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Design of a 100 VA Power Inverter

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Abstract

An inverter is an electrical device 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. However, electric energy crisis is one of the major problems in the world. Electric energy stored in the form of DC. This DC must be converted into AC by using inverter when it is applied in any appliances. 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. There are many devices where inverter is used, such as instant power supply (IPS), uninterrupted power supply (UPS), vehicles, etc. In this paper, we have attempted to design a 100 VA power inverter that can be used to operate an 80 watt bulb or an 80 watt fan or any equivalent kind of load.

***Keywords**: Inverter, amplifier, transformer, power inverter, rectifier*

INTRODUCTION

From the late nineteenth century through the middle of the twentieth century, DC-to-AC power conversion was accomplished using rotary converters or motor-generator sets (M-G sets). In the early twentieth century, vacuum tubes and gas filled tubes began to be used as switches in inverter circuits. Now-a-days, inverter is made up of transformer, MOSFET (Metal Oxide Semiconductor Field Effect Transistor), diodes, resistors, capacitors, ICs (Integrated circuit), transistors etc. (B.L Theraja, 1997) [1]. There are various types of inverter based on their operation, such as Power inverter, Solar inverter, Resonant inverters, Grid tie inverter, Synchronous inverter, Stand-alone inverter, Air conditioner inverter, Three phase inverters. Also, there are three types of inverter depending on their output waveforms, for instance, Square wave inverter, Quasi square wave or modified square wave inverters, True or Pure sine wave inverters. Square wave inverter is very simple, low cost and easy to make. But for driving inductive loads pure sine wave inverters are preferred. The output capacity of an inverter depends on the size of the transformer and MOSFET parameters. (Bedford, 1994) [2–5].

TYPES OF INVERTER

Solar Inverter

A solar inverter or PV inverter converts the variable direct current output of a photovoltaic (PV) solar panel into a utility frequency alternating current that can be fed into a commercial electrical grid or used by a local, off-grid electrical network. It is a critical component in a photovoltaic system, allowing the use of ordinary commercial appliances. Solar inverters have special functions adapted for use with photovoltaic arrays, including maximum power point tracking and anti-islanding protection (Solar inverter, 2015) [6].

Fig. 1: *Internal View of a Solar Inverter.*

Grid Tie Inverter

A grid tie inverter is a sine wave inverter designed to inject electricity into the electric power distribution system. Such inverters must synchronize with the frequency of the grid. They usually contain one or more Maximum power point tracking features to extract the maximum amount of power, and also include safety features. A grid-tie inverter (GTI) or synchronous inverter is a special type of power inverter that converts direct current (DC) electricity into alternating current (AC) and feeds it into an existing electrical grid (Bedford, B. D. Hoft R.G 1994) [2]. GTIs are often used to convert direct current produced by many renewable energy sources, such as solar panels or small wind turbines, into the alternating current used to power homes and businesses. The technical name for a grid-tie inverter is "grid-interactive inverter". Grid-interactive inverters typically cannot be used in standalone applications where utility power is not available. During a period of overproduction from the generating source, power is routed into the power grid, thereby being sold to the local power company. During insufficient power production, it allows for power to be purchased by the power company (Grid tie inverter 2015).

Fig. 2: *Inverter for Grid connected PV Systems.*

Grid Tied Solar Inverters

Solar grid-tie inverters are designed to quickly disconnect from the grid if the utility grid goes down. This is an NEC requirement that ensures that in the event of a blackout, the grid tie inverter will shut down to prevent the energy it produces from harming any line workers who are sent to fix the power grid.

Fig. 3: *A PV Inverter Installed in a Porch.*

Grid-tie inverters that are available on the market today use a number of different technologies. The inverters may use the newer high-frequency transformers, conventional low-frequency transformers, or no transformer. Instead of converting direct current directly to 120 or 240 volts AC, high-frequency transformers employ a computerized multi-step process that involves converting the power to high-frequency AC and then back to DC and then to the final AC output voltage (Grid tie inverter 2015).

Three Phase Inverters

Three-phase inverters are used for variable-frequency drive applications and for high power applications such as HVDC power transmission. A basic three-phase inverter consists of three single-phase inverter switches each connected to one of the three load terminals. For the most basic control scheme, the operation of the three switches is coordinated so that one switch operates at each 60 degree point of the fundamental output waveform. This creates a line-to-line output waveform that has six steps. The six-step waveform has a zero-voltage step between the positive and negative sections of the square-wave such that the harmonics that are multiples of three are eliminated as described above. When carrier-based PWM techniques are applied to six-step waveforms, the basic overall shape, or envelope of the waveform is retained so that the 3rd harmonic and its multiples are cancelled (Power inverter 2015) [5].

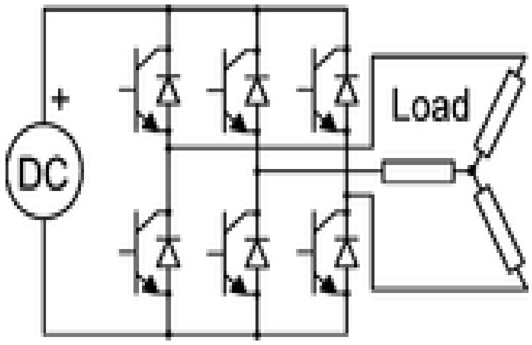

Fig. 4: *3-Phase Inverter with Wye Connected Load.*

Controlled Rectifier Inverters

Since early transistors were not available with sufficient voltage and current ratings for most inverter applications, it was the 1957 introduction of the thyristor or silicon-controlled rectifier (SCR) that initiated the transition to solid state inverter circuits. The commutation requirements of SCRs are a key consideration in SCR circuit designs. SCRs do not turn off or commutate automatically when the gate control signal is shut off. They only turn off when the forward current is reduced to below the minimum holding current, which varies with each kind of SCR, through some external process. For SCRs connected to an AC power source, commutation occurs naturally every time the polarity of the source voltage reverses. SCRs connected to a DC power source usually require a means of forced commutation that forces the current to zero when commutation is required. The least complicated SCR circuits employ natural commutation rather than forced commutation. With the addition of forced commutation circuits, SCRs have been used in the types of inverter circuits described above.

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

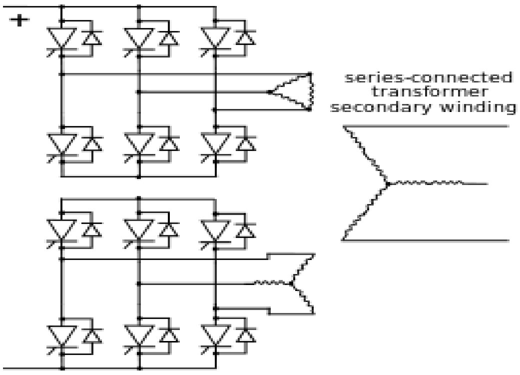

Fig. 5: *12-Pulse Line-Commutated Inverter Circuit.*

Another type of SCR inverter circuit is the current source input (CSI) inverter. A CSI inverter is the dual of a six-step voltage source inverter. With a current source inverter, the DC power supply is configured as a current source rather than a voltage source. The inverter SCRs is switched in a six-step sequence to direct the current to a three-phase AC load as a stepped current waveform. CSI inverter commutation methods include load commutation and parallel capacitor commutation. With both methods, the input current regulation assists the commutation. With load commutation, the load is a synchronous motor operated at a leading power factor (Power inverter 2015) [5].

APPLICATIONS OF INVERTER

DC Power Source Utilization

An inverter converts the DC electricity from sources such as batteries, solar panels or fuel cells to AC electricity. The electricity can be at any required voltage; in particular it can operate AC equipment designed for mains operation or rectified to produce DC at any desired voltage.

Uninterruptible Power Supplies

An uninterruptible power supply (UPS) uses batteries and an inverter to supply AC power when main power is not available. When main power is restored, a rectifier supplies DC power to recharge the batteries.

Induction Heating

Inverters convert low frequency main AC power to higher frequency for use in induction heating. To do this, AC power is first rectified to provide DC power. The inverter then changes the DC power to high frequency AC power.

HVDC Power Transmission

With HVDC power transmission, AC power is rectified and high voltage DC power is transmitted to another location. At the receiving location, an inverter in a static inverter plant converts the power back to AC.

Variable-Frequency Drives

A variable-frequency drive controls the operating speed of an AC motor by controlling the frequency and voltage of the power supplied to the motor. An inverter provides the controlled power. In most cases, the variable-frequency drive includes a rectifier so that DC power for the inverter can be provided from main AC power. Since an inverter is the key component, variable-frequency drives are sometimes called inverter drives or just inverters.

Electric Vehicle Drives

Adjustable speed motor control inverters are currently used to power the traction motors in some electric and diesel-electric rail vehicles as well as some battery electric vehicles and hybrid electric highway vehicles. Various improvements in inverter technology are being developed specifically for electric vehicle applications. In vehicles with regenerative braking, the inverter also takes power from the motor (now acting as a generator) and stores it in the batteries (Power inverter 2015) [5].

Output Waveforms of an Inverter

Square Wave

The square wave output has a high harmonic content, not suitable for certain AC loads such as motors or transformers. Square wave units were the pioneers of inverter development.

Modified Sine Wave

The output of a modified square wave, quasi square or modified sine wave inverter is similar to a square wave output except that the output goes to zero volts for a time before switching positive or negative. It is simple, low cost and is compatible with most electronic devices, except for sensitive or specialized equipment, for example certain laser printers, fluorescent lighting, audio equipment. Most AC motors will run off this power source, although, at a reduction in efficiency of approximately 20%.

Pure Sine Wave

A pure sine wave inverter produces a nearly perfect sine wave output (less than 3% total harmonic distortion) that is essentially the same as utility-supplied grid power. Thus it is compatible with all AC electronic devices. This is the type used in grid-tie inverters. Its design is more complex and costs more per unit power (Power inverter 2015)

DESIGNING OF A 100 VA POWER INVERTER

Figure 1 shows the block diagram of a power inverter. A power inverter is made up of the following units:

a. Power Supply Unit
b. DC to AC Converter Unit
c. Amplifier Unit
d. Transformer Unit and
e. Load

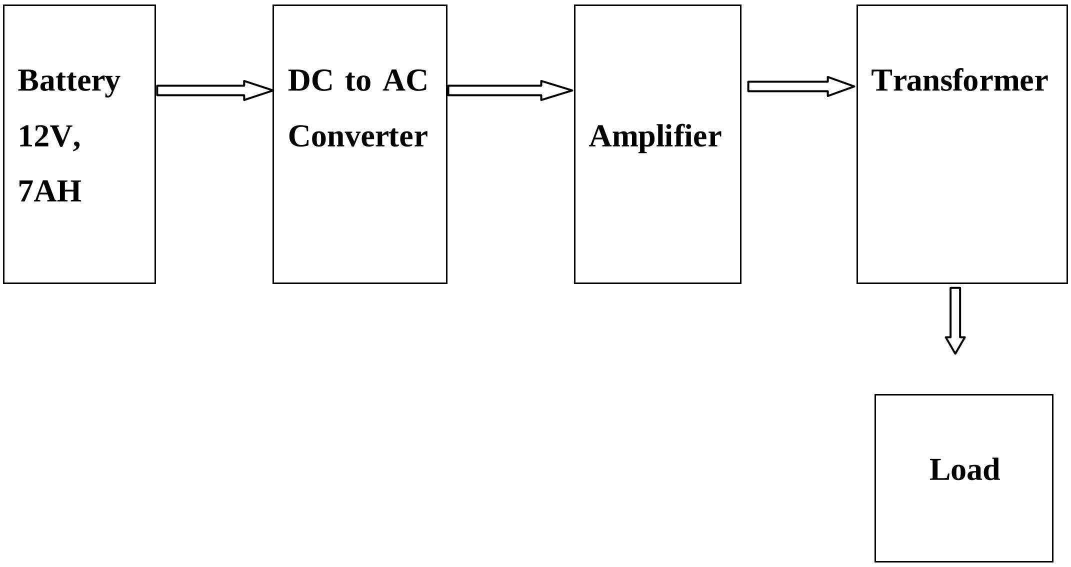

Fig. 6: *Block Diagram of a Power Inverter.*

In this design, a 12V, 7Ah battery is used as a power supply unit. A decoder IC (CD 4047) is used to convert dc to ac as a converter unit. Two MOSFETs (IRF 540) are used as an amplifier unit and step-up transformer is used to increase the voltage at the required level. Output of the transformer is connected to the load.

CIRCUIT DIAGRAM OF THE POWER INVERTER

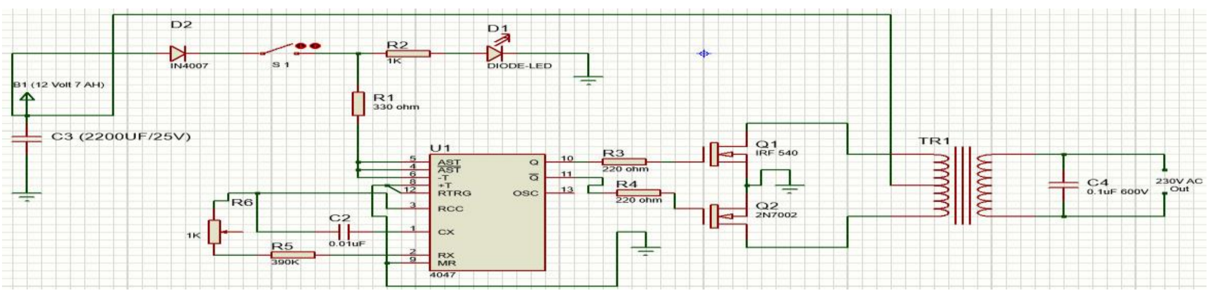

Fig. 7: *Circuit Diagram of the Power Inverter drawn in Proteus ISI*

WORKING PRINCIPLE OF THE POWER INVERTER

A 12 volt 7 Ah battery is connected to the decoder IC (CD 4047). It is a low power IC capable of operating in either in astable or monostable mode. Here IC is wired in astable mode (Low power inverter using CD 4047 2014) (Astable monostable multivibrator 2011) [7, 8]. It works by charging a capacitor (C_2) through a variable resistor, R_6 as in every astable multivibrator. Variable resistor, R_6 is provided for adjusting the output frequency exact at 50 Hz. The time period of the oscillation is given by the relation T = 4.4RC. In this IC, there are two output lines (pin 10 and 11) which are complementary to each other. A connecting wire is connected from negative terminal of the battery to IC pin 7, 8, 9, 12 and the source terminal of the MOSFET [9]. The positive terminal of the battery is connected to IC pin 4, 5, 6, 14 through a diode and switch. The positive terminal also connected to the center of primary section of the transformer. Two MOSFETs (IRF 540) are directly connected to IC by resistors. On this point, oscillation is done perfectly by this MOSFET (V.K Mehta 1994) [4]. A negative connection came from battery's negative terminal. When the switch S_1 is ON then the IC got the power from battery. IC provided output at pin 10 and 11 which is complementary to each other. This signal is fed to the MOSFETs for amplification. The amplified signal is applied to the primary side of transformer for stepping-up the voltage level. At the transformer's secondary side a large output voltage obtained. A capacitor is connected parallel to the load. Finally, a large output voltage dropped across the load.

DISCUSSION

In this work, a power inverter has been designed, a 12 volt 7 Ah battery is used and the capacity of this inverter is 100 VA. We will use this power to drive any 60 watt load such as energy saving bulb or fan. One of the major disadvantages of the device is that it discharges the battery.

For this reason, the charging circuit is required to charge the battery. Moreover, output waveforms of the circuit do not always create a pure sine wave that is why additional pulse width modulation (PWM) technique is required to get pure sine wave. If the capacity of the battery and the number of MOSFET is increases then the capacity of the inverter will be increased.

CONCLUSION

As the global population is increasing day by day, the demand of electricity is rising. But the production of electricity is not sufficient. To meet the demand of electricity, stored energy is very essential. Under such circumstances, inverters have already been proved to be an indispensable device of our life. However, our designed inverter is very cost effective. If such device is constructed individually, it would cost around TK 3000. Manufacturing cost and thus price of the inverter will be reduced drastically if it is manufactured commercially.

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