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SINGLE STAGE SINGLE PHASE RECONFIGURABLE INVERTER FOR A SOLAR POWERED HYBRID AC/DC HOME

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Abstract:

This project suggested a reconfigurable single phase inverter topology for a hybrid AC/DC solar powered home. This inverter possess a single phase single stage topology and the main advantage of this converter is that it can perform DC/DC, DC/AC and grid tie operation, thus reduces loss, cost, size of the converter. This hybrid AC/DC home has appliances of both AC and DC types. This type of home helps to reduce the power loss by avoiding unnecessary double stages of power conversion and improves the harmonic profile by isolating DC type loads to DC supply side and rest of AC side.

Keywords: DC to DC, Power Conversion, DC Type loads.

1. INTRODUCTION:

The current century has witnessed the unprecedented evolution and growth of renewable energy worldwide. There has been a substantial increase in the capacity and production of all renewable technologies and also growth in supporting policies. Between 2009- 2013, solar PVs experienced the swiftest growth rate to have added power capacity amongst all the renewable. Especially, rooftop solar PV are gaining more popularity in distribution system due to reduction in cost of solar panel, Government policies such as feed in tariffs to promote renewable energy utilization, modularity and less maintenance etc. But intermittent nature of the renewable causes the significant stability and reliability issues in the distribution system.To mitigate the uncertainty in solar PV generation, storage options are introduced such as battery system, Fuel cells etc.

1.1 RENEWABLE ENERGY

Renewable energy is generally defined as energy that comes from resources which are naturally replenished on a human time such as sunlight, wind, rain, tides, waves, and geothermal heat. Renewable energy replaces conventional fuels in four distinct areas: electricity generation, air and water heating/cooling, motor fuels, and rural (off-grid) energy services This energy consumption is divided as 9% coming from traditional biomass, 4.2% as heat energy (non-biomass), 3.8% hydro electricity and 2% is electricity from wind, solar, geothermal, and biomass, with countries like China and the United States heavily investing in wind, hydro, solar and bio-fuels.

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1.2 POWER GENERATION

Renewable hydroelectric energy provides 16.3% of the world's electricity. When hydroelectric is combined with other renewable such as wind, geothermal, solar, biomass and waste: together they make the "renewable" total, 21.7% of electricity generation worldwide. Renewable power generators are spread across many countries, and wind power alone already provides a significant share of electricity in some areas: for example, 14% in the U.S. state of Iowa, 40% in the northern German state of Schleswig-Holstein, and 49% in Denmark. Some countries get most of their power from renewable, including Iceland (100%), Norway (98%), Brazil (86%), Austria (62%), New Zealand (65%), and Sweden (54%).

1.3 HEATING

Solar water heating makes an important contribution to renewable heat in many countries, most notably in China, which now has 70% of the global total (180 GWth). Most of these systems are installed on multi-family apartment buildings and meet a portion of the hot water needs of an estimated 50–60 million households in China. Worldwide, total installed solar water heating systems meet a portion of the water heating needs of over 70 million households. The use of biomass for heating continues to grow as well. In Sweden, national use of biomass energy has surpassed that of oil. Direct geothermal for heating is also growing rapidly.

1.4 TRANSPORT FUELS

Renewable bio-fuels have contributed to a significant decline in oil consumption.oil use fell 8.5% from 2005 to 2014. The 93 billion liters of bio-fuels produced worldwide in 2009 displaced the equivalent of an estimated 68 billion liters of gasoline, equal to about 5% of world gasoline production.

1.5 WIND POWER

Fig.1.wind power

Airflows can be used to run wind turbines. Modern utility-scale wind turbines range from around 600 kW to 5 MW of rated power, although turbines with rated output of 1.5–3 MW have become the most common for commercial use; the power available from the wind is a function of the cube of the wind speed, so as wind speed increases, power output increases up to the maximum output for the particular turbine. Areas where winds are stronger and more constant, such as offshore and high altitude sites are preferred locations for wind farms. Typical capacity factors are 20-40%, with values at the upper end of the range in particularly favorable sites.

1.6 HYDROPOWER

Energy in water can be harnessed and used. Since water is about 800 times denser than air, even a slow flowing stream of water, or moderate sea swell, can yield considerable amounts of energy. There are many forms of water energy: Hydropower is produced in 150 countries, with the Asia-Pacific region generating 32 percent of global hydropower. For counties having the largest percentage of electricity from renewable, the top 50 are primarily hydroelectric. China is the largest hydroelectricity producer, with 721 terawatt-hours of production representing around 17 percent of domestic electricity use. There are now three hydroelectricity stations larger than 10 GW.

Fig.2. hydro power plant

1.7 SOLAR ENERGY

Solar energy, radiant light and heat from the sun, is harnessed using a range of ever-evolving technologies such as solar heating, photovoltaic, concentrated solar power, solar architecture and artificial photosynthesis. Solar technologies are broadly characterized as either passive solar or active solar depending on the way they capture, convert and distribute solar energy. Passive solar techniques include orienting a building to the Sun, selecting materials with favorable thermal mass or light dispersing properties, and designing spaces that naturally circulate air. Active solar technologies

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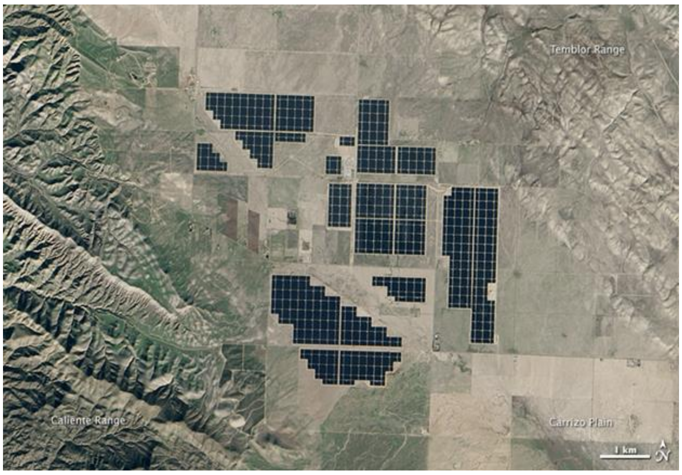

Fig.3. solar energy

1.8 GEOTHERMAL ENERGY

Geothermal energy is from thermal energy generated and stored in the Earth. Thermal energy is the energy that determines the temperature of matter. Earth's geothermal energy originates from the original formation of the planet and from radioactive decay of minerals (in currently uncertain but possibly roughly equal proportions). The geothermal gradient, which is the difference in temperature between the core of the planet and its surface, drives a continuous conduction of thermal energy in the form of heat from the core to the surface. The adjective geothermal originates from the Greek roots geo, meaning earth, and thermos, meaning heat..

Fig.4. gio thermal energy

1.9 BIO ENERGY

Biomass is biological material derived from living, or recently living organisms. It most often refers to plants or plant-derived materials which are specifically called lignocelluloses biomass. As an energy source, biomass can either be used directly via combustion to produce heat, or indirectly after converting it to various forms of bio-fuel.

Fig.5. Bio energy

1.10 HEAT PUMP

A heat pump is a device that provides heat energy from a source of heat to a destination called a "heat sink". Heat pumps are designed to move energy opposite to the direction of spontaneous heat flow by absorbing heat from a cold space and releasing it to a warmer one. A heat pump uses some amount of external power to accomplish the work of transferring energy from the heat source to the heat sink.from the ground. In heating mode, heat pumps are three to four times more efficient in their use of electric power than simple electrical resistance heaters..

Fig.6.Heat pump

1.11 GRID ENERGY STORAGE

Grid energy storage (also called large-scale energy storage) is a collection of methods used to store electrical energy on a large scale within an electrical power grid. Electrical energy is stored during times when production (especially from intermittent power plants such as renewable electricity sources such as power, tidal, solar power) exceeds consumption, and returned to the grid when production falls below consumption.

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2. PROPOSED SYSTEM:

The experimental system proposed in this thesis is a stand-alone type without backup batteries; the system is very simple and consists of a single PV or DC module, and battery and hybrid converter. The size of the system is intended to be small; therefore it could be built in the lab in the future. The system including the subsystems will be simulated to verify the functionalities.

BLOCK DIAGRAM

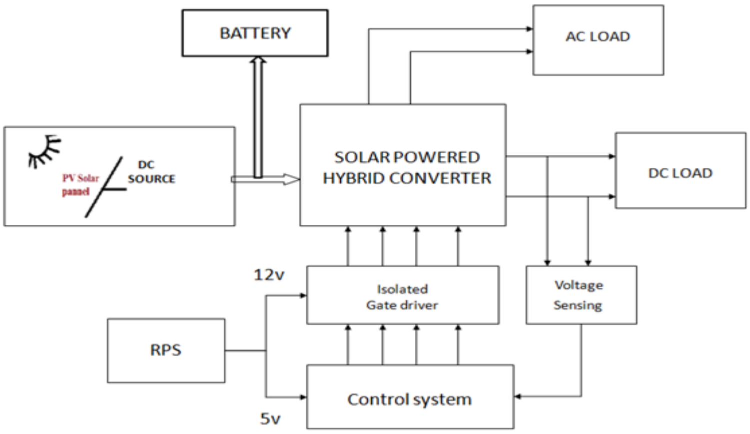

Fig.7. Block diagram of proposed system

Due to growing of nonlinear modern household equipment and new technologies in houses, which needed to improve productivity and comfort ability, are main source of generating harmonics current in distribution feeder and that adversely affecting the power quality, power losses along with creating a significant challenge for electrical engineers. Modern household loads have different characteristics compared to loads present in earlier stage. However, harmonic mitigation and/or its minimizations are big challenges in distribution system. Many literatures works have been reported to address aforementioned problems as follows. Harmonic mitigation in the distribution system using solar inverter by virtual harmonic damping impedance PV-Battery storage system is used to control the voltage stability in distribution system. The control of solar powered grid connected inverter for electric vehicle charging has proposed the DC micro grid and shown its advantages and challenges of making a complete DC home micro grid. Further, this paper has analyzed by considering all buildings in 2050, 80 % of buildings are already built. So, focus is more on improving the efficiency of existing buildings than making a new complete DC home. The efficiency of residential building when it is converted into DC house over the conventional AC distribution house.

3. HARDWARE IMPLEMENTATION:

CIRCUIT DIAGRAM:

The circuit diagram of reconfigurable solar inverter is given in the Fig. 1. Though it will reduce the no of power conversion stages but mechanical switches and cable requirement are more for this topology. The

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modes of operations of the proposed single phase single stage converter are given in Table 1. In addition, different operations modes are given in Figs

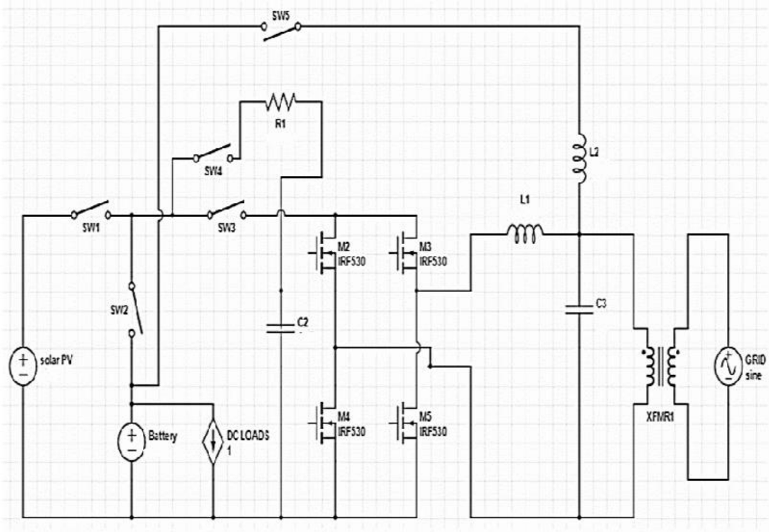

Fig.8. Circuit diagram

CIRCUIT DIAGRAM

TABLE I MODES OF OPERATION

Modes of operation	ON switches	Off switches
PV-GRID	SW1 SW3 SW 4	SW2 SW 5
PV-BATTERY-GRID	SW1 SW2 SW3 SW4	SW5
PV- BATTERY	SW1 SW3 SW5	SW2 SW4
BATTERY-GRID	SW2 SW3	SW1 SW4 SW5

4. MODES OF OPERATION

Mode-1 (PV to Grid)

The mode of operation as shown in Fig is directly connects PV to the Grid. MPPT controller is used to extract maximum power from the solar panel. Inverter controller is used to synchronize with grid and transfer active power to the grid.

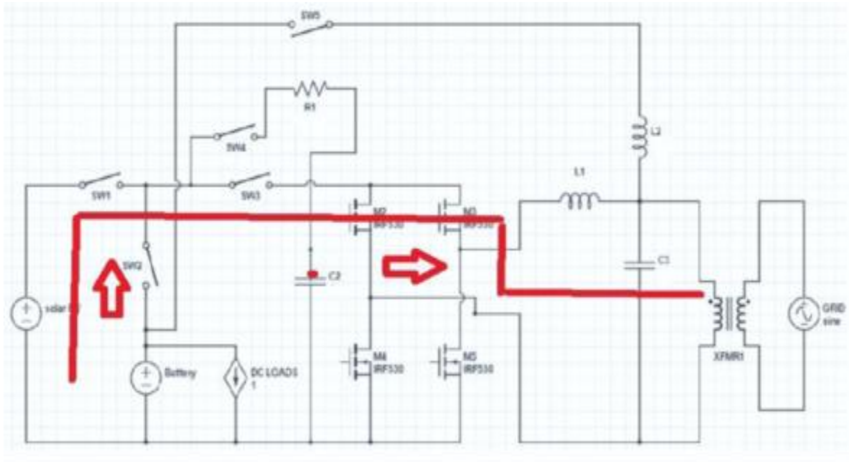

Fig.9. Mode 1 operation

Mode-2 (PV-Battery to Grid)

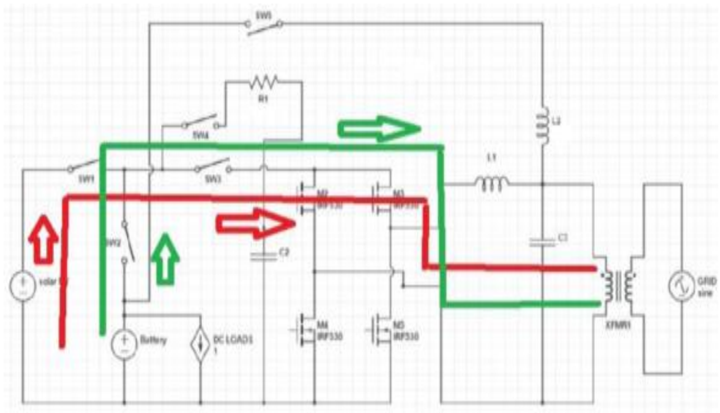

Fig .10. Mode 2 operation

In Fig the mode of operation is to supplying power to the grid from both solar PV and battery. This mode operates when there is a shortage of power from the solar PV due to external conditions, e.g., weather etc. One of the drawbacks of this connection is that the battery voltage and PV voltage should always be matching each other. Since battery voltage is stiff, MPPT controller cannot be used for this configuration.

Mode-3 (PV to Battery charging)

Figure 4 shows DC/DC operation of the proposed topology where battery is charged by a chopper action of the converter. The extra inductor is optional to reduce ripple in the charging current further. When there is an excess energy available, the battery is charged for the night time usage.

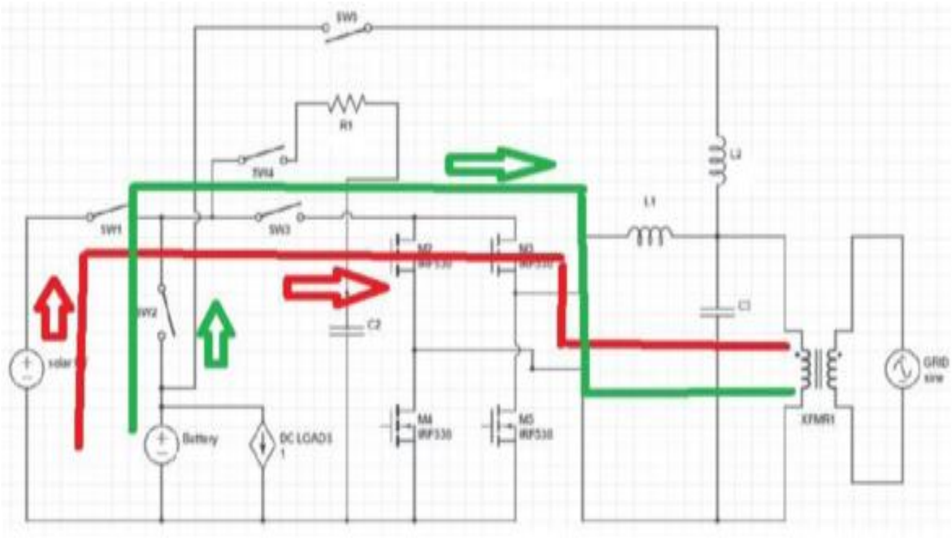

Fig.11. Mode 3 operation

Mode-4 (BATTERY TO GRID)

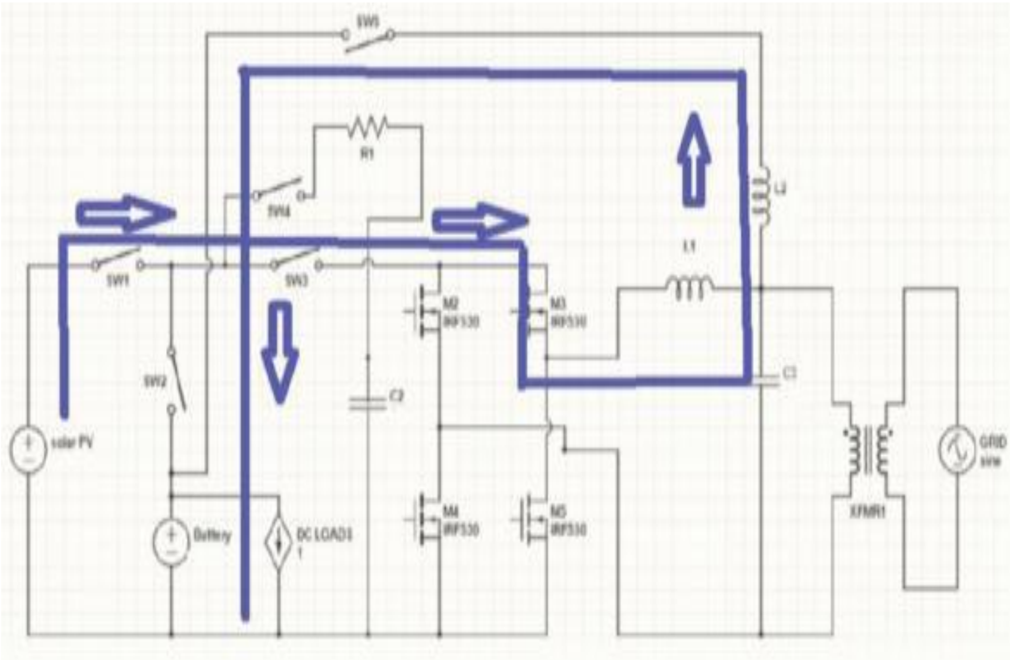

Fig.12. Mode 4 operation

From Fig. 5, the energy stored in battery can be released to the appliances or grid during the night hours or when there is no solar radiation due to clouds or rainy conditions. Battery can supply stable power to the inverter. Thus, it can be very helpful in power quality improvement and ancillary services provision

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5. SIMULATION RESULT:

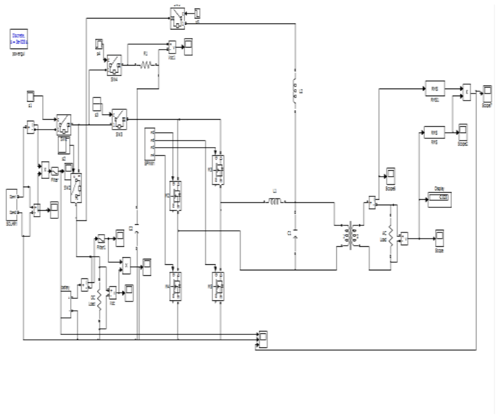

Fig.13.simulation result

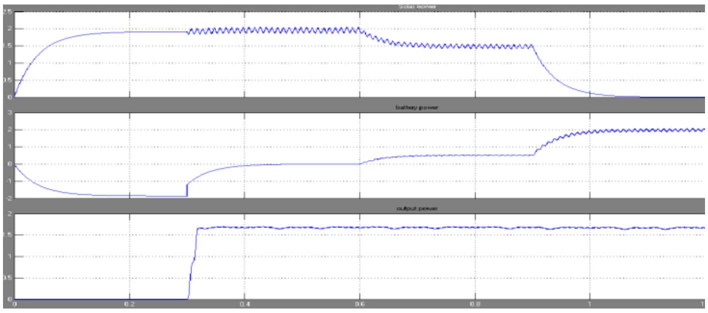

Fig.14. simulation output

6. HARDWARE RESULT

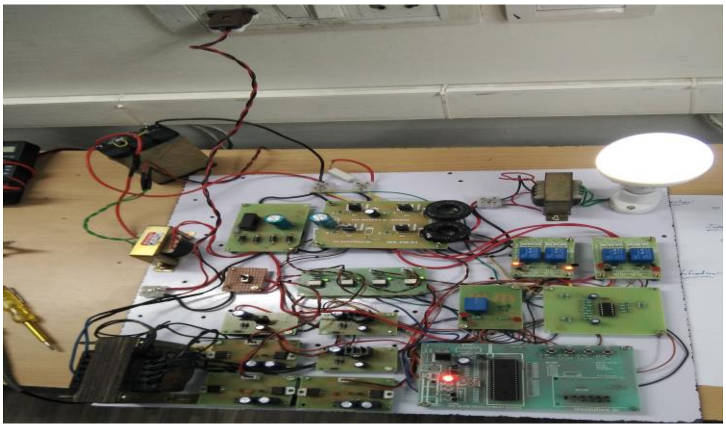

Fig.15. Hardware kit

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Fig.16

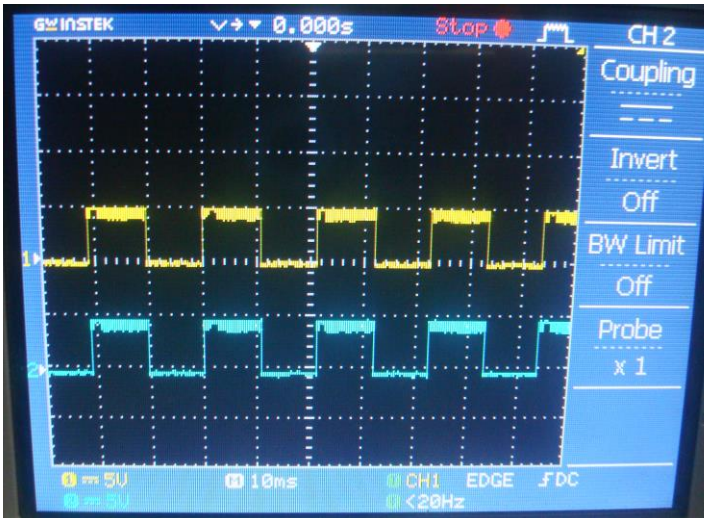

Fig.17

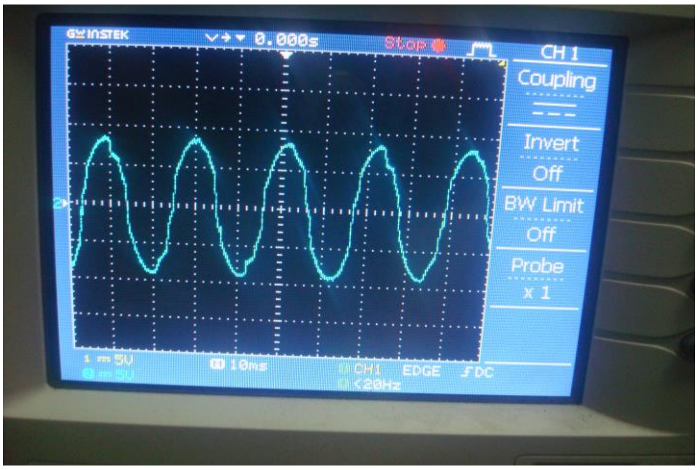

Fig.18.output voltage

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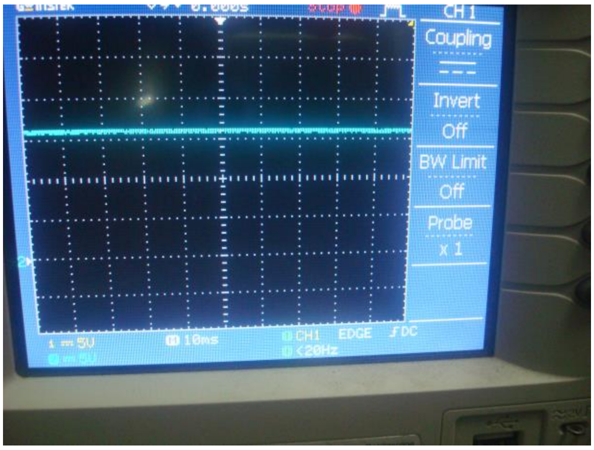

Fig.19. battery charging

CONCLUSION:

This paper suggested a more suitable converter topology for a solar powered hybrid AC/DC home. The main concepts of this topology is that a single phase single conversion of AC power to DC and vice versa is employed, which improved the efficiency, reduces volume and enhances the reliability. The hardware implementation validates that the suggested converter topology would be helpful to reduce significant amount of harmonics in the residential feeders of the future Smart Grid. Though, here only solar PV is considered as source of power, this topology could be equally applicable to wind, fuel cells etc.

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