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Design of Solar Based Integrated Dual Mode Inverter

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***Abstract* – This paper proposes a single phase solar based dual mode power inverter system for domestic and industrial use. Which allows the connection of additional energy sources and storage elements to a domestic photovoltaic grid connected system. The systems output port is designed to behave as a power source or sink, which allows the system to behave as power sink or source. It allows the connection to renewable power source and the control of the injected power within the operating range of the DC-AC grid connected inverter. The work presents the design principles using ARM LPC2138 which makes it unique of its type. The conventional solar operated inverter provides energy to load only when the mains supply is not present but proposed system provides supply according to availability of energy from solar panel. Thus helps to utilize the full efficiency of solar panels.**

***Keywords* – Single Phase Inverter, Dual Mode Energy Meter, ARM LPC2138, Transfer Switches.**

I. INTRODUCTION

India is located in equatorial Sun Belt of the earth therefore receiving radiant energy from the sun. Utilizing solar energy accurately is a big task to exploit the solar potential for power generation. Energy supply systems are facing significant changes in many countries around the globe. A good example of such a transformation is German power system where renewable energy sources are now contributing 25% of power needed to meet electricity demand compared with 5% only 20 years ago.

Solar energy has been considered as a promising solution for the energy and environmental challenges and the global warming threat. We are suffering from energy crises and environmental pollution related to fissile fuel combustion. To harvest the solar energy the most common way is to use photo voltaic panels. Solar panels receives photon energy from sun and convert it in electrical energy [2]. So to utilize the full efficiency of solar energy the proposed system can be used. Advantages of non conventional energy sources are, it is environmental friendly, pollution free and reduces green house effects etc.

Use of nonconventional energy sources for electricity generation like solar cells, wind mills are increasing day by day in industrial as well as in domestic area. Many states in Iindia are not capable to generate the required amount of enectricity because of that load shading problem occurs. To overcome this problem, the excess energy generated from industries and from domestic non conventional energy sources, can be fed to the grid i.e. can be sold to electricity compony so that this fed energy can be utilised in any another applications and the problem of loadshading can be overcome to a great extend.

India has a vast supply of renewable energy resources. It has one of the largest programs in the world for use of renewable energy products and systems. India is a significant consumer of energy resources; India currently has 15,789 MW of installed renewable energy sources out of 1,57,229 MW total installed capacities with distribution shown below.[1]

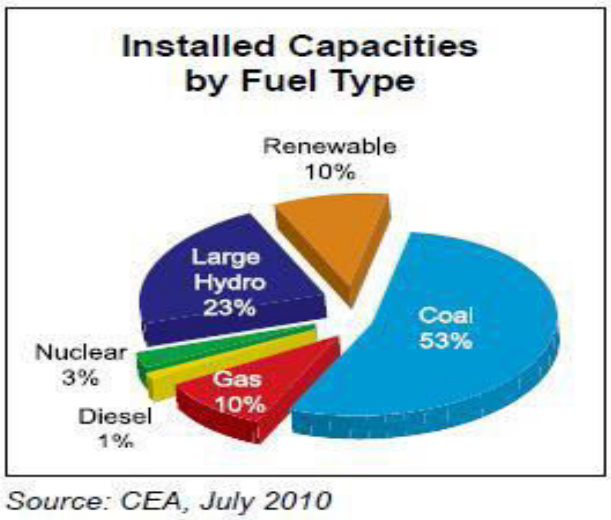

Fig.1. Generation of electricity in India by different energy sources.

To implement this idea a special type of inverter and dual mode energy meter is required which can be able to read the import energy (energy taken from mains) and the export energy (energy delivered to grid). Such type of meters are not available in market for that we are using two meters one to read import energy and one is to read export energy and our total electricity bill can be calculated as,

Electricity bill = Import energy - Export energy

The energy meter system with import and export facility is as shown in following Fig.2.

In the figure the electricity generated from solar based inverter is utilized in house hold load first and excess energy is fed to the grid and it is get recorded in meter.[4]

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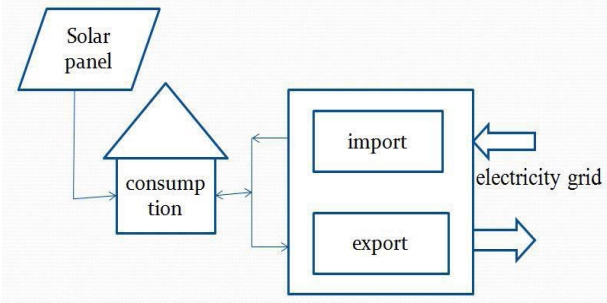

Fig.2. Energy meter system to with import and export facility.

II. Relevance of Work

Following Fig.3 shows the conventional inverter system which is also called as uninterruptable power supply system.

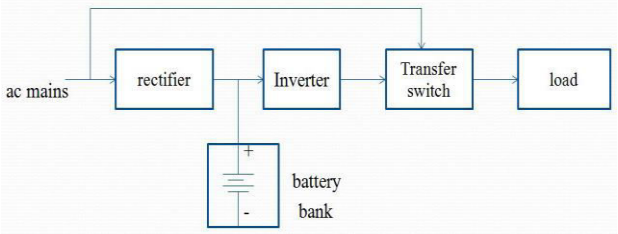

Fig.3. Conventional UPS system

The conventional UPS system operates in two modes, following Fig.4 shows mode 1 of operation where the AC mains supply is present. In this case the battery gets charged through rectifier as well as the load operates on AC mains directly.

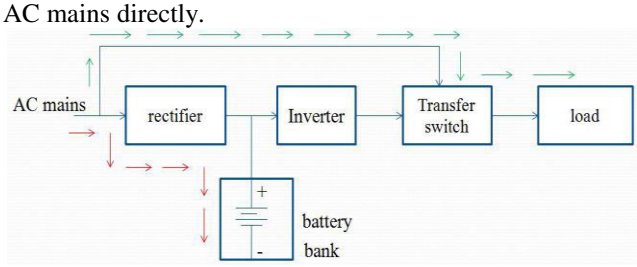

Fig.4. Mode 1 of operation of conventional UPS system

Following Fig.5 shows the mode 2 of operation where the AC mains supply is not available and load operates on battery through the inverter.

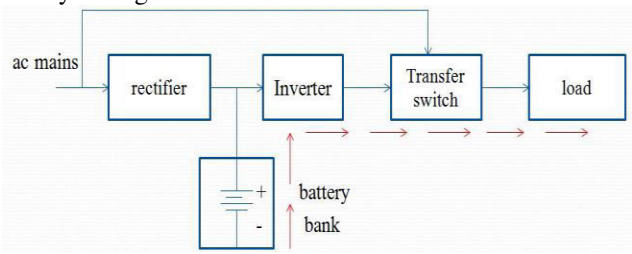

Fig.5. Mode 2 of operation where AC mains supply is not available.

III. Proposed Work

The proposed solar operated system is a grid tied system that means the inverter system is connected to AC mains supply or grid because of that it operates on both the supply from grid or from inverter. Following Fig.6. shows the proposed solar operated inverter system designed with controller and relays as transfer switch.

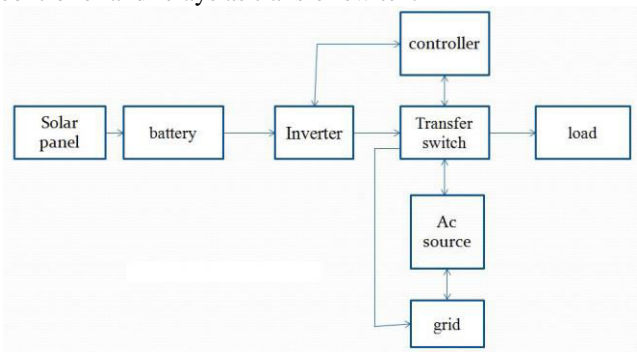

Fig.6. Proposed solar operated inverter system.

In this design the solar panel is the primary source of energy and the AC mains is the secondary source, in conventional system AC mains is the primary source and the battery bank is the secondary source, when AC mains is not available then and then only we are using the battery but in proposed method when supply from battery is insufficient or not available then only we are using AC mains supply so the proposed inverter can operate in three modes as shown in ig.7, 8, 9.

When we compare the performance of conventional system and proposed system we found that in proposed system saving of 50% to 75%of energy is possible.

In case of conventional system

Power require for charging battery = p1
Simultaneously power require for load = p2
Total power consumption (p) = p1 + p2
In case of proposed system
Power require for charging battery = p1 = 0
Power require for load = p2
Total power consumption (p) = p2
Thus power saving of 50%

The proposed system can operate in three special modes which is not possible with conventional system as shown in following figures 8, 9 and 10.

Case-1 is applicable when AC mains supply is present and the load requirement is same as battery capacity in this case whole supply is given from the battery to load thus no use from AC mains and saving of electricity bill as well as full utilization of systems capacity.

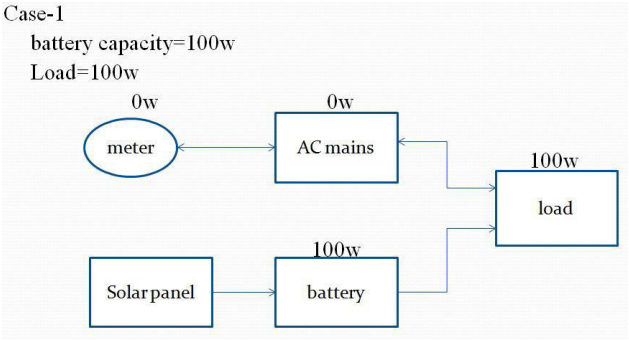

Fig.7. Special case 1 of operation.

Case-2 is applicable in cases when load requires higher power than battery capacity, for this case in conventional UPS system whole power will be delivered from the mains supply but in proposed system full capacity of battery is utilised and remained power is taken from AC mains supply thus saving of 50% electricity is possible.

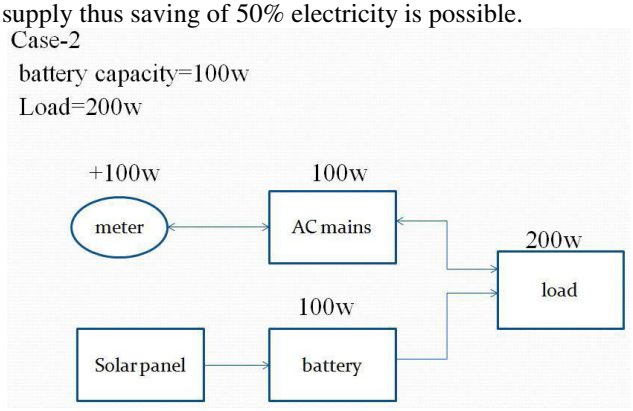

Fig.8. Special case 2 of operation

Case-3 can be observed in the applications where battery is fully charged and load is in off state or load requires less power than battery capacity in this case the excess energy generated is fed to AC grid or mains. Thus the meter will read the power delivered to load.

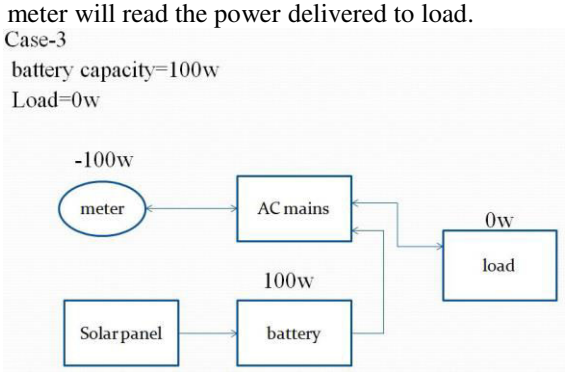

Fig.9. Special case 3 of operation

IV. Circuit Design

The inverter circuit is designed to behave such that it is capable to fed excess energy to the grid. It is as shown in following Fig.10.[3]

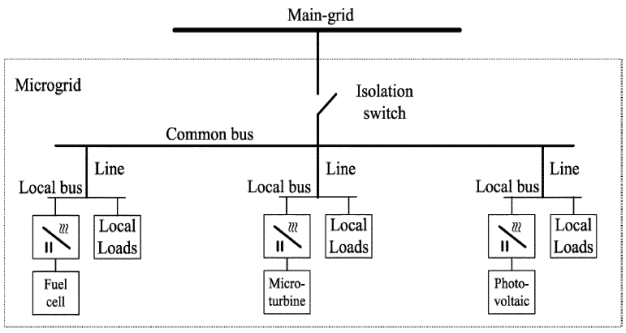

Fig.10. Grid connected system

Following Fig.11 shows the detailed block diagram of the proposed inverter system.

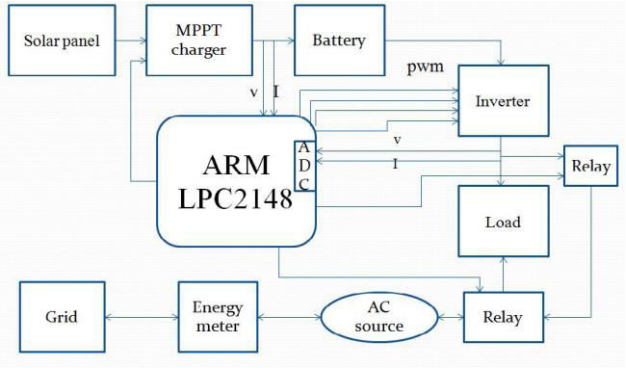

Fig.11. Block diagram of proposed system

The solar panel consists of array of photovoltaic cells which convert light energy in to electrical energy which is given to MPPT charger. MPPT is nothing but maximum power point tracking we can also call it DC to DC converter. It continuously checks the voltage getting from solar panel and converts it in smooth DC; its output is given to battery.

Battery is used to store the DC getting from MPPT. A control signal is given to MPPT charger from ARM LPC2148 and the feedback of current and voltage is taken from output of MPPT to know that it is providing proper output or not. The output of battery is given to inverter. Inverter is designed with the help of ARM LPC2148. Four control signals from the ARM are given to the four thyrester and the sample of output voltage and current is taken as a feedback from inverter for control purpose.

The relays are used as switch. Relays are controlled by ARM LPC2148. When load requires extra power then it is given by AC source and when there is excess power generated by inverter then it is given to grid.

A. DC to DC Converter

The output of solar panel does not provide fixed 12v. So to convert variable DC to fix DC or to reduce any impurities present DC to DC converter is used. The circuit up to diode D3 is buck converter or charge controller it provides constant DC irrespective of any changes in input and when battery get fully charged it cuts the battery from

the charger . To see the charging condition of battery current and voltage references are taken and given to the microprocessor. Direct 12V cannot be given to the microprocessor because it can damage it so 12v is converted in 3.6v and equivalent current is given, The circuit diagram is as shown in following Fig.12.

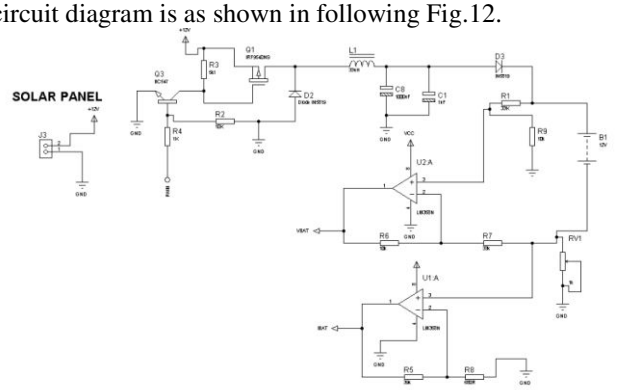

Fig.12. Circuit module of DC TO DC converter.

B. Inverter

This is the heart of our design the inverter is designed with four thirstier. The output of battery is given to the input of circuit as DC input. The gate pulses are generated from the microprocessor which is applied to the gate of thirstier for first gate pulse thirstier Q1 and Q4 are ON and provides positive half cycle at the output. For second gate pulse thirstier Q2 and Q3 conducts providing negative cycle at output. LC is used for filtering thus we get AC voltage at output. Circuit diagram of inverter is shown in Fig.13.

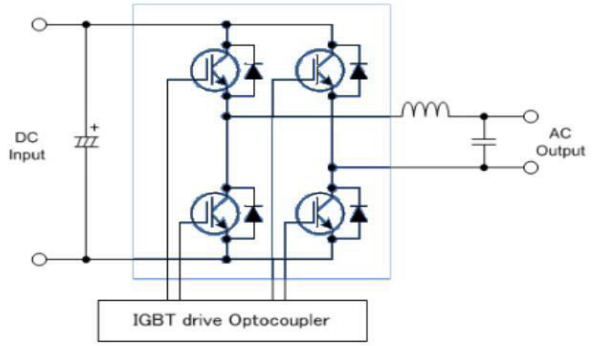

Fig.13. Circuit module of inverter.

C. Meter to Read Import Energy

We require two energy meters in the design, so this diagram is for meter to read import energy. The AC mains supply is given to meter as input. The load is connected at the output the relay is used to connect AC mains supply to load or to connect inverter output to load. The operation of relay is controlled by microprocessor. The pulses from meter are given to opto-coupler IC. Opto-coupler is used for isolation purpose. The op-amp circuitry is a unity gain amplifier or buffer it is used to protect microprocessor from excess current. Because the input impedance of op amp is very high it provides pure pulses at its output which are then given to microprocessor. Microprocessor counts pulses when there are 3600 pulses that mean 1w/h energy is consumed.

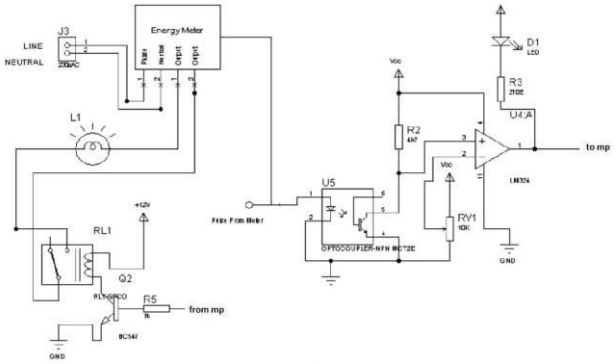

Fig.14. Module of meter to read import energy.

D. Meter to Read Export Energy

The same working principle is applicable to export meter here only input is from inverter and output is fed to AC mains supply the pulses are given to the microprocessor. The microprocessor compares the pulses from export meter and import meter and displays it on the LCD also it displays the mode of operation etc.

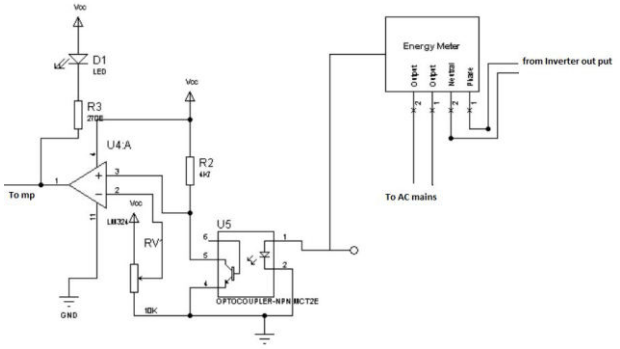

Fig.15. Circuit module of meter to read export energy

V. CONCLUSION

Thus the solar operated inverter is designed with ARM LPC2148 which can provide better output than conventional system and able to reduce up to 75% of electricity bill and utilizes full capacity of solar based inverter. The additional feature of this system is that it provides dual mode energy meter which is applicable to measure the power taken from mains as well as power delivered to grid. Proposed design is unique of its type because it can operate in special three modes which is not possible with conventional inverter systems. The system can be improved with the use of wind turbines. The solar based system has several drawbacks such as it does not work in night and in rainy days. Solar panels efficiency reduces from 10% to 30% because of dust so regular cleaning is required. Solar panel produces DC voltage only but wind mills can be used to produce DC as well as AC

also. It is possible to use wind mills and solar panels together to increase system efficiency.

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