	[E]	66	[A]	[B]	[C]	[D]	[E]	91	[A]	[B]	[C]	[D]	[E]
17	[A]	[B]	[C]	[D]	[E]	42	[A]	[B]	[C]	[D]	[E]	67	[A]	[B]	[C]	[D]	[E]	92	[A]	[B]	[C]	[D]	[E]
18	[A]	[B]	[C]	[D]	[E]	43	[A]	[B]	[C]	[D]	[E]	68	[A]	[B]	[C]	[D]	[E]	93	[A]	[B]	[C]	[D]	[E]
19	[A]	[B]	[C]	[D]	[E]	44	[A]	[B]	[C]	[D]	[E]	69	[A]	[B]	[C]	[D]	[E]	94	[A]	[B]	[C]	[D]	[E]
20	[A]	[B]	[C]	[D]	[E]	45	[A]	[B]	[C]	[D]	[E]	70	[A]	[B]	[C]	[D]	[E]	95	[A]	[B]	[C]	[D]	[E]
21	[A]	[B]	[C]	[D]	[E]	46	[A]	[B]	[C]	[D]	[E]	71	[A]	[B]	[C]	[D]	[E]	96	[A]	[B]	[C]	[D]	[E]
22	[A]	[B]	[C]	[D]	[E]	47	[A]	[B]	[C]	[D]	[E]	72	[A]	[B]	[C]	[D]	[E]	97	[A]	[B]	[C]	[D]	[E]
23	[A]	[B]	[C]	[D]	[E]	48	[A]	[B]	[C]	[D]	[E]	73	[A]	[B]	[C]	[D]	[E]	98	[A]	[B]	[C]	[D]	[E]
24	[A]	[B]	[C]	[D]	[E]	49	[A]	[B]	[C]	[D]	[E]	74	[A]	[B]	[C]	[D]	[E]	99	[A]	[B]	[C]	[D]	[E]
25	[A]	[B]	[C]	[D]	[E]	50	[A]	[B]	[C]	[D]	[E]	75	[A]	[B]	[C]	[D]	[E]	100	[A]	[B]	[C]	[D]	[E]

I used MOSFETs instead of BJTs because:

- They have low "on" resistance.
- They can handle very high currents.
- They are easy to connect in a circuit
- They work well in parallel connections.
- They are smaller than equivalent BJTs.

CHAPTER THREE: CONSTRUCTION AND TESTING

3.1 CONSTRUCTION

The circuit was first realized on a breadboard so as to enable easy testing and modifications (which were necessary), the circuit worked perfectly on the breadboard. After the breadboard stage the circuit's components were then transferred to a 65mm by 145mm veroboard where all the components in the circuit (except the transformers) were soldered and connected together as appropriate, a 40W soldering iron and some 'lead' were used to solder the components to the board. Coloured insulation wires were used to keep the circuit tidy and confusion free. After soldering the components together on the veroboard, the whole circuit was housed in a wooden case.

Several instruments were used for carrying out tests on several parts of the constructed circuit, I used two digital multimeters and one analogue multimeter to carry out all the tests (sadly, there was no oscilloscope on hand for testing purpose).

3.2 TEST RESULTS

Current drawn by oscillator and amplifier section: 0.1μA

Output voltage of 7805 regulator IC: 4.98V

Output voltage of oscillator (average): 2.45V

Output voltage of amplifier (average): 5.77V

Output voltage of transformer: 200V (approximately)

The output frequency of the oscillator section was precisely set to 50Hz by adjusting the 2.5KΩ variable resistor in the oscillator circuit and measuring this frequency with a digital multimeter which can measure frequency.

3.3 DISCUSSION OF RESULTS

The current drawn by the oscillator and amplifier sections of the circuit was found to be 0.1μA. This obtained value shows that negligible current is being drawn from the battery by these sections of the circuit, making enough battery current to be available for conversion to alternating current. This current value therefore, increases the efficiency of the inverter.

Output voltage of the 7805 IC was found to be 4.98V (approximately 5V), ideal for powering the 4069UBE IC. The oscillator's output voltage of 2.45V might seem incorrect, but on consideration it is found to be correct. This is because the oscillator's output has two values; 0V and 5V, with each value being presented for an equal amount of time, with the end result being that,

$V_{out} = V_{in} * T_{on}/(T_{on}+T_{off})$,

because $T_{on} = T_{off} \Rightarrow V_{out} = V_{in}/2$

where $V_{in} = 5V$

$V_{out} = 5/2\ V = 2.5V$.

The value of the output voltage of the amplifier section can be explained in the same way as above with the only difference being hat it is switching between 0V and 12V.

The transformer's output of 200V is due to voltage drops along the transformer windings and is to be expected. This voltage is actually okay for most appliances because they operate on a voltage profile of 200V to 240V, only in rare cases will a voltage regulator or stabilizer be required.

3.4 PRECAUTIONS.

- I used a 40W soldering iron for all soldering purposes. this I did in order to protect the NPN transistors and power MOSFETs from being damaged due to excessive soldering heat.
- I used thick wiring in the high current sections of the circuit, so that the wires do not get burnt while in use.
- I attached heat sinks to the power MOSFETs so as to quickly dissipate the heat generated in them and hence prevent them from being overheated and subsequently damaged.
- I took careful measures to ensure that the high capacity lead-acid battery never got short-circuited because of its ability to cause serious damage when short-circuited.

CHAPTER FOUR: CONCLUSION AND RECOMMENDATION

4.1 CONCLUSION

The objective of building an inverter with a battery charger has been met and from the results gotten from the testing stage, the inverter and charger worked according to expectation. In conclusion therefore, the project was successfully undertaken. Performance levels of the project was within the acceptable limits of deviation. all in all it was a worthwhile project which gave me a worthwhile experience.

4.2 RECOMMENDATIONS

I would like to make the following recommendations for this project and also for enhancement of this project.

- Inverters should be adopted nationwide to counteract the effect of frequent power outages in the country, inverters should also be used because they are noiseless, clean, need no maintenance and are far cheaper than either petrol generators or diesel generators.
- Inverter design and technology should be properly taught in the department
- The department can start producing inverters for the institution by utilizing students on SWEP or other convenient means.
- To improve the project, a transformer with a higher VA rating than that used can be employed, this will increase the inverter's maximum VA rating.
- The charger circuit's status can be upgraded to that of an automatic charger so that the charging process can be automated.
- Next time out, a modified sine wave or perhaps even a pure sine wave inverter should be built so as to provide better load compatibility.
- A single transformer with separate turns for the inverter and charger or probably, a relay can be incorporated into the circuit.

4.3 REFERENCES

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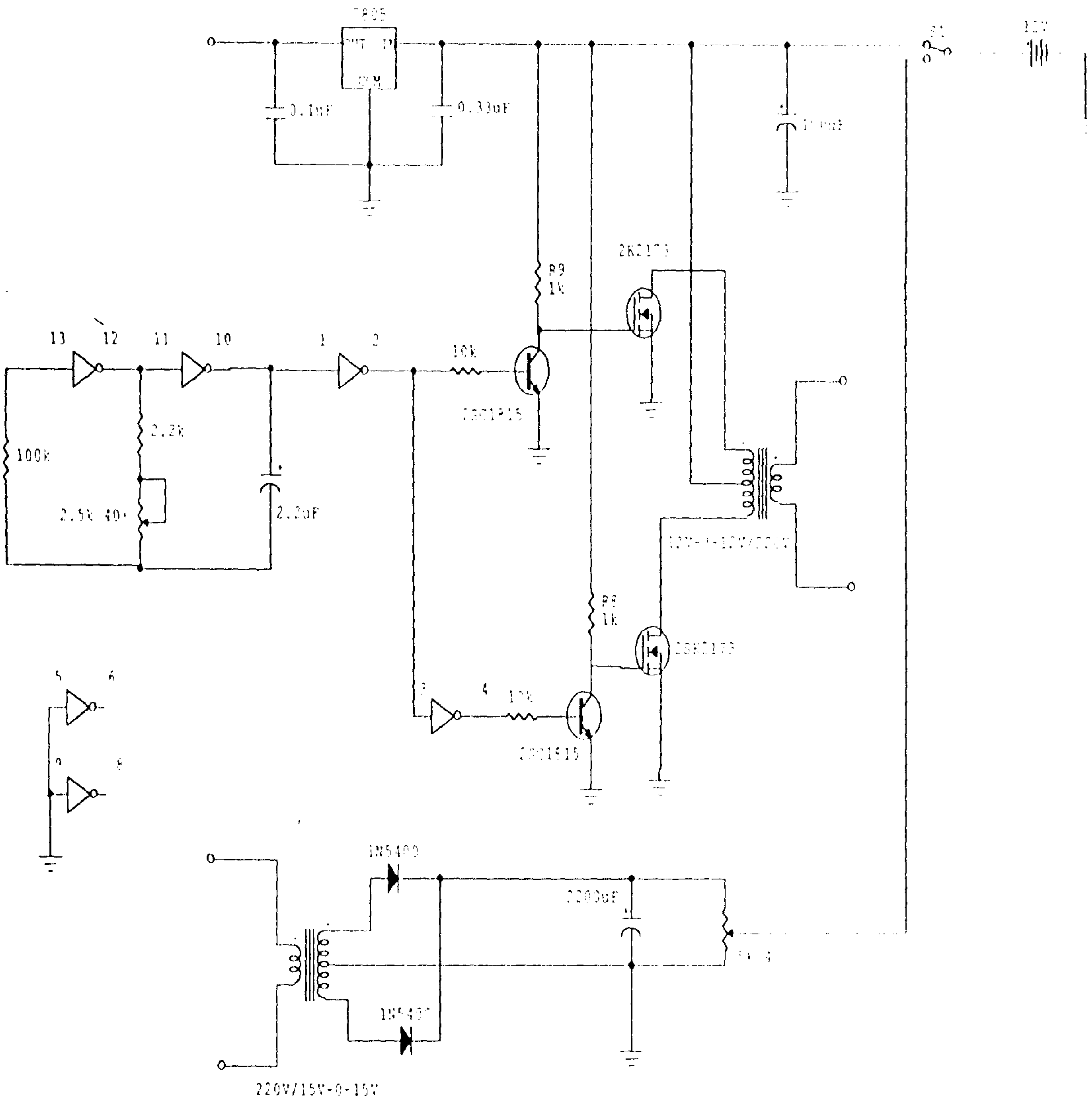
4.4 CIRCUIT DIAGRAM



Pin 14 of the IC is connected to the 7805's output while pin 7 is connected to ground.

Fig. 4.1 Complete Circuit Diagram