Single Stage Single Phase Reconfigurable Inverter Topology

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Abstract - *This paper suggest a Inverter Topology for domestic AC/DC load. This inverter is a single stage single phase reconfigurable inverter topology which can perform DC/DC, DC/AC operation. By using this inverter, Losses, Cost, Size of converter can be reduced and Harmonic profile can be improved by isolating DC type loads to DC supply side. Renewable energy sources such as Solar Power, Wind Power, etc can be used for better performance and fulfill the peak load demand. For the proposal of this inverter, Firstly Simulation is done in Proteus Software and obtained the result. Secondly these obtained result is Validated with hardware implementation using ATmega 32 Microcontroller. This type of Solar power home and inverter would be important factor for energy efficient future smart home.*

Key Words: Single stage single phase inverter, Solar power, AC/DC home, Harmonic, ATmega 32

1. INTRODUCTION

Today, electricity is very essential for survival in daily life. The demand of electricity is increasing day by day due to increasing vast population. It is so difficult for the power distribution company to provide constant power to the consumers, because of that required power is not delivered to the end user. About 80% of household equipment used are operated on DC supply, but power provided to these equipment are AC, which is converted to DC by using converter in that particular equipment. The converters used in these equipment produce various losses, and harmonic currents, which affect the system performance by causing harmonic voltage.The solution for these conditions is reconfigurable inverter. This inverter can provide DC as well AC power output, which can be used for direct DC equipment. It also fulfil the peak load demand, by using renewable energy source as a solar power. Renewable energy will give it additional feature in which solar power can directly provide to the DC Equipment.[1]

2. METHODOLOGY

In this system, the main part is micro-controller which use to control and generate the PWM for H-Bridge MOSFET. Here, we are using two microcontrollers. One is for generating Sinusoidal PWM and another is for control the modes, which is used for Operation. Atmega32 28 pin is used to generate the Sinusoidal PWM. We are using two pin of Atmega32 to give the PWM to Gate of MOSFET in Bridge. In H-Bridge there are two group of MOSFET positive and negative group, for positive group, need to generate positive sinusoidal and for negative group need to generate sinusoidal PWM. Here we are selecting two MOSFET in one group. Each MOSFET group is driven by one MOSFET driver. We are using two MOSFET drivers for two groups, (Positive group and Negative group). Positive sinusoidal PWM generated from pin no. 21 (7th Bit of Port D) and given to positive group of the MOSFET driver, And Negative sinusoidal PWM generated from pin no. 4 (3rd Bit of Port B) and given to negative group of the MOSFET driver.[2]

Now microcontroller AT mega32 8P is used to control the modes of operation, 4 relays are used to control the 4 mode. One LCD is used to show the 4 Mode and two switch is used change the modes. All these modes are operated manually by using two switches 0 and 1. These switches work on Boolean principle.

ATmaga 32 microcontroller is used to cintrol the Mosfe Driver and these mosfet driver is used to control the Mosfet Bridge. Mosfet bridge is used for the conversion of DC Sources to AC. ATmega32 is also used to control the four mode operation . Each mode has different function according to the requirement of the user. Various component used in this system has specific function and performed as per the requirement. The block diagram of he system is shown below. The power input is feed to the system from the Battery as well as Solar. The power input can be adjusted as per the condition, e.g. if the Solar power is in sufficient ammount then these power Can directly used to run the appliannces; but if the Solar power is not having the Sufficient power then the Battery and Solar both combined used to run the load and if the Solar power is not available then only Battery is used to run the Load. The system has also th option to run the DC as well as AC load.[3]

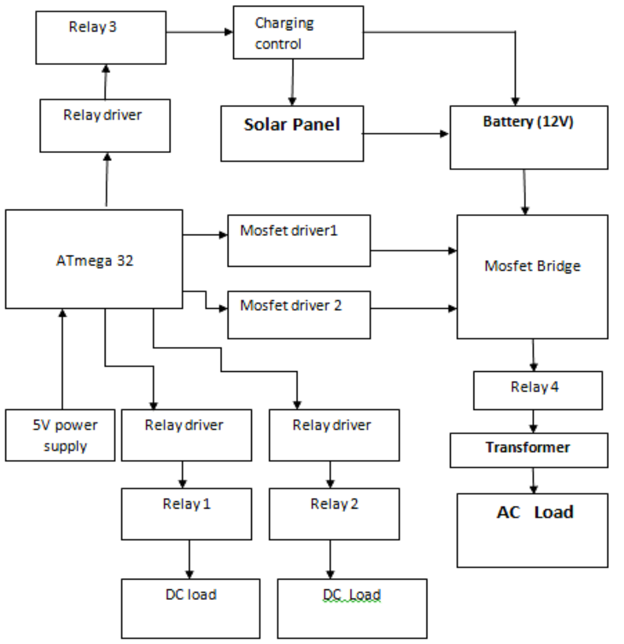

Fig -1: Block diagram of inverter

3. CONTROL STRATEGY

ATmega 32 microcontroller is used to control the overall relay operation. All the relays have their own function and they are controlled by two switches. The operating time of a relay when a pulse from UNO board is given for testing purposes of the relay is shown in Fig 1. In mode 1, to synchronize with the grid LEM (a leading company manufactures current and voltage sensors) low voltage transducer LV-25 is used to measure the voltage and it is given to the UNO analog input. Due to the interfacing with the analog input will read in and produce the synchronizing pulses using PWM pulse generator. All the modes have Specific function for the different modes. All the modes are defined as per the relay operation. There are four relays and two switches used to operate the whole system. The switch operation is tabulated below in table 1.[4]-[7]

Table -1: Switching Operation.

SWITCH 1	SWITCH 2	MODE
0	0	MODE 1
0	1	MODE 2
1	0	MODE 3
1	1	MODE 4

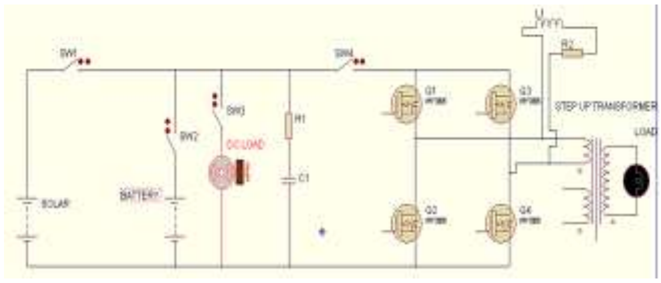

Fig -2 : Circuit diagram of mode of operation

MODE 1:- Relay 1 and Relay 4 are ON. Here, solar power will be directly connected to DC loads. Switch 1 and 2 both are pressed as shown in fig. 3.

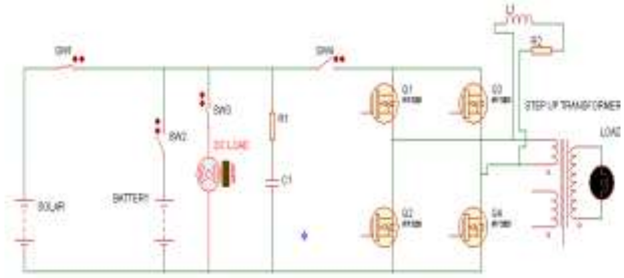

Fig -3 : Circuit diagram of mode of operation 1.

MODE 2:-Relay 1, Relay 3, Relay 4 is active. In this mode solar and battery source directly connected to DC loads. Here switch 2 is pressed as shown in fig. 4.

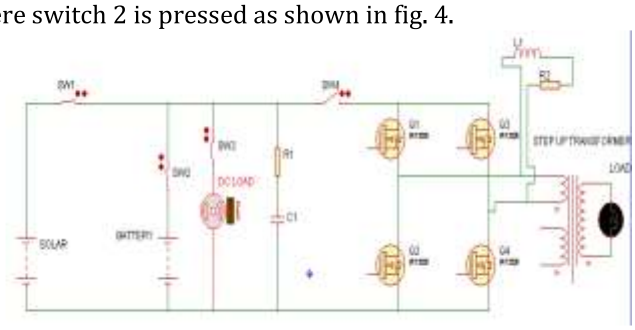

Fig -4 : circuit diagram of mode 2 operation.

MODE 3:-Relay 1, Relay 3 is active. In this mode, solar power is used to charge the battery. Here switch 2 is pressed as shown in fig. 5.

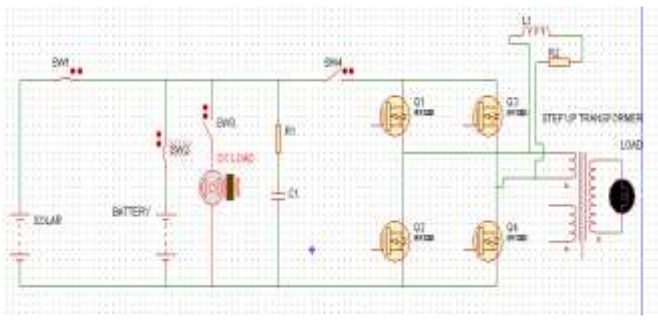

Fig -5: Circuit diagram of mode 3 operation.

MODE 4:-
Relay 1, Relay2, Relay3, and Relay 4 all are active. In this modes Battery will directly connected to AC loads as shown in fig. 6.

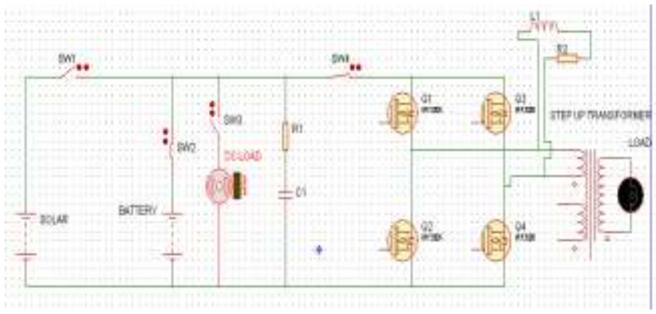

Fig -6 : Circuit diagram for mode of operation 5.

4. CALCULATION

4.1 Major system components

PV module – converts sunlight into DC electricity.
Solar charge controller – regulates the voltage and current coming from the PV panels going to battery and prevents battery overcharging and prolongs the battery life.
Inverter – converts DC output of PV panels or wind turbine into a clean AC current for AC appliances or fed back into grid line.
Battery – stores energy for supplying to electrical appliances when there is a demand.
Load – is electrical appliances that connected to solar PV system such as lights, radio, TV, computer, refrigerator, etc.[8]

4.2 Determine power consumption demands

As we are considering the load as given below:
Two 65 Watt Fan used for 5 hours per day.
Two 200 Watt Computer used for 5 hours per day.
Four 40 Watt Tube used for 6 hour per day.

4.3 Calculate total Watt-hours per day for each appliance used

Total appliance use = (2 x 65W x 5 hours) + (2 x 200 W x 5 hours) + (4 x 40 W x 6 hours)
=3610Wh/day

4.4 Calculate total Watt-hours per day needed from the PV modules.

Total PV panels energy needed
= 3610 x 1.3
= 4693Wh/day.

Where, the 1.3 is he Energy lost in the system.

4.5 Calculate the total Watt-peak rating needed for PV modules

Total Watt power of PV panel capacity needed
= 4693/ 3.4
=1380.3Wp

4.6 Calculate the number of PV panels for the system

Number of PV panels needed
= 1380.3/ 110
= 12.55modules
So this system should be powered by at least 13 modules of 110 WPV Module.

4.7 Inverter sizing

Total Watt of all appliances
=2 x 65 + 2 x 200 +4 x 40
= 690W
For safety, the inverter should be considered 25-30% bigger size. The inverter size should be about 862 W or greater.

4.8 Battery sizing

Battery Capacity (Ah) =
$$\frac{\text{Total Watt–hours per day used by appliances}}{(0.85 \text{ x } 0.6 \text{ x nominal battery voltage})} \text{xDays of Autonomy}$$
Total appliance use
= (2 x 65W x 5 hours) + (2 x 200 W x 5 hours) + (4 x 40 W x 6 hours)
=3610Wh/day
Nominal battery voltage = 12 V
Days of autonomy = 3 days
Battery capacity =
$$\frac{[(2 \text{ x } 65\text{W x 5 hours}) + (2 \text{ x } 200 \text{ W x 5 hours}) + (4 \text{ x } 40 \text{ W x 6 hours})]}{(0.85 \text{ x } 0.6 \text{ x } 12)} \text{x } 3 =$$
Total Ampere-hours required =1769.61Ah
So the battery should be rated 12V, 600Ah for 3 day autonomy.[9]-[12]

4.9 Solar charge controller sizing

According to standard practice, the sizing of solar charge controller is to take the short circuit current (Isc) of the PV array, and multiply it by 1.3
Solar charge controller rating = Total short circuit current of PV array x 1.3
PV module specification
Pm = 110 Wp

Vm = 16.7 Vdc
Im = 6.6 A
Voc = 20.7 V
Isc = 7.5 A
Solar charge controller rating
= (13 strings x 7.5 A) x 1.3 = 126.75 A
So the solar charge controller should be rated 127A at 12 V or greater.[13]

5. SIMULATION AND RESULTS

For this system, Simulation and circuit design is performed in Software named Proteus. It is a software tool used for electronic design automation. Mainly the software is used by electronic design engineers to create schematic and electronic prints for manufacturing printed circuit boards (PCB). The Proteus design suit is a Window application for schematic capture, simulation and PCB (Printed Circuit Board) layout design.The Microcontroller simulation in Proteus works by applying either a hex file or debug file to the microcontroller part on schematic. Here, the microcontroller based simulation is required for this system. The ATmega 32 microcontroller is used for the mode operation as well as relay operation. Some of the simulation design is shown below:

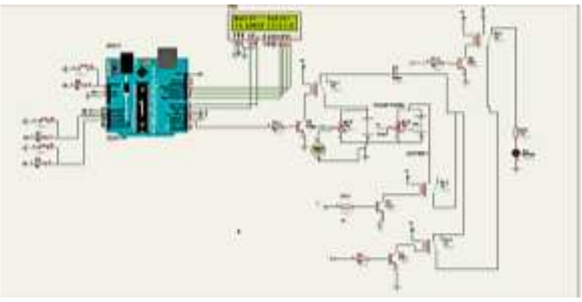

Fig -7: PCB design for the system.

For MODE 1, the simulation is done in the Proteus software as shown in fig. 8. In this mode, solar power is used to run the DC Load, if the power is in sufficient amount. The Switch SW1 and SW2 is on 0,0 Position.

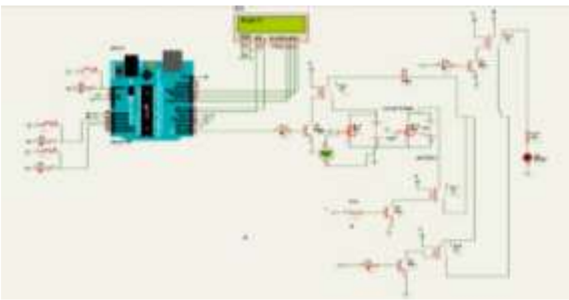

Fig -8: Simulation for MODE 1

For MODE 2, the simulation is shown in fig. 9, in this mode, solar power and Battery both is used to run the DC Load. This mode will operate at special condition; if the solar power is not able to generate required power then; Battery power along with Solar power is used to run the DC load. In this mode, Switch SW1 and SW2 is on 0,1 position.

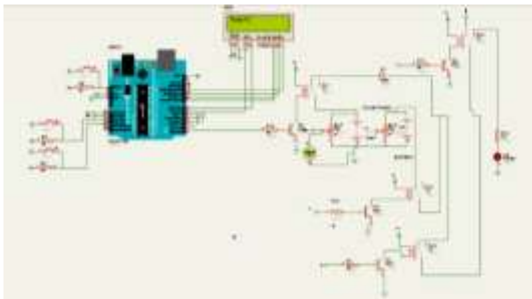

Fig -9: Simulation for Mode 2

For MODE 3, the solar power is used for the Battery Charging purpose. Battery is charged by solar power if the solar power has enough power to charge the Battery. The simulation design for mode 3 is shown in Fig. 10.

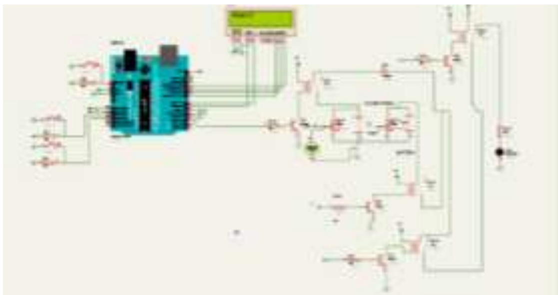

Fig -10: Simulation for Mode 3.

For MODE 4, the Battery Power is used to run the AC load by using inverter circuit. The Fig. 11 shows the mode 4 operation:

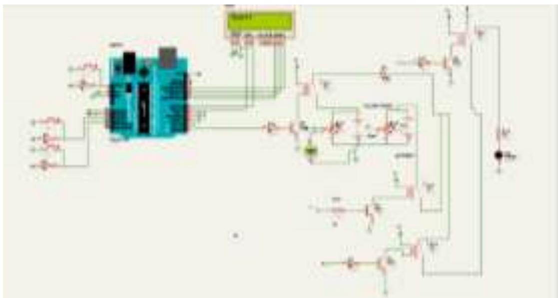

Fig -11: simulation design for Mode 4.

Table -2: Results

Vmax=2.48V	Vavg= 59.5mV	Rise= 5.900ms
Vmin=2.32V	Vrms=1.67V	Fall=5.500ms
Vamp=4.56V	Freq=50.25Hz	Duty=± 48-51%
AC output=230V	Input(Bat)=12.6V	Input(Solar)=12V

5. CONCIUSION

This paper suggested more suitable inverter topology for solar powered AC/DC home. The main purpose of this topology is to convert single phase AC power to DC and Vice versa, Due to which overall efficiency and Volume Reduced and enhancements in the reliability occurs. This inverter topology promote the renewable energy source as well as suggest to use DC load, which reduces overall losses and improve efficiency as well as Battery Backup. This system is also reconfigure in future if the additional power sources are upgraded such as ,wind power, fuel cell etc.

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