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Solar Powered Inverter with Multiple Charger Output

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***Abstract* - Inverters are widely used in the domestic as well as industrial environments to serve as second line of source in case of power cut from the electricity utility grids. However, due to low capacity of the battery the inverter dies out with the use of heavy load appliances. This project is designed in such a way that it overcomes this limitation by the use of solar energy. Hybrid Inverter with Solar Battery Charging System consists of an inverter powered by a 12V Battery. This inverter generates up to 110V AC with the help of driver circuitry and a heavy load transformer. This battery gets charged from two sources, first being the mains power supply itself. If the mains power supply is available, the relay switches to the connection using mains power supply to supply to the load. This power supply also charges the battery for using it as back up the next time there is power outage. The use of solar panel to charge the battery gives an additional advantage of surplus power in case the power outage of mains is prolonging. Thus this inverter can last for longer duration's and provide uninterrupted power supply to the user.**

Keywords: Solar Powered Inverter, Multiple Charger Output, Solar Energy System, Renewable Energy Technology, Solar Power Conversion, DC–AC Power Inverter.

I. INTRODUCTION

In today life each & every person is using a mobile. The chargers of mobile phones can carry everywhere but we can‟t say that, everywhere there is availability of electricity. During summer days this problem occurs usually more times, to overcome this problem of charging of mobile phones in public places & especially for rural people this system designed. Also now a day‟s there is no any such type of facility is available at the public places & at rural area. The mobile phone business is currently worth billions of dollars, and supports millions of phones. The need to provide a public charging service is essential. Many critics argued that a public mobile phone charging service is not a lucrative business because most users can charge their phones at home, in their office or in their cars. Coin operated mobile phone charger is new business milestone because many are attending business conventions and forgetting their charger at home or in hotel rooms. Students and many people use the public transportation that don‟t know that their level of their battery is low are prospective customers for coin operated mobile phone charger service. Recommended locations include: Hotels, Conference Centre‟s, Exhibition halls, Serviced offices, Exchange halls, Motels, Leisure Centre‟s, Health clubs, Training Centre‟s, Golf clubs, Retail outlets, Shopping malls, Internet cafes, Universities, Colleges, Airports, Train terminals, etc., so that the mobile phone users can reactivate a low or dead battery.

The increasing demand for electricity and the rapid depletion of conventional energy resources have encouraged the development of renewable energy technologies. Among the various renewable sources available, solar energy has gained significant attention due to its abundance, sustainability, and environmental friendliness. Solar photovoltaic (PV) systems convert sunlight directly into electrical energy and are widely used in residential, commercial, and industrial applications. One of the important components in a solar energy system is the inverter, which converts the direct current (DC) generated by solar panels into alternating current (AC) suitable for operating electrical appliances. With the growing use of portable electronic devices such as mobile phones, tablets, and small electronic gadgets, there is an increasing need for efficient charging solutions powered by renewable energy sources.

A solar powered inverter with multiple charger output is designed to address this requirement by integrating power conversion and multiple charging ports in a single system. This system allows the stored solar energy to be used for powering AC loads while simultaneously providing charging facilities for various DC-powered devices. Such a system is particularly useful in remote areas, rural locations, and during power outages where reliable grid electricity is not available. By utilizing solar energy effectively, the system reduces dependence on fossil fuels and contributes to sustainable energy development.

Furthermore, advancements in power electronics and energy storage technologies have made it possible to design compact and efficient solar inverter systems with multiple output capabilities. The integration of voltage regulation circuits, battery storage units, and multiple charging interfaces ensures stable power delivery and improved system reliability. The proposed system aims to provide an efficient and cost-

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effective solution for small-scale energy needs while promoting the use of renewable energy resources.

II. PROPOSED SYSTEM

The proposed system consists of a solar photovoltaic panel, charge controller, battery storage unit, inverter circuit, and multiple charger output modules. The solar panel captures sunlight and converts it into DC electrical energy. This generated energy is then regulated by a charge controller which ensures that the battery is charged safely without overcharging or deep discharge. The stored energy in the battery acts as a backup power source and provides continuous power supply even when sunlight is not available.

The inverter circuit plays a crucial role in converting the DC power stored in the battery into AC power that can be used to operate household electrical appliances. The inverter is designed using power electronic components such as switching transistors, transformers, and filtering circuits to produce a stable AC output. In addition to the AC output, the system also includes multiple DC charging outputs that allow several devices to be charged simultaneously. These outputs may include USB ports and regulated DC outputs suitable for charging mobile phones, power banks, and other electronic devices.

The system also incorporates voltage regulation and protection mechanisms to ensure safe operation. Overvoltage protection, short circuit protection, and current limiting features are included to protect both the system and the connected devices. By combining solar energy harvesting, battery storage, and multi-output charging capabilities, the proposed system provides a reliable and efficient solution for meeting small-scale energy and charging requirements.

III. BLOCK DIAGRAM AND CIRCUIT DETAILS

Block Diagram

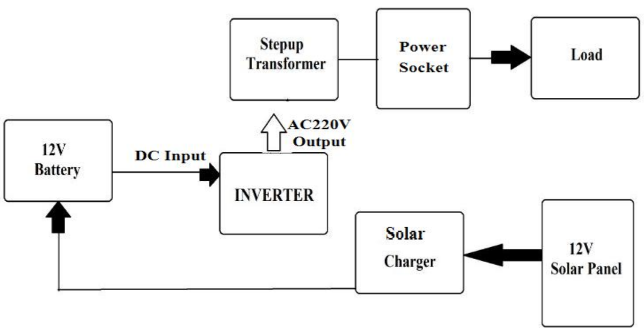

Figure 1: Block Diagram

Circuit Diagram

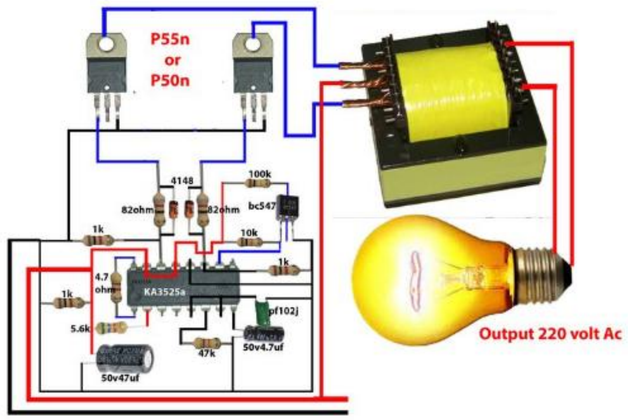

Figure 2: Circuit Diagram

12V to 220V Inverter Circuit Diagram

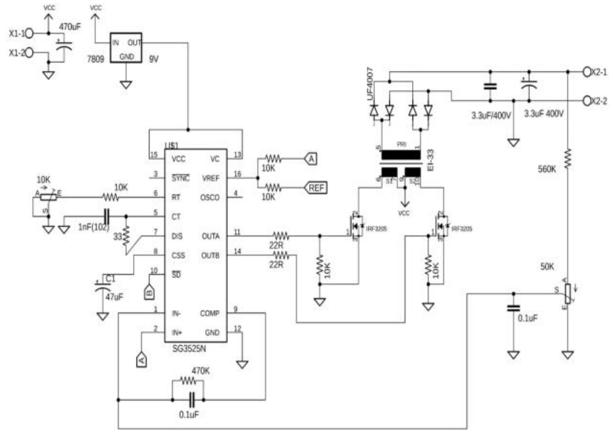

Figure 3: 12V to 220V Inverter Circuit Diagram

Working Principle

This is a 12v to 220V Inverter Circuit using Common PWM IC SG3525 / KA3525. The circuit will convert the input 12v dc to high voltage upto 300V DC you can control it by adjusting the feedback preset pot in the circuit diagram.

The inverter circuit is working based on higher frequency range so the size of the transformer is very small, comparing with low frequency inverter circuits. The IC will produce frequency about 40KHz range. The frequency will be drive by the power mosfets of IRF3205.

If you want to build more power based inverter you need to add a separate totem pole driver (which will boost the mosfet gate voltage) and also use high current mosfets, also you need to rewind the transformer or change to bigger ferrite core transformer.

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EI 33 Transformer Windings

The circuit working with high frequency range and so small ferrite core transformer will works perfect. The coil windings contains primary coil and secondary coil. The primary coil is connected with the mosfet section. so large amount of current will be deliver.

So 4 insulated wires are twisted and making as a one wire for primary windings. the copper gauge is 24AWG. The number of primary turns will be 3+3 (three turns + center tap + 3 turns).

The secondary coil is for receiving the 220v so the current is less here a single 23AWG copper wire is enough to wind the secondary section. The number of turns will be 75. Both the primary and secondary windings will be insulated for protection.

Description of Modified Sine Wave Inverter

In one of the earlier posts I discussed the pin out functioning of the IC 3525, using the data, I designed the following circuit which is though quite standard in its configuration, includes a low battery shut down feature and also an automatic output regulation enhancement.

The following explanation will walk us through the various stages of the circuit, let's learn them:

As can be witnessed in the given diagram, the IC SG3525 is rigged in its standard PWM generator/oscillator mode where the frequency of oscillation is determined by C1, R2 and P1.

P1 can be adjusted for acquiring accurate frequencies as per the required specs of the application.

The range of P1 is from 100Hz to 500 kHz, here we are interested in the 100 Hz value which ultimately provides a 50Hz across the two outputs at pin#11 and Pin#14.

The above two outputs oscillate alternately in a push pull manner (totem pole), driving the connected mosfets into saturation at the fixed frequency - 50 Hz.

The mosfets in response, "push and Pull the battery voltage/current across the two winding of the transformer which in turn generates the required mains AC at the output winding of the transformer.

The peak voltage generated at the output would be anywhere around 300 Volts which must adjusted to around 220V RMS using a good quality RMS meter and by adjusting P2.

P2 actually adjusts the width of the pulses at pin#11/#14, which helps to provide the required RMS at the output.

This feature facilitates a PWM controlled modified sine waveform at the output.

Automatic Output Voltage Regulation Feature

Since the IC facilitates a PWM control pin-out this pin-out can be exploited for enabling an automatic output regulation of the system.

Pin#1 is the sensing input of the internal built in error Opamp, normally the voltage at this pin (non inv.) should not increase above the 5.1V mark by default, because the inv pin#1 is fixed at 5.1V reference internally.

As long as pin#1 is within the specified voltage limit, the PWM correction feature stays inactive, however the moment the voltage at pin#1 tends to rise above 5.1V the output pulses are subsequently narrowed down in an attempt to correct and balance the output voltage accordingly.

A small sensing transformer TR2 is used here for acquiring a sample voltage of the output, this voltage is appropriately rectified and fed to pin#1 of the IC1.

P3 is set such that the fed voltage stays well below the 5.1V limit when the output voltage RMS is around 220V. This sets up the auto regulation feature of the circuit.

Now if due to any reason the output voltage tends to rise above the set value, the PWM correction feature activates and the voltage gets reduced.

Ideally P3 should be set such that the output voltage RMS is fixed at 250V.

So if the above voltage drops below 250V, the PWM correction will try to pull it upward, and vice versa, this will help to acquire a two way regulation of the output,

A careful investigation will show that the inclusion of R3, R4, P2 are meaningless, these may be removed from the circuit. P3 may be solely used for getting the intended PWM control at the output.

Low Battery Cut-off Feature

The other handy feature of this circuit is the low battery cut off ability. Again this introduction becomes possible due to the in built shut down feature of the IC SG3525.

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Pin#10 of the IC will respond to a positive signal and will shut down the output until the signal is inhibited.

A 741 op amp here functions as the low voltage detector.

P5 should be set such that the output of 741 remains at logic low as long as the battery voltage is above the low voltage threshold, this may be 11.5V. 11V or 10.5 as preferred by the user, ideally it shouldn't be less than 11V.

Once this is set, if the battery voltage tends to go below the low voltage mark, the output of the IC instantly becomes high, activating the shut down feature of IC1, inhibiting any further loss of battery voltage.

The feedback resistor R9 and P4 makes sure the position stays latched even if the battery voltage tends to rise back to some higher levels after the shut down operation is activated.

Conversion from Squarewave to Sine wave

You might be curious to know regarding what exactly happens in the process of the conversion which transforms the output into a pure sine wave suitable for all sensitive electronic loads.

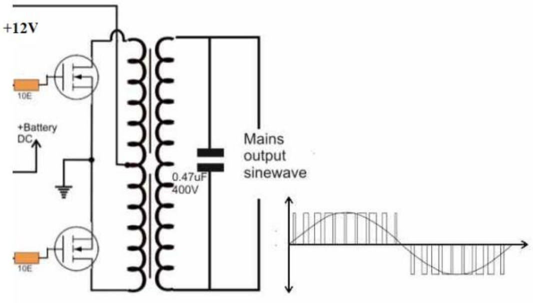

Figure 4: Conversion from Squarewave to Sine wave

It is basically done by optimizing the sharp rising and falling square wave pulses into a gently rising and falling waveform. This is executed by chopping or breaking the exiting square waves into number of uniform pieces.

In the actual sine wave, the waveform is created through an exponential rise and fall pattern where the sinusoidal wave gradually ascend and descend in the course of its cycles.

In the proposed idea, the waveform is not executed in an exponential, rather the square waves are chopped into pieces which ultimately takes the shape of a sine wave after some filtration.

The "chopping" is done by feeding a calculated PWM to the gates of the FET via a BJT buffer stage.

A typical circuit design for converting the SG3525 waveform into a pure sine wave waveform is shown below. This design is actually an universal design which may be implemented for upgrading all square wave inverters into sine wave inverters.

As may be in the above diagram, the lower two diodes are connected to a PWM feed or input, which causes the transistors to switch according to the PWM ON/OFF duty cycles.

This in turn rapidly chop the 50Hz pulses at the bases of the BC547/BC557 coming from the SG3525 output pins.

The above operation ultimately force the mosfets also to turn ON and OFF in the same pattern as the SPWM for each of the 50/60Hz cycles. This SPWM is then induced into the transformer primary by the MOSFETs, consequently producing a sine waveform at the output or the secondary side of the transformer.

If an ordinary PWM is used as explained below, then its frequency should be 4 times more than the base 50 or 60 Hz frequency. so that each 50/60Hz cycles are broken into 4 or 5 pieces and not more than this, which could otherwise give rise to unwanted harmonics and mosfet heating.

Advantages

- It overcomes the traditional limitation of inverters dying out quickly by using solar energy to provide extended backup.
- It ensures uninterrupted power supply by continuously charging the battery via a solar panel during prolonged power outages.
- It features a dual charging system, allowing the battery to charge from both the mains power supply and the solar panel.
- It is specifically designed to handle heavy load appliances without draining the battery prematurely.
- It reduces dependency on the electricity grid by harnessing free solar energy, leading to potential cost savings.
- It promotes the use of renewable energy, making it an environmentally friendly power solution.

Applications

- It can be used in residential homes to run heavy appliances like refrigerators and air conditioners during long power cuts.

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- It is suitable for small commercial establishments such as shops and clinics to ensure continuous operation of equipment.
- It serves as a reliable backup solution in areas facing frequent and extended electricity grid failures.
- It can be implemented in remote locations where mains power supply is inconsistent or unavailable.
- It is ideal for users who require an uninterrupted power supply for sensitive electronic devices during the day.

IV. RESULTS AND DISCUSSION

The performance of the solar powered inverter with multiple charger output was evaluated under different operating conditions to analyze its efficiency and reliability. Experimental testing was conducted by exposing the solar panel to varying sunlight intensities and observing the charging behavior of the battery and the output performance of the inverter. The results indicated that the solar panel was able to generate sufficient DC power to charge the battery effectively during peak sunlight hours. The charge controller maintained a stable charging process and prevented overcharging, thereby increasing the lifespan of the battery.

The inverter circuit successfully converted the stored DC energy into AC power with stable voltage levels suitable for operating small household loads such as lights and fans. In addition, the multiple charger output module demonstrated the ability to charge several electronic devices simultaneously without significant voltage fluctuations. The system maintained consistent output voltage through the use of voltage regulation circuits, ensuring safe and efficient charging of connected devices.

Further analysis showed that the system achieved improved energy utilization by distributing the stored energy to both AC loads and DC charging ports. This multi-output capability increased the overall functionality of the system compared to traditional solar inverters that provide only AC output. The results also highlight the suitability of the system for rural and off-grid applications where access to reliable electricity is limited. Overall, the proposed system demonstrates an effective approach to utilizing solar energy for powering appliances and charging multiple devices while promoting energy efficiency and sustainability.

V. CONCLUSION

We can conclude that this system is effectively used for charging of mobile phones having low cost. We can use this system at any public place. This system can be more useful in rural areas which are suffered because of electricity problems. The Inverter with Solar Battery Charging System successfully integrates solar energy with conventional backup to create a more resilient power source. This project effectively addresses the common issue of limited battery life under heavy load by ensuring continuous charging through solar panels. It provides a practical and efficient solution for ensuring uninterrupted power to users, especially during prolonged mains power cuts.

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