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Cost Less Transistorized Inverter

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Abstract

Often times the power from the wall socket is neither stable nor uninterrupted. Many abnormalities such as blackouts, spikes, surges, and noise can occur. To avoid this power failure problem, we need a power storage system. That power storage system is nothing but inverter (power inverter). Frequent power failures, tripping, utility grids, and power shortfalls have resulted in inverters forming an essential constituent of our life style.

The basic concept of an Inverter is to store energy during normal operation, by charging a battery, or bank of batteries, connected to the inverter and release the energy stored in the batteries, through DC to AC conversion, in the event of a power failure. This application note describes how to correctly select an inverter based on the environment we plan to use the system in, the total wattage of the appliances we plan to connect to the inverter and the desired functions of the power inverter system. In general inverter is an electrical device that converts DC power or direct current (DC) to AC power or alternating current (AC). The converted alternating current (AC) can be at any required voltage and frequency with the use of appropriate transformers, switching, and control circuits. An inverter can also be used for Electric vehicle drives, uninterrupted power supplies, DC power utilization.

The project Transistorized Inverter, presents a design of 50 HZ frequency DC/AC inverter for home applications using fuel cells or photovoltaic array sources. A battery bank parallel to the DC link is provided to take care of the slow dynamic response of the source. This inverter system provides a power supply to operate 12V, 9V, 5V D.C-powered instruments at up to 1A current .The battery backup takes up the load without spikes or delay when the main power is unavailable. The circuit can be assembled on a general purpose PCB. The battery used in this is a 12V, 7 Ah inverter battery and a 230V AC primary to 12-0-12V, 500mA Secondary Transformer is used. The design is based on a push-pull AC/AC converter. The objective of this project is to explore the possibility of making renewable sources of energy utility interactive by means of low cost power electronic interface.

1. INTRODUCTION

A power inverter, or inverter, is an electrical power converter that changes direct current (DC) to alternating current (AC), the converted AC can be at any required voltage and frequency with the use of appropriate transformers, switching, and control circuits.

Solid-state inverters have no moving parts and are used in a wide range of applications, from small switching power supplies in computers, to large electric utility high-voltage direct current applications that transport bulk power. Inverters are commonly used to supply AC power from DC sources such as solar panels or batteries. The inverter performs the opposite function of a rectifier. 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.

Low cost circuit for operation of discharge lamps utilizing a rectifier and a two-transistor inverter to provide high-frequency operation of ballasted discharge lamps from a relatively low frequency power source. An air-core feedback transformer is used to provide high frequency operation of the inverter and voltage-shift-initiated feedback is used to prevent "shoot-through" of the two-transistor inverter. Preferably there is, in series with the load, a series resonant combination having a resonant frequency higher than the inverter frequency, in order to minimize switching losses in the transistor inverter.

2. DESCRIPTION OF THECIRCUIT

2.1. Block diagram:

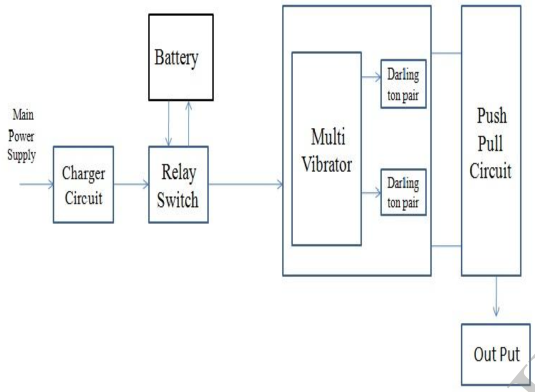

Fig 2.1 Transistorized Inverter

The blocks present in the circuit are charger circuit, battery, Relay switch, and inverter circuit. Charger circuit takes the ac input and charges the battery. And this battery output gives to the inverter circuit as input and we get the AC output which is used for the home appliances. The relay switch plays an important role in this circuit. When the power supply is ON the output is coming from the supply only. And when supply is OFF then the output is coming from the inverter circuit.

2.2. DESIGN PROCEDURE

For any electronic device we require power supply in it, which is very essential requirement for any circuit. Here we are using a 5V regulated dc supply in our circuit. To obtain 5V dc supply procedure is as following.

Power Supply:

Power supply is a supply of electrical power. A device or system that supplies electrical or other types of energy to an output load or group of loads is called a power supply unit or PSU. The term is most commonly applied to electrical energy supplies, less often to mechanical ones, and rarely to others. A power supply may include a power distribution system as well as primary or secondary sources of energy such as

Conversion of one form of electrical power to another desired form and voltage, typically involving converting AC line voltage to a well-regulated lower-voltage DC for electronic devices. Low voltage, low power DC power supply units are commonly integrated with the devices they supply, such as computers and household electronics; for other examples, see switched-mode power supply, linear regulator, rectifier and inverter (electrical).

• Batteries

• Chemical fuel cells and other forms of energy storage systems

• Solar power

• Generators or alternators

A brief description:-

- Transformer steps down high voltage AC to step-down low voltage AC.
- Rectifier - converts AC to DC, but the DC output is varying.
- Smoothing - smooth the DC from varying greatly to a small ripple.
- Regulator - eliminates ripple by setting DC output to a fixed voltage.

Transformer:

Transformer is a device which can efficiently transform the electric energy. Major use of transformer is in power distribution. Which is used in electrical devices, control systems, communication system devices etc. Step-up transformers increase voltage, step-down transformers reduce voltage. Most power supplies use a step-down transformer to reduce the dangerously high mains voltage (230V) to a safer low voltage.

The input coil is called the primary and the output coil is called the secondary. There is no electrical connection between the two coils, instead they are linked by an alternating magnetic field created in the soft-iron core of the transformer. The two lines in the middle of the circuit symbol represent the core. Transformers waste very little power so the power out is (almost) equal to the power in. Note that as voltage is stepped down current is stepped up.

The ratio of the number of turns on each coil, called the turns ratio, determines the ratio of the voltages. A step-down transformer has a large number of turns on its primary (input) coil which is connected to the high voltage mains supply, and a small number of turns on its secondary (output) coil to give a low output voltage.

$$\text{Turns ratio} = \frac{V_P}{V_S} = \frac{N_P}{N_S}$$

Vp = primary (input) voltage;
Np = number of turns on primary coil
Vs = secondary (output) voltage
Ns = number of turns on secondary coil

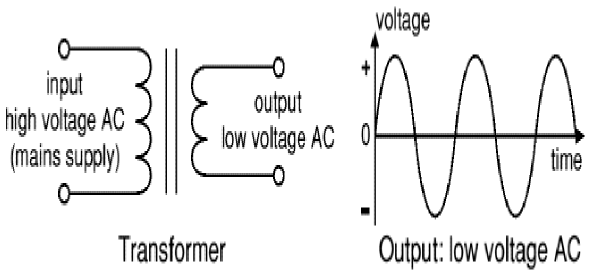

Fig 2.2: Transformer and AC waveform

The low voltage AC output is suitable for lamps, heaters and special AC motors. It is not suitable for electronic circuits unless they include a rectifier and a smoothing capacitor.

Rectifier:

There are several ways of connecting diodes to make a rectifier to convert AC to DC. The bridge rectifier is the most important and it produces full-wave varying DC. A full-wave rectifier can also be made from just two diodes if a centre-tap transformer is used, but this method is rarely used now that diodes are cheaper. A single diode can be used as a rectifier but it only uses the positive (+) parts of the AC wave to produce half-wave varying DC.

Bridge rectifier:

A bridge rectifier can be made using four individual diodes, but it is also available in special packages containing the four diodes required. It is called a full-wave rectifier because it uses the entire AC wave (both positive and negative sections). 1.4V is used up in the bridge rectifier because each diode uses 0.7V when conducting and there are always two diodes conducting, as shown in the diagram below. Bridge rectifiers are rated by the maximum current they can pass and the maximum reverse voltage they can withstand (this must be at least three times the supply RMS voltage so the rectifier can withstand the peak voltages). Please see the Diodes page for more details, including pictures of bridge rectifiers.

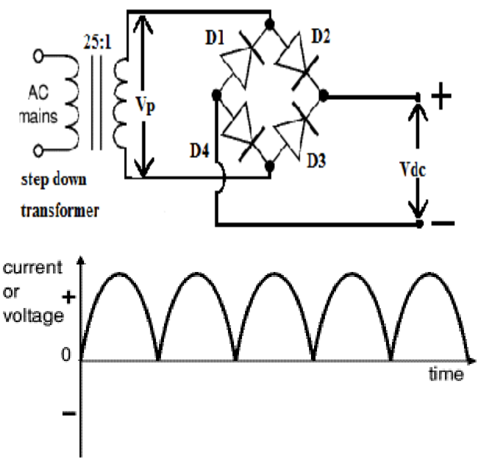

Fig 2.3: Bridge Rectifier Circuit and Waveform of DC

Smoothing:

Smoothing is performed by a large value electrolytic capacitor connected across the DC supply to act as a reservoir, supplying current to the output when the varying DC voltage from the rectifier is falling. The diagram shows the unsmoothed varying DC (dotted line) and the smoothed DC (solid line). The capacitor charges quickly near the peak of the varying DC, and then discharges as it supplies current to the output.

Smoothing is not perfect due to the capacitor voltage falling a little as it discharges, giving a small ripple voltage. For many circuits a ripple which is 10% of the supply voltage is satisfactory and the equation below gives the required value for the smoothing capacitor. A larger capacitor will give fewer ripples. The capacitor value must be doubled when smoothing half-wave DC.

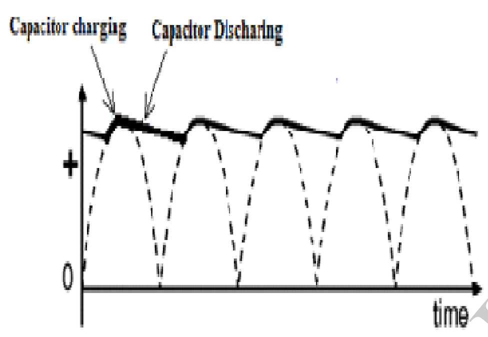

Fig 2.4: Charging and Discharging of Capacitor

From above figure, we can observe that when waveform is rising it is getting charged and when it is decaying it will discharge.

Push Pull Circuit:

A push–pull output is a type of electronic circuit that can drive either a positive or a negative current into a load. Push–pull outputs are present in TTL and CMOS digital logic circuits and in some types of amplifiers, and are usually realized as a complementary pair of transistors, one dissipating or *sinking* current from the load to ground or a negative power supply, and the other supplying or *sourcing* current to the load from a positive power supply. Two matched transistors of the same polarity (or, less often, Vacuum tubes) can be arranged to supply opposite halves of each cycle without the need for an output transformer, although in doing so the driver circuit often is asymmetric and one transistor will be used in a Common-emitter configuration while the other is used as an Emitter follower. This arrangement is less used today than during the 1970s; it can be implemented with few transistors (not so important today) but is relatively difficult to balance and so keep to a low distortion (the highly non-linear TTL circuits such as the 7400 use this arrangement).

Astable Multivibrator:

Transistorized Astable Multivibrator is a cross coupled transistor network capable of producing sharp continuous square wave. It is free running oscillator or simply a regenerative switching circuit using positive feedback. Astable Multivibrator switches continuously between its two unstable states without the need for any external triggering. Time period of Actable multivibrator can be controlled by changing the values of feedback components such as coupling capacitors and resistors. NE 555 IC based actable multivibrator circuit is already explained in the previous article. Here we are dealing with Transistorized Actable Multivibrator. Animation of working circuit is also provided with this article it makes easy to understand the basic working principle behind Astable multivibrator.

Darlington pair:

In electronics,the Darlingtontransistor (often called a Darlington pair) is a compound structure consisting of two bipolar transistors (either integrated or separated devices) connected in such a way that the current amplified by the first transistor is amplified further by the second one.[1] This configuration gives a much higher common-emitter current gain than each transistor taken separately and, in the case of integrated devices, can take less space than two individual transistors because they can use a shared collector. Integrated Darlington pairs come packaged singly in transistor-like packages or as an array of devices (usually eight) in an integrated circuit.

The Darlington configuration was invented by Bell Laboratories engineer Sidney Darlington in 1953.

He patented the idea of having two or three transistors on a single chip sharing a collector.

A similar configuration but with transistors of opposite type (NPN and PNP) is the Sziklai pair, sometimes called the "complementary Darlington."

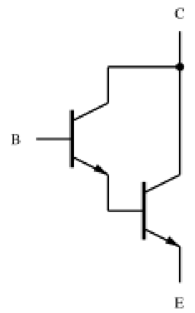

Fig 2.5 Darlington pair using NPN transistors

A Darlington pair behaves like a single transistor with a high current gain (approximately the product of the gains of the two transistors). In fact, integrated devices have three leads (B, C and E), broadly equivalent to those of a standard transistor.Darlington pair of transistor is also called as super-beta transistor. Since it has the capacity to amplify the current output many a times a normal transistor configuration.

A general relation between the compound current gain and the individual gains is given by:

$$\beta_{\mathrm{Darlington}} = \beta_1 \cdot \beta_2 + \beta_1 + \beta_2$$

If β_1 and β_2 are high enough (hundreds), this relation can be approximated with:

$$\beta_{\mathrm{Darlington}} \approx \beta_1 \cdot \beta_2$$

Darlington pairs are available as integrated packages or can be made from two discrete transistors; Q_1 (the left-hand transistor in the diagram) can be a low power type, but normally Q_2 (on the right) will need to be high power. The maximum collector current I_C(max) of the pair is that of Q_2. A typical integrated power device is the 2N6282, which includes a switch-off resistor and has a current gain of 2400 at I_C=10A.

A Darlington pair can be sensitive enough to respond to the current passed by skin contact even at safe voltages. Thus it can form the input stage of a touch-sensitive switch.

A typical modern device has a current gain of 1000 or more, so that only a small base current is needed to make the pair switch on. However, this high current gain comes with several drawbacks.

2.3 Circuit Diagram

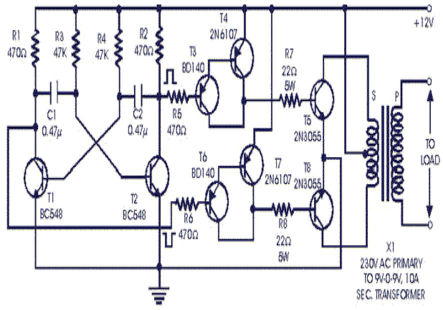

Fig 2.6 Transistorized Inverter circuit

The project Transistorized Inverter, presents a design of 50 HZ frequency DC/AC inverter for home applications using fuel cells or photovoltaic array sources. The battery used in this is a 12V, 7 Ah inverter batteries and a 230V AC primary to 12-0-12V, 1 A Secondary Transformer is used. In this circuit the multivibrator, Darlington pair, push pull circuits are present. The multivibrator used in the inverter is a 50 HZ actable multivibrator which gives the output without giving any input. Two square waves of different polarities obtained from this multi vibrator. These two waves are given to the Darlington pairs to amplify the square waves. Then this signal given to the push pull circuit which transforms the total wave without any distortion.

3. USING COMPONENTS

3.1 Capacitor:

A capacitor (originally known as condenser) is a passive two-terminal electrical component used to store energy in an electric field. The forms of practical capacitors vary widely, but all contain at least two electrical conductors separated by a dielectric (insulator). The process of storing energy in the capacitor is known as charging involves electric charges of equal magnitude, but opposite polarity, building upon each plate. Capacitors are often used electric and electronic as energy storage device. They can also used to differentiate between high frequency signal and low frequency signal.

3.2. Diodes:

Diodes allow electricity to flow in only one direction. The arrow of the circuit symbol shows the direction in which the current can flow. Diodes are the electrical version of a valve and early diodes were actually called valves. Diodes are polarized, which means that they must be inserted into the PCB the correct way round. This is because an electric current will only flow through them in one direction. They have two connections, an anode and a cathode. The cathode is always identified by a dot, ring or some other mark.

- The PCB is often marked with a + sign for the cathode end.
- Diodes come in all shapes and sizes. They are often marked with a type number. Detailed characteristics of a diode can be found by looking up the type number in a data book.

Diode characteristics:

Forward voltage drop:

Electricity uses up a little energy pushing its way through the diode, rather like a person pushing through a door with a spring.

This means that there is a small voltage across a conducting diode, it is called the forward voltage drop and is about 0.7V for all normal diodes which are made from silicon. The forward voltage drop of a diode is almost constant whatever the current passing through the diode so they have a very steep characteristic (current-voltage graph).

Reverse voltage:

When a reverse voltage is applied a perfect diode does not conduct, but all real diodes leak a very tiny current of a few μA or less. This can be ignored in most circuits because it will be very much smaller than the current flowing in the forward direction. However, all diodes have a maximum reverse voltage (usually 50V or more) and if this is exceeded the diode will fail and pass a large current in the reverse direction, this is called breakdown. Ordinary diodes can be split into two types: Signal diodes which pass small currents of 100mA or less and Rectifier diodes which can pass large currents. In addition there are LEDs and Zenger diodes.

Protection diodes for relays:

Signal diodes are also used to protect transistors and ICs from the brief high voltage produced when a relay coil is switched off. The diagram shows how a protection diode is connected 'backwards' across the relay coil. Current flowing through a relay coil creates a magnetic field which collapses suddenly when the current is switched off. The sudden collapse of the magnetic field induces a brief high voltage across the relay coil, which is very likely to damage transistors and ICs.

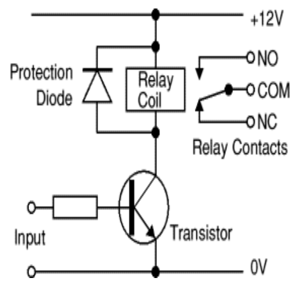

Fig 3.1: Protection diodes for relays

Bridge Rectifier:

There are several ways of connecting diodes to make a rectifier to convert AC to DC. The bridge rectifier is one of them and it is available in special packages containing the four diodes required.

Their maximum current and maximum reverse voltage rate bridge rectifiers. They have four leads or terminals: the two DC outputs are labeled + and the two AC inputs are labeled.

The diagram shows the operation of a bridge rectifier as it converts AC to DC. Notice how alternate pairs of diodes conduct. The protection diode allows the induced voltage to drive a brief current through the coil (and diode) so the magnetic field dies away quickly rather than instantly. This prevents the induced voltage becoming high enough to cause damage to transistors, IC's.

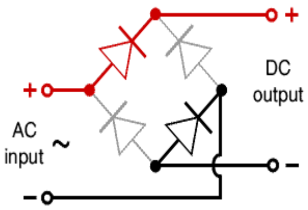

Fig 3.2: Bridge Rectifier

3.3 Resistor:

A resistor is a two- passive electronic component that implements electrical resistance as a circuit element. When a voltage V is applied across the terminals of a resistor, a current I will flow through the resistor in direct proportion to that voltage. This constant of proportionality is called conductance, G. The reciprocal of the conductance is known as the resistance R, since, with a given voltage V, a larger value of R further "resists" the flow of current I as given by Ohm's Law.

3.4 Transformer:

The Voltage Transformer can be thought of as an electrical component rather than an electronic component. The main purpose of a voltage transformer is to transfer electrical power between different circuits by converting one AC voltage source into another AC voltage at the same frequency.

Transformers are basically mechanical devices that consist of one or more coil(s) of wire wrapped around a common ferromagnetic laminated core. These coils are usually not electrically connected together however, they are connected magnetically through the common magnetic flux A_m confined to a central core.

Fig 3.3: Typical Voltage transformer

Voltage transformers work on Faraday's principal of electromagnetic induction. When a current flows through a coil, a magnetic flux (Φ) is produced around the coil. If we now place a second similar coil next to the first so that this magnetic flux cuts the second coil of wire, an e.g. voltage will be induced in the second coil. This effect is known as "mutual induction" and is the basic operation principal of voltage transformers.

The value of the induced E.M.F in the second coil is proportional to the number of turns and to the rate of change of magnetic flux. In a voltage transformer the first set of coils known as the primary and secondary windings are tightly wrapped around. A single core material such as steel or iron which improves the magnetic coupling between these two coils. Therefore, each coil has the same number of volts per turn in it producing two different voltages that are proportional to each other.

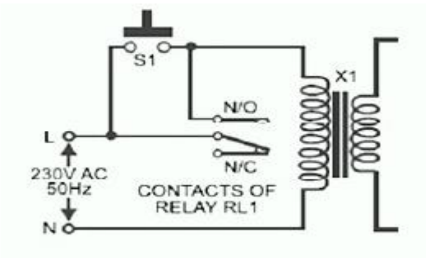

Fig 3.4: Connection of Transformer in the circuit

3.5.Transistors:

In electronics, a transistor is a semiconductor device commonly used to amplify or switch electronic signals. The transistor is the fundamental building block of computers, and all other modern electronic devices. Some transistors are packaged individually but most are found in integrated circuits.

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Using a device that allows a small current or voltage to control the flow of a much larger current can amplify an electrical signal. Transistors are the basic devices providing control of this kind. Modern transistors are divided into two main categories: bipolar junction transistors (BJTs) and field effect transistors (FETs). Applying current in BJTs and voltage in FETs between the input and common terminals increases the conductivity between the common and output terminals, thereby controlling current flow between them. The characteristics of a transistor depend on its type.

The term "transistor" originally referred to the point contact type, which saw very limited commercial application, being replaced by the much more practical bipolar junction types in the early 1950s. Today's most widely used schematic symbol, like the term "transistor", originally referred to these long-obsolete devices.

In analog circuits, transistors are used in amplifiers, (direct current amplifiers, audio amplifiers, radio frequency amplifiers), and linear regulated power supplies. Transistors are also used in digital circuits where they function as electronic switches, but rarely as discrete devices, almost always being incorporated in monolithic integrated circuits. Digital circuits include logic gates, random access memory (RAM), microprocessors, and digital signal processors (DSPs).

3.6 Relay Circuit:

A relay is an electrically operated switch. Current flowing through the coil of the relay creates a magnetic field which attracts a lever and changes the switch contacts. The coil current can be on or off so relays have two switch positions and most have double throw (changeover) switch contacts as shown in the diagram.Relays allow one circuit to switch a second circuit which can be completely separate from the first. For example a low voltage battery circuit can use a relay to switch a 230V AC mains circuit. There is no electrical connection inside the relay between the two circuits; the link is magnetic and mechanical.

The coil of a relay passes a relatively large current, typically 30mA for a 12V relay, but it can be as much as 100mA for relays designed to operate from lower voltages. Most ICs (chips) cannot provide this current and a transistor is usually used to amplify the small IC current to the larger value required for the relay coil.

The maximum output current for the popular 555 timer IC is 200mA so these devices can supply relay coils directly without amplification.

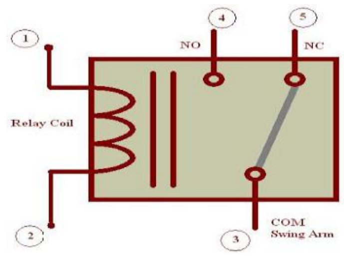

Fig 3.5: Relay Circuit

3.7 Regulator:

Voltage regulator ICs are available with fixed (typically 5, 12 and 15V) or variable output voltages. They are also rated by the maximum current they can pass. Negative voltage regulators are available, mainly for use in dual supplies. Most regulators include some automatic protection from excessive current ('overload protection') and overheating ('thermal protection').

Many of the fixed voltage regulator ICs has 3 leads and look like power transistors, such as the 7805 +5V 1A regulator shown on the right.

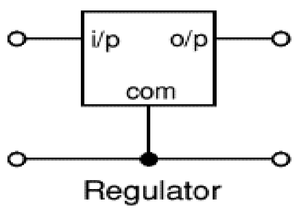

Fig3.6: Three Terminals of Regulator

From above figure we can see that regulator consists of three terminals, one is input, second is output and third one is grounded.

4. WORKING OF THE PROJECT

The circuit is assembled on a general purpose PCB. There is adequate space between the components to avoid overlapping. Heat sinks are used for transistors T4,T5,T7 and T8 to dissipate heat emerged.

Whenever the power supply is available, the charger circuit will get activated so that the 12V,7A battery will be charged. And also by using the power coming from the power supply the load will get activated.

An Astable multivibrator has two quasi-stable states, and it keeps on switching between these two states, by itself, No external triggering signal is needed. The astable multivibrator cannot remain indefinitely in any of these two states. The two amplifiers of an astable multivibrator are regeneratively cross-coupled by capacitor.

i) Since Q2 is ON, capacitor C2 charges through resistor RC1. The voltage across C2 is VCC.

ii) Capacitor C1discharges through resistor R1, the voltage across C1 when it is about to start discharging is VCC. (Capacitor C1 gets charged to VCC when Q1 is ON).

As capacitor C1 discharges more and more, the potential of point A becomes more and More positive (or less and less negative), and eventually VA becomes equal to V, the cut in voltage of T1. For VA > V, transistor T1 starts conducting. When T1 is ON Q2 becomes OFF. Similar operations repeat when T1 becomes ON and T2 becomes OFF. Thus with **T1 ON** and **T2 OFF,** capacitor C1 charges through resistor RC2 and capacitor C2 discharges through resistor R2. As capacitor C2 discharges more and more , it is seen that the potential of point B becomes less and less negative (or more and more positive), and eventually VB becomes equal to V, the cut in voltage of T2. when VB > V, transistor T2 starts conducting. When Q2 becomes On, Q1 becomes OFF.

It is thus seen that the circuit keeps on switching continuously between the two quasistable states and once in operation, no external triggering is needed. Square wave voltage are generated at the collector terminals of Q1 and Q2 i.e., at points C and D.Whenever the power supply is not available, the inverter circuit will get activated. So that, the bulb glows by the discharging of battery.The circuit immediately disconnects the load when the battery voltage reduces to 10.5V to prevent deep discharge of the battery.After making all the adjustments connect the circuit to the battery and transformer. The battery used in the circuit is a 12V, 7A battery.

5. CONCLUSION

The input given to the circuit is a 230V A.C, 50 Hz supply. This supply is step down to 12 V by using a 12-0-12 V step down transformer and the 12V A.C is converted to D.C using the Rectifier operation provided in the circuit, though the precautionary steps are taken the ripples still existed so in order to filter the left out ripples we have used capacitor filter to obtain ripple free 12V D.C voltage.

The current in the circuit is maintained at a value quite lower than the maximum ratings of the device so that the device operates at the normal operating conditions. Heat sinks are used for the Transistors and the regulator IC s (7809, 7805) so that their thermal limit is not reached and they work under a value quite lower than their thermal resistance values as per their specifications.

The circuit is assembled on a perforated normal PCB and can be used for domestic purposes. The Battery used is of rating 12V, 7A battery and it requires about 320 mA of current for normal charging which is successfully supplied by the charging circuit.This project explores the possibility of making renewable sources of energy utility interactive by means of low cost power electronic interface.

6. REFERENCES

1. Electronic Devices and Circuit Theory by Robert L.Boylestad and Louis Nashelsky, Pearson Hall, 9th Edition.
2. Electronic Devices and Circuits by J.Millman, C.C. Alkies and Satyabratha Jet Tata McGraw Hill, 2nd Edition.
3. Linear Integrated Circuit Analysis by B.C Roy and Chowder.
4. Electronic Circuit Analysis by Kill Inshore, BS Publications, 2004.
5. Electrical Technology by B.L Theresa and A.K Theresa.